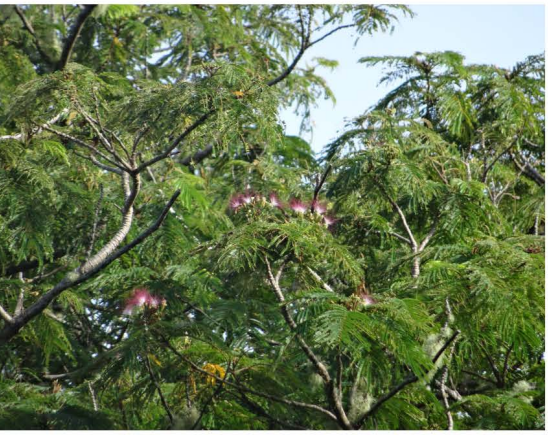
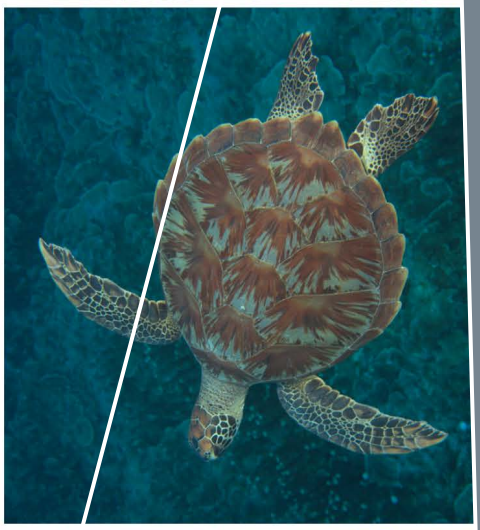










Joint Region Marianas Integrated Natural Resources Management Plan for

Joint Region Marianas-administered and Leased Lands On Guam, Tinian, and Farallon de Medinilla

September 2024

Prepared for:
Joint Region Marianas

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FINAL

INTEGRATED NATURAL RESOURCES MANAGEMENT PLAN FOR JOINT REGION MARIANAS WORK

Prepared under contract with

Naval Facilities Engineering Systems Command Marianas

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2024 INRMP 5-Year Update Summary

Per the Sikes Act (16 United States [U.S.] Code [USC] 670a et seq.), a 5-year review for operation and effect of the 2019 Integrated Natural Resources Management Plan (INRMP) was conducted to determine necessary updates to the 2019 INRMP. It was determined that minor and major updates were required. An overview of the changes made are listed below:

- All references to instructions and regulations were updated if available (e.g. OPNAVIST and OPNAV Manual).
- Overview of the climate in Guam (Section 4.1) was updated with current data available.
- The overview of non-special status wildlife in Guam (Section 4.4.2) was updated with current data available.
- The overview of special status species in Guam (Section 4.4.3 and 4.5.6) was updated with current data available, as well as within corresponding chapters for installation-specific species updates.
- The overview of special status species in the Commonwealth of the Northern Mariana Islands (CNMI) (Section 10.4.3 and 10.5.6) was updated with current data available, as well as within corresponding chapters for installation-specific species updates.
- Taxonomic and common names were updated for all threatened and endangered species where necessary, per the direct final rules from the Federal Register and the U.S. Geological Survey (USGS) Integrated Taxonomic Information System (ITIS).
- A new dataset for Special Status Species was utilized for updates to all associated figures. Associated population totals within the text and tables will be included in the next INMRP version.
- All figures were assessed and updated as needed to reflect the most recent available data.
- All tables were assessed and updated as needed to reflect the most recent available data.
- Ungulate removal projects occurring within Guam installations were updated in all corresponding chapters.
- All actions within *Management Goals, Objectives, Strategies, and Actions* sections were reviewed and updated as needed to reflect current actions.
- A section for *Management Goals, Objectives, Strategies, and Actions* was developed for Marine Corps Base (MCB) Camp Blaz Urban Training Complex and added to the INRMP (Section 9.3.7).
- Text regarding the protection and preservation of sea turtle nesting areas, foraging/resting areas, and reproduction areas were updated in Chapters 4, 5, 8, 9, 11, and 12 along with associated management actions, per guidance language provided by National Oceanic and Atmospheric Association (NOAA).
- Tables and Figures displaying the extent of submerged lands were updated to include acreages and locations of 'Managed Nearshore Areas,' to identify the areas which include conservation actions within submerged lands.

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EXECUTIVE SUMMARY

An Integrated Natural Resources Management Plan (INRMP) is a long-term planning document designed to guide the management of natural resources on military lands, support military missions, and ensure compliance with environmental laws and regulations. An INRMP also supports an installation's mission while conserving and rehabilitating installation resources for multiple use, sustainable yield, and biological integrity. INRMPs are important documents that improve the efficacy of resource management efforts undertaken by Regional Commanders, Installation Commanding Officers, and the environmental and natural resource programs of public works departments.

This INRMP complies with the Sikes Act (16 United States [U.S.] Code [USC] 670a et seq.), as amended (2015), which requires the preparation, implementation, and review for operation and effect of an INRMP at all U.S. Department of Defense (DoD) installations in the U.S. and its territories that contain significant natural resources. Section 101(a)(2) of the Sikes Act (as amended) requires the Secretary of the Navy (SECNAV) to prepare INRMPs "in cooperation with" the U.S. Fish and Wildlife Service (USFWS) and appropriate state and territorial fish and wildlife agencies. DoD Instruction (DoDI) 4715.03 instructs military installations to identify, address, and resolve INRMP issues with the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) when matters of essential fish habitat (EFH), listed marine species, and/or marine fisheries are involved.

This INRMP is focused on Joint Region Marianas (JRM)-administered and leased terrestrial and submerged lands. The U.S. Navy has partnered with the USFWS, NMFS, the Guam Department of Agriculture's Division of Aquatic and Wildlife Resources (Guam DAWR), and the Commonwealth of the Northern Mariana Islands (CNMI) Department of Land and Natural Resources' (DLNR) Division of Fish and Wildlife (DFW) to provide technical assistance, review, and expert guidance regarding terrestrial and marine resources addressed in this INRMP, in particular, species listed under the Endangered Species Act (ESA) (16 USC 1531 et seq.), Migratory Bird Treaty Act (MBTA) (16 USC 703-712), Marine Mammal Protection Act (MMPA) (16 USC 1361 et seq.), and species and habitats covered under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) (i.e., EFH) (16 USC 1801 et seq.). This INRMP furthermore reflects mutual agreement between the U.S. Navy and its partnering agencies on the conservation of the natural resources.

PURPOSE

The purpose of this INRMP is to maintain long-term ecosystem health and operational requirements of the DoD's mission while minimizing impacts to natural resources at JRM sites. It is also the intent of this INRMP to provide a conservation benefit to federally protected species and their designated critical habitats under the ESA. In order to meet these purposes, this INRMP establishes a list of management projects designed to protect species and their habitat at JRM sites without infringing on the DoD's military mission.

GOALS AND OBJECTIVES

In May 2016, DoD and agency stakeholders involved in the preparation of this INRMP developed goals and objectives for the management of natural resources on JRM-administered terrestrial and submerged lands. These goals and objectives guided the preparation of the revised JRM INRMP with the intent of preparing a document that reflects mutual agreement of the stakeholders. Following are the goals used to guide the development of resource specific projects, strategies, and actions, which are presented in Chapters 5-9, 11, and 12:

- Goal #1: Ensure Military Mission Sustainability and Environmental Compliance
- Goal #2: Provide Ecosystem-based Adaptive Management to Preserve, Protect, and Enhance Natural Resources and Native Biodiversity
- Goal #3: Provide a Conservation Benefit to Protected Species and Species of Concern
- Goal #4: Interdiction, Control, and Eradication of Terrestrial and Marine Invasive and Nuisance Species
- Goal #5: Integrate Climate Change into Adaptive Management Strategies, Missions, and Operations to Ensure the Long-Term Sustainability of Marine and Terrestrial Ecosystems
- Goal #6: Enhance Opportunities for Environmentally Sustainable Commercial, Recreational, and Cultural Activities within JRM-administered Terrestrial and Submerged Lands where Appropriate, Including Access by the General Public
- Goal #7: Develop and Encourage Coordination, Communication, Outreach, and Partnerships between JRM and Federal, Guam, and CNMI Government Agencies, and Other Stakeholders

MANAGEMENT PROJECTS AT JOINT REGION MARIANAS SITES

This INRMP provides a list of management projects at JRM sites that will guide the practice of effective ecosystem management and address results of federal ESA section 7 consultations and other agreements. The management projects include those that are ongoing as well as new actions that were identified as priorities during the development of the INRMP. The number of projects, by type and JRM site, are presented in Tables ES-1 and ES-2. Table ES-1 relates to management projects for terrestrial species and Table ES-2 relates to management projects for marine species. Each JRM site has a representative chapter in the INRMP where details on each management project can be reviewed.

Table ES-1. Number of Terrestrial Management Projects per Installation

Facility Name	*Terrestrial Habitat Management (THM)*	*Terrestrial Exotic and Invasive Species Management (TIS)*	*Terrestrial Protected Species Management (TPS)*	*Migratory Bird Management (MIG)*	*Terrestrial Natural Resources Educational Outreach (TEDU)*	*Terrestrial Natural Resources Law Enforcement (TLAW)*	*Terrestrial Geographic Information System (GIS) and Data Management (TGIS)*	*Total*
Naval Base Guam (NBG) Main Base	1	7	5	2	2	1	1	**19**
Naval Munitions Site (NMS)	3	7	7	1	2	1	1	**22**
Various DoD Lands	2	7	3	1	2	1	1	**17**
Marine Corps Base (MCB) Camp Blaz	3	7	4	1	2	1	1	**19**
Andersen Air Force Base (AFB)	3	8	7	1	2	1	1	**23**
Tinian Military Lease Area (MLA)	1	2	7	1	1	1	1	**14**
Farallon de Medinilla (FDM)	0	2	2	1	1	0	1	**7**
Total	**13**	**40**	**35**	**8**	**12**	**6**	**7**	**121**

Table ES-2. Number of Marine Management Projects per Installation

Facility Name	*Marine Habitat Management (MHM)*	*Marine Invasive Species Management (MIS)*	*Marine Protected Species Management (MPS)*	*Marine Natural Resources Educational Outreach (MEDU)*	*Marine Natural Resources Law Enforcement (MLAW)*	*Marine GIS and Data Management (MGIS)*	*Total*
NBG Main Base	8	2	3	2	2	1	**18**
MCB Camp Blaz	4	2	2	2	1	1	**12**
Andersen AFB	3	2	2	2	1	1	**11**
Tinian MLA	3	2	3	1	1	1	**11**
FDM	2	0	2	1	1	1	**7**
Total	**20**	**8**	**12**	**8**	**6**	**5**	**59**

ENDANGERED SPECIES ACT-LISTED PROTECTED SPECIES

The management projects are designed to protect federal and local ESA-listed species at JRM sites without infringing on the military missions that take place at those sites. The species that will be protected by the management projects are listed, by type and JRM site, in Tables ES-3 and ES-4. Table ES-3 relates to terrestrial species and Table ES-4 relates to marine species. Each JRM site has a representative chapter in the INRMP where details on each species can be reviewed.

Table ES-3. Number of Terrestrial Federal and Local ESA-listed Species per Installation

Facility Name	*Mammals*	*Birds*	*Reptiles*	*Invertebrates*	*Plants*	*Total*
NBG Main Base	1	2	2	3	11	**19**
NMS	1	2	3	2	13	**21**
Various DoD Lands						
Apra Heights/Apra Palms/Apra View	0	0	0	1	0	**1**
Sasa Valley and Tenjo Vista Tank Farms	1	1	0	1	0	**3**
Naval Computer and Telecommunications Station Barrigada	1	0	0	1	3	**5**
Barrigada Transmitter Site	0	0	0	0	0	**0**
MCBCB Urban Training Complex	0	0	0	1	3	**4**
MCB Camp Blaz	1	1	5	4	7	**18**
Andersen AFB	1	2	8	3	13	**27**
Tinian MLA	1	2	3	1	3	**10**
FDM	1	1	0	0	0	**2**

Table ES-4. Number of Marine Federal and Local ESA-listed Species per Installation

Facility Name	*Invertebrates (Corals)*	*Fish*	*Reptiles*	*Mammals*	*Total*
NBG Main Base	1	3	2	1	**7**
MCB Camp Blaz	1	3	2	4	**10**
Andersen AFB	1	3	2	4	**10**
Tinian MLA	1	3	2	5	**11**
FDM	1	3	2	5	**11**

THE WAY AHEAD

The final INRMP reflects mutual agreement of the USFWS, NMFS, Guam DAWR, and CNMI DFW representatives concerning the conservation of the natural resources under their respective legal authorities, consistent with the U.S. Department of the Interior's Memorandum of Understanding (MOU). In order to evaluate the effectiveness of INRMP implementation, an annual Natural Resources Conservation Metrics Meeting is held. The Natural Resources Conservation Metrics Meeting will enable installation natural resources staff and agency partners to measure both successes and shortcomings of INRMP implementation. In addition to facilitating annual coordination with the resource agency partners, results of the evaluation are used by natural resources managers to support the ESA expenditure reporting to Congress, inform DoD and U.S. Navy chains of command regarding the status of natural resources programs, and to provide data for the U.S. Department of the Navy (DON) portion of the DoD annual report to Congress.

The annual Natural Resources Conservation Metrics Meeting, along with other meetings between JRM and resource agency partners, will identify necessary modifications to the INRMP resulting from changes in mission, existing baseline natural resources conditions, and the status of listed species. In addition, the meetings are intended to facilitate "adaptive management" with respect to ongoing actions or new data regarding species or habitats by providing an opportunity for the parties to review the goals and objectives of the INRMP. Any modifications that emerge from the meetings will be incorporated into annual updates that will be incorporated internally (i.e., JRM and agencies will apply them as part of the INRMP) on an ongoing basis and will then be incorporated into ensuing 5-year INRMP updates, which are available for public review. It is through this process that JRM will ensure the continued support of DoD's current and evolving mission requirements while conserving and managing the natural resources on JRM-administered lands.

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FINAL
INTEGRATED NATURAL RESOURCES MANAGEMENT PLAN
JOINT REGION MARIANAS

TABLE OF CONTENTS

EXECUTIVE SUMMARY ES-1

1 OVERVIEW 1-1
1.1 PURPOSE AND SCOPE 1-3
1.2 ANNUAL REVIEW AND UPDATE PROCESS 1-7
1.3 RESPONSIBILITIES 1-9
1.3.1 United States Department of Defense Stakeholders 1-9
1.3.1.1 Commander, Navy Installations Command 1-9
1.3.1.2 Naval Facilities Engineering Systems Command 1-9
1.3.1.3 Joint Region Marianas 1-10
1.3.2 External Stakeholders 1-13
1.3.2.1 United States Fish and Wildlife Service 1-14
1.3.2.2 Guam Department of Agriculture, Division of Aquatic and Wildlife Resources 1-15
1.3.2.3 Commonwealth of the Northern Mariana Islands Department of Land and Natural Resources, Division of Fish and Wildlife 1-16
1.3.2.4 National Oceanic and Atmospheric Administration 1-17
1.3.2.5 United States Department of Agriculture Animal and Plant Health Inspection Service 1-17
1.3.2.6 United States Geological Survey 1-18
1.4 FORMAL ADOPTION/MUTUAL AGREEMENT 1-18

2 MILITARY MISSION AND OVERVIEW OF HISTORY AND LAND USE 2-1
2.1 LOCATION 2-1
2.2 MILITARY MISSION 2-1
2.2.1 Joint Region Marianas 2-1
2.2.2 Naval Base Guam 2-7
2.2.2.1 Naval Base Guam Tenants 2-7
2.2.3 Andersen Air Force Base 2-8
2.2.3.1 Andersen Air Force Base Tenants 2-8
2.2.4 Marine Corps Base Camp Blaz 2-9
2.2.4.1 MCB Camp Blaz Tenants 2-9
2.3 ABBREVIATED HISTORY OF GUAM, TINIAN, AND FARALLON DE MEDINILLA 2-9
2.3.1 Territory of Guam 2-9
2.3.2 Commonwealth of the Northern Mariana Islands 2-10
2.3.2.1 Tinian 2-11
2.3.2.2 Farallon de Medinilla 2-11
2.4 REGIONAL LAND USE 2-11
2.4.1 Guam 2-11
2.4.2 Tinian 2-11
2.4.3 Farallon de Medinilla 2-12

3 ENVIRONMENTAL MANAGEMENT STRATEGY AND MISSION SUSTAINABILITY 3-1
3.1 ECOSYSTEM MANAGEMENT AND ADAPTIVE MANAGEMENT 3-1
3.1.1 Climate Change 3-4
3.2 INTEGRATING MILITARY MISSION AND SUSTAINABLE LAND USE DECISIONS 3-6

3.2.1 Natural Resources Military Mission Constraints 3-7
3.3 NATURAL RESOURCES MANAGEMENT GOALS AND OBJECTIVES 3-8
3.3.1 Goals and Objectives 3-10
3.4 FEDERAL REGULATORY REQUIREMENTS AND POLICIES 3-12
3.4.1 Natural Resources Consultation Requirements 3-17
3.4.1.1 Endangered Species Act 3-17
3.4.1.2 Migratory Bird Treaty Act and Executive Order 13186 3-22
3.4.1.3 Magnuson-Stevens Fishery Conservation and Management Act 3-23
3.4.1.4 Marine Mammal Protection Act 3-23
3.4.1.5 Fish and Wildlife Coordination Act 3-24
3.4.1.6 National Environmental Policy Act Compliance 3-24
3.4.1.7 Clean Water Act Section 404/401 Permitting 3-25
3.4.1.8 Coastal Zone Management Act 3-25
3.4.1.9 Guam Regulations and Guam Federal Regulation Implementation 3-25
3.4.1.10 Guam Landscaping Guidelines 3-26
3.4.1.11 Commonwealth of the Northern Mariana Islands Regulations 3-27
3.5 INTEGRATION WITH OTHER JOINT REGION MARIANAS SITE PLANS AND REGIONAL PROGRAMS 3-28
3.5.1 Management Plans for Joint Region Marianas-administered and Leased Lands 3-29
3.5.2 Regional Biosecurity Plan for Micronesia and Hawai‘i 3-29
3.5.3 Guam National Wildlife Refuge Comprehensive Conservation Plan 3-30
3.5.4 Bird/Animal Aircraft Strike Hazard Programs 3-34
3.5.5 Guam Comprehensive Wildlife Conservation Strategy 3-35
3.5.6 Commonwealth of the Northern Mariana Islands Wildlife Action Plan 3-35
3.5.7 Fishery Ecosystem Plan for the Mariana Archipelago 3-35
3.5.8 Guam’s Coral Reef Management Priorities and Commonwealth of the Northern Mariana Island’s Coral Reef Management Priorities 3-36
3.5.9 Pacific Islands Regional Action Plan – National Oceanic and Atmospheric Administration Fisheries Climate Science Strategy 3-36
3.6 BENEFICIAL PARTNERSHIPS AND COLLABORATIVE RESOURCE PLANNING 3-36
3.6.1 Other Department of Defense Organizations and Programs 3-37
3.6.1.1 Partners in Amphibian and Reptile Conservation 3-37
3.6.1.2 Department of Defense Legacy Resources Management Program 3-37
3.6.1.3 National Military Fish and Wildlife Association 3-38
3.6.1.4 Space and Naval Warfare Systems Command and Naval Facilities Engineering Systems Command Engineering and Expeditionary Warfare Center 3-38
3.6.1.5 United States Army Corps of Engineers 3-38
3.6.1.6 Armed Forces Pest Management Board 3-38
3.6.2 Other Federal Agencies and Programs 3-39
3.6.2.1 United States Environmental Protection Agency 3-39
3.6.2.2 United States Fish and Wildlife Service 3-39
3.6.2.3 National Oceanic and Atmospheric Administration, National Marine Fisheries Service 3-40
3.6.2.4 United States Department of Agriculture, Natural Resources Conservation Service 3-40
3.6.2.5 United States Department of Agriculture, Animal and Plant Health Inspection Services 3-40
3.6.2.6 United States Geological Survey 3-41
3.6.2.7 National Park Service National Natural Landmarks Program 3-41

3.6.3 Territory of Guam 3-41
3.6.3.1 Department of Agriculture, Division of Aquatic and Wildlife Resources 3-41
3.6.3.2 Department of Agriculture, Division of Forestry and Soil Resources 3-41
3.6.3.3 Bureau of Statistics and Plans 3-41
3.6.3.4 Guam Environmental Protection Agency 3-41
3.6.3.5 Guam Department of Parks and Recreation 3-41
3.6.4 Commonwealth of the Northern Mariana Islands 3-42
3.6.4.1 Department of Land and Natural Resources, Division of Fish and Wildlife 3-42
3.6.4.2 Department of Land and Natural Resources, Division of Agriculture, Forestry Section 3-42
3.6.4.3 Bureau of Environmental and Coastal Quality, Division of Coastal Resources Management 3-42
3.6.4.4 Bureau of Environmental and Coastal Quality, Division of Environmental Quality 3-42
3.6.4.5 Department of Land and Natural Resources, Division of Parks and Recreation 3-42
3.6.4.6 Division of Historic Preservation 3-42
3.6.5 Other Partners 3-43

4 OVERVIEW OF GUAM 4-1
4.1 CLIMATE 4-1
4.2 GEOLOGY, TOPOGRAPHY, AND SOILS 4-2
4.2.1 Geology 4-2
4.2.1.1 Geologic Units 4-6
4.2.1.2 Karst Geology 4-6
4.2.1.3 Seismology 4-8
4.2.2 Topography 4-8
4.2.3 Soils 4-8
4.3 HYDROLOGY 4-12
4.3.1 Surface Water 4-12
4.3.2 Groundwater 4-16
4.4 TERRESTRIAL BIOLOGICAL ENVIRONMENT 4-19
4.4.1 Vegetation Communities 4-20
4.4.1.1 Effect of Brown Treesnake on Native Vegetation 4-29
4.4.2 Terrestrial Wildlife 4-29
4.4.2.1 Mammals 4-29
4.4.2.2 Birds 4-31
4.4.2.3 Reptiles and Amphibians 4-32
4.4.2.4 Freshwater Fishes 4-35
4.4.2.5 Invertebrates 4-35
4.4.3 Terrestrial Protected Species 4-38
4.4.3.1 Mammals 4-40
4.4.3.2 Birds 4-43
4.4.3.3 Reptiles 4-45
4.4.3.4 Invertebrates 4-47
4.4.3.5 Plants 4-48
4.4.4 Stressors on the Terrestrial Environment of Guam 4-52
4.5 MARINE BIOLOGICAL ENVIRONMENT 4-53

4.5.1 Physical Environment....4-53
4.5.1.1 Bathymetry and Currents....4-53
4.5.1.2 Turbidity and Water Quality....4-54
4.5.1.3 Waves and Storms....4-54
4.5.2 Marine Habitats....4-54
4.5.2.1 Bottom Habitat....4-55
4.5.2.2 Coastal Habitat....4-57
4.5.2.3 Essential Fish Habitat....4-58
4.5.3 Marine Flora....4-59
4.5.3.1 Native Species....4-59
4.5.3.2 Non-native and Nuisance Species....4-60
4.5.4 Marine Invertebrates....4-60
4.5.4.1 Native Species....4-60
4.5.4.2 Non-native and Nuisance Species....4-62
4.5.5 Marine Fishes....4-64
4.5.5.1 Native Species....4-64
4.5.5.2 Bottomfish Species....4-65
4.5.5.3 Pelagic Species....4-65
4.5.6 Marine Protected Species....4-66
4.5.6.1 Marine Mammals....4-69
4.5.6.2 Reptiles....4-70
4.5.6.3 Marine Fishes....4-70
4.5.6.4 Invertebrates (Corals)....4-72
4.5.7 Stressors on the Marine Environment of Guam....4-74
4.5.7.1 Climate Change....4-74
4.5.7.2 Ocean Acidification....4-75
4.5.7.3 Coral Stressors....4-75
4.5.7.4 Marine Fish Stressors....4-77
4.5.7.5 Other Anthropogenic Stressors....4-78

5 NAVAL BASE GUAM MAIN BASE....5-1

5.1 CURRENT OPERATIONS AND LAND USE....5-1
5.1.1 Land Ownership and Management....5-1
5.1.2 Apra Harbor Assets and Uses....5-3
5.1.3 Inner Apra Harbor Assets and Uses....5-4
5.1.4 Training Areas....5-4
5.1.5 Explosive Safety Quantity Distance Arcs....5-7
5.1.6 Special Conservation Areas....5-7
5.1.6.1 Overlay Refuge Lands....5-7
5.1.6.2 Orote Peninsula Ecological Reserve Area....5-7
5.2 TERRESTRIAL ENVIRONMENT....5-9
5.2.1 Geology, Topography, and Soils....5-9
5.2.1.1 Geology....5-9
5.2.1.2 Topography....5-10
5.2.1.3 Soils....5-10
5.2.2 Hydrology....5-10
5.2.2.1 Surface Water....5-10
5.2.2.2 Groundwater....5-10
5.2.3 Vegetation Communities....5-10
5.2.3.1 Upland Communities....5-10
5.2.3.2 Wetland Communities....5-15

5.2.4 Terrestrial Wildlife 5-19
5.2.4.1 Mammals 5-19
5.2.4.2 Birds 5-20
5.2.4.3 Reptiles and Amphibians 5-22
5.2.4.4 Freshwater Fishes 5-23
5.2.4.5 Invertebrates 5-24
5.2.5 Terrestrial Protected Species 5-25
5.2.5.1 Mammals 5-26
5.2.5.2 Birds 5-26
5.2.5.3 Reptiles 5-29
5.2.5.4 Invertebrates 5-31
5.2.5.5 Plants 5-33
5.3 MARINE ENVIRONMENT 5-34
5.3.1 Joint Region Marianas-administered Submerged Lands 5-34
5.3.2 Physical Environment 5-37
5.3.3 Outer Apra Harbor Marine Environment 5-37
5.3.3.1 Bathymetry and Currents 5-37
5.3.3.2 Turbidity and Water Quality 5-40
5.3.3.3 Marine Habitats 5-41
5.3.3.4 Marine Flora 5-46
5.3.3.5 Marine Invertebrates 5-47
5.3.3.6 Marine Fishes 5-50
5.3.3.7 Marine Protected Species 5-51
5.3.4 Inner Apra Harbor Marine Environment 5-56
5.3.4.1 Bathymetry and Currents 5-56
5.3.4.2 Turbidity and Water Quality 5-57
5.3.4.3 Marine Habitats 5-57
5.3.4.4 Marine Flora 5-58
5.3.4.5 Marine Invertebrates 5-58
5.3.4.6 Marine Fishes 5-63
5.3.4.7 Marine Protected Species 5-63
5.3.5 Luminao/Glass Breakwater Marine Environment 5-64
5.3.5.1 Bathymetry and Currents 5-64
5.3.5.2 Turbidity and Water Quality 5-64
5.3.5.3 Marine Habitats 5-65
5.3.5.4 Marine Flora 5-65
5.3.5.5 Marine Invertebrates 5-66
5.3.5.6 Marine Fishes 5-67
5.3.5.7 Marine Protected Species 5-67
5.3.6 Orote Peninsula Marine Environment 5-68
5.3.6.1 Bathymetry and Currents 5-68
5.3.6.2 Turbidity and Water Quality 5-69
5.3.6.3 Marine Habitats 5-69
5.3.6.4 Marine Flora 5-70
5.3.6.5 Marine Invertebrates 5-70
5.3.6.6 Marine Fishes 5-72
5.3.6.7 Marine Protected Species 5-73
5.3.7 Dadi Marine Environment 5-74
5.3.7.1 Bathymetry and Currents 5-74
5.3.7.2 Turbidity and Water Quality 5-74
5.3.7.3 Marine Habitats 5-75

5.3.7.4 Marine Flora 5-75
5.3.7.5 Marine Invertebrates 5-76
5.3.7.6 Marine Fishes 5-77
5.3.7.7 Marine Protected Species 5-78
5.3.8 Offshore Naval Base Guam Main Base Marine Environment 5-80
5.3.8.1 Bathymetry and Currents 5-80
5.3.8.2 Marine Habitats 5-80
5.3.8.3 Marine Protected Species 5-81
5.3.8.4 Marine Resources Monitoring 5-83
5.4 MANAGEMENT GOALS, OBJECTIVES, STRATEGIES, AND ACTIONS 5-83
5.4.1 Terrestrial Ecosystem Management 5-84
5.4.1.1 Terrestrial Habitat Management 5-84
5.4.1.2 Terrestrial Exotic and Invasive Species Management 5-85
5.4.1.3 Terrestrial Protected Species Management 5-89
5.4.1.4 Migratory Bird Management 5-92
5.4.1.5 Terrestrial Natural Resources Educational Outreach 5-93
5.4.1.6 Terrestrial Natural Resources Law Enforcement 5-95
5.4.1.7 Terrestrial Geographic Information System and Data Management 5-95
5.4.1.8 Summary – Terrestrial Ecosystem Management 5-96
5.4.2 Marine Ecosystem Management 5-97
5.4.2.1 Marine Habitat Management 5-99
5.4.2.2 Marine Invasive Species Management 5-105
5.4.2.3 Marine Protected Species Management 5-106
5.4.2.4 Marine Natural Resources Educational Outreach 5-108
5.4.2.5 Marine Natural Resources Law Enforcement 5-109
5.4.2.6 Marine Geographic Information System and Data Management 5-110
5.4.2.7 Summary – Marine Ecosystem Management 5-111

6 NAVAL BASE GUAM NAVAL MUNITIONS SITE 6-1
6.1 CURRENT OPERATIONS AND LAND USE 6-1
6.1.1 Land Ownership and Management 6-1
6.1.2 Naval Munitions Site Assets and Uses 6-1
6.1.3 Training Areas 6-3
6.1.4 Explosive Safety Quantity Distance Arcs 6-4
6.1.5 Special Conservation Areas 6-4
6.1.5.1 Overlay Refuge Lands 6-4
6.1.5.2 Government of Guam Conservation Areas 6-4
6.2 TERRESTRIAL ENVIRONMENT 6-7
6.2.1 Geology, Topography, and Soils 6-7
6.2.1.1 Geology 6-7
6.2.1.2 Topography 6-9
6.2.1.3 Soils 6-9
6.2.2 Hydrology 6-9
6.2.2.1 Surface Water 6-9
6.2.2.2 Groundwater 6-12
6.2.3 Vegetation Communities 6-12
6.2.4 Terrestrial Wildlife 6-20
6.2.4.1 Mammals 6-20
6.2.4.2 Birds 6-21
6.2.4.3 Reptiles and Amphibians 6-23
6.2.4.4 Freshwater Fishes 6-25

6.2.4.5 Invertebrates 6-25
6.2.5 Terrestrial Protected Species 6-27
6.2.5.1 Mammals 6-29
6.2.5.2 Birds 6-31
6.2.5.3 Reptiles 6-35
6.2.5.4 Invertebrates 6-35
6.2.5.5 Plants 6-36
6.3 MANAGEMENT GOALS, OBJECTIVES, STRATEGIES, AND ACTIONS 6-39
6.3.1 Terrestrial Ecosystem Management 6-39
6.3.1.1 Terrestrial Habitat Management 6-39
6.3.1.2 Terrestrial Exotic and Invasive Species Management 6-43
6.3.1.3 Terrestrial Protected Species Management 6-47
6.3.1.4 Migratory Bird Management 6-50
6.3.1.5 Terrestrial Natural Resources Educational Outreach 6-50
6.3.1.6 Terrestrial Natural Resources Law Enforcement 6-52
6.3.1.7 Terrestrial Geographic Information System and Data Management 6-52
6.3.1.8 Summary – Terrestrial Ecosystem Management 6-53

7 APRA HEIGHTS, SASA VALLEY AND TENJO VISTA TANK FARMS, NAVAL COMPUTER AND TELECOMMUNICATIONS STATION BARRIGADA, AND BARRIGADA TRANSMITTER SITE 7-1

7.1 APRA HEIGHTS 7-1
7.1.1 Current Operations and Land Use 7-1
7.1.2 Geology, Topography, and Soils 7-1
7.1.2.1 Geology 7-1
7.1.2.2 Topography 7-1
7.1.2.3 Soils 7-1
7.1.3 Hydrology 7-1
7.1.3.1 Surface Water 7-1
7.1.3.2 Groundwater 7-1
7.1.4 Vegetation Communities 7-5
7.1.5 Terrestrial Wildlife 7-5
7.1.5.1 Mammals 7-5
7.1.5.2 Birds 7-7
7.1.5.3 Reptiles and Amphibians 7-7
7.1.5.4 Invertebrates 7-7
7.1.6 Terrestrial Protected Species 7-8
7.1.6.1 Invertebrates 7-8
7.2 SASA VALLEY AND TENJO VISTA TANK FARMS 7-8
7.2.1 Current Operations and Land Use 7-8
7.2.1.1 Special Conservation Areas 7-11
7.2.2 Geology, Topography, and Soils 7-11
7.2.2.1 Geology 7-11
7.2.2.2 Topography 7-11
7.2.2.3 Soils 7-11
7.2.3 Hydrology 7-13
7.2.3.1 Surface Water 7-13
7.2.3.2 Groundwater 7-13
7.2.4 Vegetation Communities 7-15
7.2.4.1 Sasa Valley Tank Farm 7-15
7.2.4.2 Tenjo Vista Tank Farm 7-15

7.2.5 Terrestrial Wildlife 7-17
7.2.5.1 Mammals 7-17
7.2.5.2 Birds 7-17
7.2.5.3 Reptiles and Amphibians 7-17
7.2.5.4 Invertebrates 7-17
7.2.6 Current Operations and Land Use 7-18
7.2.7 Terrestrial Protected Species 7-18
7.2.7.1 Mammals 7-18
7.2.7.2 Birds 7-18
7.2.7.3 Invertebrates 7-18
7.2.7.4 Plants 7-20
7.3 NAVAL COMPUTER AND TELECOMMUNICATIONS STATION BARRIGADA AND BARRIGADA TRANSMITTER SITE 7-20
7.3.1 Naval Computer and Telecommunications Station Barrigada 7-20
7.3.1.1 Barrigada Transmitter Site 7-22
7.3.2 Geology, Topography, and Soils 7-22
7.3.2.1 Geology 7-22
7.3.2.2 Topography 7-22
7.3.2.3 Soils 7-22
7.3.3 Hydrology 7-22
7.3.3.1 Surface Water 7-22
7.3.3.2 Groundwater 7-25
7.3.4 Vegetation Communities 7-25
7.3.4.1 NCTS Barrigada 7-25
7.3.4.2 Barrigada Transmitter Site 7-25
7.3.5 Terrestrial Wildlife 7-27
7.3.5.1 Mammals 7-27
7.3.5.2 Birds 7-27
7.3.5.3 Reptiles and Amphibians 7-29
7.3.5.4 Invertebrates 7-29
7.3.6 Terrestrial Protected Species 7-30
7.3.6.1 NCTS Barrigada 7-30
7.3.6.2 Barrigada Transmitter Site 7-33
7.4 MANAGEMENT GOALS, OBJECTIVES, STRATEGIES, AND ACTIONS 7-34
7.4.1 Terrestrial Ecosystem Management 7-34
7.4.1.1 Terrestrial Habitat Management 7-35
7.4.1.2 Terrestrial Exotic and Invasive Species Management 7-36
7.4.1.3 Terrestrial Protected Species Management 7-39
7.4.1.4 Migratory Bird Management 7-41
7.4.1.5 Terrestrial Natural Resources Educational Outreach 7-42
7.4.1.6 Terrestrial Natural Resources Law Enforcement 7-43
7.4.1.7 Terrestrial Geographic Information System and Data Management 7-44
7.4.1.8 Summary – Terrestrial Resources Ecosystem Management 7-45

8 ANDERSEN AIR FORCE BASE 8-1
8.1 CURRENT OPERATIONS AND LAND USE 8-1
8.1.1 Land Ownership and Management 8-2
8.1.2 Andersen Air Force Base Assets and Uses 8-2
8.1.2.1 Andersen Main Base 8-2
8.1.2.2 Northwest Field 8-2
8.1.2.3 Munitions Storage Areas 8-4

8.1.2.4 Tarague Basin Combat Arms and Training Maintenance Range 8-4
8.1.2.5 Explosive Ordnance Disposal Range 8-4
8.1.3 Training Areas 8-5
8.1.4 Danger Zones 8-5
8.1.5 Special Conservation Areas 8-5
8.1.5.1 Overlay Refuge Lands 8-9
8.1.5.2 Pati Point Nature Area and Andersen Air Force Base Marine Resources Preserve 8-9
8.1.5.3 Habitat Management Unit 8-9
8.1.5.4 Guam Kingfisher Memorandum of Agreement Recovery Habitat 8-10
8.2 TERRESTRIAL ENVIRONMENT 8-10
8.2.1 Geology, Topography, and Soils 8-10
8.2.1.1 Geology 8-10
8.2.1.2 Topography 8-13
8.2.1.3 Soils 8-13
8.2.2 Hydrology 8-13
8.2.2.1 Surface Water 8-13
8.2.2.2 Groundwater 8-16
8.2.3 Vegetation Communities 8-16
8.2.4 Terrestrial Wildlife 8-21
8.2.4.1 Mammals 8-21
8.2.4.2 Birds 8-22
8.2.4.3 Reptiles and Amphibians 8-24
8.2.4.4 Invertebrates 8-26
8.2.5 Terrestrial Protected Species 8-27
8.2.5.1 Mammals 8-29
8.2.5.2 Birds 8-30
8.2.5.3 Reptiles and Amphibians 8-34
8.2.5.4 Invertebrates 8-36
8.2.5.5 Plants 8-39
8.3 MARINE ENVIRONMENT 8-45
8.3.1 Joint Region Marianas-administered Submerged Lands 8-45
8.3.2 Physical Environment 8-45
8.3.2.1 Bathymetry and Currents 8-47
8.3.2.2 Turbidity and Water Quality 8-47
8.3.2.3 Waves and Storms 8-49
8.3.3 Marine Habitats 8-50
8.3.3.1 Bottom Habitat 8-50
8.3.3.2 Coastal Habitat 8-50
8.3.4 Marine Flora 8-50
8.3.4.1 Native Species 8-50
8.3.4.2 Non-native and Nuisance Species 8-53
8.3.5 Marine Invertebrates 8-54
8.3.5.1 Native Species 8-54
8.3.5.2 Non-native and Nuisance Species 8-56
8.3.6 Marine Fishes 8-56
8.3.6.1 Native Species 8-56
8.3.6.2 Non-native and Nuisance Species 8-58
8.3.7 Marine Protected Species 8-58
8.3.7.1 Invertebrates – Corals 8-62
8.3.7.2 Fishes 8-62

8.3.7.3 Sea Turtles 8-62
8.3.7.4 Marine Mammals 8-64
8.3.8 Marine Resources Monitoring 8-68
8.4 MANAGEMENT GOALS, OBJECTIVES, STRATEGIES, AND ACTIONS 8-69
8.4.1 Terrestrial Ecosystem Management 8-69
8.4.1.1 Terrestrial Habitat Management 8-69
8.4.1.2 Terrestrial Exotic and Invasive Species Management 8-71
8.4.1.3 Terrestrial Protected Species Management 8-75
8.4.1.4 Migratory Bird Management 8-80
8.4.1.5 Terrestrial Natural Resources Educational Outreach 8-81
8.4.1.6 Terrestrial Natural Resources Law Enforcement 8-82
8.4.1.7 Terrestrial Geographic Information System and Data Management 8-82
8.4.1.8 Summary – Terrestrial Ecosystem Management 8-83
8.4.2 Marine Ecosystem Management 8-84
8.4.2.1 Marine Habitat Management 8-86
8.4.2.2 Marine Invasive Species Management 8-89
8.4.2.3 Marine Protected Species Management 8-90
8.4.2.4 Marine Natural Resources Educational Outreach 8-91
8.4.2.5 Marine Natural Resources Law Enforcement 8-93
8.4.2.6 Marine Geographic Information System and Data Management 8-93
8.4.2.7 Summary – Marine Ecosystem Management 8-94

9 MARINE CORPS BASE CAMP BLAZ 9-1
9.1 MAIN CANTONMENT AND MCB CAMP BLAZ SOUTH 9-1
9.1.1 Current Operations and Land Use 9-1
9.1.1.1 Land Ownership and Management 9-1
9.1.1.2 Training Areas 9-1
9.1.2 Special Conservation Areas 9-3
9.1.2.1 Haputo Ecological Reserve Area 9-3
9.1.2.2 Overlay Refuge 9-3
9.1.2.3 Caiguat Forest Enhancement Site 9-5
9.1.2.4 Taguac Forest Enhancement Site 9-5
9.1.2.5 Guam Micronesian Kingfisher Memorandum of Agreement Recovery Habitat 9-5
9.1.3 Terrestrial Environment 9-6
9.1.3.1 Geology, Topography, and Soils 9-6
9.1.3.2 Hydrology 9-9
9.1.3.3 Vegetation Communities 9-9
9.1.3.4 Terrestrial Wildlife 9-13
9.1.3.5 Terrestrial Protected Species 9-18
9.1.4 Marine Environment 9-27
9.1.4.1 Joint Region Marianas-administered Submerged Lands 9-28
9.1.4.2 Physical Environment 9-28
9.1.4.3 Marine Habitats 9-32
9.1.4.4 Marine Flora 9-34
9.1.4.5 Marine Invertebrates 9-36
9.1.4.6 Marine Fishes 9-41
9.1.4.7 Marine Protected Species 9-42
9.1.4.8 Marine Resources Monitoring 9-48
9.1.5 Management Goals, Objectives, Strategies, and Actions 9-49
9.1.5.1 Terrestrial Ecosystem Management 9-49

9.1.5.2 Terrestrial Habitat Management 9-50
9.1.5.3 Terrestrial Exotic and Invasive Species Management 9-52
9.1.5.4 Terrestrial Protected Species Management 9-56
9.1.5.5 Migratory Bird Management 9-58
9.1.5.6 Terrestrial Natural Resources Educational Outreach 9-59
9.1.5.7 Terrestrial Natural Resources Law Enforcement 9-60
9.1.5.8 Terrestrial Geographic Information System and Data Management 9-61
9.1.5.9 Summary – Terrestrial Resources Ecosystem Management 9-61
9.1.5.10 Marine Ecosystem Management 9-62
9.1.5.11 Marine Habitat Management 9-64
9.1.5.12 Marine Invasive Species Management 9-68
9.1.5.13 Marine Protected Species Management 9-69
9.1.5.14 Marine Natural Resources Educational Outreach 9-70
9.1.5.15 Marine Natural Resources Law Enforcement 9-71
9.1.5.16 Marine Geographic Information System and Data Management 9-72
9.1.5.17 Summary – Marine Ecosystem Management 9-73
9.2 LIVE-FIRE TRAINING RANGE COMPLEX 9-74
9.2.1 Current Operations and Land Use 9-74
9.2.1.1 Land Ownership and Management 9-74
9.2.1.2 Training Areas 9-74
9.2.2 Special Conservation Areas 9-74
9.2.2.1 Overlay Refuge Lands 9-75
9.2.2.2 Ungulate Exclosures 9-75
9.2.2.3 Guam Micronesian Kingfisher Memorandum of Agreement Recovery Habitat 9-75
9.2.2.4 USGS BTS Closed Population Research Unit 9-75
9.2.3 Terrestrial Environment 9-75
9.2.3.1 Geology, Topography, and Soils 9-76
9.2.3.2 Hydrology 9-76
9.2.3.3 Vegetation Communities 9-77
9.2.3.4 Terrestrial Environment 9-78
9.2.3.5 Terrestrial Protected Species 9-81
9.2.3.6 Mammals 9-83
9.2.3.7 Birds 9-83
9.2.3.8 Invertebrates 9-84
9.2.4 Management Goals, Objectives, Strategies, and Actions 9-84
9.2.4.1 Terrestrial Ecosystem Management 9-84
9.2.4.2 Terrestrial Habitat Management 9-85
9.2.4.3 Terrestrial Exotic and Invasive Species Management 9-87
9.2.4.4 Terrestrial Protected Species Management 9-91
9.2.4.5 Migratory Bird Management 9-95
9.2.4.6 Terrestrial Natural Resources Educational Outreach 9-95
9.2.4.7 Terrestrial Natural Resources Law Enforcement 9-97
9.2.4.8 Terrestrial Geographic Information System and Data Management 9-97
9.2.4.9 Summary – Terrestrial Ecosystem Management 9-98
9.3 MCBCB URBAN TRAINING COMPLEX 9-99
9.3.1 Operations and Land Use 9-99
9.3.1.1 Current Operations and Land Use 9-99
9.3.1.2 Proposed Operations and Land Use 9-99
9.3.2 Geology, Topography, and Soils 9-102
9.3.2.1 Geology 9-102

9.3.2.2 Topography 9-102
9.3.2.3 Soils 9-104
9.3.3 Hydrology 9-104
9.3.3.1 Surface Water 9-104
9.3.3.2 Groundwater 9-104
9.3.4 Vegetation Communities 9-104
9.3.5 Terrestrial Wildlife 9-107
9.3.5.1 Mammals 9-107
9.3.5.2 Birds 9-107
9.3.5.3 Reptiles and Amphibians 9-108
9.3.5.4 Invertebrates 9-108
9.3.6 Terrestrial Protected Species 9-109
9.3.6.1 Invertebrates 9-112
9.3.6.2 Plants 9-112
9.3.7 Management Goals, Objectives, Strategies, and Actions 9-115
9.3.7.1 Terrestrial Ecosystem Management 9-115
9.3.7.2 Terrestrial Habitat Management 9-115
9.3.7.3 Terrestrial Exotic and Invasive Species Management 9-117
9.3.7.4 Terrestrial Protected Species Management 9-121
9.3.7.5 Migratory Bird Management 9-124
9.3.7.6 Terrestrial Natural Resources Educational Outreach 9-125
9.3.7.7 Terrestrial Natural Resources Law Enforcement 9-126
9.3.7.8 Terrestrial Geographic Information System and Data Management 9-126
9.3.7.9 Summary – Terrestrial Ecosystem Management 9-127

10 OVERVIEW OF THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS 10-1

10.1 CLIMATE 10-1
10.2 GEOLOGY, TOPOGRAPHY, AND SOILS 10-4
10.2.1 Geology 10-4
10.2.2 Topography and Soils 10-6
10.3 HYDROLOGY 10-6
10.3.1 Surface Water 10-6
10.3.2 Groundwater 10-6
10.4 TERRESTRIAL BIOLOGICAL ENVIRONMENT 10-7
10.4.1 Vegetation Communities 10-7
10.4.2 Terrestrial Wildlife 10-8
10.4.2.1 Mammals 10-8
10.4.2.2 Birds 10-9
10.4.2.3 Reptiles and Amphibians 10-10
10.4.2.4 Freshwater Fishes 10-11
10.4.2.5 Invertebrates 10-11
10.4.3 Terrestrial Protected Species 10-12
10.4.3.1 Mammals 10-14
10.4.3.2 Birds 10-15
10.4.3.3 Reptiles 10-16
10.4.3.4 Invertebrates 10-16
10.4.3.5 Plants 10-17
10.4.4 Stressors on the Terrestrial Environment of the Commonwealth of the Northern Mariana Islands 10-21
10.5 MARINE BIOLOGICAL ENVIRONMENT 10-22

10.5.1 Physical Environment 10-22
10.5.1.1 Currents 10-22
10.5.2 Marine Habitats 10-23
10.5.2.1 Coastal Habitat 10-23
10.5.2.2 Essential Fish Habitat 10-24
10.5.3 Marine Flora 10-24
10.5.3.1 Native Species 10-24
10.5.3.2 Non-native and Nuisance Species 10-25
10.5.4 Marine Invertebrates 10-25
10.5.4.1 Native Species 10-25
10.5.4.2 Non-native and Nuisance Species 10-26
10.5.5 Marine Fishes 10-27
10.5.5.1 Native Species 10-27
10.5.5.2 Non-native and Nuisance Species 10-27
10.5.6 Marine Protected Species 10-28
10.5.7 Stressors on the Marine Environment of Commonwealth of the Northern Mariana Islands 10-30
10.5.7.1 Climate Change 10-30
10.5.7.2 Ocean Acidification 10-31
10.5.7.3 Coral Stressors 10-31
10.5.7.4 Marine Fish Stressors 10-32
10.5.7.5 Other Anthropogenic Stressors 10-33

11 TINIAN MILITARY LEASE AREA 11-1

11.1 CURRENT OPERATIONS AND LAND USE 11-1
11.1.1 Tinian Assets and Uses 11-3
11.1.2 Special Conservation Areas 11-5
11.2 TERRESTRIAL ENVIRONMENT 11-5
11.2.1 Geology, Topography, and Soils 11-5
11.2.1.1 Geology 11-5
11.2.1.2 Topography 11-7
11.2.1.3 Soils 11-7
11.2.2 Hydrology 11-7
11.2.2.1 Surface Water 11-11
11.2.2.2 Groundwater 11-13
11.2.3 Vegetation Communities 11-13
11.2.3.1 Limestone Native Forest 11-15
11.2.3.2 Mixed Introduced Forest 11-16
11.2.3.3 Other Scrub/Grassland 11-16
11.2.3.4 Casuarina Forest 11-16
11.2.3.5 Tangantangan Forest 11-17
11.2.3.6 Coconut Forest 11-17
11.2.3.7 Strand 11-17
11.2.3.8 Agriculture 11-17
11.2.3.9 Barren (Soil, Sand, or Rock) 11-17
11.2.3.10 Developed Land 11-17
11.2.3.11 Wetlands 11-18
11.2.4 Terrestrial Wildlife 11-19
11.2.4.1 Mammals 11-19
11.2.4.2 Birds 11-20
11.2.4.3 Reptiles and Amphibians 11-22

11.2.4.4 Invertebrates 11-24
11.2.5 Terrestrial Protected Species 11-25
11.2.5.1 Mammals 11-26
11.2.5.2 Birds 11-27
11.2.5.3 Reptiles 11-35
11.2.5.4 Invertebrates 11-37
11.2.5.5 Plants 11-37
11.3 MARINE ENVIRONMENT 11-39
11.3.1 Joint Region Marianas Submerged Lands 11-39
11.3.2 Physical Environment 11-41
11.3.2.1 Bathymetry and Currents 11-41
11.3.2.2 Turbidity and Water Quality 11-42
11.3.2.3 Waves and Storms 11-44
11.3.3 Marine Habitats 11-45
11.3.3.1 Bottom Habitat 11-45
11.3.3.2 Coastal Habitat 11-45
11.3.4 Marine Flora 11-48
11.3.4.1 Native Species 11-48
11.3.4.2 Non-native and Nuisance Species 11-49
11.3.5 Marine Invertebrates 11-50
11.3.5.1 Native Species 11-50
11.3.5.2 Non-native and Nuisance Species 11-52
11.3.6 Marine Fishes 11-53
11.3.6.1 Native Species 11-53
11.3.6.2 Non-native and Nuisance Species 11-54
11.3.7 Marine Protected Species 11-54
11.3.7.1 Invertebrates – Corals 11-56
11.3.7.2 Fishes 11-56
11.3.7.3 Sea Turtles 11-57
11.3.7.4 Marine Mammals 11-58
11.3.8 Marine Resources Monitoring 11-61
11.4 MANAGEMENT GOALS, OBJECTIVES, STRATEGIES, AND ACTIONS 11-61
11.4.1 Terrestrial Ecosystem Management 11-61
11.4.1.1 Terrestrial Habitat Management 11-62
11.4.1.2 Terrestrial Exotic and Invasive Species Management 11-63
11.4.1.3 Terrestrial Protected Species Management 11-65
11.4.1.4 Migratory Bird Management 11-69
11.4.1.5 Terrestrial Natural Resources Educational Outreach 11-69
11.4.1.6 Terrestrial Natural Resources Law Enforcement 11-70
11.4.1.7 Terrestrial Geographic Information System and Data Management 11-71
11.4.1.8 Summary – Terrestrial Ecosystem Management 11-72
11.4.2 Marine Ecosystem Management 11-72
11.4.2.1 Marine Habitat Management 11-74
11.4.2.2 Marine Invasive Species Management 11-77
11.4.2.3 Marine Protected Species Management 11-78
11.4.2.4 Marine Natural Resources Educational Outreach 11-80
11.4.2.5 Marine Natural Resources Law Enforcement 11-81
11.4.2.6 Marine Geographic Information System and Data Management 11-81
11.4.2.7 Summary – Marine Ecosystem Management 11-82

12 FARALLON DE MEDINILLA 12-1
12.1 CURRENT OPERATIONS AND LAND USE 12-1
12.1.1 Farallon de Medinilla Assets and Uses 12-1
12.1.2 Special Conservation Areas 12-2
12.2 TERRESTRIAL ENVIRONMENT 12-4
12.2.1 Geology, Topography, and Soils 12-4
12.2.1.1 Geology 12-4
12.2.1.2 Topography 12-4
12.2.1.3 Soils 12-4
12.2.2 Hydrology 12-6
12.2.2.1 Surface Water 12-6
12.2.2.2 Groundwater 12-6
12.2.3 Vegetation Communities 12-6
12.2.3.1 Non-native Species 12-7
12.2.4 Terrestrial Wildlife 12-8
12.2.4.1 Mammals 12-8
12.2.4.2 Birds 12-8
12.2.4.3 Reptiles and Amphibians 12-11
12.2.4.4 Invertebrates 12-11
12.2.5 Terrestrial Protected Species 12-11
12.2.5.1 Mammals 12-12
12.2.5.2 Birds 12-12
12.2.5.3 Reptiles and Amphibians 12-13
12.2.5.4 Invertebrates 12-13
12.2.5.5 Plants 12-13
12.3 MARINE ENVIRONMENT 12-13
12.3.1 Joint Region Marianas Submerged Lands 12-14
12.3.2 Physical Environment 12-14
12.3.2.1 Bathymetry and Currents 12-15
12.3.2.2 Turbidity and Water Quality 12-18
12.3.2.3 Waves and Storms 12-18
12.3.3 Marine Habitats 12-19
12.3.3.1 Bottom Habitat 12-19
12.3.3.2 Coastal Habitat 12-22
12.3.4 Marine Flora 12-22
12.3.4.1 Native Species 12-22
12.3.4.2 Non-native and Nuisance Species 12-22
12.3.5 Marine Invertebrates 12-23
12.3.5.1 Native Species 12-23
12.3.5.2 Non-native and Nuisance Species 12-24
12.3.6 Marine Fishes 12-25
12.3.6.1 Native Species 12-25
12.3.6.2 Non-native and Nuisance Species 12-27
12.3.7 Marine Protected Species 12-27
12.3.7.1 Invertebrates – Corals 12-27
12.3.7.2 Fishes 12-27
12.3.7.3 Sea Turtles 12-29
12.3.7.4 Marine Mammals 12-30
12.3.8 Marine Resources Monitoring 12-32
12.4 MANAGEMENT GOALS, OBJECTIVES, STRATEGIES, AND ACTIONS 12-32

12.4.1 Terrestrial Ecosystem Management 12-33
12.4.1.1 Terrestrial Exotic and Invasive Species Management 12-33
12.4.1.2 Terrestrial Protected Species Management 12-35
12.4.1.3 Migratory Bird Management 12-36
12.4.1.4 Terrestrial Natural Resources Educational Outreach 12-37
12.4.1.5 Terrestrial Geographic Information System and Data Management 12-37
12.4.1.6 Summary – Terrestrial Ecosystem Management 12-38
12.4.2 Marine Ecosystem Management 12-39
12.4.2.1 Marine Habitat Management 12-41
12.4.2.2 Marine Protected Species Management 12-42
12.4.2.3 Marine Natural Resources Educational Outreach 12-43
12.4.2.4 Marine Natural Resources Law Enforcement 12-44
12.4.2.5 Marine Geographic Information System and Data Management 12-44
12.4.2.6 Summary – Marine Ecosystem Management 12-45

13 PLANNING, INTEGRATION, AND IMPLEMENTATION 13-1

13.1 RESPONSIBILITIES FOR IMPLEMENTATION 13-2
13.2 INTEGRATED NATURAL RESOURCES MANAGEMENT AT JOINT REGION MARIANAS 13-2
13.2.1 Planning and the National Environmental Policy Act 13-3
13.2.2 Environmental Compliance 13-3
13.2.3 Cultural Resources Program Coordination 13-3
13.2.4 Installation Restoration and Military Munition Response Programs 13-4
13.3 FACILITIES INTERFACE AND COMPLIANCE WITH THE INTEGRATED NATURAL RESOURCE MANAGEMENT PLAN 13-4
13.3.1 Integrated Facilities Planning and Compatible Use 13-4
13.3.2 Site Approval Process 13-5
13.4 PLANNING FOR PROPOSED ACTIONS 13-5
13.5 COMPLYING WITH NATURAL RESOURCES LAWS AND REGULATIONS 13-7
13.5.1 Endangered Species Act 13-7
13.5.2 Migratory Birds 13-8
13.5.3 Magnuson-Stevens Fishery Conservation and Management Act 13-8
13.5.4 Marine Mammal Protection Act 13-9
13.5.5 Fish and Wildlife Coordination Act 13-9
13.5.6 Clean Water Act 13-10
13.5.7 Avoidance, Minimization, and Compensatory Mitigation 13-10
13.6 FUNDING INTEGRATED NATURAL RESOURCES MANAGEMENT PLAN IMPLEMENTATION 13-10
13.6.1 Environmental Program Requirements 13-11
13.6.2 Department of the Navy Assessment Levels for Budget Prioritization 13-11
13.6.3 Department of Defense Funding Classifications 13-12
13.6.3.1 Recurring Natural Resource Conservation Management Requirements 13-12
13.6.3.2 Non-recurring Current Compliance 13-12
13.6.3.3 Non-recurring Maintenance Requirements 13-12
13.6.3.4 Non-recurring Enhancement Actions beyond Compliance 13-13
13.6.4 Natural Resources Personnel 13-14
13.6.5 Funding Sources 13-15
13.7 IMPLEMENTATION PROCESS 13-15
13.7.1 Programmatic Management 13-15
13.7.2 Partnerships and Project Support 13-16
13.7.2.1 Resource Partners 13-16

13.7.2.2 Contractors 13-17
13.7.2.3 Interagency Agreements 13-17
13.7.2.4 Cooperative Agreements and Partnerships 13-18
13.7.2.5 Volunteer Groups 13-18
13.7.2.6 Non-governmental Organizations 13-19
13.8 Integrated Natural Resources Management Plan Review, Update, and Revision 13-19
13.8.1 Annual Metrics Review 13-19
13.9 Integrated Natural Resources Management Plan Implementation Summary and Schedule 13-20

14 LIST OF PREPARERS 14-1
14.1 Department of Defense 14-1
14.1.1 United States Navy 14-1
14.1.2 United States Marine Corps 14-1
14.1.3 Department of the Air Force 14-2
14.2 Contractors 14-2

15 REFERENCES 15-1
15.1 Chapter 1 – Overview Integrated Natural Resources Management Plan 15-1
15.2 Chapter 2 – Military Mission and Overview of History and Land Use 15-3
15.3 Chapter 3 – Environmental Management Strategy And Mission Sustainability 15-4
15.4 Chapter 4 – Overview of Guam 15-7
15.5 Chapter 5 – Naval Base Guam Main Base 15-28
15.6 Chapter 6 – Naval Base Guam Naval Munitions Site 15-43
15.7 Chapter 7 – Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada and Barrigada Transmitter Site, and MCBCB Urban Training Complex 15-51
15.8 Chapter 8 – Andersen Air Force Base 15-55
15.9 Chapter 9 – Marine Corps Base Camp Blaz 15-68
15.10 Chapter 10 – Overview of the Commonwealth of the Northern Mariana Islands 15-81
15.11 Chapter 11 – Tinian Military Lease Area 15-96
15.12 Chapter 12 – Farallon de Medinilla 15-111
15.13 Chapter 13 – Planning, Integration, and Implementation 15-118

FIGURES

(*Note*: All figures in this INRMP were compiled by Stantec GS, Inc. [Stantec, formerly Cardno], except if noted, using GIS and other data believed to be accurate at the time of publication. However, a degree of error is inherent in all figures. The figures are distributed "As-Is," without warranties of any kind, expressed, or implied, including, but not limited to, warranties of suitability to a particular purpose or use. No attempt has been made in either the design or production of the figures to define the limits or jurisdiction of any federal, territorial, commonwealth, or local government. The figures are intended for use only at the published scale. Detailed on-the-ground surveys and historical analyses of sites may differ from the figures. The JRM or installation natural resources manager should be contacted for the most current map information.)

Figure 1-1. Overview of Natural Resources Management at JRM 1-4
Figure 1-2. Location of Guam, Tinian, and FDM 1-5
Figure 2-1. Location of Mariana Islands Archipelago, Guam, and the CNMI 2-2
Figure 2-2. JRM-administered Lands of Guam 2-3
Figure 2-3. JRM-administered Submerged Lands of Guam 2-4
Figure 2-4. JRM Leased Lands and Submerged Lands on Tinian 2-5
Figure 2-5. JRM Leased Lands and Submerged Lands on FDM 2-6
Figure 3-1. Ecosystem Management-based Decision Process 3-3
Figure 3-2. Mitigation Areas in Guam 3-16
Figure 3-3. Informal ESA Consultation Process, Adapted from USFWS and NMFS (1998) 3-19
Figure 3-4. Formal ESA Consultation Process, Adapted from USFWS and NMFS (1998) 3-21
Figure 3-5. Overlay Refuge Lands and Critical Habitat on Northern Guam 3-32
Figure 3-6. Overlay Refuge Lands on Southern Guam 3-33
Figure 4-1. Average Monthly Rainfall in Guam (1963-2023) 4-1
Figure 4-2. Average Annual Rainfall in Guam 4-3
Figure 4-3. Tropical Storms and Typhoons within 100 Miles of Guam (2000-2023) 4-4
Figure 4-4. Geological Features in Guam 4-5
Figure 4-5. Topographical Features in Guam 4-9
Figure 4-6. Soils in Guam 4-10
Figure 4-7. Major Rivers and Streams in Guam 4-13
Figure 4-8a. Drainage Basins on Northern Guam 4-14
Figure 4-8b. Drainage Basins on Southern Guam 4-15
Figure 4-9. Surface and Marine Water Quality Criteria Designations in Guam 4-17
Figure 4-10. Groundwater Resources in Guam 4-18
Figure 4-11. General Nearshore Marine Benthic Habitats in Guam 4-56
Figure 4-12. General Characteristics of a Fringing Coral Reef 4-57
Figure 4-13. COTS Densities within the Mariana Archipelago (2003-2011) 4-64
Figure 4-14. Known Locations of Federal ESA-listed Corals in Guam 4-73
Figure 5-1. Overview of NBG Main Base 5-2
Figure 5-2. Orote Peninsula ERA and Overlay Refuge Lands - NBG Main Base 5-8
Figure 5-3. Soils - NBG Main Base 5-11
Figure 5-4. Surface Waters and Wetlands on NBG Main Base 5-12
Figure 5-5. Vegetation Communities - Northern NBG Main Base 5-13
Figure 5-6. Vegetation Communities - Southern NBG Main Base 5-14
Figure 5-7. Protected Terrestrial Species - NBG Main Base 5-27
Figure 5-8. Green Sea Turtle Nest and Non-Nesting Emergences Recorded on NBG Main Base at Spanish Steps (October 2009–February 2018) 5-30
Figure 5-9. Submerged Lands Jurisdiction - Apra Harbor, Orote Peninsula, and Vicinity 5-35
Figure 5-10. Marine Environments of NBG Main Base 5-36
Figure 5-11. General Bathymetry of Apra Harbor and Inner Apra Harbor 5-38
Figure 5-12. General Circulation of Outer Apra Harbor and Inner Apra Harbor 5-39
Figure 5-13. Benthic Habitats - Apra Harbor and Inner Apra Harbor 5-42
Figure 5-14. Fishing Areas with Specific Regulations near JRM-administered Submerged Lands on NBG Main Base 5-45

Figure 5-15. Protected Marine Species - NBG Main Base 5-53
Figure 5-16. Location and Layout of the X-Ray Wharf Coral Translocation Experiment 5-61
Figure 5-17. Location of Proposed Mooring Buoys within Outer Apra Harbor and the south side of Orote Peninsula at NBG Main Base 5-102
Figure 6-1. Overview of NMS 6-2
Figure 6-2. ESQD Arcs on NMS 6-5
Figure 6-3. Overlay Refuge Lands on NMS and Adjacent GovGuam Conservation Lands 6-6
Figure 6-4. Topographic Features on NMS 6-8
Figure 6-5. Soils on NMS 6-10
Figure 6-6. Surface Waters, Wetlands, and Watersheds on NMS 6-11
Figure 6-7. Vegetation Communities on Northern NMS 6-13
Figure 6-8. Vegetation Communities on Central NMS 6-14
Figure 6-9. Vegetation Communities on Southern NMS 6-15
Figure 6-10. Protected Terrestrial Species on NMS 6-30
Figure 6-11. Individual Mariana Swiftlet Population Estimates Recorded at Mahlac, Fachi, and Maemong Caves, NMS (1986-2023) 6-32
Figure 6-12. Number of Surveys Conducted/Quarter for Mariana Swiftlet Caves (a) and Number of BTS Observed per Survey at Mariana Swiftlet Caves as a Function of Survey Date (b) 6-33
Figure 6-13. Number of Mariana Common Moorhens Recorded at Fena Valley Reservoir, 1987-2013 6-34
Figure 6-14. Ungulate Fencing on NMS 6-41
Figure 7-1. Overview of Apra Heights 7-2
Figure 7-2. Soils - Apra Heights 7-3
Figure 7-3. Surface Waters and Watersheds - Apra Heights 7-4
Figure 7-4. Vegetation Communities - Apra Heights 7-6
Figure 7-5. Protected Species - Apra Heights 7-9
Figure 7-6. Overview of Sasa Valley and Tenjo Vista Tank Farms 7-10
Figure 7-7. Soils - Sasa Valley and Tenjo Vista Tank Farms 7-12
Figure 7-8. Surface Waters, Wetlands, and Drainage Basins - Sasa Valley and Tenjo Vista Tank Farms 7-14
Figure 7-9. Vegetation Communities - Sasa Valley and Tenjo Vista Tank Farms 7-16
Figure 7-10. Protected Species - Sasa Valley and Tenjo Vista Tank Farms 7-19
Figure 7-11. Overview of NCTS Barrigada and Barrigada Transmitter Site 7-21
Figure 7-12. Soils - NCTS Barrigada and Barrigada Transmitter Site 7-23
Figure 7-13. Wetlands and Drainage Basins - NCTS Barrigada and Barrigada Transmitter Site 7-24
Figure 7-14. Vegetation Communities - NCTS Barrigada and Barrigada Transmitter Site 7-26
Figure 7-15. Protected Species and Butterfly Host Plants - NCTS Barrigada and Barrigada Transmitter Site 7-32
Figure 8-1. Overview of Andersen AFB 8-3
Figure 8-2. Special Conservation Areas on Andersen AFB 8-8
Figure 8-3. Geological Features on Western Andersen AFB 8-11
Figure 8-4. Geological Features on Eastern Andersen AFB 8-12
Figure 8-5. Soils on Western Andersen AFB 8-14
Figure 8-6. Soils on Eastern Andersen AFB 8-15
Figure 8-7. Vegetation Communities on Western Andersen AFB 8-18
Figure 8-8. Vegetation Communities on Central Andersen AFB 8-19
Figure 8-9. Vegetation Communities on Eastern Andersen AFB 8-20
Figure 8-10. Protected Terrestrial Species Recorded on Southwestern Andersen AFB 8-31
Figure 8-11. Protected Terrestrial Species Recorded on Eastern Andersen AFB 8-32
Figure 8-12. Protected Terrestrial Species Recorded on Northern Andersen AFB 8-33
Figure 8-13. Green Sea Turtle Emergences Recorded on Andersen AFB Beaches (2014 – 2022) 8-35

Figure 8-14. Protected Terrestrial Species Recorded on Northern Andersen AFB 8-37
Figure 8-15. Protected Terrestrial Species Recorded on Eastern Andersen AFB 8-38
Figure 8-16. Protected Terrestrial Species Recorded on Southwestern Andersen AFB 8-40
Figure 8-17. Protected Terrestrial Species Recorded on Northern Andersen AFB 8-41
Figure 8-18. Protected Terrestrial Species Recorded on Northern Andersen AFB 8-42
Figure 8-19. JRM-administered Submerged Lands on Andersen AFB 8-46
Figure 8-20. General Bathymetry of JRM-administered Submerged Lands on Andersen AFB 8-48
Figure 8-21. Benthic Habitats Offshore Andersen AFB 8-51
Figure 8-22. Benthic Morphology Offshore Andersen AFB 8-52
Figure 8-23. Selected Marine Protected Species Recorded in JRM-administered Submerged Lands off Andersen AFB 8-60
Figure 8-24. Selected Marine Protected Species Recorded in Andersen AFB Northwest Field Submerged Lands 8-61
Figure 8-25. Migration Pattern of Satellite Tagged Green Sea Turtle from Andersen AFB 8-63
Figure 9-1. Overview of Marine Corps Base Camp Blaz 9-2
Figure 9-2. Special Conservation Areas - Marine Corps Base Camp Blaz 9-4
Figure 9-3. Geological Features on Marine Corps Base Camp Blaz 9-7
Figure 9-4. Soils on Marine Corps Base Camp Blaz 9-8
Figure 9-5. Vegetation Communities on Marine Corps Base Camp Blaz 9-11
Figure 9-6. Protected Species Recorded on Marine Corps Base Camp Blaz 9-20
Figure 9-7. Protected Species Recorded on Marine Corps Base Camp Blaz 9-21
Figure 9-8. High Value Trees Recorded on Marine Corps Base Camp Blaz 9-26
Figure 9-9. JRM-administered Submerged Lands on Marine Corps Base Camp Blaz 9-29
Figure 9-10. General Bathymetry of Submerged Lands - Marine Corps Base Camp Blaz 9-30
Figure 9-11. Benthic Habitats on JRM-administered Submerged Lands 9-33
Figure 9-12. Hard and Soft Bottom Substrates – Marine Corps Base Camp Blaz 9-35
Figure 9-13. Selected Marine Protected Species Occurrences in Marine Corps Base Camp Blaz Submerged Lands 9-44
Figure 9-14. Overview of MCBCB Urban Training Complex 9-100
Figure 9-15. Training Areas on MCBCB Urban Training Complex 9-101
Figure 9-16. Soils on MCBCB Urban Training Complex 9-103
Figure 9-17. Drainage Basins on MCBCB Urban Training Complex 9-105
Figure 9-18. Vegetation Communities on MCBCB Urban Training Complex 9-106
Figure 9-19. Little Fire Ant Colonies Recorded on MCBCB Urban Training Complex 9-110
Figure 9-20. Protected Species and Butterfly Host Plants Recorded on MCBCB Urban Training Complex 9-111
Figure 9-21. High Value Trees Recorded on MCBCB Urban Training Complex 9-114
Figure 10-1. Location of the Mariana Islands Archipelago, Guam, and the CNMI 10-2
Figure 10-2. Tropical Storms and Typhoons within 50 Miles of Tinian, Saipan, and FDM (2000-2023) 10-3
Figure 11-1. Overview of Tinian 11-2
Figure 11-2. Geological Features - Tinian 11-6
Figure 11-3. Physiographic and Topographic Features - Tinian 11-8
Figure 11-4. Soils - Tinian 11-10
Figure 11-5. Groundwater and Surface Water - Tinian 11-12
Figure 11-6. Vegetation - Tinian 11-14
Figure 11-7. Estimated Tinian Monarch Population on Tinian (1999–2012) 11-22
Figure 11-8. Historical Observations of ESA- and CNMI-listed Terrestrial Species 11-29
Figure 11-9. Occurrences of Mariana Common Moorhen within the Tinian MLA 11-31
Figure 11-10. Mariana Common Moorhen Recorded at Lake Hagoi on Tinian (1999-2022) 11-32
Figure 11-11. Submerged Lands Jurisdiction - Tinian MLA 11-40

Figure 11-12. General Bathymetry of Submerged Lands Offshore Tinian....11-43
Figure 11-13. Benthic Habitats on Tinian....11-46
Figure 11-14. Hard/Soft Benthic Habitat Offshore Tinian....11-47
Figure 12-1. Overview of FDM....12-3
Figure 12-2. Topograpy - FDM....12-5
Figure 12-3. Occurrence of Seabirds and Micronesian Megapode - FDM....12-10
Figure 12-4. Submerged Lands Jurisdiction - FDM....12-16
Figure 12-5. General Bathymetry of Submerged Lands Offshore FDM....12-17
Figure 12-6. Visually Identified Nearshore Marine Habitat Types on FDM....12-20
Figure 12-7. Nearshore Benthic Morphology - FDM....12-21

TABLES

Table ES-1. Number of Terrestrial Management Projects per Installation....ES-3
Table ES-2. Number of Marine Management Projects per Installation....ES-3
Table ES-3. Number of Terrestrial Federal and Local ESA-listed Species per Installation....ES-4
Table ES-4. Number of Marine Federal and Local ESA-listed Species per Installation....ES-4
Table 1-1. JRM-administered and Leased Terrestrial and Submerged Lands....1-2
Table 3-1. Definition of Planning Terms Used in this INRMP....3-9
Table 3-2. Active Land Use and Natural Resource Agreements Regarding JRM Sites....3-12
Table 3-3. Area of Guam NWR Overlay Refuge Units....3-31
Table 4-1. Soil Classes in Guam....4-11
Table 4-2. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded in Guam....4-41
Table 4-3. High Value Trees Recorded in Guam....4-52
Table 4-4. JRM-administered Submerged Lands in Guam....4-53
Table 4-5. Federal and Guam ESA-listed Threatened and Endangered and MMPA-protected Marine Species Recorded within JRM-administered Submerged Lands in Guam....4-67
Table 5-1. JRM-administered Lands and Submerged Lands of NBG Main Base....5-1
Table 5-2. Summary of Training Areas on NBG Main Base....5-5
Table 5-3. Vegetation Communities on NBG Main Base....5-15
Table 5-4. Area of Wetlands on NBG Main Base....5-16
Table 5-5. Bird Families Recorded at NBG Main Base....5-20
Table 5-6. Reptile and Amphibian Species Recorded on NBG Main Base....5-22
Table 5-7. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded on NBG Main Base....5-25
Table 5-8. Sea Turtle Nests and Non-nesting Emergences Recorded on NBG Main Base Beaches (October 2009 – September 2016; September 2021 – June 2024)....5-30
Table 5-9. JRM-administered Submerged Lands of NBG Main Base....5-37
Table 5-10. Federal and Guam ESA-listed Threatened and Endangered Marine Species Recorded on JRM-administered Submerged Lands at NBG Main Base....5-52
Table 5-11. Sea Turtle Observations and Captures Recorded within the vicinity of NBG (2014–2022)....5-56
Table 5-12. Sea Turtle Observations and Captures Recorded at Agat Bay (2011, 2014, 2015)....5-79
Table 5-13. Spinner Dolphin Sightings Recorded at Agat Bay during COMPACFLT Monitoring....5-79
Table 5-14. Marine Mammal Sightings Other Than Spinner Dolphin at Agat Bay during COMPACFLT Monitoring....5-81
Table 6-1. Vegetation Communities on NMS....6-17
Table 6-2. Bird Species Recorded on NMS....6-22
Table 6-3. Reptile and Amphibian Species Recorded on NMS....6-23
Table 6-4. Freshwater Macrofauna Recorded on NMS....6-26

Table 6-5. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Recorded Species on NMS 6-28
Table 6-6. Number of Federal ESA-listed Threatened and Endangered Plant Species Recorded on NMS 6-36
Table 7-1. Vegetation Communities on Apra Heights 7-5
Table 7-2. Vegetation Communities on Sasa Valley Tank Farm 7-15
Table 7-3. Vegetation Communities on Tenjo Vista Tank Farm 7-17
Table 7-4. Vegetation Communities on NCTS Barrigada 7-25
Table 7-5. Vegetation Communities on Barrigada Transmitter Site 7-27
Table 7-6. Bird Species Recorded on NCTS Barrigada and Barrigada Transmitter Site 7-28
Table 7-7. Reptile and Amphibian Species Recorded on NCTS Barrigada and Barrigada Transmitter Site 7-29
Table 7-8. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded on NCTS Barrigada 7-31
Table 8-1. Summary of Training Areas on Andersen AFB 8-6
Table 8-2. Special Conservation Area Acreage on Andersen AFB 8-7
Table 8-3. Vegetation Communities on Andersen AFB 8-17
Table 8-4. Summary of Ungulate Removal on Andersen AFB (Oct 2014–Sept 2023) 8-21
Table 8-5. Bird Species Recorded on Andersen AFB 8-23
Table 8-6. Reptile and Amphibian Species Recorded on Andersen AFB 8-26
Table 8-7. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded on Andersen AFB 8-28
Table 8-8. Green Sea Turtle Nests and Non-Nesting Emergences Recorded on Andersen AFB Beaches (2014 to 2022) 8-35
Table 8-9. Federal and Guam ESA-listed Threatened and Endangered Marine Species Recorded on JRM-Administered Submerged Lands on Andersen AFB 8-59
Table 9-1. Vegetation Communities on MCB Camp Blaz 9-10
Table 9-2. Bird Species Recorded on MCB Camp Blaz 9-15
Table 9-3. Reptile and Amphibian Species Recorded on MCB Camp Blaz 9-16
Table 9-4. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded on MCB Camp Blaz 9-18
Table 9-5. High Value Trees Recorded on MCB Camp Blaz 9-27
Table 9-6. Federal and Guam ESA-listed Threatened and Endangered Marine Species on JRM-administered Submerged Lands on MCB Camp Blaz 9-43
Table 9-7. Vegetation Communities on Live-Fire Training Range Complex 9-77
Table 9-8. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded on Live-Fire Training Range Complex 9-81
Table 9-9. Vegetation Communities on MCBCB Urban Training Complex 9-104
Table 9-10. Bird Species Recorded on MCBCB Urban Training Complex 9-107
Table 9-11. Reptile and Amphibian Species Recorded on MCBCB Urban Training Complex 9-108
Table 9-12. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded on MCBCB Urban Training Complex 9-109
Table 9-13. High Value Trees Recorded on MCBCB Urban Training Complex 9-113
Table 10-1. Federal and CNMI ESA-listed Threatened and Endangered Terrestrial Species Recorded within the CNMI 10-12
Table 10-2. Federal and CNMI ESA-listed Threatened and Endangered and MMPA-protected Marine Species Recorded within JRM Submerged Lands of the CNMI 10-28
Table 11-1. DoD Training Activities in the EMUA and LBA of Tinian 11-4
Table 11-2. General Soil Classes – Tinian 11-9
Table 11-3. Surface Water Features on the Tinian MLA 11-11
Table 11-4. Vegetation Communities on Tinian 11-15

Table 11-5. Federal and CNMI ESA-listed Threatened and Endangered Species Recorded on Tinian 11-26
Table 11-6. Bird Species Recorded on Tinian and Protected under the MBTA 11-28
Table 11-7. Estimates of Select Total Physical Characteristics on Tinian 11-39
Table 11-8. Coral Species Richness on Tinian Beaches Surveyed in 2013 11-50
Table 11-9. Federal and CNMI ESA-listed Marine Species Recorded on JRM Submerged Lands of Tinian MLA 11-55
Table 11-10. Sea Turtle Population Estimates by Island Sector for Tinian Summer 2013 11-58
Table 12-1. Plant Species Recorded on FDM 12-6
Table 12-2. Bird Species Recorded on FDM 12-9
Table 12-3. Federal and CNMI ESA-listed Threatened and Endangered Species on FDM 12-12
Table 12-4. Most Frequently Observed Stony Coral Species on FDM 12-23
Table 12-5. Fish Families Observed on FDM 12-26
Table 12-6. Federal and CNMI ESA-listed Marine Species on JRM Submerged Lands of FDM 12-28
Table 12-7. Sea Turtles Recorded on FDM between 2005 and 2020 12-29
Table 13-1. DON Environmental Readiness Levels 13-13
Table 13-2. NAVFAC Marianas Environmental Schedule of Coordination and Collaboration with Resource Partner Agencies 13-17
Table 13-3. Codes for Missions Supported 13-21
Table 13-4. Codes for Ecosystems Supported 13-21
Table 13-5. Planned Implementation Summary of Projects Supported by DON Personnel 13-22
Table 13-6. Planned Implementation Summary of JRM Regional Projects 13-23
Table 13-7. Planned Implementation Summary of Projects at NBG Main Base 13-27
Table 13-8. Planned Implementation Summary of Projects at NMS 13-39
Table 13-9. Planned Implementation Summary of Projects at Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, Barrigada Transmitter Site, and MCBCB Urban Training Complex 13-45
Table 13-10. Planned Implementation Summary of Projects at MCB Camp Blaz 13-50
Table 13-11. Planned Implementation Summary of Projects at Andersen AFB 13-61
Table 13-12. Planned Implementation Summary of Projects on Tinian 13-75
Table 13-13. Planned Implementation Summary of Projects on FDM 13-82

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1 OVERVIEW

An Integrated Natural Resources Management Plan (INRMP) (see Appendix A for a list of acronyms and abbreviations found throughout the document) is a long-term planning document designed to guide the Joint Region Marianas (JRM) Regional Commander, Installation Commanding Officers, and installation personnel, specifically the public works, environmental and natural resource programs, in the management of natural resources on military lands. The INRMP supports an installation's mission while conserving and rehabilitating installation resources for multiple use, sustainable yield, and biological integrity.

This INRMP complies with the Sikes Act (16 United States [U.S.] Code [USC] 670a et seq.) (see Appendix B for a list of laws and regulations discussed throughout the document), as amended (2015), which requires the preparation, implementation, and review for operation and effect of an INRMP at all U.S. Department of Defense (DoD) installations in the U.S. and its territories that contain significant natural resources. This INRMP was prepared by the U.S. Navy, represented by JRM, in cooperation with DoD stakeholders, and the U.S. Fish and Wildlife Service (USFWS), including the Guam National Wildlife Refuge (NWR), Guam Department of Agriculture, Guam Division of Aquatic and Wildlife Resources (Guam DAWR), and Commonwealth of the Northern Mariana Islands (CNMI) Department of Lands and Natural Resources' (DLNR) Division of Fish and Wildlife (DFW).

Section 101(a)(2) of the Sikes Act (as amended) requires the Secretary of the Navy prepare INRMPs "in cooperation with" the USFWS and appropriate state fish and wildlife agencies. DoD Instruction (DoDI) 4715.03 instructs military installations to identify, address, and resolve INRMP issues with the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) when matters of essential fish habitat (EFH), listed marine species, and/or marine fisheries are involved. Therefore, the U.S. Department of the Navy (DON) has partnered with NMFS to provide technical assistance, review, and expert guidance regarding marine resources addressed in this INRMP, in particular marine species listed under the Endangered Species Act (ESA) (16 USC 1531 et seq.), Marine Mammal Protection Act (MMPA) (16 USC 1361 et seq.), and species and habitats covered under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) (i.e., EFH) (16 USC 1801 et seq.).

The final INRMP reflects mutual agreement of the USFWS, NMFS, Guam DAWR, and CNMI DFW concerning the conservation of the natural resources under their respective legal authorities.

The INRMP provides DoD with an implementable framework for managing the natural resources on the land and nearshore areas it owns, leases, or controls (Table 1-1). It is the primary means by which natural resources compliance and stewardship priorities are set and funding requirements are determined for DoD installations. In accordance with DoDI 4715.03, the INRMP provides for no net loss in the capability of installation lands to support the military mission, pursuant to section 670a(b)(1)(I) of the Sikes Act (as amended).

Table 1-1. JRM-administered and Leased Terrestrial and Submerged Lands*

Facility Name	*Other or Previous Name(s)*	*Terrestrial Lands (acres)*	*Submerged Lands (acres)*	*Managed Nearshore Areas (acres)*	*ERA[(1)] (acres)*	*Overlay Refuge Lands[(2)] (acres)*
NBG Main Base	Waterfront Annex	3,455	30,867	4,696	163[(3)]	506
NMS	Ordnance Annex, Naval Magazine	8,645	NA	NA	NA	8,307
MCB Camp Blaz Main Cantonment	NBG TS	2,949	11,241	752	252[(4)]	2,604
MCB Camp Blaz South	NA	290	5,388	1	NA	NA
NCTS Barrigada	Communications Annex Barrigada; Navy Barrigada	1,366	NA	NA	NA	NA
Barrigada Transmitter Site	Air Force Barrigada	432	NA	NA	NA	NA
Andersen AFB	NSA Andersen	14,079	37,869	1,734	NA	8,941
MCB Camp Blaz Urban Training Complex	Andersen South	2,031	NA	NA	NA	NA
Live-Fire Training Range Complex	NA	711	NA	NA	NA	711
North Ramp	NA	103	NA	NA	NA	NA
Sasa Valley Tank Farm	NA	428	NA	NA	NA	395
Tenjo Vista Tank Farm	NA	231	NA	NA	NA	230
Apra Heights/Palms/View	NA	284	NA	NA	NA	NA
Tinian MLA	NA	15,347	47,418	2,179	NA	NA
FDM	NA	182	25,094	364	NA	NA
Total Managed Acreage		**50,533**	**157,877**	**7,183**	**415**	**21,694**

Notes: *Some DoD-managed training areas are included in acreage totals; however, are not covered within the INMRP. Total acreages of such areas are marginal (such as Tanguisson and Piti).
(1) Terrestrial lands of ERAs are included in the Guam NWR Overlay Refuge; JRM-administered submerged lands of the ERAs are not included in the Overlay Refuge.
(2) Guam NWR.
(3) Orote Peninsula ERA: 30 acres (12 hectares) of terrestrial lands; 133 acres (54 hectares) of JRM-administered submerged lands.
(4) Haputo ERA: 180 acres (73 hectares) of terrestrial lands; 72 acres (29 hectares) of JRM-administered submerged lands

Key: AFB = Air Force Base; ERA = Ecological Reserve Area; FDM = Farallon de Medinilla; JRM = Joint Region Marianas; MARBO = Marianas Bonins; MCB = Marine Corps Base; MLA = Military Lease Area; NA = not applicable; NBG = Naval Base Guam; NCTAMS = Naval Computer and Telecommunications Area Master Station; NCTS = Naval Computer and Telecommunications Station; NMS = Naval Munitions Site; NSA = Naval Support Activity; NWR = National Wildlife Refuge; TS = Telecommunications Site.

Source: DON 2010; JRM 2019, 2022.

The Sikes Act (as amended) stipulates that this INRMP provide for:

- conservation and rehabilitation of natural resources;
- sustainable, multi-purpose use of resources;
- public access that is necessary and appropriate for the use described above, subject to safety and military security requirements;
- specific natural resource goals and objectives, and timeframes for acting on them;

- fish and wildlife management, land management, and forest management;
- fish and wildlife habitat enhancement or modifications;
- wetlands protection, enhancement, and restoration where necessary for support of fish, wildlife, and/or plants;
- integration of and consistency among various activities conducted under the INRMP;
- sustainable use by the public of natural resources to the extent that use is not inconsistent with the needs of fish and wildlife resources;
- enforcement of natural resource laws and regulations;
- no net loss in the capability of the military installation lands to support the military mission of the installation; and
- such other activities as the Secretary of the Navy (SECNAV) determines appropriate.

This INRMP is designed to support the military mission, manage natural resources, and ensure compliance with related environmental laws and regulations. The INRMP ensures the presence and maintenance of sustainable quality training land, thereby supporting the DoD in accomplishing its military mission. The purpose of this INRMP is to ensure the continued ability of JRM to support the DoD's current and evolving mission requirements while conserving the natural resources on JRM-administered lands, work cooperatively with other agencies to manage those resources, and apply the principles of ecosystem management and adaptive management.

1.1 PURPOSE AND SCOPE

The purpose of this INRMP is to chart a course for natural resources management of DON holdings in Guam and DON-leased lands on Tinian and Farallon de Medinilla (FDM) that are part of JRM under Commander, Navy Installations Command (CNIC). Management of the JRM conservation program is supported and implemented by Naval Facilities Engineering Systems Command (NAVFAC) Marianas and natural resource managers on each installation (i.e., Naval Base Guam [NBG], Andersen Air Force Base [AFB], and Marine Corp Base [MCB] Camp Blaz) (Figure 1-1). MCB Camp Blaz is also involved in the management of natural resources associated with the buildup of U.S. Marine Corps (USMC) activities in Guam. According to the Office of the Chief of Naval Operations [OPNAV] Notice 5400, Establishment of U.S. Naval Support Activity Andersen Guam, Mariana Islands, the U.S. Air Force (USAF) holdings on Andersen AFB were included under DON in 2009 as a result of Base Realignment and Closure actions (OPNAV Notice 2009). The USAF continues to manage their mission-essential activities on Andersen AFB including aircraft operations and runways.

This INRMP was developed based on a thorough review of the 2013 Final JRM INRMP; review of new data pertaining to these JRM sites; and detailed discussions with NAVFAC Marianas, JRM, installation personnel, NAVFAC Pacific, NAVFAC Headquarters, CNIC, OPNAV, and various INRMP stakeholders. This INRMP provides technical guidance to persons planning and/or preparing installation approvals, management projects, orders, instructions, guidelines, Standard Operating Procedures, and other plans for integrating natural resources management efforts into JRM's planning and decision-making processes. The projects contained in this INRMP include a combination of ongoing natural resources management actions from previous years and new actions identified as priorities during the review process. In addition, this INRMP includes projects to address conservation measures and recommendations resulting from ESA section 7 consultations and other agreements.

The JRM-administered and leased terrestrial and submerged lands addressed in this INRMP are identified in Table 1-1 and shown in Figure 1-2 and include:



Figure 1-1. Overview of Natural Resources Management at JRM

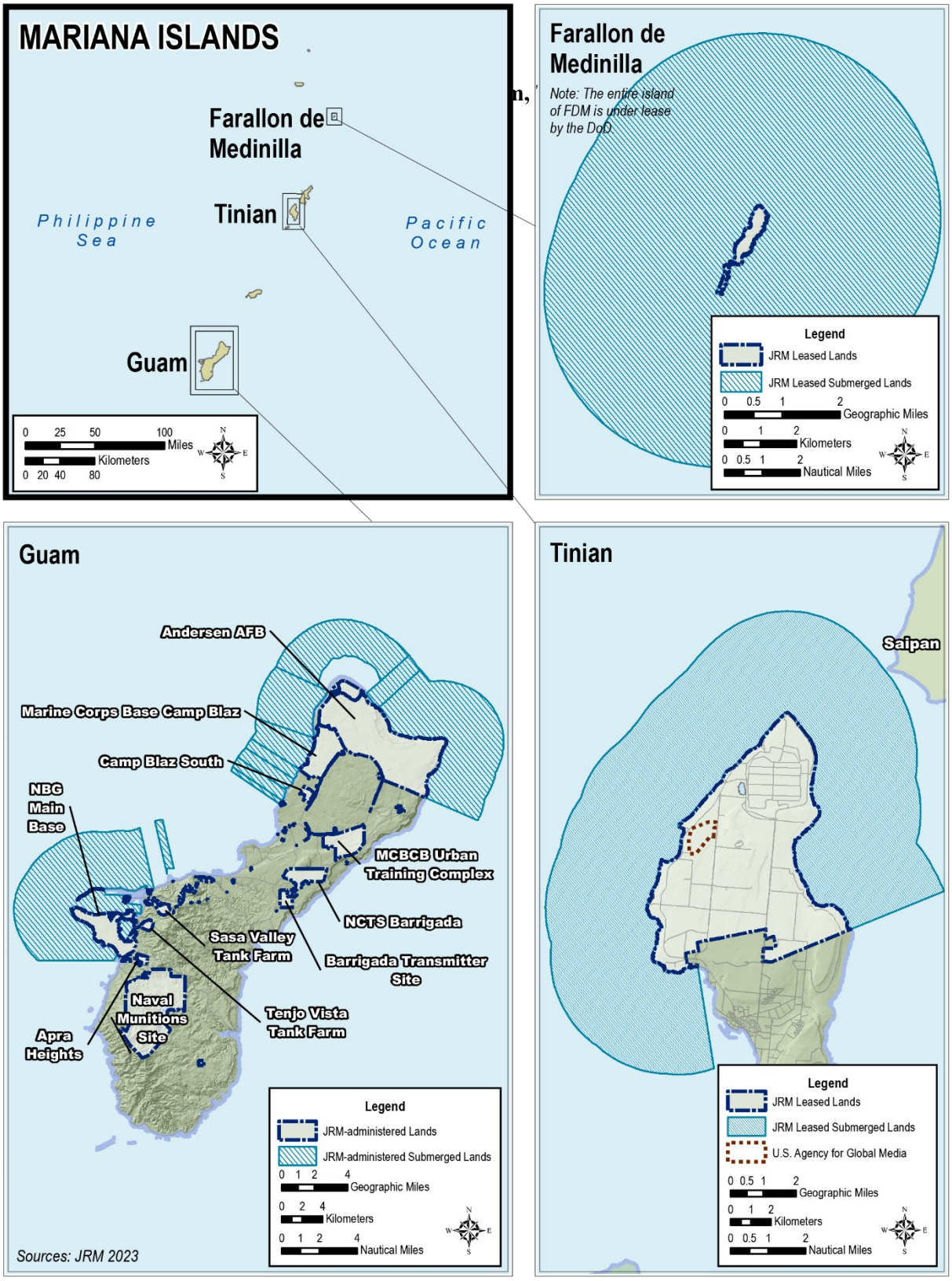


Figure 1-2
Location of Guam, Tinian, and FDM

- NBG Main Base
- Naval Computer and Telecommunications Station (NCTS) Barrigada
- Naval Munitions Site (NMS)
- Barrigada Transmitter Site
- Andersen AFB
- MCB Camp Blaz Main Cantonment
- MCB Camp Blaz South
- Marine Corps Base Camp Blaz (MCBCB) Urban Training Complex
- Live-Fire Training Range Complex
- Sasa Valley Tank Farm
- Tenjo Vista Tank Farm
- Apra Heights/Apra Palms/Apra View
- Tinian Military Lease Area (MLA)
- FDM

This INRMP provides a description of JRM sites (e.g., location, history, and mission), information about the surrounding physical and biotic environment, and an assessment of the impacts on natural resources as a result of mission activities. Furthermore, this INRMP recommends various management projects, in concert with federal, territory, commonwealth, and local standards, designed to minimize impacts of the mission on local ecosystems.

OPNAV Instruction (OPNAVINST) 5090.1 (2021), Environmental Readiness Program and implementing guidance from the OPNAV Manual (OPNAV M) 5090.1 (2021) Section 12-3.4b states that "Navy INRMPs shall provide for the conservation of installation watersheds, shorelines, and nearshore areas such that benefits are provided to aquatic species and habitats in waters adjacent to Navy installations." Therefore, in addition to terrestrial natural resources, this INRMP also addresses JRM-administered and submerged lands or nearshore waters, which extend 3 miles (4.8 kilometers) offshore from JRM terrestrial holdings in Guam, the Tinian MLA, and FDM. For the purposes of this INRMP and in accordance with OPNAV M-5090.1 (Section 12-5.38) and DoDI 4715.03, nearshore waters are defined as those waters and submerged lands adjoining the installation from the mean high water mark (i.e., the line on the shore established by the average of all high tides) to the boundaries of installation waterfront activities where DON controls access, and that are subject to the immediate authority of the JRM Regional Commander or Installation Commanding Officer or tenant commands.

The intent of this INRMP is to utilize adaptive management to maintain long-term ecosystem health and minimize impacts to natural resources consistent with the operational requirements of the DoD's mission. SECNAV Instructions (SECNAVINST) 5090.6A and 5090.8A require DON to ensure ecosystem management is the basis for all management of its lands (DoD 2011) (Sikes Act, as amended; DoDI 4715.03). It is also the intent of this INRMP to provide a conservation benefit to existing federally protected species and their designated critical habitats under the ESA by providing adequate special management or protections. In accordance with USFWS policy, adequate special management may be provided by an INRMP that addresses the maintenance and improvement of habitat (and/or essential features) important to the species and manages for the long-term conservation of the species. Three criteria are used to determine if such special management or protections are provided: (1) there is a conservation benefit, (2) there are assurances that the management plans will be implemented, and (3) there are assurances that the conservation efforts will be effective (USFWS 2015). The projects presented in this INRMP will meet these three criteria; additional detail is provided in Chapter 3, *Environmental Management Strategy and Mission Sustainability*.

Benefits of INRMP implementation include:

- helping natural resource managers more effectively manage natural resources to ensure installation lands remain available and in good condition to support the military mission;
- conserving and rehabilitating natural resources on lands administered by JRM;
- supporting sustainable multi-purpose use of the resources and public access, subject to safety requirements and military security, to military installations to facilitate the use of those natural resources;
- participating, as appropriate, in regional ecosystem initiatives;
- precluding designation of critical habitat; and
- complementing Guam and CNMI natural resource management objectives.

1.2 ANNUAL REVIEW AND UPDATE PROCESS

Section 101(b)(2) of the Sikes Act (as amended) specifically directs that INRMPs be reviewed "as to operation and effect" by the primary parties "on a regular basis, but not less often than every five years," emphasizing that the review is intended to determine whether existing INRMPs are being implemented to meet the requirements of the Sikes Act (as amended) and contribute to the conservation and rehabilitation of natural resources on military installations. The Office of the Secretary of Defense (May 17, 2005) guidance states that joint review should be reflected in a memorandum or letter. The Annual Review process is broadly guided by DoDI 4715.03, *Natural Resources Conservation Program* (DoD 2011), OPNAVINST 5090.1, *Environmental Readiness Program* (OPNAVINST 2021), and the USFWS *Guidelines for Coordination on INRMPs* (USFWS 2015).

The INRMP Implementation Guidance (October 10, 2002 Memorandum) improved coordination external (USFWS, state agencies, and the public) and internal to DoD (military operators and trainers, cultural resources managers) (DoD 2002). The document also added new tracking procedures (metrics) to ensure proper INRMP coordination occurs and that projects are implemented. See Chapter 13, *Planning, Integration, and Implementation* for more detail.

The DoD and DON require completion of the Annual Natural Resources Conservation/INRMP Metrics. The U.S. Navy uses the Navy Conservation Website, hosted on the U.S. Navy Environmental Portal, to collect metrics data at:

> https://eprweb.cnic.navy.mil/eprwebnet/web/Logon.aspx (website intended for authorized government users only)

In order to ensure completion of the metrics data, an Annual Metrics meeting should be held in cooperation with the Sikes Act partners, including the USFWS, Guam DAWR, CNMI DFW, and NMFS, to enable partners to both measure the successes and identify the issues resulting from INRMP implementation. Other participants may include internal DON and external stakeholders. The Annual Metrics meeting evaluates performance in the following focus areas:

- INRMP Implementation
- Listed Species and Critical Habitat
- Sikes Act Cooperation (Partnership Effectiveness)
- Recreational Use and Access
- Team Adequacy
- Natural Resources Management (Ecosystem Integrity)
- INRMP (Natural Resources Program) Support of the Installation Mission

The annual review is discussed with the agencies at the annual fall meeting and any updates are finalized and distributed to partners. In addition, annual reviews facilitate "adaptive management" with respect to ongoing actions or new data regarding species or habitats by providing an opportunity for the parties to review the goals and objectives of the INRMP. Results of the evaluation are used by natural resources managers to determine the effectiveness of the installation natural resources management program; to facilitate annual coordination with the USFWS, Guam DAWR, CNMI DFW, and NMFS; and to provide data for the DON portion of the DoD annual report to Congress.

According to OPNAV guidance (DON 2006), INRMPs must also be reviewed by installations at least once per year to verify the following:

- All "must fund" projects and activities have been budgeted for and implementation is on schedule.
- All required, trained natural resources positions are filled or are in the process of being filled.
- Projects and activities for the upcoming year have been identified and included in the INRMP (an updated project list does not necessitate INRMP revision).
- All required coordination has occurred.
- All significant changes to the installation's mission requirements or its natural resources have been identified.

Any modifications that emerge from annual reviews will be incorporated into annual updates that will be incorporated internally (i.e., JRM and agencies will apply them as part of the INRMP). If the review for operation and effect results in major revisions to the INRMP, JRM must solicit public review and comments (DON 2006; OPNAVINST 2021). The National Environmental Policy Act (NEPA) process may be used to meet public review requirements if the public is provided a meaningful opportunity to comment on the Draft Revised INRMP and associated NEPA documents (OPNAVINST 2021). Further detail is provided in Chapter 3, *Environmental Management Strategy and Mission Sustainability*. Specific documents that identify and provide detailed guidance on the required elements to be included in the preparation and update of INRMPs include:

- Updated Guidance for Implementation of the Sikes Act Improvement Act of October 10, 2002 (DoD 2002)
- Office of the Under Secretary of Defense Supplemental Guidance for Implementation of the Sikes Act Improvement Act of November 1, 2004 (DoD 2004)
- Office of the Under Secretary of Defense Supplemental Guidance for Implementation of the Sikes Act Improvement Act of September 5, 2005 (DoD 2005)
- DoDI 4715.03 Natural Resources Conservation Program (DoD 2011)
- DoD Manual (DoDM) 4715.03 Integrated Natural Resources Management Plan (INRMP) Implementation Manual (DoD 2013)
- SECNAV Instruction 5090.8A Policy for Environmental Protection, Natural Resources, and Cultural Resources Programs (SECNAV 2006)
- Integrated Natural Resources Management Plan Guidance For Navy Installations (DON 2006)
- OPNAVINST 5090.1 (OPNAVINST 2021) and the OPNAV M-5090.1 Manual (OPNAV M 2021)
- 2013 Memorandum of Understanding for a Cooperative Integrated Natural Resource Management Program on Military Installations between the DoD, USFWS, and Association of Fish and Wildlife Agencies regarding cooperation in preparation of INRMPs (DoD et al. 2013)
- USFWS Guidelines for Coordination on Integrated Natural Resources Management Plans (USFWS 2015)

1.3 RESPONSIBILITIES

Successful implementation of an INRMP requires the support of natural resources personnel, other installation staff, command personnel, and installation tenants. This section discusses the internal and external stakeholders for this INRMP and describes their responsibilities and participation in the development of this document. Additional INRMP partners' roles are described in Chapter 3, *Environmental Management Strategy and Mission Sustainability*.

Based on the Joint Region Agreement, JRM oversees management of natural resources, which are managed based on applicable laws, regulations, and DoD, DON, and U.S. Navy policies. Key directives are Sikes Act; ESA; DoDI and DoDM; SECNAV Memo; OPNAVINST 5090.1, *Environmental Readiness Program;* and OPNAV M-5090.1, *Environmental Readiness Program Manual*, which implements the policy set forth in OPNAVINST 5090.1. The following sections describe command authority for natural resources management under OPNAVINST 5090.1 and OPNAV M-5090.1 and will be revised following the release of future versions of the OPNAVINST.

1.3.1 United States Department of Defense Stakeholders

1.3.1.1 Commander, Navy Installations Command

CNIC provides support for U.S. Navy-wide shore installation management. The role of the CNIC in natural resources management is as follows:

- Ensure all lands owned, leased, withdrawn, permitted, or otherwise under the control of DON are evaluated for significant natural resources.
- Ensure installations under their command develop, implement, review, and revise INRMPs as necessary.
- Provide overall program management oversight for all natural resources program elements.
- Program and budget resources to fund both routine and recurring costs to operate and maintain natural resources management planning and INRMP implementation.
- Work with NAVFAC field offices to develop and maintain liaisons with appropriate federal, state, and local agencies and other organizations to facilitate implementation of INRMPs.
- Implement DON policy to ensure stewardship of DON lands and resources and compliance with natural resources laws and regulations.
- Implement policy for managing and conserving soil, water, forest, land, fish and wildlife, wetlands, floodplains, coral reefs, and natural areas.

1.3.1.2 Naval Facilities Engineering Systems Command

NAVFAC is the U.S. Navy's engineering command. NAVFAC has 13 component commands, nine of which are Facilities Engineering Commands that report to two NAVFAC Commands: NAVFAC Atlantic in Norfolk, Virginia, and NAVFAC Pacific in Honolulu, Hawai'i. NAVFAC Atlantic and NAVFAC Pacific fall under the authority of NAVFAC Headquarters, located in Washington, D.C. (NAVFAC 2018). According to OPNAV M-5090.1, the role of the NAVFAC is to:

- Provide natural resources technical expertise and services to assist CNIC and other budget submitting offices (BSOs) with their roles and responsibilities for the execution of the requirements of this chapter.
- Maintain a Conservation website: https://www.navfac.navy.mil/products_and_services/ev.html, and establish scientific standards for data compiled, stored, and analyzed therein.

- Provide overall management and oversight of U.S. Navy forestry agricultural outlease programs and the fees and permits program, and submit an expenditure report for the preceding Fiscal Year (FY) for each program, to CNIC N41 by November 15 of each year.
- Ensure natural resources managers are professionally trained and receive all required supplemental training.
- Ensure lower NAVFAC echelon commands identify all developing critical habitat proposals that may affect the Navy mission through effective and positive communications with local USFWS and NMFS staffs and by monitoring daily publications of the Federal Register. Engage in early coordination at the local level to achieve desired outcomes before proposed rules are published. Desired outcomes include critical habitat exclusions based on INRMPs, where applicable. Draft responses to proposed rules for critical habitat designations are published in the Federal Register for OPNAV (N41) review and signature. Ensure responses to critical habitat proposals are coordinated with fleets, system commands, and CNIC when such proposals overlap areas of responsibility.
- Assist OPNAV (N41), as needed, in addressing natural resources issues that may affect the U.S. Navy shore support and at sea missions.
- Assist OPNAV (N41), as requested, with Deputy Under Secretary of Defense for Installations and Environment (DUSD[I&E]) reporting requirements, programs, initiatives, and partnerships involving natural resources.
- Assist OPNAV (N41), as requested, with coordination of natural resources policy and program matters with Assistant Secretary of Navy for Energy, Installations, and Environment (ASN[EI&E]), DUSD(I&E), other Military Services, and other federal agencies.

1.3.1.3 Joint Region Marianas

JRM is a joint U.S. Military command in Guam established in 2009. While NBG, MCB Camp Blaz, and Andersen AFB each maintain commanding officers who oversee their respective mission requirements and operations, JRM oversees support services, policies, and resources for the three bases (JRM 2020). JRM's mission is to provide executive level installation management support to all DoD components and tenants through assigned regional installations in Guam and the Northern Mariana Islands in support of training in the Marianas; to act as the interface between the U.S. Navy and the civilian community; to ensure compliance with all environmental laws and regulations, safety procedures, and equal opportunity policy; and perform other functions and tasks as may be assigned (CNIC 2018). According to OPNAV M-5090.1, the role of the JRM Region Commander is to:

- Ensure stewardship of natural resources on DON lands and at sea, in compliance with natural resources laws and regulations, DUSD(I&E), ASN(EI&E), and OPNAV (N41) policies as required by this chapter.
- Ensure the programming and budgeting of resources necessary to implement the requirements as described in Chapter 13, *Planning, Integration, and Implementation*.
- Establish positive, productive relationships with local and regional authorities responsible for natural resource conservation for the benefit of subordinate command functions.
- Advise OPNAV (N41), via the chain of command, of situations involving natural resources that require national-level coordination with other federal agencies.
- Coordinate with Commander, NAVFAC component commands to promote and ensure regional efficiencies in implementing the requirements of this chapter.
- Ensure installations comply with DUSD(I&E), ASN(EI&E), and OPNAV (N41) policies on INRMP preparation, implementation, review, updates, and revision.

- Ensure installations under their command with INRMPs complete the annual INRMP metric review and endorse the results prior to submittal to CNIC via the chain of command.
- Approve budgets and plans for management of Navy forestry and agricultural outlease programs.
- Consider the expertise and services of NAVFAC in fulfilling the requirements of this chapter.
- Assist OPNAV (N41) and BSOs, as needed, in addressing natural resources issues that may affect the Navy mission.
- Assist OPNAV (N41) and BSOs, as requested, with DUSD(I&E) reporting requirements, programs, initiatives, and partnerships involving natural resources.
- Assist OPNAV (N41) and BSOs, as requested, with coordination of natural resources policy and program matters with ASN(EI&E), DUSD(I&E), other Military Services, and other federal agencies.

Naval Facilities Engineering Systems Command Marianas

NAVFAC Marianas provides oversight and support for the development, maintenance, and implementation of the JRM INRMP and the natural resources program. In accordance with DON's Concept of Operations, NAVFAC Marianas integrates the planning, programming, and execution of facilities engineering and environmental services to supported commands. The role of NAVFAC Marianas in natural resources management is as follows:

- provide technical assistance for both compliance and stewardship obligations;
- develop and evaluate requests for funds for natural resources projects;
- seek necessary permits and approvals;
- establish appropriate acquisition tools to support the execution of program requirements; and
- coordinate natural resources requirements with other federal, territorial, or commonwealth agencies, including the execution of INRMP mutual agreements between DON, USFWS, NMFS, Guam DAWR, and CNMI DFW.

Naval Base Guam

The Installation Commanding Officer of NBG has the ultimate responsibility for ensuring that installation activities comply with applicable substantive and procedural federal and local environmental laws and regulations and is in charge of the overall management of the facilities and for successfully carrying out the mission. Responsibilities include implementing and enforcing this INRMP and managing installation operations, including the facilities and security directorates and contingency operations. The Installation Commanding Officer is responsible for ensuring that NBG has the funding, staff, and other resources necessary to effectively manage the installation's natural resources to fulfill the environmental stewardship component of the mission. The responsibilities of the Installation Commanding Officer regarding natural resources management on JRM-administered lands at NBG are described in OPNAV M-5090.1 (OPNAV M 2021).

United States Air Force

Andersen AFB, located in Guam's northern plateau, is home to Pacific Air Forces' 13th Air Force and the 36th Wing, Air Mobility Command's 634th Air Mobility Support Squadron, 36th Contingency Response Group, 36th Maintenance Group, 36th Medical Group, 36th Mission Support Group, and 36th Operations Group. There are 10 Wing staff agencies at Andersen AFB including the 36th Comptroller Squadron. Base tenant agencies include the 624th Regional Support Group, Air Mobility Command Passenger Terminal, Detachment 1 of the 69th Reconnaissance Group, Detachment 5 of the 22nd Space Operations Squadron,

Detachment 602 of the Air Force Office of Special Investigations, HSC-25 Islands Knights, Task Force Talon, and the U.S. Department of Agriculture (USDA).

Along with NBG, Andersen AFB was placed under the command of JRM on October 1, 2009. The Installation Commander of Andersen AFB has the same responsibilities as the Installation Commanding Officer for NBG to ensure that installation activities comply with applicable substantive and procedural federal and local environmental laws and regulations. The Installation Commander has charge of the overall management of the facilities and for successfully carrying out the mission. The responsibilities of the Installation Commander regarding natural resources management on JRM-administered lands are described in OPNAV M-5090.1 (OPNAV M 2021).

United States Marine Corps

Marine Corps Activity Guam was de-established after the activation of MCB Camp Blaz on October 1, 2020. The delegation of environmental authorities from Commander JRM to the MCB Camp Blaz Commanding Officer (CO) is pending a future JRM Memorandum of Agreement change. MCB Camp Blaz Environmental Division (NAVFAC Marianas) supports MCB Camp Blaz CO and Commander JRM with environmental oversight for the construction and activation program for facilities and infrastructure in support of the relocation of Marines to Guam. The boundaries of the new installation under MCB Camp Blaz CO authority include the following areas:

- MCB Camp Blaz
- MCB Camp Blaz South
- Lot "A," Andy South
- Live-Fire Training Range Complex
- Urban Training Complex

MCB Camp Blaz is aligned and supports activities under the oversight of Marine Corps Installations Pacific. Marine Corps Installations Pacific exercises command and control, oversight, and budgetary guidance over the Marine Corps' network of Advanced Naval Bases in the Indo-Pacific in order to: (1) secure and protect our capabilities, (2) strengthen our alliances, and (3) expand the capabilities of forward-deployed naval expeditionary forces.

MCB Camp Blaz is responsible for supporting the development of infrastructure related to the buildup of forces in Guam, and programs to cooperate with JRM in the protection of cultural and natural resources. Implementation of the buildup would include: (a) development and construction of facilities and infrastructure to support approximately 5,000 Marines and approximately 1,300 dependents being relocated from Okinawa to Guam, and (b) development and construction of facilities and infrastructure to support training and operations in Guam and Tinian.

United States Army

The Headquarters of the U.S. Army's 3rd Battalion, 196th Infantry Brigade, the Training Support Battalion (TSB), is located in Barrigada, Guam. The small number of Army personnel stationed in Guam provide training support for the Guam Army National Guard and Army Reserve Marianas to ensure that partnered units are fully prepared to deploy in support of Overseas Contingency Operations and other operations as directed. The Army TSB also provides Guam's Defense Coordinating Element for operations requiring military support to civil authorities in Guam and neighboring islands. It also provides mobilization and/or demobilization assistance teams to support other military units in Guam, Saipan, and Tinian.

A U.S. Army Terminal High-Altitude Area Defense (THAAD) ballistic missile defense battery, and an associated cargo drop zone (CDZ) training area, are located in northern Guam. The battery is under the direction of the U.S. Army Space and Missile Defense Command/Army Forces Strategic Command.

There are also seven Army Reserve Units located in Guam: the 797th Engineer Company (Vertical); the 3303rd Mobilization Support Battalion; the 302nd Quartermaster Company; the 368th Military Police Company; E Company, 100th Battalion, 442nd Infantry Regiment; the 3rd Platoon, 962nd Quartermaster Company (Evacuation and Mortuary Platoon); and a detachment of U.S. Army Reserve Theater Support Group. U.S. Army Reserve Center Barrigada, Guam serves as headquarters for these units.

The Guam Field Office of the U.S. Army Corps of Engineers (USACE) is located on NBG Main Base and is a branch of the Honolulu District. Personnel assigned to the Guam Field Office administer USACE's regulatory program, which serves to protect the nation's waters for current and future generations, while allowing for reasonable economic development. Regulatory efforts protect a wide variety of aquatic resources, including wetlands, rivers, streams, tidal waters, coral reefs, shellfish beds, and the oceans. The office administers the Department of the Army Permit Program under Section 404 of the Clean Water Act (CWA) and Section 10 of the Rivers and Harbors Act and manages USACE's civil works activities in Guam and the CNMI.

United States Coast Guard

U.S. Coast Guard (USCG) Sector Guam is a unit of the Fourteenth Coast Guard District, which is based in Honolulu, Hawai'i. USCG Sector Guam's area of responsibility includes Guam, the CNMI, the Republic of Palau, and the Federated States of Micronesia (Kosrae, Pohnpei, Chuuk, and Yap). Its primary missions include: Search and Rescue, Law Enforcement, Ports Waterways and Coastal Security, Marine Inspection, Mariner's Licensing and Documentation, Port Safety, and Marine Environmental Protection. The USCG also enforces various international agreements related to environmental stewardship to include the International Maritime Organization's 1973 International Convention and 1978 Protocol for the Prevention of Pollution from Ships, 2004 International Convention for the Control and Management of Ships' Ballast Water and Sediments, and 1990 Convention on Oil Pollution, Preparedness, Response and Cooperation. It also enforces federal law on waters subject to U.S. jurisdiction and in international waters (14 USC Section 2, 89). USCG Pacific Area can board, search, detain, arrest, and seize violators (14 USC Section 2, 89); protect endangered species, prevent illegal taking of marine mammals and fish, and guard against encroachment into the U.S. Exclusive Economic Zone (EEZ) (16 USC); and enforce regulations that address working conditions on drilling and production operations on the outer continental shelf (43 USC) and elsewhere in the maritime domain.

The USCG Station Apra Harbor is located at Victor Pier at NBG Main Base. Sector Guam consists of five units, including the U.S. Coast Guard cutters (CGC): CGC Washington, CGC Assateague, and CGC Sequoia; Electronic Systems Support Detachment Guam; and Marine Safety Detachment Saipan.

1.3.2 External Stakeholders

In addition to DoD's annual review policy, the Sikes Act (as amended) requires that an installation work together with USFWS and other regulatory agencies, both federal and local, to formally review INRMPs for operation and effect at least every 5 years. Primary federal partner agencies involved in the development and implementation of the JRM INRMP include USFWS and NMFS. Primary local partner agencies involved in the development and implementation of the JRM INRMP include Guam DAWR and the CNMI DFW. These and other partner agencies are described below.

1.3.2.1 United States Fish and Wildlife Service

The Sikes Act (as amended) requires DoD installations and the USFWS to enter into voluntary cooperative agreements to develop and implement mutually agreed upon INRMPs (USFWS 2004). The USFWS has responsibility for the conservation and management of fish, wildlife, and plants and their habitats occurring in the U.S. and its territories that are protected under a suite of federal laws including the ESA (16 USC Section 1531 et seq.), Migratory Bird Treaty Act (MBTA) (16 USC 703-712; Chapter 128; July 13, 1918; 40 Statute 755), MMPA (16 USC 1361 et seq.; Chapter 31; December 21, 1972; 40 Statute 755), Fish and Wildlife Coordination Act (16 USC 661-667e; March 10, 1934; Chapter 55; 48 Statute 401), Coastal Barrier Resources Protection Act (Public Law [PL] 97-348), CWA (33 USC; Chapter 26; Section 1251-1387), and Federal Power Act (16 USC; Chapter 12; Statute 791a), among others. The Ecological Services Program administers the ESA and is responsible for:

- the listing and recovery of candidate, threatened, and endangered species and the designation of critical habitat
- environmental review of federal projects (section 7 consultation)
- habitat conservation planning and technical assistance for non-federal entities to avoid or minimize harmful effects on wildlife and habitats; providing funding to state, territorial, and commonwealth agencies for the conservation of candidate and listed species
- delivering technical assistance regarding invasive species threats and biosecurity issues as they relate to candidate and listed species
- providing oversight of environmental contaminants and CWA permitting
- coordinating INRMP development and reviews through the Ecological Services Program and, in some cases, Fish and Aquatic Conservation Program field offices, which are the lead offices for implementing Sikes Act (as amended) activities

The Wildlife and Sport Fish Restoration Program administers grant programs that provide funding to states, territories, and insular areas to conserve, protect, and enhance fish, wildlife, their habitats, and the hunting, sport fishing, and recreational boating opportunities they provide. The NWR System administers a national network of lands and waters for the conservation, management, and restoration of the fish, wildlife, and plant resources and their habitats for the benefit of present and future generations of Americans, and in Guam provides for resource management, law enforcement, public use, and research within the Ritidian Unit of the Guam NWR. The Office of Law Enforcement enforces federal and international laws and treaties governing the conservation of fish, wildlife, and plants.

The DON and USAF entered into Cooperative Agreements with the USFWS in 1994 to designate portions of NBG Main Base, NMS, and Andersen AFB as Overlay Refuge units of the Guam NWR (DON and USFWS 1994; USAF and USFWS 1994). These lands are managed cooperatively by the USFWS and JRM natural resources personnel for protection of threatened and endangered species and other native flora and fauna, maintenance of native ecosystems, and the conservation of native biological diversity, consistent with the national defense mission of DON and USAF (see Section 2.4, *Regional Land Use,* for additional discussion).

The Sikes Act (as amended) requires preparation of an INRMP in cooperation with USFWS and the appropriate state fish and wildlife agencies (16 USC 670a et seq.). The final INRMP shall reflect mutual agreement of the USFWS concerning the conservation of the natural resources under its legal authorities (DoD et al. 2013).

1.3.2.2 Guam Department of Agriculture, Division of Aquatic and Wildlife Resources

Under the Guam Department of Agriculture, Guam DAWR is the designated Government of Guam (GovGuam) agency responsible for fisheries, wildlife, and other natural resources management in Guam. Guam DAWR has an active natural resources management program that includes:

- research on the natural history of local and federally endangered species
- recovery of federally endangered species
- captive breeding of the endangered Guam kingfisher (*Todiramphus cinnamominus*) and Guam rail (*Gallirallus owstoni*)
- monitoring of endangered species populations and trends
- wetland studies and delineations
- research into the control of the brown treesnake (BTS) (*Boiga irregularis*)
- fisheries surveys and management
- sea turtle monitoring
- environmental education of the public
- public hunting and game management
- control of invasive species
- consultations for the protection of threatened and endangered species and their habitats under the federal ESA
- other programs

GovGuam administers several conservation areas, including Bolanos, Cotal, and Anao. Except as otherwise provided by law, GovGuam has concurrent jurisdiction over submerged lands around Guam in accordance with 48 USC Section 1704. On May 16, 1997, PL 24-21 created five marine preserves in Guam and revised fishing regulations in these locations. One such preservation area is the Pati Point Preserve located within the 3-mile (4.8-kilometer) limit of JRM-administered submerged lands on the eastern coastal boundary of Andersen AFB.

Conservation Officers with Guam DAWR are deputized by the USFWS and authorized to enforce federal fish and wildlife laws. Through the signing of this INRMP, Guam DAWR is a party, with the USFWS, for the protection, development, and management of fish and wildlife resources on JRM sites in accordance with the Sikes Act (as amended). Funding for Guam DAWR is provided by the USFWS through the Fish and Aquatic Conservation, Wildlife and Sport Fish Restoration, and Ecological Services programs. Local funding is available for Guam DAWR to support law enforcement agents and Conservation Officer programs and policies for regulation of wildlife (permits, etc.).

The Sikes Act (as amended) requires preparation of an INRMP in cooperation with the appropriate state fish and wildlife agencies (16 USC 670a et seq.). The final INRMP reflects mutual agreement of Guam DAWR concerning the conservation of the natural resources under its legal authorities.

1.3.2.3 Commonwealth of the Northern Mariana Islands Department of Land and Natural Resources, Division of Fish and Wildlife

Under the CNMI DLNR, the CNMI DFW is tasked with conserving, protecting, and enhancing the fish, game, and wildlife resources including threatened and endangered species of the CNMI for the benefit of present and future generations. The CNMI DFW was created in 1981 by the Fish, Game, and Endangered Species Act, PL 2-51 and is responsible for ensuring wildlife conservation on all of the Northern Mariana Islands. CNMI DFW provides and enforces regulations governing hunting, fishing, harvesting, and taking of species as well as human behavior and activities in protected and conservation areas in the CNMI. The CNMI DFW seeks to ensure the long-term survival and sustainability of the CNMI's natural resources through an active natural resources management program. The CNMI DFW's mandate includes but is not limited to the following:

- monitoring
  - monitoring endangered and common species populations and trends
  - monitoring and control of invasive species including the BTS
- management of fish and wildlife species and habitat
  - game species
  - protected species
  - native and endemic species habitat
  - consultations for the protection of threatened and endangered species and their habitats under the federal ESA
  - avoidance, minimization, and mitigation of impacts on sensitive and listed wildlife from proposed development
- research and program development
  - research the natural history of native species including local and federally endangered species
  - research evaluating wildlife and fisheries species health and population vitality
  - research targeting understanding habitat quality and wildlife-habitat relationships
  - recovery of federally endangered species
  - data collection and analysis
  - ensure proposed scientific research benefits and avoids harming native wildlife and ecosystems
- restoration
- enforcement
  - enforcement of hunting, fishing, and protected species regulations
  - enforcement of protected species regulations
- environmental education and public outreach

Without discounting DoD property interests, the CNMI has jurisdiction over lands on the 14 Northern Mariana Islands, offshore banks and reefs, and submerged lands extending to 3 miles (4.8 kilometers) from coasts. Within waters and lands, the CNMI DFW administers conservation and management throughout several wildlife conservation areas and marine protected areas. One such marine protected area, the Tinian Marine Reserve, was established by PL 15-90 on October 2, 2007, and amended by PL 17-14 on September 24, 2010.

1.3.2.4 National Oceanic and Atmospheric Administration

NOAA is dedicated to understanding and predicting changes in climate, weather, oceans, and coasts; to sharing that knowledge and information with others; and to conserving and managing coastal and marine ecosystems and resources (NOAA 2016). The NMFS, also referred to as NOAA Fisheries, is the lead federal agency responsible for the stewardship of the nation's ocean resources and their habitat. It is the mission of NMFS to ensure productive and sustainable fisheries, safe sources of seafood, and the recovery and conservation of protected resources (e.g., whales, dolphins, sea turtles, corals, and fish) and healthy marine ecosystems (NMFS 2016). NMFS works within the MSFCMA, MMPA, ESA, and Coastal Zone Management Act (CZMA) to fulfill its mission of promoting healthy ecosystems.

The USFWS and NMFS share jurisdiction over sea turtles that are listed under the ESA. The USFWS has jurisdiction over sea turtles when they come ashore to nest, while NMFS retains management control while sea turtles are in the ocean. In addition, both agencies enforce federal laws concerning wildlife trade in endangered species. The NMFS coordinates with other agencies and Guam DAWR in the review of federal projects that may potentially impact marine resources under ESA section 7. The NMFS also maintains law enforcement personnel in Guam to enforce certain provisions of the MMPA, ESA, and MSFCMA.

Although cooperative preparation with NMFS is not required under the Sikes Act (as amended), coordination with NMFS is appropriate when the nearshore environment will benefit from INRMP implementation. The NMFS will take INRMPs into consideration when making critical habitat determinations for listed species under their jurisdiction and when critical habitat exclusions in the nearshore environment may be necessary to support the installation mission.

1.3.2.5 United States Department of Agriculture Animal and Plant Health Inspection Service

The USDA Animal and Plant Health Inspection Service (APHIS) is a multi-faceted agency with a mission that includes wildlife damage and disease management, regulation of genetically engineered crops and animal welfare, and protection of public health and safety as well as natural resources that are vulnerable to invasive pests and pathogens.

APHIS is involved in managing potential pest and disease threats and preventing the introduction of new invasive species. In the event that a pest or disease of concern is detected, APHIS implements emergency protocols and partners with affected states and territories to quickly manage or eradicate the outbreak. This aggressive approach has enabled APHIS to successfully prevent and respond to potential pest and disease threats to U.S. agriculture.

As well as preventing the introduction of invasive species, APHIS is involved in the management, control, and eradication of invasive species already introduced and established. Through USDA APHIS Wildlife Services, a program and protocols are in place to prevent the spread of the BTS, an invasive reptile introduced to Guam during World War II (Rodda and Savidge 2007). USDA APHIS Wildlife Services has established outbound interdiction protocols in Guam and inbound interdiction protocols on other islands, emphasizing dog-aided inspections of cargo coming from Guam. Sentinel traps have been placed within port areas in the Northern Mariana Islands to assist detection and capture of arriving BTS.

Although cooperative preparation with USDA is not required under the Sikes Act (as amended), coordination with USDA is appropriate when INRMP implementation will affect or be affected by USDA-led research.

1.3.2.6 United States Geological Survey

The U.S. Geological Survey (USGS) is a non-regulatory federal science agency within the U.S. Department of the Interior. It provides impartial, scientific information on the health of ecosystems and environment, natural hazards, natural resources, and impacts of climate and land use change. A variety of divisions within USGS support research on environmental components, such as soil and water, and inform management decisions on military installations.

The USGS also established a Rapid Response Team, which consists of trained snake responders; provides information on how to identify, search for, and trap invasive reptiles; and educates people on impacts of invasive snakes to the environment and public safety. In coordination with the military in Guam, USGS conducts research on eradication methods for the BTS on military installations.

Although cooperative preparation with USGS is not required under the Sikes Act (as amended), coordination with USGS is appropriate when INRMP implementation will affect or be affected by USGS-led research.

1.4 FORMAL ADOPTION/MUTUAL AGREEMENT

The final INRMP reflects mutual agreement of the USFWS and State fish and wildlife agency representatives concerning the conservation of the natural resources under their respective legal authorities, consistent with the U.S. Department of the Interior's memorandum of understanding.

2 MILITARY MISSION AND OVERVIEW OF HISTORY AND LAND USE

2.1 LOCATION

The Mariana Islands include Guam and the Commonwealth of the Northern Mariana Islands (CNMI), both of which are sovereign (self-governing) territories of the United States (U.S.). CNMI is comprised of 14 islands, territorial waters, and submerged lands immediately north of Guam (Figure 2-1).

Guam is located in the Western Pacific Ocean and is situated approximately 3,700 miles (5,955 kilometers) west/southwest of Hawai‘i and 1,560 miles (2,511 kilometers) south-southeast of Japan. Guam is the southernmost and largest island of the Mariana Islands archipelago (Figure 2-1). The island is approximately 30 miles (48 kilometers) long by 4–8 miles (6–13 kilometers) wide and has a total area of approximately 209 square miles (541 square kilometers). Joint Region Marianas (JRM)-administered lands are located throughout the island and include both Naval Base Guam (NBG) and Andersen Air Force Base (AFB) sites (Figure 2-2). Figure 2-3 depicts the JRM-administered submerged lands around Guam. Section 4.5, *Marine Biological Environment*, *Overview of Guam* provides additional detail on the management of submerged lands for Guam addressed in this Integrated Natural Resources Management Plan (INRMP).

Land and jurisdictional issues in Guam are complex. The key guidance documents are the Territorial Submerged Lands Act (Public Law [PL] 93-435), effective October 5, 1974, and the Presidential Proclamation 4347, effective February 1, 1975. The PL authorizes JRM to retain title of submerged lands adjacent to property owned by the U.S. above the mean high tide. The Presidential Proclamation authorizes JRM to retain title of submerged lands within Inner and Outer Apra Harbor and submerged lands adjacent to several other upland areas.

Tinian is the fourth island, south to north, in the Mariana Archipelago (Figure 2-1). It is located 100 miles (161 kilometers) north-northeast of Guam and approximately 3 miles (5 kilometers) southwest of Saipan. Tinian is roughly 12 miles (20 kilometers) long and 6 miles (10 kilometers) wide at its widest point with a total land area of 39 square miles (101 square kilometers). Figure 2-4 depicts the JRM leased lands on and submerged lands around Tinian.

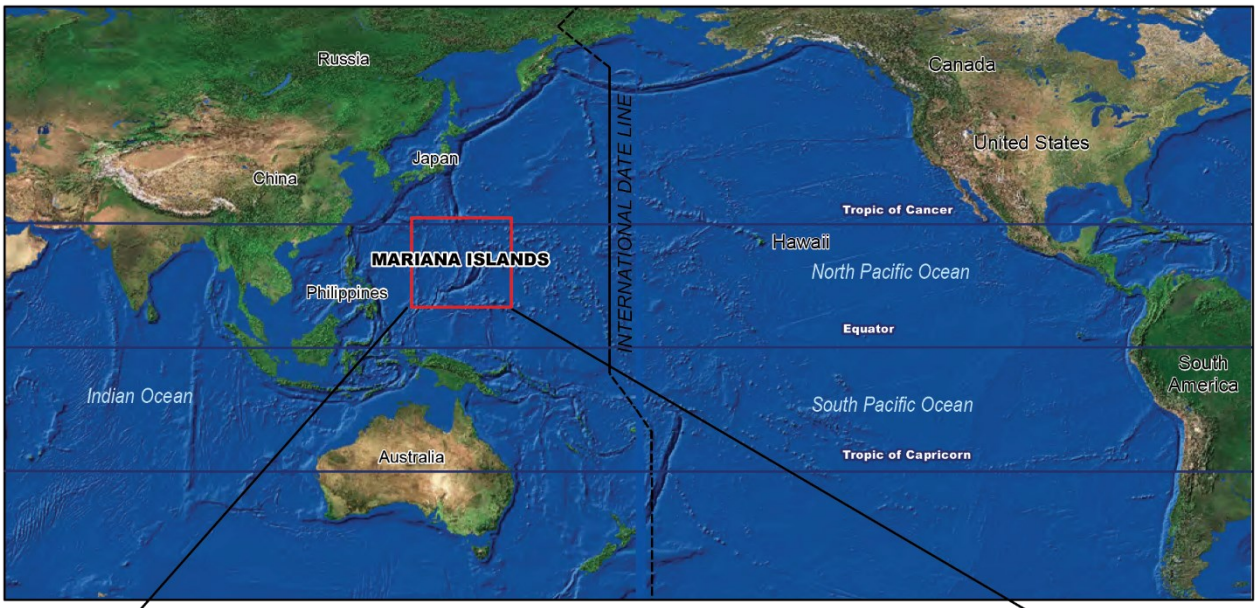
Farallon de Medinilla (FDM) is the sixth island, south to north, and is the northernmost island of the southern volcanic arc of the Mariana Archipelago (Figure 2-1). Located approximately 70 miles (113 kilometers) northeast of Tinian and 182 miles (293 kilometers) northeast of Guam, FDM is approximately 1.7 miles (2.7 kilometers) long and 0.3 mile (0.5 kilometer) wide at its widest point and covers approximately 221 acres (89 hectares). FDM is an uninhabited island and is difficult to access except by helicopter. Figure 2-5 depicts the JRM leased lands on and submerged lands around FDM.

2.2 MILITARY MISSION

The following sections describe the military missions of NBG, MCB Camp Blaz, and Andersen AFB components of JRM.

2.2.1 Joint Region Marianas

The mission of JRM is to provide executive level installation management support to all Department of Defense (DoD) components and tenants through assigned regional installations in Guam and the CNMI in support of training in the Marianas; to act as the interface between U.S. Department of the Navy (DON) and the civilian community; to ensure compliance with all environmental laws and regulations, safety procedures, and equal opportunity policy; and to perform other functions and tasks as may be assigned (Commander, Navy Installations Command [CNIC] 2018).



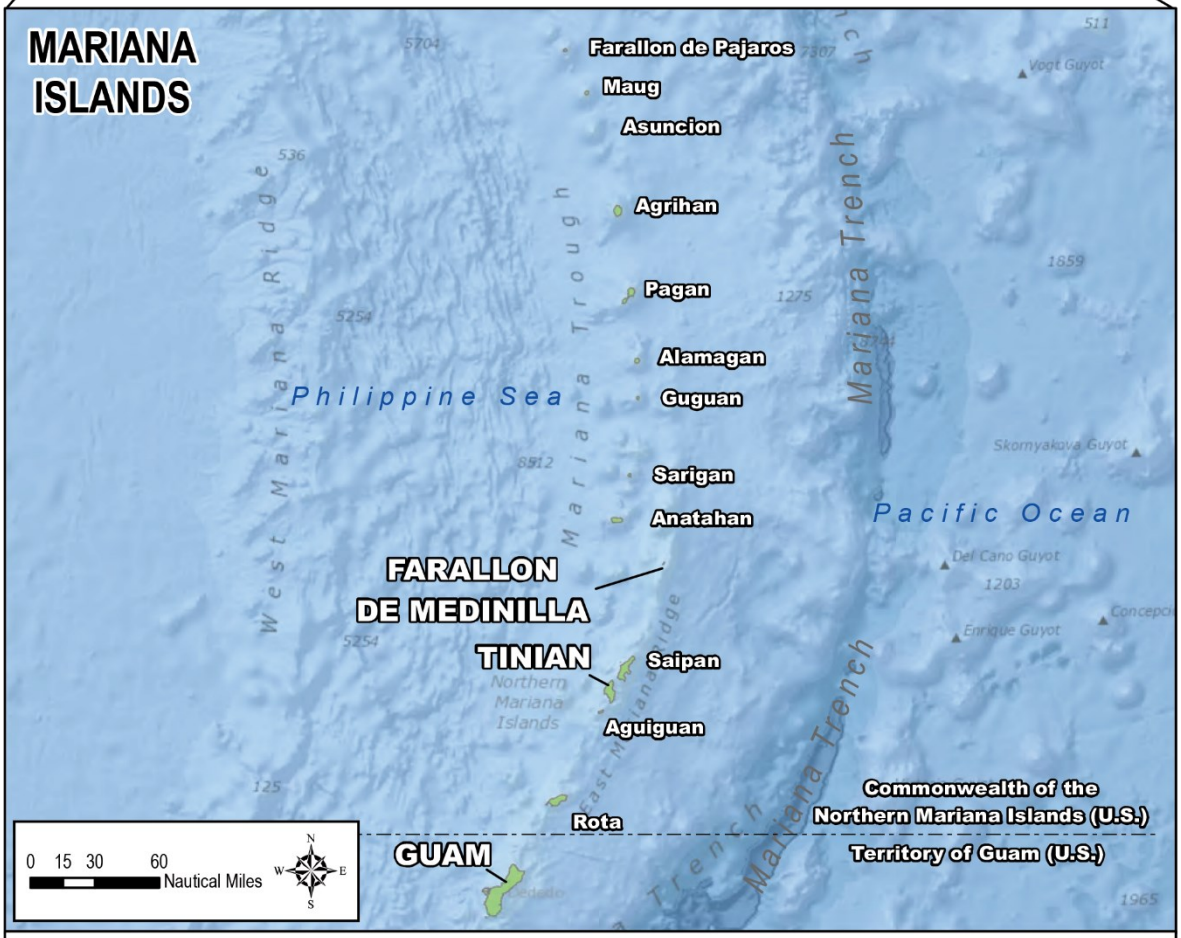


Figure 2-1
Location of Mariana Islands Archipelago, Guam, and the CNMI



Figure 2-2
Location of JRM-administered Lands of Guam

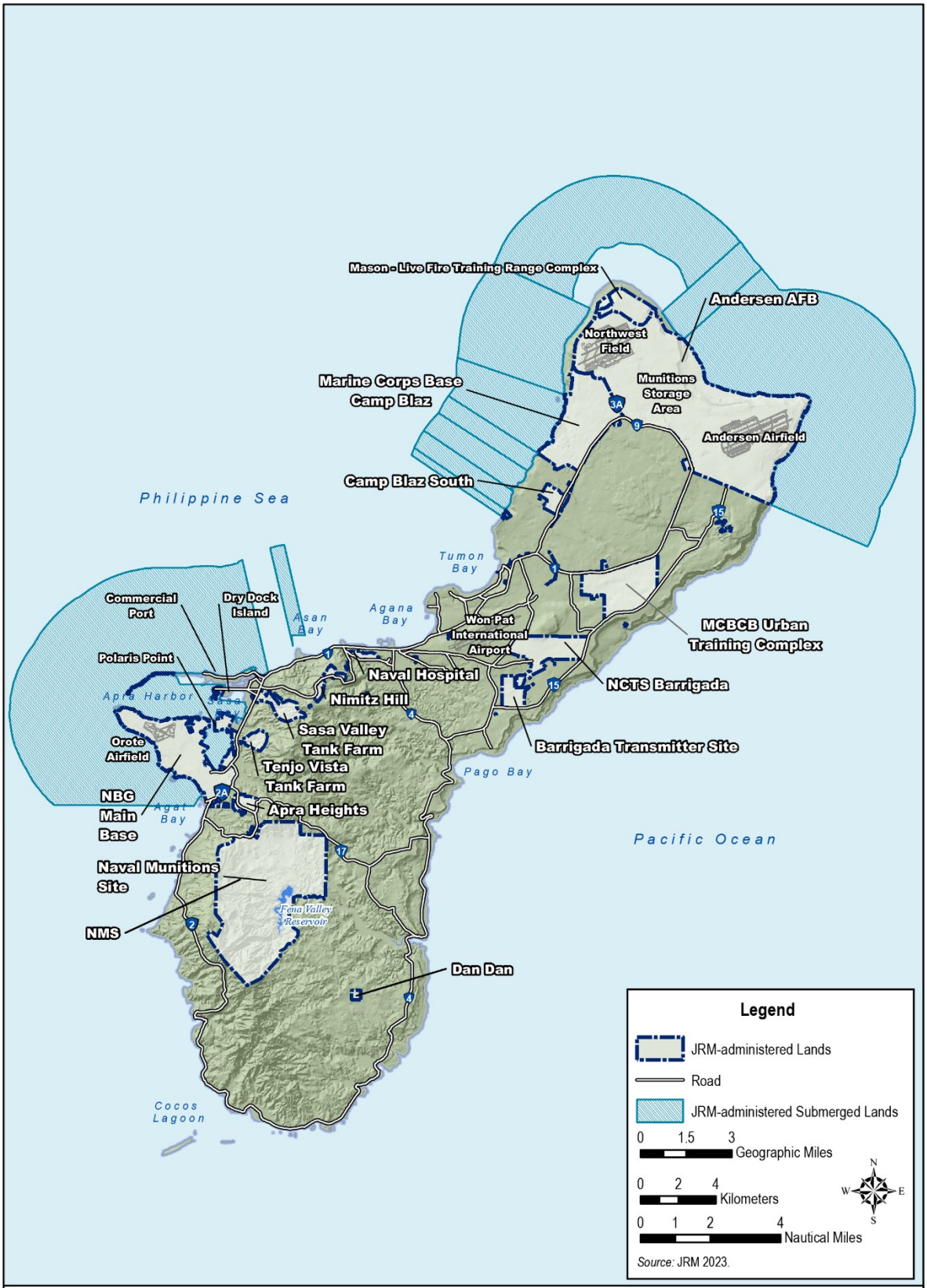


Figure 2-3
JRM-administered Submerged Lands of Guam



Figure 2-4
JRM Leased Lands and Submerged Lands on Tinian

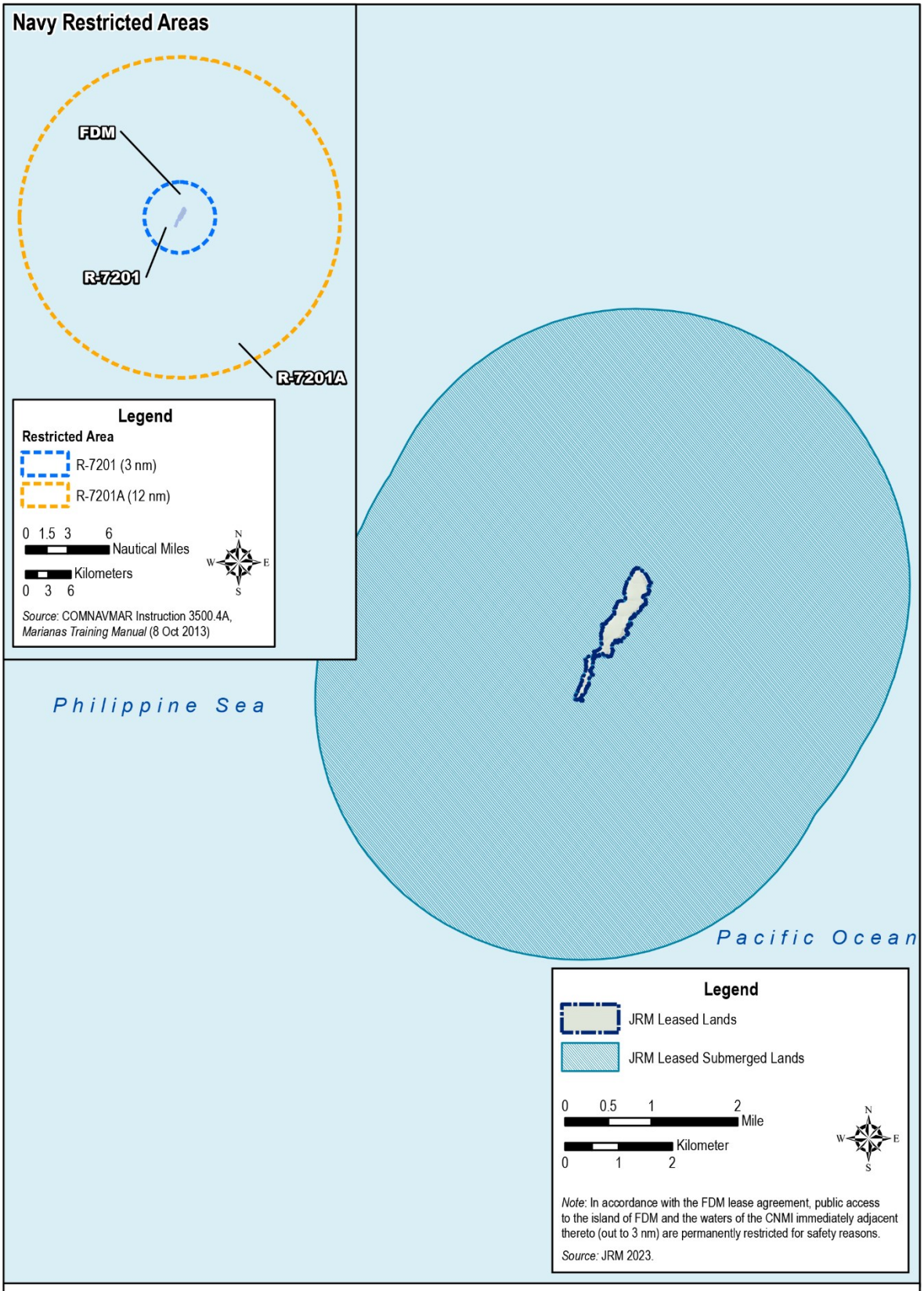


Figure 2-5
JRM Leased Lands and Submerged Lands on FDM

2.2.2 Naval Base Guam

The mission of NBG is to support the U.S. Pacific Fleet and other forces operating from, serviced by, or supplied through Guam; to support the warfighters based at NBG or attached to tenant commands; and to support the families of sailors stationed in Guam. Both Tinian and FDM are operationally considered part of JRM and are used for training exercises that support the readiness of U.S. and allied troops (Commander Naval Forces Marianas [COMNAVMAR] 2013).

NBG is a DON installation comprised of several components across the island. NBG is home of Commander Naval Forces Marianas, Submarine Squadron 15, Coast Guard Sector Guam, and Naval Special Warfare Unit One and supports 28 other tenant commands. It is the home base of three Los Angeles-class submarines and dozens of units operating in support of U.S. Indo-Pacific Command (USINDOPACOM), U.S. Pacific Fleet, Seventh Fleet, and Fifth Fleet.

DON supports numerous tenant commands and activities on three primary sites: NBG Main Base, Naval Munitions Site (NMS), and NBG Telecommunications Site (TS) (see Figure 2-2). In total, NBG lands in Guam cover approximately 17,000 acres (6,880 hectares). In addition, JRM administers all submerged lands adjacent to its holdings from the shoreline out 3 miles (4.8 kilometers). JRM-administered submerged lands that surround NBG total approximately 47,495 acres (19,221 hectares).

2.2.2.1 Naval Base Guam Tenants

Below is a list of the primary tenants on NBG, but others include the U.S. Coast Guard (USCG), DoD Education Activity school system, base housing, Morale Welfare Recreation, Navy Exchange, and the Naval hospital.



View towards the interior of Sumay Cove, Apra Harbor, from the Morale Welfare and Recreation facility. The small trees on the cove margins are mangroves.
(*Photo*: M. Lybolt)

Submarine Squadron 15

The mission of Submarine Squadron 15 is to prepare assigned and visiting units for forward-deployed operations in the Western Pacific. It maintains the highest level of readiness to permit surge operations when called upon to respond to emergent theater commander tasking in support of the nation's Maritime Strategy efforts. NBG is the home base of four forward-deployed Los Angeles-class attack submarines. Submarine Squadron 15 provides maintenance, administrative, and logistics support to numerous forward-deployed or deploying submarines in Guam.

Military Sealift Command Ship Support Unit

Military Sealift Command (MSC) Ship Support Unit Guam provides operational, engineering, logistics, contracting, medical, and administrative support to all MSC vessels operating in the Western Pacific. In addition to supporting Fleet Support Command responsibilities for MSC's government-owned, government-operated vessels, MSC Ship Support Unit Guam provides regional support to MSC's special mission and strategic sealift vessels and prepositioning vessels, such as forward-deployed Maritime Prepositioning Ship Squadron Three.

Explosive Ordnance Disposal Mobile Unit 5

Explosive Ordnance Disposal (EOD) Mobile Unit 5 deploys and employs tailored EOD units to locate, identify, render safe and remove conventional chemical, biological, nuclear, radiological, and improvised explosive hazards in order to enable access for joint, naval, and special operations forces within the Western Pacific Theater of Operations and elsewhere, when directed.

Navy Munitions Command Unit East Asia Division – Guam

Navy Munitions Command Unit East Asia Division – Guam is DON's largest and most capable overseas mine shop. Its mission is to store, maintain, assemble, and deliver underwater mines in response to tasking from Unified Theater Commanders. It directly supports aircraft and submarines for Commander Seventh Fleet; however, U.S. Air Force (USAF) bombers flying missions from Andersen AFB are the primary supported mine delivery platforms.

Naval Airborne Weapons Maintenance Unit 1

Naval Airborne Weapons Maintenance Unit 1 is a munitions maintenance activity and combat support unit that conducts intermediate and selected depot level maintenance. The command tests and repairs air and select surface-launched missiles and guided weapons and their components in support of DON worldwide.

Coastal Riverine Group 1, Detachment Guam

Coastal Riverine Group 1 provides rapidly deployable forces to conduct or support anti-terrorism/force protection (AT/FP) missions.

2.2.3 Andersen Air Force Base

Andersen AFB serves as a stopping point for numerous aircraft en route to Japan, Korea, and other Asian locations. Operational and mission activities conducted at Andersen AFB are considered USAF mission functions (e.g., runways, aircraft operations), while installation support activities, including natural resource management, are JRM functions supported by Naval Facilities Engineering Systems Command (NAVFAC) Marianas.

Andersen AFB is the home of the 36th Wing (36 WG). The mission of Andersen AFB is to provide the President of the United States sovereign options to decisively employ airpower across the entire spectrum of engagement (USAF 2013). The 36 WG has maintained a Continuous Bomber Presence of four to six heavy bombers since the USINDOPACOM-directed mission started in 2004. In 2005 under the USINDOPACOM-directed mission, six KC-135 tankers were assigned; despite normally rotating through different installation locations, these six KC-135 tankers are continuously at Andersen AFB under the 36 WG, similar to the Continuous Bomber Presence mission.

The USAF supports one primary site in Guam: Andersen AFB. Andersen AFB is about 8 miles by 4 miles (13 kilometers by 6 kilometers) and covers 15,400 acres (6,232 hectares) of a relatively flat, uplifted limestone plateau at the northern end of the island. JRM-administered submerged lands associated with Andersen AFB total approximately 37,869 acres (15,325 hectares).

2.2.3.1 Andersen Air Force Base Tenants

Below is a list of the primary tenants on Andersen AFB, but others include the 734th Air Mobility Squadron and 22nd Space Operations Squadron, Detachment 5.

36th Mobility Response Squadron

The mission of the 36th Mobility Response Squadron is to train, organize, equip, and lead cross-functional forces, providing initial USAF presence within potentially austere forward operating locations as directed by Commander Pacific Air Forces.

Helicopter Sea Combat Squadron 25

The mission of Helicopter Sea Combat Squadron 25 is to deploy helicopter detachments to conduct Sea Combat operations in support of the Fleet and the National Defense and to provide logistics, search and rescue, force protection, and disaster response support to Guam and the CNMI.

69th Reconnaissance Group, Detachment 1

The mission of Detachment 1 of the 69th Reconnaissance Group is to provide a broad spectrum of intelligence, surveillance, and reconnaissance collection capabilities to support joint commanders in worldwide peacetime, contingency, and wartime operations in the Pacific region. This is achieved by deploying the RQ4 Global Hawk unmanned aircraft system to a wide range of locations.

644th Combat Communications Squadron

The mission of the 644th Combat Communications Squadron is to rapidly deploy combat-ready Airmen and communications in support of Pacific Theater contingencies. It is a rapid deployment unit designed to deploy all or part of a 32-person team "within a moment's notice" to establish and provide "initial" secure/non-secure electronic and voice capabilities.

94th Army Air and Missile Defense Command

U.S. Army Terminal High Altitude Area Defense (THAAD) Ballistic Missile Defense Battery was deployed in April 2013 as an emergency response to potential North Korean missile launch activity. Task Force Talon led the expeditionary placement and operation of the THAAD battery under the command of the 94th Army Air and Missile Defense Command.

2.2.4 Marine Corps Base Camp Blaz

MCB Camp Blaz was activated on October 1, 2020. In accordance with a 2006 agreement between the U.S. and Japan, DON relocated Marines from installations in Japan to Guam, which expanded the military mission of JRM (DON 2010, 2015a, 2015b; DON and Department of the Army 2010). The construction phase for the Marine Corps Relocation program has already begun and will gradually decline sometime prior to 2030. The newly activated MCB Camp Blaz is comprised of the Main Cantonment (formerly NBG TS), Family Housing at Andersen AFB, Live-Fire Training Range Complex north of Andersen AFB Northwest Field, and Non-Live-fire Training Range Complex and Hand Grenade Range at Marine Corps Base Camp Blaz (MCBCB) Urban Training Complex (formerly Andersen South) (see Figure 2-2). In addition, JRM manages all submerged lands adjacent to MCB Camp Blaz from the shoreline out 3 miles (4.8 kilometers). The Main Cantonment supports industrial, shopping/entertainment, recreational, temporary lodging, and administrative functions. MCB Camp Blaz Environmental Division delivers installation support services to oversee and execute environmental mitigation projects associated with consultations, agreements, and decision documents.

2.2.4.1 MCB Camp Blaz Tenants

Current tenant information is not available at this time as the buildup of MCB Camp Blaz is not complete. This information will be added in future updates as it becomes available.

2.3 ABBREVIATED HISTORY OF GUAM, TINIAN, AND FARALLON DE MEDINILLA

2.3.1 Territory of Guam

The original inhabitants of Guam are believed to be descendants of seafaring Austronesian people originating from Southeast Asia as early as 2000 BC, having language and cultural similarities to Malaysia, Indonesia, and the Philippines. These people evolved into the Chamorro people that flourished as an advanced horticultural and hunting society. The first European contact occurred in 1521 when the Portuguese navigator Ferdinand Magellan reached the island of Guam. In 1565, General Miguel Lopez de Legazpi claimed the Mariana Islands (Guam and Northern Mariana Islands) for Spain. Spanish colonization commenced in 1668 with the arrival of Padre San Vitores, who established the first Catholic mission. The

islands were then governed from the Philippines as part of the Spanish East Indies. Between 1668 and 1815, Guam was an important resting stop on the Spanish trade route between Mexico and the Philippines. Guam, along with the rest of the Mariana and Caroline islands, was treated by Spain as part of their colony in the Philippines. The Chamorro culture of both Guam and the Northern Mariana Islands was heavily influenced by Spanish culture and traditions (Rogers 2011).

The U.S. took control of Guam in 1898 at the end of the Spanish-American War. Guam came to serve as a station for American ships traveling to and from the Philippines. During World War II (WWII), Guam was invaded by Japan on December 8, 1941. During this period, the indigenous people of Guam were subjected to forced labor, family separation, incarceration, execution, and living in concentration camps. The earlier U.S. capture and occupation of Saipan and Tinian from the Japanese's Northern Mariana Islands Territories was used to stage the Battle of Guam on July 21, 1944 and recapture the island from the Japanese. After the war, the Guam Organic Act of 1950 established Guam as an unincorporated, organized territory of the U.S., which provided for the structure of the island's civilian government and granted the people U.S. citizenship.



Apra Harbor and Orote Peninsula, circa 1945 (*Source:* JRM)



Andersen AFB circa 1945 (*Source:* JRM)

2.3.2 Commonwealth of the Northern Mariana Islands

Prior to Spanish occupation, the Chamorro population in the Mariana Islands was estimated to be between 40,000 and 73,000. Intermittent arrivals of Carolinian people also occurred during this period. By 1825, however, after two centuries of Spanish rule, war, famine, and disease, the native population was reduced to 600 (Bowers 1950).

Spain claimed the Northern Mariana Islands from the native population in 1565. Germany purchased the Northern Mariana Islands from Spain in 1899, but German control over the Northern Mariana Islands was lost in 1914 when it was annexed by Japan (Spennemann 1999). Japan retained possession of the Northern Mariana Islands until the U.S. invaded certain islands and Japan was defeated during WWII. The Chamorro population in the Mariana Islands did not begin to re-establish until after WWII (DON 2017). The U.S. administered the Northern Mariana Islands from 1945 to 1972 as part of the United Nations Trust Territory of the Pacific Islands. In 1972, negotiations with the U.S. began for territorial status of the Northern Mariana Islands. In 1975, Mariana Islands residents approved a covenant establishing a Commonwealth, and they entered into a union with the U.S. in 1976. The CNMI Government adopted its own constitution in 1977, and the constitutional government took office in January 1978.

2.3.2.1 Tinian

The Spanish took formal possession of Tinian in 1565. At that time, the native population was estimated to be 7,000 people. In 1899, Germany purchased the Northern Mariana Islands from Spain. German control over the Northern Mariana Islands was lost in 1914 when it was annexed by Japan (Spennemann 1999). Tinian came under control of imperial Japan in 1914. Large-scale sugar production was established on 80–90% of the island's tillable soil, which resulted in the destruction of forests and archaeological sites. Japan retained possession until the invasion of Saipan and Tinian by American forces, which occurred in June and July 1944 during WWII. Following the battle for Tinian, the U.S. military transformed the island into the largest B-29 base in the Pacific and the largest operational base in the world. The existing North Field was expanded, and West Field was developed to accommodate two 8,500-foot (2,600-meter) runways. Among the purposes of the Marianas operation was the provision of a base to initiate the B-29 bombings of Japanese home islands. The *Enola Gay* and *Bockscar* bomber aircraft that dropped an atomic bomb on Hiroshima and Nagasaki, respectively, were based on Tinian. Since the 1990s, Tinian's economy has been led by tourism and local government employment (U.S. Census Bureau 2014).

2.3.2.2 Farallon de Medinilla

Archaeological surveys conducted on FDM concluded that it is unlikely that a permanent human population ever resided on the island due to the lack of water, its exposed environment, and difficult beach landing (Belt Collins Hawai'i 1997). The Spanish took formal possession of FDM in 1565 and Germany purchased the Northern Mariana Islands from Spain in 1899. The German administration issued leases for collection of exotic bird feathers from FDM and seven other islands from 1909–1911. The lease was terminated in 1911 after a lessee breached their contract by failing to plant coconut trees (Spennemann 1999). By the end of the lease, bird numbers were reduced to the point where further hunting was uneconomical. German control over the Northern Mariana Islands was lost in 1914 when it was annexed by Japan (Spennemann 1999). Japan retained possession of FDM until 1944 when the U.S. defeated Japan during WWII.

2.4 REGIONAL LAND USE

2.4.1 Guam

Residents of Guam depend primarily on the U.S. military and tourism from Korea and Japan for their economy. Nearly 1.3 million tourists visit Guam each year, including about 831,000 from Japan and 295,000 from Korea (Guam Visitors Bureau 2014). NBG is a major shore-leave destination for sailors and visiting port-of-call for the Seventh Fleet and many foreign vessels. Most food and industrial goods are imported; however, some crops, primarily fruits and vegetables, are grown on the island. As tourism continues to grow, more and more land will be developed to support the industry. In addition, with the proposed relocation of approximately 5,000 Marines and approximately 1,300 dependents from Okinawa to Guam, more development of military facilities and island infrastructure will be needed to support military and associated civilian personnel.

2.4.2 Tinian

Public land uses on Tinian include tourism, agriculture, livestock grazing, commerce, recreation, and communication. The CNMI Division of Coastal Resources Management has designated areas of particular concern and is responsible for regulating the use of these areas.

The northern two-thirds of Tinian is leased by the U.S. military and is known as the Military Lease Area (MLA) (see Figure 2-4). The MLA currently comprises approximately 15,347 acres (6,211 hectares). Within the southern portion of the MLA, the U.S. has sublet 7,779 acres (3,148 hectares) back to the CNMI

in an area called the Lease Back Area (LBA). The International Broadcasting Bureau (IBB) uses another 777 acres (314 hectares) of the MLA under a separate agreement (see Figure 2-4). The remaining portion (7,568 acres [3,063 hectares]) of the northern portion of the MLA is set aside as an Exclusive Military Use Area (EMUA) for military activities; however, the North Field National Historic Landmark is contained within the EMUA and military training activities occur there in accordance with a Programmatic Agreement. Civilian and military land uses overlap to some extent; for example, public recreational use is permitted within the MLA. The submerged lands depicted in Figure 2-4 represent the areas adjacent to leased lands on Tinian, extending 3 miles seaward from the high tide line, which were excepted from transfer to the CNMI by Presidential Proclamation of January 15, 2014. Further detail regarding the MLA is provided in Chapter 11, *Tinian Military Lease Area*.

2.4.3 Farallon de Medinilla

The island of FDM is leased to the U.S. military for naval and aircraft live-fire training (see Figure 2-5). The U.S. Navy has leased FDM from the CNMI since 1971 and on January 6, 1983, renegotiated a 50-year lease agreement for military purposes. The lease agreement contains a renewable provision for another 50 years of use of the island (DON 1983). In accordance with the lease agreement, the island, submerged lands, and overlying restricted airspace out to 3 miles[1] (4.8 kilometers), designated Restricted Area (R-) 7201, are closed to the public because of unexploded ordnance concerns. No commercial or recreational activities are permitted on or near the island; aircraft and marine vessels are restricted from entering within 3 miles (4.8 kilometers) around FDM. Notice to Mariners and Notice to Airmen are issued at least 72 hours in advance of potentially hazardous FDM range events. In addition, R-7201A extends an additional 9 miles (14.5 kilometers) from R-7201 (or 12 miles [19.3 kilometers] from FDM) and restricts all private and commercial vessels from entering the area when, and only when, hazardous activities are scheduled. Further detail regarding FDM is provided in Chapter 12, *Farallon de Medinilla*. Under Presidential Proclamation 9077, submerged lands in the CNMI were conveyed back to the Commonwealth on January 16, 2014, with the exception of the submerged lands adjacent to federally leased lands on Tinian and FDM and those adjacent to Farallon de Pajaros, Maug, and Asuncion.

[1] The lease agreement between the CNMI and the U.S. measures the 3-mile (5-kilometer) FDM boundary in geographical miles. The units "nautical mile" and "geographical mile" originally shared the same definition. The nautical mile remained defined as 6,076 feet (1,852 meters), but the geographical mile became more precisely defined with modern geodetic measurements and is now 6,080.4 feet (1,855.3 meters). The worldwide convention is to write "nautical mile" for the benefit of improved comprehension, even when a legal boundary is measured in geographical miles. Because these units differ by only 10.8 feet (3.3 meters), using the more familiar "nautical mile" is inconsequential for practical purposes.

3 ENVIRONMENTAL MANAGEMENT STRATEGY AND MISSION SUSTAINABILITY

The United States (U.S.) Navy's mission is to maintain, train, and equip combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas (Chief of Naval Operations [OPNAV] Manual [OPNAV M] 2021). The U.S. Navy has responsibilities for the stewardship of natural resources on land and at sea (Secretary of the Navy [SECNAV] 2006). In addition to compliance with all appropriate environmental laws and regulations, the U.S. Navy has a mandate to implement a program for the conservation of natural resources (SECNAV 2004) on lands and in nearshore areas that are either titled to or are under the U.S. Navy access control. Professionally trained natural resources managers are assigned the responsibility of implementing these requirements.

This chapter presents the Joint Region Marianas' (JRMs') overall environmental management strategy and discusses how the strategy supports the military mission. Chapter 3 also provides an overview of applicable laws, policies, and regulations that are considered in the planning and implementation of training, testing, and operations, as well as natural resource management projects.

3.1 ECOSYSTEM MANAGEMENT AND ADAPTIVE MANAGEMENT

Department of Defense Instruction (DoDI) 4715.03 requires that Integrated Natural Resource Management Plans (INRMPs) incorporate the principles of ecosystem management for natural resources under the stewardship and control of Department of Defense (DoD). The goal of ecosystem management within the DoD is to preserve and enhance ecosystem integrity as well as to sustain biological diversity and continued availability of those resources for military readiness and sustainability and other human uses (as defined in OPNAV M 5090.1) (OPNAV M 2021). The basic principles and guidelines of ecosystem management are as follows:

- maintain and improve the sustainability and native biological diversity of ecosystems
- consider ecological units and timeframes in management decisions
- support sustainable human activities
- develop a vision of ecosystem health that includes social and economic conditions
- develop priorities and reconcile conflicts
- develop coordinated approaches to work toward ecosystem health that involve the military operational community and regional stakeholders
- rely on best science and available data
- use goals and objectives to monitor and evaluate outcomes
- use adaptive management

DoDI 4715.03 also requires DoD components to ensure that their INRMPs provide for no net loss in the capability of installation lands to support the military mission, pursuant to section 670a(b)(1)(I) of the Sikes Act, to the extent appropriate, applicable and consistent with the installation's use (DoD 2011).

Ecosystem function is a result of interactions of its various components: geologic and soil features, climatic elements, plants, animals, humans, and current and past disturbances (including past management practices). The function, integrity, and overall health of an ecosystem are measured in terms of diversity, nutrient availability (productivity), structural complexity, and properly functioning natural physical processes. Ecosystem health may be defined as the capacity for maintaining biological and social organization on the one hand, and the ability to achieve reasonable and sustainable human goals on the other.

The 1994 DoD policy memorandum, *Implementation of Ecosystem Management*, was developed to ensure that resources on DoD installations were managed in a manner to conserve and protect biological diversity through adopting an ecosystem management approach to natural resources management (Benton et al. 2008). The policy states that "military installations will use ecosystem management to:

- restore and maintain ecological associations that are of local and regional importance and compatible with existing geophysical components (e.g., soil, water);
- restore and maintain biological diversity;
- restore and maintain ecological processes, structures, and functions;
- adapt to changing conditions;
- manage for viable populations; and
- maintain ecologically appropriate perspectives of time and space."

The DoD leadership further strengthened the need to manage resources using an ecosystem management approach in DoDI 4715.03, *Natural Resources Conservation Program* (March 18, 2011), and DoD Manual (DoDM) 4715, *Integrated Natural Resources Management Plan (INRMP) Implementation Manual* (November 25, 2013), which stress the importance of recognizing the relationship between ecosystem management and biodiversity conservation. The DoDI outlines four goals for installations to preserve and enhance biodiversity:

- Maintain or restore remaining native ecosystem types across their natural range of variation.
- Maintain or re-establish viable populations of native species on an installation, when practical.
- Maintain ecological processes, such as disturbance regimes, hydrological processes, and nutrient cycles, to the extent practicable.
- Manage and monitor resources over sufficiently long time periods to allow for adaptive management and assessment of changing ecosystem dynamics (i.e., incorporate a monitoring component to management plans).

The Sikes Act ensures that DoD develops all INRMPs with an ecosystem management approach to overall natural resources management. Ecological integrity is one of the primary facets of ecosystem management, and maintaining system integrity is consistent with DoDI 4715.03. Ecosystem integrity is defined as "the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region" (Angermeier and Karr 1994). The INRMP is developed to conserve and protect ecological integrity by promoting a proactive, as opposed to a reactive, strategy for managing resources. Figure 3-1 provides an outline of an ecosystem management-based decision process.

The ecosystem management mandate is accomplished by applying principles of sustainable use at several scales with emphasis on partnerships, public outreach, long-term monitoring, and adaptive management. Consistent with Department of the Navy (DON) policy, ecosystem-based management shall include (OPNAV M 2021) the following:

- a shift from single species to multiple species conservation
- formation of partnerships necessary to consider and manage ecosystems that cross boundaries
- use of the best available scientific information and adaptive management techniques

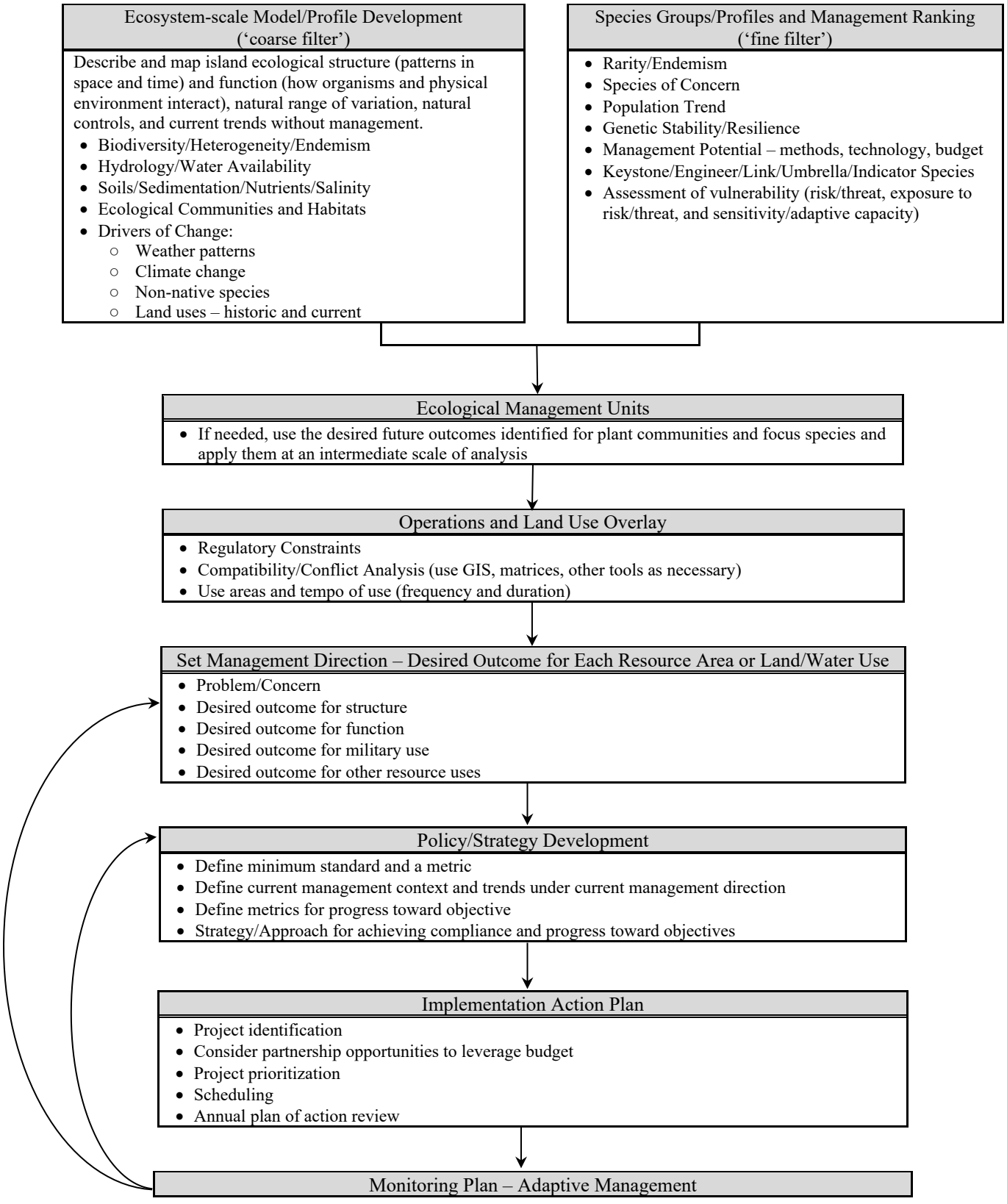


Figure 3-1. Ecosystem Management-based Decision Process

Adaptive management is an iterative cycle of planning, monitoring, evaluation, adjustment, and implementation that is best used to assess ecosystem function and health and the effectiveness of management practices. Adaptive management is addressed through regulatory processes and the annual Natural Resources Conservation INRMP Metrics review (see Section 1.2, *Annual Review and Update Process*), and partly through the DON's Environmental Management System (EMS). The EMS is used to integrate environmental considerations into day-to-day activities across all levels and functions of DON enterprise. The EMS is a formal management framework that provides a systematic way to review and improve operations, create awareness, and improve environmental performance.

Integrating systematic environmental management as a part of day-to-day decision making, as well as long-term planning processes is important to supporting mission readiness and effectively using resources. The most significant resource for every organization is their senior leadership's commitment and visibility in EMS implementation and sustainability. A robust EMS is essential to sustaining compliance, reducing pollution, and minimizing risk to the mission.

DoD and DON policies require that INRMPs are updated annually, but not less often than every 5 years, and are reviewed for operation and effect to ensure that these documents remain as living documents that can be revised based on changes to current conditions (including changes as a result of climate). In particular, the implementation of monitoring for tracking trends in ecosystem health provides the objective basis for the annual updates and 5-year reviews. Monitoring and mapping includes measures of climate at ecologically relevant scales so that climate change effects can be evaluated and incorporated into management decisions. The goals and objectives developed for this INRMP were developed using an ecosystem management approach that is flexible, takes into account ecosystem changes resulting from various factors including climate change, and is centered on the requirements for military readiness.

In accordance with the Sikes Act and DoDI 4715.03, DoD components will apply regional approaches to natural resource management in cooperation with other installations and other federal and state or territorial agencies. The purpose of this regional outreach is to share information and collaborate on natural resource projects across jurisdictions. Such efforts include coordination with State Wildlife Action Plans, species recovery plans, land use conservation plans, landscape management plans, area master plans, and others as appropriate.

The DoD Readiness Environmental Protection Integration (REPI) Program is a key tool for combating encroachment that can limit or restrict military training, testing, and operations. The REPI Program protects these military missions by helping remove or avoid land use conflicts near installations and addressing regulatory restrictions that inhibit military activities. REPI also benefits the environment by conserving land near military installations and ranges. These partnerships often work across boundaries and protect wildlife habitat, water resources, natural spaces for recreational opportunities, and threatened and endangered species.

3.1.1 Climate Change

In May 2022, DON created an extensive climate action document, *Climate Action 2030*, which emphasizes the existential threat that climate change poses to DON operations and readiness. Climate change is referred to as any significant change in measures of climate (e.g., temperature, precipitation, wind) lasting for an extended period of time (decades or longer) (U.S. Environmental Protection Agency [USEPA] 2016). As summarized in OPNAV M-5090.1 (2021), assessing the impacts of climate change is best approached by first identifying an environmental baseline that considers potential future differences in landscape form and function caused by climate change and other stressors on the landscape. Conducting a climate change

vulnerability assessment may guide essential monitoring requirements, as well as the development of appropriate adaptive management projects.

Changes in global climate have caused rising sea levels, recurring flooding, and more frequent and destructive hurricanes that threaten coastal DoD infrastructure and installations and create increased challenges for DON forces, platforms, and supporting communities. To combat these impacts, the DON has an urgent charge to build a climate-ready force and has identified and committed to meeting two performance goals:

1) Build Climate Resistance: Ensure that DON forces, systems, and facilities can continue to operate effectively and achieve the mission in the face of changing climate conditions and worsening climate impacts.

2) Reduce Climate Threat: The Department must reduce its greenhouse gas emissions and draw greenhouse gases out of the atmosphere, stabilize ecosystems, and achieve, as an enterprise, the nation's commitment to net-zero emissions by 2050.

The U.S. has emphasized the need to achieve net-zero emissions economy-wide by 2050, and DON has committed to drawing down the equivalent of 1 million cars' worth of carbon dioxide (CO_2) on DON lands by 2027 through nature-based solutions and to install cyber-secure microgrids or other resilience technology to support all critical missions (DON 2022). The DON will organize around five Lines of Effort consistent with those laid out in the DoD's climate adaptation plan. These include climate-informed decision making; training and equipping for climate resilience; resilient built and natural infrastructure; supply chain resilience and innovation; and enhanced mitigation and adaptation through collaboration.

The DON approach will be data-driven, grounded in science, and focused on enhancing mission accomplishment, and will include a wide range of partners such as the Department of Energy, the Department of Agriculture, the DoD Readiness and Environmental Protection Integration program, to name a few. JRM will collaborate with regional partners on initiatives, such as those outlined in National Oceanic and Atmospheric Administration (NOAA) Fisheries Pacific Islands Regional Action Plan and the upcoming University of Guam (UOG) Guam Vulnerability Assessment. However, the abundance and distribution of species and habitats on DON properties may be too small in scale to address comprehensive climate change vulnerabilities. Therefore, regional partnerships may be the most appropriate means to conduct such assessments and to develop and implement adaptive management projects. In general, natural resources managers should identify and implement natural resource conservation projects that provide benefits to the ecosystem regardless of the spatial or temporal aspects of climate change.

Per DoD Directive 4715.21, *Climate Change Adaptation and Resilience* (January 14, 2016), the DoD must be able to adapt current and future operations to address the impacts of climate change in order to maintain an effective and efficient U.S. military (DoD 2016). Mission planning and execution must include:

a. Identification and assessment of the effects of climate change on the DoD mission.
b. Taking those effects into consideration when developing plans and implementing procedures.
c. Anticipating and managing any risks that develop as a result of climate change to build resilience.

DoDI 4715.03 (2011) (Enclosure 3, Section 1c) states: "All DoD Components shall, in a regionally consistent manner, and to the extent practicable and using the best science available, utilize existing tools to assess the potential impacts of climate change to natural resources on DoD installations, identify significant natural resources that are likely to remain on DoD lands or that may in the future occur on DoD lands and, when not in conflict with mission objectives, take steps to implement adaptive management to ensure the long-term sustainability of those resources."

The DON has also developed *A Cooperative Strategy for 21st Century Seapower* that addresses a need for adaptive management in the face of a changing climate (DON et al. 2015). In addition, the 2008 DON Environmental Strategy, *Sustaining our Environment, Protecting our Freedom*, states the importance of all Naval bases to evaluate activities and ensure that best management practices (BMPs) have been put into place to reduce the overall environmental footprint of DON and enhance sustainability (DON 2008).

In May 2009, the DON created a task force to explore and develop policies and strategies that address climate change. The Task Force Climate Change is made up of senior DON staff and other stakeholders, and findings will be based on many factors, including the most current scientific research. In tandem with the 2022 climate resilience document, the DON is initiating a 90-day implementation process in which stakeholders across the DON will work to identify initiatives and make progress towards performance goals. Additionally, DON serves as the Executive Steering Committee to ensure cohesive implementation of the strategy across the enterprise.

3.2 INTEGRATING MILITARY MISSION AND SUSTAINABLE LAND USE DECISIONS

To accomplish the mission of national security, the public has endowed the DoD with an investment in public lands. Proper management of natural resources on JRM-administered and leased terrestrial and submerged lands in Guam, Tinian, and Farallon de Medinilla (FDM), including maintaining or improving ecological conditions and capability of natural landscapes, has numerous effects. These include:

- the ability to support military training and readiness
- an improvement in the quality of life of military personnel
- a streamlining of the compliance process and a reduction in conflicts
- a reduction in littering, pollution, and poaching of wildlife and vegetation resulting in improved ecosystem integrity

In keeping with the principal use of military installations to ensure the preparedness of the U.S. Armed Forces, the Sikes Act, and emphasized in the U.S. Navy INRMP Guidance (DON 2006), mandates that the INRMP will meet two basic purposes:

1. Ensure “no net loss of the capability of military installation lands to support the military mission of the installation” into the future.
2. Ensure “the sustainability of all ecosystems encompassed by an installation.”

Maintaining compliance with the numerous laws, policies, and regulations that provide protection of environmental elements and guidance for management of natural resources may affect the military mission. Some of these laws include the Endangered Species Act (ESA), Migratory Bird Treaty Act (MBTA), Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), National Invasive Species Act, Clean Water Act (CWA), Rivers and Harbors Act, and Coastal Zone Management Act (CZMA) (refer to Appendix B for a full list of all relevant environmental laws, regulations, policies, guidance, instructions, and Executive Orders [EOs]). Effects may include limiting access or restricting activities to certain areas. Natural resources management may temporarily preclude use of areas to prevent damage to soils and wildlife during periods required for vegetation recovery or during breeding seasons. Without the management of natural resources, military use could degrade the land and decrease the ability of JRM-administered terrestrial and submerged lands to support the training mission.

Operational sustainability seeks to keep intact the long-term carrying capacity of JRM-administered terrestrial and submerged lands for military readiness purposes. These lands support the mission by providing the following:

- availability of sufficient space to conduct military operations and training
- capability of supporting sufficient instrumentation to support training
- availability of effective infrastructure to support training
- availability of multiple media (e.g., land, air, sea) to coordinate combined exercises
- capability to support live-fire training scenarios on certain properties
- capability to support essential training tempo and intensity to attain sufficient readiness to deploy
- capability to successfully coordinate and deconflict natural resources management with training requirements to provide realistic warfare training opportunities

For the purpose of this INRMP, an impact to mission accomplishment has occurred when any of the above are constrained or when one of the following conditions occurs:

- quality of military training is impacted by natural resources restrictions
- training qualification objectives to deploy are not accomplished without significant delay or conflict
- scheduled rotations are impacted by natural resources issues
- conflict resolution impacts training intensity or tempo and the target resource condition is impacted

Appropriate management goals and objectives to protect mission capabilities of installation lands (from which annual projects are developed) are clearly articulated in the planning process and are high in INRMP resourcing priorities. The effectiveness of the INRMP in providing for "no net loss of military installation lands to support the military mission" is evaluated annually. Mission requirements and priorities identified in the INRMP are, where applicable, integrated in other environmental programs and policies (e.g., see Section 3.5, *Integration with Other Joint Region Marianas Site Plans and Regional Programs*). It is not the intent that natural resources are to be consumed by mission requirements, but rather sustained to support mission requirements. In order to achieve this, environmental programs and policies must have the goal of controlling environmental encroachment and preserving an unencumbered environment for the purpose of the mission. Through implementing effective planning and conservation measures, the INRMP also provides a guide for meeting natural resources and conservation compliance requirements.

Chief of Naval Operations Instruction (OPNAVINST) 5090.1 requires that each command establish procedures to keep U.S. Navy decision makers informed of the requirements, the current conditions of natural resources, and status of natural resources stewardship objectives contained within this INRMP. Land use practices and decisions must be based on scientifically sound conservation procedures and techniques, and use scientific methods and an ecosystem management approach.

The JRM is well-positioned to implement and demonstrate environmentally sound land use planning and development through its National Environmental Policy Act (NEPA) processes, interdepartmental coordination, adherence to U.S. Navy guidance and regulations, and timely review and revision of installation site development plans. In addition, U.S. Navy policy requires that all military construction projects meet a Silver rating under the U.S. Green Building Council Leadership in Energy and Environmental Design (LEED) Green Building Rating System (DON 2006).

3.2.1 Natural Resources Military Mission Constraints

The U.S. Navy INRMP Template (DON 2006) requires constraints and opportunities maps for all JRM-administered terrestrial and submerged lands addressed in this INRMP. *Constraints* include known locations of federal ESA-listed and other special status species, previously identified conservation areas preferentially managed for special status species, and locations associated with a regulatory driver (e.g., jurisdictional waters or migratory bird nest sites). Within constrained areas there may be limitations on

certain activities, such as prohibiting access in order to preclude damage to important natural resources. Constraints do not always totally prevent activities. Some constraints may be temporal, others may only constrain certain activities (e.g., digging). *Opportunities* include situations related to natural resources in which DON might be able to increase efficiency, reduce costs, increase the quality of projects, or otherwise enhance military mission sustainability through coordination with outside entities, internal coordination among departments on specific projects, or achieve the solution to multiple challenges through one unified approach. Discussion and depiction of the constraints and opportunities for each JRM installation or parcel are provided in Chapters 5-9, 11, and 12.

3.3 NATURAL RESOURCES MANAGEMENT GOALS AND OBJECTIVES

Natural resources management conducted on JRM-administered terrestrial and submerged lands strives to integrate biodiversity conservation and an ecosystem-based approach into an adaptive management framework compatible with the military mission. As a result, the natural resources program consists of multiple resource disciplines that are frequently interconnected and share similar objectives. Management projects and plans often consist of multiple program elements with several different resource experts collaborating together.

The vision for this INRMP is to ensure the continued ability of the DoD to support its current and evolving mission requirements on JRM-administered terrestrial and submerged lands while conserving the natural resources on those lands, cooperatively working with other agencies to manage those resources, and applying the principles of ecosystem management and adaptive management in an integrated approach.

This INRMP helps to guide the improvement of conditions for long-term certainty and permanence for DON's mission on JRM-administered terrestrial and submerged lands. This is accomplished by defining appropriate natural resources projects, strategies, actions, and conservation measures that comply with regulatory requirements and reduce impacts to military training activities and natural resources. The standards of success for achieving this vision include the following:

- DoD mission accomplishment that is unimpeded
- net gain in ecological productivity, natural biodiversity, and sensitive species recovery
- ecosystems and habitats that are resilient and require minimal human intervention to remain intact and functional
- DoD projects that are not delayed and contribute no net loss to conservation goals
- interagency partnerships that result in mutual benefits and improved cost-effectiveness of the work undertaken
- implementation of management projects that allow progressive implementation of programs that contribute to ecosystem health while maintaining military operational flexibility

All INRMPs have specific goals that are shaped by DoD guidelines and directives, pertinent laws and regulations, cooperation with partner agencies, public needs, public values, ecological theory, and practice and management experience. A goal statement is necessary for setting the course toward a successful plan. The planning terms used in this document such as goal, objective, strategy, and action cover a gradient of specificity and durability ranging from a very broad, enduring goal to specific actions (Table 3-1).

Table 3-1. Definition of Planning Terms Used in this INRMP

Term	*Definition*
Goal	Broad statement of intent, direction, and purpose. An enduring, visionary description of where you want to go – an outcome. A goal is not necessarily completely attainable. It describes a desired outcome related to the mission, rather than an activity or process.
Objective	Specific statement that describes a desired future condition or successful outcome. Can be quantitative. Should be followed by a "standard," which is an observable indicator by which successful attainment of a condition stated in the objective is measured. "How do we know we are making progress or have attained the desired condition or successful outcome?"
Strategy	Explicit description of ways and means chosen to achieve objectives. "What are we going to do about it?"
Action	Specific step, practice, or method to meet the defined objective based on the identified strategy.

Key: INRMP = Integrated Natural Resources Management Plan.

As stated in Chapter 1, *Overview*, the goal of the JRM INRMP is to utilize adaptive management to maintain long-term ecosystem health and minimize impacts to natural resources consistent with the operational requirements of the DoD's mission. This INRMP will identify key strategies and actions that accomplish the following:

- facilitate sustainable military readiness and foreclose no options for future requirements of the DoD
- conserve, maintain, and restore priority native species and habitats to reach self-sustaining levels through improved conditions of terrestrial, coastal, and nearshore ecosystems
- promote ecosystem sustainability to support testing and training requirements
- maintain the full suite of native species with appropriate emphasis on endemics and regionally rare or imperiled species

To achieve this goal, resource-specific goals and objectives have been developed to guide natural resources management on JRM-administered terrestrial and submerged lands. Each of the management projects described in this INRMP should be monitored so that changes can be made as environmental conditions change. INRMP goals may be revised over time to reflect changing missions and environmental conditions. Any future changes in mission, training activity, or technology should be analyzed to assess their impacts on natural resources. As installation plans and DON guidance and regulations are developed or revised, they will be integrated into this INRMP. The INRMP should be reviewed, assessed, and updated annually, but not less often than every 5 years as required by the Sikes Act.

Throughout the development of this INRMP, management projects were identified in a number of natural resources subject areas. Some of these natural resources projects could have an adverse impact on the mission or future planning operations of JRM sites. One of the purposes of this INRMP is to identify goals and objectives for JRM and to obtain workable and useful solutions (strategies) for each project to ensure no net loss in the capability of JRM-administered terrestrial and submerged lands to support the military mission.

This INRMP serves as a planning tool for CNIC, JRM, and the installations, and provides a list of projects to enable the natural resources department to practice effective ecosystem management. It provides guidance to the resource managers on projects to implement for the next 10-20 years. DON will implement projects in the INRMP within the framework of regulatory compliance (e.g., regulatory requirements under ESA and associated biological opinions [BOs]), national Navy mission obligations, anti-terrorism/force protection (AT/FP) limitations, and funding constraints. Funds necessary for projects in this INRMP are subject to availability through appropriation by Congress, and none of the proposed projects shall be

interpreted to require obligation or payment of funds in violation of any applicable federal law, including the Anti-Deficiency Act (31 U.S. Code [USC] Section 1341 et seq.), legislation designed to prevent the obligation, making, or authorizing of expenditures in excess of amounts available in appropriations or funds.

3.3.1 Goals and Objectives

In May 2016, DoD and agency stakeholders involved in the preparation of this INRMP held a meeting in Guam to discuss and develop goals and objectives for the management of natural resources on JRM-administered terrestrial and submerged lands. These goals and objectives guided the preparation of the revised JRM INRMP with the intent of preparing a document that reflects mutual agreement of the stakeholders. The following provides a summary of those goals and objectives that were presented and discussed. These goals and objectives were used to guide the development of resource-specific projects, strategies, and actions, which are presented in Chapters 5-9, 11, and 12.

- GOAL #1: ENSURE MILITARY MISSION SUSTAINABILITY AND ENVIRONMENTAL COMPLIANCE
  a) Objective #1. Improve stewardship of natural resources on JRM installations by integrating natural resource conservation program requirements with mission operations and planning.
  b) Objective #2. Ensure compliance with all applicable federal and territorial laws, regulations, policies, and legal decisions governing JRM natural resources program activities.
  c) Objective #3. Develop and maintain a natural resources enforcement program capable of enforcing all JRM natural resources rules and regulations at Guam and Commonwealth of the Northern Mariana Islands (CNMI).
  d) Objective #4. Develop an INRMP implementation tracking system.
  e) Objective #5. Facilitate the communication of updates from INRMP implementation tracking to DoD operations managers to ensure environmental compliance and no net loss in the capability of JRM-administered lands (terrestrial and submerged) to support the military mission.

- GOAL #2: PROVIDE ECOSYSTEM-BASED ADAPTIVE MANAGEMENT TO PRESERVE, PROTECT, AND ENHANCE NATURAL RESOURCES AND NATIVE BIODIVERSITY
  a) Objective #1. Protect and manage sufficient habitats by identifying landscapes and nearshore habitat needed for species conservation.
  b) Objective #2. Protect and manage sufficient habitats by securing and managing unprotected areas.
  c) Objective #3. Maintain ecological function, services, and diversity through management focused on maintaining and restoring marine and terrestrial ecosystems.
  d) Objective #4. No net loss of habitat currently managed for species recovery and conservation.
  e) Objective #5: Conservation of rare or unique habitats.
  f) Objective #6. Restore habitat and expand species range.
  g) Objective #7. Maintain, protect, and enhance water quality and contain/minimize runoff into marine waters.
  h) Objective #8. Work with other Guam, CNMI, and federal partners to prioritize watershed restoration activities to protect key coral reef areas that have been identified as resistant or resilient to disturbance.

- GOAL #3: PROVIDE A CONSERVATION BENEFIT TO PROTECTED SPECIES AND SPECIES OF CONCERN
  a) Objective #1. Ensure self-sustaining, resilient populations to maintain and increase native species and diversity.
  b) Objective #2. Ensure self-sustaining, resilient populations to include the use of novel techniques in the adaptive management of "target" species populations.
  c) Objective #3. Reintroduce extirpated species.
  d) Objective #4. No loss of current species range.
  e) Objective #5. Support recovery of ESA-listed species

- GOAL #4: INTERDICTION, CONTROL, AND ERADICATION OF TERRESTRIAL AND MARINE INVASIVE AND NUISANCE SPECIES
  a) Objective #1. Maintain ecological function and diversity through prevention of the introduction and spread of brown treesnake (BTS) (*Boiga irregularis*), other high-risk invasive species, and nuisance species.
  b) Objective #2. Maintain ecological function and diversity through control and eradication of established invasive species, particularly BTS and ungulates.
  c) Objective #3. Early detection and response to incipient invasive and nuisance species populations.
  d) Objective #4. Prevent the introduction of new marine invasive and nuisance species to Guam and the CNMI and prevent the transfer of potentially new invasive and nuisance marine species out of JRM.

- GOAL #5: INTEGRATE CLIMATE CHANGE INTO ADAPTIVE MANAGEMENT STRATEGIES, MISSIONS, AND OPERATIONS TO ENSURE THE LONG-TERM SUSTAINABILITY OF MARINE AND TERRESTRIAL ECOSYSTEMS
  a) Objective #1. Ensure that coral reef monitoring programs include methods that can document coral bleaching impacts, coral disease, ocean acidification, and sea level rise and help identify resilient reef areas.
  b) Objective #2. Encourage natural resource management and monitoring programs that incorporate climate resiliency.

- GOAL #6: ENHANCE OPPORTUNITIES FOR ENVIRONMENTALLY SUSTAINABLE COMMERCIAL, RECREATIONAL, AND CULTURAL ACTIVITIES WITHIN JRM-ADMINISTERED TERRESTRIAL AND SUBMERGED LANDS WHERE APPROPRIATE, INCLUDING ACCESS BY THE GENERAL PUBLIC
  a) Objective #1. Ensure that outdoor activities are not in conflict with DoD mission and natural resource management objectives.
  b) Objective #2. Coordinate as applicable with Morale, Welfare, and Recreation departments on installations.

- GOAL #7: DEVELOP AND ENCOURAGE COORDINATION, COMMUNICATION, OUTREACH, AND PARTNERSHIPS BETWEEN JRM AND FEDERAL, GUAM, AND CNMI GOVERNMENT AGENCIES, AND OTHER STAKEHOLDERS
  a) Objective #1. Increase or maintain outreach events, and participation with partners by promoting the natural resources program and their goals at JRM.
  b) Objective #2. Develop targeted outreach and education programs to provide awareness of natural resources on JRM installations.

c) Objective #3. Establish and maintain communication and collaboration networks with local and federal regulatory and natural resource-related agencies that can assist in the development and implementation of the natural resources program at JRM.

3.4 FEDERAL REGULATORY REQUIREMENTS AND POLICIES

This INRMP was developed consistent with guidance and regulations provided in the following:

- Sikes Act, as amended (16 USC 670a et seq.)
- DoDI 4715.03, *Natural Resources Conservation Program* (DoD 2011)
- DoD Manual 4715.03, *Integrated Natural Resources Management Plan (INRMP) Implementation Manual* (November 25, 2013) (DoD 2013)
- OPNAVINST 5090.1, *Environmental Readiness Program* (June 25, 2021) (OPNAVINST)
- OPNAV M-5090.1, *Environmental Readiness Program Manual* (June 25, 2021) (OPNAV M), which implements the policy set forth in OPNAVINST 5090.1
- Associated DoD, DON, and U.S. Navy natural resources, specifically INRMP-related, guidance

These guidance documents collectively require a plan and management approach that integrates mission support, multi-purpose use, ecosystem- or landscape-level management, and environmental compliance and stewardship. In addition, active BOs, permits, leases, and other Memoranda of Understanding (MOUs) or Memoranda of Agreement (MOAs) between JRM and other federal, territory, and Commonwealth land managers are listed in Table 3-2. Further discussion of these BOs, MOUs, MOAs, etc. and applicability of required conservation measures will be provided, as appropriate and applicable, within the site-specific discussions in Chapters 4-12. Figure 3-2 shows mitigation lands in Guam. A summary of all active BOs and their conservation measures, as well as natural resource mitigation measures under NEPA documents for actions on JRM-administered terrestrial and submerged lands, is provided in Appendix F. In addition, a list of all relevant environmental laws, regulations, policies, guidance, instructions, EOs, and consultations are provided in Appendix B.

Table 3-2. Active Land Use and Natural Resource Agreements Regarding JRM Sites

JRM Site(s)	*Agreement*	*Date*
BOs, PERMITS, AND CORRESPONDENCE WITH USFWS AND NMFS		
USFWS		
NBG Main Base, NMS, Andersen AFB, MCB Camp Blaz (formerly Andersen South), Tinian	BO for the JGPO Relocation of the USMC from Okinawa to Guam and Associated Activities in Guam and Tinian	September 2010
Guam, Tinian, FDM	BO for the MITT Program	February 2015
MCB Camp Blaz	Clarification of the 2010 BO for the DON's Relocation of the USMC from Okinawa to Guam and Associated Activities in Guam	July 2015
Guam, Tinian, FDM	Revision to BO of the MITT Program	February 2016
Guam	BO for the Permanent Stationing of the THAAD System	July 2016

Table 3-2. Active Land Use and Natural Resource Agreements Regarding JRM Sites

JRM Site(s)	*Agreement*	*Date*
NBG Main Base, NMS, MCB Camp Blaz (formerly NBG TS), Andersen AFB	Reinitiation of the 2015 BO for the DON's Relocation of the USMC from Okinawa to Guam and Associated Activities in Guam	July 2017
Andersen AFB	BO for the Brown Tree Snake Control in the Habitat Management Unit, Andersen AFB, Guam	May 2018
MCB Camp Blaz	Amendment to the 2017 BO Relocation of the USMC from Okinawa to Guam and Associated Activities in Guam	October 2018
JRM	Recovery Permit for Green Sea Turtle, Hawksbill Sea Turtle, Mariana Common Moorhen, Micronesian Megapode, the Nightingale Reedwarbler, and 15 Federally-Listed Plant Species	February 2019
MCB Camp Blaz	Clarification of the 2018 BO for the DON's Relocation of the USMC from Okinawa to Guam and Associated Activities in Guam	February 2020
MCB Camp Blaz	BO for the Removal of Ungulates from Haputo Ecological Reserve Area, Marine Corps Base Camp Blaz, Guam	May 2022
Andersen AFB	BO for the Construction of 48 Munition Storage Igloos at Andersen Air Force Base, Guam	June 2020
MCB Camp Blaz	BO for Relay Ground Station-Asia, Marine Corps Base Camp Blaz, Guam	December 2022
MCB Camp Blaz	BO for Firefighter Training Facility Marine Corps Base Camp Blaz, Guam	September 2023
NMFS		
NBG Main Base, NMS, MCB Camp Blaz (formerly NBG TS), Andersen AFB	BO for the DON's Proposed Guam and CNMI Military Relocation	August 2010
NBG Main Base	BO for Sumay Cove Repair and Modernization, NBG	August 2011
JRM-wide	Regional Stranding Investigation Assistance Plan with NMFS	2013
Guam, Tinian, FDM	BO for U.S. Military MITT Activities and Letter of Authorization under MMPA	June 2015
PERMITS ISSUED BY U.S. ARMY CORPS OF ENGINEERS		
NBG Main Base	Final Mitigation Plan for MILCON P-502 Kilo Wharf Extension Project	2008
NBG Main Base	MILCON P-502 Kilo Wharf Extension	2008
MOUS, MOAS, AND COOPERATIVE AGREEMENTS		
NBG Main Base, NMS, MCB Camp Blaz (formerly NBG TS), Andersen AFB	MOU among the GovGuam and the USAF and the DON and the USFWS for the Establishment and Management of the Guam NWR	December 1993

Table 3-2. Active Land Use and Natural Resource Agreements Regarding JRM Sites

JRM Site(s)	*Agreement*	*Date*
NBG Main Base, NMS, MCB Camp Blaz (formerly NBG TS)	Cooperative Agreement between the DON and the USFWS for the Establishment and Management of the Guam NWR, Guam	February 1994
Andersen AFB	Cooperative Agreement between the USAF and the USFWS for the Establishment and Management of the Guam NWR, Guam	March 1994
JRM	MOA between DON, Supporting Component and USAF and USMC, Supported Component(s) for Fully Implementing Base Realignment and Closure 2005 Joint Base Decisions	2009
Guam and CNMI	MOA on BTS control among the DOI, DoD, USDA, DOT, NISC, Government of Guam, State of Hawaii, and the CNMI	2011
Andersen AFB, MCB Camp Blaz (formerly NBG TS)	MOA between DON and USFWS Regarding Conservation of Guam Micronesian Kingfisher (*Todiramphus cinnamominus*) Recovery Habitat in Northern Guam	June 2015
Andersen AFB, MCB Camp Blaz (formerly NBG TS)	Modification to MOA between DON and USFWS: Designation of Alternative Configuration for Guam Micronesian Kingfisher Recovery Habitat in Northern Guam	December 2015
NBG Main Base, NMS, MCB Camp Blaz (formerly NBG TS), Andersen AFB	DON-Guam Preservation Trust Multi-Year Encroachment Protection Agreement	2021
NBG Main Base, NMS, MCB Camp Blaz (formerly NBG TS), Andersen AFB	MOA between DON, USFWS, and USGS Regarding Management of the Ritidian Unit of the Guam National Wildlife Refuge, the U.S. Geological Survey Brown Treesnake Research and Rapid Response Facilities, and Operation of Overlapping Surface Danger Zones.	2015
NBG Main Base, NMS, MCB Camp Blaz (formerly NBG TS), Andersen AFB	MOU for REPI funding in support of a cooperative agreement with the National Fish and Wildlife Foundation to support conservation initiatives of the Guam Department of Agriculture and the USFWS.	October 2020
LEASE OR PERMIT WITH STATE OR OTHER GROUP		
Tinian	Technical Agreement Regarding Use of Land to be Leased by the U.S. in the Northern Mariana Islands	February 1975
Tinian and FDM	Use by the U.S. of FDM Island and a Portion of Tinian Island in the Northern Mariana Islands	January 1978
Tinian	Lease Agreement Made Pursuant to the Covenant to Establish a CNMI in Political Union with the U.S.	January 1983
Tinian	Leaseback Agreement between the CNMI and the U.S. of America made pursuant to the Covenant to Establish the CNMI in Political Union with the U.S. of America	December 1988

Table 3-2. Active Land Use and Natural Resource Agreements Regarding JRM Sites

JRM Site(s)	*Agreement*	*Date*
Tinian	Leaseback and Disposal Agreement between the CNMI and the U.S. made Pursuant to the Covenant to Establish a CNMI in Political Union with the U.S. of America	August 1994
Tinian	Partial Release of Leasehold Interest by and between the CNMI and the U.S.	September 1999
Tinian	Dedication of Tinian Military Retention Area Land for Wildlife Conservation	September 1999
NBG – off-site	Declaration of Deed Restriction for Cetti Bay Parcel No. 275	June 2008
	Conservation and Construction Easement	

Key: AFB = Air Force Base; BO = Biological Opinion; BTS = Brown Tree Snake; CNMI = Commonwealth of the Northern Mariana Islands; DoD = Department of Defense; DOI = Department of the Interior; DON = U.S. Department of the Navy; DOT = Department of Transportation; FDM = Farallon de Medinilla; GovGuam = Government of Guam; ISR = Intelligence/Surveillance/Reconnaissance; JGPO = Joint Guam Program Office; JRM = Joint Region Marianas; MCB = Marine Corps Base; MILCON = Military Construction; MITT = Mariana Islands Training and Testing; MMPA = Marine Mammal Protection Act; MOA = Memorandum of Agreement; MOU = Memorandum of Understanding; NBG = Naval Base Guam; NISC = National Invasive Species Council; NMFS = National Marine Fisheries Service; NMS = Naval Munitions Site; NWR = National Wildlife Refuge; REPI = Readiness and Environmental Protection Integration Program; THAAD = Terminal High Altitude Area Defense; TS = Telecommunications Site; U.S. = United States; USAF = U.S. Air Force; USDA = U.S. Department of Agriculture; USFWS = U.S. Fish and Wildlife Service; USMC = U.S. Marine Corps.

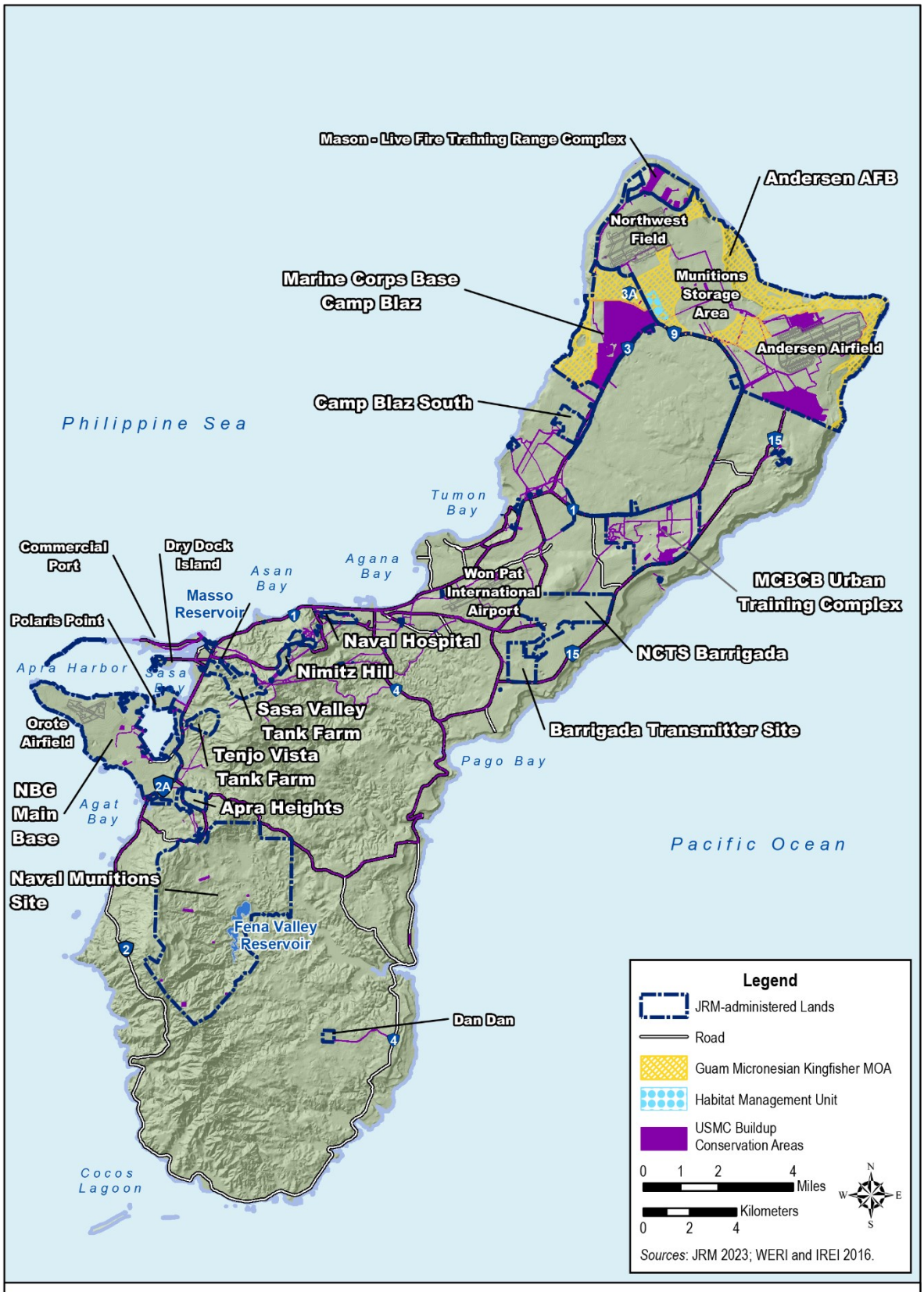


Figure 3-2
Mitigation Areas in Guam

The Office of the Under Secretary of Defense (OUSD) Installations and Environment (I&E) has developed several memoranda concerning INRMP preparation, including *Best Practices for Integrated Natural Resources Management (INRMP) Implementation* (OUSD I&E 2005). In addition, DoD developed a handbook to assist resource managers with developing and implementing INRMPs: *Conserving Biodiversity on Military Lands: A Guide for Natural Resources Managers* (Benton et al. 2008). The DON issued its implementing guidance on Sikes Act Improvement Act and INRMP requirements in OPNAVINST 5090.1 (OPNAVINST 2021). The JRM INRMP is consistent with and was developed in accordance with these guidance memoranda.

It is the policy of DON to act responsibly and in the public interest to restore, improve, preserve, and properly use natural resources. DON is charged with complying with federal laws, regulations, and policies, and showing a conscientious and active concern for the inherent value of natural resources in all DON plans, actions, and programs. DON's environmental strategy is to protect the environment and conserve natural resources for present and future generations through compliance, conservation, pollution prevention, and stewardship. DON must ensure their operations comply with federal, local, and host nation environmental requirements, which include endangered species and wetlands. Conservation is achieved through protecting and enhancing the life-sustaining quality of the land and waterways under DON protection. DON manages, conserves, and rehabilitates the land and natural resources such as fish, wildlife, forests, and submerged lands. Additionally, DON strives to prevent or reduce pollution at its source through increased efficiency in the use of raw materials, energy, water, or other resources.

3.4.1 Natural Resources Consultation Requirements

A number of federal laws, including the ESA, MBTA, MSFMCA, NEPA, and CWA, require consultation with a designated federal regulatory agency such as U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), or the U.S. Army Corps of Engineers (USACE) if a federal action has the potential to adversely impact a regulated resource.

3.4.1.1 Endangered Species Act

The ESA of 1973 aims to conserve and protect endangered and threatened species and the habitats on which they depend. It is administered by the USFWS and the NMFS. USFWS has primary responsibility for terrestrial and freshwater organisms, while NMFS has the responsibilities for marine wildlife such as whales and anadromous fish such as salmon.

When a species is listed as threatened or endangered, it is protected from unauthorized "take," being traded or sold. Section 3(18) of the ESA defines "take" to include "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." The law also protects against interfering in vital breeding and behavioral activities of threatened and endangered species. When a species is proposed for listing as endangered or threatened, USFWS and/or NMFS must consider whether there are areas of habitat believed to be essential to the species' conservation, in which case it may be proposed for designation as critical habitat. To qualify as potential critical habitat, the area must be within the geographical area occupied by the species at the time it is listed, the biological features of the area must be essential to the conservation of the species, and the area may require special management considerations or protection. Areas outside the geographical area occupied by the species at the time it is listed may be designated as critical habitat if that area is essential for the conservation of the species. Critical habitat may not be designated on any areas owned, controlled, or designated for use by DoD that are subject to an INRMP prepared under section 101 of the Sikes Act, if the Secretary determines in writing that such plan provides a benefit to the species for which critical habitat is proposed for designation. The ESA further requires each agency to use the best scientific and commercial data available. No terrestrial or marine

critical habitat is designated on lands or submerged lands owned, leased, or otherwise managed by DoD in Guam, Tinian, or FDM.

The U.S. Navy's guidance for federal ESA-listed threatened and endangered species is found in OPNAV M-5090.1 (OPNAV M 2021). Specifically, the U.S. Navy shall consult with USFWS and/or NMFS when any action authorized, funded, or to be carried out by the U.S. Navy may affect any federal ESA-listed threatened or endangered species or primary constituent elements of designated critical habitat. Some species (e.g., sea turtles, anadromous fishes) are jointly managed by both USFWS and NMFS, so it is important to identify the life stage of the species potentially affected by a proposed action, as this will determine the agency with which to consult.

If a proposed action may affect federal ESA-listed species or designated critical habitat, the action proponent must request ESA section 7 consultations with USFWS and/or NMFS per reference (40 Code of Federal Regulations [CFR] 1700). There is no statutory obligation to consult with USFWS and/or NMFS if a proposed action does not affect federal ESA-listed species or designated critical habitat.

The trigger for conferences for species proposed for listing is a potential jeopardy situation, and the trigger for conferences for proposed designated critical habitat is a potential destruction or adverse modification. However, it is unlikely that the U.S. Navy's action proponents have all the information necessary to make those determinations. Instead, it is the U.S. Navy's policy to request conferences when the action proponent determines that species proposed for listing, or critical habitat proposed for designation, may be affected by the proposed action. This proactive step will also allow any conference opinion issued by USFWS and/or NMFS to serve as a BO, without the necessity to initiate consultation, should the species become listed or the critical habitat become designated.

Consultations and conferences shall be conducted by U.S. Navy staff (i.e., both natural resources and action proponent subject matter experts [SMEs]) representing the Installation Commanding Officer or other class I property authority, or the appropriate echelon 2 authority. OPNAV (N41) must approve exceptions in advance. Action proponents shall coordinate consultation requests of national or regional scope with OPNAV (N41) via the chain of command. A draft NEPA analysis may be used to make the initial determination as to whether a proposed action may affect federal ESA-listed species.

Section 7 of the ESA directs all federal agencies to work to conserve endangered and threatened species and to use their authorities to further the purposes of the ESA. Section 7 of the ESA is the mechanism by which federal agencies ensure the actions they take, including those they fund or authorize, do not jeopardize the existence of any federal ESA-listed species. There are two types of section 7 ESA consultations: informal and formal.

Informal Consultation

An informal consultation is conducted when an action may affect, but is not likely to adversely affect a federal ESA-listed species (i.e., all effects are beneficial, insignificant, or discountable). An informal consultation requires written concurrence from the USFWS and/or NMFS with DON's determination of the "not likely to adversely affect" assessment. A flow chart illustrating the informal section 7 ESA consultation process is presented in Figure 3-3.

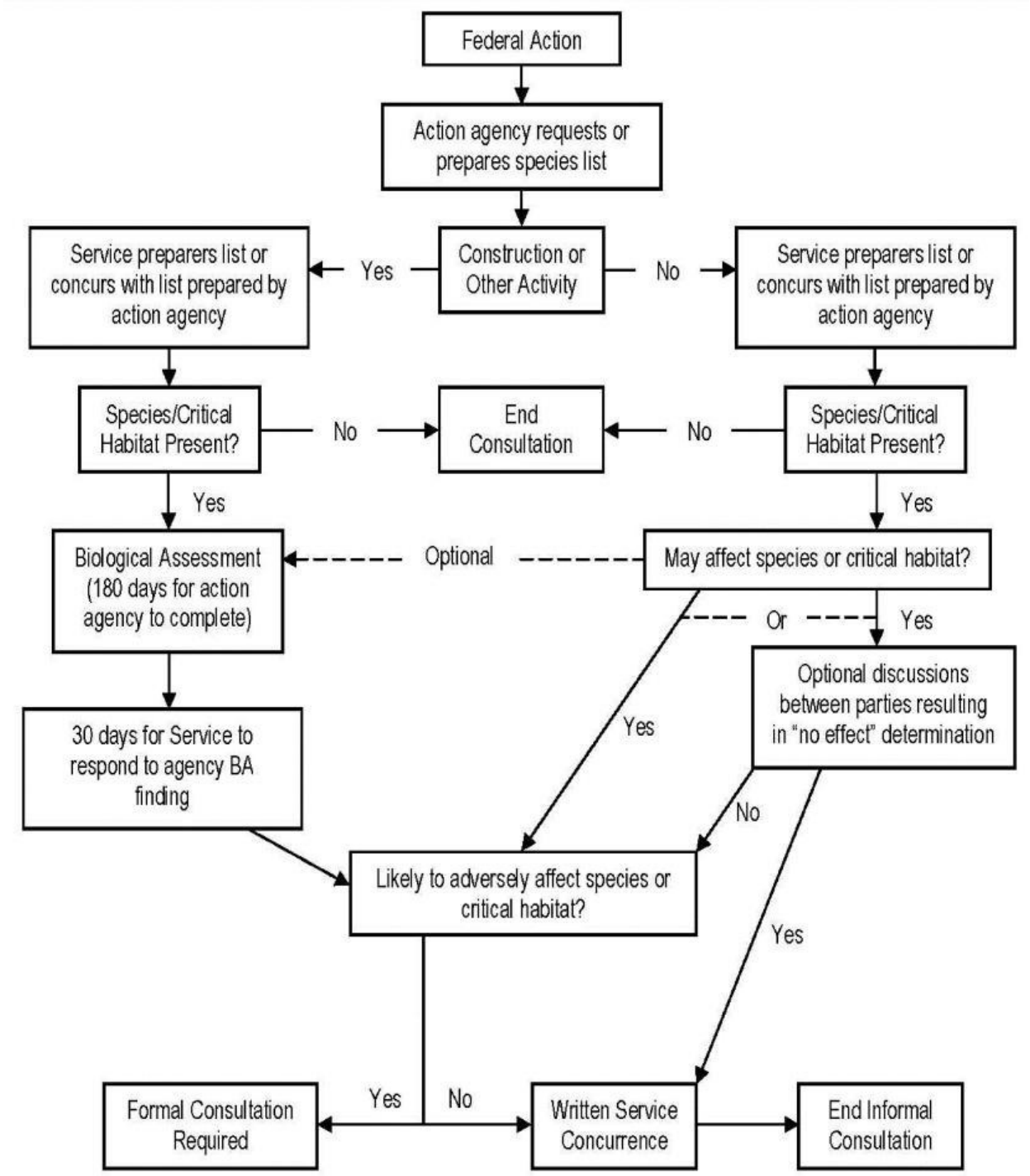


Figure 3-3. Informal ESA Consultation Process, Adapted from USFWS and NMFS (1998)

Formal Consultation

A formal consultation is necessary when a proposed action may affect and is likely to adversely affect a federal ESA-listed species. For DON to proceed legally with the proposed action, the USFWS or NMFS must issue a BO and incidental take statement. ESA section 7 requires minimization of the level of take. Conservation measures are actions or projects that are included as part of the proposed action that serve to reduce the level or amount of adverse impacts to listed species or critical habitat without compromising mission objectives. The USFWS or NMFS may also specify reasonable and prudent measures and their implementing terms and conditions. Reasonable and prudent measures and the implementing terms and conditions are actions necessary to minimize the impacts of incidental take that is anticipated to result from implementing an action that USFWS or NMFS regarded as not likely to jeopardize the species or adversely modify designated critical habitat. Additionally, reasonable and prudent alternatives are alternative methods of action implementation, offered in a BO reaching a jeopardy or adverse modification conclusion, which would avoid the likelihood of jeopardy to the species or adverse modification of critical habitat. Reasonable and prudent alternatives must not violate the Minor Change Rule (USFWS 2015). Conditions are conveyed to the action agency in the form of an incidental take statement. They are non-discretionary and must be undertaken by the agency so that they become binding conditions of any grant or permit issued to an applicant for the exemption in section 7 to apply. A flow chart illustrating the formal section 7 ESA consultation process is presented in Figure 3-4.

Formal ESA consultations require DON to prepare a Biological Assessment/Biological Evaluation (BA/BE). The BA/BE should be a standalone document that includes all requirements of 50 CFR 402.14(c). The BA/BE should include a thorough analysis describing the effects of the action and whether those effects are likely to adversely affect a listed species or designated critical habitat. The length of time to prepare a BA/BE may vary depending on a number of factors such as project complexity, number of listed species, and available information. Natural Resource managers will ensure that BA/BE submittals are complete and provide sufficient information to support immediate initiation of consultation. Once USFWS or NMFS accepts a BA/BE as complete, the consultation timeline begins, and the agencies are to provide their Final Biological Opinion within 135 days.

If the USFWS or NMFS determine that the BA/BE is not complete, or request additional information, the consultation clock may restart. For additional detail on this topic, refer to the *Endangered Species Consultation Handbook: Procedures for Conducting Consultations and Conference Activities under section 7 of the Endangered Species Act* (USFWS and NMFS 1998).

Prior ESA section 7 consultations between the DON and USFWS Region 1 addressing DON actions in the Pacific theatre had been challenging and extended beyond the statutory 135-day timeframe for completing consultation. Therefore, a Consultation Agreement was established between the two parties in March 2019 to facilitate timely, effective, and efficient coordination of legal requirements of section 7 ESA and to support the DON's U.S. Code title 10 requirements in the Pacific Region (DON 2019). The agreement establishes a formal procedure for coordination, defines the information required to initiate a section 7 consultation, establishes timelines for correspondence, consultation, and coordination efforts supporting the section 7 consultation process addressing DON actions, confirms procedures for timeline extensions, and establishes a process to resolve conflicts between the two parties. The agreement expires in December 2028 unless an extension is agreed upon by both USFWS and DON.

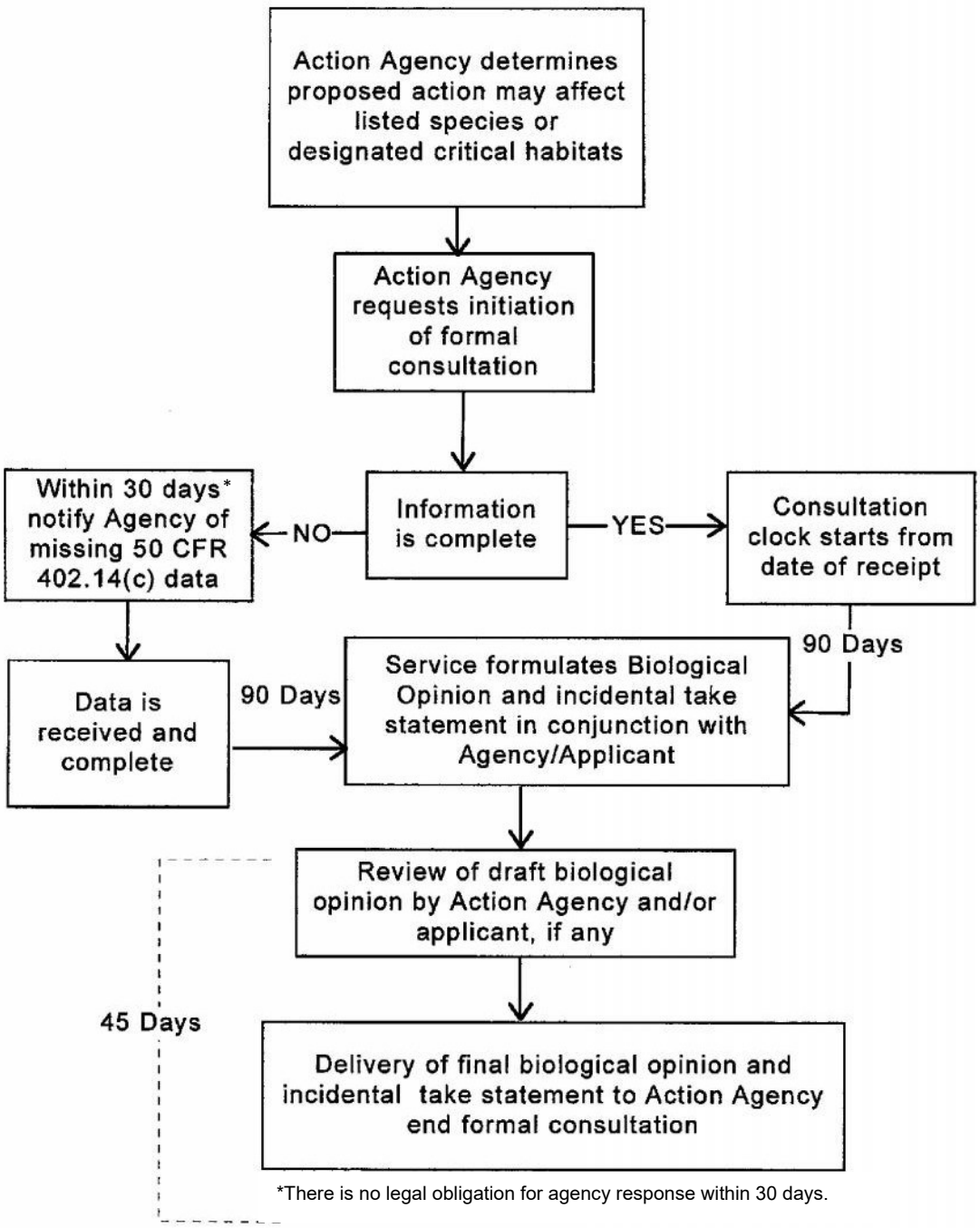


Figure 3-4. Formal ESA Consultation Process, Adapted from USFWS and NMFS (1998)

3.4.1.2 Migratory Bird Treaty Act and Executive Order 13186

The MBTA of 1918 implements four bilateral treaties between the U.S. and Canada, Japan, Mexico, and the former Soviet Union (now Russia) for the protection of migratory birds. Under the Act, pursuing, hunting, taking, capturing, killing, and/or possessing (or attempting to do so) migratory birds, their eggs, parts, and nests, are prohibited unless permitted by regulations (e.g., salvage permit, depredation permit, issued by the USFWS). An exemption to the MBTA that allows incidental take of migratory birds by DoD during military readiness activities, known as the DoD Military Readiness Rule, was finalized in February 2007 (USFWS 2007). As directed by Section 315 of the 2003 National Defense Authorization Act, this rule authorizes such take, with limitations, that result from military readiness activities. If DoD determines that a proposed or an ongoing military readiness activity might result in a significant adverse effect on a population of a migratory bird species, they must confer and cooperate with the USFWS to develop appropriate and reasonable conservation measures to minimize or mitigate identified significant adverse effects. MBTA-listed species known to occur in Guam, Tinian, and FDM are listed in Appendix E and addressed specifically in Chapters 4-12.



An adult male Pacific golden plover (*Pluvialis fulva*) in breeding plumage. Pacific golden plovers breed in the Arctic tundra and migrate south to Australasia and the Pacific Islands, including the Mariana Islands. (*Photo*: Audubon Society [No copyright infringement is intended])

DoD installations must ensure that INRMPs and NEPA analyses adequately address migratory bird management and the potential impacts of proposed military activities—readiness and nonreadiness related alike—on migratory birds. Section 315 of the 2003 National Defense Authorization Act and the Military Readiness Rule (50 CFR Part 21) authorizes, with certain limitations, the incidental take of migratory birds during military readiness activities. Nonetheless, the Armed Forces must give appropriate consideration to protecting migratory birds when planning and executing military readiness activities; however, implementing protections must not diminish the effectiveness of those activities. This requirement pertains to all military readiness activities, not just those that may result in a significant adverse effect on a population of a migratory bird species (see Preamble to Final Rule on the Take of Migratory Birds by the Armed Forces, 72 Federal Register 8931-8950 (February 28, 2007) (USFWS 2007). OPNAV Manual 5090.1 (2021) states: Military Readiness Rule Part 21.15 authorizes incidental take of migratory birds for military readiness activities provided the U.S. Navy action proponent confers with USFWS to develop and implement appropriate conservation measures to minimize or mitigate negative effects of the proposed action if the action will have a significant negative effect on the sustainability of a population of a migratory bird species. Potential impacts to migratory bird populations and MBTA compliance shall be addressed in NEPA analysis using information from the appropriate INRMP where applicable, and the best scientific data available.

EO 13186 outlines responsibilities of federal agencies to protect migratory birds. The 2014 MOU between the DoD and USFWS to *Promote the Conservation of Migratory Birds* includes specific measures to promote the conservation of migratory bird populations while sustaining the use of military managed lands and airspace for testing, training, and operations. These measures include, but are not limited to, developing policies and procedures for facilities designs that integrate bird safe building glass, strategic siting to avoid important habitats, maximizing the use of native landscaping to promote migratory bird habitat (except in areas subject to Bird Aircraft Strike Hazards [BASH]), turning off interior building lighting at night, and

follow best practices in coordination with USFWS when planning construction of new utility and energy systems and associated infrastructure.

3.4.1.3 Magnuson-Stevens Fishery Conservation and Management Act

The MSFCMA is the primary law governing marine fisheries management in U.S. federal waters. Its purpose is to prevent overfishing, rebuild overfished stocks, ensure conservation, facilitate long-term protection of Essential Fish Habitat (EFH), and to realize the full potential of U.S. fishery resources. Authority to implement the MSFCMA is given to the Secretary of Commerce.

The MSFCMA sets mandates for NMFS, regional fishery management councils, and federal action agencies to identify, delineate, and protect important marine and anadromous fish habitat as EFH in fishery management plans or fishery management plan amendments. The EFH is the legal tool that NMFS uses to manage marine habitat through collaboration with regional fishery management councils and federal action agencies to ensure that federally managed fisheries have a healthy future.



Spiny lobster (*Panulirus penicillatus*) are listed as a CNMI species of Greatest Conservation Need, but are also part of a managed fishery.
(*Photo*: R. Whitton)

The MSFCMA requires federal agencies to consult with NMFS on activities that could adversely affect EFH or when NMFS independently learns of a federal activity that could adversely affect EFH. The MSFCMA defines an adverse effect as "any impact which reduces quality and/or quantity of EFH [and] may include direct (e.g., contamination or physical disruption), indirect (e.g., loss of prey, reduction in species' fecundity), site-specific or habitat wide impacts, including individual, cumulative, or synergistic consequences of actions" (50 CFR 600.810). OPNAV M-5090.1 (2021) describes DON policy on EFH assessments and consultations and clarifies the MSFCMA consultation requirements with NMFS. Naval Base Guam (NBG) Instruction 5090.2A, *Saltwater Fishing* describes NBG's installation-specific instructions.

All of the water column and benthic nearshore resources and submerged lands under the management responsibility of JRM are designated as EFH under the MSFCMA. EFH in Guam, Tinian, and FDM may include streams, estuaries, and offshore subtidal habitats that may be important for marine and anadromous fish species. Seagrass is also designated as an EFH pursuant to the MSFCMA.

3.4.1.4 Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) established a federal responsibility to protect and manage marine mammals. The MMPA prohibits, with certain exceptions, the "take" of marine mammals in U.S. waters and by U.S. citizens in international waters, and the importation of marine mammals and marine mammal products into the U.S. "Take" of marine mammals is defined as the harassment, hunting, capturing or killing, or the attempt of such actions. The USFWS is responsible for the following marine mammals: sea otters, walrus, polar bear, manatees, and dugong. Those mammals that are truly marine inhabitants, cetaceans and pinnipeds, other than walrus, are the responsibility of NMFS.

OPNAVINST 5090.1 (2021) and DoDI 4715.03 (2011) require that activities affecting marine species and U.S. Navy-administered submerged lands be addressed in the INRMP.

Unlike the ESA, there is no consultation requirement under the MMPA. If take (lethal and non-lethal) is reasonably foreseeable, DON must obtain a Letter of Authorization (LOA; for potential lethal take) or an

Incidental Harassment Authorization (IHA; no potential for lethal take) from NMFS. Obtaining a LOA takes 12-18 months, while an IHA can take as little as 6-9 months. An IHA may be issued if, (a) there is no potential for serious injury or mortality; or (b) the potential for serious injury or mortality can be negated through mitigation requirements.

3.4.1.5 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (FWCA) ensures that water resources development programs must consider wildlife conservation. Under this Act, federal agencies proposing actions that result in the control or modification of a natural stream or body of water, including issuance of permits, must consult with the USFWS, NMFS, and the affected state or territory's fish and wildlife management agency. Typical actions that would fall under the jurisdiction of the FWCA include: discharges of pollutants, including industrial, mining, and municipal wastes or dredged and fill material into a body of water or wetlands; and projects involving construction of dams, levees, impoundments, stream relocation, and water-diversion structures. Consultation is to be undertaken for the purpose of "preventing loss of and damage to wildlife resources." The FWCA provides a basic procedural framework for the orderly consideration of fish and wildlife conservation measures to be incorporated into federal and federally-permitted or licensed water development projects.

3.4.1.6 National Environmental Policy Act Compliance

NEPA requires an environmental analysis of major federal actions, including actions that occur with federal funding or on federal lands. NEPA requires the evaluation of the environmental effects of proposed land use, development, and military training activities. The Council on Environmental Quality (CEQ) defines an INRMP as a major federal action requiring NEPA analysis. As a result, the DON Office of General Counsel has determined that Sikes Act requirements for INRMP implementation necessitates the preparation of NEPA documentation prior to INRMP approval. It is expected that annual updates and revisions would be covered under the original NEPA documentation unless there has been a major change in installation mission or program scope. The NEPA process requires coordination with appropriate federal and state agencies and the general public. The public review process scopes or identifies significant issues to develop and evaluate alternatives. The preparation of an Environmental Impact Statement (EIS) occurs only if significant impacts are identified. If the Environmental Assessment (EA) finds "no significant impacts," the DON would complete the preparation of a formal Finding of No Significant Impact and make it available for public review.

The Memorandum from Chief of Naval Operations (N41) dated 10 April 2006 and OPNAVINST 5090.1 provide additional guidance on NEPA compliance for the development of INRMPs. DoDI 4715.03 (2011) states that installations should offer members of the public an opportunity to comment on an INRMP revision, as appropriate (although not expressly required by the Sikes Act). In addition, if the proposed revisions reflect changes in the natural resources management projects described in the existing INRMP, NEPA review must, in most cases, be performed before the new INRMP may be adopted. Installations should afford the appropriate USFWS and state or territorial fish and wildlife management offices the opportunity to review all public comments received on any revised INRMP.

JRM uses the NEPA planning processes and documentation to guide specific management projects, and document choices and enforce mitigation measures proposed in those NEPA documents. An EA has been developed in association with this INRMP to comply with CEQ and NEPA requirements. The EA evaluated the INRMP to ensure that there will be no negative environmental or social consequences for implementing the plan and its associated management projects. The full EA can be found in Appendix H.

3.4.1.7 Clean Water Act Section 404/401 Permitting

Under Section 404 of the CWA, discharge of dredge and fill material into waters of the U.S., including wetlands, is prohibited unless a permit is issued by the USACE. These areas also require a Section 401 water quality permit for certain discharges. In addition, wetlands (e.g., salt marsh) and vegetated shallows (e.g., eelgrass and surf grass stands) are considered Special Aquatic Sites under Section 404 of the CWA; therefore, any type of in-water construction that affects substrate or causes discharge of dredge or fill must be permitted and impacts mitigated. Some water bodies are specifically exempted from regulation, such as irrigation ditches or drainage ditches excavated in uplands.

3.4.1.8 Coastal Zone Management Act

The National Coastal Zone Management Program is a voluntary partnership between the federal government and U.S. coastal states and territories and Great Lakes states authorized by the CZMA to address national coastal issues. Federal consistency is a unique aspect of coastal zone management under the Act that ensures that federal actions with reasonably foreseeable effects on coastal uses and resources must be consistent with the enforceable policies of a state's or territory's NOAA-approved coastal management program.

The entire island of Guam is classified as a coastal zone under the CZMA, excluding lands solely under federal jurisdiction. The Guam Coastal Management Program was established in 1979 through a Cooperative Agreement between NOAA and the Bureau of Planning Office of the Governor. According to the program's website (Guam Coastal Management Program 2018), the program's authorities were provided for in the CZMA, as well as by the regulatory and enforcement authorities of a network of local agencies, including the Department of Land Management, Public Works, Parks and Recreation, Agriculture, and Guam EPA. The Program and its networking agencies are linked by Guam's EO 78-37 on land use, which established Guam's policies for development and resource protection.

The entire land and water area of the 14 islands that make up the CNMI is included within the coastal zone under the CZMA. The NOAA approved of the Northern Mariana Islands Coastal Management Program in 1980 (NOAA Office for Coastal Management 2019). The program is currently overseen by the CNMI's Division of Coastal Resources Management (DCRM). According to the program's website, DCRM was established in February 1983 within the Office of the Governor to promote the conservation of and sustainable development around the CNMI's coastal resources (DCRM 2019). The DCRM has since been moved to fall under the authority of the Bureau of Environmental and Coastal Quality (BECQ) by the Governor's EO 2013-24.

3.4.1.9 Guam Regulations and Guam Federal Regulation Implementation

Guam Soil Erosion and Sedimentation Control Regulations/Permits

Clearing, grading, and stockpiling permits are issued directly by Guam Environmental Protection Agency (Guam EPA) for federal activities while the Guam Department of Public Works (GDPW) issues the same permit for public and private development as part of its building permit system. For most clearing and/or grading permits, there must be an accompanying Erosion Control Plan to specify enforceable measures to maintain water quality in the affected surface water and/or groundwater resource. The regulations also require use of the 2006 CNMI Guam Stormwater Management Manual as a design reference (for facilities and roadways) and include stormwater performance standards that are intended to complement federal requirements.

Guam Water Quality Standards

The Guam Water Quality Standards aim to conserve, protect, maintain, and improve the quality of Guam's waters.

National Pollutant Discharge Elimination System (Guam Implementation)

National Pollutant Discharge Elimination System (NPDES) is a federal permit for all stormwater and other point source pollution discharges. Guam EPA assists in the administration of these permits, reviews and certifies permits for CWA Section 401 Water Quality Certification, and ensures compliance with all local regulations and policies and in accordance with the Guam Water Quality Standards.

Pollution Discharge and Operating Permit

For discharges similar to those covered by the NPDES permit, Guam EPA may require a Government of Guam (GovGuam) Pollution Discharge Permit. This permit may be issued for any number of liquid, gaseous, solid, or thermal discharges to territorial waters that fall below the minimum criteria defined in the federal CWA.

Test Boring and Dewatering Permits

Individuals conducting soil test boring and measurements activities may be required to obtain a Guam EPA Test Boring Permit. Test boring activities include drilling and excavations deeper than 6 feet (2 meters) deep for soil and structural engineering analysis work. In addition, if the water table is encountered during excavation work for building foundations and similar construction activities, a Dewatering Permit may be required to control and treat water pumped from the excavation prior to final discharge. Dewatering permits may apply to dredging operations as well.

Clean Water Act Section 401 Water Quality Certification (Guam Implementation)

CWA Section 401 Water Quality Certification issuance identifies that construction or operation of a proposed project or facility would be conducted in a manner consistent with Guam Water Quality Standards. As part of a Water Quality Certification, an Environmental Protection Plan is required. Environmental Protection Plans describe the methods, practices, and equipment to be used on-site; expected or anticipated environmental problems during and after construction; and the methods, practices, and equipment that may be used to avoid, mitigate, or control potential adverse effects on the environment. Environmental Protection Plans are specifically identified in 22 Guam Administrative Rule, Division II, Chapter 10, Section 10103.C.5(d). For work occurring within or affecting surface waters, a USACE permit applicant must prepare a Water Quality Monitoring Plan that describes measures to maintain Guam Water Quality Standards. These measures typically include procedures for monitoring, corrective actions, reporting, and recordkeeping. The local requirement for a Water Quality Monitoring Plan is usually incorporated by the USACE or Guam EPA in their permit programs regulating activities affecting surface water or wetlands.

3.4.1.10 Guam Landscaping Guidelines

The U.S. Navy developed the 2011 Final Guam Landscaping Guidelines as a tool to promote beneficial landscaping practices and reduce poor planting practices in urban landscapes. The guide provides information in Guam's unique environment and flora to aid in the development of successful landscape plans that adhere to all policies, laws, regulations, and EOs. The guide provides landscape design guidelines specific to appropriate plant selection and establishment, and contains an approved native and non-native plant list as appendices to assist with planning landscape projects for all U.S. Navy projects. Landscape

architecture standards (not for species selection) for proven construction systems appropriate for Guam's environment, which is subject to a salty atmosphere, high wind velocity, and strong seismic forces, are found in Installation Appearance Plans.

3.4.1.11 Commonwealth of the Northern Mariana Islands Regulations

Authority of the CNMI

The CNMI has the authority to issue any necessary order to enforce regulations designed to protect the natural resources found within and under the jurisdiction of the territory. The order may require that any person violating the regulation or term cease and desist from such violation immediately or within a stated period of time, and may require that the person take any mitigating measures as may be necessary to reverse or reduce any significant adverse effect of the violation. The CNMI may also institute a civil action in the Commonwealth Superior Court for a temporary restraining order, injunction, or other appropriate remedy to enforce any regulation.

Federal Aid in Wildlife Restoration Act and the Fish Restoration and Management Projects Act (CNMI Implementation)

Through the proper channels, the CNMI may enter into Cooperative Agreements with any governmental, regional, or private entity to further regulate fish and wildlife within the CNMI. This includes the ability to develop and implement plans, projects, and conservation programs relating to fish, game, nongame fish and wildlife, marine mammals, and threatened and endangered species.

Title 2 Section 5103: Conservation Officers

CNMI Department of Fish and Wildlife (DFW) has the authority to appoint Conservation Officers to enforce CNMI laws and regulations issued under Title 2. Conservation Officers are deemed law enforcement officers and have the same powers of law enforcement officers to carry arms and to make arrests for any violations of regulation issued under Title 2.

Title 2 Section 5105 of the CNMI Commonwealth Code: Interagency Cooperation

CNMI requires consultation with the director of the CNMI Department of Lands and Natural Resources (DLNR) for any actions that adversely affect fish, game, or endangered or threatened species, including destruction of any critical habitat.

Title 2 Section 5108: Endangered and Threatened Species

After due consideration for the status of a species and proper consultation with appropriate Commonwealth, federal, regional, and foreign officials, as well as a public hearing on the proposed designation and other regulations relating to the species has taken place, CNMI DLNR has the authority to designate species as threatened or endangered as well as designate any portion of said species' range as critical habitat in order to protect said species from extinction.

Title 85 Section 30.1-100: Threatened and Endangered Species

According to Title 85 of the CNMI Administrative Code, species listed as threatened or endangered by the CNMI may not be harvested, captured, harassed, or propagated except under the terms of a special permit issued by the director for scientific purposes, or for propagation in captivity for the purpose of preservation. Persons in violation of these regulations, intentionally or not, are subject to penalties.

Title 85 Section 30.1-200: Licenses

A person may not take regulated fish or game without an issued license from CNMI DFW. Unprotected wildlife may be taken year-round without a hunting license. A license is required for the taking of any of the following fish and game: Sambar deer (*Cervus unicolor*), Island collared dove (*Streptopelia bitorquata*), coral species in the Corallim genus as well as hermatypic and other hard corals, soft corals and stony hydrozoans, terrestrial land crabs including *Discoplax hirtipes* and *Cardisoma carnifex*, coconut crab (*Birgus latro*), and any species of fish or marine invertebrates taken by a method or for a purpose regulated by Title 85, Section 30.1-400.

Persons may obtain a scientific research license through CNMI DFW to gain access to research data acquired in the CNMI for use in resource management.

Title 85 Section 30.1-330: Wildlife Conservation Areas

To protect important wildlife populations and their habitat, the director may acquire and designate land and/or aquatic habitats or easements as wildlife sanctuaries in accordance with 2 Commonwealth Code Section 5104(a)(5).

CNMI Water Quality Standards

In 2013, the CNMI Office of the Governor merged the Division of Environmental Quality and the Coastal Resources Management Office into the BECQ to increase efficiency in overlapping efforts and goals in the monitoring and remediation of marine waters and freshwater stream systems. Under the newly established BECQ, the Water Quality Surveillance and Non-Point Source Program was also created in 2013 as a response to EPA's growing water quality program requirements.

The Water Quality Surveillance and Non-Point Source Program monitors and evaluates the health of marine waters and freshwater streams through regular sampling and analysis, and ground-truthed assessments. Waters that fail to meet the CNMI water quality microbial standards are flagged in public beach advisories, and waters that are frequently flagged or fail to meet other water quality standards are listed as impaired. Impaired waters are further surveyed to identify and map the source of pollutants. Water quality results are included in reports as required by the CWA and used to create Conservation Action Plans to address the sources of pollution using best management practices, engage and inform individuals living within the watershed, and restore the quality of the waters to appropriate levels.

3.5 INTEGRATION WITH OTHER JOINT REGION MARIANAS SITE PLANS AND REGIONAL PROGRAMS

JRM could be affected both internally and externally by growth in the JRM region. Internal factors include meeting the needs of existing mission partners, AT/FP standards, and a potential increase in requests from federal agencies for real property assets in terms of facilities and buildable land at JRM sites.

Outside factors expected to drive growth and development immediately adjacent to JRM include a reduction in available land in the region, a continuing increase in population growth, and development in the coming decades. Consequently, the impacts of planning and future development in Guam and Tinian are inextricably linked.

The recognition of internal and external factors demands that natural resources management on JRM sites be integrated with other disciplines, programs, and planning beyond the scope of traditional fish and wildlife management. On a day-to-day basis, INRMP goals, objectives, projects, strategies, and actions are

integrated with other installation plans to sustain mission-oriented activities while managing the natural resources.

The following JRM site plans were reviewed to highlight key interrelationships, and recommendations contained within these plans were used in the development of this INRMP. Note that the INRMP is not intended to compile detailed information on each plan and its contents.

3.5.1 Management Plans for Joint Region Marianas-administered and Leased Lands

- Management Plan for the Haputo Ecological Reserve Area (ERA): January 1986
- Guam Submerged Lands Management Plan. U.S. Joint Region Marianas: September 2007
- 36th Wing Bird Aircraft Strike Hazard Plan, Andersen AFB, Guam: March 1, 2008
- Final Mariana Fruit Bat (*Pteropus mariannus mariannus*) Management Plan for Andersen AFB, Guam: August 2008
- Final INRMP and EA for Andersen AFB, Guam: July 2009
- Interim Final INRMP, Plan Years 2009–2014. Navy Base Guam: 2009
- Update of INRMPs for Navy Leased Lands on Tinian and FDM, Plan Years 2010–2015: May 2010
- Orote Peninsula ERA General Management Plan: August 2010
- Haputo ERA General Management Plan: August 2010
- Draft Adaptive Management Plan, Andersen AFB, Guam: February 2011
- JRM NBG Ungulate Management Plan: December 2013
- JRM Andersen AFB Ungulate Management Plan: December 2013
- MOA, and associated modification, between the DON and USFWS Regarding Conservation of Guam Micronesian Kingfisher Recovery Habitat in Northern Guam: June and December 2015
- Integrated Cultural Resources Management Plan, NBG: May 2015
- Integrated Cultural Resources Management Plan, Andersen AFB: May 2015
- Integrated Cultural Resources Management Plan, Tinian and FDM, CNMI: May 2015
- Navy Bird and Animal Aircraft Strike Hazard Program: August 2017
- U.S. Air Force Mishap Prevention Program (Air Force Instruction [AFI] 91-202): May 25, 2017
- Sea Turtle (*Chelonia mydas*) Management Plan for Andersen AFB, Guam: January 2023
- JRM Marine Invasive Species Management Plan: October 2023

3.5.2 Regional Biosecurity Plan for Micronesia and Hawai‘i

To address pathways and encourage a more holistic approach to managing invasive species, the DON funded the development of a Regional Biosecurity Plan (RBP) for Micronesia and Hawai‘i (formerly referred to as the Micronesia Biosecurity Plan) (DON 2015c).

The Guam Marine Biosecurity Action Plan (Miller 2014) represents a parallel process, integrated with the RBP but confined to Guam. Individual activities for various species will continue under the RBP, but the DON and others agree it is more efficient to manage pathways and prescribe corrective measures for a suite of species, which will be monitored at discrete control points over time. The RBP provides stakeholders in Micronesia and Hawai‘i with a platform for coordination and integration of interagency invasive species management efforts such as control, interdiction, eradication, and research.



The Machinist, known locally as "big blue," is a floating dry dock moored at the Ship Repair Facility. Unlike most naval ships, its hull is not cleaned and it was intensively examined for non-native species when it arrived from Hawai‘i in 1999.
(*Photo*: M. Lybolt)

EO 13751, *Safeguarding the Nation from the Impacts of Invasive Species*, defined an invasive species, with regard to a particular ecosystem, as "a non-native organism whose introduction causes or is likely to cause economic or environmental harm, or harm to human, animal, or plant health." Similarly, the National Invasive Species Act (16 USC 4701 et seq.), defined aquatic nuisance species as a nonindigenous species that "threatens the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural or recreational activities dependent on such waters." Invasive species can be plants, animals, and other organisms (e.g., microbes). A non-native species or alien species is further defined as, with respect to a particular ecosystem, "an organism, including its seeds, eggs, spores, or other biological material capable of propagating that species, that occurs outside of its natural range." Although an invasive species is by definition non-native or nonindigenous, not all non-native species are invasive (e.g., the violet demoiselle [*Neopomacentrus violascens*]). The term nuisance is no longer used interchangeably with nonindigenous or invasive marine species. A *nuisance marine species* is native, but occasionally exhibits blooms or outbreaks or other undesirable characteristics (e.g., blooms of the native angel hair algae [*Chaetomorpha* spp.]). The RBP also explains the inconvenient realities of these definitions, and the difficulties of classifying a species as "native" or the subjective distinction between non-native and invasive.

3.5.3 Guam National Wildlife Refuge Comprehensive Conservation Plan

The Guam National Wildlife Refuge (NWR) was established in 1993 by an MOU with the USFWS, DON, U.S. Air Force (USAF), and GovGuam (GovGuam et al. 1993). Cooperative Agreements were signed in 1994 to establish the Overlay Refuge and define the management, administrative roles, and responsibilities (DON and USFWS 1994; USAF and USFWS 1994). The 1994 Cooperative Agreements provide a commitment by the DON, USAF, and USFWS for a coordinated program centered on the protection of threatened and endangered species and other native flora and fauna, maintenance of native ecosystems, and the conservation of native biological diversity in cooperation with Guam Division of Aquatic and Wildlife Resources (Guam DAWR), recognizing that the primary purpose of lands within the Overlay Refuge is to support the national defense missions of the DON and USAF. Excess military land at Ritidian Point was then transferred to USFWS under the federal excess property regulations for inclusion in the Guam NWR as the 1,217-acre (492-hectares) Ritidian Unit. The MOU and Cooperative Agreements are included in Appendix B.

The Guam NWR is comprised of three units: the Ritidian Unit, the Andersen AFB Overlay Unit, and the Navy Overlay Unit (Table 3-3). The Ritidian Unit is located on the northern tip of Guam and encompasses 1,217 acres (493 hectares), including 385 acres (156 hectares) of terrestrial lands and 832 acres (337 hectares) of submerged lands (USFWS 2009). The Andersen AFB and U.S. Navy overlay units are collectively referred to as Overlay Refuge lands and total 21,187 acres (8,779 hectares). The Andersen AFB Overlay Unit covers approximately 9,652 acres (3,906 hectares) and the Navy Overlay Unit covers approximately 11,535 acres (4,668 hectares). Figures 3-5 and 3-6 show the Guam NWR Overlay Refuge areas on NBG and Andersen AFB.

Table 3-3. Area of Guam NWR Overlay Refuge Units

Unit	*Installation/Parcel*	*Area (acres)*	
Navy Overlay Unit	NBG Main Base	506	12,042
	MCB Camp Blaz	2,604	
	NMS	8,307	
	Tenjo Vista Tank Farm	230	
	Sasa Valley Tank Farm Upper	323	
	Sasa Valley Tank Farm Lower	72	
Andersen AFB Overlay Unit	Live-Fire Training Range Complex	711	9,652
	North Ramp	NA	
	Andersen AFB	8,941	
Ritidian Unit	Guam NWR (terrestrial)	385	1,217
	Guam NWR (submerged)	832	
		Total	**22,911**

Key: AFB = Air Force Base; MCB = Marine Corps Base; NA = Not Applicable; NBG = Naval Base Guam; NMS = Naval Munitions Site; NWR = National Wildlife Refuge; TS = Telecommunications Site.

The purposes of the Overlay Refuge lands are separate from the purposes of the Ritidian Unit. The following purposes for the Overlay Refuge units are specified in the establishing Cooperative Agreements (DON and USFWS 1994; USAF and USFWS 1994; USFWS 2009):

- "…to conserve (A) fish or wildlife which are listed as endangered species or threatened species…or (B) plants… (C) the ecosystems upon which endangered species and threatened species depend..." 16 USC § 1534 (ESA).
- "…shall be administered by him (Secretary of the Interior) directly or in accordance with cooperative agreements… and in accordance with such rules and regulations for the conservation, maintenance, and management of wildlife, resources thereof, and its habitat thereon..." 16 USC 664 (FWCA).
- "…for the development, advancement, management, conservation, and protection of fish and wildlife resources" 16 USC § 742f(a)(4) (Fish and Wildlife Act of 1956).
- "…for the benefit of the United States Fish and Wildlife Service, in performing its activities and services. Such acceptance may be subject to the terms of any restrictive or affirmative covenant, or condition of servitude, if such terms are deemed by the Secretary to be in accordance with law and compatible with the purposes for which acceptance is sought." 16 USC § 742f(b)(1) (Fish and Wildlife Act of 1956).
- "…(1) Incidental fish and wildlife-oriented recreational development, (2) the protection of natural resources, (3) the conservation of endangered species and threatened species." 16 USC 460k-l (Refuge Recreation Act).

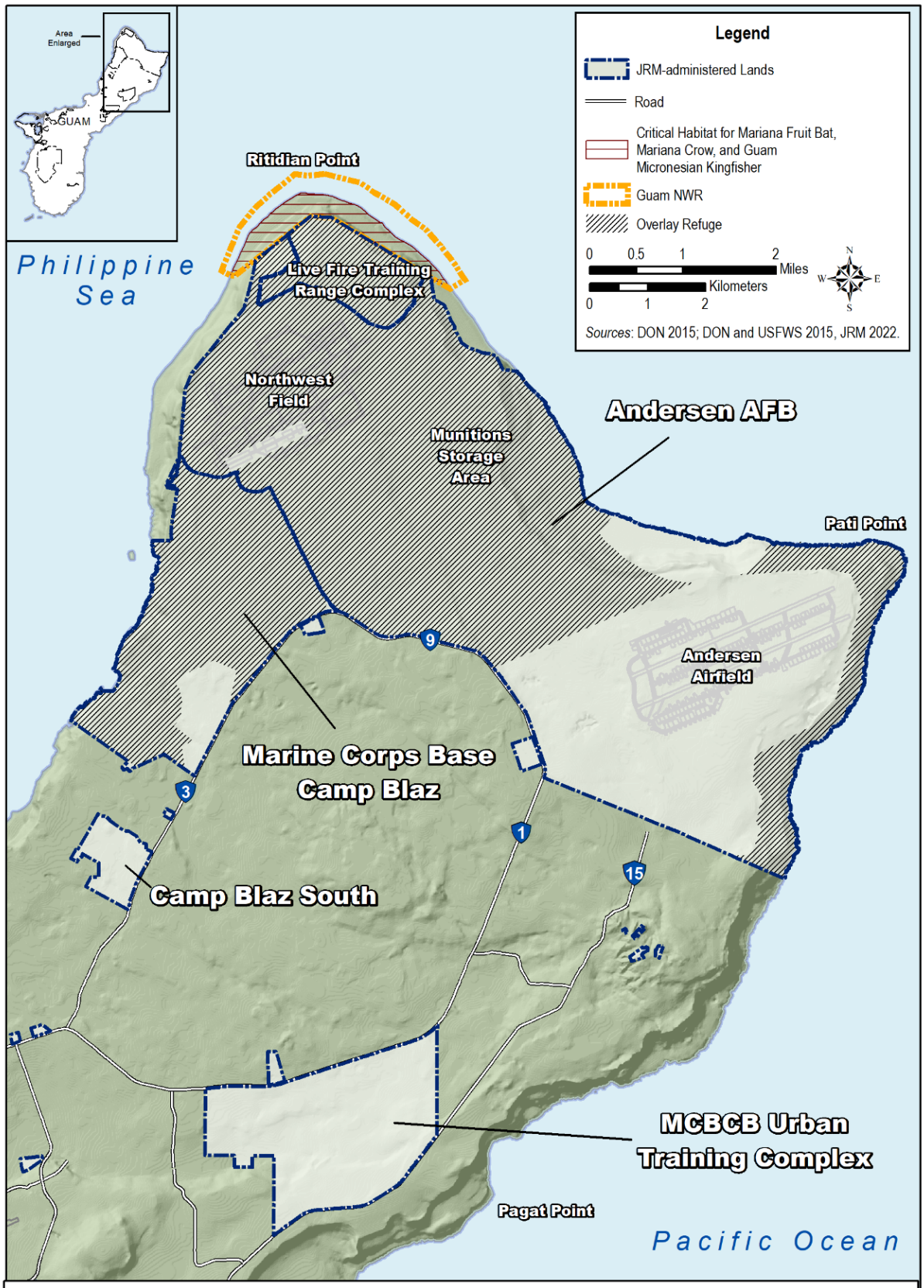


Figure 3-5
Overlay Refuge Lands and Critical Habitat on Northern Guam



Figure 3-6
Overlay Refuge Lands on Southern Guam

- "…the Secretary…may accept and use…donations of…real…property. Such acceptance may be accomplished under the terms and conditions of restrictive covenants imposed by the donors..." 16 USC 460k-2 (Refuge Recreation Act).
- "To ensure that (Air Force and Navy) lands within the Guam National Wildlife Refuge remain available for the use of the (Air Force and Navy) to carry out its responsibilities to organize, supply, equip, train, service, mobilize, demobilize, administer, and maintain forces." 10 USC 8013.

Currently, the majority of the approximate 23,000-acre (9,300-hectare) Guam NWR is Overlay Refuge on lands administered by JRM (see Table 3-3). Natural resources management on the Ritidian Unit is addressed by the USFWS in their Comprehensive Conservation Plan (USFWS 2009), while natural resources management on JRM-managed Overlay Refuge lands is addressed in this INRMP.

In 2004, the USFWS designated 376 acres (152 hectares) of land as critical habitat under the ESA for the Guam kingfisher, Mariana crow (*Corvus kubaryi*), and Mariana fruit bat on the Ritidian Unit of the Guam NWR (USFWS 2004). USAF lands were exempted under section 4(a)(3) of the ESA based on the Andersen AFB INRMP. The DON lands were excluded under section 4(b)(2) of the ESA based upon a determination by the Secretary of the Interior that the benefits of excluding these lands, including benefits to national security and existing management plans and conservation efforts, outweighed the benefits of designating them as critical habitat. The 376 acres (152 hectares) of the Guam NWR (Ritidian Unit) is the only designated critical habitat in Guam.

3.5.4 Bird/Animal Aircraft Strike Hazard Programs

Wildlife collisions with aircraft are a serious safety and economic problem throughout the U.S. and the world. Millions of dollars in damage occur to civilian and military aircraft, and loss of human life, on an annual basis. Globally, wildlife strikes with aircraft have killed more than 250 people and destroyed more than 245 aircraft since 1988. Wildlife strikes cause more than 590,000 hours of aircraft down time and cost the nation's civil aviation industry approximately $937 million annually, and U.S. military aircraft sustain losses exceeding $10 million annually (U.S. Department of Agriculture [USDA] Animal and Plant Health Inspection Services [APHIS] Wildlife Services 2016a).

Both the USAF and the U.S. Navy promulgate guidance to minimize the loss of military resources and protect personnel from death, injury, or occupational illnesses by managing risks on and off-duty. The USAF Mishap Prevention Program, AFI 91-202, dated May 25, 2017, provides BASH program guidance for Andersen AFB. CNIC Instruction 3750.1 dated August 9, 2017 provides implementation guidance for the U.S. Navy's bird/animal aircraft strike hazard program. U.S. Navy guidance requires that INRMPs address the BASH program and coordinate INRMP revisions and updates with Air Operations. At Andersen AFB, the Operations Group Commander manages the BASH program and directs operational changes to avoid areas and times of known hazardous bird concentrations as the mission permits. The USDA APHIS Wildlife Service office in Guam assists the military with clearing wildlife hazards from runways when requested to do so.

According to Naval Facilities Engineering Systems Command (NAVFAC) Marianas (2013), birds can be encountered up to altitudes of 30,000 feet (9,144 meters) and higher. However, most birds fly close to ground level, and more than 95 percent (%) of all reported incidents in which an aircraft has struck a bird have been below 3,000 feet (914 meters) above ground level (AGL). Approximately half of these bird strikes occur in the airfield environment, and approximately one-quarter occur during low-altitude training. Strike rates rise significantly as altitude decreases, which is partly due to the greater number of low-altitude missions, but mostly because birds are commonly active close to the ground (NAVFAC Marianas 2013).

In 2016, Eurasian tree sparrows (*Passer montanus*), Pacific golden plovers (*Pluvialis fulva*), yellow bitterns (*Ixobrychus sinensis*), feral rock pigeons (*Columba livia*), island collared doves (*Streptopelia bitorquata*), ruddy turnstones (*Arenaria interpres*), and Eastern cattle egrets (*Bubulcus coromandus*) were the most common bird species intentionally dispersed or removed from airports in Guam (USDA APHIS Wildlife Services 2016b). Abundance of birds on JRM lands peaks during the spring and fall migration periods; abundance remains relatively high throughout the nonbreeding season (September–May). Proximity of habitat commonly utilized by bird and other wildlife species to the airfield, including Mariana fruit bats, Philippine deer (*Rusa marianna*), feral pigs (*Sus scrofa*), dogs (*Canis lupus familiaris*) and cats (*Felis catus*) are also considered as a part of BASH management planning.

3.5.5 Guam Comprehensive Wildlife Conservation Strategy

In order to receive federal funds through a State/Territorial Wildlife Grants Program, Congress charged each state and territory with developing a state- or territory-wide comprehensive wildlife conservation plan by October 1, 2005, through the Consolidated Appropriations Act of 2005 (Public Law [PL] 108-447). The State/Territorial Wildlife Grants Program provides federal money to every state and territory for cost-effective conservation aimed at preventing wildlife from becoming endangered.

Congress directed that the strategies developed in the comprehensive wildlife conservation plan identify and be focused on the species of greatest conservation need (SOGCN), while addressing the full array of wildlife and wildlife-related issues. The Guam Comprehensive Wildlife Conservation Strategy (CWCS) was completed in 2006 and goals and objectives for managing 65 species were identified within the plan. In addition, conservation actions that affect general groups of species were identified. Strategies such as the development of MOUs, rehabilitation of habitats, public education, and law enforcement, were then included (Guam DAWR 2006).

Guam DAWR is currently preparing the revised CWCS. As with the 2006 CWCS, the revised plan identifies conservation actions to be undertaken to restore and protect wildlife and their habitats in Guam. To the greatest extent practicable, the conservation actions identified by the Guam DAWR in the Revised Draft CWCS were taken into consideration in the preparation of this INRMP.

3.5.6 Commonwealth of the Northern Mariana Islands Wildlife Action Plan

The CNMI CWCS was completed in 2005 and goals and objectives for managing 65 species were identified within the plan (Berger et al. 2005). CNMI DFW completed the updated and revised CWCS for the CNMI in 2015, now called a Wildlife Action Plan (WAP) (Liske-Clark 2015). The 2015 plan identifies conservation actions to be undertaken to restore and protect wildlife and their habitats on the islands of the CNMI. A number of changes from the 2005 plan are reflected in the 2015 plan: (a) measurable objectives associated with the defined priorities and actions, (b) discussion and evaluation of the effects of climate change, (c) description of marine habitats, and (d) adoption of a formal, structured approach to evaluate candidates for SOGCN using unbiased objective criteria. To the greatest extent practicable, the conservation actions identified in the 2015 CNMI WAP were taken into consideration in the preparation of this INRMP.

3.5.7 Fishery Ecosystem Plan for the Mariana Archipelago

The MSFCMA authorizes fishery management councils to create fishery management plans (FMPs). The Western Pacific Regional Fishery Management Council (WPRFMC) developed the Fishery Ecosystem Plan (FEP) for the Mariana Archipelago as an FMP, consistent with the MSFCMA and the national standards for fishery conservation and management (WPRFMC 2009). The FEP represented the first step in an incremental and collaborative approach to implement ecosystem approaches to fishery management in Guam and the CNMI. The 2009 Mariana Archipelago FEP established the framework under which the

Council manages fishery resources and began the integration and implementation of ecosystem approaches to management in Guam and the CNMI. The WPRFMC released a Draft Revised Marianas FEP for public review on March 1, 2016 (WPRFMC 2016).

3.5.8 Guam's Coral Reef Management Priorities and Commonwealth of the Northern Mariana Island's Coral Reef Management Priorities

The identification of Guam's and CNMI's coral reef management priorities was facilitated by the NOAA Coral Reef Conservation Program (CRCP) as part of an ongoing effort to develop place-based, local coral reef management priorities in each of the seven U.S. state and territorial coral reef jurisdictions (American Samoa, CNMI, Florida, Hawai'i, Guam, Puerto Rico, and the U.S. Virgin Islands) and conduct capacity assessments to identify the support needed to accomplish those priorities (CNMI and NOAA CRCP 2010; GovGuam and NOAA CRCP 2010).

3.5.9 Pacific Islands Regional Action Plan – National Oceanic and Atmospheric Administration Fisheries Climate Science Strategy

Recognizing the growing need for information on how to better prepare for and respond to climate-related impacts on the nation's living marine resources and resource-dependent communities, NOAA Fisheries developed a Climate Change Strategy (NMFS 2023) to provide a national framework designed to be customized and implemented at regional and national levels by NMFS Science Centers, regional offices, programs, and partners. The development of Regional Action Plans addresses the unique combination of ecosystem conditions, climate-related challenges, capabilities, and information needs that will need to be considered to implement the strategy in each region. The Pacific Islands Regional Action Plan reviews the region's current or recent climate activities and results, noting strengths, weaknesses, and opportunities (Polovina et al. 2016). The second part of the plan outlines directions for the region's climate activities through 2024 following the seven research objectives identified in the NOAA Fisheries Climate Science Strategy.

3.6 BENEFICIAL PARTNERSHIPS AND COLLABORATIVE RESOURCE PLANNING

Collaborative partnerships are not only important for effective ecosystem-level management, but they also promote the sharing of personnel, data, and other resources among agencies/stakeholders, which can expedite project implementation and progress, and reduce overall costs.

JRM currently collaborates with or will collaborate in the future with the USFWS, NMFS, U.S. Geological Survey (USGS), USDA, USACE, Guam DAWR, Guam EPA, Guam Department of Parks and Recreation (GDPR), CNMI DLNR (including CNMI DFW), CNMI Bureau of Environmental and Coastal Quality, and the UOG for management, conservation, and preservation of all natural resources on JRM-administered and leased terrestrial and submerged lands. These relationships are critical for achieving the goals set forth in this INRMP, sharing resources and data, and developing ecosystem-level management practices that are not bound by political or property boundaries.

Currently, Guam DAWR assists the Conservation Resources staff in collaborative management of the installation resources at Andersen AFB. JRM is evaluating the potential for a MOA between JRM, USFWS, and Guam DAWR to provide similar assistance on other JRM sites where consistent and compatible with security and mission requirements. A MOA between JRM and CNMI DFW for collaborative management of natural resources on Tinian is being considered as well.

3.6.1 Other Department of Defense Organizations and Programs

The DoD Partners in Flight (PIF) program sustains and enhances the military's testing, training, operational, and safety missions through proactive, habitat-based management strategies that maintain healthy landscapes and training lands. DoD PIF representatives provide assistance to installation natural resources managers for monitoring and inventory, research and management, and education programs involving birds and their habitats. DoD PIF offers a wide variety of resources to help natural resources managers better comply with relevant laws and policies and incorporate migratory bird information into installation INRMPs. The PIF includes working groups to deal with local and regional problems.

3.6.1.1 Partners in Amphibian and Reptile Conservation

Partners in Amphibian and Reptile Conservation (PARC) is an inclusive partnership dedicated to the conservation of the herpetofauna (i.e., reptiles and amphibians) and their habitats. Their mission is to conserve amphibians, reptiles, and their habitats as integral parts of our ecosystem and culture through proactive and coordinated public/private partnerships. The DoD arm of PARC has a primary responsibility to ensure that the DoD has the operational and logistical flexibility necessary for testing and training exercises.

3.6.1.2 Department of Defense Legacy Resources Management Program

Congress instituted the DoD Legacy Resources Management Program in 1990 to promote stewardship of natural and cultural resources on DoD lands. The program assists DoD in protecting and enhancing resources while supporting military readiness. Legacy projects typically demonstrate innovative techniques for management, conservation, and preservation of natural resources. A Legacy project may involve regional ecosystem management initiatives, habitat preservation efforts, invasive species control, and/or monitoring and predicting migratory patterns of birds and animals. Three principles guide the Legacy program: stewardship, leadership, and partnership. Stewardship initiatives assist DoD in safeguarding its irreplaceable resources for future generations. By embracing a leadership role as part of the program, the DoD serves as a model for respectful use of natural resources. The DoD Legacy Program, managed by Deputy Assistant Secretary of Defense (Environment, Safety, and Occupational Health), annually releases a request for proposals specifying areas of interest, typically in March, and full proposals are then due in September. Generally, funding announcements are made between February and April of the following year. Proposals may be submitted by DoD, other agencies, universities, non-governmental organizations, and the general public.

3.6.1.3 National Military Fish and Wildlife Association

The National Military Fish and Wildlife Association was officially chartered in 1983 by a small group of dedicated DoD resource management professionals. These individuals recognized the critical need for enhanced awareness of natural resource conservation requirements in order to provide for both long-term sustainability of resource diversity and the successful accomplishment of the military training mission on public lands administered by the DoD.

The National Military Fish and Wildlife Association is a non-profit organization consisting of professional resource managers working to protect and manage wildlife and other natural resources on DoD lands. Through publication of a quarterly Newsletter (Fish and Wildlife News), and hosting an annual Training and Business Conference, members and supporters remain actively involved and engaged in issues of national and local importance to the objectives of the association.

Currently, membership includes wildlife and fisheries biologists, botanists, ecologists, range conservationists, foresters, cultural resource managers, and wildlife/cultural law enforcement agents. Members may work for the DoD or other federal, state, or local agencies, universities, conservation organizations, or private businesses which are directly involved in conservation and management of natural resources on military lands.

3.6.1.4 Space and Naval Warfare Systems Command and Naval Facilities Engineering Systems Command Engineering and Expeditionary Warfare Center

The Space and Naval Warfare Systems Command (SPAWAR) and the NAVFAC Engineering and Expeditionary Warfare Center assist JRM primarily with marine resource surveys and reporting in support of marine resource monitoring and management, and with associated technology development related to the marine environment.

3.6.1.5 United States Army Corps of Engineers

The USACE provides contract management, construction management, disaster recovery assistance, and technical support for its nationwide and international programs. DoD has the option to use USACE contracts as vehicles for natural resources management and to access USACE organizations, such as the U.S. Army Engineer Research and Development Center, for technical assistance and support for natural resources projects. In addition, the USACE has regulatory authority over waters of the U.S., which include activities within perennial and intermittent streams and wetlands. Section 404 of the CWA authorizes the Secretary of the Army, acting through the Chief of Engineers, to issue permits for the discharge of dredged or fill materials into the waters of the U.S., including wetlands. Therefore, even an inadvertent encroachment into wetlands or other waters of the U.S. resulting in displacement or movement of soil or fill materials has the potential to be viewed as a violation of the CWA if an appropriate permit has not been issued by the USACE. Additionally, the USACE administers navigation improvement and maintenance projects, ecosystem restoration, storm risk management, real estate support, hydropower studies, and other civil works projects approved by Congress.

3.6.1.6 Armed Forces Pest Management Board

The Armed Forces Pest Management Board recommends policy, provides guidance, and coordinates the exchange of information on all matters related to pest management throughout the DoD. The Armed Forces Pest Management Board's mission is to ensure that environmentally sound and effective programs are

present to prevent pests and disease vectors from adversely affecting DoD operations. The Armed Forces Pest Management Board Natural Resources Committee provides guidance on integrating pest management and natural resources management programs including the following:

1. Addressing wildlife damage management and pest management requirements in aquatic, riparian, and wetland environments
2. Identifying conflicts between threatened and endangered species and pest management actions
3. Integrating pest management considerations with natural resources program responsibilities regarding vegetation management, forest insect and disease damage, and pest damage to ornamentals
4. Coordinating approval and use of pesticides for vegetation management and other natural resources programs
5. Initiating or reviewing research regarding natural resources pest management requirements/ considerations

3.6.2 Other Federal Agencies and Programs

3.6.2.1 United States Environmental Protection Agency

The USEPA leads the nation's environmental science, research, education, and assessment efforts. Its activities include developing and enforcing environmental regulations; providing financial assistance to state and territory environmental programs, non-profits, and educational institutions; performing environmental research at laboratories nationwide; sponsoring voluntary partnerships and programs; and providing environmental education (USEPA 2017).

To ensure the health of natural resources on JRM-administered lands, the U.S. Navy must comply with rules and regulations enforced by the USEPA including the Clean Air Act; Spills Prevention, Control, and Countermeasure; and the Pollution Prevention Act. To ensure compliance with these laws, installations develop management plans such as the following:

- Dust Control Plan
- Range Fire Management Plan
- Diesel Emissions Control on Off-road Equipment
- Spill Prevention and Response Procedures
- Stormwater Management Plan
- Stormwater Pollution Prevention Plan
- Solid Waste Management Plan
- Erosion Control Plan

3.6.2.2 United States Fish and Wildlife Service

The USFWS guides the conservation, development, and management of the Nation's fish and wildlife resources, and administers a national program to provide the public opportunities to understand, appreciate, and wisely use fish and wildlife resources. Principal functions of the agency include key roles in enforcement of federal wildlife laws, protection of endangered species, management of migratory bird resources, restoration of nationally significant fisheries, conservation and restoration of wildlife habitats including wetlands and some coastal resources. The USFWS also funds territorial and Commonwealth initiatives through the Wildlife Sport Fish and Restoration Program.

In accordance with the Sikes Act and NEPA, the USFWS cooperates on INRMP implementation with DoD, NMFS, and other federal agencies, and with Guam DAWR and CNMI DFW and other local agencies. Cooperative efforts with USFWS involve identifying potential federal ESA-listed threatened and endangered species on JRM-administered lands, and conducting informal and/or formal consultations prior to implementation of any action that may affect species, or species proposed for listing. Sikes Act activities and coordination with JRM are managed by the Pacific Region of USFWS, primarily by the Division of Ecological Services at the Pacific Islands Fish and Wildlife Office in Honolulu, and a field office in Guam.

3.6.2.3 National Oceanic and Atmospheric Administration, National Marine Fisheries Service

The NMFS is responsible for the stewardship of the nation's ocean resources and their habitat, and provides services related to productive and sustainable fisheries, safe sources of seafood, the recovery and conservation of federally listed species, the protection and conservation of marine mammal species, and maintenance of healthy ecosystems. The agency administers the MMPA, National Marine Sanctuaries Act, Shark Conservation Act, and plays a key role in other laws pertaining to marine fisheries and coastal zone management. Under the ESA, NMFS is required to designate critical habitat for listed marine species based upon the best available scientific data and other relevant factors. Under the Sikes Act, areas owned or administered by the DoD are exempt from critical habitat designation if NMFS determines that an INRMP provides sufficient benefit to the affected species.

The Pacific Islands Regional Office of NMFS, located in Pearl Harbor, Hawai'i manages Sikes Act coordination with JRM, with assistance from field offices in Guam and Saipan. The agency has issued numerous BOs addressing terrestrial natural resources conservation for DoD activities within Guam and CNMI.

3.6.2.4 United States Department of Agriculture, Natural Resources Conservation Service

The USDA Natural Resources Conservation Service (NRCS) has several natural resources conservation programs that could assist JRM in managing resources including conserving soils, improving water quality, increasing wildlife habitat, and reducing damage resulting from floods or other natural disasters (USDA NRCS 2017). A District Conservationist, Conservation Specialist, and Soil Conservation Technician staff the Guam Service Center of NRCS, which is located in Barrigada.

3.6.2.5 United States Department of Agriculture, Animal and Plant Health Inspection Services

The mission of the USDA APHIS is to protect the health and value of agriculture and natural resources. USDA APHIS is "a multi-faceted Agency with a broad mission area that includes protecting and promoting U.S. agricultural health, regulating genetically engineered organisms, administering the Animal Welfare Act and carrying out wildlife damage management activities. These efforts support the overall mission of USDA, which is to protect and promote food, agriculture, natural resources, and related issues" (USDA APHIS Wildlife Services 2016c).

Under USDA APHIS, the Wildlife Services program provides "federal leadership in managing problems caused by wildlife...[by] helping to solve problems that occur when human activity and wildlife are in conflict with one another" (USDA APHIS Wildlife Services 2016c). The Wildlife Services is currently funded by JRM to conduct BTS control and interdiction work.

3.6.2.6 United States Geological Survey

The USGS is a multidisciplinary organization that provides scientific information on biology, geography, geology, geospatial information, and water, to minimize damage from natural disasters; and manage the nation's water, biological, energy, and mineral resources. The USGS could assist JRM by helping design biological, water quality, and hydrologic surveys, and facilitating the integration of JRM data into national or regional databases. The USGS Brown Treesnake Project has been conducting research pertaining to BTS population dynamics and life history on Andersen AFB for more than 10 years. In addition, the USGS has also researched and developed BTS barrier technology that has been used on Andersen AFB.

3.6.2.7 National Park Service National Natural Landmarks Program

Mount Lamlam is the remnant of a great caldera, and a key site illustrating the major volcanism that created the island of Guam. The National Park Service designated Mount Lamlam as a National Natural Landmark in 1972.

3.6.3 Territory of Guam

3.6.3.1 Department of Agriculture, Division of Aquatic and Wildlife Resources

The Guam DAWR is the equivalent of a State Fish and Game Agency. The mission of the Fisheries Section of the Guam DAWR is to restore, conserve, manage, and enhance the aquatic resources in Guam and to provide for the public use of and benefits from these resources. The mission of the Wildlife Section is to manage Guam's wildlife resources for the benefit of present and future generations with the vision to recover endangered animal and plant species, manage sustainable populations of game species, and promote public awareness of natural resources.

3.6.3.2 Department of Agriculture, Division of Forestry and Soil Resources

The Guam Department of Agriculture, Division of Forestry and Soil Resources mission is to conserve, protect, and enhance Guam's vegetative environment and sustain the natural resources which are dependent on healthy forests. The department is responsible for protecting and restoring forest ecosystems in Guam.

3.6.3.3 Bureau of Statistics and Plans

The Guam Bureau of Statistics and Plans serves as the territorial clearinghouse and is the lead agency for the Coastal Zone Management Program. It is tasked with land use planning guidance as well as networking among agencies and federal consistency for coastal management. The Bureau has a component of terrestrial lands (uplands) within its program to promote a watershed approach to maintaining healthy submerged lands.

3.6.3.4 Guam Environmental Protection Agency

The Guam EPA is an agency of GovGuam established to protect human health and the environment by regulating industries and public utilities and enforcing the environmental laws of Guam. Guam EPA ensures that territorial environmental standards are met for Installation Restoration Program projects on JRM sites.

3.6.3.5 Guam Department of Parks and Recreation

The GDPR provides technical guidance on outdoor recreation programs at Andersen AFB under provisions of a Cooperative Agreement executed with the USAF. The State Historic Preservation Officer within the

GDPR reviews all federal actions that might affect listed or potential historic or archaeological sites for compliance with the National Historic Preservation Act (NHPA) on JRM sites.

3.6.4 Commonwealth of the Northern Mariana Islands

3.6.4.1 Department of Land and Natural Resources, Division of Fish and Wildlife

The CNMI DFW was created in 1981 by the Fish, Game and Endangered Species Act, PL Number 2-51. The Division endeavors to conserve fish, game, and wildlife, and to protect endangered and threatened species. Through research, monitoring, regulation, enforcement, planning, and management, the Division seeks to ensure the long-term survival and sustainability of the CNMI's natural resources for present and future generations. The Division is directed by CNMI DLNR and authorized by Title 85 of the CNMI Administrative Code to provide and enforce regulations governing hunting, fishing, harvesting, and taking of species; and human behavior and activities in protected and conservation areas in the CNMI. The CNMI DLNR also reviews all development proposals submitted to the Coastal Resources Management Office and Division of Environmental Quality to ensure that negative impacts on all wildlife species, particularly endangered and threatened species, are minimized, mitigated, or avoided.

3.6.4.2 Department of Land and Natural Resources, Division of Agriculture, Forestry Section

The mission of the CNMI Forestry Section under the Division of Agriculture departments is the protection, management, wise use, and improvement of forest resources throughout the CNMI.

3.6.4.3 Bureau of Environmental and Coastal Quality, Division of Coastal Resources Management

The Division of Coastal Resources Management program was established in order to promote conservation of CNMI's coastal resources and oversee wise development that may impact those coastal resources.

3.6.4.4 Bureau of Environmental and Coastal Quality, Division of Environmental Quality

The Division of Environmental Quality was established to serve the public through wise management of CNMI natural resources, and by supporting healthy communities, a sustainable environment, and a vibrant economy.

3.6.4.5 Department of Land and Natural Resources, Division of Parks and Recreation

The CNMI DLNR Division of Parks and Recreation is empowered by the Commonwealth legislature to enhance, maintain, and beautify public parks, recreational areas, and tourist sites within the CNMI.

3.6.4.6 Division of Historic Preservation

Under the Department of Community and Cultural Affairs, the Division of Historic Preservation ensures the protection, preservation, and regulation of historic and cultural sites pursuant to the CNMI Historic Preservation Act of 1982. The State Historic Preservation Officer within the Division of Historic Preservation reviews all federal actions that might affect listed or potential historic or archaeological sites for compliance with the NHPA on JRM sites on Tinian.

3.6.5 Other Partners

JRM works with many other partners including academic institutions, contractors, volunteers, and non-governmental organizations, to study, survey, and monitor natural resources. Examples of these partners include UOG, Colorado State University, volunteers who assist with the Andersen AFB annual fruit bat counts and sea turtle observations, and The Nature Conservancy. Information on key partners and the partnerships are discussed in Section 13.8.2, *Project Support*. There are many other national and local non-governmental organizations that DoD could partner with in the future to assist with achieving natural resources management goals and objectives.

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4 OVERVIEW OF GUAM

The following sections present an overview of Guam's physical and biological environments. This information provides the context for the site-specific discussions of the individual Joint Region Marianas (JRM)-managed installations and various Department of Defense (DoD) properties in Guam found in Chapters 5-9.

4.1 CLIMATE

Guam is located in the low-latitudes zone (between 13 degrees [°] and 14° North) and has a maritime tropical climate with a mean average temperature of 82 degrees Fahrenheit (°F) (28 degrees Celsius [°C]) and average relative humidity for 2023 was 83 percent (%) (National Weather Service 2023).

The seasonal variation in precipitation is strongly influenced by the position of the Inter-tropical Convergence Zone and the subtropical high-pressure zones. These zones shift latitudinally in a seasonal cycle, resulting in two distinct climatic seasons: wet and dry. Approximately 73% of the annual precipitation in Guam occurs June through November (the wet season). Precipitation then declines significantly from December through May (the dry season), with only 27% of the annual rainfall occurring during these months (Figure 4-1). Typically, the months of August and March report the highest and lowest average rainfall during the year at 15 inches (38 centimeters) and 3 inches (8 centimeters), respectively. Total rainfall varies considerably among years, although it averages 95 inches (241 centimeters) per year (National Weather Service 2023). There is increasing evidence suggesting that rainfall variability throughout the Western Pacific is associated with the periodic oscillation in the atmosphere-ocean system known as the El Nino–Southern Oscillation. During periods of El Nino-Southern Oscillation, rainfall levels can decline significantly, resulting in extended periods of drought (Kellman and Tackaberry 1997).

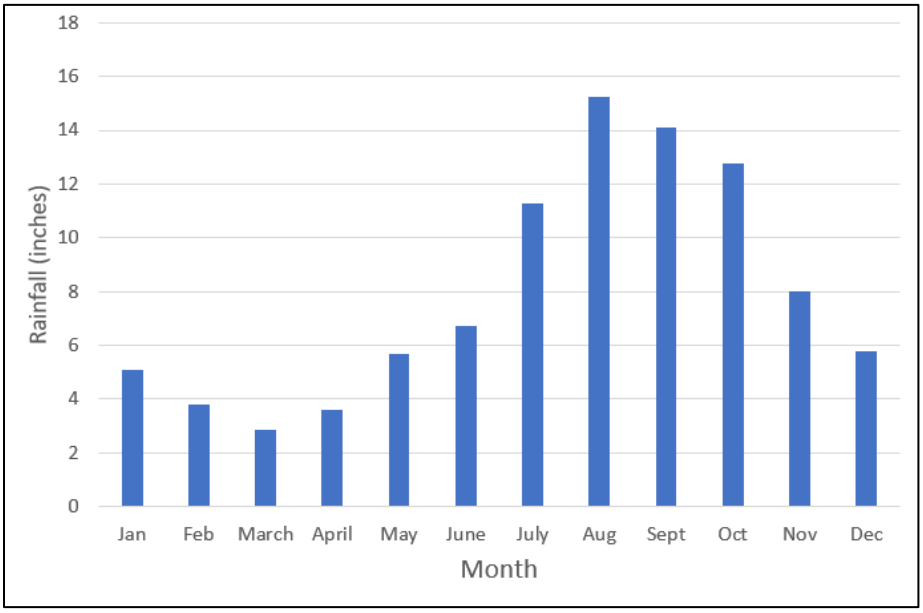


Figure 4-1. Average Monthly Rainfall in Guam (1963-2023)
Source: National Weather Service 2023.

The annual rainfall distribution across Guam shows that the major rainfall patterns are generally oriented north-northeast—south-southwest, with maximum and strong rainfall gradients located along the western and southern mountains (Figure 4-2) (Water and Environmental Research Institute [WERI] of the Western Pacific and Island Research & Education Initiative [IREI] 2016).

Persistent easterly winds (trade winds) dominate the circulation pattern of Guam's climate during the drier months. Trade winds are typically from the east at less than 10 miles per hour (mph) (16 kilometers per hour [kph]), but are variable in late summer.

Typically, tropical storms and typhoons also originate to the east of Guam. Based on data from 1951 to 2015, an average of six tropical storms (39 to 73 mph [63 to 118 kph] winds) or typhoons (greater than 74 mph [119 kph] winds) pass within 186 miles (300 kilometers) of Guam every year. In 2023, there were 12 recorded typhoons and five recorded tropical storms in the West Pacific; the accumulated cyclone energy was about 11% below the 1991–2020 average (NOAA National Centers for Environmental Information 2023). Figure 4-3 depicts the tropical storms and typhoons that have occurred within 100 miles (161 kilometers) of Guam from 2000 to 2023.

4.2 GEOLOGY, TOPOGRAPHY, AND SOILS

4.2.1 Geology

Guam is the largest and the southernmost island in the Mariana Archipelago. The Mariana Islands are a volcanic island archipelago resulting from subduction of the Pacific plate beneath the Philippine Sea plate at the Mariana Trench, which runs south and east of Guam. The island of Guam was formed by two separate emergent mountains that fused to form one island. Southern Guam is made up of volcanic hills, which rise to a maximum height of 1,334 feet (407 meters) above sea level. Over time, rivers cut through this terrain to create several high waterfalls. The central and northern sections of the island consist of a limestone plateau that rises as high as 600 feet (183 meters) above sea level with steep cliffs dropping down to a narrow coastal shelf. The upper few hundred feet of the island are composed of basalt and andesite, tuff-derived sedimentary rock, and limestone (Tracey et al. 1964). Figure 4-4 depicts the geology of Guam.

The island is separated into three main structural provinces: northern, central, and southern. The Pago-Adelup Fault is the dividing line between southern and north/central Guam. The northern structural province is composed of the limestone plateau, the central structural province consists of folded volcanic rocks, and the southern province includes east-dipping volcanic rocks (Tracey et al. 1964). Most of the older northern half of the island is a relatively flat plateau overlain with the Mariana Limestone formation of the Quaternary Period (deposited less than 2 million years ago), which was formed from the growth of coral carbonate reefs. Smaller areas of the island are covered in older limestone of the Neogene Period (25 to 2 million years ago). The island has experienced alternating emergence and submergence below sea level during the past 20 million years, allowing the limestone reef cap to develop into a thickness of up to 600 feet (183 meters) in some areas.

Volcanic rock forms the foundation of the island and is exposed over approximately 35% of the island's surface, predominantly in central and southern Guam. Neogene and Quaternary limestone overlie the volcanic rock and is exposed over approximately 60% of the island, mainly in northern Guam. The high porosity of the limestone gives it high permeability, whereas the texture and poor sorting of the volcanic basement material usually gives it much lower permeability. All major limestone units have undergone pervasive meteoric diagenesis; thus, most porosity and permeability is secondary. Faults transect the island throughout, complicating the structure and permeability of the rock units. Guam comprises seven major geologic units (Gingerich 2003) as summarized below.

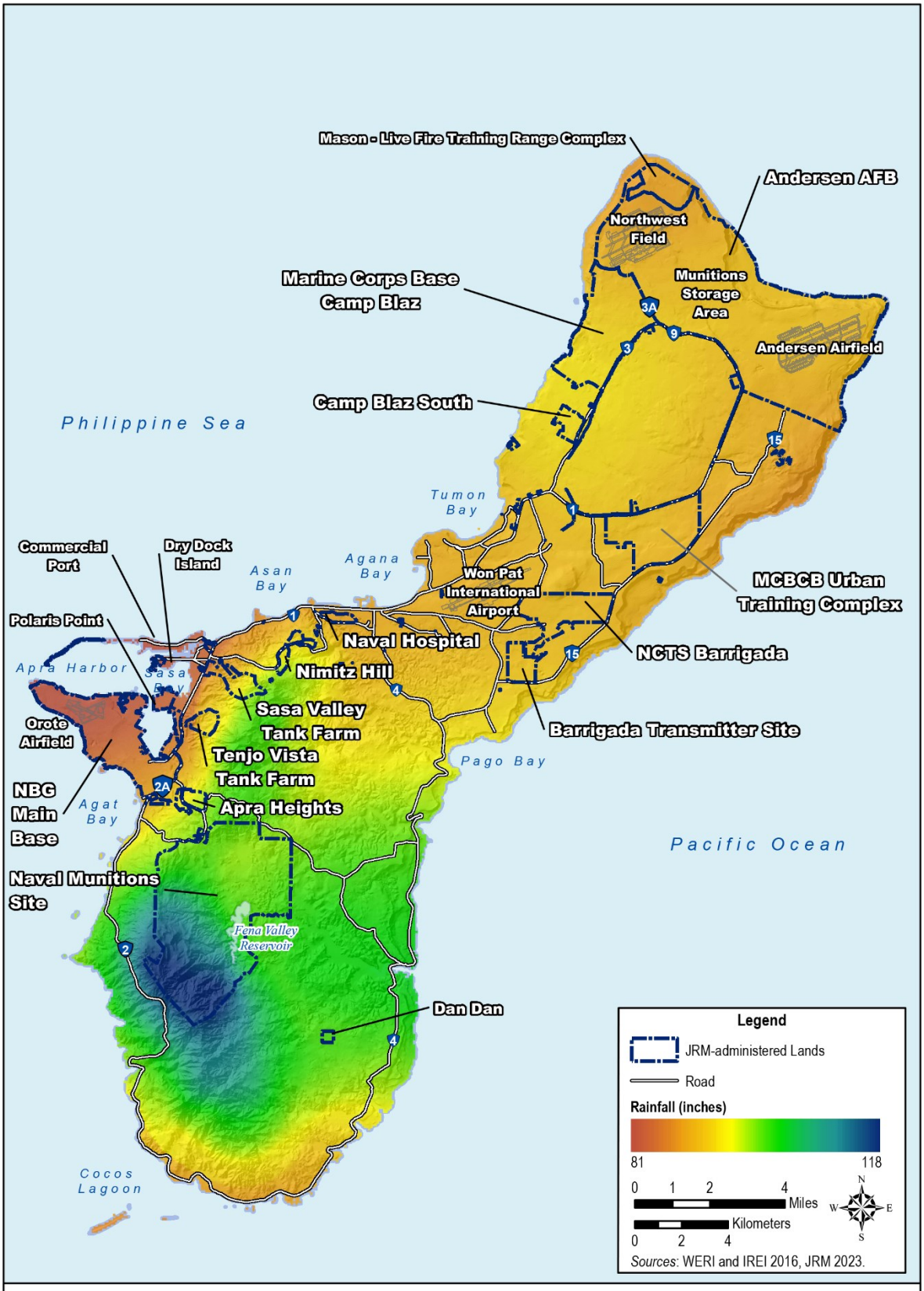


Figure 4-2
Average Annual Rainfall in Guam

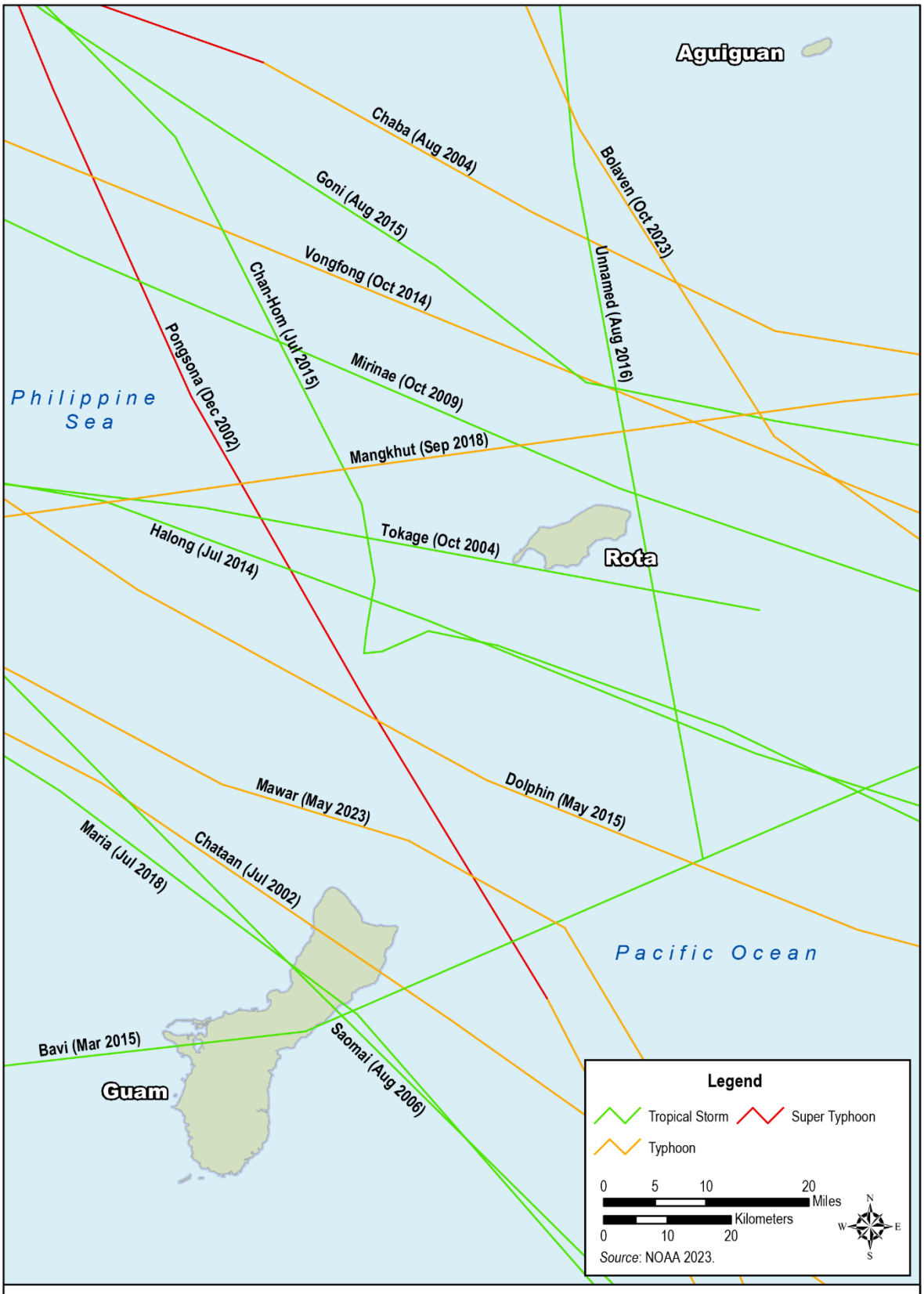


Figure 4-3
Tropical Storms and Typhoons within 100 Miles of Guam (2000-2023)



Figure 4-4
Geological Features in Guam

4.2.1.1 Geologic Units

Volcanic Units

The Facpi and Alutom Formations, which are volcanic in origin, underlie all rock units on the island. These formations are exposed over approximately 20% of the island's surface and are found at the highest elevations of northern Guam and on the highlands of central and southern Guam. Contained within these formations are pillow basalts and pyroclastic rocks from tuffaceous shale, conglomerates of coarse boulders, and breccia. Due to their variable composition, the permeability of these formations is low.

The Umatac Formation, which is underlain by the Alutom Formation, is exposed over approximately 15% of the island, mainly in the southern and central highlands and plateaus. The Umatac Formation increases in thickness moving south to 1,050 feet (320 meters) along its southwestern edge. It is composed of reef limestone, tuff breccias, volcanic conglomerate, and basalt flows. Due to its composition, the permeability of this formation is low.

Limestone Units

Overlying the Alutom and Umatac Formations is Older Limestone, which is composed of three limestone units: Bonya and Alifan Limestones and the Janum Formation. These units cover approximately 5% of the island's surface and range in thickness from 70 to 200 feet (21 to 61 meters). The Bonya Limestone and Janum Formation are considered to be permeable but only contain small amounts of water due to their small size. The Alifan Limestone is highly permeable and acts as a feed for perennial springs on the southern part of Guam.

Barrigada Limestone covers approximately 9% of Guam's surface and contains much of the groundwater in the northern part of the island. The material is highly permeable, formed of fine-grained foraminifera detrital limestone greater than 540 feet (165 meters) thick.

Mariana Limestone covers much of the northern half and parts of the southeastern area of Guam, approximately 45% of the island's surface area. The material is composed of fore-reef faces and lagoonal limestone that is rich in clay near the uplands. The areas without clay are considered highly permeable due to the abundance of fissures and channels, while permeability in the clay-rich areas is moderate to high. The unit is thickest near the coast and thins to near zero thickness inland.

Beach Deposits, Reef Deposits, and Alluvium

Reef beach deposits, reef limestone, and alluvium cover approximately 7% of the island surface. These deposits are composed of poorly consolidated sediments, the origin of which is calcareous sand and gravel and volcanic sand. Such deposits reach thicknesses up to 200 feet (61 meters) near river mouths. Merizo Limestone is composed of reef deposits and may be 12 feet (4 meters) in thickness, while stream valleys and coastal lowlands are covered with alluvial clay deposits.



Native flora and fauna in Guam and elsewhere in the Mariana Islands have evolved over millennia to thrive on limestone karst formations like this one on Andersen AFB.
(*Photo*: L. Shaughnessy)

4.2.1.2 Karst Geology

Limestone is a soluble rock primarily composed of calcium carbonate (Taborosi 2004; Islam 2005). Karst is a distinctive landscape formed by dissolution of soluble rocks (e.g., limestone) by surface water or groundwater. This solubility



Karst shoreline showing deeply incised erosion. Combined with sea spray, the margin of karst shorelines are inhospitable to most plants. Drone camera, elevation 60 feet, looking southeast from Puntan Diablo towards San Jose on Tinian.
(*Photo*: M. Mendoza)

creates large voids such as sinkholes and caves, as well as smaller features characterized by rough surfaces, little soil, and small cavities known as epikarst. The epikarst commonly acts as a conduit for surface water (such as rainfall) to the underlying groundwater aquifer by percolation or channelization through connected subsurface voids or cavities. Unsaturated epikarst may provide a large amount of water storage in voids; however, the fast flow of water through the joints and planes of the epikarst does not allow for adsorption, uptake, or microbial processes to remove pollutants from groundwater (Islam 2005).

Sinkholes, the second type of karst feature, are a type of concave surface depression that results from karst that collapses and then acts as catchment for surface water, which collects and infiltrates to the aquifer below. Northern Guam has 1,252 identified sinkholes that range in depth to over 98 feet (30 meters) and attain lengths of hundreds of feet. Fewer sinkholes are located in southern Guam, with only 197 identified. The largest concentration in northern Guam is found northeast of Fena Valley Reservoir (Taborosi 2004).

Although sinkholes can be hazardous and cause many environmental problems, they also provide an outlet for movement of stormwater. During times of heavy rain, sinkholes support natural ponding; however, severe flooding can occur if a sinkhole is blocked by debris or inundated by excess runoff. Additionally, sinkholes may collapse, thereby destroying any structures built above. Sinkholes are not only relevant to geological processes, they can potentially contain archaeological resources and be culturally significant (Taborosi 2004; Islam 2005).



Karst sinkholes are common both on land and under sea. This particular sinkhole is about 16 feet (5 meters) in diameter and 3 feet (1 meter) deep, near Puntan Atgidon on Tinian.
(*Photo*: A. Reyes)

Filling sinkholes increases flooding risk and is prohibited without approval from Guam Environmental Protection Agency (Guam EPA) (Section 10106F of 22 Guam Administrative Rules and Regulations Chapter 10). Before construction occurs in areas of karst geology, subsurface voids must be identified and examined. Construction activities are a major source of karst collapse and can occur as a result of excavation, change in drainage patterns, and lowering of groundwater. Soil disturbance from construction causes deposits to form in openings near the bedrock surface that get heavier when saturated, causing the underlying structure to collapse.

Three main types of caves, the third type of karst feature, are found in Guam: stream caves, pit caves, and flank margin caves. Stream caves are formed through the contact of streams with soluble limestone surfaces, which tends to form large springs. They may be found near Naval Munitions Site (NMS) and Mount Almagosa in the south, and the flanks of Mount Santa Rosa in the north. Pit caves, found primarily in northern Guam, are conglomerations of voids that transport water from the epikarst to groundwater. These caves, although not usually large in size, increase the rate of water transport to the subsurface. Flank margin caves are low, wide chambers that form in the zone of continual and rapid erosion at the coast and are regularly exposed by cliff collapse along Guam's coastal cliffs and terraces. Due to their shape and

orientation, these caves act as mixing zones for fresh and saltwater rather than as water conduits (Taborosi 2004; Taborosi et al. 2005).

4.2.1.3 Seismology

Guam is located on the eastern edge of the Philippine Sea plate where it meets the western subduction boundary of the Pacific plate (Karolle 1993). The Mariana Trench marks the boundary of the subduction zone. Movements of the lithospheric plates generate earthquakes of a sizeable magnitude. Between 1825 and 2016, 16 earthquakes with a magnitude of 7.0 or greater on the Richter scale occurred in the Mariana Islands. The most recent occurred in July 2016 north of Pagan and registered 7.7 on the Richter scale. In August 1993, the largest earthquake ever recorded in the region occurred about 37 miles (60 kilometers) south-southeast of Hagatna and measured 8.1 on the Richter scale. Liquefaction and lateral spreading caused major damage to commercial and naval port facilities in Guam (see Figure 4-4) (Mueller et al. 2012; Earthquaketrack.com 2017).

Guam has two major fault zones, the Pago-Adelup and the Talofofo faults. The topography, surface drainage, distribution of bedrock and soils, groundwater storage and discharge, landslide potential, and coastal formation of the island is strongly affected by the numerous smaller faults, vertical joints, and local fractures associated with these fault zones (Tracey et al. 1964; Mueller et al. 2012) (see Figure 4-4).

According to the 2014 Final Guam Hazard Mitigation Plan (Guam Homeland Security 2014), the areas in Guam determined to be susceptible to a large tsunami include all landmasses below 16 feet (5 meters) in mean sea elevation and the inundation areas for the five bays (Apra Harbor, Tumon Bay, Pago Bay, Hagatna Bay, and Inarajan Bay). Historical records show that 12 tsunami events have affected Guam. The largest documented tsunami was in 1849, with a vertical wave run-up of 11.4 feet (3.5 meters). The most recently documented tsunami occurred after the August 1993 earthquake; the only recorded damage of which was of a truck parked on the beach in Pago Bay that was struck by a wave (Guam Homeland Security 2014).

4.2.2 Topography

Topography comprises the natural and man-made features of a place or region that shows relative positions and elevations. Topography generally dictates the suitability of land for building purposes and can be a major factor in defining an appropriate use of an area. Northern Guam is a flat limestone plateau ranging in elevation from 98 feet (30 meters) to 482 feet (147 meters), central Guam is composed of rolling limestone hills and plateaus, and southern Guam is mountainous with numerous steep river valleys running throughout. Figure 4-5 depicts the topography of Guam.

4.2.3 Soils

The soils in Guam are in a pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the island. Guam soils are grouped into three broad classes: soils on bottomlands, soils on volcanic uplands, and soils on limestone uplands (Figure 4-6). Soils developed on volcanic rock tend to be poorly drained clays, while soils developed on limestone are usually shallow and highly porous. Soils on bottomlands consist of a single map unit that occupies 4% of the island, soils on volcanic uplands consist of two map units covering 35% of the island, and soils on limestone uplands consist of five map units covering 61% of the island (U.S. Department of Agriculture [USDA] 1988; WERI and IREI 2016). In addition, coastal lands are found in small pockets along the coast. Soil classes across Guam were identified by the USDA Soil Conservation Service in 1985 (USDA 1988), and the descriptions of each soil type are summarized in Table 4-1. Table 4-1 shows that Inarajan Variant and Pulantat soils have the highest erodibility factors (K values of 0.24-0.28) and are the most vulnerable to sheet and rill erosion. These soil types are found in southern Guam near Naval Base Guam (NBG) and NMS.



Figure 4-5
Topographical Features in Guam

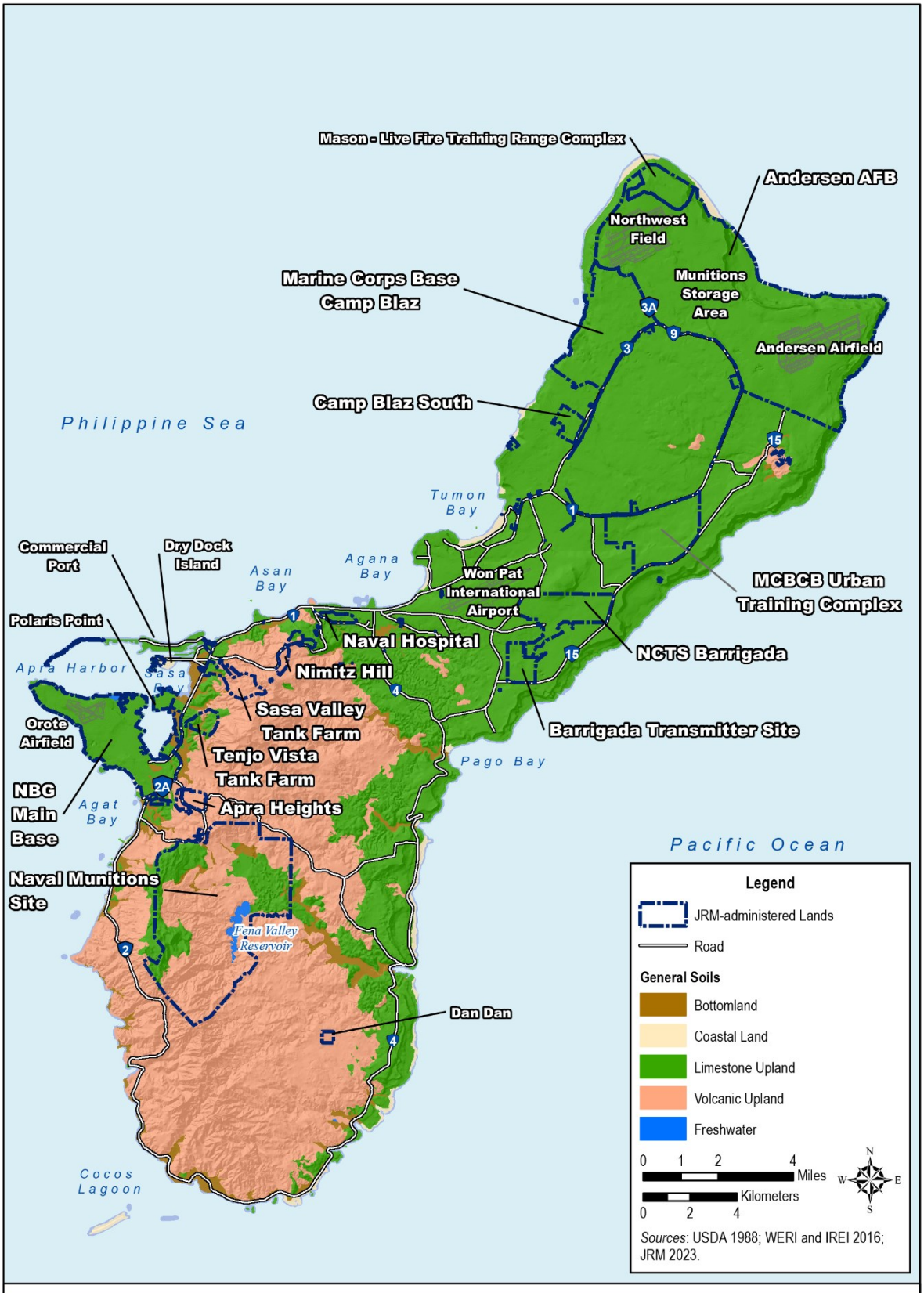


Figure 4-6
Soils in Guam

Table 4-1. Soil Classes in Guam

Soil Class	*Soil Description*	*Runoff Rate*	*Permeability*	*Erodibility Factor (K)*
Bottomlands				
Inarajan–Inarajan Variant	Deep and very deep, somewhat poorly drained and poorly drained, level and nearly level soils; on valley bottoms and coastal plains	Medium	0.02–0.5	0.24
Volcanic Uplands				
Akina	Very shallow to very deep, well drained, moderately steep to extremely steep soils; on strongly dissected mountains and plateaus	Slow	1.5–5.0	0.20
Agfayan	Very shallow to very deep, well drained, moderately steep to extremely steep soils; on strongly dissected mountains and plateaus	Slow	0.5–1.5	0.20
Togcha	Very deep, somewhat poorly drained and well drained, gently sloping soils; on plateaus and in basins	Slow	0.5–1.5	0.15
Ylig	Very deep, somewhat poorly drained and well drained, gently sloping soils; on plateaus and in basins	Medium	0.5–1.5	0.24
Limestone Uplands				
Chacha–Chacha Variant	Shallow, deep and poorly drained; on steep slopes, plateaus and hills	Medium	0.02–0.5	0.15
Guam Cobbly Clay Loam	Very shallow, well drained, nearly level to moderately sloping soils; on plateaus	Slow	5.0–15.0	0.05
Guam Urban Land	Very shallow and shallow, well drained, level to gently sloping soils, and Urban land; on plateaus	Slow	5.0–15.0	0.05
Ritidian–Rock outcrop	Very shallow, well drained, gently sloping to extremely steep soils, and rock outcrop; on plateaus, mountains, and escarpments	Very slow	5.0–15.0	0.02
Pulantat	Shallow, well drained, gently sloping to steep soils; on dissected plateaus and hills	Medium	0.02–0.5	0.24
Pulantat–Kagman–Clay	Shallow, deep, and very deep, somewhat poorly drained and well drained, nearly level to strongly sloping soils; on plateaus and hills	Medium	0.02–0.5	0.15
Coastal Lands				
Shioya Loamy Sand	Deep, rapidly permeable, well-drained soil; on coastal strands	Slow	15.0–50	0.15

Source: USDA 1988.

4.3 HYDROLOGY

As stated in Section 4.1, *Climate*, rainfall in Guam averages 93 inches (236 centimeters) a year, most of which falls during the wet season from June through November. See Figure 4-2 in Section 4.1, *Climate*, for the average annual distribution of rainfall in Guam. On average, southern Guam receives more rain than northern Guam, especially around NMS.

Water resources are sources of water available for use by humans, flora, or fauna, including surface water and groundwater. Surface water is classified as water that collects on the surface. Surface water resources are important for economic, ecological, recreational, and human health reasons. Groundwater may be used for potable water, agricultural irrigation, and industrial applications. Groundwater is classified as any source of water beneath the ground surface and is the primary source of potable water used to support human consumption in Guam. All surface water and groundwater in Guam discharges into the Pacific Ocean. The following description of Guam's hydrology (i.e., surface water and groundwater) has been adapted from Gingerich (2003), unless otherwise noted.

4.3.1 Surface Water

Surface water resources consist of rivers, streams, lakes, reservoirs, ponds, and wetlands. Guam has 97 rivers and streams, ranging in length from 0.6 mile (1 kilometer) to more than 3 miles (5 kilometers). All of the rivers and streams are found in the central and southern half of the island. Of Guam's named rivers and streams, 46 drain directly into the ocean. Figure 4-7 shows Guam's major rivers and streams and illustrates the lack of surface water in the northern part of the island. Figures 4-8a and 4-8b depict the major drainage basins or watersheds of Guam.

Northern Guam does not have perennial streams due to the karst geology of this area. Water in the area does not flow on the surface due to the high permeability of the limestone: runoff quickly infiltrates the limestone resulting in recharge of the freshwater groundwater lens. Due to the lack of perennial streams, there are no estuaries located in the northern part of the island.

In southern Guam, a mountain ridge runs along the western coast, creating small, steep drainage basins to the west. To the east, broader floodplains drain into longer, larger rivers. Southern Guam has many freshwater bodies including water impoundments such as the 30-acre (12-hectare) Masso Reservoir and 200-acre (81-hectare) Fena Valley Reservoir, the largest freshwater body in Guam. Ponds on golf courses, or created for agricultural purposes, are also common.

Stormwater is an important component of surface water systems because of its potential to introduce sediments and other contaminants that could degrade aquatic systems. The volume and velocity of stormwater flows can increase as a result of increases in impervious surfaces associated with buildings, roads, and parking lots. Higher densities of development require greater degrees of stormwater management because of the higher proportions of impervious surfaces. Failure to properly manage increases in stormwater runoff can result in downstream bank and channel scouring, water quality degradation, and downstream flooding. Stormwater management systems are designed to control flow volume and velocity and to convey precipitation away from developed sites to appropriate receiving waters. Properly designed management systems can reduce runoff volume and velocity to pre-development conditions and reduce the transport of sediments and other contaminants that would otherwise flow directly into surface waters.



Figure 4-7
Major Rivers and Streams in Guam

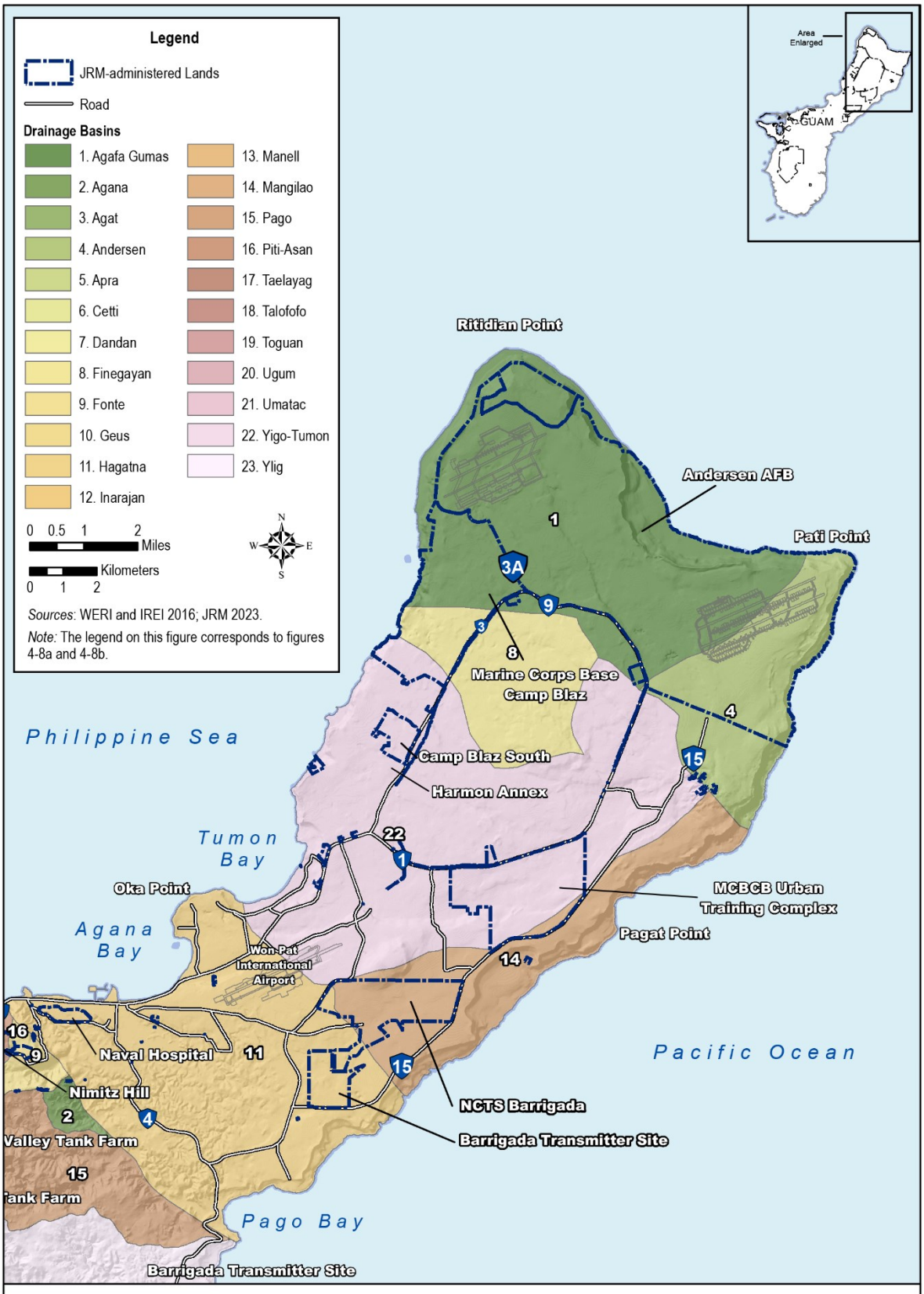


Figure 4-8a
Drainage Basins in Northern Guam

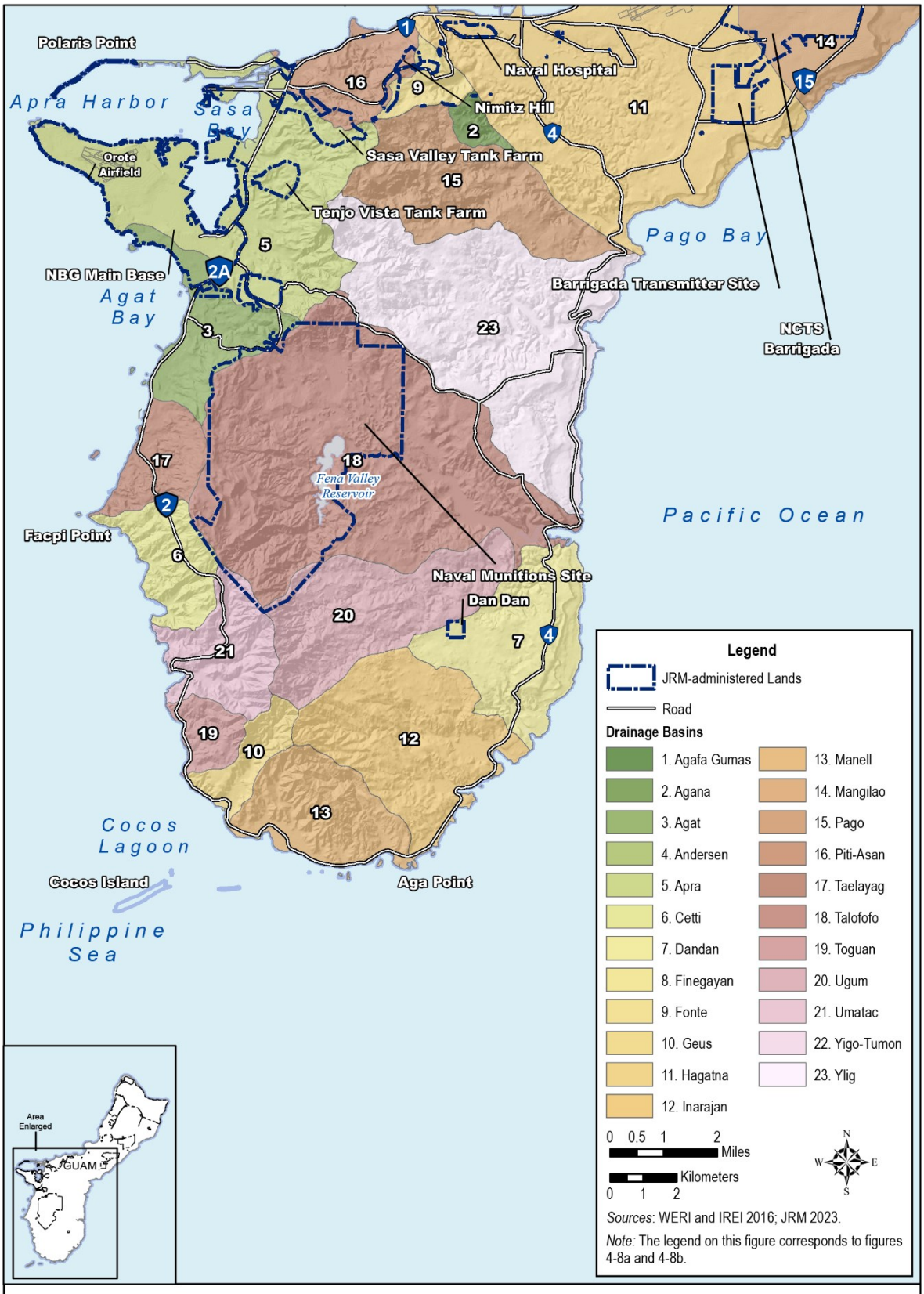


Figure 4-8b
Drainage Basins in Southern Guam

Generally, the quality of Guam's surface water is high, but it is vulnerable to contamination from sewage disposal overflows, animal waste, and sediment erosion that is carried into streams during periods of heavy rainfall. Inland surface water bodies are of highest quality, whereas coastal regions contain surface water bodies of moderate quality (Horsley Witten Group, Inc. 2006) (Figure 4-9).

4.3.2 Groundwater

On oceanic islands such as Guam, freshwater commonly forms a body of water called a freshwater lens that floats on denser saltwater and is separated from the saltwater by a transition zone of brackish water. The freshwater, brackish water, and saltwater are all part of the freshwater-lens system. Salinity in a freshwater-lens system is gradational, from an upper freshwater core through the underlying transition zone to saltwater. Freshwater-lens systems are recharged by direct infiltration of rainfall and by inflow from perched groundwater systems.

The primary aquifer in Guam is the Northern Guam Lens Aquifer (NGLA) that extends from the northernmost tip of the island to where the southern highlands start north of Apra Harbor. The NGLA is composed of six distinct groundwater sub-basins: Hagatna, Mangilao, Andersen, Agafa-Gumas, Finegayan, and Yigo-Tumon (Gingerich 2013) (Figure 4-10). The NGLA was designated as a sole-source aquifer in 1978 because it supplies drinking water to approximately 80% of the island's residents. Potable drinking water is obtained from approximately 180 wells that tap the upper part of the NGLA. Water levels in the NGLA vary daily and seasonally in response to ocean tides, recharge rates, and groundwater withdrawal. Daily fluctuation of water levels driven by tidal changes are about 0.5 foot (0.2 meter) in wells near the coast, but these fluctuations decrease as distance from the coast increases and as the permeability of the aquifer material decreases. Well water levels in limestone formations can increase several feet in a matter of days when large storm events and associated recharge occur. As rainfall is episodic and seasonal, lens volume fluctuates naturally with time. Groundwater discharges continuously throughout the year, but the lens shrinks during dry periods when recharge diminishes or ceases and expands when recharge increases. Discharge from the freshwater-lens system in northern Guam is by diffuse seepage near the coast and to subaerial and submarine coastal springs.

In southern Guam, perched water is found in areas where low-permeability rocks impede the downward movement of groundwater sufficiently to allow a perched water body to develop within otherwise unsaturated rocks. Minor perched systems are found in some of the higher-altitude limestone overlying the volcanic rocks of southern Guam. The height of the water table above sea level and the extent of the perched system are respectively dependent on the altitude and areal extent of the low-permeability rocks and the rate and duration of recharge. Water from perched systems can discharge to springs and streams or downward to a lower water table or evaporate into the atmosphere. As much of the groundwater discharges directly to stream valleys above sea level, where the ground surface intersects the water table, the main source of freshwater in southern Guam is from surface water, which runs off the weathered volcanic rocks that are exposed over much of the area.

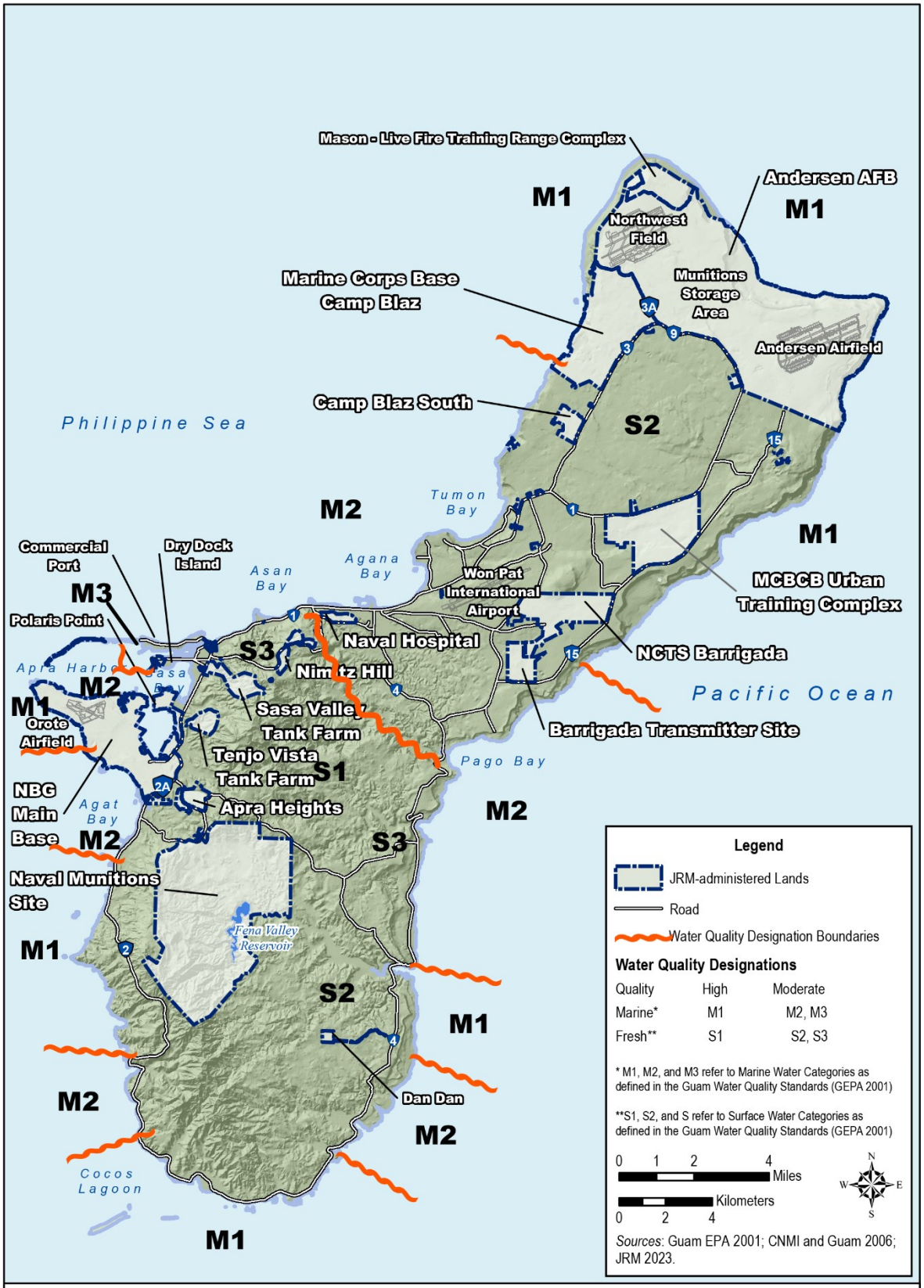


Figure 4-9
Surface and Marine Water Quality Criteria Designations in Guam

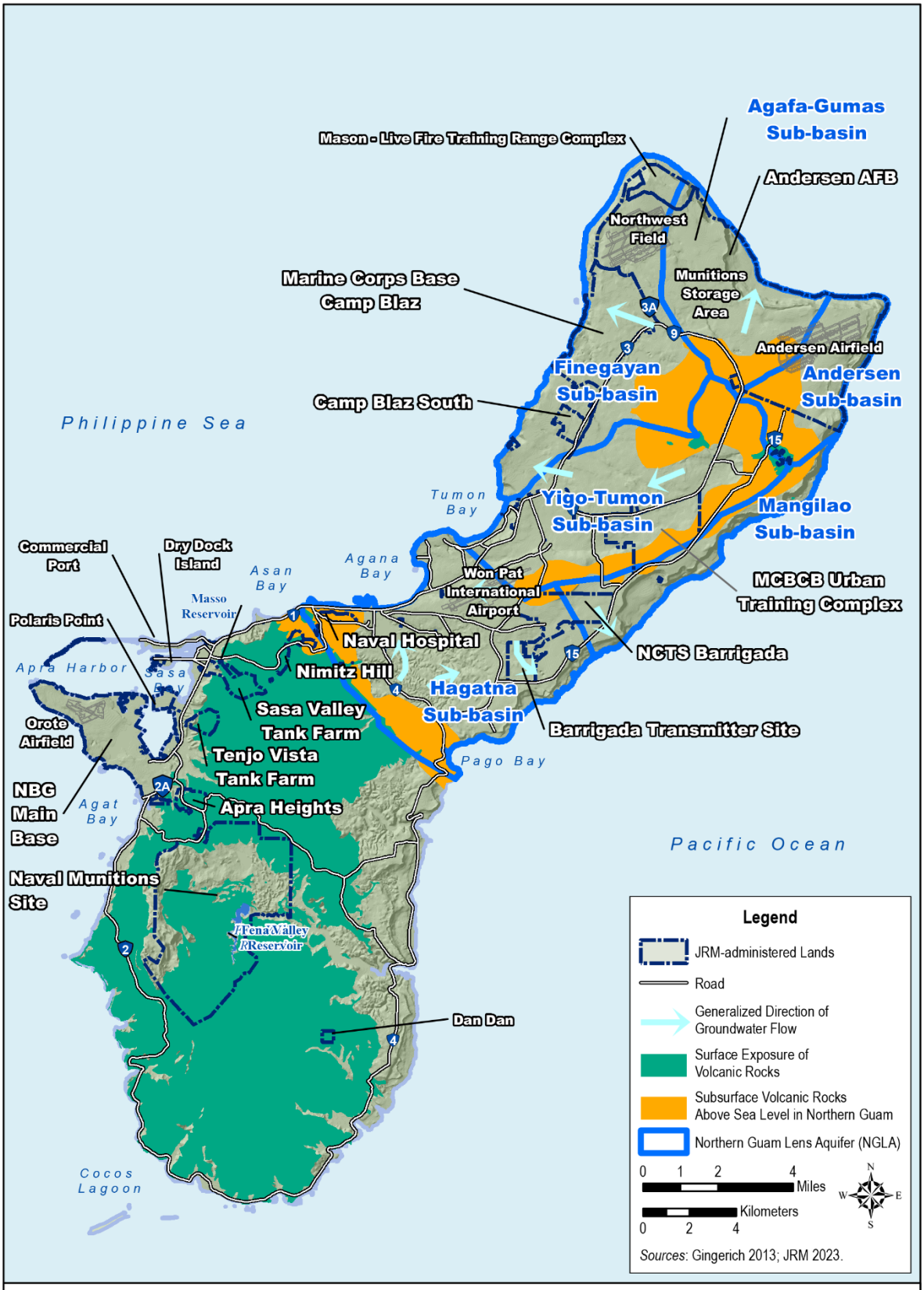


Figure 4-10
Groundwater Resources in Guam

4.4 TERRESTRIAL BIOLOGICAL ENVIRONMENT

The biological environment in Guam is comprised of native and non-native species. Native species are those that arrived to the island via natural dispersal, whereas non-native species are organisms that were introduced by humans, either intentionally or unintentionally. A non-native species is defined as, with respect to a particular ecosystem, an organism, including its seeds, eggs, spores, or other biological material capable of propagating that species, that occurs outside of its natural range. An invasive species is defined in Executive Order (EO) 13751, *Safeguarding the Nation from the Impacts of Invasive Species*, as a species that is non-native (i.e., alien or exotic) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human, animal, or plant health. Invasive species can be plants, animals, or other organisms (e.g., microbes). A non-native species may or may not be invasive. Some non-native species that were brought to the island occur occasionally but do not outcompete native plants for space and resources.

Invasive species have had a catastrophic effect on the native flora and fauna of Guam. Typically, islands have lower numbers of species than mainland areas, which results in fewer predators that would prey upon invasive species and fewer species to compete with invasive species for resources, thereby increasing the likelihood for establishment of invasive species on the island. Attributes of island biota that make it particularly sensitive to invasive species include small geographic ranges and population size, low reproductive rates, and inability to coevolve with invasive species and disturbed habitats. Abiotic disturbances, including typhoons and fire, contribute to the successful spread and establishment of invasive species, as well as provide points of entry to the interiors of forest fragments. These limitations in Guam have resulted in replacement of many island species by exotic and invasive species (Wiles et al. 2003).

To address pathways and encourage a more holistic approach to evaluating and managing terrestrial, marine, and freshwater invasive species risks, the United States (U.S.) Department of the Navy (DON) funded and assisted a multi-disciplinary effort of federal and regional scientists and experts to develop the Regional Biosecurity Plan (RBP) for Micronesia and Hawai‘i (formerly referred to as the Micronesia Biosecurity Plan) (DON 2015a). This effort functions in concert with the Guam Marine Biosecurity Action Plan (Miller 2014). The purpose of the RBP was to evaluate terrestrial, marine, and freshwater invasive alien species risks to Micronesia (i.e., Guam, Commonwealth of the Northern Mariana Islands [CNMI], Republic of the Marshall Islands, Republic of Palau, Federated States of Micronesia) and Hawai‘i. The RBP is a regionally vetted biosecurity plan that is intended to provide for the improvement and harmonization of biosecurity across Micronesia and Hawai‘i. The RBP provides stakeholders in Micronesia and Hawai‘i with a framework for implementation and a platform for coordination and integration of inter-agency invasive species management efforts such as control, interdiction, eradication, and research.

The final RBP became effective in March 2015 and consists of four volumes:

- Volume I: Overview and Strategic Implementation Plan
- Volume II: Executive Summary to the Risk Assessments and the Freshwater Systems Risk Assessment
- Volume III: Marine Systems Risk Assessment and Supplement to the Regional Biosecurity Plan for Micronesia and Hawai‘i Marine Risk Assessment
- Volume IV: Terrestrial Systems Risk Assessment

While the development of the RBP was a Conservation Measure in the 2010 Biological Opinion (BO) for the Guam Military Relocation, Attachment M of the RBP contains recommendations applicable to all DoD activities within JRM’s Area of Responsibility, and Volume III includes more than a dozen

recommendations specific to DoD. A commitment to implementing applicable recommendations was made in the 2015 BO for the Guam Military Relocation. A number of the DoD recommendations are currently incorporated as best management practices (BMPs) for Military Relocation actions in Guam, and JRM is working to further implement applicable DoD recommendations across all activities. To ensure the RBP remains current, DoD recommendations contained in Attachment M of the RBP will be updated, in coordination with responsible military components, on a 3-year cycle and will be communicated to regional stakeholders and partners.

The following sections provide a brief overview of the major terrestrial species, native and non-native, that occur in Guam. Further details regarding the installations and DoD properties are discussed as appropriate in each installation chapter, Chapters 5-9. See Appendix E for a complete list of plants and animals recorded on JRM-administered lands mentioned in this Integrated Natural Resources Management Plan (INRMP).

4.4.1 Vegetation Communities

The post-World War II (WWII) vegetation of Guam was described by Fosberg (1960), a comprehensive flora was published a decade later (Stone 1970), and an update to Fosberg (1960) was published in 1998 (Mueller-Dombois and Fosberg 1998). The U.S. Forest Service (USFS) (2006) also provided an important update and classification of Guam's vegetation communities. These authors demonstrated that Guam hosts a diverse flora of over 600 species of vascular plants, including more than 100 species of trees. In addition, the flora of Guam is unique, with 21% of its native vascular plants endemic to the Mariana Islands.

The distribution of vegetation in Guam is influenced by three main factors: (1) the sharply contrasting soil types between the north and south, (2) anthropogenic (e.g., development, fire, non-native ungulates, brown treesnake [BTS] [*Boiga irregularis*] predation) and natural (e.g., windthrow from hurricanes) disturbances, and (3) loss of seed dispersal from intact to degraded forests (Caves et al. 2013). The floristic complexity of Guam's plant communities and the absence of distinct associations of species have led ecologists to emphasize the underlying soils and the relative degree of disturbance in classifying plant communities rather than solely their floristic composition. Fosberg (1960) classified Guam's principal vegetation types based primarily on general soils and recognized that his grouping of the vegetation types did not result from any of the original plant communities because of the degree of modification by human activities. Stone (1970) adopted Fosberg's classification system and summarized the following nine vegetation types:

1. Forest on elevated hard limestone
2. Ravine forest
3. Marshes
4. Swamps-mangroves
5. Strand vegetation
6. Savannas on volcanic soils
7. Argillaceous limestone vegetation
8. Coconut (*Cocos nucifera*) groves
9. Weed communities

Donnegan et al. (2004) completed a forest inventory for Guam and estimated that approximately 48% of the island was forested. The forested area included 44,404 acres (17,970 hectares) classified as limestone forest, with most found in northern Guam, and 19,129 acres (7,741 hectares) classified as volcanic forest, with most found in southern Guam. Other vegetation or cover types included 44,455 acres (17,991 hectares) of savanna and 23,956 acres (9,695 hectares) of urban land.

In the past, vegetation communities in Guam military lands were independently mapped for each installation by DON and the U.S. Air Force (USAF). In 2015, DON funded a study to update and synchronize classifications used to describe vegetation communities for most JRM-administered lands in Guam (Naval Facilities Engineering Systems Command [NAVFAC] Marianas 2014a, 2015a). Areas included in the study were NBG Main Base, NMS, NBG Telecommunications Site (TS), and Andersen Air Force Base (AFB). The project included assigning vegetation community and other land use categories for all study areas based on aerial imagery and previous vegetation mapping. Some of these communities were also assessed through field verification during site visits (NAVFAC Marianas 2016a).

The 25 vegetation community categories developed in the study were determined to be the best representative descriptors given the following considerations: (1) the previous categories used within all study areas, (2) usefulness to environmental managers, (3) Guam-specific considerations, and (4) uniform naming of all categories to the extent possible. Descriptions of the vegetation communities defined in NAVFAC Marianas (2015a) are provided below. Vegetation communities and the acreages found on each military installation in Guam are provided in the Vegetation Communities section for each installation and DoD property in Chapters 5-9.

- *Acacia Plantation:* This community consists of planted species of *Acacia*. Of JRM sites, it is only present on NMS.
- *Antigonon leptopus:* This community is dominated by the small, non-native tree, hedge acacia (tangantangan) (*Leucaena leucocephala*), but the canopy is covered almost entirely by the non-native invasive climbing vine (i.e., chain-of-love vine, coral vine, or Mexican creeper [*Antigonon leptopus*]). The *Antigonon leptopus* community is most abundant on Orote Peninsula where it forms large and often pure stands that smother the underlying vegetation.
- *Bambusa Forest*: Dense monocultures of the non-native bamboo (*Bambusa vulgaris*) are typically found in small areas within ravine forests adjacent to streams or wet areas. This vegetation community is readily visible in aerial imagery.
- *Barren*: These areas are characteristic of barren, non-vegetated areas of soil, sand, or rock and occur both inland and along the coastline.
- *Casuarina Forest*: Ironwood (*Casuarina equisetifolia*), also known as Australian pine, tolerates dry and salty or exposed conditions. It forms a sparse forest or woodland with little understory. This vegetation community is readily visible in aerial imagery.
- *Coconut Forest*: Large areas of forest that are often dominated almost exclusively by the coconut palm are present in areas on Andersen AFB and NMS. These stands may have minimal understory or may support a relatively diverse understory of mixed native and non-native shrubs and herbs or ferns. Some of these stands are remnants of previous coconut plantations but others are likely due to natural dispersion. This vegetation community is readily visible in aerial imagery.
- *Developed:* These are human-occupied or otherwise highly disturbed areas that include lawns and other landscaped areas or actively maintained areas (e.g., mowed fields, utility corridors, etc.), buildings, roads, parking lots, and other paved areas.



Coconut forest found on Orote Peninsula at Spanish Steps.
(*Photo*: L. Shaughnessy)

- *Heterospathe Forest:* Small, wet areas that are heavily dominated by the Sagisi palm (*Heterospathe elata*).
- *Leucaena Forest:* This plant community typically occurs on limestone and is dominated by the small, non-native tangantangan. This plant community is most abundant on the Orote Peninsula where it forms large and often pure stands. In some places where it is found adjacent to native forest, it is invading the native forest and mixing with native woody species. This vegetation community is readily visible in high-quality aerial imagery.



Leucaena forest is dominated by the small, non-native tangantangan tree (_Leucaena leucocephala_), which creates open understory (left). While native woody species can be found scattered throughout a _Leucaena_ forest, the overstory is dominated by tangantangan (right), and is readily visible in high-quality aerial imagery.
(*Photo*: L. Shaughnessy)

- *Limestone Coastal Scrub:* This plant community is present on limestone terraces and cliff edges and is most common on Andersen AFB. The presence of drying winds, exposure to salt spray, and excessively drained limestone soils result in a microclimate that supports a stunted, wind-pruned plant community. The floristic composition may either be simple or complex and comprised of a few or many species. Species may include some of those found in limestone native forest (see below), such as nunu (*Ficus* spp.), but are stunted by the climatic conditions. Other woody species such as *Pemphis acidula* and qualitay (*Callicarpa candicans*) are found near coastlines.
- *Limestone Degraded Forest:* Limestone forest plant communities in many areas have been significantly disturbed by clearing, invasive plants, and introduced animal species. This plant community has one or more of the following characteristics: (1) dominated by a variety of non-native woody species, (2) substantial forest clearings visible in aerial imagery, or (3) dominated by pago (*Hibiscus tiliaceus*), a tree species usually indicative of disturbance in Guam's limestone forests. The most common non-native tree species in limestone degraded forest are vitex (*Vitex parviflora*), a non-native medium- to large-sized tree (in many areas it forms a monotypic canopy, and this community type is separated and described below) or tangantangan. Native tree species in these forests usually include one or more of the following: *Premna serratifolia*, kafu (*Pandanus tectorius)*, paipai (*Meiogyne cylindrocarpa)*, and mapunyao (*Aglaia mariannensis*). The limestone degraded forest community was categorized separately from the limestone native forest community due to the prevalence of these degraded lands in Guam and to aid natural resource managers in identifying areas for potential restoration. "Secondary limestone forest" was a vegetation classification term used in previous classification schemes. This term was not used in the current vegetation classification scheme because this term typically indicates that the forest has been previously cleared. However, there are areas labeled as limestone degraded forest throughout

the JRM installations evaluated where it is not clear if degradation was caused by human activity, ungulate activity, and/or invasive plant encroachment.

- *Limestone Native Forest:* This community type is a relatively undisturbed (i.e., never totally cleared) forest on shallow limestone soils and is dominated by native tree and shrub species. Forest clearings, resulting from ungulate or other disturbances, are absent or very limited based on aerial imagery. The term "primary limestone forest" has sometimes been used in the past and refers to forests that have never been totally cleared. However, for this study, the limestone native forest community name is used, which may include previously cleared areas that have regrown to be dominated by native tree and shrub species. Dominant tree species in these forests usually include one or more of the following: fagot (*Ochrosia* [=*Neisosperma*] *oppositifolia*), nunu, *P serratifolia*, *Pandanus* spp., *M. cylindrocarpa,* pago*,* beach cherry (*Eugenia reinwardtiana*), gulos (*Cynometra ramiflora*), *Aglaia mariannensis*, and macaranga (*Macaranga thompsonii*). The very large canopy-emergent trees, seeded breadfruit (*Artocarpus mariannensis*), or joga (*Elaeocarpus joga*), may be present. Faniok (*Merrilliodendron megacarpum*) and a few other species are dominant in small areas. *Ochrosia mariannensis* may also be dominant on Andersen AFB in edge habitats, and, although it is of small stature, dense stands dominated by this species are considered limestone native forest. This community was previously identified as eight categories in the Andersen AFB (2008) vegetation classification system.



Limestone native forest featuring *Cycas micronesica* and fagot (*Ochrosia* [=*Neisosperma*] *oppositifolia*) in the understory below a canopy of gulos (*Cynometra ramiflora*).
(*Photo*: L. Shaughnessy)

- *Non-native Forest:* This community encompasses small areas of forest that are often dominated almost exclusively by non-native tree species (e.g., teak [*Tectona* spp.], *Tabebuia* spp., *Acacia* spp.). It is present on NBG on Orote Peninsula and NMS.
- *Open Water:* Natural and man-made areas of open water.
- *Other Shrub/Grassland:* This community is characterized by the presence of shrubs and grasses. Other shrub/grassland communities are often present in degraded forest areas as clearings with herbaceous vegetation and scattered shrubs. Also included in this category are areas that have been cleared in the relatively recent past or are being mowed periodically to prevent forest regeneration. These areas may consist primarily of grassland with limited regrowth of woody species. Areas dominated by swordgrass (*Miscanthus floridulus*) are not included and instead are separated into the savanna complex community (see below).
- *Pimenta Forest:* Small areas on somewhat dry limestone ridges and slopes in northern NMS are dominated by the non-native bay rum tree (*Pimenta racemosa*). Few other woody plants grow in areas dominated by this species. Where the bay rum tree is concentrated, it is spreading into adjacent areas. This vegetation community is readily visible in high-quality aerial imagery.

- *Ravine Forest:* This community is characterized by forest vegetation on volcanic or on argillaceous limestone soils in valleys and ravines in southern Guam. Ravine forest communities can be quite variable in floristic composition due to soil moisture, microclimate, and disturbance regime. Common species found within ravine forest include coconut, gulos, *P. tectorius*, pago, noni (*Morinda citrifolia*), and *P. serratifolia*. Langaasag (*Barringtonia racemosa*) is a dominant tree in forested wetland areas of eastern NMS and are typically the predominant native species in ravine forests. This species may form thick stands in some areas. In some areas the non-native betelnut palm (*Areca catechu*) is often present in areas that are moist and humid, and vitex is often present in areas that are dry (see also *Vitex* forest below). In some areas, the differentiation between limestone forest and ravine forest was difficult to determine. Soils and topography, in addition to vegetation, were used to help distinguish these vegetation communities (USDA 1988). At times, the betelnut palm was used as an indicator species for the ravine forest community due to its consistent presence in moist ravine areas and its high visibility in aerial imagery.



Ravine forest from above (left) and below (right) the canopy. Coconut (*Cocos nucefera*) and betelnut (*Areca catechu*) palms are dominant features in this ravine forest found on NMS.
(*Photo*: L. Shaughnessy)

- *Savanna Complex:* Savannas are defined as grasslands with scattered or clumps of woody vegetation. Savanna complex is predominantly found on highly weathered volcanic soils and can be the result of fire, grazing, cultivation, or clearing. Swordgrass is the primary grass species in Guam. In some areas, bare mineral soil is present from erosion of the clumping characteristic of swordgrass. This community is present in large areas of NMS, where it is often intersected by drainage ravines. Swordgrass is highly visible in aerial imagery.



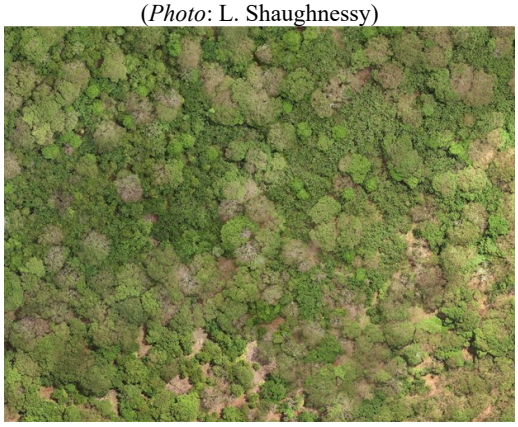
Savanna complex, or grasslands with scattered or clumped woody vegetation and intersected by ravines, can be easily seen across the hills on NMS.
(*Photo*: L. Shaughnessy)

- *Scrub/Shrub:* This plant community is characterized by the predominance of low-stature woody vegetation that may be a mixture of native and non-native species. The vegetation may be comprised of a secondary thicket of woody species but may also include some interspersed herbaceous vegetation. The woody vegetation is too low or sparse to be characterized as forest. The low-stature character may be caused by human disturbance or physical conditions, such as fire, soil saturation, or poor soils. The limestone coastal scrub community is a type of scrub/shrub community growing in coastal areas that has been separated into its own vegetation category.

- *Spathodea Forest:* This forest community is heavily dominated by the non-native African tulip tree (*Spathodea campanulata*). It is present on Marine Corps Base (MCB) Camp Blaz.
- *Strand:* Strand plant communities are flat, sandy areas behind coastal bare beach areas, and are found primarily on Andersen AFB. Strand vegetation is adapted to excessively drained soils and salt spray from the adjacent coastal waters. These areas are occasionally inundated with saltwater during storm events which imposes a controlling influence on the vegetation. Plants that typically compose this vegetation community include ironwood, tree heliotrope (*Tournefortia argente*), coconut, yellow necklacepod (*Sophora tomentosa*), nanaso (*Scaevola taccada*), and beach morning glory (*Ipomoea pes-caprae*).



Tree heliotrope (*Tournefortia argente*) growing on a section of strand in northern Andersen AFB. (*Photo*: L. Shaughnessy)



Aerial imagery of *Vitex* forest at Andersen AFB. (*Photo:* USFS 2014)

- *Vitex Forest:* This community is usually dominated by vitex, a medium- to large-sized tree in the canopy layer. In some areas, pago may also be scattered through the community. The understory of this forest community is often dominated by the native *P. tectorius*, which may be present as small trees, shrubs, or saplings. This community is prevalent within all study areas addressed in this report with the exception of NBG Main Base, and, in most areas, is readily visible in high-quality aerial imagery.
- *Wetland Herbaceous**: This community is dominated by herbaceous species, and, in most cases, they are floristically simple, with only a few dominant plant species. The most common herbaceous species is tall reed (*Phragmites karka*), a perennial grass that often forms a dense monoculture. This species is often visible in aerial imagery. In some areas, bulrushes, sedges, and other grasses may also be common.
- *Wetland Mangrove**: This community is located in estuaries and is characterized by flooded, brackish water conditions and the dominance of one or more tree or shrub species that are only found in this type of habitat. Species present in this community include loop-root mangrove (*Rhizophora mucronata*) and white mangrove (*Avicennia marina*).
- *Wetland Shrub/Herb**: Wetland plant communities are found in areas subject to permanent or periodic inundation or prolonged soil saturation by either fresh or brackish water. Areas mapped as wetland shrub/herb are dominated by shrubs or a mixture of shrubs and herbs. Wetland shrub/herb communities are located in low-lying areas along the coast, along streams, in depressions, or in poorly drained areas with volcanic soils. Pago is the woody species usually associated with these wetlands.

*Areas mapped as wetland vegetation communities were defined as such only when wetland boundaries were known with some confidence based on previous site visits and interpretation of aerial imagery. These communities do not fall into the category of delineated wetlands as defined by the Clean Water Act (CWA).

Non-native Species

Invasive plant species have affected all terrestrial environments in Guam and have limited the ability of native plants to sustain significant populations. These species are generally very aggressive and can displace native vegetation for resources such as water and nutrients. Disturbances due to human activity, feral ungulates, or other causes have the effect of making areas vulnerable to the establishment of invasive species. For example, wildland fires are often illegally and intentionally set in Guam, leading to increased spread and establishment of invasive species. Fires cause erosion along the forest edge and increase the spread of both native grasses (such as swordgrass) and non-native invasive species. Some of the invasive plant species present in Guam are of particular concern to JRM natural resources staff due to their abundance, aggressive growth, and invasion of native habitats. These species of particular concern are summarized in the following paragraphs from the USFS Pacific Island Ecosystems at Risk project (USFS 2013) and the Guam Department of Agriculture's Guam Statewide Forest Resource Assessment and Resource Strategy (Guam Department of Agriculture 2010).



Chromolaena (*Chromolaena odorata*) is an herbaceous weed that grows in dense stands. (*Photo*: L. Gutierrez)

- Chromolaena (*Chromolaena odorata*)*:* Chromolaena, also known as Siam weed, grows in dense stands, outcompeting native species and preventing the establishment of other species via allelopathy. Chromolaena is a skin irritant and an allergen. The establishment of this species can lead to uncontrollable brushfires.
- Tangantangan: Tangantangan is a fast-growing nitrogen-fixing tree that has typically been planted as a windbreak or for reforestation and erosion control. It can form dense monotypic thickets that replace naturally occurring vegetation communities and is difficult to eradicate once established. Tangantangan is insect pollinated, wind dispersed, and spreads and establishes easily on disturbed soils such as road edges and clearings. Flowering and fruiting occur throughout the year, with individuals also being capable of self-fertilization (Global Invasive Species Database [GISD] 2010).
- Guinea grass (*Megathyrsus maximus = Panicum maximum*): Guinea grass is native to the Old World tropics, but has become widely naturalized in tropical countries worldwide, where it is often used as a forage grass. It is an invader of open grasslands, riverbanks, and forests, and is adapted to a wide variety of well drained soils. Guinea grass is shade-tolerant and can displace native species by forming dense stands that grow to a height of up to 6 feet (2 meters) and shade-out and outcompete native seedlings. It is very drought and fire resistant, producing abundant biomass as fuel for wildfires and regenerating quickly afterwards (GISD 2006).
- Bitter vine or mile-a-minute vine (*Mikania micrantha*): Bitter vine is a fast-growing perennial vine that interferes with the growth of native vegetation, where its climbing behavior poses a competition for light and potentially nutrients and water. It also releases chemicals to inhibit the growth of other plants. It occurs in coastal and riverine areas, forest edges, and disturbed sites. Bitter vine also has a variable growth form: it can either grow 3 to 13 feet (1 to 4 meters) tall with strong support or remain as a matted ground cover (GISD 2005a).
- Ivy gourd (*Coccinia grandis*): Ivy gourd is a perennial vine that forms a dense canopy over underlying vegetation, preventing the production of flowers and fruits and forage for native wildlife

(GISD 2005b). Although not common in native landscapes to date, ivy gourd has become a severe pest in gardens, on utility poles, disturbed areas, and roadsides. In Guam, ivy gourd's sole dispersal method is through roots, pieces, and cuttings, as the entire ivy gourd population is male (GISD 2005b). Biocontrol methods in Guam have been effective, particularly use of the weevil (*Acythopeus burkhartorum*) and stem-boring moth (*Melittia oedipus*) (Reddy et al. 2011; Muniappan and Reddy 2015). In addition, the U.S. Fish and Wildlife Service (USFWS) has identified the ivy gourd as a threat to those plant species in Guam that are listed under the federal Endangered Species Act (ESA) (USFWS 2015a).

- Indian snakeweed (*Stachytarpeta indica*): Indian snakeweed is an aggressive woody sub-shrub that outcompetes native plants and grows in disturbed areas, such as along roadsides, forest gaps, pig wallows, fallow fields, and forest edges. It is also known to grow in rice fields and coconut plantations.
- Giant sensitive plant (*Mimosa diplotricha*): In Guam, giant sensitive plant is found in disturbed habitats such as roadsides, dumpsites, and cleared limestone areas. It smothers other plants by growing over the top of them. Once established, giant sensitive plants can prevent animals from using the natural forage.
- Chain-of-love vine: Chain-of-love vine smothers other plant communities by blocking sunlight. It also produces large quantities of seeds that are spread by water and animals that consume the fruits. Control is difficult due to tubers that re-sprout after cutback of vegetative growth.
- Mission grass (*Pennisetum polystachion*): Mission grass competes with native plant species, especially on open hillsides. Well established populations can serve as a fuel source for brushfires.



The chain-of-love vine (*Antigonon leptopus*) forms large and often pure stands that smother the underlying vegetation.
(*Photo*: L. Shaughnessy)

- Common bamboo (*Bambusa vulgris*): Common bamboo grows in very dense clumps, displacing native vegetation. It also spreads rapidly by its rhizomes. Its vegetative shoots are a food source for feral pigs (*Sus scrofa*).
- Burr marigold (*Bidens pilosa*): Burr marigold is abundant in disturbed areas in Guam. It is extremely common in waste grounds and at the fringes of forest, at times forming dense thickets nearly 3 feet (1 meter) tall (Stone 1970).
- Burr grass (*Cenchrus echinatus*): Burr grass is common in disturbed sites, particularly near the ocean, on beaches, and on limestone soils. It colonizes bare or open ground, quickly filling gaps in cultivated fields, abandoned fields, pastures, field margins, along roadsides, in lawns, on dunes, along river sands, and in sandy soils along beaches. The plants can withstand repeated defoliation in lawns, in frequently harvested forage crops, or in pastures (Holm et al. 1977).
- Tall reed: Although a native species, tall reed can form dense, monotypic stands in disturbed wetland habitat, resulting in the suppression of other native species. For this reason, it is of particular concern to JRM natural resources staff and listed with other non-native invasive species.

- African tulip tree: The African tulip tree invades agricultural areas and natural ecosystems. This tropical plant smothers other trees and crops, often becoming the dominant plant in the area. It spreads rapidly by sending up shoots from its roots and is considered one of the 100 most invasive plants worldwide (DON 2009).
- Vitex: Vitex is a tree from the Philippines that was introduced to Guam prior to 1970 and has since become a common component of forests on the island. Vitex quickly establishes in disturbed areas, displacing native vegetation. It produces numerous seeds, which are spread by birds, Philippine deer (*Rusa marianna*), feral pigs, and other animals. *Vitex negundo* var. *bicolor* also occurs in Guam, but it is believed to be a native species and is not invasive (Stone 1970).
- *Triphasia trifolia*: *T. trifolia* is a common, naturalized shrub present in limestone forests, often forming dense, impenetrable spiny thickets of undergrowth along forest edges, coastal strand/limestone, cliffline edges, and disturbed forests. This species flowers and spreads by sprouting from roots and dispersal of seeds by birds (DON 2009).
- Bay rum: Bay rum is a tree native to the Caribbean and northern South America. It has been reported as introduced in a few African and Asian countries, Pacific islands, and Florida. It has been recorded as invasive only in the Pacific, including some of the Cook Islands, Fiji, Hawai‘i, and Tonga, where it can form dense patches that crowd out native species (Centre for Agriculture and Biosciences International 2018). Bay rum flowers occasionally in Guam and spreads primarily by rhizomes/roots.
- Custard apple (*Annona reticulata*): Custard apple forms dense, monotypic stands that displace native vegetation. It is a prolific fruit bearer and a food source for feral pigs, which help to accelerate seed dispersal.
- Cuban pink trumpet tree or white cedar (*Tabebuia pallida*): This tree is a characteristic species of tropical dry and moist forests in its native range of Florida and the Caribbean. It is propagated by wind-borne seed and establishes well in disturbed sites and volcanic slopes. It forms dense thickets that shade-out native plants, strongly reducing species richness and displacing native savanna complex vegetation. Due to this growth behavior, regeneration of native shrubs and trees is prevented, hindering natural succession and forest regeneration (USFS 2013; USDA Natural Resources Conservation Service [NRCS] 2017).



African tulip tree (*Spathodea campanulata*)
(*Photo*: L. Gutierrez)



***Triphasia trifolia* often forms dense thickets in the understory of disturbed limestone forests.**
(*Photo*: L. Gutierrez)



Chinese inkberry or day jasmine (*Cestrum diurnum*)
(*Photo*: L. Gutierrez)

- Chinese inkberry or day jasmine (*Cestrum diurnum*): This large, woody shrub is dispersed by seed via birds and forms dense thickets in disturbed limestone forest gaps and open fields. Initially, it was widespread in Guam but is now more of a localized nuisance, possibly indicating local limiting factors (USFS 2013; USDA NRCS 2017).
- Creeping oxeye or Singapore daisy (*Sphagneticola trilobata*): Originally used as an ornamental, this plant thrives in agricultural areas, along roadsides and trails, in open lots, waste places and garbage dumps, and other disturbed sites. It forms a dense ground cover, crowding out or preventing regeneration of other species. This species propagates vegetatively and commonly spreads by dumping of garden waste (USFS 2013).
- *Tetrastigma pubinerve*: A member of the grape family, this climbing vine thrives in hot, sunny conditions and can drape a tree or fence, forming a dense screen that smothers other plant communities by blocking sunlight (USFS 2013).

4.4.1.1 Effect of Brown Treesnake on Native Vegetation

Conservation of native forest vegetation in the Mariana Islands is strongly dependent upon seed dispersal by avian frugivores (Caves et al. 2013). Recently, Caves et al. (2013) provided experimental evidence demonstrating the cessation of native plant seed dispersal from intact to degraded forests in Guam due to the loss of avian frugivores from BTS predation. This problem complicates the management of native forest restoration efforts, and as a result, numerous INRMP strategies and actions for individual installations in Guam address this issue.

4.4.2 Terrestrial Wildlife

The current distribution, diversity, and abundance of wildlife species in Guam is related to habitat fragmentation/loss, invasive species, and management efforts by federal and territorial natural resources programs. Native wildlife populations have dramatically declined, while introduced avian, mammal, reptile, and amphibian species have become more abundant (Christy et al. 2007; Rodda and Savidge 2007).

4.4.2.1 Mammals

Native Species

Historically, three species of bats (Mariana fruit bat [*Pteropus mariannus mariannus*], little Mariana fruit bat [*Pteropus tokudae*], and Pacific sheath-tailed bat [*Emballonura semicaudata rotensis*]) were the only native mammals in Guam (Wiles 2005). The Mariana fruit bat is federal ESA-listed as threatened, the little Mariana fruit bat is considered extinct, and the Pacific sheath-tailed bat has been extirpated from Guam. See Section 4.4.3, *Terrestrial Protected Species*, for additional information regarding threatened and endangered mammals in Guam.

Non-native Species

The current distribution, diversity, and abundance of wildlife species on Guam is related to habitat fragmentation/loss, invasive species, and management efforts by federal and territorial natural resources programs. directly related to the occurrence of the introduced brown tree snake (BTS). Although native wildlife populations have dramatically declined, other introduced avian, mammal, reptile, and amphibian

species have become more available and abundant as food resources for the BTS (Christy et al. 2007; Rodda and Savidge 2007). A total of 14 non-native mammal species have been introduced and established in Guam. Spanish introductions included Asiatic water buffalo or carabao (*Bubalus bubalis*), Philippine deer, dogs (*Canis familiaris*), cats (*Felis catus*), feral pigs, goats (*Capra hircus*), and cattle (*Bos taurus*). Other introduced species include the Asian house shrew (*Suncus murinus*), house mouse (*Mus musculus*), black rat (*Rattus rattus*), Malaysian house rat *(Rattus rattus diardii*), Asian house rat (*R. tanezumi*), Norway rat (*R. norvegicus*), and Pacific rat (*R. exulans*) (Wiles 2005).

Many of the native species in Guam are imperiled due to loss of habitat and introduced species, such as feral cats and dogs, shrews, and feeding behavior of ungulates, such as the Philippine deer and feral pig. Rat species have colonized the island and prey on the eggs and young of native species and destroy native flora (USFWS 1990, 2009a; Wiles et al. 2003; Wiewel et al. 2009).



Feral pigs (*Sus scrofa*) foraging. Two female adults seen with piglets.
(*Photo*: A. DeNicola 2015)

Dogs and cats, both as pets and feral, are a common occurrence on Guam. Each military command in Guam provides detailed instructions for the boarding, transportation, quarantine, vaccination, and registration of pet dogs and cats. Feral dogs and cats have detrimental impacts to public health and safety and to populations of native wildlife (Nogales et al. 2004; Young et al. 2011; Lardner et al. 2013) through aggressive behavior, predation on wildlife, and the spread of parasites and disease. A joint instruction from the U.S. Army, Navy, and Air Force prohibits dogs, cats, and other privately owned or feral animals from running at large on military installations (Army Regulation 40-905/Secretary of the Navy Instruction [SECNAVINST] 6401.1B/Air Force Instruction [AFI] 48-131 2006) and more specific guidance is issued by the installations. The number of feral dogs and cats in Guam was last estimated in 1967 as between 20,000 and 60,000 (Glosser and Yarnell 1970). One study in 2014 estimated a population of 61,000 dogs (owned and feral) (Boone 2014). Furthermore, there is a perception that feral dog populations are on the rise in Guam (Chargualaf 2017; Bocanegra 2017). USDA Animal and Plant Health Inspection Service (APHIS) Wildlife Services in Guam removed 11 free-ranging dogs and 21 feral/free-ranging cats from the wild in 2016. Dogs and cats as threats to native wildlife are also addressed in the RBP for Hawai‘i and Micronesia (DON 2015a) and in the Guam Division of Aquatic and Wildlife Resources (Guam DAWR) Guam Wildlife Action Plan (2019).



Ungulate rooting has caused significant damage to the trunk of a *Cycas micronesica*, an ESA-listed tree native to Guam.
(*Photo*: L. Shaughnessy)

Feral pigs, deer, and Asiatic water buffalo (carabao) impact forest composition and native species in multiple ways. Ungulates tear up the ground rooting in soil for earthworms, rhizomes, and tubers, causing damage to roots, seeds, seedlings, and saplings and can be vectors for parasites and diseases (Weaver 2022). Native tree seedlings tend to grow slower than non-native trees and remain more susceptible to grazing than faster growing non-native species (Schreiner 1997; Perry and Morton 1999; Ritter and Naugle 1999). Overgrazing destroys foliage, fruits, and flowers. These actions reduce canopy cover, which alters the amount of light and humidity in the forest, thus altering soil properties such as temperature, salinity, and soil structure. Additionally, this causes a disruption to ecosystem function by increasing the rate of decomposition and evaporation (Ford and Grace 1998). Damage to forest understory increases the likelihood for non-native plants to establish and outcompete native species (Diong 1982; LaRosa 1992; Stone et al. 1992). Trampling causes soil compaction and leads to nutrient depletion (Van Driesche and Van Driesche 2004), while tree rubbing removes bark and can eventually kill the plant. The combined effect of the various types of ungulate damage eventually leads to barren land and causes extensive soil erosion (Tep and Gaines 2003; Liddle et al. 2006).

4.4.2.2 Birds

Native Species

Of the approximate 132 bird species recorded in Guam, 105 are migratory or wintering non-breeding species, 7 are breeding residents, and 14 are extinct or extirpated from Guam (Wiles 2005). Of the 14 extinct or extirpated species, 13 were directly impacted by the introduced BTS, and predation by the BTS was likely the single most important factor in the decline of these species. The remaining extinct or extirpated species, the mallard (*Anas platyrhynchos*), went extinct in Guam in 1967 due to habitat loss and overhunting (USFWS 2004a). The seven breeding resident species include yellow bittern (*Ixobrychus sinensis*), Pacific reef heron (*Egretta sacra*), Mariana common moorhen (*Gallinula chloropus guami*), brown noddy (*Anous stolidus*), white tern (*Gygis alba*), Mariana swiftlet (*Aerodramus bartschi*), and Micronesian starling (*Aplonis opaca*). The black noddy (*Anous minutus*) is known to nest only on Cocos Island. The yellow bittern is the only native land bird that is still considered to be common in Guam. The moorhen, swiftlet, and starling are all federal and/or Guam ESA-listed species and are addressed in Section 4.4.3, *Terrestrial Protected Species*. The non-native breeding species are addressed below. Appendix E provides a list of all bird species currently known to occur in Guam, including those listed under the Migratory Bird Treaty Act (MBTA).

Common seabird species seen in Guam include brown noddy, white tern, black noddy, and brown booby (*Sula leucogaster*). The coastal islets, reef flats, grassy fields, and other open areas in Guam provide seasonal foraging habitat to many migratory avian species. Most common among the annual visitors to the island are the Pacific golden plover (*Pluvialis fulva*), lesser sand plover (*Charadrius mongolus*), grey-tailed tattler (*Tringa brevipes*), whimbrel (*Numenius phaeopus*), ruddy turnstone (*Arenaria interpre*s), and Western cattle egret (*Bubulcus ibis*) (Wiles 2005).

Non-native Species

There are seven known non-native avian species that are resident breeders in Guam. Some were unintentionally introduced while others were intentionally introduced to provide hunting resources. These six introduced avian species include the island collared dove (*Streptopelia bitorquata*), rock dove (*Columba livia*), Eurasian tree sparrow (*Passer montanus*), black francolin (*Francolinus francolinus*), blue quail or king quail (*Excalfactoria chinensis*), black drongo (*Dicrurus macrocercus*), and jungle fowl (*Gallus gallus*). Introduced by the Spanish in 1771, the island collared dove is one of the most common species in Guam. The Eurasian tree sparrow and rock dove are commonly observed in small flocks, usually in urbanized areas. Black francolins were introduced to southern Guam as a game bird by the USFWS in 1961 and inhabit savanna and forest edge communities across Guam. The Spanish introduced the blue quail from the Philippines in 1894 as a game bird (Baker 1951). It is uncommon within the grasslands of southern Guam. The black drongo was introduced to the Mariana Islands by the Japanese in the 1930s and occurs mostly in developed areas. These introduced avian species persist in the presence of BTS likely due to the roosting and nesting selections and are known prey items for BTS, especially in urban areas (Vice et al. 2005).

4.4.2.3 Reptiles and Amphibians

Native Species

There is little consensus in the scientific literature on the biogeography of Guam reptiles and amphibians. Few scientists are willing to offer definitive statements about which species are native or introduced. Due to predation by the introduced BTS, of the 14 terrestrial reptile species originally found in Guam that are considered to be native, only 9 are known to currently occur. Seven of these native reptile species known to currently occur include the mutilating gecko (*Gehyra mutilata*), monitor lizards (*Varanus tsukamotoi*), Pacific blue-tailed skink (*Emoia caeruleocauda*), tide-pool skink (*Emoia astrocostata*), moth skink (*Lipinia noctua*), Pacific slender-toed gecko (*Nactus pelagicus*), and mourning gecko (*Lepidodactylus lugubris*) (Rodda et al. 1992; Rodda and Savidge 2007; Weijola et al. 2020; NAVFAC Pacific 2010, 2011a, 2013a, 2013b). The Pacific blue-tailed skink and mourning gecko are common, while the mutilating gecko is uncommon in many areas but locally common in others. The moth skink, tide-pool skink, and Pacific slender-toed gecko are rare and currently known only from restricted localities (NAVFAC Pacific 2010, 2011b, 2013a, 2013b).



Pacific blue-tailed skink (*Emoia caeruleocauda*)
(*Photo*: L. Shaughnessy)



Mourning gecko (*Lepidodactylus lugubris*)
(*Photo*: L. Shaughnessy)

Management projects are implemented to control monitor lizards in areas of highest conservation concern. They are typically found in the forested habitats or associated edges and disturbed habitats and have also been observed in more developed areas. Guam's monitors have adapted to disturbed habitats and eat a variety of invertebrates and vertebrates (Dryden 1965). Rodda et al. (1992) suggested that juvenile monitor lizards are preyed upon by BTS. Pregill and Steadman (2009) suggest that some are killed by people and others possibly die from ingesting marine toads (*Rhinella* [=*Bufo*] *marina*).

Five native species are considered extirpated from Guam: snake-eyed skink (*Cryptoblepharus poecilopleurus*), azure-tailed skink (*Emoia cyanura*), Micronesian gecko (*Perochirus ateles*), oceanic gecko (*Gehyra oceanica*), and Slevin's skink (*Emoia slevini*). The Government of Guam (GovGuam) lists all of these species as endangered under the Guam ESA. Presently, the oceanic gecko and Slevin's skink are only found on Cocos Island. Slevin's skink was recently listed as endangered under the federal ESA. See Section 4.4.3, *Terrestrial Protected Species*, for additional information regarding threatened and endangered reptiles in Guam, including sea turtles.

Non-native Species

Five non-native terrestrial reptiles have been introduced to Guam: BTS, Brahminy blind snake (*Ramphotyphlops braminus*), curious skink (*Carlia ailanpalai*), house gecko (*Hemidactylus frenatus*), and green anole (*Anolis carolinensis*).



Curious skink (*Carlia ailanpalai*)
(*Photo*: L. Shaughnessy)

Five species of introduced freshwater turtles are believed to have breeding populations in Guam and include the Chinese soft-shell turtle (*Pelodiscus sinensis*), three-toed box turtle (*Terrapene carolina triunduis*), red-eared slider (*Trachemys scripta elegans*), Chinese stripe-necked turtle (*Mauremys sinensis*), and the common snapping turtle (*Chelydra serpentina*) (Leberer 2003; Kerr 2013a).

Although there are no native amphibian species in Guam, 11 non-native amphibians have been introduced: marine toad, greenhouse frog (*Eleutherodactylus planirostris*), eastern dwarf tree frog (*Litoria fallax*), Guenther's Amoy frog (*Sylvirana guentheri*), Pacific chorus frog (*Pseudacris regilla*), slender-digit chorus frog (*Kaloula picta*), white-lipped tree frog (*Polypedates leucomystax*), crab-eating frog (*Fejervarya cancrivora*), marbled pygmy frog (*Microhyla pulchra*), grass frog (*Fejervarya limnocharis*), and Hong Kong whipping frog (*Polypedates megacephalus*). Zug (2013) lists the Hong Kong whipping frog as *P. braueri* and comments that *braueri* was separated from *megacephalus* in 2011. Zug (2013) also notes that the identity of the Hong Kong whipping frog in Guam is tentative, although Guam individuals most closely match the traits of *P. braueri.* While the grass frog has been reported in Guam, it has apparently been confused with the crab-eating frog (Lardner 2016). Molecular data identify Guam *Fejervarya* sp. found in Guam as identical to *F. cancrivora* from Taiwan (Wostl et al. 2016).

Incidental occurrences of the Malaysian narrowmouth toad (*Kaloula pulchra*) and coqui (*Eleutherodactylus coqui*) have also been recorded but they do not appear to have become established (Christy et al. 2007; Kerr 2013a). Lardner (2016) believes that there are only seven anurans established in Guam: marine toad, greenhouse frog, eastern dwarf tree frog, Guenther's Amoy frog, marbled pygmy frog, the Hong Kong whipping frog, and the grass frog.

These introduced amphibian species may contribute to the suite of prey items for BTS, but there have not been any specific studies to validate the speculation that they may support the increase of BTS populations (Christy et al 2007).

Brown Treesnake

Shortly after WWII, the BTS was inadvertently transported from the Admiralty Islands north of New Guinea to Guam on cargo movements related to the war. In Guam, the snake spread across the island, resulting in the devastation of Guam's native fauna and causing widespread ecological impacts at multiple levels. Encountering few predators, competitors, or pathogens, and an abundance of prey unaccustomed to a predatory snake, the BTS spread across the entire island reaching the northern end of Guam by the 1980s (Savidge 1987). At its peak in the 1980s, the snake population was estimated at 2 million and reached densities in excess of 100 snakes per acre in favorable habitats (Rodda et al. 1992; Rodda and Savidge 2007).



Brown treesnake (*Boiga irregularis*) resting on a fence post in an urban area on Guam
(*Photo*: M. Kempen)

Ecologically, the BTS caused the extinction or extirpation of 13 of the 21 native breeding birds and 13 native reptile species originally found in Guam (Rodda et al. 1992; Rodda and Savidge 2007; NAVFAC Pacific 2010, 2011a, 2013a, 2013b). The invasive, introduced BTS is suspected to prey on non-volant young Mariana fruit bats left at the roost site by their mothers during feeding and reducing recruitment into the bat population, but no direct evidence or observations have been recorded (Wiles 1987; Wiles et al. 1995; Brooke 2008). There is evidence that loss of native birds has caused and continues to cause cascading ecological effects on the island's native plants and animals through the loss of pollinating species; forest regeneration and future forest structure in Guam is impacted (Rodgers et al. 2017).



BTS entering a trap used by USDA APHIS Wildlife services around Guam and the Mariana Islands to conduct BTS control.
(*Photo*: C. Martin)

To prevent the spread of BTS to other Pacific islands including the CNMI and Hawai'i, the Navy funds a program to conduct BTS control and interdiction efforts on NBG and Andersen AFB to prevent snakes from getting into the DoD transportation network; once MCB Camp Blaz is operational, interdiction and control will be provided at critical locations. For all training events in the JRM area of operation that originate from Guam, the JRM Biosecurity Program coordinates with regional stakeholders (USFWS, CNMI Division of Fish and Wildlife [DFW], USDA APHIS Wildlife Services) to determine the necessary level of BTS control and interdiction needed. The Biosecurity Program develops BTS control and interdiction plans for each training event or military exercise that involves the movement of personnel and assets from Guam to the CNMI or other locations in the JRM area of operation. Additional BTS inspections and control measures are implemented in the CNMI when determined necessary by the stakeholders.

The BO for the Mariana Islands Training and Testing (MITT) Program contains specific commitments for the U.S. Navy related to the management and control of BTS in Guam (Appendix F). DoD facilitates land access for BTS researchers on military installations in Guam and funds research directed toward BTS control and large-scale suppression. Ongoing research by the U.S. Geological Survey (USGS) Fort Collins

Science Center, Invasive Species Science Branch, USGS Pacific Island Ecosystems Research Center, and the USDA National Wildlife Research Center includes development of snake control methods, establishment of snake-free areas, and study of basic snake ecology. In addition, several projects addressing control and suppression have either been initiated or are planned for future implementation on JRM-administered lands in Guam. Examples of these projects include targeted aerial application of acetaminophen, research on large-scale population suppression efforts, and development of self-resetting multi-kill traps for BTS control.

4.4.2.4 Freshwater Fishes

Native Species

Guam's freshwater ecosystems have not been well studied. All of the indigenous fish found in Guam are diadromous, requiring access to both saltwater and freshwater during their life cycles. Native diadromous species in the families Angullidae (eels), Eleotridae (sleepers), Gobiidae (gobies), and Kuhliidae (flagtails) inhabit streams from estuaries inland, nearly to the headwaters. Native gobies (family Gobiidae), including one endemic blind species found only in Guam caves, are common. All of the goby species, except the blind cave species, are amphidromous (i.e., migrate between freshwater and saltwater, but not for breeding) (Myers and Donaldson 2003).

Characteristic diadromous species in Guam include: Japanese eels (*Anguilla japonica*), common glass fish (*Ambassis buruensis*), dusky sleeper (*Eleotris fusca*), marbled eel (*Anguilla marmorata*), rock flagtail (*Kuhlia rupestris*), silver moony (*Monodactylus argenteus*), Engel's mullet (*Moolgarda engeli*), bluespot mullet (*Moolgarda seheli*), bandfin mullet goby (*Mugilogobius cavifrons*), mudskipper (*Periophthalmus argentilineatus*), bigmouth goby (*Redigobius bikolanus*), gobies (*Stenogobius* spp.), and feathered river-garfish (*Zenarchopterus dispar*) (Guam DAWR 2008; NAVFAC Pacific 2010, 2013a).

Non-native Species

Two species of tilapia (*Oreochromis mossambicus* and *Coptodon zillii*), mosquito fish (*Gambusia affinis*), guppies (*Poecilia reticulata*), peacock cichlid (*Cichla ocellaris*), small mouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), and channel catfish (*Ictalurus punctatus*) occur in Fena Valley Reservoir (Maciolek 1984; BioSystems Analysis, Inc. 1989; Nico and Walsh 2011). Other aquatic non-native species occur in the reservoir (Guam DAWR 2006), but since they are not studied often, the diversity and impact is not well known (Englund 2011); however, they may pose a threat to native fishes and invertebrates within downstream waters (DON 2009). Stock assessment of fish in Fena Valley Reservoir have not been conducted since 1969. It should be noted that recreational fishing is not permitted in NMS for safety and security reasons. There are no active management actions for these species.

4.4.2.5 Invertebrates

Native Species

Guam is home to dozens of endemic invertebrate species, many of which are rare or have extremely limited ranges. Two butterfly species and three tree snail species found in Guam were listed under the federal ESA in 2015 (USFWS 2015a). Refer to Section 4.4.3, *Terrestrial Protected Species*, for additional information regarding threatened and endangered invertebrates in Guam. Guam also has a number of endemic invertebrate cave species that are likely extremely limited in their distribution due to their specific habitat requirements. Among these are the Almagosa Cave amphipod (*Melita* sp.), at least three Almagosa isopods (*Isabelloscia* spp.), and the Guam karst katydid (*Salomona guamensis*).

The native mangrove crab (*Cardisoma carnifex*), land hermit crab (*Coenobita brevimanus*), as well as several other species of hermit crab and coconut crab (*Birgus latro*) begin life in the sea. After a planktonic larval stage, small crabs emerge from the ocean to live on land. Mangrove crabs live in burrows among the roots of riverbank trees. Land hermit crabs rely on borrowed shells for protection throughout their lives, often using the shell of the non-native African land snail (*Achatina fulica*). Coconut crabs are the largest terrestrial land arthropod on earth. Like hermit crabs, juvenile coconut crabs use empty gastropod shells for protection, but the adults develop a tough exoskeleton on their abdomen and stop carrying a shell. Coconut crabs hide in holes during the day and, like the land hermit crab, forage at night. Coconut crabs are susceptible to overharvesting and Guam DAWR has restrictions on hunting. Land crabs are omnivorous and eat foods such as fruits, seeds, plants, rotting wood, dead insects, and carrion. Coconut and other land crab species are found throughout Guam in suitable habitat. Threats to these species include rats, feral pigs, dogs, and monitor lizards.



Land hermit crab (*Coenobita brevimanus*)
(*Photo*: L. Shaughnessy)



Coconut crab (*Birgus latro*) concealed in vegetation
(*Photo*: L. Shaughnessy)

Guam has 17 species of native freshwater snails that belong to two families (i.e., Nertidae and Thiaridae). The only freshwater invertebrates of concern in Guam are *Stenomelania plicaria*, a thiarid snail, and *Neritodryas subsulcata*, a neritid snail. *S. plicaria* has a limited distribution in Guam, being found in a few rivers. *N. subsulcata* is very uncommon in Guam. Neritids have an amphidromous life history, similar to that of the gobies described in Section 4.4.2.4, *Freshwater Fishes*. Adults deposit their eggs in freshwater where the young hatch and are then swept to the ocean. After a marine larval stage, they return to freshwater to mature. Thiarids, which live their entire life cycle in freshwater, are normally found on sand or other soft substrates, where they spend a good portion of the day buried (Guam DAWR 2006).

Guam has at least 12 species of freshwater crustaceans: nine species of freshwater shrimp, and at least three species of freshwater crab. All of these crustacean species are amphidromous, with a marine larval stage and a freshwater adult stage. Two families of shrimp are represented in Guam: Atyidae and Palaemonidae. The genera *Atyoida* and *Atyopsis* of the Atyidae family are generally found in high-current, shallow waters, and species of the *Caradina* genus are generally found in slow-moving, deeper waters. *Halocaradina trigonopthalma* occurs only in caves and sinkholes along the east coast. Palaemonid shrimp are widespread in Guam in rivers, reservoirs, and caves. They are able to survive in intermittent pools in the headwaters of streams and, frequently, are the only fauna found in such habitats. The Tahitian prawn (*Macrobrachium lar*) is also present in freshwater streams in Guam. Three species of freshwater crab are known to occur in Guam: *Ptychognathus* sp., *Sesarma* sp., and *Varuna* cf. *littorata* (Guam DAWR 2006). These freshwater crabs are poorly known and form a rather inconspicuous part of the freshwater fauna. Macroinvertebrates (e.g., arthropods, mollusks, and worms), have not been extensively studied in freshwater streams on JRM-administered lands.

Non-native Species

The coconut rhinoceros beetle (CRB) (*Oryctes rhinoceros*) was first detected in Guam in the Tumon Bay area on September 12, 2007. CRB was considered to have spread island-wide by 2010. This large scarab beetle is a serious pest to palm trees, including coconut and betelnut, and *Pandanus* sp. Adult CRBs damage palms by boring into the center of the crown, where they injure the young growing tissues while feeding on the exuded sap (Moore et al. 2015). In addition, the beetle is also known to attack banana, taro, pineapple, and sugar cane. The beetle's activities can lead to reduced or dead leaves, decreased plant production or regeneration, and disease or death of plants.

DON has implemented a CRB interdiction program on NBG and Andersen AFB since 2020 with the implementation of CRB interdiction trapping via black panel traps baited with CRB-specific pheromone lures and the identification and removal of potential breeding sites (i.e., dead palm trees). These interdiction measures are intended to reduce the risk of CRB getting into the DoD transportation network.

The Asian cycad scale (*Aulacaspis yasumatsui*) is native to Southeast Asia and is spreading rapidly worldwide. The scale has destroyed in excess of 70% of the endemic *Cycas micronesica* in Guam (Marler and Lawrence 2012). Scale populations quickly reach high densities, causing necrosis of fronds and eventually plant death. *C. micronesica* in Guam are important culturally as a historic food source for making flour, and important for soil nitrogen fixation in association with various cyanobacteria living in the roots (Marler and Terry 2011; NAVFAC Marianas 2016b).

The cycad blue butterfly (*Luthrodes pandava*) is a non-native insect first discovered on Andersen AFB in northern Guam in July 2005 and quickly spread throughout the island (Andersen AFB 2013). The butterfly is one of several herbivorous predators that cause damage to *C. micronesica*. While herbivory by the cycad blue butterfly does not directly lead to plant mortality, it does reduce the resistance of an individual (NAVFAC Marianas 2016b).



Cycad blue butterfly (*Luthrodes pandava*)
(*Photo*: L. Shaughnessy)

DON has funded several studies to determine the impact of cycad scale to the endemic *C. micronesica* in Guam. A few of these studies include research on the relationship between insects and reproduction in seed-bearing plants (including *C. micronesica*); studies on injecting chemicals directly into the *C. micronesica* to control not only Asian cycad scale but also the cycad blue butterfly; and studies into using a scale-eating ladybug beetle as a form of biocontrol (Andersen AFB 2015).

Native to Central and South America, the little fire ant (LFA) (*Wasmannia auropunctata*) is listed by GISD as one of the top 100 worst invasive species worldwide and is considered the greatest invasive ant threat to the Pacific region (GISD 2009). LFA was confirmed in Guam in November 2011, and based on the largest LFA infestation in Guam (5 acres [2 hectares]), it is hypothesized that LFA arrived in Guam between 2002 and 2007. The first sighting was on Yigo, followed by subsequent discoveries in Piti, Merizo, Santa Rita, and Umatac (Raymundo and Miller 2012). As of July 2024, there were an estimated 209 colonies across Guam to include locations on DoD installations (personal communications, Chris Rosario, Guam Biosecurity Division). Thirty-two locations have been identified on Guam installations with the majority of locations being found on installations borders. This species is a generalist in its diet and life history and occurs in trees, on plants, in the grass, and under leaf debris and stones. It is highly destructive to the local ecology. Occurring in groups numbering into the hundreds, the species bites en masse if disturbed by an animal or human, causing a rash and severe itching. It is

particularly problematic for children. Eradication measures include proper management of green waste, destruction of existing colonies with pesticides, and reducing plant movement in Guam (Raymundo and Miller 2012).

In 2017, the DON initiated a LFA early detection, control, and eradication program to prevent the incursion of LFA onto and within Guam installations. The LFA management program focuses on 1) preventing LFA impacts to ESA listed species, 2) exclusion from the DoD transportation network, and 3) prevention of the movement of LFA from known installation locations.

The greater banded hornet (*Vespa tropica*) was first identified in Guam in July 2016, based on collected specimens from Dededo and the Leo Palace Resort. This species is normally found in China, Japan, Malaysia, Hong Kong, Singapore, India, and the Philippines and is known to attack the nests of the local boonie bees (paper wasps or *Ropalidia marginata*) in order to obtain these larvae to feed to their own larvae. Although larval paper wasps are considered the prey of choice, they sometimes catch honeybees (Subfamily Apinae). Banded hornets usually nest underground or in a tree hollow or similar enclosed space, where the nest is seldom seen (Rosario et al. 2016).

The New Guinea flatworm (*Platydemus manokwari*) is a terrestrial flatworm that preys heavily on land snails, including the partulid tree snails. The flatworm was introduced to Guam in 1978 to control the African land snail and was found throughout Guam by 1980, with the population exploding in the mid-1980s (Hopper and Smith 1992). The flatworm is a serious threat to the survival of tree snails in Guam. Field observations have established that the flatworm will readily feed on tree snails native to Pacific islands, including the endangered tree snails of the Mariana Islands. In addition to Guam, the New Guinea flatworm has been considered the cause of multiple extinction or extirpation events of native land snails on other Pacific islands. During tree snail surveys in Guam, flatworms were occasionally found but never in high enough numbers to make a correlation between their presence and the absence of tree snail species (NAVFAC Marianas 2013, 2014b, 2014c).



New Guinea flatworm (*Platydemus manokwari*) (*Photo*: L. Shaughnessy)

Two species of scarab beetle, *Protaetia orientalis* and *P. pryeri*, were first noted in Guam in 1976 and 1990, respectively. Both scarab beetle species are present on JRM-administered lands in Guam and continue to be a threat to native vegetation. These species can lead to reduced or dead leaves, decreased plant production or regeneration, and disease or death of plants. In addition, these insects are impacting species that are concurrently affected by habitat loss and reduced recruitment, including the *C. micronesica*. Adult *P. orientalis* are reported as serious pests of agriculture, being found in great abundance on coconut, betelnut, papaya, and mango blossoms and feeding upon tassels, silk, and, occasionally, kernels of corn (Schreiner and Nafus 1986). More recently, this species has also become a threat to native plant species. As of 2003, the feeding by adult *P. orientalis* on flowering ifit trees (*Intsia bijuga*) had reduced the seed set of this important native forest tree on JRM-administered lands in Guam by almost 98% (Brooke 2017).

4.4.3 Terrestrial Protected Species

Terrestrial species with the potential to occur in Guam and listed as threatened or endangered by the USFWS or GovGuam are listed in Table 4-2 and discussed in the following sections. There are 25 federally threatened and endangered terrestrial species known to or with the potential to occur in Guam, including 1 mammal species, 2 bird species, 3 reptile species, 4 invertebrate species, and 15 plant species. There are

20 species listed under the Guam ESA, including 1 mammal species, 4 bird species, 9 reptile species, 3 invertebrate species, and 3 plant species. Overall, 11 species are both federal and Guam ESA-listed, including 1 mammal species, 2 bird species, 3 reptile species, 3 invertebrate species, and 2 plant species.

Species with a former range that includes Guam, are listed as threatened and endangered by the USFWS or Guam DAWR, but are considered extinct or extirpated are not listed in Table 4-2. One mammal (the little Mariana fruit bat); four birds (Guam flycatcher [*Myiagra freycineti*], bridled white-eye [*Zosterops conspicillatus saypani*], Rufous fantail [*Rhipidura rufifrons*], and Micronesian myzomela [*Myzomela rubratra saffordi*]); and one invertebrate (Mount Alifan tree snail [*Partula salifana*]) are extinct, and two Guam endemic birds (Guam rail [*Gallirallus owstoni*] and Guam kingfisher [*Todiramphus cinnamominus*]) survive only in zoos or in an experimental population outside its native range (Guam rail on Cocos Island and Rota). In addition, one mammal (Pacific sheath-tailed bat), five species of birds (nightingale reed-warbler [*Acrocephalus luscinia*], Mariana crow [*Corvus kubaryi*], Micronesian megapode [*Megapodius laperouse*], White-throated ground dove [*Alopecoenas xanthonurus*], and Mariana fruit dove [*Ptilinopus roseicapilla*]), and one invertebrate (Mariana wandering butterfly [*Vagrans egistina*]) are extirpated from Guam but still occur within the CNMI.

In 2004, the USFWS designated federal ESA critical habitat on 363 acres (147 hectares) of the Guam National Wildlife Refuge (NWR) (Ritidian Unit) for three species: Mariana fruit bat, Guam kingfisher, and Mariana crow (refer to Figure 3-4) (USFWS 2004b). This is the only designated critical habitat in Guam.

The following sections provide a brief overview of the protected terrestrial species known to occur in Guam or that have historically occurred in Guam.

4.4.3.1 Mammals

Mariana Fruit Bat



Mariana fruit bat
(*Pteropus mariannus mariannus*).
(*Photo*: Guampedia 2018a)

The Mariana fruit bat is a gregarious species that forms colonies and roosts in trees within limestone native forest communities. Historically, the Mariana fruit bat inhabited the native limestone forests throughout all the Mariana Islands except Farallon de Pajaros (USFWS 2009a). Currently, the majority of fruit bats in Guam form a population on Andersen AFB. Beginning in 2014, the collaborative fruit bat monitoring project between the UOG and Andersen AFB began using base-wide counts to estimate fruit bat populations. These simultaneous counts use multiple (>80) volunteer observers stationed throughout Andersen AFB for a specified amount of time to yield a single annual estimate of the number of bats on Andersen AFB (NAVFAC Marianas and Andersen AFB 2015; DON 2017a). The population estimates from the 2014 and 2015 base-wide counts were 15 and 24 individuals, respectively (NAVFAC Marianas and Andersen AFB 2015). In December 2015, a population with an estimated 112 individuals appeared within the Habitat Management Unit (HMU) of Andersen AFB. In March 2016, the fruit bats were no longer present within the HMU and had either left Guam or had dispersed to other areas in Guam (NAVFAC Marianas 2016c; Guampedia 2018a). Base-wide surveys were conducted from 2018 to 2022, and the current estimated bat population on Andersen AFB is now 104 (U.S Navy 2023a). Individuals have been observed on other parts of Guam, and surveys conducted in 2023 found more than 100 bats in a roosting area within NMS (U.S. Navy 2023b).

Table 4-2. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded in Guam

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat*	*Occurrence*
Mammals					
Mariana fruit bat/ Fanihi	*Pteropus mariannus mariannus*	T	E	Limestone native and coconut forests	Y
Birds					
Mariana swiftlet/ Chachaguak or Yayaguak	*Aerodramus bartschi*	E	E	Mahlac Cave, Fachi Cave, and Maemong Cave	Y
Micronesian starling/Sali	*Aplonis opaca*	--	E	All habitat types	Y
Mariana common moorhen/Pulattat	*Gallinula chloropus guami*	E	E	Wetland (herbaceous, mangrove, and shrub/herb)	Y
Reptiles					
Green sea turtle/ Haggan	*Chelonia mydas*	E[2]	T	Open water and strand	Y
Hawksbill turtle/ Haggan karai	*Eretmochelys imbricata*	E	E	Open water and strand	Open water: Y Strand: PU
Snake-eyed skink/ Gualiek halumtano	*Cryptoblepharus poecilopleurus*	--	E	Strand	PU[3]
Tide-pool skink/ Gualiek halumtasi	*Emoia atrocostata*	--	E	Strand and wetland	PU[3]
Azure-tailed skink/ Gualiek halumtano	*Emoia cyanura*	--	E	Forest edge	PU[3]
Slevin's skink/ Gualiek halumtano	*Emoia slevini*	E	E	Limestone native forest	PU[3]
Moth skink/ Gualiek halumtano	*Lipinia noctua*	--	E	Limestone native forest	Y
Pacific slender-toed gecko/Gualiek or Achiak	*Nactus pelagicus*	--	E	Limestone native forest.	Y
Micronesian gecko/Gualiek	*Perochirus ateles*	--	E	Limestone native forest	PU[3]
Invertebrates					
Humped tree snail/ Akaleha	*Partula gibba*	E	E	Limestone native and ravine forests	Y
Guam tree snail/ Akaleha	*Partula radiolata*	E	E	Limestone native and ravine forests	Y
Fragile tree snail/ Akaleha	*Samoana fragilis*	E	E	Limestone native and ravine forests	Y
Mariana eight-spot butterfly/Ababbang	*Hypolimnas octocula marianensis*	E	--	Limestone native forest	Y
Plants					
None/Siboyas halumtano	*Bulbophyllum guamense*	T	--	Limestone native forest	Y
Tree fern/Satsa	*Sphaeropteris lunulata*	--	E	Ravine forest and savanna complex	PU[3]
None/Fadang	*Cycas micronesica*	T	--	Limestone native and degraded forests, ravine forest, and savanna complex summits	Y

Table 4-2. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded in Guam

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat*	*Occurrence*
None/None	*Dendrobium guamense*	T	--	Limestone native forest and limestone coastal scrub	Y
None/Aaban or aabang	*Eugenia bryanii*	E	--	Limestone coastal scrub	Y
None/None	*Hedyotis megalantha*	E	--	Savanna complex	Y
None/ Ufa halumtano	*Heritiera longipetiolata*	E	E	Limestone native forest	Y
None/None	*Maesa walkeri*	T	--	Limestone native and degraded forests and savanna complex	Y
None/Seyaihagon or Maisa ulu	*Nervilia jacksoniae*	T	--	Limestone native and degraded forests	Y
Safford's Leafflower/None	*Phyllanthus saffordii*	E	--	Savanna complex	Y
None/Aplokating-palaoan	*Psychotria malaspinae*	E	--	Limestone native forest and limestone coastal scrub	Y
Fire tree/Hayun lago	*Serianthes nelsonii*	E	E	Limestone native forest	Y
None/Biringenas halumtano	*Solanum guamense*	E	--	Limestone native forest and limestone coastal scrub	PU[3]
None/None	*Tabernaemontana rotensis*	T	--	Limestone native and degraded forests	Y
None/None	*Tinospora homosepala*	E	--	Limestone native forest and limestone coastal scrub	Y
None/None	*Tuberolabium guamense*	T	--	Limestone native forest and limestone coastal scrub	Y

Notes: [1] Chamorro names from GovGuam (2009), Liske-Clark (2015), USFWS (2015a), Topping et al. (1975), Safford (2009), and Kerr and Bauman (2013).
[2] Central West Pacific Distinct Population Segment.
[3] Historical Occurrence.

Key: -- = not listed; E = endangered; ESA = Endangered Species Act; PU = potential for occurrence, but unlikely; T = threatened; Y = yes, known to occur.

Sources: Guam DAWR 2006; GovGuam 2009; Safford 2009; USFWS 2015a, 2017.

4.4.3.2 Birds

Mariana Swiftlet

The Mariana swiftlet is federal and Guam ESA-listed as endangered. It is endemic to the Mariana Islands and is known historically from Guam, Rota, Aguiguan, Tinian, and Saipan but is currently found only in Guam, Saipan, and Aguiguan. They nest and roost colonially in caves, using moss and saliva to construct a nest on the cave wall. The reasons for the decline of the endangered Mariana swiftlet are not completely understood, but stressors such as human disturbance of nesting and roosting caves, predation on swiftlets by BTS in Guam, habitat alteration by deforestation, typhoons, pesticides, and disease have contributed to their current status (USFWS 1991). There are only four known nesting/roosting caves in Guam for this species, three of which are located in the northeastern area of NMS.



A Mariana swiftlet (*Aerodramus bartschi*) seen flying above Mount Tapochau on Saipan.
(*Photo*: L. Shaughnessy)

Micronesian Starling

The Micronesian starling is found on the Mariana Islands of Guam, Rota, Tinian, Saipan, Asuncion, Agrihan, Pagan, Alamagan, Guguan, Sarigan, Anatahan, Farallon de Medinilla (FDM), and Aguiguan. Starlings are cavity nesters and have been found nesting in the cavities of trees and rocky cliffs (Baker 1951; Jenkins 1983). At one time, Micronesian starlings were found throughout Guam, but predation by the BTS has restricted them primarily to Cocos Island, Andersen AFB housing, parts of Hagatna and certain coastal areas in the south, infrequently on NBG Main Base, and in the vicinity of Sumay Marina. Their island-wide population reached an estimated low of 50–100 birds in the early 1990s but have since recovered to approximately 1,500 birds, still mainly concentrated in the urbanized areas of Andersen AFB (NAVFAC Marianas 2023). Although the Micronesian starling is not a federal ESA-listed species, due to the overall population decline of the species, Guam has listed the species as endangered and designated it as a Species of Greatest Conservation Need (SOGCN) (Guam DAWR 2006; GovGuam 2009).

Mariana Common Moorhen

The Mariana common moorhen is federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. The moorhen is also protected under the MBTA. Moorhens in the Mariana Islands are found primarily in freshwater, typically in both seasonal and permanent man-made and natural wetlands. They are also occasionally recorded in brackish water wetlands. Island-wide surveys for the endangered moorhen were conducted in Guam in 2001, and the total adult moorhen population at that time was estimated to be 90 (Takano and Haig 2004). Per USFWS, populations in 2020 were estimated to have slightly declined over the past two decades to approximately 75 birds (CNMI DFW 2023). Possible stressors on the moorhen

population include loss of habitat, predation of moorhen eggs and chicks by BTS, and predation by feral cats and dogs.

Guam Rail



A Guam rail (*Gallirallus owstoni*)
(*Photo*: Guampedia 2018b)

The Guam rail is federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. Historically, it was widely distributed across various habitats in Guam, including forest, savanna, scrub, secondary grassland, fern thickets, and agricultural areas (but not in freshwater wetland habitats). Along with most other indigenous species, population levels began to decline in 1968, and a 1981 population count determined that approximately 2,000 rails remained on the island (Engbring and Ramsey 1984). Captive breeding of the rail began in 1984. By July 1985, a single rail was located in the flightline area of Andersen AFB, and by 1987, the species had been extirpated from the wild (USFWS 1990). Since 1989, efforts have been underway to establish a self-sustaining, experimental population on the nearby, BTS-free Rota, with over 1,000 birds released to date. Currently, there are an estimated 100 rails on Rota.

In 1997, a BTS exclusion fence was installed in Area 50, a 59-acre (24-hectare) plot of secondary forest located in Northwest Field on Andersen AFB. As a result of this installation, BTSs were reduced enough to allow captive-bred Guam rails to reproduce: 16 captive-bred rails were released in 1998, and 42 chicks were hatched in 1999. Since then, this small population is believed to have been extirpated by feral cats and other predators. While the chain link fence at Area 50 has been maintained, the site is currently within a restricted area and is not accessible. A second attempt to allow captive breeding included the release of 44 captive-bred rails within Munitions Storage Area (MSA) 1 on Andersen AFB in 2003. Of these, 26 rails were fitted with radio transmitters, 21 of which died as a result of cat predation. No rails have been spotted in the area in several years, and the remaining 23 rails from the 2003 release are presumed deceased (JRM 2013). In November 2010 and 2012, Guam DAWR released a total of 26 Guam rails on Cocos Island and breeding has been observed (Guam DAWR 2015; Guampedia 2018b). At the time of release, the island was free of rats, cats, and BTS; however, BTS was found on the island in 2020 and is no longer snake free.

Guam Kingfisher



Guam kingfisher (*Todiramphus cinnamominus*)
(*Photo*: E. Savage and World of Birds.com 2018)

The Guam kingfisher is federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. It was endemic to Guam and inhabited mature limestone forests, mixed woodlands, secondary growth stands, scrub forests of the northern plateau, coconut forest, and riparian forest (Jenkins 1983; USFWS 1990). In 1981, the population was estimated at 3,000 birds (Engbring and Ramsey 1984), and by 1988, the Guam kingfisher was extirpated due to predation by BTS (Wiles et al. 2003). Currently, the species only occurs in captivity, with 12 birds in Guam at the Guam DAWR facility and about 140 birds in various U.S. mainland zoos (Guam DAWR 2006). In 2004, the USFWS designated 363 acres (147 hectares) of critical habitat for the kingfisher on the Guam National Wildlife Refuge (NWR) (Ritidian Unit) (USFWS 2004b). Under a 2015 Memorandum of Agreement (MOA) between the USFWS and DON to offset impacts from the Guam Military Relocation action, the USFWS identified 5,211 acres (2,108 hectares) of recovery habitat for the kingfisher in northern Guam, predominantly on Andersen AFB. This recovery habitat will provide durable habitat protection for the recovery and survival of the Guam kingfisher (DON and USFWS 2015a, 2015b). Further detail on the MOA is provided in Chapter 8, *NBG Telecommunications Site*, and Chapter 9, *Andersen Air Force Base*.

White-throated Ground Dove

Although the Guam-listed endangered white-throated ground dove (*Alopecoenas xanthonurus*) is reported as extirpated from Guam due to the BTS (Guam DAWR 2006), it is documented in Guam on rare occasions (Wiles 2005), primarily within the MSA and the southeastern corner of Andersen AFB. On October 18, 2011, a white-throated ground dove was heard vocalizing near Anao Conservation area border with Andersen AFB during migratory bird surveys (NAVFAC Marianas 2013). Observed individuals are thought to be transients from Rota and a resident or breeding population does not occur in Guam (Guam DAWR 2006; NAVFAC Marianas 2013).

Mariana Crow

The Mariana crow is federal and Guam ESA-listed as endangered. It is considered extirpated from Guam as there have been no recent sightings of the species. Recovery habitat for the Mariana crow is located in undeveloped portions of MCB Camp Blaz (USFWS 2009b, 2010).

4.4.3.3 Reptiles

Five native reptile species are considered extirpated from Guam: snake-eyed skink, tide-pool skink, azure-tailed skink, Micronesian gecko, and oceanic gecko. All of these species are listed as endangered under the Guam ESA. While not currently found in Guam, all of these species have been reported to occur on Cocos Island; however, their current status is unknown (Guam DAWR 2006; NAVFAC Pacific 2013a). Extirpation is thought to be a result of the introduction of competing species or predatory species such as the BTS.

Sea Turtles



Sea turtle hatchlings on a Guam beach.
(*Photo*: DON 2023)

Sea turtles occur throughout the Mariana Archipelago, including Guam, but are threatened by human activities both at sea and on their nesting beaches (NAVFAC Marianas and Andersen AFB 2017; Summers et al. 2017). Federal and Guam ESA-listed endangered green sea turtles (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*) are known to nest in Guam beaches. The leatherback turtle (*Dermochelys coriacea*) and loggerhead turtle (*Caretta caretta*) are likely present in the waters around Guam, but they have not been documented to nest in Guam. JRM and cooperators have conducted studies of turtle populations and nesting activity in Apra Harbor (NBG Main Base); Haputo (MCB Camp Blaz); Tarague, Scout, Sirena, and Pati Beaches (Andersen AFB) (summarized in Grimm and Farley 2008; Brindock 2015; Martin and Jones 2016, 2017), which are discussed in more detail in the following chapters. In-water capture and tagging of resident sea turtles has been conducted by NOAA via an Interagency Agreement with JRM bi-annually since 2014 (NAVFAC Marianas and Andersen AFB 2023). The Marine Turtle Biology and Assessment Program uses satellite telemetry data to assess movements, habitat use, distribution and migratory patterns of sea turtles in the nearshore waters of NBG. Observations and counts of sea turtles are also recorded. Since its commencement, the program has recorded a total of 503 green sea turtles and 55 hawksbill turtles around Guam from 2014-2022 (NAVFAC Marianas and Andersen AFB 2023).

Guam experiences year-round nesting for green sea turtles, with peak activity from March through August. From October 2022 to August 2023, a total of 28 nests were observed on NBG (NAVFAC Marianas and NGB 2023). All activities were created by the green sea turtle; no evidence of the hawksbill sea turtle was documented. NBG implemented a nesting beach habitat enhancement program through the JRM INRMP which includes removal of invasive vegetation and marine debris, and trapping/removal of monitor lizards to prevent predation at Spanish Steps (NAVFAC Marianas 2016c). Between September 2015 and October 2016, five monitor lizards were removed (three females, of which one had 11 eggs), one male, and one (sex unknown). The lizards were captured via noose traps and air rifle (NAVFAC Marianas 2016c). Noose traps were again deployed at Spanish Steps beach between October 17 and November 7, 2022. During this trapping period, (at least) five monitor lizards were captured; stomach contents did not contain evidence of hatchling predation. NBG began utilizing self-releasing screens in 2017 at Spanish Steps to prevent depredation of nests/hatchlings by monitor lizards. NBG also placed barricades (10–20 foot in length) at six access points along Dadi Beach allowing pedestrian access while at the same time restricting vehicular access to protect sea turtle nests (NAVFAC Marianas 2016c). Vegetation removal was also completed at the Spanish Steps in late February 2023 (NAVFAC Marianas and NBG 2023).

During project planning, JRM environmental planners take into consideration potential in-water construction, obstructions, barriers, or activity (e.g., dredging, training, etc.) impacts that would disrupt resting/foraging areas (e.g., destroy, damage, or adversely modify seagrass, macroalgae, invertebrates, or coral reefs) as well as those which would disrupt reproductive areas (e.g., disrupt sea turtle mating, prevent females from accessing nesting beaches and using inter-nesting habitats in nearshore waters, or prevent the egress of hatchlings) while also taking into consideration current, mission requirements, long-term mission

planning, and future mission flexibility. Resting/foraging areas are the marine areas, from the mean high water (MHW) line to 20 meter depth, where sea turtles forage on macroalgae, seagrass, and invertebrates and rest in refugia, such as coral reefs. Reproductive areas are the marine areas adjacent to nesting beaches, from the MHW line to 20 meter depth, where sea turtles mate, inter-nest, and transit onto and off nesting beaches. Planners minimize potential impacts while ensuring mission requirements are met.

Skinks and Geckos

Slevin's skink, the only reptile species endemic to the Mariana Islands, is a species of the forest floor and has been recorded from Sarigan, Alamagan, Guguan, Pagan, and Asuncion (Reed et al. 2010). Listed as endangered under the federal ESA in 2015, Slevin's skink is currently found only on Cocos Island and has not been recorded elsewhere in Guam since 1945 (McCoid et al. 1995; USFWS 2015a).

The moth skink is found across much of the Western Pacific, but has only been recorded in Guam in the Mariana Islands. Moth skinks are not common but can still be found in native forests in central and northern Guam (Guam DAWR 2006; NAVFAC Pacific 2010, 2013a). The moth skink is not a federal ESA-listed species, but it is listed as an endangered species under the Guam ESA.

The Pacific slender-toed gecko is known to occur throughout the Western Pacific, and in the Mariana Islands, it has been recorded in Guam, Rota, Anatahan, Alamagan, and Sarigan. This gecko is not common in Guam but can still be found in native forests in central and northern Guam (Guam DAWR 2006; NAVFAC Pacific 2013a). It is not a federal ESA-listed species, but it is listed as an endangered species under the Guam ESA.

4.4.3.4 Invertebrates

Mariana Eight-spot Butterfly

The eight-spot butterfly (*Hypolimnas octocula mariannensis*) has been divided into eight subspecies occurring in the south and west Pacific islands (Sampson 1986; Tennent 2006). The subspecies, *H. o. mariannensis,* is endemic to the islands of Guam and Saipan. Although habitat requirements for the Mariana eight-spot butterfly have not been described in detail, it is dependent upon two relatively rare herbaceous host plant species found in limestone forest habitats: *Procris pedunculata* and *Elatostema calcareum*. Host plant distribution in Guam has been significantly altered as a result of deer and feral pig browsing. The current population of the Mariana eight-spot butterfly is threatened by habitat alteration, predation by ants, and parasitism by parasitic wasps. Recent surveys conducted across Guam have found the Mariana eight-spot butterfly in areas where host plants have not been impacted by ungulates, primarily areas of coastal karst on Andersen AFB, Haputo Ecological Reserve Area (ERA), Guam NWR, and east of Andersen South and Route 15 (Holland and Rubinoff 2014; NAVFAC Marianas 2014b, 2015b; USFWS 2015a; Rubinoff 2016).

Tree Snails

Native tree snails are found primarily in native limestone forest habitat with sufficiently high and dense understory to provide shade, high humidity, and reduced airflow (Crampton 1925). The native tree snails of the Mariana Islands continue to decline and are threatened by deforestation; introduced predatory flatworms, cats, Asian house shrews, and rats; and by alteration of the habitat by feral ungulates (Kerr 2013b; USFWS 2015a). Recent surveys have observed three tree snail species native to Guam (humped, Guam, and fragile) on the Haputo ERA and Andersen AFB (NAVFAC Marianas 2014c, 2015b; USFWS 2015a), two tree snail species (Guam and fragile) at the Sasa Valley Tank Farm (Island Eco Services 2021), and one tree snail species (Guam) on Andersen South (Lujan 2017).

4.4.3.5 Plants

Of the 16 federal ESA-listed plant species that occur in Guam, all but one species (*Serianthes nelsonii*) were recently listed in October 2015 (USFWS 2015a). These species are described below.

Bulbophyllum guamense, Dendrobium guamense, and *Tuberolabium guamense*

These epiphytic orchids are typically found on tree branches of limestone forests utilizing a variety of native and non-native host trees (e.g., vitex, *M. cylindrocarpa*, *O. mariannensis*, *A. mariannae*) and are federal ESA-listed as threatened. At the time of the listing of these species by the USFWS, the final rule stated that there were only seven occurrences of approximately 500 individuals of all three species in Guam (*Dendrobium guamense*: four occurrences of 250 individuals; *Bulbophyllum guamense*: three occurrences of 250 individuals; *Tuberolabium guamense*: one occurrence of one individual) (USFWS 2015a). However, after the final rule was issued, surveys were conducted within JRM-administered lands and many more individuals of these species were observed (NAVFAC Marianas 2016d, 2016e). These surveys only sampled a small area of suitable habitat. It is expected that these species are more prevalent throughout Guam within suitable habitat than previously understood. Surveys beginning in 2019 found an increase in individuals of all three orchids on NMS (NAVFAC Marianas 2023b).



ESA-listed orchids native to Guam (from left to right): *Tuberolabium guamense, Bulbophyllum guamense*, and *Dendrobium guamense.*
(*Photo*: L. Shaughnessy)

Sphaeropteris lunulata

Sphaeropteris lunulata (previously *Cyathea lunulata*) is a tree fern native to Guam and is listed as endangered under the Guam ESA. *Sphaeropteris* occurs on volcanic clay soils in southern Guam, typically near the edge of ravine forest and savanna habitats and usually on muddy hill slopes. It is not common and has become increasingly rare due to savanna fires that kill the ferns and destroy their habitat. They have also been collected for planting as landscaping plants (Raulerson and Rinehart 1992; Guam DAWR 2006). As there have been no surveys for this species, its current status in Guam is unknown.

Cycas micronesica



Cycas micronesica
(*Photo*: L. Shaughnessy)

Cycas micronesica is federal ESA-listed as threatened, CNMI ESA-listed as threatened and endangered, and CNMI-designated as SOGCN. Based on a forest inventory conducted in 2002, *C. micronesica* was the most abundant tree in Guam (Donnegan et al. 2004). This tree is currently known to occur in the forest and savanna ecosystems of Guam, Rota, Palau, Yap (Raulerson 2006; USFWS 2015a) and potentially on Pagan (Pratt 2011). It is not known to have occurred historically on Tinian. In Guam, *C. micronesica* is severely impacted by the non-native cycad scale (*Aulacaspis yasumatsui*), leaf miner (*Erechthias* sp.), cycad blue butterfly (*Luthrodes pandava*), and the native longhorn beetle (*Dihammus marianarum*). Guam's populations of feral pigs and deer also feed on *C. micronesica* plants (Marler and Lawrence 2012). Leaf damage caused by deer herbivory is not consequential, but feeding on stem tissue by pigs is a major threat to plants that are first damaged by one of the invasive insect pests. The habitats that contained the highest plant densities in pre-invasion years (350-400 plants/hectare) sustained about 230 plants/hectare in early 2016. Across the majority of Guam, the remaining live trees are in poor health and show signs of damage from one or more of the insect arthropod pests. Seed production is low, germination rate is minimal, and the few seedlings that emerge are rapidly killed by the scale insect (Andersen AFB 2013; NAVFAC Marianas 2016b).

In response to the rapid rate of mortality, Joint Region Marianas contracted surveys and collected viable seed for propagation from habitats throughout Guam in 2005. More than 3,000 *C. micronesica* seeds were collected, cleaned of scale insects, and the source of each seed documented by individual mother-tree habitat type. Seeds were then stored over a period of 12 months, and then transported to a nursery on Tinian until they reached maturity. In 2008, 1,000 of these individuals were planted in a mapped experimental design on Tinian. During 2019 maintenance activities, scale insect was discovered within the MLA plots. Despite control efforts, the scale insect spread throughout all plots and caused significant mortality. As of January 2023, about 200 live cycads remain within the plots (UOG 2023). Approximately 1,000 *C. micronesica* individuals were observed during surveys conducted from 2022 through 2023 at Andersen AFB (NAVFAC Marianas 2023b).

Eugenia bryanii



Flowering *Eugenia bryanii*
(*Photo*: L. Shaughnessy)

A perennial shrub in the myrtle family, the species is known only from the island of Guam and is federal ESA-listed as endangered. Historically, *E. bryanii* is known from windy exposed coastal cliffs and in lowland/limestone forests along the Pigua River. At the time of the listing of this species as endangered by the USFWS, the final rule stated that there were only five occurrences in Guam, totaling fewer than 420 individuals (USFWS 2015a). However, after the final rule was issued, surveys were conducted within JRM-administered lands and many more individuals of this species were observed (e.g., 608 at Northwest Field on Andersen AFB) (NAVFAC Marianas 2016f). It is expected that this species is more prevalent throughout Guam within suitable habitat

than previously understood. *E. bryanii* was not observed during plant and invertebrate surveys conducted from 2022 through 2023 at Andersen AFB, NBG, or MCB Camp Blaz (NAVFAC Marianas 2023b).

Hedyotis megalantha

A perennial herb in the coffee family, this species occurs in savanna areas in southern Guam and is federal ESA-listed as endangered. To date, *H. megalantha* is known from one large scattered occurrence totaling fewer than 1,000 individuals in southern Guam, between Mt. Alutom and Tarzan Falls. This species typically occurs as lone individuals rather than in patches or groups (USFWS 2015a). *H. megalantha* has not been recently observed in Guam.

Heritiera longipetiolata

Heritiera longipetiolata is listed as endangered under both the federal and Guam ESAs. It is endemic to the Mariana Islands and is an important canopy tree in limestone forests. It grows from limestone, often in the rough limestone karst terrain of coastal cliffs and terraces. *H. longipetiolata* is known from four occurrences in Guam, totaling approximately 90 individuals (USFWS 2015a). *H. longipetiolata* was not observed during plant and invertebrate surveys conducted from 2022 through 2023 at Andersen AFB, NBG, or MCB Camp Blaz (NAVFAC Marianas 2023b).



Mature *Heritiera longipetiolata* tree surrounded by seedlings.
(*Photo*: L. Shaughnessy)

Maesa walkeri

Maesa walkeri is listed as endangered under the federal and Guam ESAs. A shrub or small tree in the primrose family typically found in limestone forests, this species was known from only two individuals in Guam at the time of the final rule, one of which is located along the southwestern border of NMS (USFWS 2015a). However, after the USFWS final rule was issued in October 2015, surveys were conducted within JRM-administered lands and seven additional individuals of this species were observed within NMS. (NAVFAC Marianas 2016e). These are the remaining occurrences of this species in Guam.



Maesa walkeri
(*Photo*: L. Shaughnessy)

Nervilia jacksoniae

A small herb in the orchid family, this species is found in lowland/limestone forests. At the time of the listing of this species as endangered by the USFWS, the final rule stated that there were only two occurrences in Guam totaling fewer than 200 individuals (USFWS 2015a). However, after the final rule was issued in October 2015, surveys were conducted within JRM-administered lands, and approximately 200 individuals of this species were observed on NMS within a limited survey area along the ridgeline of Mt. Alifan-Mt. Lamlam (NAVFAC Marianas 2016e). These individuals are the only known *N. jacksoniae* occurrences in Guam.

Phyllanthus saffordii

This woody endemic shrub is federal ESA-listed as endangered. It is known from four scattered occurrences on southern Guam within savanna areas: Mt. Alutom, Piti Hills, Nimitz Hill "War in the Pacific Lookout," and near the Cetti Bay Watershed (USFWS 2015a). During surveys of ESA-listed threatened plant species in the NMS, 279 *Phyllanthus saffordii* (226 mature and 53 juvenile) were observed (NAVFAC Marianas 2022). However, the population in Guam is decreasing from initial numbers observed in Guam, and is at risk, due to continued habitat loss and destruction from agriculture, urban development, non-native animals and plants, fires, and typhoons, and direct damage by recreational vehicles. The effects of climate change will likely further exacerbate many of these threats in the future.

Psychotria malaspinae

A shrub or small tree in the coffee family, this species is federal ESA-listed as endangered and found in lowland/limestone forests. *Psychotria malaspinae* was known historically on the northeast and southwest sides of Guam in the forest ecosystem, specifically Andersen AFB. *P. malaspinae* is known from five occurrences in Guam, with each occurrence consisting of one or a few individuals (USFWS 2015a). There is much debate over the taxonomic status of *P. malaspinae,* and the distinction between *P. malaspinae* and *P. hombroniana* var. *Malaspinae* (see Section 8.2.5.5).

Serianthes nelsonii

Serianthes nelsonii is endemic to Guam and Rota. It was listed as endangered under the federal ESA in 1987. It is also listed as endangered under the Guam ESA. To date, only six adult trees have been recorded in Guam since the 1970s, located in the areas of Ritidian Point, Pati Point, and Tarzan River. At the time of federal ESA-listing as an endangered species, there were at least two known mature (seed-bearing) trees in Guam in limestone forest at Andersen AFB. Currently, there is one mature tree and associated seedlings on MCB Camp Blaz at Ritidian Point, nine outplanted saplings on Andersen AFB, three outplanted saplings at Guam NWR, 60 seedlings at UOG, and 100 seedlings at Main Command Center/Installation Entry System nursery for MCB Camp Blaz Forest Enhancement Area (M. Martinez, personal communications, November 2023).

Solanum guamense

Solanum guamense is a small shrub in the nightshade family that occurs within limestone forests. It is listed as endangered under the federal ESA. *S. guamense* is known from a single occurrence of one individual in Guam (USFWS 2015a). *S. guamense* was not observed during plant and invertebrate surveys conducted from 2022 through 2023 at Andersen AFB, NBG, or MCB Camp Blaz (NAVFAC Marianas 2023b).

Tabernaemontana rotensis

Tabernaemontana rotensis is a small to medium-sized tree in the dogbane family and federal ESA-listed as threatened. *T. rotensis* is known from six occurrences totaling approximately 21,000 individuals, the majority of which occur on Andersen AFB (USFWS 2015a). Over 900 *T. rotensis* were observed during plant and invertebrate surveys conducted from 2022 through 2023 at Andersen AFB, NBG, or MCB Camp Blaz (NAVFAC Marianas 2023b).

Tinospora homosepala

Tinospora homosepala is federal ESA-listed as endangered. A vine in the moonseed family found in limestone forests, the species is known from four occurrences in Guam totaling approximately 300 individuals (USFWS 2015a; Island Eco Services 2021). *T. homosepala* was not observed during plant and invertebrate surveys conducted from 2022 through 2023 at Andersen AFB, NBG, or MCB Camp Blaz

(NAVFAC Marianas 2023b). A population of 120 individuals was documented in 2021 during surveys at the sasa Valley Tank Farm (Island Eco Services 2021).

High Value Trees

"High Value Trees" is a list of plant species that have high cultural and/or ecosystem value and will require additional handling and processing procedures during pre-construction clearing activities on JRM-administered lands. The list of plants includes both trees and herbaceous species and was developed by JRM natural resources personnel in coordination with the GovGuam, Department of Chamorro Affairs (Table 4-3) (NAVFAC Marianas 2016e). Other species may be added to the list and will require further coordination with JRM on a project-specific basis.

Table 4-3. High Value Trees Recorded in Guam

Common Name/ Chamorro Name(1)	*Scientific Name*
Seedless Breadfruit/Lemai	*Artocarpus artilis*
Seeded Breadfruit/Dukduk	*Artocarpus mariannensis*
None/Fadang	*Cycas micronesica* (T, SOGCN)
None/Joga	*Elaeocarpus joga*
None/None	*Elatostema calcareum*
None/Aaban or aabang	*Eugenia bryanii* (E)
Banyan/Nunu	*Ficus prolixa*
Dyer's fig/Hodda	*Ficus tinctoria*
None/Ufa halumtano	*Heritiera longipetiolata* (E, SOGCN)
None/Ifit	*Intsia bijuga*
None/Luluhut	*Maytenus thompsonii*
None/None	*Procris pedunculata*
None/Aplokating-palaoan	*Psychotria malaspinae* (E)
Fire tree/Hayun lago	*Serianthes nelsonii* (E, SOGCN)
None/None	*Tabernaemontana rotensis* (T, SOGCN)

Notes: (1) Chamorro names from GovGuam (2009), Guam DAWR (2015), Safford (2009) and USFWS (2015a).
Key: E = listed as an endangered species under the federal ESA; T = listed as a threatened species under the federal ESA; SOGCN = Species of Greatest Conservation Need, by GovGuam.
Source: NAVFAC Marianas 2016e.

4.4.4 Stressors on the Terrestrial Environment of Guam

In addition to the impacts of invasive species, climate change and other anthropogenic stressors such as habitat loss and poaching have major impacts to the terrestrial environment. Climate change has and will continue to cause fluctuations in temperature and precipitation averages and increase the frequency and intensity of droughts and storm events (Leong et al. 2014). Sea level rise will lead to saltwater intrusions and affect the level of freshwater in island aquifers. Limited freshwater will stress native plants and animals, and changes in forest composition will alter the levels of humidity and sunlight in which they thrive. Endangered partulid tree snails, for example, are at risk of extinction as forest composition changes. Climate change will impact the native flora and fauna adapted to Guam's terrestrial ecosystems, reducing their chances of outcompeting invasive species that are present and continually introduced to the island.

Habitat loss and fragmentation is a result of a variety of factors, including climate change and urbanization. Climate change affects the distribution of vegetation types, decreasing the available habitat for species that rely on those vegetation types. The displacement of natural habitat due to infrastructural needs for increasing human populations alone is inevitable. In Guam, human population sizes have almost tripled in

the last 50 years (Worldometers 2018), and these pressures are expected to increase with the anticipated relocation of 5,000 marines to Guam by 2026 (DON 2015b). In Guam, loss of habitat is one of the driving factors in the reduction of Mariana fruit bat populations. A major threat to Guam sea turtles is nesting habitat destruction, which has resulted mainly from construction and development due to increased tourism (National Marine Fisheries Service [NMFS] and USFWS 2016).

Illegal hunting is considered to be one of the top threats to some threatened and endangered species in Guam and throughout the Mariana Islands. The decline of the fruit bats in Guam is attributed to illegal hunting and continues to be a threat despite their rarity on the island (USFWS 2007; Mildenstein 2008; USFWS 2009a; Wiles and Brooke 2009; USFWS 2014). Poaching of sea turtle eggs as well as harvest of nesting females is a known ongoing problem in Guam (NMFS and USFWS 2016).

Efforts to reduce the impacts of the terrestrial stressors by DON and the individual installations in Guam include the development of management plans such as the Mariana Fruit Bat Management Plan for Andersen AFB and the implementation of BMPs during construction and training activities (DON 2015c).

4.5 MARINE BIOLOGICAL ENVIRONMENT

This INRMP addresses nearshore areas adjacent to JRM terrestrial holdings in Guam. The geographic extent of JRM-administered submerged lands is from the mean high tide line out 3 miles (4.8 kilometers), including estuary, nearshore, and deep water environments (>5,400 feet [1,650 meters] depth) (see Figure 2-3). Based on this geographic extent, approximately 85,364 acres (34,546 hectares), just under one half of the total Guam submerged lands, are under the administration of JRM (Table 4-4). In addition, JRM installations include approximately 41 miles (66 kilometers) of shoreline in Guam, or 27% of Guam's total shoreline. See Appendix E for a complete list of plants and animals that are mentioned in this INRMP.

Table 4-4. JRM-administered Submerged Lands in Guam

Parcel	*Submerged Lands (acres)*	*Managed Nearshore Areas (acres)*	*Coastline (miles)*
NBG Main Base	30,867	4,696	25
MCB Camp Blaz Main Cantonment and MCB Camp Blaz South	16,629	753	3
Andersen AFB	37,869	1,734	13
Total DoD	**85,364**	**7,183**	**41**
Total Guam	**195,302**	**-**	**150**
% JRM-administered	**44%**	**-**	**27%**

Key: % = percent; AFB = Air Force Base; DoD = Department of Defense; JRM = Joint Region Marianas; MCB = Marine Corps Base.
Source: JRM 2019.

4.5.1 Physical Environment

4.5.1.1 Bathymetry and Currents

Guam's currents are heavily influenced by the North Pacific Equatorial Current, which flows in response to the trade winds in a westerly direction across the Pacific between 10° and 15° North. During the fall and winter months (predominantly the dry season), surface currents tend to be quite uniform, having a significant west-northwesterly component. As the surface current approaches and bifurcates around Guam from the east, the currents in the south tend to be more westerly, while currents in the north tend to be

toward the west-northwest. This pattern creates an area of variable current patterns directly in the lee of the island, with surface currents capable of flowing back toward Guam on occasion. In the summer months (predominantly the wet season), surface currents are slightly more variable on a month to month basis and the net current direction tends to flow in a more southwesterly direction (NAVFAC Pacific 2007).

4.5.1.2 Turbidity and Water Quality

Turbidity increases with suspended sediment delivered to the coast in freshwater runoff or by sediment resuspension from wave activity. The northern region of Guam is dominated by limestone, and, consequently, freshwater inputs typically occur as groundwater seeps that do not deliver significant suspended sediment to coastal waters. However, this region is exposed to relatively constant wave activity, particularly on the east side of the island and around Pati Point due to trade wind-driven waves impinging on the island from the northeast (Brainard et al. 2012), which may cause resuspension of calcareous sediments close to shore. Turbidity on the southern half of Guam is influenced by volcanic soils and is tightly coupled with freshwater inputs from sediment laden stream and river discharge, which have a distinct seasonal weather pattern (i.e., wet season) that is punctuated with tropical storms and typhoons.

4.5.1.3 Waves and Storms

Storm waves and surge associated with tropical storms and typhoons have a significant impact on littoral ecosystems within the Mariana Archipelago. The most frequent and consistent wave energy impacting Guam is caused by the northeast trade winds, which are generally strong during the dry season, November–April. Guam's windward coast is usually exposed and the leeward coasts are relatively sheltered (Brainard et al. 2012; NAVFAC Pacific 2013c).

Attributes of Guam's climate were presented in Section 4.1, *Climate*. Tropical storms and typhoons typically originate to the east of Guam, and can cause significant wave energy and currents to impact the island (Brainard et al. 2012). An average of six tropical storms pass within 186 miles (300 kilometers) of Guam every year. Figure 4-3 depicts the tropical storms and typhoons that have occurred within 100 miles (161 kilometers) of Guam from 2000 to 2023.

Seafloor movements that generate tsunamis may include faulting (earthquakes), landslides, and submarine volcanic eruptions. Undersea earthquakes around the Pacific Rim, where colliding plates lead to an unusually high level of seismic activity, generate more than 80% of tsunamis worldwide (Koenig 2001). Of the 12 recorded tsunamis affecting Guam, only 3 were large enough to cause damage—in 1849, 1892, and 1993 (Lander et al. 2002). No record of damaging tsunamis was found for the Mariana Archipelago after 1993.

4.5.2 Marine Habitats

In 2005, the National Oceanic and Atmospheric Administration (NOAA) and the Office of Insular Affairs funded the preparation of the *Guam Coastal Atlas*, which provided the first extensive look at how marine habitats are distributed around Guam (NOAA National Centers for Coastal Ocean Science [NCCOS] 2005). The Coastal Atlas was derived in part from benthic habitat data developed by the NCCOS from satellite and aerial photography, but these habitat maps are depth-limited. High-resolution bathymetric maps were also compiled from multibeam and light detection and ranging (known as LIDAR) data collected from 2001-2008 by NOAA's Pacific Islands Benthic Habitat Mapping Center. A series of benthic maps that describe slope, substrate type, and rugosity were generated. For both mapping products, the bottom habitat classifications were developed by NOAA (Monaco et al. 2012). Analyses of these data were reported as part of the larger dataset, which provides a valuable reference for island-wide and inter-island comparisons. These habitat map products are generally useful for applications that require only coarse resolution. They

have been shown to be accurate in many areas for fine-resolution applications, but they should also be used cautiously for fine-resolution applications because they are inaccurate in other areas. For example, areas of Apra Harbor with well-developed and diverse coral reefs are not shown on the habitat maps. DON proposes to develop improved maps for use in resource management.

4.5.2.1 Bottom Habitat

Bottom habitats are generally classified according to their cover or composition (e.g., macroalgae [cover] or soft bottom [composition]). Coral reefs and other rocky substrates are classified as types of hard bottom habitat, whereas unconsolidated sand and mud substrates are classified as types of soft bottom habitat. Compiled from the Coastal Atlas, Figure 4-11 depicts the distribution and extent of Guam's primary nearshore benthic habitat types and is based on the visual analysis of IKONOS satellite imagery. The *Guam Coastal Atlas* products, together with subsequent acoustic imaging products discussed above, can be combined to inform managers about marine habitats of interest, but they are not integrated and remain depth-limited. For example, in Apra Harbor, acoustic imaging from NOAA's Pacific Islands Benthic Habitat Mapping Center depicts hard bottom habitats where there is substantial coral below 50 feet (15 meters), but the Coastal Atlas methods could not distinguish relevant classifications. Figure 4-11 shows these as "unclassified", but subsequent backscatter analysis of acoustic imaging combined with LIDAR produced highly accurate habitat maps and classifications.

Coral Reefs

Coral reefs are singled out among hard bottom habitat types because a reef creates its own hardbottom. Guam lies relatively close to the Indo-Pacific center of coral reef biodiversity and possesses one of the most species-rich marine ecosystems among U.S. jurisdictions (Burdick et al. 2008). In addition to supporting a very diverse mix of corals, Guam also has five of the six major reef types: fringing reefs, patch reefs, submerged reefs, offshore banks, and barrier reefs. Atolls are the only major reef type missing from Mariana Islands. Guam is almost entirely surrounded by fringing reefs. The fringing reef is interrupted at several locations along the coastline by bays and channels. Corals found above the 98-foot (30-meter) isobath in this area include encrusting or massive growth forms of corals and columnar, platy, and branching growth forms, which are conditioned to withstand heavy wave action.

Fringing reefs extend directly from the shoreline down to the insular shelf and have characteristic zones. They are typically characterized by shallow lagoons or reef flats that are protected by a shallow reef crest that slopes down to the coastal shelf (Figure 4-12).

The shallow reef slopes are also known as fore reefs. The steepness of reef slopes are variable, and can level out substantially as they descend from the photic zone to the abyssal zone; these are often referred to as reef margins or terraces. Barrier reefs are not common in the Mariana Islands, but two barrier-lagoon structures are found in Guam. One is Cocos Lagoon on the southern tip of Guam, and the other is Apra Harbor–its modern highly-modified barrier consisting of natural and artificial structures (e.g., Luminao Reef and glass breakwater).

Major coral reef habitats in Guam are identified as aggregate reef, patch reef, spur and groove, and pavement. However, soft bottom habitats (e.g., sand and seagrass) are integrated into the coral reef framework and together they form a matrix of habitats that support a highly diverse and valuable marine ecosystem. Each habitat type has characteristic physical substrate features and biological community components that together describe the entire coral reef ecosystem.

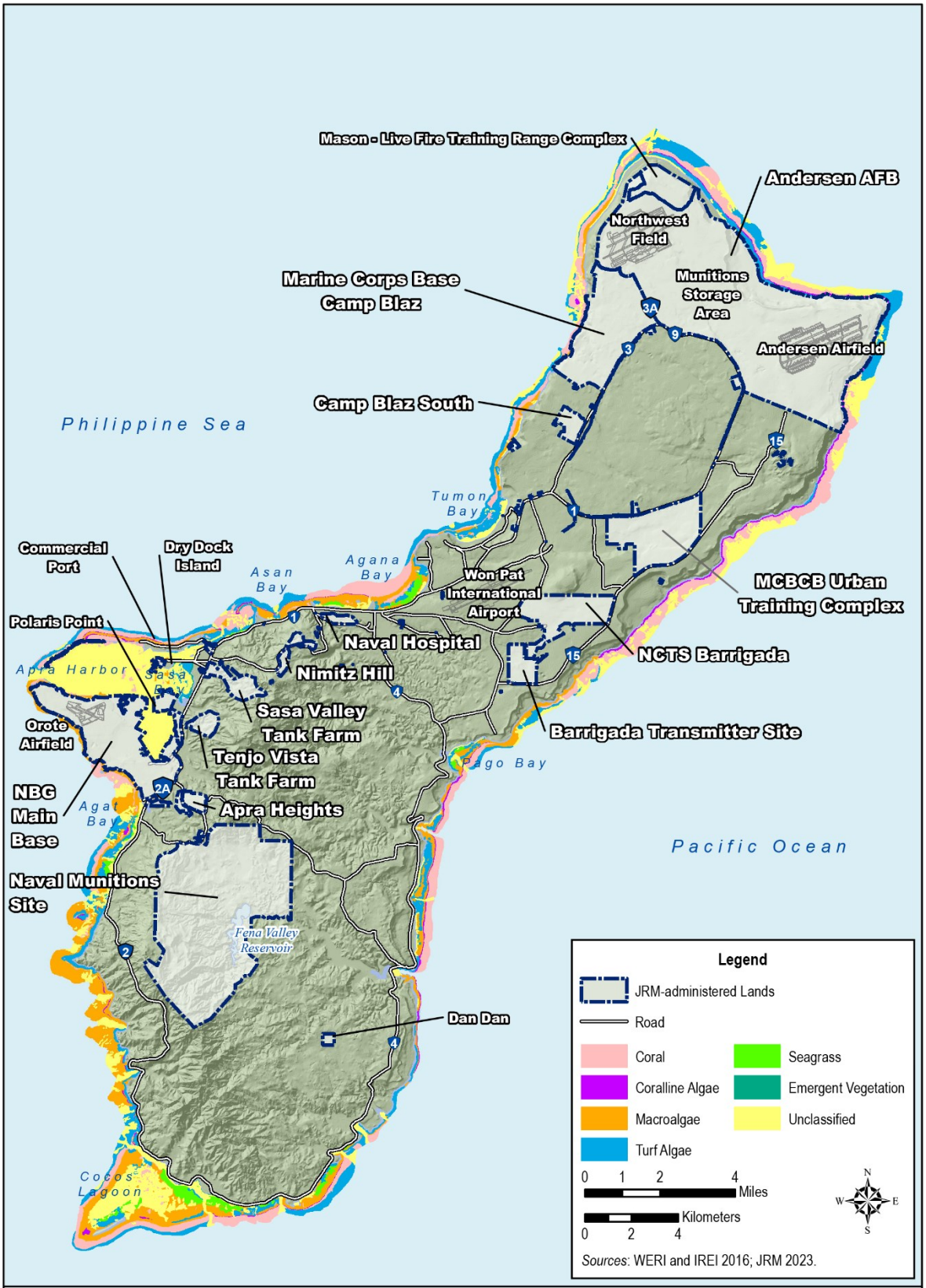


Figure 4-11
General Nearshore Marine Benthic Habitats in Guam

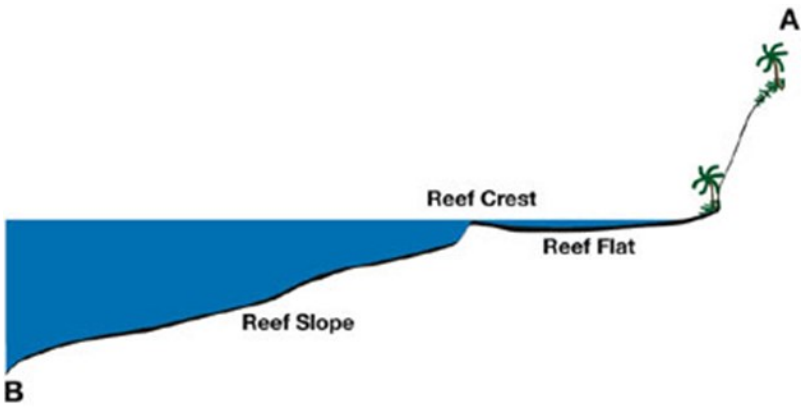


Figure 4-12. General Characteristics of a Fringing Coral Reef

Corals from one or more taxa are present from the North Pole to the South Pole and from the intertidal zone to the abyss. Corals addressed in this document are exclusively tropical species occurring (primarily) at depths of less than 325 feet (100 meters). The Coral Reef Conservation Act of 2000 defines several related terms: coral, coral reef, and coral reef ecosystem as follows.

- *Coral*: species of the phylum Cnidaria, including all species of the orders Antipatharia (black corals), Scleractinia (stony corals), Gorgonacea (horny corals), Stolonifera (organpipe corals and others), Alcyonacea (soft corals), and Coenothecalia (blue coral), of the class Anthozoa, and all species of the order Hydrocorallina (fire corals and hydrocorals) of the class Hydrozoa.
- *Coral Reef*: any reefs or shoals composed primarily of corals. One important regulatory definition of coral reef comes from the CWA Section 404(b)1 regulations (40 Code of Federal Regulations [CFR] 230): "Coral reefs consist of the skeletal deposit, usually of calcareous or silicaceous materials, produced by the vital activities of anthozoan polyps or other invertebrate organisms present in growing portions of the reef."
- *Coral Reef Ecosystem*: coral and other species of reef organisms (including reef plants) associated with coral reefs, and the nonliving environmental factors that directly affect coral reefs, that together function as an ecological unit in nature.

4.5.2.2 Coastal Habitat

Guam coastlines that are exposed to tidal inundation include cliffs and hardened/developed man-made structures, rocky and sandy beaches, and estuarine wetlands. Wharf faces and constructed coastlines function much like cliff faces do, providing hard bottom vertical surfaces that are colonized by a diverse community of invertebrates and algae. Depending upon the geology and the exposure to waves, rocky and sandy coastlines vary in composition and substrate size from very fine sand to large boulders. Estuarine wetlands are typically defined by connectivity to the marine environment and, therefore, a variety of salinity regimes. Estuarine wetlands with the greatest amount of marine connectivity are typically dominated by mangrove forest that plays a vital watershed role by filtering land-based sediments (Furukawa et al. 1997).



Dadi reef flat with mixed seagrass. Looking north from Dadi towards NBG Main Base.
(*Photo*: M. Lybolt)

4.5.2.3 Essential Fish Habitat

As stated in Section 3.4.1.3, *Magnuson-Stevens Fishery Conservation and Management Act*, the Mariana Islands are within the jurisdiction of the Western Pacific Regional Fisheries Management Council (WPRFMC), which has designated the marine waters around Guam as Essential Fish Habitat (EFH), and adopted a precautionary approach to EFH designation due to the lack of scientific data. The WPRFMC currently manages fisheries in the Mariana Islands under two Fishery Ecosystem Plans (FEPs): Mariana Archipelago FEP and Pacific Pelagic FEP. Each of these FEPs identifies areas of EFH and Habitat Areas of Particular Concern (HAPC) for different life stages of species managed under the respective plan, although the Marianas FEPs currently manage benthic EFH by depth. The Mariana Archipelago FEP addresses the following Management Unit Species (MUS) that occur within the nearshore waters of Guam: bottomfish and seamount groundfish fishery, crustacean fishery, precious coral fishery, and coral reef ecosystem fishery (WPRFMC 2009a). Altogether, these EFH types encompass the seafloor and water column from shore to 1,970 feet (600 meters) depth. The Pacific Pelagic FEP addresses federally managed pelagic species, and encompasses the pelagic water column from the surface to 3,280 feet (1,000 meters) depth. (WPRFMC 2009b) (see Section 4.5.5.3, *Pelagic Species*, for further detail).

EFH habitats in Guam include the following components:

- *Intertidal Zones.* This habitat includes a small margin of seabed existing between the highest and lowest extent of the tides extending around Guam.
- *Seagrass Beds.* Seagrass beds occur in Outer and Inner Apra Harbor, Hagatna Bay, Agat, and other isolated areas around Guam.
- *Macroalgae.* Macroalgae habitats occur within most areas around Guam.
- *Mangrove Forests/Wetlands.* These forests are primarily associated with back-barrier lagoons and most occur in the coastal intertidal portions of Apra Harbor and Cocos Lagoon. Isolated mangrove stands occur at river mouths and other locations.
- *Coral Reefs and Colonized Hardbottom.* Reefs and colonized hard bottom occur around most of the island, interrupted at most rivers by fluvial sand deposits. Additional reefs are located on shoals in lagoons (e.g., within Cocos Lagoon and Apra Harbor).
- *Estuarine Water Column.* This habitat includes river mouth areas and portions of Apra Harbor. Estuarine water and mangrove stands usually co-occur.
- *Marine Water Column.* This habitat is the space between the sea surface and the sea floor. Many managed species occur in this habitat and rely on this for development, dispersal, or feeding.
- *Unconsolidated Bottom.* This habitat includes loose rubble, sand, and mud substrates that are concentrated in the back-barrier lagoons of Cocos Lagoon and Apra Harbor and at most river mouths.

In addition, HAPCs have been designated in Guam. HAPCs, a subset of EFH, are habitat types and/or geographic areas identified by the regional fishery management councils and NMFS as priorities for habitat conservation, management, and research. HAPCs are specific areas that are essential to the life cycle of species. At least one or more of the following criteria established by NMFS must be met for HAPC designation: (1) the ecological function provided by the habitat is important; (2) the habitat is sensitive to human-induced environmental degradation; (3) development activities are, or would be, stressing the habitat type; or (4) the habitat type is rare. It is possible that an area can meet one HAPC criterion and not be designated an HAPC. The WPRFMC used a fifth criterion, not established by NMFS, in HAPC designation of areas that are already protected, such as wildlife refuges (WPRFMC 2009a). The WPRFMC has designated HAPCs for Coral Reef Ecosystem MUS at five locations in Guam: Jade Shoals, Ritidian

Point, Haputo ERA, Orote Peninsula ERA, and Cocos Lagoon. Jade Shoals, Haputo ERA, and Orote Peninsula ERA are located on JRM-administered submerged lands. On the basis of the known distribution and habitat requirements of adult bottomfish, the WPRFMC designated all slopes and escarpments between 131-919 feet (40-280 meters) as HAPC.

4.5.3 Marine Flora

4.5.3.1 Native Species

There are about 237 benthic macroalgae species on Guam (Lobban and Tsuda 2003). They are primary producers in the reef community and also hold sediment. An abundance of crustose coralline algae is associated with reef health for its complementary role in coral recruitment (Figure 4-11). Macroalgae compete with corals for space on the reef, and abundance is controlled by herbivory pressures and nutrient availability. Coral reefs can undergo phase shifts from highly productive, coral dominated habitats to less productive algal dominated habitats.



Common macroalgae in the Marianas. *Caulerpa serrulata* (center), *Padina* sp. (periphery). Also, bite marks from parrotfish (center).
(*Photo*: M. Lybolt)

Seagrasses are unique among flowering plants in that all but one genus can live entirely immersed in sea water. Tropical seagrass meadows typically occur in shallow, sheltered, soft-bottomed marine coastlines and estuaries. Barrier reefs protect coastlines and the lagoon formed between the reef and the mainland is protected from waves, allowing mangrove and seagrass communities to develop. Tropical seagrasses are important in their interactions with mangroves and coral reefs. Seagrasses trap sediment and slow water movement, causing suspended sediment to fall out (Bos et al. 2007). This trapping of sediment benefits coral and reef organisms by reducing sediment loads in the water. These systems exert a stabilizing effect on the environment, resulting in important physical and biological support for other marine communities.

There are three known seagrass species in Guam (Lobban and Tsuda 2003): tape seagrass (*Enhalus acoroides*), narrowleaf seagrass (*Halodule uninervis*), and hartog seagrass (*Halophila minor*). Of these, the dominant one is *Enhalus acoroides*; *Halophila minor* and *Halodule uninervis* are physically smaller and somewhat seasonal (NAVFAC Marianas 2011). Seagrasses are much more abundant in the upper 6 feet (2 meters) of the water column (NOAA 2017a) but *Halophila*, the small paddle-shaped grass, can be found to approximately 131 feet (40 meters) deep. The genus *Halophila* is under revision. *Halophila minor* may have a name change, and an additional species may be recognized in the CNMI (Fonseca and Olsen 2016).

Mangroves are a type of estuarine swamp environment dominated by mangroves and other saltwater-tolerant trees. All mangrove areas in Guam are located in the southern half of the island, with the largest concentrations found along the eastern shores of Sasa Bay and Inner Apra Harbor and smaller areas present in Merizo and Inarajan. Encompassing approximately 173 acres (70 hectares), the mangrove communities of Apra Harbor are the most developed mangrove forests in the Mariana Islands (Burdick et al. 2008). Species of mangrove known from JRM-administered lands and submerged lands in Guam include:

loop-root/red/Asiatic mangrove (*Rhizophora mucronata*), red/tall-stilt mangrove (*Rhizophora apculata*), cannonball/cedar mangrove (*Xylocarpus moluccensis*), grey/white mangrove (*Avicennia marina*), black mangrove (*Lumnitzera littorea*), and large-leaf orange/oriental/black mangrove (*Bruguiera gymnorrhiza*). Mangroves are important species that can moderate coastal dynamics, provide important nearshore habitat for diverse fish species, and bring indirect benefits to coral reefs. Mangroves are important habitats for juveniles and adults of many fish species as well as many specialized invertebrates. In addition, they act as filters, trapping sediment from rivers before it can be deposited on sensitive coral reef habitat (Furukawa et al. 1997; Nagelkerken et al. 2008).

4.5.3.2 Non-native and Nuisance Species

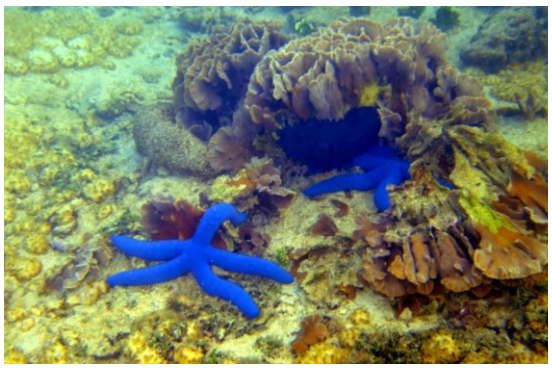
The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.2, *Regional Biosecurity Plan for Micronesia and Hawai'i.*

Large numbers of foreign flag commercial fishing vessels and inter-island cargo ships visit Apra Harbor, and this is a main focus of the Guam Marine Biosecurity Action Plan (Miller 2014). Hull maintenance on the majority of these vessels is poor and they are heavily fouled. The potential for the introduction of non-native species is far greater from these vessels than from DoD vessels, whose hulls are extremely well maintained/cleaned. Without sunlight, it is extremely unlikely for marine flora to be introduced from ballast water.

Gracilaria salicornia and *Acanthophora spicifera* are considered native to Guam and CNMI, but are considered invasive elsewhere in the Pacific (e.g., Hawai'i) (Tsuda 1985; Lobban and Tsuda 2003; NAVFAC Pacific 2011b). A nuisance marine species is native, but occasionally exhibits blooms or outbreaks or other undesirable characteristics. The marine species named angel hair algae (*Chaetomorpha* spp.) is native to Guam and CNMI (Lobban and Tsuda 2003) but has become a nuisance around Guam, and long mats of the algae can foul shorelines, get tangled in propellers, and impact vessel operations (Schils 2015).

4.5.4 Marine Invertebrates

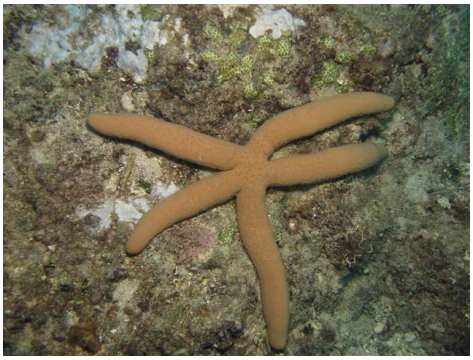
4.5.4.1 Native Species



The blue seastar (*Linckia laevigata*) is ubiquitous on Guam reef habitats.
(*Photo*: L. Shaughnessy)

With almost 4,000 species identified, marine invertebrate biodiversity in Guam is very high (Burdick et al. 2008). For example, Ward (2003) recorded 21 species of cephalopods, Newman et al. (2003) 59 species of flatworms, Bailey-Brock (2003) 104 species of segmented worms, Smith (2003) 895 species of snails, and Carlson and Hoff (2003) 467 species of sea slugs. However, a few groups of invertebrates are particularly important for their habitat forming characteristics or their detectability and, thus, ability to serve in comparative analyses (either over time or to other areas). These groups are typically referred to as macroinvertebrates, and include the anthozoid class of cnidarians, echinoderms, crustaceans, and bivalves.

The most notable Anthozoid cnidarians are stony corals, which form the framework for coral reefs. There are approximately 375 species of the order Scleractinia (stony corals) in Guam. All other groups of corals (taxonomic orders) are represented in Guam, including 10 species of the order Antipatharia (black corals and wire corals), 60 species of the order Alcyonacea (soft corals and Tubipora corals), 20 species of the order Gorgonacea (horny corals/sea fans), and 1 species of the order Helioporacea (blue corals). The corals of the class Hydrozoa (hydrocorals) are also represented in Guam with approximately 5 species of the order Milleporina (fire corals) and 21 species of the order Stylasterina (lace corals) (Paulay et al. 2001; Riegl et al. 2008).



Very uncommon yellow variant of the "blue seastar" (*Linckia laevigata*). The blue variant is ubiquitous on Guam reef habitats.
(*Photo*: D. Snyder)

A total of 124 species of siliceous sponges (those with a silica structure) and 4 species of calcareous sponges (those with a calcium-based structure) have been identified in the Mariana Islands. The diversity of sponge fauna of the Mariana Islands is expected to be considerably higher than what has been reported, because many species, especially cryptic and encrusting species, have yet to be collected and studied (Kelly et al. 2003).

While stony corals build long lasting habitat features that are structurally complex, other coral types and sponges also contribute to habitat complexity, although the structure of sponges is not enduring in the way that corals are long lasting. Sponge diversity is greatest, regardless of depth, on coral reefs, in caves, and vertical areas not colonized by hard corals. They are also abundant in seagrass beds, mangroves, and other environments, providing residence for a huge variety of animals, including crustaceans, annelids, and echinoderms. Resident mobile epibenthic macroinvertebrate groups such as these serve as a useful indicator because their relative abundance is linked to habitat complexity and quality. There are a number of species of sponge around Guam that are particularly conspicuous and large and are therefore major contributors to habitat structure.

In general, coral cover in Guam was estimated to be similar to other southern Mariana Islands, but lower than the northern islands. Because coral distribution and coral cover on reefs is naturally patchy and heterogeneous (Figure 4-11), a single island-wide number is not a particularly useful summary of the coral community. Long-term monitoring surveys conducted by NOAA's Coral Reef Ecosystem Division Pacific Assessment and Monitoring Program collect synoptic and spatially-explicit data approximately bi-annually. Recent island-wide figures found approximately 10–15% coral cover overall (e.g., Brainard et al. 2012), but the recent multi-year coral bleaching events have had dramatic, if patchy, consequences for the reef communities in Guam.

Aside from coral and sponges, macroinvertebrates are important indicators of coral reef health. They perform various ecological functions such as filtration and grazing and can even be habitat structuring benthos. The Mariana Archipelago Reef Assessment and Monitoring Program focused macroinvertebrate estimates on just a few major groups of animals that were conspicuous and important ecologically and economically: giant clams (*Tridacna* spp.), sea urchins, and sea cucumbers (Echinoidea). Giant clams are filter feeders that are sought after in the Indo-Pacific for their meat and shells. Sea urchins are important algal grazers and bioeroders and are also harvested for food. Sea cucumbers, sand-producing detritus foragers, are harvested for food. Species richness was homogenous throughout the archipelago, but abundance was heterogenous with no overall pattern. Guam had low abundance of giant clams and sea

urchins, and moderate abundance of sea cucumber (Burdick et al. 2008). Species richness for sea urchins and sea cucumbers was moderate and high, respectively (Brainard et al. 2012). A number of stocks of macroinvertebrates that are collected for food around Guam are either depressed or severely depressed due to overfishing like many other fisheries stocks around Guam.

The crustaceans around Guam include a group of species managed by the WPRFMC under EFH: spiny lobsters (Palinuridae) and slipper lobsters (Scyllaridae), Kona crabs (*Ranina ranina*), and deepwater shrimp (Caridea). The spiny and slipper lobsters are the main invertebrates landed in Guam. The group consists of four species that all inhabit reefs and nearshore habitat: spiny lobsters (*Panulirus penicillatus* and *Panulirus* sp.), ridgeback spiny lobster (*Scyllarides haani*), and Chinese slipper lobster *(Parribacus antarcticus*). Spiny lobsters are typically found on rocky substrates in well-protected areas, in crevices, and under rocks. Large adult spiny lobsters are captured at depths as shallow as 9 feet (3 meters). In the southwestern Pacific, spiny lobsters are typically found in association with coral reefs. Note that the WPRFMC includes Kona crabs and ridgeback spiny lobster as managed species even though they have never been recorded in the Mariana Archipelago. The WPRFMC has designated all banks with summits less than 98 feet (30 meters) from the surface as HAPCs for lobsters (WPRFMC 2009a).

4.5.4.2 Non-native and Nuisance Species

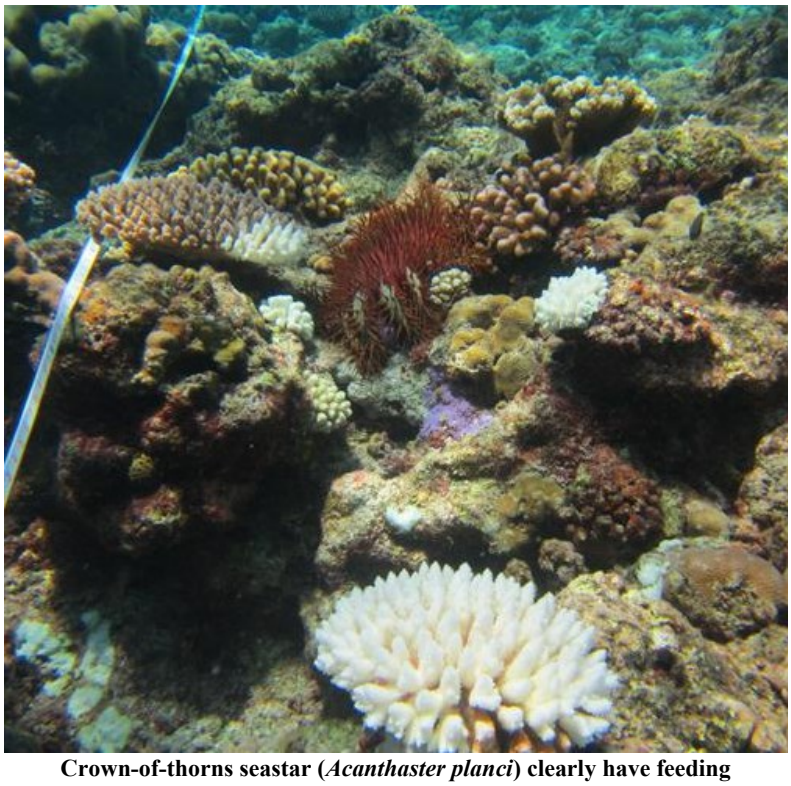
Large numbers of foreign flag commercial fishing vessels and inter-island cargo ships visit Apra Harbor, and this is a main focus of the Guam Marine Biosecurity Action Plan (Miller 2014). Hull maintenance on the majority of these vessels is poor and they are heavily fouled. The potential for the introduction of non-native species is far greater from these vessels than from DoD vessels, whose hulls are extremely well maintained/cleaned. There is much greater potential for hull transport than ballast transport to be the main source of nonindigenous invertebrate species introduction to Guam. With an importing economy, much more cargo is offloaded on the island than is taken away, minimizing the need for ballast water discharge. The unique environment of Apra Harbor provides habitat for many invertebrate species that are found nowhere else in Guam. The restriction of many indigenous species to the harbor, however, also makes the identification of nonindigenous species in Guam more difficult.

Paulay et al. (2002) conducted marine biodiversity surveys in Guam focusing on nonindigenous species. The main criteria used for recognizing nonindigenous species in Guam were distribution outside Guam, and association with, or restriction to, artificial substrata, including vessels that could affect dispersal (Chapman and Carlton 1991). The study indicated there have been 79 nonindigenous marine invertebrate species recorded in Guam–though not all of these persist in the wild. Of these, 35 species can be categorized as introduced, 44 as cryptogenic (i.e., species that have obscure origins and distributions, or lack clear evidence of their introduction), 9 species represent purposeful introductions, and 70 are accidental introductions. A striking feature of the nonindigenous marine biota of Guam is the preponderance of sessile species: 76% among all and 86% among accidentally introduced or cryptogenic species live attached. Only three of the mobile species have not been purposely introduced or transported on vessel hulls and, thus, are candidates for introduction via ballast water. Sessile nonindigenous species include numerous sponges, hydroids, anemones, cemented and strongly byssate bivalves, barnacles, bryozoans, and ascidians. In contrast to their predominance among nonindigenous species, sessile species compose less than 20% of Guam's documented indigenous marine fauna. The preponderance of sessile species in the nonindigenous fauna supports the importance of hull transport compared with ballast transport as the main source of introduced species in Guam (Paulay et al. 2002). Not all of the 79 non-native species reported by Paulay et al. (2002) persist in the environment. Even at the time of publication, in 2002, 13% of non-native species

were extirpated or living only in mariculture. To date, there is not yet evidence that any of these non-native species are invasive.

Sponges were not considered a threat to entire reefs until unprecedented spreading of the encrusting sponge *Terpios hoshinota* on the coral reefs of Guam in the 1970s (Bryan 1973). *Terpios* is a nuisance species, and though there is no evidence that *Terpios* is definitively an invasive species, its ecology and impacts are most appropriately understood in the context of marine invasive species. *Terpios* has a high growth rate that can encrust every type of hermatypic coral encountered (Ruetzler and Muzik 1993). The sponge is known to survive in polluted and stressed coral reefs. Damage caused by an invasion of *Terpios* caused nearly 30% loss of coral coverage on some reefs in Guam (Plucer-Rosario 1987). The complete recovery from a *Terpios* encrustation in Guam took more than 10 years from the time when the disturbance level decreased. During growth, *Terpios* moves forward by lateral propagation, extending short, fine tendrils across crevices to new substrate (Ruetzler and Muzik 1993). *Terpios* can also develop tissue threads, instead of whole sheets of tissue, to move over a shaded area and establish new territory (Soong et al. 2009). However, *Terpios* occasionally exhibits retrogression (i.e., negative growth) and can even be overgrown by some corals (e.g., *Montipora* and *Porites*) or red calcareous algae (Plucer-Rosario 1987). Thus, *Terpios* does not always win during its advance. Tang et al. (2011) indicated that invasion by *Terpios* onto corals initiates a shift in the coral bacterial community from one on healthy corals to the coral bacterial community found on corals with blackband disease. Their results suggested that harmful bacteria weakening the coral might favor *Terpios* outcompeting the coral for substratum.

Crown-of-thorns seastar (COTS) (*Acanthaster planci*) is a native coral eating seastar found throughout the Indo-Pacific region and occasionally becomes a nuisance species. Periodic outbreaks of COTS have occurred in Guam and have been reasonably well documented since the 1960s (e.g., outbreak in 1968-1969: [Colgan 1987]; outbreak in 1972: [Randall 1972]; outbreak in 2007: [Timmers et al. 2012]). Burdick et al. (2008) found that the widespread, persistent nature of these outbreaks, as well as observations of high COTS predation mortality among less-preferred coral species, suggest that these outbreaks have had, and are continuing to have, a severe impact on many of Guam's reefs. Ecologically, outbreaks severely impact reef systems by altering community structure, promoting algal colonization, and affecting reef fish populations (Timmers et al. 2012).



Crown-of-thorns seastar (*Acanthaster planci*) clearly have feeding preferences. This individual has eaten colonies of Acropora globiceps, Acropora digitifera, and Stylophora pistillata while passing over six other coral species.
(*Photo*: V. Bonito)

The effect of its population explosions in Guam went unnoticed until the late 1960s, although outbreaks had been observed almost a decade earlier. On Tanguisson Reef in 1968−1969, a population explosion of COTS devastated the coral community and resulted in a 99% loss of coral cover. Based on biennial surveys of COTS in Guam since 2003, the COTS calculated densities were especially high in 2007 (4,550 per square mile [1,750 per square kilometer]) and 2009 (3,250 per square mile [1,250 per square kilometer]); data has not been released by the NOAA Pacific Islands Fisheries Science Center (PIFSC) since 2011 (Figure 4-13) (NMFS 2017). The NOAA surveys for COTS are now triennial (Timmers 2016).

Although the factors that trigger an initial outbreak may vary, successive outbreaks within and across regions are assumed to spread via the planktonic larvae released from a primary outbreak (Timmers et al. 2012). Targeted eradication programs can help control outbreaks. COTS are easily identifiable and can be killed with injections of bile salts, lime juice, or vinegar (Rivera-Posada et al. 2013; Moutardier et al. 2015). A long-term objective for Guam marine resource managers to consider is reducing nutrient input into the marine system, which is believed to be one of the primary root causes of COTS outbreaks (Randall 1972; Brodie et al. 2005; Fabricius et al. 2010).

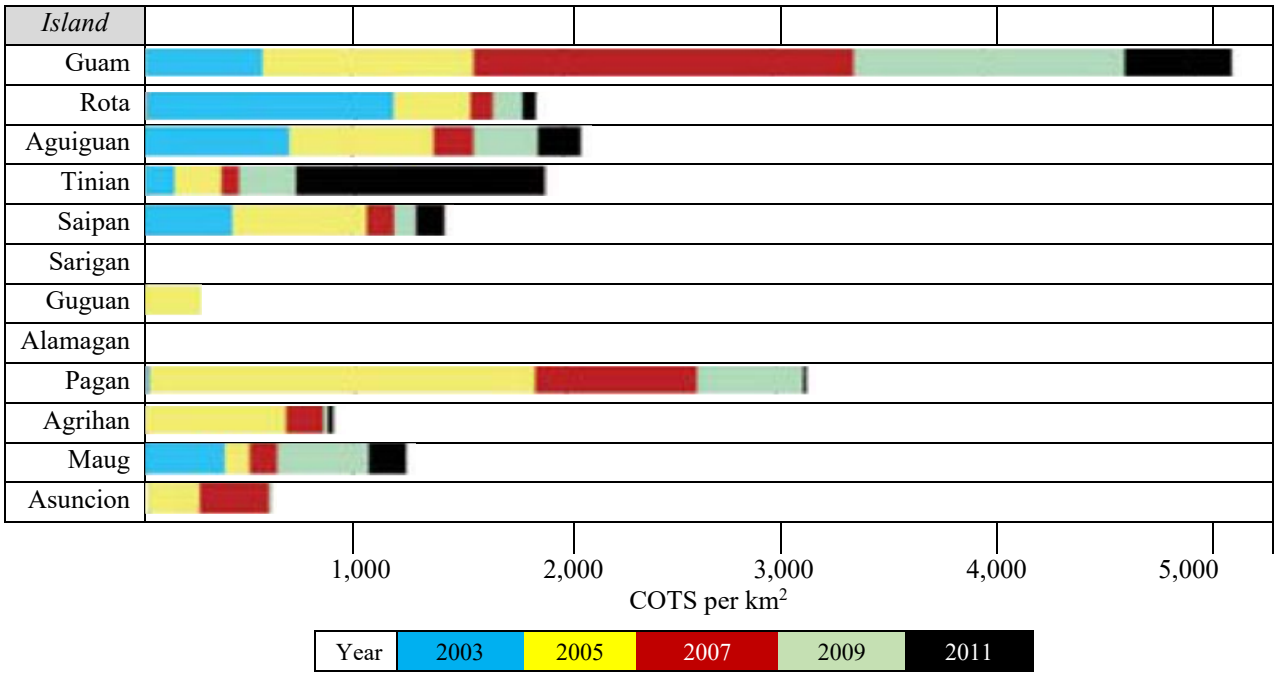


Figure 4-13. COTS Densities within the Mariana Archipelago (2003-2011)
Source: NMFS 2017.

4.5.5 Marine Fishes

4.5.5.1 Native Species

Myers and Donaldson (2003) estimated that over 1,000 species of shorefish occur in the Mariana Archipelago. Guam has complex habitats, which support greater fish species richness compared to other Mariana Islands (Donaldson et al. 1994; Donaldson 1995). There is a substantial range of size and ecological role of marine fish, from sharks to gobies. However, many species are highly mobile and others have unevenly distributed distributions due to niche and preferred habitat associations.

Guam's fisheries currently target a large number of fishes and invertebrates from pelagic and coral reef habitats (WPRFMC 2016a). Catch per unit effort and landings have declined over the past 50 years for

shore-based fisheries in Guam (Porter et al. 2005; Burdick et al. 2008). There are multiple lines of evidence consistent with systematic overfishing, and this trend is largely unchanged since the implementation of national fisheries management programs (Williams et al. 2011; Brainard et al. 2012; Heenan et al. 2015; WPRFMC 2016b).

4.5.5.2 Bottomfish Species

Seventeen species of bottomfish are managed by the WPRFMC through the Mariana Archipelago FEP. In Guam, the commercial fishery is divided into a shallow-water complex and a deepwater complex based on depth and species composition. The shallow-water (100-500 feet [30-152 meters]) bottomfish fishery targets the redgill emperor (*Lethrinus rubrioperculatus*) and is mostly commercial but also includes subsistence fishermen. The deepwater (>500 feet [152 meters]) bottomfish fishery is primarily commercial, targeting snappers and groupers. The snappers targeted include members of *Etelis* and *Pristipomoides*, whereas the eight-band grouper (*Epinephelus octofasciatus*) is the only targeted grouper (WPRFMC 2009a).

Except for several of the major commercial species, very little is known about the life histories, habitat use patterns, food habits, or spawning behavior of most adult bottomfish and seamount groundfish species. Furthermore, very little is known about the distribution and habitat requirements of juvenile bottomfish. Generally, the distribution of adult bottomfish in the Western Pacific Region is closely linked to suitable physical habitat. Adult bottomfish are usually found in habitats characterized by a hard substrate of high structural complexity. Deepwater snappers tend to aggregate in association with prominent underwater features, such as headlands and promontories.

The eggs and larvae of all Bottomfish MUS are pelagic, floating at the surface until hatching and subject thereafter to prevailing ocean currents. There have been few taxonomic studies of these life stages of snappers and groupers. EFH for adult and juvenile bottomfish is the water column and all bottom habitat extending from the shoreline to a depth of 1,300 feet (400 meters), encompassing the steep drop-offs and high-relief habitats that are important for bottomfish. EFH for bottomfish eggs and larvae is the water column extending from the shoreline to the outer boundary of the Exclusive Economic Zone (EEZ) to a depth of 1,300 feet (400 meters).

4.5.5.3 Pelagic Species

Thirty-three pelagic species are currently managed as Pelagic Management Unit Species (PMUS) by the WPRFMC through the Fishery Management Plan for Pelagic Fishery of the Western Pacific Region and subsequent amendments. These are divided into the following species complex designations: marketable species, nonmarketable species, and sharks. The marketable species complex has been further divided into temperate and tropical assemblages. The temperate species complex includes those PMUS that are found in greater abundance outside tropical waters at higher latitudes (e.g., broadbill swordfish [*Xiphias gladius*], bigeye tuna [*Thunnus obesus*], Pacific bluefin tuna [*T. orientalis*], and albacore tuna [*T. alalunga*]). Additionally, a squid PMUS consisting of three flying squid species was incorporated into the existing Pelagic FMP.

The PMUS are typically found in epipelagic to pelagic waters; however, shark species can be found in inshore benthic, neritic to epipelagic, and mesopelagic waters. Factors such as gradients in temperature, oxygen, or salinity can affect the suitability of a habitat for pelagic fishes. Skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*T. albacares*), and Indo-Pacific blue marlin (*Makaira nigricans*) prefer warm surface layers, where the water is well-mixed and relatively uniform in temperature. Species such as albacore tuna, bigeye tuna, striped marlin (*Kajikia audax*), and broadbill swordfish prefer cooler temperate

waters associated with higher latitudes and greater depths. Certain species, such as broadbill swordfish and bigeye tuna, are known to aggregate near the surface at night. However, during the day, broadbill swordfish can be found at depths of 2,625 feet (800 meters) and bigeye tuna around 902 to 1,804 feet (275 to 550 meters). Juvenile albacore tuna generally concentrate above 295 feet (90 meters) with adults found in deeper waters (295 to 902 feet [90 to 275 meters]).

Migration and life history patterns of most pelagic species in the Pacific Ocean are poorly understood. Additionally, very little is known about the distribution and habitat requirements of the juvenile lifestages of tuna and billfish prior to recruitment into fisheries. Seasonal movements of cooler-water tunas such as the Pacific bluefin (*Thunnus orientalis*) and albacore (*T. alalunga*) are more predictable and better defined than billfish migrations. Tuna and related species tend to move toward the poles during the warmer months and return to the equator during cooler months. Most pelagic species make daily vertical migrations, inhabiting surface waters at night and deeper waters during the day. Spawning for pelagic species generally occurs in tropical waters but can include temperate waters during warmer months. Very little is known about the life history stages of species that are not targeted by fisheries in the Pacific such as gempylids, sharks, and pomfrets.

Non-native and Nuisance Species

Large numbers of foreign flag commercial fishing vessels and inter-island cargo ships visit Apra Harbor, and this is a main focus of the Guam Marine Biosecurity Action Plan (Miller 2014). Hull transport is an unlikely vector for the introduction of non-native fish. The potential for the inadvertent introduction of non-native fish species is far greater from ballast transport or live animal trade. With an importing economy, much more cargo is offloaded on the island than is taken away, minimizing the need for ballast water discharge. The unique environment of Apra Harbor provides habitat for many fish species that are found nowhere else in Guam. The restriction of many indigenous species to the harbor, however, also makes the identification of nonindigenous species in Guam more difficult.

Paulay et al. (2002) conducted marine biodiversity surveys in Guam, focusing on nonindigenous species. The study indicated there were six fish species categorized as introduced. One additional non-native fish species is farmed in freshwater enclosures but can tolerate brackish conditions and has the potential to become invasive in a small habitat range. To date, there is not yet evidence that any of these non-native species are invasive.

4.5.6 Marine Protected Species

Table 4-5 provides a list of the federal and Guam ESA-listed species that are known to occur within or in the vicinity of JRM-administered submerged lands. Species listed as threatened or endangered under the federal ESA that have the potential to occur within JRM-administered submerged lands are discussed briefly in the following sections. Further details regarding the installations are discussed as appropriate in each installation chapter, Chapters 5-9.

Although critical habitat for the green sea turtle and three threatened coral species is expected in the near future (see Section 4.5.6.4, *Invertebrates [Corals]*), at this time critical habitat has not been designated for any listed marine species in Guam. The DON will continue to coordinate closely with NMFS during this process and will update the INRMP, as necessary, to incorporate appropriate information regarding critical habitat.

While there are few long-term historical datasets monitoring trends of marine species in Guam, a recent study analyzed five decades of systemic aerial survey data from Guam DAWR to estimate relative abundances, trends, and geographic distributions of sea turtles, elasmobranchs, and cetaceans around Guam

(Martin et al. 2016). Observations of large dolphin species were low, but increased slightly over time and were most dense along the southwest and north coasts. Abundance of green sea turtles increased dramatically, but the increase was constrained to a single location on southern Guam. Shark numbers declined sharply and the remaining animals were more often recorded along the east and north coasts. Unspecified manta species were infrequently seen, and observations were concentrated in the northwest near the Marine Protected Area (Martin et al. 2016).

Table 4-5. Federal and Guam ESA-listed Threatened and Endangered and MMPA-protected Marine Species Recorded within JRM-administered Submerged Lands in Guam

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat*[2]	*Occurrence*[3]
Invertebrates (Corals)					
Coral/Acho Tasi	*Acropora globiceps*	T	--	Intertidal zone, upper reef slopes, and reef flats at depths <26 feet (8 meters)	Y
Coral/Acho Tasi	*Acropora retusa*	T	--	Shallow reef slope and back-reef areas at depths of 3-16 feet (1-5 meters)	Y
Coral/Acho Tasi	*Seriatopora aculeata*	T	--	Shallow reef slopes at depths of 10-131 feet (3-40 meters)	P
Fish					
Oceanic whitetip shark/Haluu	*Carcharhinus longimanus*	T	--	Open ocean, usually well offshore	PU
Giant manta ray/Afula or Hafula or Fanihen Tasi	*Manta birostris*	T	--	Coastlines, oceanic island groups, and offshore pinnacles and seamounts	P
Scalloped hammerhead shark/ Haluun kiluus or Ulon matiyu na huluu	*Sphyrna lewini*	T[4]	--	Coastal seas from intertidal to depths of 1,640 feet (500 meters); nearshore nursery habitat includes bays and estuaries	Y
Reptiles					
Green sea turtle/Haggan	*Chelonia mydas*	E[5]	T	Nearshore waters, nesting beaches, and offshore waters	Y
Hawksbill turtle/Haggan karai	*Eretmochelys imbricata*	E	E	Nearshore waters, nesting beaches, and offshore waters	Y
Loggerhead turtle/Haggan	*Caretta caretta*	E[6]	--	Offshore waters	PU
Leatherback turtle/Haggan	*Dermochelys coriacea*	E	E	Offshore waters	PU
Olive ridley turtle/Haggan	*Lepidochelys olivacea*	T	--	Offshore waters	PU
Marine Mammals					
Common minke whale/ Salungai or Bayena	*Balaenoptera acutorostrata*	MMPA	--	Prefers temperate/boreal waters, uncommon in the tropics	Y
Sei whale/Salungai or Bayena	*Balaenoptera borealis*	E	--	Offshore, prefers deeper waters	P
Bryde's whale/Salungai or Bayena	*Balaenoptera edeni*	MMPA	--	Offshore, sometimes near a shore/shelf break	Y
Fin whale/Salungai or Bayena	*Balaenoptera physalus*	E	--	Generally near the 656-foot (200-meter) isobath	P

Table 4-5. Federal and Guam ESA-listed Threatened and Endangered and MMPA-protected Marine Species Recorded within JRM-administered Submerged Lands in Guam

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat*[2]	*Occurrence*[3]
Pygmy killer whale/ Salungai or Bayena	*Feresa attenuata*	MMPA	--	Offshore, prefers deeper waters	Y
Short-finned pilot whale/Salungai or Bayena	*Globicephala macrorhynchus*	MMPA	--	Various tropical and temperate waters	Y
Risso's dolphin/ Salungai or Bayena	*Grampus griseus*	MMPA	--	Deep waters generally >3,281 feet (>1,000 meters) depth	Y
Dwarf sperm whale/ Salungai or Bayena	*Kogia sima*	MMPA	--	Generally near the 656 foot (200 meter) isobath	Y
Humpback whale/ Salungai or Bayena	*Megaptera novaeangliae*	E[7]	--	Coastline to 5,906 foot (1,800 meter) isobath	P
Blainville's beaked whale/Salungai or Bayena	*Mesoplodon densirostris*	MMPA	--	Upper continental slope near 656-6560 feet (200-2,000 meters)	Y
Killer whale/Salungai or Bayena	*Orcinus orca*	MMPA	--	Prefers temperate/polar waters, less common in the tropics	Y
Melon-headed whale/Salungai or Bayena	*Peponocephala electra*	MMPA	--	Offshore, prefers deeper waters	Y
Sperm whale/ Salungai or Bayena	*Physeter macrocephalus*	E	--	Deep waters generally >3,281 feet (>1,000 meters) depth	Y
False killer whale/ Salungai or Bayena	*Pseudorca crassidens*	MMPA	--	Deep waters generally >3,281 feet (>1,000 meters) depth	Y
Pantropical spotted dolphin/Tuninos	*Stenella attenuata*	MMPA	--	Coastal waters to 3,281 feet (1,000 meters)	Y
Spinner dolphin/Tuninos	*Stenella longirostris*	MMPA	--	Coastal waters to 3,281 feet (1,000 meters)	Y
Rough-toothed dolphin/Tuninos	*Steno bredanensis*	MMPA	--	Offshore, prefers deeper waters	Y
Bottlenose dolphin/Tuninos	*Tursiops truncatus*	MMPA	--	Coastal waters to 6,562 feet (2,000 meters)	Y
Cuvier's beaked whale/Tuninos	*Ziphius cavirostris*	MMPA	--	Deep waters generally >3,281 feet (>1,000 meters) depth	Y

Notes: [1] Chamorro names from GovGuam (2009), Kerr (1990, 2012), and Topping et al. (1975).
[2] Dominant adult habitat. Not necessarily inclusive of other life stages (e.g., egg/larvae/juvenile/breeding habitat).
[3] Occurrences approximated to JRM-administered submerged lands, but some fishery-based and acoustic-based records have imprecise locations.
[4] Indo-West Pacific Distinct Population Segment.
[5] Central West Pacific Distinct Population Segment.
[6] North Pacific Distinct Population Segment.
[7] Western North Pacific Distinct Population Segment.

Key: -- = not listed; E = endangered; ESA = Endangered Species Act; JRM = Joint Region Marianas; MMPA = Marine Mammal Protection Act; P = potential for occurrence; PU = potential for occurrence, but unlikely; T = threatened; Y = yes, known to occur.

Sources: Guam DAWR 2006; NMFS and USFWS 2007, 2016; GovGuam 2009; NMFS 2011a, 2014a, 2014b, 2018a, 2018b; Brown 2015; USFWS 2015b; Lybolt 2015; Hill et al. 2017.

4.5.6.1 Marine Mammals

Since 2010, visual surveys by National Marine Fisheries Service (NMFS) PIFSC have been conducted aboard small boats off the southernmost islands of the Mariana Archipelago (Guam, Rota, Saipan, Tinian, and Aguiguan). The observer team encountered 27 cetacean groups during the small-boat surveys off Guam and Rota in 2015, resulting in the collection of more than 8,000 photos and 20 biopsy samples (Martin et al. 2016). The encountered species included spinner dolphins (*Stenella longirostris*), bottlenose dolphins (*Tursiops truncates*), pantropical spotted dolphins (*Stenella attenuate*), Blainville's beaked whales (*Mesoplodon densirostris*), Bryde's whales (*Balaenoptera edeni*), false killer whales (*Pseudorca crassidens*), and pygmy killer whales (*Feresa attenuate*). Pantropical spotted dolphins were the most frequently sighted species (n=10) during the summer surveys, and most encounters were in deeper offshore waters of Guam. Spinner dolphins were the second most frequently sighted species (n=6). In addition to the number of times encountered, the number of individuals observed at one sighting off Tumon Bay, Guam, recorded over 100 individuals.

Fin Whales

Acoustic equipment has recorded the presence of fin whales (*Balaenoptera physalus*) in the Western Pacific waters around Guam; however, it is not known if they were in or near MCB Camp Blaz (Klinck et al. 2015, 2016; Oleson et al. 2015; Martin et al. 2016).

Humpback Whales

Acoustic equipment has recorded the presence of many humpback whales (*Megaptera novaeangliae*) in the Western Pacific waters around Guam and CNMI, especially in the waters south of Guam and southeast of Tinian (Klinck et al. 2015, 2016; Oleson et al. 2015). One humpback whale was sighted 9 miles (15 kilometers) off the northeast coast of Saipan in 2007 (Fulling et al. 2011), and more recently in 2015, four humpback whale mom/calf pairs and four other humpback whales were sighted off the west coasts of Saipan and Tinian (Hill et al. 2016; Martin et al. 2016). Multiple observations of humpback whales were recorded opportunistically in the nearshore waters of FDM during monthly aerial seabird monitoring surveys from 2001–2007 (Uyeyama 2014). The most recent sighting of humpback whales in the nearshore waters surrounding FDM was in 2017 (NOAA 2017b).

Sei Whales

Sei whales (*Balaenoptera borealis*) were sighted during the 2007 Mariana Islands Sea Turtle and Cetacean Survey. All confirmed sightings of sei whales were south of Saipan (approximately 15° North) (Fulling et al. 2011). Acoustic equipment has recorded the presence of sei whales in the Western Pacific waters around Guam; however, it is not known if they were near MCB Camp Blaz (Klinck et al. 2015, 2016; Oleson et al. 2015; Martin et al. 2016).

Sperm Whales

Sperm whales (*Physeter microcephalus*) tend to inhabit areas with water depths of 1,968 feet (600 meters) or more but are recorded with some regularity close to the Mariana Islands because deep water occurs close to shore in some locations. There are records of the species being observed close to Guam (e.g., Orote Peninsula, Agat Bay) (Hill et al. 2014) with visual sightings and acoustic detections recorded in 2007, 2010, 2012, 2014, and 2015 (Fulling et al. 2011; NAVFAC Pacific 2012; Klinck et al. 2015, 2016; Martin et al. 2016).

4.5.6.2 Reptiles

The leatherback turtle, loggerhead turtle, and olive ridley turtle (*Lepidochelys olivacea*) are infrequently near Guam. They do not nest or forage in Guam's nearshore environment, and they are not carried forward in this discussion (NAVFAC Marianas and Andersen AFB 2017).

Green Sea Turtle

In March 2015, the USFWS and NMFS determined that the green sea turtle (*Chelonia mydas*) is composed of 11 Distinct Population Segments (DPSs) that qualified as "species" for listing under the ESA and proposed the removal of the range-wide listing of the species and listing of each DPS as threatened or endangered. In April 2016, eight DPSs were listed as threatened and three as endangered (NMFS and USFWS 2016). Green sea turtles in Guam are considered part of the Central West Pacific DPS which is listed as endangered. The most common sea turtle within the Mariana Islands, the green sea turtle is regularly seen in the coastal waters of Guam and also known to nest on numerous beaches throughout Guam, including JRM-administered lands (Jones et al. 2015; Martin et al. 2016). In-water capture and tagging of resident sea turtles has been conducted by NOAA via an Interagency Agreement with JRM bi-annually since 2014 (NAVFAC Marianas and Andersen AFB 2023). The Marine Turtle Biology and Assessment Program uses satellite telemetry data to assess movements, habitat use, distribution and migratory patterns of sea turtles in the nearshore waters of NBG. Observations and counts of sea turtles are also recorded. Since its commencement, the program has recorded a total of 503 green sea turtles around Guam from 2014-2022 (NAVFAC Marianas and Andersen AFB 2023). Guam experiences year-round nesting for green sea turtles, with peak activity from March through August. From October 2022 to August 2023, a total of 28 green sea turtle nests were observed on NBG (NAVFAC Marianas and NGB 2023) (see Section 4.4.3.3 for additional details).

Hawksbill Turtle

Adult and juvenile hawksbill turtles (*Eretmochelys imbricata*) forage in tropical nearshore waters associated with coral reefs, hard bottoms, or estuaries with mangroves (Musick and Limpus 1997). Hawksbill turtles are seen in Guam but at much lower numbers than green sea turtles and are rare nesters in Guam beaches (Jones et al. 2015). The Marine Turtle Biology and Assessment Program has found 55 hawksbill turtles around Guam between the years of 2014-2022 (NAVFAC Marianas and Andersen AFB 2023). Although turtles are present in the area, there was no evidence of hawksbill nesting during surveys conducted at NBG from October 2022 to August 2023 (NAVFAC Marianas and Naval Base Guam 2023).

4.5.6.3 Marine Fishes

Oceanic Whitetip Shark

Effective January 30, 2018 (83 FR 4153), the oceanic whitetip shark (*Carcharhinus longimanus*) was listed as threatened (NMFS 2018a). Though frequently encountered in pelagic longline and seine fisheries, they are very uncommon in nearshore waters. The only life stage observed close to shore are pregnant females, but there are no observations from inshore waters (Young et al. 2016). Based on the animals' known habitat use and life history, occurrence of oceanic whitetip sharks in JRM-administered submerged lands is possible.

Giant Manta Ray

Effective January 22, 2018 (83 FR 2916), the giant manta ray (*Manta birostris*) was listed as threatened (NMFS 2018b). This species is found worldwide in tropical, subtropical, and temperate waters and is known to occur around Guam. No systematic data exists that reports the occurrence of giant manta rays in or near

JRM-administered submerged lands. During a marine mammal monitoring survey in 2012, a manta ray that was not identified to the species level was observed southwest of the Orote Peninsula, estimated to be a little more than 3 miles (5 kilometers) from shore (NAVFAC Pacific 2012).

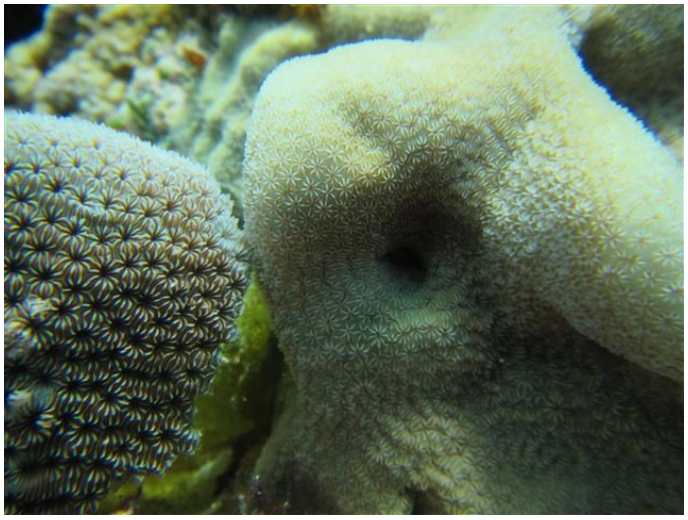
Scalloped Hammerhead Shark

In July 2014, the NMFS listed two of the six DPSs for scalloped hammerhead sharks (*Sphyrna lewini*) as threatened and two as endangered. Sharks in Guam are within the Indo-West Pacific DPS, which was listed as threatened (NMFS 2014b). The earliest confirmed record of a scalloped hammerhead in Guam was in 1968 and confirmed sightings remain rare to today (Kami 1971; NMFS 2014b; Adams 2018). Adult scalloped hammerhead sharks have been observed at multiple locations around Guam, including multiple locations within Outer Apra Harbor; Sasa Bay; in the southernmost part of Inner Apra Harbor; along the outer coastline of the Orote Peninsula near the Orote Airfield; the north end of Piti Bay, which is between Asan Bay and Apra Harbor in the south; along Tarague Beach; and around Pago Bay (NMFS 2015; Adams 2018). Juvenile scalloped hammerhead sharks have been observed near northern Piti, Sasa Bay, the Pago Bay river mouth, and the Ylig River mouth, which is about 2.5 miles (4 kilometers) south of Pago Bay.

The species information suggests that Sasa Bay in Apra Harbor is a potential nursery area (NOAA 2005; NMFS 2015). There is no proof that the site is used as a nursery, but there are several secondhand accounts of fishermen who accidentally caught young-of-the-year (age >1 year old) hammerheads near Sasa Bay (NMFS 2015; Resko 2018). If Apra Harbor acts as a nursery for this species, it would be reasonable to expect neonates, juveniles, and adult females to occur seasonally.

4.5.6.4 Invertebrates (Corals)

In September 2014, NMFS listed 20 coral species under the federal ESA as threatened, 15 of which occur in the Indo-Pacific region that includes Guam. Four of the species were originally stated to occur in Guam: *Acropora globiceps*, *Acropora retusa*, *Seriatopora aculeata*, and *Pavona diffluens* (NMFS 2014a). During ESA consultations in December 2014 for the Guam Military Relocation Supplemental Environmental Impact Statement (EIS), NMFS informed DON that they had no evidence that *P. diffluens* occurred in Guam (Campbell 2015). Specifically, the NMFS Final Listing Determination specifically states that the listing applies to the species called *P. diffluens* in the Indian Ocean and Red Sea and that corals fitting the description of *P. diffluens* in the Pacific are a different species (NMFS 2014a). The specimens observed in Guam are identifiable as the *Pavona* species described in Randall and Meyers (1983). There is insufficient morphological evidence to make a distinction between the "local" *P. diffluens* and the ESA threatened *P. diffluens*, consequently it is shown as 'probable' but not subject to the ESA. For the other three species, NMFS provided data regarding the known occurrences of the three federal ESA-listed corals in Guam as of 2015 (Figure 4-14).



***Pavona diffluens* is present on Guam and Tinian. *P. diffluens* at left, *Pavona duerdeni* at right.**
(*Photo*: V. Bonito)



***Acropora globiceps*, ESA-listed as threatened, is relatively common in the Marianas.**
(*Photo*: V. Bonito)



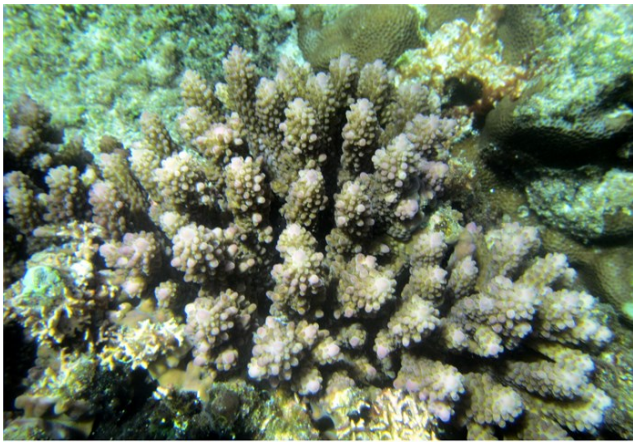
Figure 4-14
Known Locations of Federal ESA-listed Corals in Guam

Acropora globiceps

This species of scleractinian coral occurs on upper reef slopes and reef flats. It appears to prefer environments where wave motion can be relatively strong. Of the three federal ESA-listed species known to occur in Guam, it has the greatest number of records (24) from various locations in Guam (see Figure 4-14).

Acropora retusa

This coral occurs on upper reef slopes and tide pools. This species has only been observed at two locations in southern/southwestern Guam (see Figure 4-14), and its distribution and preferred habitat is not well known.



A colony of *Acropora retusa* from Rota, showing the usual irregularly spiky look. This species is rare but has been confirmed in Guam and CNMI.
(*Photo*: D. Fenner)



***Seriatopora aculeata* from Guam. This species is rare and has not yet been confirmed in CNMI.**
(*Photo*: D. Burdick)

Seriatopora aculeata

Only one record along the southwest coast exists for *Seriatopora aculeata* in Guam (see Figure 4-14), and its distribution and preferred habitat is not well known.

4.5.7 Stressors on the Marine Environment of Guam

4.5.7.1 Climate Change

The main consequences of global climate change have been measurable for several decades (U.S. Environmental Protection Agency [USEPA] 2016; DON 2017b), including sea level rise, stress on groundwater and disruptions to food supplies, plant and animal range shifts, and destruction of shallow coral reefs (Hughes et al. 2017). Many cyclic events are becoming more frequent and intense, including storms, droughts, floods, heat waves, and disease outbreaks (Hughes et al. 2003; Hoegh-Guldberg and Bruno 2010). Consequences of climate change in the marine environment are primarily driven by increased heat content of the oceans and how that increased heat content affects physical, chemical, and biological processes. Thermal expansion is a major contributor to sea level rise and also accelerates melting of glaciers, a positive feedback that further accelerates sea level rise (Hoegh-Guldberg and Bruno 2010; USEPA 2016; DON 2017b).

Increased heat content alters current patterns, with major consequences to the distribution and abundance of marine species. Because ocean currents strongly influence weather and climate on the continents, there is disruptive positive feedback between marine and terrestrial consequences of climate change (Hoegh-Guldberg and Bruno 2010; DoD 2014). Increased heat content lowers the total quantity of oxygen that seawater can carry and also enhances the stratification of oxygen in seawater, which causes a positive feedback that further lowers oxygen content (NMFS 2023; Polovina et al. 2016). Increased heat content alters many chemical processes, with major physiological consequences to organisms including reduced

reproduction, reduced survival of juveniles, skeletal deformations, and reduced awareness of predators (NMFS 2023; Hughes et al. 2017). Similar heat-related chemical processes increase the toxicity of many pollutants and also decrease an organism's capacity to detoxify pollutants, which causes a positive feedback that degrades an organism's ability to heal, grow, or reproduce (Andersson et al. 2015). Increased physiological stress makes plants and animals more susceptible to disease, and the disruptions to ecosystems, heat content, and oxygenation causes a positive feedback that makes diseases more transmissible and more severe (Hoegh-Guldberg and Bruno 2010; Hughes et al. 2017).

DoD is implementing several global and regional strategies to address climate change that are discussed in Section 3.1.1, *Climate Change*. The following text highlights select differential consequences of climate change among JRM-administered and leased lands and submerged lands in Guam, Tinian, and FDM. Consequences of sea level rise will be more intense in Guam because it has much more shallow marine habitat than Tinian or FDM, and more of the shoreline is susceptible to coastal erosion. Consequences of stress on groundwater, disruptions to food supplies, and destruction of shallow coral reefs will be more intense in Guam because it has much greater human population density than Tinian and FDM. This results in much greater dependence on the marine environment for food and socioeconomic value, but simultaneously results in much greater local anthropogenic stress to the marine environment (Hoegh-Guldberg and Bruno 2010; Polovina et al. 2016; Hughes et al. 2017).

4.5.7.2 Ocean Acidification

Ocean acidification is one of the major impacts on the marine environment. It is a separate process from climate change as it is driven directly by carbon dioxide (CO_2) rather than being a consequence of rising temperatures. The effects of ocean acidification on marine communities and ecosystems vary among geographic regions due to local climate, hydrography, seawater chemistry, nutritional status, proximity to land, human influences, biodiversity, and the resilience of ecosystems (Andersson et al. 2015). If CO_2 emissions continue to increase at the present rate, model projections suggest that surface seawater acidity will increase by an additional 100–150% by the end of this century (Orr et al. 2005; Joos et al. 2011). The effects on marine organisms and marine ecosystems are varied and depend on the ability of species to adapt. Calcifying organisms (e.g., mollusks, crustaceans, coral, etc.) are negatively impacted by higher CO_2 levels due to negative effects on growth, calcification rate, and survival. However, elevated seawater CO_2 stimulates the productivity of some marine algae and seagrasses. Temperature increases, de-oxygenation, and changes in food webs are particularly important co-stressors because they are pervasive, and both their causes and effects are often linked to acidification. Multiple stressors also need to be considered for management, mitigation, and adaptation to acidification and to increase public and policy recognition of the importance of addressing acidification in the context of the other stressors with which it potentially interacts (Breitburg et al. 2015).

JRM can incorporate ocean acidification monitoring (e.g., partial pressure of carbon dioxide [pCO_2] sensors and diver tows examining coral bleaching) into their marine ecosystem monitoring projects. By incorporating climate change indicators into current monitoring of JRM-administered submerged lands and natural resources, JRM can better determine how to protect EFH and federal ESA-listed marine species.

4.5.7.3 Coral Stressors

The most consequential overarching stressors to coral reefs are pollution, overfishing, ocean acidification, and climate change (Jackson et al. 2001; Bahr et al. 2016). Like many other islands with significant nearshore marine resources and developed urban and suburban infrastructure, Guam's marine environment is threatened by human disturbance. Many of the threats are local in origin but are exacerbated or synergistic

with global climate change that is also threatening coral reefs on its own. Until the mid-2000s, Guam had generally avoided widespread detrimental effects of bleaching that had been seen in other parts of the world. Starting in 2006, bleaching events became more notable and severe (Burdick et al. 2008). In the past several years, corals have been bleaching regularly each summer and recovery has been limited, leading to significant levels of coral mortality (Harvey 2016; Raymundo et al. 2017). The projected onset of annual severe bleaching events for the coral reefs surrounding Guam range from 2034 to 2042 (Keener et al. 2018).

The stress on coral that comes periodically from bleaching is increased by a series of anthropogenic stressors, including sedimentation and runoff caused by coastal development and severe upland erosion. These stressors are the result of deforestation and illegal burning by hunters and farmers, particularly in watersheds on the southwest coast (Wolanski et al. 2003; Davis et al. 2010; Prouty et al. 2014; NAVFAC Pacific 2015). High nitrogen from sewage treatment plants that are inadequate and periodically exceed limits of their permits as well as sewer lines, septic tank/leaching field systems, golf courses, farms, pig farms, fish farms, chicken farms, pastures, and ponding basins also degrade water quality around Guam (McDonald 2002). Nutrient imbalance in the water may be a direct cause of coral disease and decline, but results are inconsistent (McKenna et al. 2001; Szmant 2002; Redding et al. 2013). According to 2008 *State of the Coral Reef Ecosystems of Guam* report, "White Syndrome appears to be the most prevalent (observed in 9 out of 10 sites) and the source of greatest tissue mortality (Burdick et al. 2008). Black Band Disease, the only documented circumtropical disease, is rare in Guam reefs." Nutrient imbalances are also related to periodic outbreaks of COTS, which are coral predators, and can lead to high levels of coral death (Colgan 1987; Brodie et al. 2005; Timmers et al. 2012). Stormwater drainage and urban runoff that occur often from heavy rain events can include inorganic and organic pesticides, halogenated solvents, petroleum, polychlorinated biphenyls, and other contaminants from dump sites (Burdick et al. 2008). Prioritization of these multiple stressors for management is a challenge, and coordinated approaches such as the 2017 Guam Coral Bleaching Response Plan (Hoot and Burdick 2017) and Guam's Local Action Strategy and Coral Reef Management Priorities under the U.S. Coral Reef Task Force are useful organizing frameworks for DoD actions.

Coral reefs are particularly vulnerable to ocean acidification due to being calcifying organisms. Studies have shown that biological response to temperature and pCO_2 elevation is highly species-specific (Bahr et al. 2016). Certain species, such as *Leptastrea purpurea*, showed no change in calcification or mortality under treatments of high temperature, high pCO_2, or combined high temperature and pCO_2 (Bahr et al. 2016). Incorporating resilient areas and resilient corals into reef management requires knowledge of the location of resilient reefs (Marshall and Schuttenberg 2006). Coral reefs are also subject to other disturbances that are driven, in part, by climate change, such as increasing ocean temperatures and acute disturbances like coral bleaching.

In order to monitor the impact of ocean acidification on coral reefs, it is important to have a historical baseline of coral cover and health in order to monitor impacts from ocean acidification and other climate change stressors over time. The Guam Long-term Coral Reef Monitoring Program is a multi-agency effort established in 2010 led by UOG with support from NOAA Fisheries Pacific Islands Regional Office and funding from the U.S. Coral Reef Task Force Coral Reef Conservation Plan to monitor seven sites across Guam: Tumon, East Hagatna Bay, Piti, Western Shoals, Fouha Bay, Achang, and Cocos East. A proportion of sampling sites is permanent, and a proportion is randomized. The split panel design maximizes the ability to detect changes in reef health over time. Benthic community data, reef fish, and water quality data are collected. Critical indicators to measure changes in any shallow coral reef monitoring program include: temperature and vertical thermal structure, carbonate chemistry, coral growth rate, coral and fish

abundance, coral and fish size structure, coral and fish key species, coral condition (e.g., bleaching disease, mortality), benthic percent cover, and rugosity (surface roughness) (Sutton et al. 2015).

4.5.7.4 Marine Fish Stressors

Overfishing is the most serious threat, having led to listing of ESA-protected marine species (Kappel 2005; Crain et al. 2009), with habitat loss also contributing to extinction risk (Musick et al. 2000; Dulvy and Polunin 2004; Cheung et al. 2007). Overfishing occurs when the rate of removal from a stock is too high, and a stock is considered overfished when the population falls below a prescribed threshold (NMFS 2011b). Overfishing impacts both targeted species and non-targeted species (or "bycatch" species) that are often important in marine food webs. Bycatch may also include seabirds, turtles, and marine mammals. In recent decades, marine fisheries have targeted species lower on the food web as abundance of higher-level predators has decreased; some entire marine food webs have collapsed as a result (Pauly and Palomares 2005; Crain et al. 2009). Reduction in grazing species through fishing can have an effect on the algae in reef communities, which, in turn, changes the communities on coral reefs (Miller and Hay 1996; Burkepile and Hay 2006; Kopp et al. 2010). Guam fisheries show clear signs of overexploitation. Catch per unit effort and landings have declined over the past 50 years for shore-based fisheries in Guam (Porter et al. 2005; Burdick et al. 2008). There are multiple lines of evidence consistent with systematic overfishing, and this trend is largely unchanged since the implementation of national fisheries management programs in accordance with ship husbandry manuals (Williams et al. 2011; Brainard et al. 2012; Heenan et al. 2015; WPRFMC 2016b).

While overfishing is the primary threat to marine fish in Guam, fish stressors are generally amplified by climate- and acidification-related stressors (see Section 4.5.7.1, *Climate Change*, and Section 4.5.7.2, *Ocean Acidification*). In 2023, NOAA released the *NOAA Fisheries Climate Science Strategy* (NMFS 2023), which outlines the following seven objectives to better understand the impact of climate change on marine fish:

- *Objective 1*: Identify appropriate, climate-informed reference points for managing living marine resources (LMRs)
- *Objective 2:* Identify robust strategies for managing LMRs under changing climate conditions
- *Objective 3:* Design adaptive decision processes that can incorporate and respond to changing climate conditions
- *Objective 4:* Identify future states of marine and coastal ecosystems, LMRs, and LMR-dependent human communities in a changing climate
- *Objective 5:* Identify the mechanisms of climate impacts on ecosystems, LMRs, and LMR-dependent human communities
- *Objective 6:* Track trends in ecosystems, LMRs, and LMR-dependent human communities and provide early warning of change
- *Objective 7:* Build and maintain the science infrastructure needed to fulfill NOAA Fisheries mandates with changing climate conditions

While JRM is not responsible for managing marine fish directly, JRM is responsible for supporting the conservation of EFH and recovery of federal ESA-listed marine fish (e.g., scalloped hammerhead shark). Climate change impacts on marine fish can include range shifts, reproductive changes, and behavior changes (Milazzo et al. 2016).

In addition to the synergistic stressors of climate change and ocean acidification, other stressors to marine fish include habitat loss, pollution, and a variety of lesser stressors such as noise. Pollution primarily

impacts coastal fish near the pollution source. However, global oceanic circulation patterns scatter a considerable amount of marine pollutants and debris throughout the open ocean (Crain et al. 2009). Pollutants in the marine environment that may impact marine fishes include organic contaminants (e.g., pesticides, herbicides, polycyclic aromatic hydrocarbons, flame retardants, oil, etc.), inorganic chemicals (e.g., heavy metals), and debris (e.g., plastics and wastes) (Pew Oceans Commission 2003). High chemical pollutant levels in marine fishes may induce behavioral changes, physiological changes, or genetic damage in some species (Pew Oceans Commission 2003; van der Oost et al. 2003; Moore 2008). Bioaccumulation of metals and organic pollutants is also a concern in coastal portions of Guam (Burdick et al. 2008). This is also a concern to human health because people consume top predators with possibly high pollutant loads. Bioaccumulation is the net buildup of substances (e.g., chemicals or metals) in an organism that results from taking in contaminated water or sediment through the gills or skin, from ingesting food containing the substances (Brown and Depledge 1998), or from ingesting those substances directly (Moore 2008). The physical presence of marine debris such as abandoned nets and lines also poses a threat to marine fishes. Entanglement in abandoned commercial and recreational fishing gear has caused declines of some marine fishes (Musick et al. 2000).

Underwater noise is a threat to marine fishes (Popper et al. 2014). However, physiological and behavioral responses of marine fishes to underwater noise have been investigated for only a limited number of species (approximately 100; many of which are freshwater species) (Popper and Hastings 2009). In addition to vessels, other sources of underwater noise include pile-driving activity, sonar, explosives, and seismic activity (Feist et al. 1996; California Department of Transportation 2001; Nedwell et al. 2003; Popper et al. 2006; Carlson et al. 2007; Popper and Hastings 2009; Mueller-Blenkle et al. 2010).

4.5.7.5 Other Anthropogenic Stressors

Some anthropogenic stressors also affect nearshore resources around Guam, such as overuse or misuse of popular scuba and snorkeling sites, personal watercraft, and anchoring damage (Allen and Bartram 2008; Burdick et al. 2008). Off-road vehicles, illegal fires, and overgrazing by deer and pigs can cause extensive upland erosion that degrades stream and nearshore water quality around Guam. Guam also suffers from relatively high fishing pressure, and some of the fishing methods and practices are destructive toward reefs (Burdick et al. 2008). GovGuam created a system of five marine preserves designed to increase fish stocks by establishing areas where limited or no harvest of marine species is permitted. Two of the preserves are in JRM nearshore waters: Pati Point Marine Preserve is on Andersen AFB and part of Sasa Bay Marine Preserve is on NBG Main Base. Many anthropogenic stressors are affected by JRM management projects, or may be managed under future project implementation on JRM-administered lands in Guam. Managing these stressors is a challenge and coordinated approaches such as Guam's Local Action Strategy and Coral Reef Management Priorities under the U.S. Coral Reef Task Force are useful organizing frameworks for DoD actions.

5 NAVAL BASE GUAM MAIN BASE

5.1 CURRENT OPERATIONS AND LAND USE

The Department of Defense (DoD) in Guam supports naval activities to maintain operational readiness, which involves preserving the ability of units to respond to threats and to protect the interests of the United States (U.S.) and its allies in the region. Naval Base Guam (NBG) consists of numerous installations, but the primary properties are Main Base, Naval Munitions Site (NMS) (refer to Chapter 6); Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, Naval Computer and Telecommunications Station (NCTS) Barrigada, Barrigada Transmitter Site, and Andersen South (Chapter 7); Andersen Air Force Base (Chapter 8); and Marine Corps Base (MCB) Camp Blaz (Chapter 9) (refer to Figure 2-2).

NBG Main Base is the Department of the Navy's (DON's) operations center, and it includes facilities around Apra Harbor and on the Orote Peninsula (Figure 5-1). DON shares management of Apra Harbor with the Port Authority of Guam. The Port Authority's Commercial Port is a transshipment hub for the Micronesian region and the shipping and receiving point for containers destined for DoD installations in Guam. The primary function of NBG Main Base is to support fleet units and operational forces of the Fifth and Seventh Fleets. It serves as a forward deployment base and logistics hub, and includes a distribution center for material, personnel, and munitions that support sea, land, and air forces operating in Asia and the Western Pacific (NBG 2016).

5.1.1 Land Ownership and Management

The 3,455-acre (1,398-hectare) NBG Main Base consists of several sites controlled and administered by DON, including the Main Base, Glass Breakwater, Polaris Point, and Dry Dock Island (Table 5-1 and Figure 5-1). The U.S. Coast Guard (USCG) controls 14 acres (6 hectares) at Victor Wharf in Inner Apra Harbor as shown on Figure 5-1. On the south side of Orote Peninsula is the Orote Peninsula Ecological Reserve Area (ERA), which is discussed in further detail in Section 5.1.6.2, *Orote Peninsula Ecological Reserve Area*.

Table 5-1. JRM-administered Lands and Submerged Lands of NBG Main Base

Facility Name	*Other or Previous Name(s)*	*Terrestrial Lands (acres)*	*Submerged Lands* (acres)*	*Managed Nearshore Areas (acres)*
NBG Main Base	Waterfront Annex	--	30,867	4,696
Main Base (Cantonment)	(none)	3,114	--	--
Glass Breakwater	(none)	40	--	--
Polaris Point	(none)	253	--	--
Dry Dock Island	Delta/Echo Fuel Piers	48	--	--
	Total	**3,455**	**30,867**	**4,696**

Note: *Submerged lands are addressed in more detail in Section 5.3.1, *Joint Region Marianas-administered Submerged Lands* and Table 5-9.
Key: JRM = Joint Region Marianas; NBG = Naval Base Guam.
Sources: NAVFAC Marianas 2010; JRM 2015, 2019.

NBG is responsible for all naval properties in Guam and hosts several key tenant commands such as the Commander, Submarine Squadron Fifteen, the USS *Frank Cable*, Coastal Riverine Group 1, Naval Special Warfare Unit One, and USCG Sector Guam. It also supports 28 other tenant commands and is the home base to dozens of Pacific Command, U.S. Pacific Fleet, and Seventh Fleet units. Camp Covington is also located within NBG Main Base. This installation supports Naval Mobile Construction Battalions (SeaBees) (NBG 2016). See Section 2.2.2, *Naval Base Guam* for further details on NBG's mission and tenants.

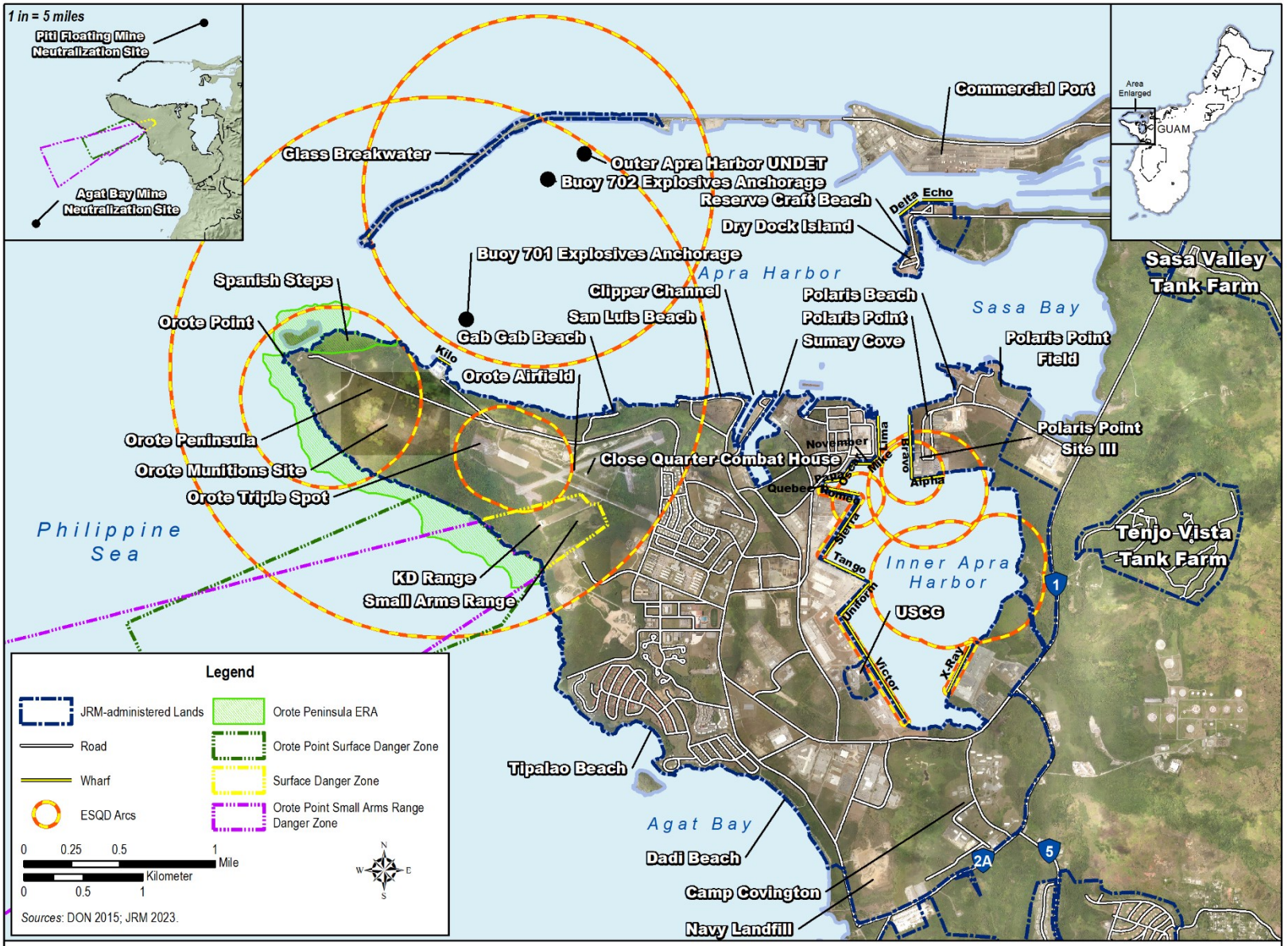


Figure 5-1
Overview of NBG Main Base

Joint Region Marianas (JRM)-administered lands at Apra Harbor accommodate a variety of land use types, including industrial and recreational facilities. Shore-based mission support includes warehouses, power, water, sewage treatment, fuel transfer, and other facilities. NBG Main Base also supports military housing areas, schools, medical and dental facilities, recreational facilities, food services, and DON commissary and exchanges. In addition, NBG Main Base provides facilities and infrastructure to support biosecurity inspection and interdiction requirements for cargo and personnel leaving NBG via ship. This includes office space and kennels in support of the Navy's brown treesnake (BTS) (*Boiga irregularis*) interdiction program.

5.1.2 Apra Harbor Assets and Uses

Apra Harbor is a deep lagoon on the mid-western shore of Guam with depths of over 150 feet (45 meters). It has two recognized major harbor zones: Outer Apra Harbor and Inner Apra Harbor. Apra Harbor is bordered by the 2.8-mile (4.5-kilometer) long Glass Breakwater (DON property) to the north and Orote Peninsula to the south (see Figure 5-1). The majority of the JRM-administered submerged land within Apra Harbor are under DON control; however, civilian vessels generally have access to most of Outer Apra Harbor. A portion fronting the Port Authority of Guam's Commercial Port facilities in the northeastern portion of Outer Apra Harbor is under the control of the Government of Guam (GovGuam) (see Figure 5-1). A civilian marina, Harbor of Refuge, is located at the eastern end of the Commercial Port. In addition to vessel traffic, Apra Harbor is used for military training and recreational activities (e.g., Atlantis Submarine, scuba diving, sailing, jet skiing, and canoe paddling). Refer to Section 5.3, *Marine Environment*, for a detailed discussion of JRM-administered submerged lands and the marine environment of NBG Main Base.

Commanding Officer USCG Sector Guam is the Captain of the Port and oversees Apra Harbor. DON Security zones extend outward from DON-controlled waterfront and related military anchorages/moorings. DON vessel traffic and wharf assignments are managed by DON Port Operations. The Port Authority of Guam provides a similar function for commercial vessels at the Commercial Port. Both entities track vessel traffic. The USCG has multiple missions, including port and waterway security and maritime safety. All watercraft, including recreational boats, are subject to federal rules and regulations that are enforced by the USCG.

For public health, security, and anti-terrorism/force protection (AT/FP) reasons, DON imposes restrictions on non-DoD operations and establishes standoff distances from DON facilities and vessels, including DON anchorages and buoys in Apra Harbor. The arrival and departure of large vessels, such as aircraft carriers, temporarily restricts the movement of civilian vessel traffic in Apra Harbor.

DON fueling wharves (i.e., Echo and Delta; see Figure 5-1) are south of the Commercial Port on Dry Dock Island. Between Dry Dock Island and Polaris Point is the GovGuam-designated Sasa Bay Marine Preserve. Polaris Point Beach, a military recreation facility, is located in the northern portion of Polaris Point. There are ballfields and open space areas to the east of Polaris Beach. There is a guard tower and minor utility buildings to the west of Polaris Beach, but the man-made coastline is generally undeveloped. The interior of the Polaris Point area is vacant and landscaped.

Gab Gab Beach is a recreational area on the northern coast of Orote Peninsula west of Sumay Cove. DON munitions wharf, Kilo Wharf, is located west of Gab Gab Beach on the north side of Orote Peninsula near the entrance to Outer Apra Harbor. Munitions operations at Kilo Wharf often require closure of the western portion of Gab Gab Beach for safety reasons. Access to Orote Point and Spanish Steps is also controlled and generally restricted when there are active operations at Kilo Wharf.

5.1.3 Inner Apra Harbor Assets and Uses

Inner Apra Harbor is under the authority of the NBG Installation Commanding Officer and is restricted to military use, which includes naval and USCG vessels from allied nations. No recreational uses are permitted in Inner Apra Harbor. NBG Port Operations controls the use of the wharves and moorings, and there are areas designated for specific types of operations. Fourteen wharves are located within Inner Apra Harbor to support DON and USCG vessels and operations. These wharves include Alpha, Bravo, Lima, Mike, November, Oscar, Papa, Quebec, Romeo, Sierra, Tango, Uniform, Victor, and X-ray. Berthing of vessels requires adequate water depth (approximately 35 feet [11 meters]), adequate standoff from Explosive Safety Quantity Distance (ESQD) arcs, and security around the vessels while in port. The following discussion covers assets and uses in Inner Apra Harbor, describing facilities in a clockwise sequence around Inner Apra Harbor, beginning with Polaris Point (see Figure 5-1).

Submarines and the submarine tenders are generally docked at Polaris Point, and at Alpha and Bravo wharves; however, these vessels can use other Inner Apra Harbor wharves as needed. Munitions operations to support the submarines generate an ESQD arc, as shown on Figure 5-1. Supply vessels that are not carrying fuel or munitions are docked in Inner Apra Harbor, with X-Ray Wharf being the location for loading and offloading ship supplies. There are large temperature-controlled warehouses at X-Ray Wharf for food storage.

The entire length of the western side of the Inner Apra Harbor is developed with the following wharves, which are listed from south to north: Victor, Uniform, Tango, Sierra, Romeo, Quebec, Papa, Oscar, November, Mike, and Lima. Victor Wharf is the longest of the wharves, having six berths. The USCG operates from their compound on Victor Wharf. It owns 200 feet (61 meters) and leases another 510 feet (155 meters) along the wharf. There is an area adjacent to the wharf for USCG support facilities. Limited munitions operations are allowed at Victor Wharf and the ESQD arc is shown on Figure 5-1. Major reconstruction and strengthening of Tango Wharf and Uniform Wharf was completed in 2014.

Port operations facilities, Navy diver support services (i.e., the Dive Locker), and a hyperbaric chamber are located at Tango Wharf. Approximately 100 feet (31 meters) of the wharf is reserved for emergency access. Sierra and Romeo are general purpose wharves and have limited munitions handling capabilities that generate ESQD arcs as shown on Figure 5-1.

5.1.4 Training Areas

Training activities at NBG Main Base include beach landings, riverine training, small unit maneuvers, rappelling, helicopter insertion and extraction, rapid runway repair, field exercises, small arms and pistol marksmanship, stress control training, and fire and maneuver training. Training activities within Apra Harbor includes explosive ordnance disposal (EOD) deep water mine countermeasures, helicopter paradrops, helicopter cast and recovery, drown-proofing, heliborne firebucket (offload), helicopter search and rescue, and diving/swimming. Table 5-2 and Figure 5-1 provide a summary of training areas associated with NBG Main Base and the offshore waters.

Table 5-2. Summary of Training Areas on NBG Main Base

Training Area[1]	*Description*
Offshore	
Agat Bay Mine Neutralization Site (see inset on Figure 5-1)	• Agat Bay supports MCM training, military dive activities, and parachute insertion training. Used by divers training to conduct UNDET exercises with charges up to 20 pounds (9 kilograms) NEW. Hydrographic surveys to determine hazards for military approaches are periodically conducted in this area. • Exclusion Zone: o Minimum 2,099-feet (640-meter) radius and is located beyond 3 miles (4.8 kilometers) of Guam. o No CFR danger zone or safety zone rule established. Temporary safety zones are established by the USCG as required, and announced in Local Notice to Mariners and Broadcast Notice to Mariners.
Piti Floating Mine Neutralization Area (see inset on Figure 5-1)	• Lies northeast of the Glass Breakwater and supports EOD training. Used by divers to conduct UNDET exercises with charges up to 10 pounds (5 kilograms) NEW. • Exclusion Zone: o Minimum 2,099-feet (640-meter) radius and is located within 3 miles (4.8 kilometers) of Guam. o No CFR danger zone or safety zone rule established. Temporary safety zones are established by the USCG as required, and announced in Local Notice to Mariners and Broadcast Notice to Mariners.
Apra Harbor	Apra Harbor supports frequent and varied training requirements for Navy SEAL teams; EOD; and Marine Support Squadrons including military diving, logistics training, small boat activities, security activities, drop zones, amphibious craft navigation, and VBSS training.
Outer Apra Harbor UNDET Site	• Used by divers training to conduct UNDET exercises using explosive charges up to 10 pounds (5 kilograms) NEW are permitted at a site near Buoy 702 Explosive Anchorage. • Exclusion Zone: o Minimum 2,099-feet (640-meter) radius; Glass Breakwater forms the northern edge of Exclusion Zone. o No CFR danger zone or safety zone rule established. Temporary safety zones are established by the USCG as required, and announced in Local Notice to Mariners and Broadcast Notice to Mariners.
Outer Apra Harbor	
Kilo Wharf	Used as the primary ordnance handling wharf and is a training site with limited capabilities due to explosive safety constraints; however, when explosive constraints are reduced it is used for AT/FP and VBSS training.
Gab Gab Beach	Used for both military and recreational activities. The western half of Gab Gab Beach is primarily used to support EOD and NSW training requirements. Activities include military diving, logistics training, small boat activities, security activities, drop zones, and AT/FP training.
Reserve Craft Beach	A small beach area located on the western shoreline of Dry Dock Island that supports both military and recreational activities. Used as an offload area for amphibious landing craft, EOD inert training activities, military diving, logistics training, small boat activities, security activities, and AT/FP training.
Sumay Cove/Channel	Supports both military and recreational activities by providing moorage for recreational boats and an EOD small boat facility. Used for insertion/extraction training for NSW and amphibious vehicle ramp activity, military diving, logistics training, small boat activities, security activities, and AT/FP training.
Clipper Channel	Provides insertion/extraction training for NSW, military diving, logistics training, small boat activities, security activities, and AT/FP training; has the potential to support amphibious vehicle ramp activity.
San Luis Beach	Used for both recreational and military activities including EOD and NSW training requirements, military diving, logistics training, small boat activities, security activities, drop zones, and AT/FP training.

Table 5-2. Summary of Training Areas on NBG Main Base

Training Area[(1)]	*Description*
Inner Apra Harbor	
Inner Apra Harbor	DON-controlled and includes the submerged lands, waters, shoreline, wharves, and piers and is associated with the NBG Main Base. Activities include military diving, logistics training, small boat activities, security activities, drop zones, torpedo/target recovery training, VBSS, and amphibious landings.
USCG Facilities	USCG berthing and crew support building.
Polaris Point	
Polaris Point Field	Supports both recreational and military activities including beach access to small landing craft, small field training exercises, temporary bivouac, craft laydown, parachute insertions (freefall), assault training activities, and AT/FP, EOD, and Special Forces training.
Polaris Point Beach	Supports both recreational and military activities including beach access to small landing craft, military diving, logistics training, small boat activities, security activities, drop zones, and AT/FP training.
Polaris Point Site III	Location of Guam-homeported submarines and submarine tender and the primary site for docking, training, and support infrastructure; also supports AT/FP and torpedo/target logistics training.
Polaris Point LCAC/AAV Area	Location for storing, maintaining, and deploying amphibious craft.
Orote Peninsula	
Tipalao Beach and Dadi Beach	Currently supports military diving activities and hydrographic survey training. These beaches also provide access to areas capable of supporting shallow draft amphibious landing craft and have been proposed for use as LCAC and AAV landing sites.
Orote Airfield	Consists of expeditionary runways and taxiways used in field training exercises by helicopters and some fixed-wing aircraft. The airfield has no services or instrumentation and is constrained by the Kilo Wharf ESQD arc and associated ammunitions storage. Runways are used for vertical and short field military aircraft and provide a large flat area that supports FTX, parachute insertions, emergency vehicle driver training, and EOD and NSW training.
Close Quarter Combat House (or Kill House)	Small one-story building providing limited small arms live-fire training as part of MOUT-type training.
Orote Small Arms Range/ KD Range and SDZ	Supports small arms and machine gun training (up to 7.62 millimeters), and sniper training out to a distance of 500 yards (457 meters). The range is a long flat cleared area with an earthen berm that is used to support marksmanship. Down range SDZ extends over the nearshore waters off Orote Peninsula. 1. SDZ is closed to the public and shipping on specific dates to be designated for actual firing, and no person, vessel, or other craft shall enter or remain in the SDZ designated for firing except as may be authorized by the enforcing agency. Notification to maritime interests of specific dates of firing will be disseminated by the enforcing agency. On dates not specified for firing, the SDZ shall be open to normal maritime traffic. 2. The regulations are enforced by the Installation Commanding Officer, NBG, and such agencies as he may designate.
Orote Triple Spot	Helicopter landing zone on the Orote Airfield that supports personnel transfer, logistics, parachute training, and a variety of training activities reliant on helicopter transport.

Note: [(1)] Refer to Figure 5-1 for locations of all training areas.

Key: AAV = amphibious assault vehicle; AT/FP = Anti-Terrorism/Force Protection; CFR = Code of Federal Regulations; DON = Department of the Navy; EOD = Explosive Ordnance Disposal; ESQD = Explosive Safety Quantity Distance; FTX = Field Training Exercise; KD = known distance; LCAC = landing craft, air cushion; MCM = Mine Countermeasure; MOUT = Military Operations in Urban Terrain; NBG = Naval Base Guam; NEW = net explosive weight; NSW = Naval Special Warfare; SDZ = surface danger zone; SEAL = Sea, Air, and Land; UNDET = underwater detonation; USCG = United States Coast Guard; VBSS = visit, board, search, and seizure.

Sources: DON 2010, 2015a.

5.1.5 Explosive Safety Quantity Distance Arcs

ESQD arcs associated with Alpha, Bravo, Kilo, Romeo, and Sierra Wharves, Buoy 702 Explosives Anchorage, and various mooring buoys in Inner Apra Harbor (see Figure 5-1), demarcate their use for munitions operations up to a specified Net Explosive Weight. Kilo Wharf is the primary munitions wharf. ESQD arcs may encumber the navigation channel through Apra Harbor, portions of Hotel Wharf at the Commercial Port, and recreational activities in the harbor depending upon the amount of Net Explosive Weight. The arcs shown on Figure 5-1 are the Inhabited Building Distance arcs, within which buildings that are routinely inhabited are not permitted for safety reasons. Smaller diameter public transportation route ESQD arcs (not shown on Figure 5-1) are generated from the munitions operation site. The public transportation route refers to public road, highway, or navigable waterway. On Orote Peninsula, there are other facilities that generate arcs because they are used for temporary or long-term munitions storage (e.g., Orote munitions site).

5.1.6 Special Conservation Areas

5.1.6.1 Overlay Refuge Lands

As stated in Section 3.5.3, *Guam National Wildlife Refuge Comprehensive Conservation Plan*, Overlay Refuge lands were established in 1994. The refuge provides a commitment by DON and U.S. Fish and Wildlife Service (USFWS) for a coordinated program centered on the protection of threatened and endangered species and other native flora and fauna, maintenance of native ecosystems, and the conservation of native biological diversity in cooperation with Guam Division of Aquatics and Wildlife Resources (Guam DAWR). However, the program acknowledges that the primary purpose of lands within the Overlay Refuge is to support the national defense mission of DON.

Approximately 506 acres (205 hectares) of Overlay Refuge lands are designated on NBG Main Base (Figure 5-2) and were originally identified as providing important habitat for federal Endangered Species Act (ESA)-listed species (e.g., Mariana crow [*Corvus kubaryi*], Guam kingfisher [*Todiramphus cinnamominus*], Mariana common moorhen [*Gallinula chloropus guami*]) as well as other Guam native species. Of this acreage, 159 acres (64 hectares) is located on the southern portion of Orote Peninsula (including the Orote Peninsula ERA, see Section 5.1.6.2, *Orote Peninsula Ecological Reserve Area*), with the remaining acreage associated with wetland areas to the east and south of Inner Apra Harbor (i.e., Atantano, Abo Cove, and Camp Covington wetlands). The Overlay Refuge lands on Orote Peninsula consist primarily of limestone native forest, limestone degraded forest, and limestone coastal scrub, which encompass 77 acres (31 hectares). The Overlay Refuge also contains approximately 62 acres (25 hectares) of tangantangan (*Leucaena leucocephala*) vegetation.

5.1.6.2 Orote Peninsula Ecological Reserve Area

An ERA is defined as an area dedicated primarily or exclusively to preserving examples of ecosystems and genetic diversity while providing opportunities for scientific research and education (Office of the Chief of Naval Operations Manual [OPNAV M] 2021). Natural areas on JRM-administered lands that warrant special conservation efforts may be identified as ERAs. These areas should include characteristic or outstanding ecological, geological, and scenic features or processes (OPNAV M 2021). While established with the emphasis on conservation of natural resources, the Orote Peninsula ERA also provides a benefit to and protection of cultural resources.

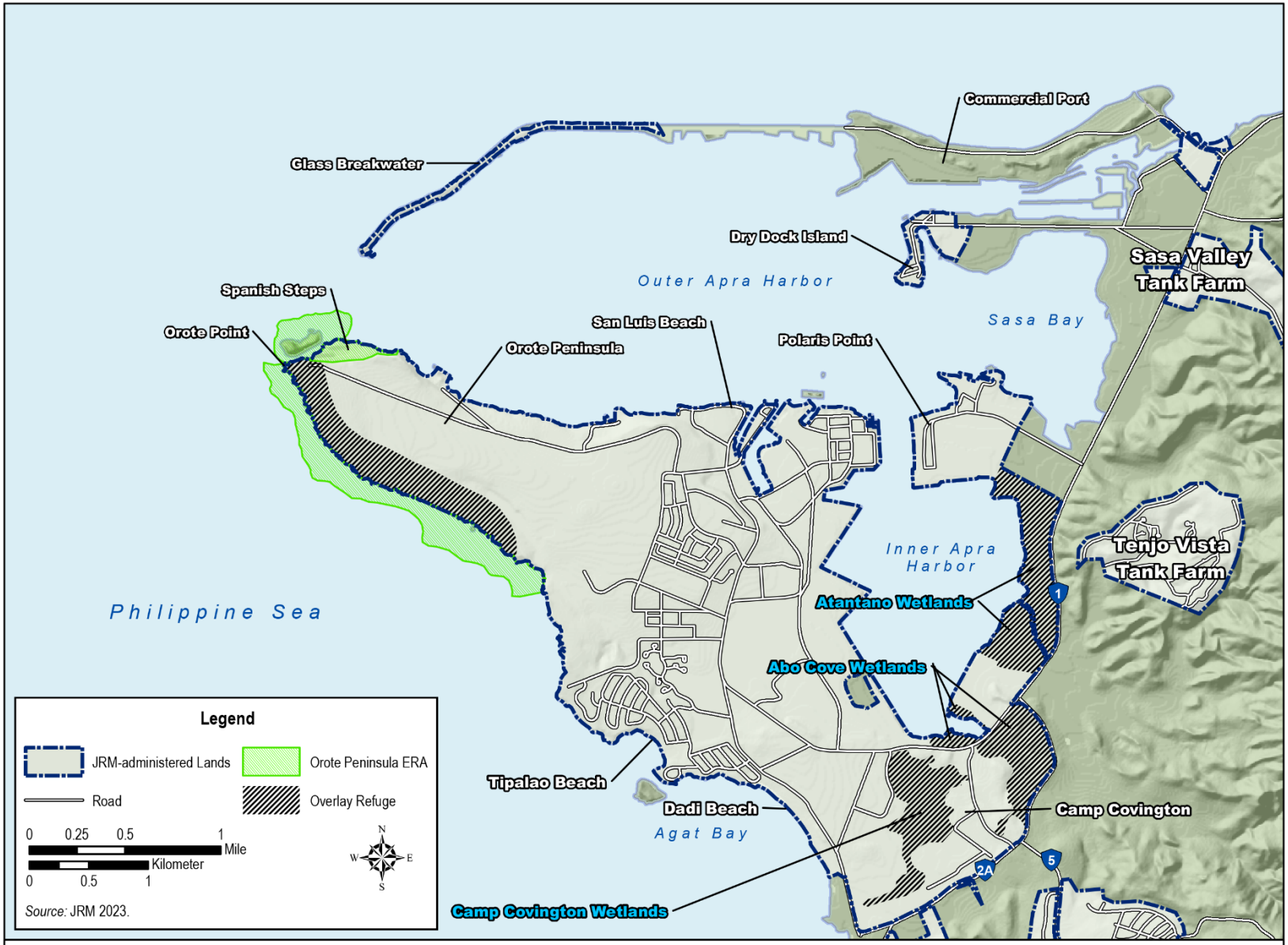


Figure 5-2
Orote Peninsula ERA and Overlay Refuge Lands - NBG Main Base

DON established the 163-acre (66-hectare) Orote Peninsula ERA in 1984 as a mitigation measure under section 404 of the Clean Water Act (CWA) for the construction of Kilo Wharf (see Figure 5-1). The ERA was established to protect two biological units:

- *Terrestrial Unit:* Consists of 30 acres (12 hectares) (or 18 percent [%] of the ERA) extending inland from the mean lower low water line to the upper edge of the cliff. Of this 30 acres (12 hectares), 13 acres (5 hectares) are remnant cliffline native limestone coastal scrub and limestone forest that provide habitat for native forest species. The remaining approximate 17 acres (7 hectares) consists of 16 acres (6 hectares) of barren or strand vegetation and 1 acre (0.4 hectare) of tangantangan.
- *Marine Unit*: Consists of 133 acres (54 hectares) (or 82% of the ERA) of JRM-administered submerged lands from the mean lower low water line to a depth of 120 feet (37 meters). The area encompasses a coral reef consisting of three general habitat types: cliff reef, reef slope, and reef drop off.

The Orote Peninsula ERA is intended for limited research, education, and recreational purposes. The first management plan for the ERA was prepared in 1986 and allocated management responsibilities among the Installation Commanding Officer Naval Communication Area Master Station Western Pacific (now NBG), Naval Facilities Engineering Systems Command (NAVFAC) Pacific, USFWS, National Marine Fisheries Service (NMFS), and GovGuam. It provided for natural resource surveys, boundary identification, control measures, habitat protection and improvement, and maintenance of the ERA. The management plan also identified access procedures for permitted activities.

In 1994, the 30-acre (12-hectares) terrestrial unit of the Orote Peninsula ERA became part of the Overlay Refuge lands (see Section 5.1.6.1, *Overlay Refuge Lands*). The current management plan was prepared in 2010 with an overall objective similar to the 1986 plan: to ensure that the natural resources within the ERA are protected from physical, biological, and human-induced stressors that result in adverse changes to the ecological characteristics that made the area eligible to be an ERA (NAVFAC Marianas 2010b).

5.2 TERRESTRIAL ENVIRONMENT

Refer to Section 5.1, *Current Operations and Land Use*, for an overview of NBG Main Base and a discussion of the shore assets and uses.

5.2.1 Geology, Topography, and Soils

5.2.1.1 Geology

Geologic Units

NBG Main Base is located primarily in limestone units, and the surrounding coastline includes a relatively narrow margin of beach interspersed with basalt or limestone rock formations.



Limestone rock formations along the coastline at Spanish Steps.
(*Photo*: L. Shaughnessy)

Seismology

NBG Main Base lies near a major fault line and is subject to earthquake events. For more details on seismic activity in Guam, see Section 4.2.1.3, *Seismology*. According to the 2014 Guam Hazard Mitigation Plan, the areas in Guam determined to be susceptible to a large tsunami include all landmasses below 16 feet (5 meters) above mean sea elevation. Apra Harbor and the surrounding areas are susceptible to tsunami inundation from distances of 0.5 mile (0.8 kilometer) to more than 1 mile (1.6 kilometers) inland from Inner Apra Harbor (Guam Homeland Security 2014).

5.2.1.2 Topography

Orote Peninsula is a raised limestone plateau reaching 190 feet (58 meters) above mean sea level (MSL). The plateau slopes eastward to near sea level. Much of the land area has been substantially altered by shaping, dredging, and filling. Dry Dock Island, Polaris Point, and sections of the shoreline are man-made and created from dredging and filling activities.

5.2.1.3 Soils

NBG Main Base is dominated by limestone upland soils (Figure 5-3); the descriptions of each soil type are summarized in Table 4-1. Large areas of the Orote Peninsula have highly disturbed soils classified as urban, and extensive areas along Apra Harbor consist of coastal fill covered by roads, buildings, and parking lots. Coastal and depressional areas often include poorly drained soils formed from a variety of sources, such as limestone, volcanic, and beach deposits (U.S. Department of Agriculture [USDA] 1988).

5.2.2 Hydrology

5.2.2.1 Surface Water

NBG Main Base is within the Apra Watershed. Four rivers flow into Apra Harbor (Atantano, Sasa, Laguas, and Aguada), with one emptying into Inner Apra Harbor (Atantano River), and the other three emptying into Sasa Bay (Figure 5-4). Surface waters including wetlands and ponds are discussed below in Section 5.2.3.2, *Wetland Communities.*

5.2.2.2 Groundwater

NBG Main Base is located over 4 miles (6.4 kilometers) from the Northern Guam Lens Aquifer (NGLA) and is not located within the groundwater protection zone (refer to Figure 4-10). The installation is located primarily on porous coralline limestone and disturbed or created land. Infiltration in the highly permeable coralline limestone is rapid and the water table is near sea level (Water and Environmental Research Institute [WERI] and Island Research & Education Initiative [IREI] 2016). The Fena Valley Reservoir is the principal potable water source for NBG Main Base (SWCA and Tom Nance Water Resource Engineering [TNWRE] 2007).

5.2.3 Vegetation Communities

5.2.3.1 Upland Communities



The chain of love vine (*Antigonon leptopus*) is well established on NBG Main Base, and easy to spot as it forms green mats with pink flowers over large areas of vegetation.
(*Photo*: L. Shaughnessy)

NBG Main Base landforms consist of coastal lowlands and limestone headlands on Orote Peninsula. The classification system used to describe the vegetation on NBG Main Base is described in Section 4.4.1, *Vegetation Communities.* The primary vegetation community found on NBG Main Base is *Leucaena* Forest, particularly on Orote Peninsula, comprising approximately 50% of the total vegetated, undeveloped area on NBG Main Base (Table 5-3; Figures 5-5 and 5-6). The invasive vine, chain-of-love (*Antigonon leptopus*), covers a substantial area (7% of the vegetated, undeveloped area) on Orote Peninsula, smothering all other vegetation, and spreading rapidly (NAVFAC Marianas 2016a). Several areas, mostly on the south side of Orote Peninsula, contain significant areas of limestone native forest and coastal scrub in areas with rugged limestone terrain. The common dominant tree species in these areas are native nunu (*Ficus* spp.).

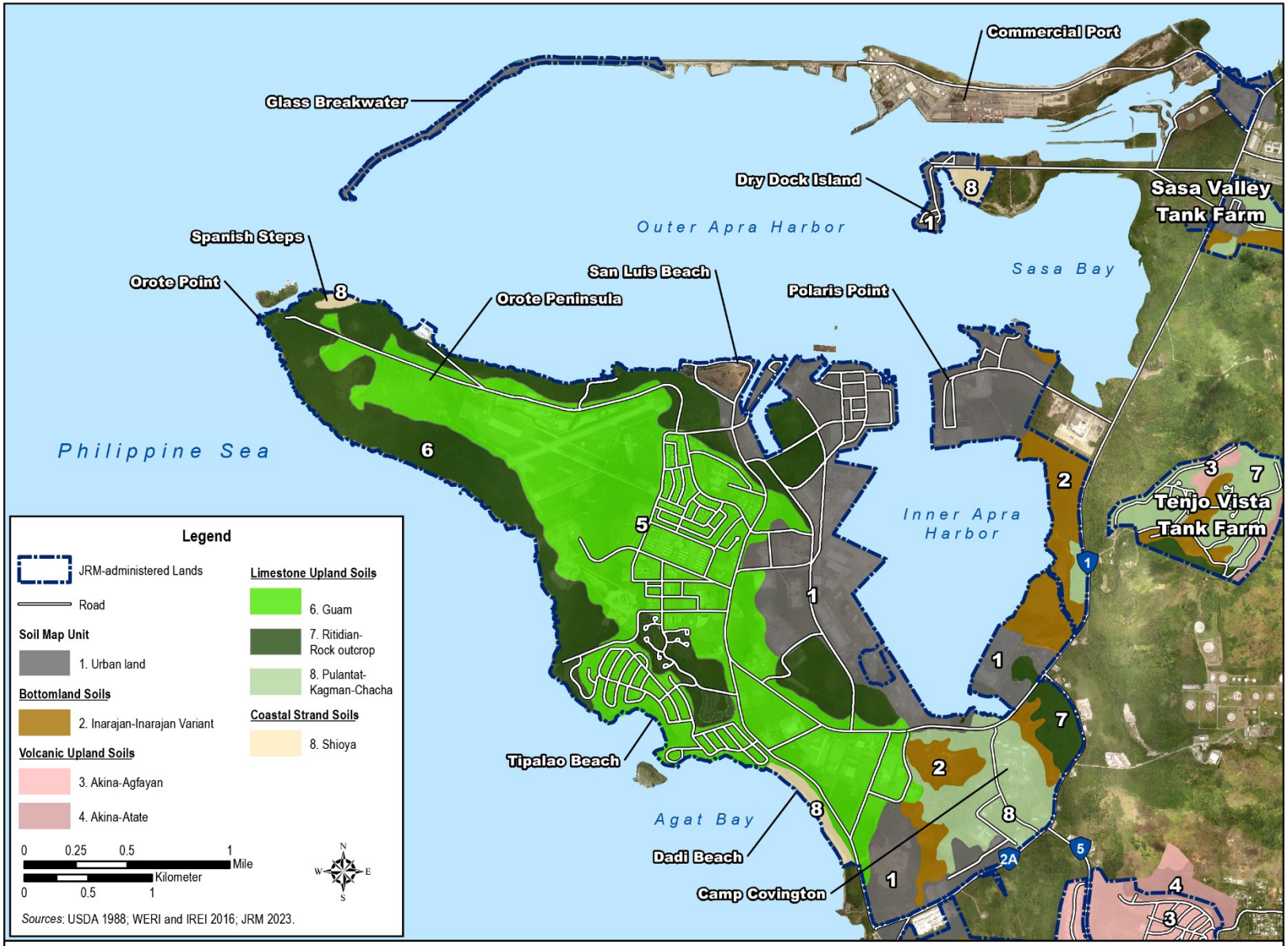


Figure 5-3
Soils - NBG Main Base

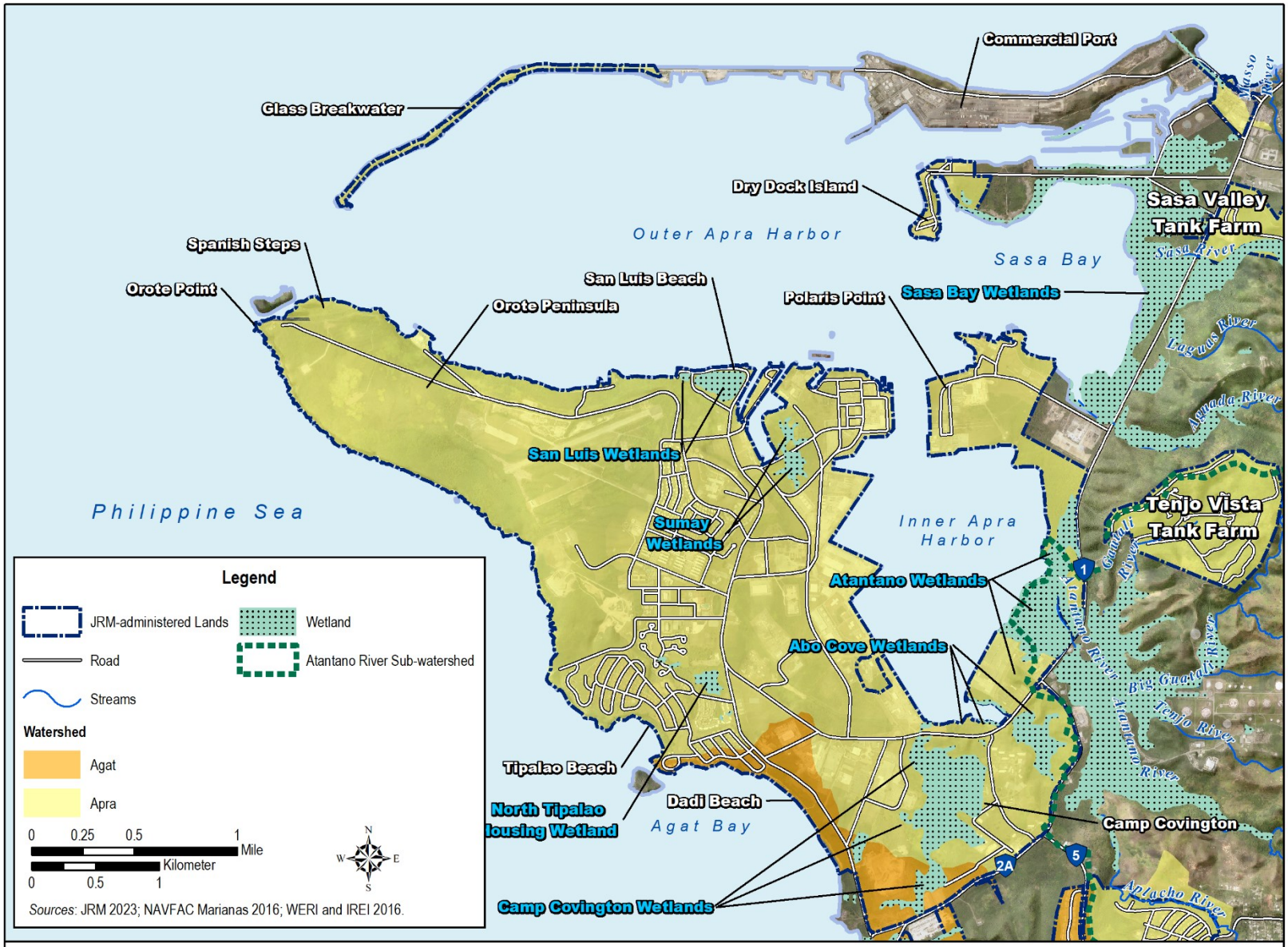


Figure 5-4
Surface Waters and Wetlands on NBG Main Base

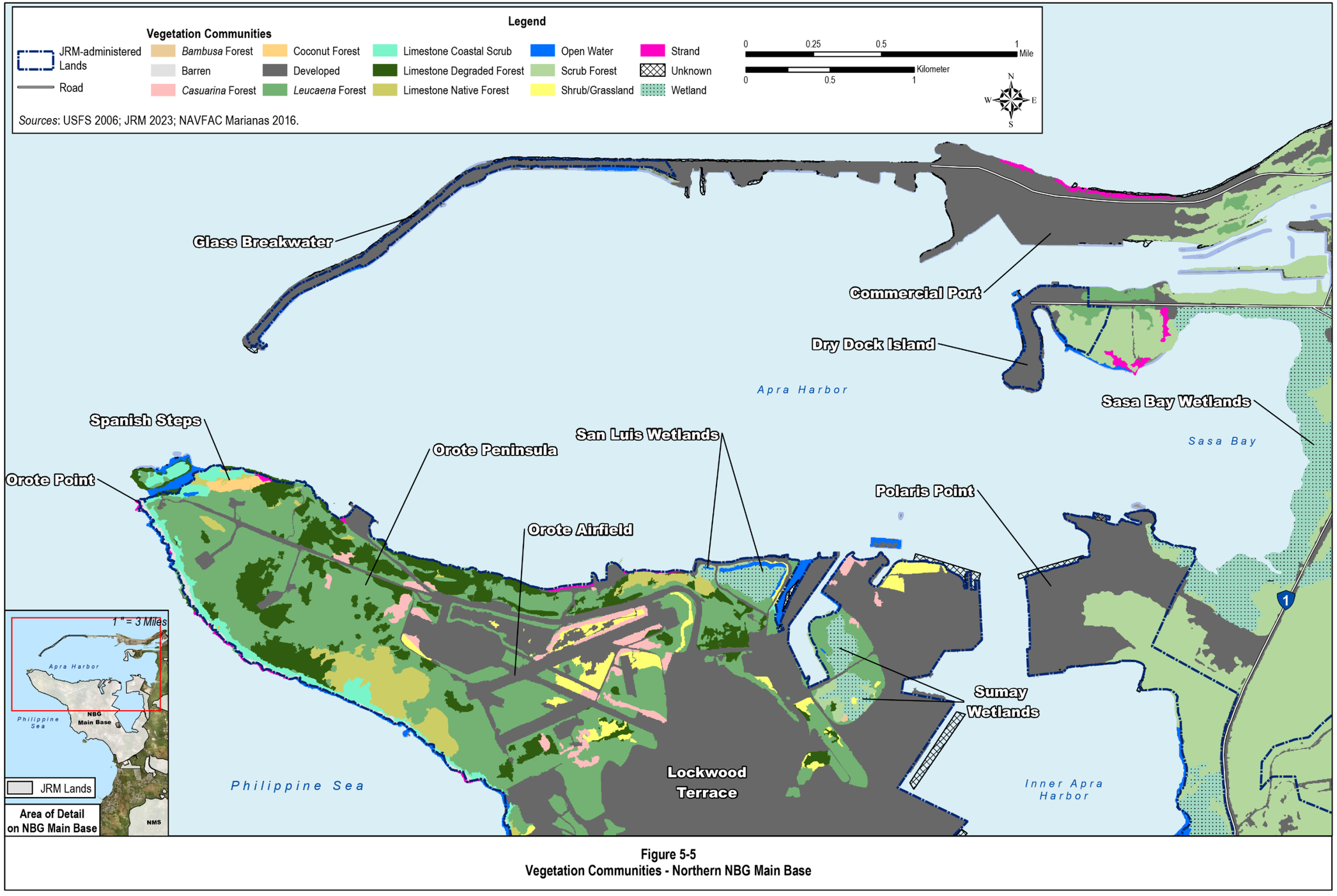


Figure 5-5
Vegetation Communities - Northern NBG Main Base

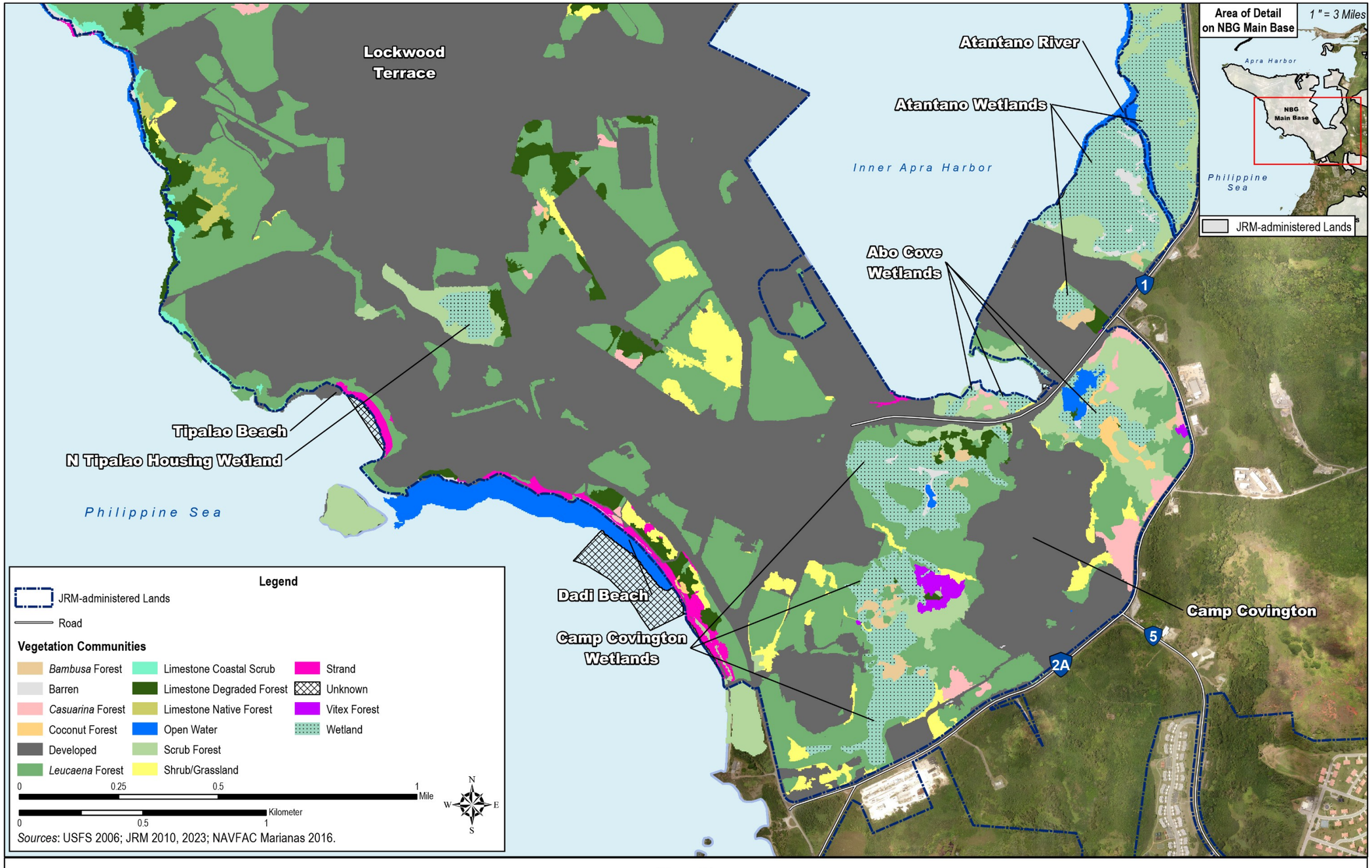


Figure 5-6
Vegetation Communities - Southern NBG Main Base

Vegetated areas that have been disturbed by clearing, construction, and other activities on NBG Main Base are dominated by non-native and invasive plant species. Yerbas babui (*Ruellia protrata*) and creeping oxeye or Singapore daisy (*Sphagneticola trilobata*) are invasive understory ground cover plants found in *Leucaena* forest. African tulip tree (*Spathodea campanulata*) is a canopy tree found in limestone degraded forest.

Table 5-3. Vegetation Communities on NBG Main Base

Vegetation Community	*Area (acres)*	*% of Total Area*	*% of Vegetated, Undeveloped Area*
Casuarina Forest	52.22	1.5	3.2
Coconut Forest	9.57	0.3	0.60
Limestone Coastal Scrub	34.55	1.0	2.1
Limestone Degraded Forest	174.56	5.0	10.8
Limestone Native Forest	63.03	1.8	3.9
Non-native Forest			
Bambusa Forest	8.57	0.2	0.53
Leucaena Forest	798.54	23.0	49.4
Vitex Forest	5.47	0.2	0.34
Other Shrub/Grassland	84.77	2.4	5.2
Scrub/Shrub	178.80	5.2	11.1
Strand	16.65	0.5	1.0
Wetland			
Wetland	188.61	5.4	11.7
Non-vegetated Categories			
Barren	14.55	0.4	NA
Developed	1,822.18	52.5	NA
Open Water	13.44	0.4	NA
Unknown	5.91	0.2	NA
Total	**3,471.40**		

Key: % = percent; NA = not applicable; NBG = Naval Base Guam.
Sources: U.S. Forest Service [USFS] 2006; NAVFAC Marianas 2023.

5.2.3.2 Wetland Communities

The wetland areas of NBG Main Base were originally delineated and mapped in 1998 (Dueñas and Associates 1998). In 2007, wetland areas on NBG Main Base were reassessed and it was concluded that the 1998 boundaries had not changed in most locations (AECOS, Inc. and Wil Chee Planning, Inc. 2009). In 2012, the Camp Covington and Atantano Wetlands were evaluated in detail as part of a *Moorhen Habitat Wetland Restoration Feasibility Study* (NAVFAC Pacific 2013a).

Based on the original 1998 and subsequent 2007 and 2012 surveys, there are approximately seven areas containing a total of 190 acres (77 hectares) of wetlands located within NBG Main Base (Table 5-4). These areas are found primarily along the eastern shore of Inner Apra Harbor, within Camp Covington south of Inner Apra Harbor, and along the eastern shoreline of Sasa Bay. There is also one wetland area located within the North Tipalao Housing Area northeast of Tipalao Beach and two areas near Clipper Channel and Sumay Cove (see Figures 5-4, 5-5, and 5-6).

Table 5-4. Area of Wetlands on NBG Main Base

Wetland Classification	Wetland (acres)[1]							Total
	San Luis Point Pond	Sumay	Sasa Bay[2]	Atantano[2]	Abo Cove	Camp Covington	N Tipalao Housing	
Herbaceous	15.4	16.4	0	10.5	3.0	58.0	6.1	**109.4**
Mangrove	0	0	3.9	58.9	10.9	0	0	**73.7**
Shrub/Herb	0	3.8	0	0.2	>0.1	1.5	1.4	**6.9**
Total	**15.4**	**20.2**	**3.9**	**69.6**	**13.9**	**59.5**	**7.5**	**190.0**

Notes: [1] Refer to Figures 5-4, 5-5, and 5-6 for the locations of the listed wetlands.
[2] Acreages on DoD property only. Total area of wetlands on DoD and non-DoD property at Sasa Bay = 146.3 acres (59.2 hectares); and Atantano = 75.6 acres (30.6 hectares).
Key: < = less than; NBG = Naval Base Guam.
Sources: USFS 2006; NAVFAC Marianas 2016a; WERI and IREI 2016.

Estuarine Wetlands

Estuarine wetlands are salty to brackish water habitats enclosed in large part by land but have open, partly obstructed, or sporadic access to the ocean. They are transitional areas between freshwater and marine communities and are strongly influenced by tidal action. Approximately 74 acres (30 hectares) of estuarine wetlands are found on NBG Main Base along the eastern shores of Inner Apra Harbor and Sasa Bay and classified as mangrove wetlands. Mangroves are the predominant woody trees that are adapted to tidal estuarine communities. Plant species include Asiatic mangrove (*Rhizophora mucronata*), Indo-West Pacific stilt mangrove (*Rhizophora apiculata*), large-leafed mangrove (*Bruguiera gymnorrhiza*), grey mangrove (*Avicennia marina*), teruntum merah (*Lumnitzera littorea*), nipa palm (*Nypa fruticans*), *Xylocarpus moluccensis*, looking-glass-tree (*Heritiera littoralis*), pago (*Hibiscus tiliaceus*), and golden leather fern (*Acrostichum aureum*) (Guam DAWR 2006). Much of Inner Apra Harbor supported mangrove communities prior to the dredging and filling of the harbor in the 1940s. Remnant mangrove communities are still present along the shoreline of Inner Apra Harbor and extend inland along coastal streams that receive tidal waters (AECOS, Inc. and Wil Chee Planning, Inc. 2009).

Abo Cove Wetlands. Abo Cove is an eastward extending finger of Inner Apra Harbor located near the NBG Main Base main security entrance gate. The 14-acre (6-hectare) Abo Cove wetlands consist of three wetlands along the shore of the cove, and a large wetland that extends inland, connected by a culvert under Marine Corps Drive (Route 1) (see Figure 5-6). This wetland area contains both estuarine and palustrine systems. The estuarine portions are the three areas surrounded by mangroves on the north side of Marine Corps Drive and the larger southeast side of Marine Corps Drive just inside the Main Gate. The palustrine portion is the area farthest inland from Marine Corps Drive. As this wetland area contains both estuarine and palustrine systems, it exhibits some of the more diverse wetland vegetation on JRM-administered lands. The three smaller wetlands along Abo Cove and north of Marine Corps Drive consist of mangrove (*Rhizophora* spp.) swamp with pago trees. The larger area across from Abo Cove and southeast of Marine Corps Drive is dominated by a mangrove swamp (Asiatic and grey mangroves) and bulrush (*Schoenoplectus litoralis*). Further inland, the palustrine vegetation encompasses tall reed (*Phragmites karka*) intermixed with wild cane (*Saccharum spontaneum*), and pago trees in tangled stands (AECOS, Inc. and Wil Chee Planning, Inc. 2009).

San Luis Point Ponds. Consisting of a small eastern pond and a larger western pond, the San Luis Ponds appear isolated (i.e., lacking a surface water connection to the sea), but they are influenced by saline groundwater. These isolated ponds are therefore brackish (estuarine) and show a much-attenuated tidal response.

The western pond is a 1.5-acre (0.6-hectare) site located directly at San Luis Point (see Figure 5-5). This wetland is an open water pond surrounded by a marsh created by berms that were constructed out onto the fringing reef off San Luis Point, probably in the 1940s (Wiles and Ritter 1993). Vegetation is primarily bulrush, surrounded by golden leather fern, *Pluchea indica*, pago, tall reed, and wild cane (AECOS, Inc. and Wil Chee Planning, Inc. 2009).

The eastern wetland is an approximate 14-acre (6-hectare) pond and marsh located directly east of the western pond (a berm with roadway separates the two) off San Luis Point. Like the western pond, the eastern pond was created by berms constructed into a fringing reef east of San Luis Point. The marsh vegetation is dominated by bulrush, with golden leather fern and *Pluchea indica* along the margins. The salinity in this eastern pond has been measured at 25.5 parts per thousand, in contrast to the adjacent western pond whose salinity was only 1.5 parts per thousand (AECOS, Inc. and Wil Chee Planning, Inc. 2009).

Although the vegetation is similar in these two wetlands, the salinity and species diversity indicate somewhat different hydrologic regimes. The western wetland is smaller and influenced to a greater degree by freshwater inflow from springs, whereas the eastern pond is influenced primarily by saline groundwater (AECOS, Inc. and Wil Chee Planning, Inc. 2009).

Sasa Bay Wetlands. The mangrove forest present in Sasa Bay is the largest native mangrove community on U.S. land in the Pacific. The 146-acre (59-hectare) Sasa Bay wetlands consist of a 126-acre (51-hectare) coastal mangrove wetland extending along the eastern shore of Sasa Bay from Dry Dock Island to Polaris Point and approximately 20 acres (8 hectares) of herbaceous wetlands on the east side of Marine Corps Drive on non-DoD property (see Figure 5-5). Approximately 4 acres (1.6 hectares) of mangrove wetlands are found on DoD property within a small area at Polaris Point.

The Sasa Bay wetlands complex is fed by the Aguada, Laguas, and Sasa rivers. Marine Corps Drive divides the wetland features into coastal, mangrove swamps, and coastal plain, generally palustrine marshes to the east of Marine Corps Drive. This wetland area is vegetated with Indo-West Pacific stilt mangrove and dense bulrush. Along the margin of the bulrush is a narrow band of glory bower (*Clerodendrum inerme*), and beyond that, tall reed with nipa palm fronting the pago forest extending into the uplands. The area is also characterized by a very diverse group of species, particularly for a mangrove wetland: nanaso (*Scaevola taccada*), teruntum merah, *Rhizophora* sp., tall reed, *Scleria polycarpa*, tropical fimbry (*Fimbristylis cymosa*), and common bamboo (*Bambusa vulgaris*) (AECOS, Inc. and Wil Chee Planning, Inc. 2009).

Atantano Wetlands. The approximate 76-acre (31-hectare) Atantano Wetlands are located along the southeastern shore of Inner Apra Harbor (see Figure 5-6). These wetlands constitute the northern boundary of the Atantano River Delta, which discharges into Inner Apra Harbor. These wetlands begin in the upper reaches of the Atantano River to the east of Marine Corps Drive and stretch across the highway via a culvert to the mouth of the Atantano River and include the isolated 3-acre (1.2-hectare) wetland south of the main Atantano Wetlands and west of Marine Corps Drive. Approximately 6 acres (2.4 hectares) of herbaceous wetlands to the east of the highway are located on non-DoD property. The 70 acres (28 hectares) of wetlands to the west of the highway on DoD property are primarily estuarine in nature and form the Atantano River Delta (AECOS, Inc. and Wil Chee Planning, Inc. 2009). Previous studies reported that this area supports one of Guam's most developed mangrove communities and that the area contains Guam's largest grove of grey mangrove (Moore et al. 1977; Wiles and Ritter 1993). Observations during the 2012 site assessment confirmed prior studies and found that the estuarine Atantano Wetlands are dominated by several mangrove species, including Asiatic mangrove, Indo-West Pacific stilt mangrove, large-leafed mangrove, and grey mangrove. The main areas of open or ponded water observed within these wetlands included the main river

channel and several deep secondary channels located toward the southern end of the wetland (NAVFAC Pacific 2013b). Refer to NAVFAC Pacific (2013b) for a detailed description of this wetland complex.

Palustrine Wetlands

Palustrine wetlands are nontidal brackish to freshwater habitats dominated by trees, shrubs, persistent emergent, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 parts per thousand. Palustrine wetlands (on Figures 5-5 and 5-6) on NBG Main Base are the result of closed-basin features or lowlands isolated by fill features as the military base developed (AECOS, Inc. and Wil Chee Planning, Inc. 2009). These wetland communities include the Sumay, North Tipalao Housing, and Camp Covington wetlands (see Figures 5-5 and 5-6). Approximately 116 acres (47 hectares) of palustrine wetlands are found on NBG Main Base and classified as either herbaceous or shrub/herb wetlands. Approximately 109 acres (44 hectares) of herbaceous wetlands are found primarily at Camp Covington. Approximately 7 acres (3 hectares) of shrub/herb wetlands are also found at Sumay, Camp Covington, and North Tipalao Housing (see Table 5-4).

Sumay Wetlands. The 20-acre (8-hectare) Sumay wetlands are divided by a coral-gravel-filled roadway. The wetland is primarily a marsh with pago swamp areas to the west and south (see Table 5-4 and Figure 5-5). The herbaceous vegetation includes *Brachiaria mutica*, bulrush, golden leather fern, wild cane, and *Thelypteris interrupta* (Dueñas and Associates 1998; AECOS, Inc. and Wil Chee Planning, Inc. 2009).

North Tipalao Housing Wetlands. The 7.5-acre (3.0-hectare) North Tipalao wetlands occur on a limestone plateau with typical karst topography consisting of shallow depressions of various sizes. Two palustrine wetlands, encompassing 6 acres (2.4 hectares) (Wetland Herbaceous) and 1.4 acres (0.6 hectares) (Wetland Shrub/Herb), were delineated in this area (see Table 5-4 and Figure 5-6). The larger wetland is surrounded by pago, golden leather fern, and *Thelypteris interrupta*. The smaller wetland contains *Polygonum minus* fringing a shallow open water area, along with typical weedy vegetation consisting of wild cane, para grass (*Urochloa muticum*), and *Cyperus ligularis* occurring around the perimeter (Dueñas and Associates 1998).

Camp Covington Wetlands. The 60-acre (24-hectare) Camp Covington wetland complex is located south of Marine Corps Drive and is bordered by Camp Covington to the east, the DON Exchange to the west, and the sanitary landfill to the southwest (see Figure 5-6). The Camp Covington wetland complex consists of four to five separate palustrine wetland areas. The number of separate areas varies based on the data source and associated geographic information system (GIS) files (Dueñas and Associates 1998; AECOS, Inc. and Wil Chee Planning, Inc. 2009; NAVFAC Pacific 2013a, 2013b). Historically, migratory birds and the federally endangered Mariana common moorhen utilized these wetlands. Overgrowth of emergent vegetation, especially tall reed, has reduced the quality of these wetlands as moorhen habitat (Takano and Haig 2004; AECOS, Inc. and Wil Chee Planning, Inc. 2009; USFWS 2010).

The northern portion of the wetland complex is dominated by tall reed, which forms monotypic stands interspersed with swamp morning glory (*Ipomoea aquatica*), elephant grass (*Pennisetum purpureum*), and para grass. The golden leather fern is also present and has been observed growing as a floating mat of vegetation, which could support the weight of a person. This northern portion is the only wetland in the Camp Covington complex with significant areas of open water identified. Depending on the season and associated rainfall, small pockets of open water are known to occur in the northern end of the wetland, and a significant pocket of open water has been present in the eastern portion, to the east of the small forested island (see Figure 5-6). These areas of open water roughly correlate with open water areas identified in historical photos. These open water areas may have contained another significant wetland vegetation species, possibly bulrush, but the expansion of tall reed over the decades has resulted in the loss of the

bulrush. In addition, one eastern arm of the northern area appears to have been filled in as a result of building Camp Covington (NAVFAC Pacific 2013b).

The southern portion includes areas dominated by monotypic stands of tall reed, while areas in the northeastern corner are characterized by muddy soil with little standing water and dominated by pago. This area also supports ponded water during the wet season but these areas are small and being encroached by tall reed. The area surrounding the wetland is dominated by pago, which grades into a surrounding *Leucaena* forest. There are also significant patches of common bamboo (NAVFAC Pacific 2013b). Refer to NAVFAC Pacific (2013b) for a detailed description of this wetland complex. Also present in Camp Covington wetlands is the dominant, native but invasive giant reed (*Arundo donax*).

5.2.4 Terrestrial Wildlife

5.2.4.1 Mammals

Native Species

The only native mammal currently occurring in Guam is the Mariana fruit bat (*Pteropus mariannus mariannus*), which is discussed below in Section 5.2.5, *Terrestrial Protected Species*.

Non-native Species

While few small mammal surveys have been conducted on NBG Main Base, it is expected that the common non-native small mammals found throughout Guam would also be found on the installation. These include Norway rat (*Rattus norvegicus*), black rat (*Rattus diardi*), Polynesian rat (*Rattus exulans*), house mouse (*Mus musculus)*, and musk shrew (*Suncus murinus*) (USFWS 1986; Wiles 2005; Wiewel et al. 2009). Feral dogs and cats (which are also threats to native wildlife), are addressed in the Regional Biosecurity Plan (RBP) for Hawai‘i and Micronesia (DON 2015b) and in the Guam DAWR Draft State Wildlife Action Plan (2015).

Feral pigs (*Sus scrofa*) occur on NBG Main Base, particularly within the undeveloped areas of the Orote Peninsula and Camp Covington wetlands. Feral pigs cause extensive habitat damage by rooting and digging and pose threats to sea turtle nests.

Philippine deer (*Rusa marianna*) are invasive ungulates found throughout JRM-administered lands in Guam. These deer have significantly impacted natural ecosystems on NBG by causing loss of native plant and animal species and degradation of native species' habitat. Additionally, deer grazing on native tree seedlings is suspected to adversely affect native tree regeneration and cause erosion.

Feral pig control on NBG Main Base was first conducted on a large scale from 2013 through 2016 through an Interagency Agreement with USDA Animal and Plant Health Inspection Service (APHIS) Wildlife Services (DON 2015a; USDA APHIS Wildlife Services 2015a, 2015b). From April 2013 through June 2015, 524 feral pigs were removed from NBG Main Base. In 2014, a segment of fencing was installed along Route 2A. This segment completed the installation fence line and completely enclosed NBG Main Base to help prevent further feral pig encroachment onto the installation (USDA APHIS Wildlife Services 2014, 2015a, 2015b). However, trail camera surveys performed by USDA APHIS Wildlife Services in March and April 2016 at NBG Main Base produced a population estimate of 489 pigs with 95% confidence interval of 363-615 pigs (Vogt 2018).

In 2016, a cooperative agreement was entered into with White Buffalo, Inc. for field-based feral pig and deer control, eradication, and research operations on JRM-administered lands in Guam. Operations ran from October 2021 to November 2023. During the first year, White Buffalo conducted vegetation clearing

operations along conservation fences to ensure essential travel corridors for eradication actions and removed 34 pigs from NBG and 36 pigs from Polaris Point (NAVFAC Marianas 2022). Monitoring operations for ungulates were also conducted, and no deer were found in this area. During the second year of operations, only five pigs were removed from NBG. Due to the success of year one eradication efforts, Polaris Point was excluded from year two operations. Monitoring operations for ungulates were still conducted on NBG, and similar to year one, no deer were found (NAVFAC Marianas 2022).

5.2.4.2 Birds

Native Species

Standardized bird surveys have been conducted on NBG Main Base since 2008. Surveys are conducted at 14 sites within seven areas (e.g., open fields, runways/helicopter landing zones, beaches, shorelines, and wetlands) every 2 weeks during the peak migration and residency of wintering birds (September 1–June 1) and every 4 weeks during the remainder of the year (June 1–August 30), resulting in approximately 300 surveys per year. Additional project-specific surveys have also been conducted periodically. Based on surveys conducted through September 2014, 38 bird species have been documented (Table 5-5) (Eggleston 2009; NAVFAC Pacific 2010a; NAVFAC Marianas 2011a; Brindock 2012, 2013; Wenninger 2016a). The majority of birds observed on the installation are protected under the Migratory Bird Treaty Act (MBTA) (33 or 87%) and one species is further protected by the federal ESA and Guam ESA (Mariana common moorhen, which is discussed below in Section 5.2.5, *Terrestrial Protected Species*). Table 5-5 summarizes the number of species in each family of birds documented on NBG Main Base. The following summary does not include those species that may occur in nearshore or offshore waters of NBG Main Base and are not expected to make landfall on the installation (e.g., seabirds such as shearwaters). Appendix E provides further detail on bird species observed at NBG Main Base.

Table 5-5. Bird Families Recorded at NBG Main Base

Category[1]/Family	*No. of Species*
Federal ESA-listed	
Rallidae (Rails, Coots, Gallinules)	1
Listed under MBTA	
Scolopacidae (Sandpipers, Snipes)	15
Charadriidae (Plovers)	1
Laridae (Gulls, Terns)	6
Anseriformes (Waterfowl)	1
Ardeidae (Herons, Bitterns)	6
Sulidae (Boobies, Gannets)	1
Rallidae (Rails, Coots, Gallinules)	1
Recurvirostridae (Stilts, Avocets)	1
Accipitridae (Hawks, Eagles, Kites)	1
Strigidae (Owls)	1
Guam ESA-listed	
Rallidae (Rails, Coots, Gallinules)	1
Guam Species of Greatest Conservation Need	
Charadriidae (Plovers)	1
Scolopacidae (Sandpipers, Snipes)	15
Ardeidae (Herons, Bitterns)	1
Sulidae (Boobies, Gannets)	1
Rallidae (Rails, Coots, Gallinules)	1
Sturnidae (Starlings)	1

Table 5-5. Bird Families Recorded at NBG Main Base

Category[(1)]/Family	*No. of Species*
Native Breeding Resident	
Laridae (Gulls, Terns)	1
Ardeidae (Herons, Bitterns)	1
Rallidae (Rails, Coots, Gallinules)	1
Sturnidae (Starlings)	1
Non-native Breeding Resident	
Passeridae (Old World Sparrows)	1
Dicruridae (Drongos)	1
Columbidae (Doves, Pigeons)	1
Phasianidae (Pheasants and Allies)	1
Non-breeding Visitor	
Charadriidae (Plovers)	1
Scolopacidae (Sandpipers, Snipes)	15
Laridae (Gulls, Terns)	5
Ardeidae (Herons, Bitterns)	5
Sulidae (Boobies, Gannets)	1
Recurvirostridae (Stilts, Avocets)	1
Accipitridae (Hawks, Eagles, Kites)	1
Strigidae (Owls)	1

Note: [(1)] Families overlap between categories.
Key: ESA = Endangered Species Act; MBTA = Migratory Bird Treaty Act; NBG = Naval Base Guam; No. = Number
Sources: Guam DAWR 2006; Eggleston 2009; NAVFAC Pacific 2010a; NAVFAC Marianas 2011a; Brindock 2012, 2013; Wenninger 2016a.

The majority of birds observed from September through April were migratory shorebirds (16 species of sandpipers and plovers) with an additional 6 species of gulls and terns, and 6 species of herons, egrets, and bitterns. Of the observed species, three species accounted for approximately 90% of the observations: Pacific golden plover (*Pluvialis fulva*) 65−70%, whimbrel (*Numenius phaeopus*) 15%, and ruddy turnstone (*Arenaria interpres*) 10%; the remaining 33 species accounted for 10% of the observations. Migrants were more frequently observed on grass fields or concrete runways/helicopter landing zones than in shoreline or wetland habitats.

While the majority of bird species on the installation are native to the region, most are seasonal visitors, annually migrating to either winter or summer destinations. Migratory birds either spend the winter in Guam or migrate through during the spring and fall to breeding areas to the north and south. The coastal islets, reef flats, wetlands, grassy fields and other open areas on NBG Main Base provide seasonal foraging habitat for migratory bird species.

Although the native Micronesian starling (*Aplonis opaca*) is not listed under the MBTA, federal ESA, or Guam ESA, it is Guam-designated as a Species of Greatest Conservation and Need (SOGCN). The Pacific reef heron (*Egretta sacra*), brown booby (*Sula leucogaster*), and all migratory shorebirds are also Guam-designated as SOGCN (Guam DAWR 2006).

The yellow bittern (*Ixobrychus sinensis*) and white tern (*Gygis alba*) are native breeding residents. The brown noddy (*Anous stolidus*) is an uncommon native resident that roosts on steep cliffs, rocky offshore islets, and channel markers in Outer Apra Harbor. It previously nested on Orote Island located just off the end of Orote Peninsula; it currently nests only on Cocos Island. Brown boobies also nested on Orote Island before the construction of Kilo Wharf, but no longer nest in Guam. Many of the native species that

previously nested on NBG Main Base (such as the brown noddy and certain egrets) are unable to successfully nest due to the presence of the BTS, which preys on eggs and young.

Non-native Species

The black francolin (*Francolinus francolinus*), island collared dove (*Streptopelia bitorquata*), Eurasian tree sparrow (*Passer montanus*), rock pigeon (*Columba livia*), and black drongo (*Dicrurus macrocercus*) are common non-native breeding residents on NBG Main Base. These species are not listed under the MBTA.

5.2.4.3 Reptiles and Amphibians

Native Species

Six native herpetofauna species have been documented from NBG Main Base (Table 5-6). Green sea turtle (*Chelonia mydas*) adults and hatchlings occur at Spanish Steps, Dadi Beach, Family Beach, Gab Gab, Tipalao, and Kilo Wharf. Hawksbill turtles (*Eretmochelys imbricate*) have historically nested on NBG Main Base beaches. These sea turtle species are both federal ESA-listed and discussed in further detail in Section 5.2.5, *Terrestrial Protected Species*. The native Pacific blue-tailed skink (*Emoia caeruleocauda*), mutilating gecko (*Gehyra mutilata*), and mourning gecko (*Lepidodactylus lugubris*) can be found in virtually all habitats. Monitor lizards (*Varanus tsukamotoi*) are native to the Mariana Islands (Weijola et al. 2020). Management projects are implemented to control monitor lizards in areas of highest conservation concern. Guam has no native amphibian species.



The monitor lizard (*Varanus indicus*) feeds on native skinks and bird eggs. Management projects are implemented to control monitor lizards in areas of highest conservation concern.
(*Photo*: L. Shaughnessy)

Table 5-6. Reptile and Amphibian Species Recorded on NBG Main Base

Common Name/ Chamorro Name(1)	*Scientific Name*	*Residence Status*	*Orote Peninsula*	*Main Base(2)*	*Polaris Point*
Brown treesnake/Kolepbla	*Boiga irregularis*	Non-native	X	X	X
Brahminy blind snake/None	*Ramphotyphlops braminus*	Non-native	n/a	n/a	n/a
Curious skink/Gualiek halumtano	*Carlia ailanpalai*	Non-native	X	X	X
Green sea turtle/Haggan	*Chelonia mydas*	Native	X	--	--
Hawksbill turtle/Haggan	*Eretmochelys imbricate*	Native	--	X	--
Green anole/Achiak betde	*Anolis carolinensis*	Non-native	n/a	n/a	n/a
Pacific blue-tailed skink/Gualiek halumtano	*Emoia caeruleocauda*	Native	X	X	X
Crab-eating frog/Kairo	*Fejervarya limnocharis*	Non-native	--	X	--
Mutilating gecko/Achiak	*Gehyra mutilata*	Native	X	--	X
House gecko/Achiak	*Hemidactylus frenatus*	Non-native	X	X	X

Table 5-6. Reptile and Amphibian Species Recorded on NBG Main Base

Common Name/ Chamorro Name[(1)]	*Scientific Name*	*Residence Status*	*Orote Peninsula*	*Main Base[(2)]*	*Polaris Point*
Barking frog/ None	*Hylarana guentheri*	Non-native	n/a	X	n/a
Gunther's Amoy frog/Kairo	*Sylvirana guentheri*	Non-native	--	X	--
Greenhouse frog/ None	*Eleutherodactylus planirostris*	Non-native	n/a	n/a	n/a
Eastern Dwarf treefrog/ None	*Litoria fallax*	Non-native	n/a	n/a	n/a
Mourning gecko/Achiak	*Lepidodactylus lugubris*	Native	X	--	--
Marbled Pygmy frog/ None	*Microhyla pulchra*	Non-native	n/a	X	n/a
Marine toad or Cane toad/Kairo	*Rhinella* (=*Bufo*) *marina*	Non-native	X	X	X
Monitor lizard/Hilitai	*Varanus tsukamotoi*	Native	X	X	X
Taiwan Whipping frog/None	*Polypedates braueri*	Non-native	n/a	X	n/a

Notes: [(1)] Common and scientific names based on Gill and Donsker (2017). Chamorro names from GovGuam (2009), Liske-Clark (2015), Topping et al. (1975), and USFWS (2015a),
[(2)] Main Base includes the area of NBG Main Base east of the Orote Airfield and south of the Atantano River/Wetlands.
Key: NBG = Naval Base Guam, n/a = information is not available.
Sources: USFWS 1986; AECOS, Inc. and Wil Chee Planning, Inc. 2009; NAVFAC Pacific 2010a; NAVFAC Marianas 2013, 2014a. J. Martin, personal communications, 4 December 2023

Non-native Species

Table 5-6 lists a total of 13 non-native herpetofauna species that have been documented as occurring on NBG Main Base (NAVFAC Pacific 2013b). The introduced curious skink (*Carlia ailanpalai*) and house gecko (*Hemidactylus frenatus*) are found in all habitats, although the house gecko, as its name implies, is more common within developed areas. The curious skink and house gecko are considered the most abundant skink and gecko species in Guam. Three non-native amphibian species, Crab-eating frog (*Fejervarya limnocharis*), Gunther's Amoy frog (*Sylvirana guentheri*), and marine toad (*Rhinella* [=*Bufo*] *marina*) have been observed or heard primarily within the Camp Covington wetlands and San Luis Ponds (see Table 5-6).



The marine toad (*Rhinella* [=*Bufo*] *marina*) is a non-native amphibian species present on NBG Main Base.
(*Photo*: L. Shaughnessy)

The continued widespread presence of the BTS, the curious skink, and other non-native reptile and amphibian species are of concern because of each species' potential deleterious impacts in Guam's native reptiles. Of particular concern is the potential for introduced species to serve as additional food sources for the BTS (NAVFAC Pacific 2010a).

5.2.4.4 Freshwater Fishes

Native Species

Species on NBG Main Base within Atantano, Aguada, and Sasa rivers generally use the freshwater and estuarine components of the river, and many spend a portion of their life cycle within the ocean. Native

species that have been observed within the Atantano River include common glassfish (*Ambassis buruensis*), dusky sleeper (*Eleotris fusca*), marbled eel (*Anguilla marmorata*), rock flagtail (*Kuhlia rupestris*), silver moony (*Monodactylus argenteus*), bluespot mullet (*Moolgarda seheli*), bandfin mullet goby (*Mugilogobius cavifrons*), mudskipper (*Periophthalmus argentilineatus*), bigmouth goby (*Redigobius bikolanus*), gobies (*Stenogobius* spp.), and feathered river-garfish (*Zenarchopterus dispar*). Native fish species observed within the Aguada River include the marbled eel and bigmouth goby. Native species observed within the Sasa River include Engel's mullet (*Moolgarda engeli*), bandfin mullet goby, mudskipper, and feathered river-garfish (Guam DAWR 2008; NAVFAC Pacific 2010a, 2013b).

Non-native Species

Non-native species that have been observed within the Atantano River include the mosquitofish (*Gambusia affinis*) and guppy (*Poecilia reticulata*). Introduced species observed within the Sasa River include the Mozambique tilapia (*Oreochromis mossambicus*) (Guam DAWR 2008; NAVFAC Pacific 2010a, 2013b).

5.2.4.5 Invertebrates

Native Species

Native land hermit crab (*Coenobita brevimanus*) and coconut crab (*Birgus latro*) are present on Orote Peninsula and in coastal and estuarine areas. Also, mangrove crab (*Scylla serrata*), fiddler crab (*Uca* sp.), tree-climbing crab (*Labuanium* spp.), hermit crabs (Family Coenobitidae), and red-claw crab (*Cardisoma carnifex*) inhabit mangroves in the coastal areas (Wiles and Ritter 1993; NAVFAC Pacific 2013b). Macroinvertebrates observed within the Atantano River include the native species ninja shrimp (*Caridina serratirostris*), Tahitian prawn (*Macrobrachium lar*), and the snail *Neritina squamipicta*. Native macroinvertebrates observed within the Aguada River include green lace shrimp (*Atyoida pilipes*), shrimp (*Caridina* spp.), red-rimmed melania (*Melanoides tuberculata*), the snail *Neritina petitii*, mayfly larvae (order Ephemeroptera), dragonfly larvae (order Odonata), and pyralid caterpillars (Pyralidae) (Guam DAWR 2008; NAVFAC Pacific 2010a).



Hermit crabs (Family Coenobitidae) at Spanish Steps use a variety of shells.
(*Photo*: L. Shaughnessy)

Non-native Species

African land snails (*Achatina fulica*), unnamed snail *Thiara granifera,* coconut rhinoceros beetles (CRB) (*Oryctes rhinoceros*), two species of scarab beetles (*Protaetia pryeri* and *Protaetia orientalis*), Erythrina gall wasps (*Quadrastichus erythrinae*), cycad scale (*Aulacaspis yasumatsui*), New Guinea flatworm (*Platydemus manokwari*), and over 26 species of ants are non-native invertebrates known in Guam. These species represent threats to native palms, native *Cycas micronesica*, native ifit (*Intsia bijuga*), *Erythrina* trees, native tree snails, and other native species.

The little fire ant (LFA) (*Wasmannia auropunctata*) was accidentally introduced to northern Guam in 2011 and has spread to many locations throughout Guam due to the movement of infested green waste and illegal dumping. LFA represents a serious threat to native invertebrate and vertebrate species in Guam. Infestations have been found at two locations (Polaris Point and Dadi Beach) on NBG Main Base. LFA control and eradication efforts are ongoing as infestations are found on the installation.

5.2.5 Terrestrial Protected Species

A total of seven federal ESA-listed species are known to occur on NBG Main Base, with an additional 12 species potentially occurring (Table 5-7). Of the 12 species that may potentially occur, 8 of them are recently listed plant species that have not yet been adequately surveyed to determine their presence on NBG Main Base. In addition, five Guam ESA-listed species are also known to occur, all of which are also federal ESA-listed. Following is a summary of known and potential occurrences of protected species on NBG Main Base.

Table 5-7. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded on NBG Main Base

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat*	*Occurrence*
Mammals					
Mariana fruit bat/Fanihi	*Pteropus mariannus mariannus*	T	E	Limestone native forest	P[2]
Birds					
Mariana common moorhen/Pulattat	*Gallinula chloropus guami*	E	E	Wetland (herbaceous, mangrove, and shrub/herb)	Y
Micronesian starling/Sali	*Aplonis opaca*	--	E	All habitat types	P
Reptiles					
Green sea turtle/Haggan	*Chelonia mydas*	E[3]	T	Open water and strand	Open water and strand: Y
Hawksbill turtle/Haggan karai	*Eretmochelys imbricata*	E	E	Open water and strand	Open water: Y; strand: PU[2]
Invertebrates					
Fragile tree snail/Akaleha	*Samoana fragilis*	E	E	Limestone native and ravine forests	Y
Guam tree snail/Akaleha	*Partula radiolata*	E	E	Limestone native and ravine forests	Y
Mariana eight-spot butterfly/Ababbang	*Hypolimnas octocula marianensis*	E	--	Limestone native forest	PU[2]
Plants					
None/Siboyas halumtano	*Bulbophyllum guamense*	T	--	Limestone native and degraded forests	P
None/Fadang	*Cycas micronesica*	T	--	Limestone native and degraded forests, ravine forest, and savanna complex summits	Y
None/None	*Dendrobium guamense*	T	--	Limestone native forest and limestone coastal scrub	P
None/Aaban or aabang	*Eugenia bryanii*	E	--	Limestone coastal scrub	P
None/Ufa halumtano	*Heritiera longipetiolata*	E	E	Limestone native forest.	Y
None/None	*Maesa walkeri*	T	--	Limestone native and degraded forests	P

Table 5-7. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded on NBG Main Base

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat*	*Occurrence*
None/Seyaihagon or Maisa ulu	*Nervilia jacksoniae*	T	--	Limestone native and degraded forests	P
None/Aplokating-palaoan	*Psychotria malaspinae*	E	--	Limestone native forest and limestone coastal scrub	P
None/None	*Tabernaemontana rotensis*	T	--	Limestone native and degraded forests	Y
None/None	*Tinospora homosepala*	E	--	Limestone native forest and limestone coastal scrub	P
None/None	*Tuberolabium guamense*	T	--	Limestone native forest and limestone coastal scrub	P

Notes: [1] Chamorro names from GovGuam (2009), Topping et al. (1975), Safford (2009), and USFWS (2015a).
[2] Historical occurrence.
[3] Central West Pacific Distinct Population Segment.
Key: -- = not listed; E = endangered; ESA = Endangered Species Act; NBG = Naval Base Guam; P = potential for occurrence; PU = potential for occurrence, but unlikely; T = threatened; Y = yes, known to occur.
Sources: Schreiner and Nafus 1997; Guam DAWR 2006; GovGuam 2009; USFWS 2011, 2015b; NAVFAC Pacific 2013b; NAVFAC Marianas 2014a, 2014b, 2016.

5.2.5.1 Mammals

Mariana Fruit Bat

The Mariana fruit bat is federal ESA-listed as threatened, Guam ESA-listed as endangered, and Guam-designated as SOGCN. Historical fruit bat colony roosts have been reported from forested cliffline habitat on NBG Main Base at Orote Point. From January to April 1966, 100 to 300 bats were observed at Orote Point, and by June of that year, the total had increased to 600. In 1971, a colony of 150 fruit bats was observed at Orote Point (Wheeler 1979) and no fruit bats were detected during four days of fruit bat surveys conducted at Orote Point in 2008 (Brooke 2008). Although there are no recent reported detections of resident fruit bats on NBG, a roosting colony with over 200 bats was found on NMS in 2023 (U.S. Navy 2023).

5.2.5.2 Birds

Mariana Common Moorhen

The Mariana common moorhen is federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. The moorhen is also protected under the MBTA. There are six wetland areas on NBG Main Base that have either historically supported moorhens or currently support them (Figure 5-7). Moorhens may occupy these wetlands at least during the wet season, and possibly also in the dry season, if open water habitat remains present.



Mariana common moorhen (*Gallinula chloropus guami*)
(*Photo*: iNaturalist.org)

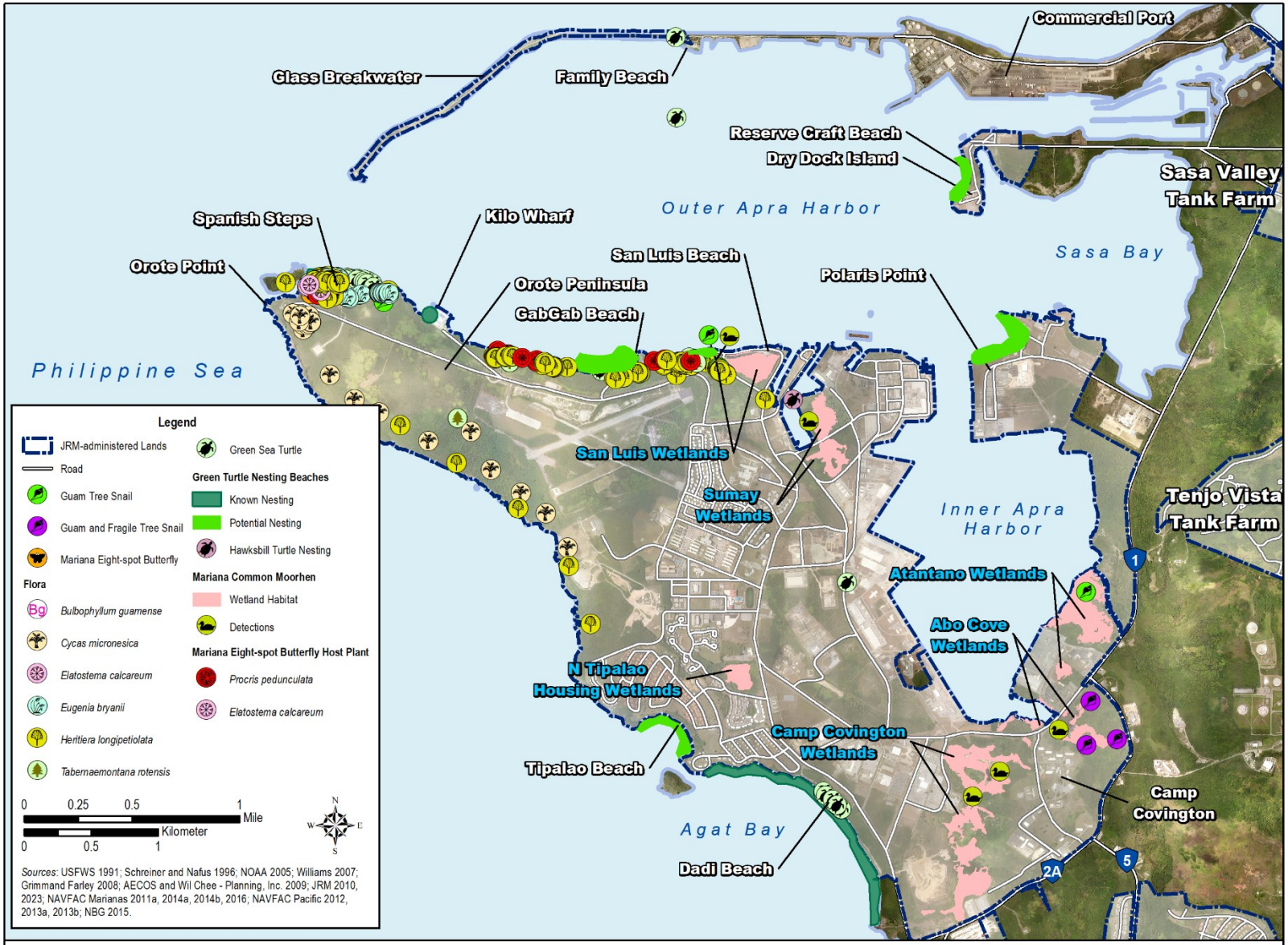


Figure 5-7
Protected Terrestrial Species - NBG Main Base

San Luis Ponds. These ponds have historically been used by moorhens (BioSystems Analysis, Inc. 1988). In the 1991 recovery plan for the moorhen, the USFWS considered the San Luis Ponds as "secondary" wetlands or habitat for moorhens (USFWS 1992). "Primary" habitats are defined as "those sites providing the highest present or potential value as moorhen habitat, based on such factors as size, number of moorhens previously observed, consistency of water levels, quality of vegetation for moorhens, and location." "Secondary" habitats are "low in value compared to primary habitats and may accommodate other uses. Much of the information on habitat quality is preliminary and should be further researched and refined."

Two Mariana common moorhens were observed at the San Luis Ponds during the wetland delineation and site characterizations and surveys conducted in October 2010 and February 2011 (JRM 2013). The most recent surveys conducted in the wet and dry seasons of 2013–2014 detected moorhens at the western pond in the dry season, but they were not detected in the wet season. Pockets of open water, stands of bulrush, and clumps of golden leather fern are present in the interior of the western pond thereby providing suitable moorhen habitat (NAVFAC Marianas 2014b).

Sumay Wetlands. In the moorhen recovery plan, the USFWS considered these two ponds as secondary habitat for moorhens (USFWS 1992). Surveys conducted in 2014 detected one adult moorhen during each of the dry and wet season surveys at the northern pond; moorhens were not detected at the southern pond during either season (NAVFAC Marianas 2014b).

North Tipalao Housing Wetlands. Standing water in the dry season was present only in depressions around golden leather fern clumps. During wet season surveys, standing water was 2–3 feet (0.6–0.9 meter) deep, but it was not sufficient to overtop existing vegetation and create open water habitats favored by moorhens. No moorhens were detected in this wetland area during wet and dry season surveys in 2013–2014 (NAVFAC Marianas 2014b). Given the lack of open water during the wet season, it is unlikely moorhens would use this area.

Camp Covington Wetlands. Also known as "Naval Station Marsh," this wetland complex is considered one of three primary wetland areas in Guam that support moorhens (USFWS 1992). Small numbers of moorhens have been regularly recorded from this wetland area (Wiles and Ritter 1993). A survey conducted in December 2009 did not detect any moorhens within this wetlands complex. During a September 2012 site visit to conduct an assessment of the wetlands but not to conduct formal moorhen surveys, two adult moorhens were detected (one visually, one aurally), and one nest with two eggs and one unoccupied nest were observed (NAVFAC Pacific 2013a). During wet season surveys in 2014, three adult moorhens were detected within the northern portion of the complex (NAVFAC Marianas 2014b).

Abo Cove Wetlands. The Abo Cove wetlands consist of estuarine wetlands along the shore of the cove, and a large palustrine wetland that extends inland to the southeast of Marine Corps Drive (see Figure 5-6). While no historical data exists regarding usage of this wetland by moorhens, adults and juveniles have been observed regularly during migratory bird surveys since 2014 (NAVFAC Marianas 2014b; Wenninger 2016a).

Atantano Wetlands. The Mariana common moorhen typically occupies freshwater wetland habitats, but is also known to use brackish water and mangrove habitats for limited periods of time (USFWS 1992). Suitable open water areas that could potentially serve as habitat for the moorhens do not occur within the delta portion of the Atantano Wetlands. Most of the existing open water areas (main river channel, small isolated stormwater pools, etc.) are strongly influenced by tides and therefore are probably too saline to be used extensively by moorhens. The moorhen recovery plan identifies the Atantano Wetlands area east of Marine Corps Drive as secondary habitat (USFWS 1992). Wiles and Ritter (1993) state that moorhens nest

in the freshwater marsh on the east side of the road, but their abundance and seasonal occurrence are poorly known.

Micronesian Starling

The Micronesian starling is Guam-designated as SOGCN. It was once considered one of the most common and abundant species in Guam, and was found throughout the island, occupying all habitats. As with the other Guam bird species, the principal cause of decline is due to predation by BTS. In response to this, a BTS exclusion and monitoring program was developed on Andersen AFB, and as of 2023, the starling population has increased to over 1,600 birds (NAVFAC Marianas 2023a).

Starlings are also now found infrequently within the main gate area of MCB Camp Blaz, Mount Santa Rosa, central Dededo, Tumon, and Inarajan. In addition, Guam DAWR (2006) reported a small population of less than 100 birds on Cocos Island, south of Guam. Grimm (2015) confirmed that there were still starlings on Cocos. Many of the areas where Micronesian starlings are known to occur are protected from BTS by trapping and special nest boxes.

5.2.5.3 Reptiles

Green Sea Turtle

The Central West Pacific Distinct Population Segment (DPS) of the green sea turtle is federal ESA-listed as endangered and Guam ESA-listed as threatened. They are known to use the nearshore waters of the Orote Peninsula and Outer Apra Harbor waters and nest on six beaches within NBG Main Base: Spanish Steps, Dadi Beach, Family Beach, Gab Gab, Tipalao, and pocket beaches at Kilo Wharf. Sea turtle nesting surveys are conducted regularly at Spanish Steps and Dadi Beach, and infrequently during the nesting season at other NBG Main Base beaches that may potentially support nesting sea turtles (i.e., Sumay and Polaris Point). Data for the Spanish Steps survey area show that the main period of green sea turtle nesting and non-nesting emergences (also known as nesting attempts) (e.g., false crawls) is March–July (Figure 5-8), with some nesting activity observed from December through February.

While the majority of nesting events (nest and non-nesting emergence) at NBG Main Base occurred on Spanish Steps, the 2009–2016 survey data show 14 nesting events for other beaches (Table 5-8). Data for Dadi Beach show nine nesting attempts (one each in April and July 2013 and July 2015; three nesting events each in May and June 2013) and one non-nesting emergence each in May and June 2013. There was one observed non-nesting emergence at Gab Gab Beach in May 2012 and two nesting events at Family Beach on the Breakwater in 2015. There were no other observed nesting events or non-nesting emergences at other potential sea turtle nesting beaches on NBG Main Base during the 2009–2016 period (Wenninger 2016b).

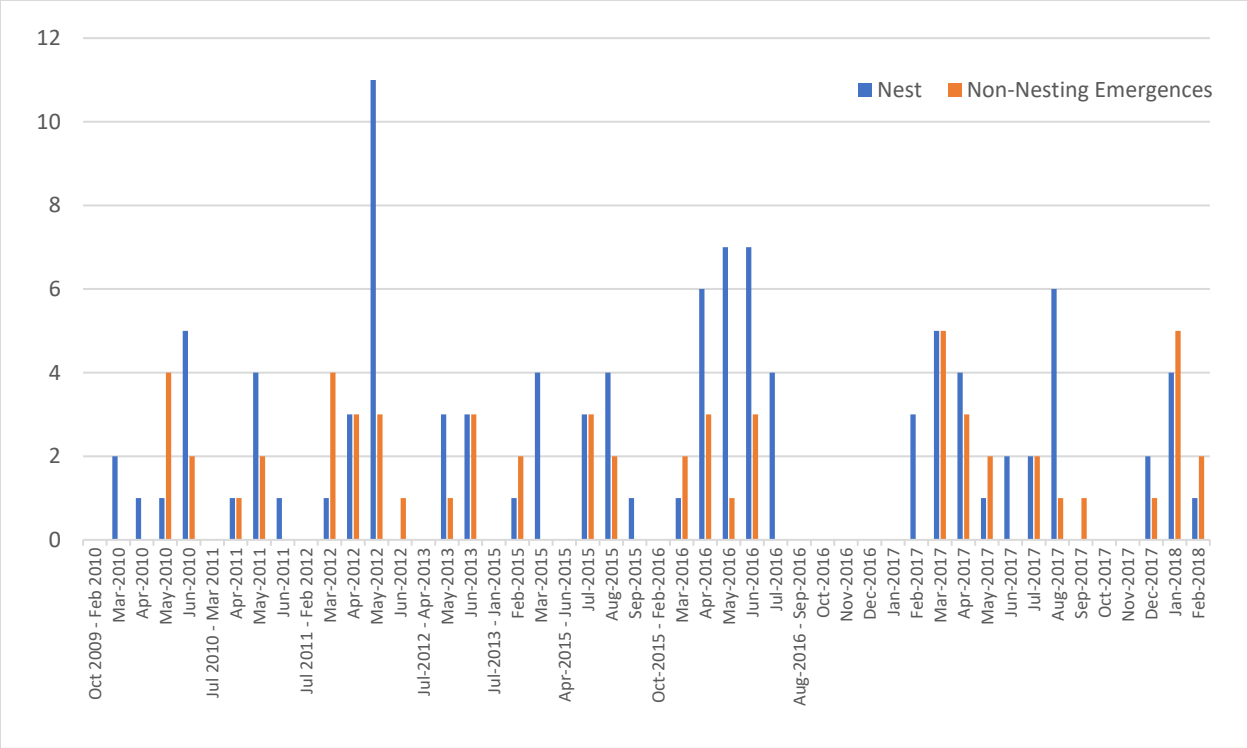


Figure 5-8. Green Sea Turtle Nest and Non-Nesting Emergences Recorded on NBG Main Base at Spanish Steps (October 2009–February 2018)

Source: Wenninger 2016b; NBG 2018.

Table 5-8. Sea Turtle Nests and Non-nesting Emergences Recorded on NBG Main Base Beaches (October 2009 – September 2016; September 2021 – June 2024)

Beach	*Nest*	*Non-Nesting Emergences*
Spanish Steps Beaches 1, 2, and 3	74; 105	40; 9
Dadi Beach	9; 3	2; 0
Gab Gab Beach	0; 0	1; 0
Family Beach	2; 0	0; 0
All other beaches: (including Sumay [alternatively known as Reserve Craft Beach], San Luis, Polaris Point, and Tipalao)	0; 0	0; 1
Total	**85; 108**	**43; 10**

Key: NBG = Naval Base Guam.
Source: Wenninger 2016b; DON 2023.

Sea turtle nesting surveys were conducted on NBG beaches from October 2022 and August 2023. A total of 28 nests (protected with wire mesh screening) and zero non-nesting emergences were observed (NAVFAC Marianas and NGB 2023). Out of all survey sites, turtle activity occurred solely at the Spanish Steps beach, and all activities were created by the green sea turtle; no evidence of hawksbill turtle activity was documented. Vegetation removal was also executed at the Spanish Steps in late February 2023 as invasive vines at the site can entangle female nesting turtles and impede hatchling emergence (NAVFAC Marianas and NGB 2023).

In 2014, National Oceanic and Atmospheric Administration (NOAA) and JRM entered into an Interagency agreement to address the data needs associated with marine turtles using DON lands. Over the succeeding 7 years, researchers conducted surveys to quantify sea turtle use in the area, and deployed satellite tags onto nine nesting green turtles. The four turtles tagged within Apra Harbor and the five tagged on the north coast remained in the vicinity of their nesting beach throughout their inter-nesting period, elucidating the overall core-use areas for these turtles (NOAA 2022). Post inter-nesting phase, eight of the females migrated to other islands in the Pacific. The remaining female stayed in Guam waters, migrating to the east side of the island after depositing her egg clutches on the west side of the island (at Spanish Steps, within Apra Harbor) (NOAA 2022).

Nest inventories were performed on 20 nests at Spanish Steps beach between June 28, 2017 and December 18, 2017 in cooperation with, and under the guidance of, USFWS-permitted Guam DAWR staff. Of the excavated nests, hatching success was 87.1%; however, most of these nests were preyed on by monitor lizards, causing a marked decrease in emergence success (83%). Self-releasing screens were placed over clutch locations to deter predators. Additionally, predator management at Spanish Steps is being adaptively managed in an effort to decrease predation on green sea turtle hatchlings.

Hawksbill Turtle

Hawksbill turtles are federal and Guam ESA-listed as endangered. They are known to use the nearshore waters of the Orote Peninsula and Outer Apra Harbor waters. The only known nesting of hawksbill turtles on NBG Main Base was recorded on a small beach within the Sumay inlet; however, nesting by hawksbill turtles has not been observed on NBG Main Base since 1995 (Commander Naval Forces Marianas [COMNAVMAR] 2001; DON 2009; Wenninger 2015).

Skinks and Geckos

Although suitable habitat for the federal and Guam ESA-listed skinks and geckos occurs on NBG Main Base, particularly on the Orote Peninsula, no federal ESA-listed skink or gecko has been recorded on the installation. The Slevin's skink (*Emoia slevini*) is federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. Though originally found in Guam, Slevin's skink has not been recorded in Guam since 1945 and is believed to be extirpated. It currently occurs only on Cocos Island (USFWS 2015b).

Surveys on the Orote Peninsula and Polaris Point in 2008 and 2009 did not detect any protected species (NAVFAC Pacific 2010a). As with the other Guam native species, the principal cause of decline of native skinks and geckos is believed to be predation by BTS. In addition, the introduced curious skink and marine toad (*Rhinella* [=*Bufo*] *marina*) are also known predators of native reptiles (Fritts and Rodda 1998; Christy et al. 2007). Vogt (2017) suggested that skinks may be less abundant on islands with shrews, and believes that shrews may be a factor in skink population decline. He further suggests that Guam's shrew population has been reduced due to BTS. Although not occurring on JRM-administered lands, it is worth noting the record of a capture of the Guam ESA-listed endangered moth skink (*Lipinia noctua*) on Cabras, just east of Dry Dock Island, which indicates the moth skink may occur on NBG Main Base (NAVFAC Pacific 2010a).

5.2.5.4 Invertebrates

Mariana Eight-spot Butterfly

The Mariana eight-spot butterfly (*Hypolimnas octocula marianensis*) is federal ESA-listed as endangered. In 1995, three adult Mariana eight-spot butterflies and four larvae were observed in the Spanish Steps area of Orote Point; larvae were observed on the host plant *Elatostema calcareum* (Schreiner and Nafus 1996) (see Figure 5-7). Rubinoff and Haines (2012) observed the host plant *E. calcareum* at Spanish Steps in

2012, and stated, "…we found abundant hostplant and eight different groups of nymphalid caterpillars on *Elatostema*. We are confident that these are eight-spot butterfly since they fit its description in every way, including the 'greasy' appearance, black head capsule and reddish spines. However, we strongly recommend that a rearing effort be made to distinguish the eight-spot from *Hypolimnas anomala* and to confirm that *H. anomala* does not occur on the two eight-spot hosts. Regardless, the Spanish Steps area is ungulate-free and represents excellent habitat for the eight-spot. This area represents a good population of host and butterfly." Subsequent targeted surveys of Orote Point in 2014 found "…15 blue moon (*Hypolimnas bolina*) larvae and numerous chrysalides were observed near large patches of *Procris pedunculata* and *E. calcareum*. More than 50 larvae of *H. bolina* were also observed at Orote Point and many of them occupying the host plants for the eight-spot. This is the first documented occurrence of *H. bolina* occupying *E. calcareum* or *P. pedunculata*. These and other larvae were identified using a combination of known species specific larval characteristics (head color) that are informative in larger larvae and confirmed by genetic analysis of larval molts found with them" (NAVFAC Marianas 2014a). Therefore, although eight-spot host plants are present, no eight-spot butterfly adults, larvae, or eggs were observed and it is very likely that the caterpillars observed by Rubinoff and Haines (2012) were actually *H. bolina*.

Tree Snails

The humped tree snail (*Partula gibba*) and the Guam tree snail (*Partula radiolata*) are federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. In 1920, humped tree snail and Guam tree snails were observed during surveys of the Orote Point area (Crampton 1925). In 1989, the Orote Point area was resurveyed and only Guam tree snails were observed (Hopper and Smith 1992). Surveys of NBG Main Base in 2014 failed to find either species within the Orote Point area or within two other areas of NBG Main Base (NAVFAC Marianas 2014a). The three reports do not provide a specific description or mapped location showing the boundaries of Orote Point area.

In 1998, Guam tree snails were observed at the Atantano Wetlands on coconut, pago, papaya, and a fern (*Polypodium punctatum*) (Dueñas and Associates 1998). The current status of this population is not known.

Two separate groups of Guam tree snails were observed within the area of the San Luis Ponds during surveys conducted in November 2011 (NAVFAC Pacific 2012a) (see Figure 5-7). The first group was observed in backstrand vegetation at San Luis Beach immediately west of the small western San Luis Pond. The population extended from the picnic pavilion west to the point where the backstrand vegetation and beach ends at a limestone cliff. The second smaller population of the tree snails was observed in a stand of *Barringtonia asiatica* trees located in limestone forest along the southern edge of the smaller western San Luis Pond. During 2014 moorhen surveys, Guam tree snails were again observed in this same strand of *B. asiatica* along the southern edge of the western San Luis Pond (NAVFAC Marianas 2014b) (see Figure 5-7).

In 1998, Guam tree snails were observed on coconut leaves in the "southwestern and northeastern sectors" of the Abo Cove wetland (Dueñas and Associates 1998). Exact locations within the Abo Cove wetlands were not provided. During surveys in October 2012, three separate populations of both Guam tree snails were observed in the Abo Cove wetlands during a reconnaissance study of the wetlands (NAVFAC Pacific 2013b) (see Figure 5-7). It is unknown whether these 1998 and 2013 observations were in the same area(s) of the Abo Cove wetlands. The current status of these populations is unknown.

5.2.5.5 Plants

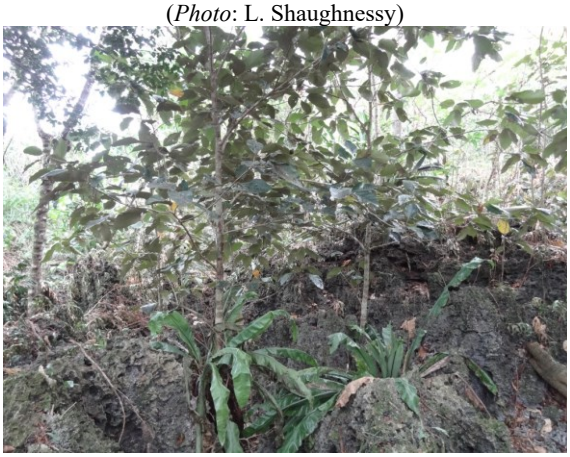
Of the 11 federal ESA-listed plant species that have the potential to occur on NBG Main Base (see Table 5-7), only three have known occurrences: *Cycas micronesica*, *Heritiera longipetiolata*, and *Tabernaemontana rotensis*. *C. micronesica* and *T. rotensis* are federal ESA-listed as threatened and Guam-designated as SOGCN. *H. longipetiolata* is federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. These three species were recorded during previous surveys targeting Guam ESA-listed endangered or Guam-designated as SOGCN species. As suitable habitat for the other federal ESA-listed plant species occurs on NBG Main Base within the cliffline and limestone forest areas of Orote Peninsula, nine listed species might be found there with sufficient survey effort: *Bulbophyllum guamense*, *Dendrobium guamense*, *Eugenia bryanii*, *Maesa walkeri*, *Nervilia jacksoniae*, *Psychotria malaspinae*, *Solanum guamense*, *Tinospora homosepala,* and *Tuberolabium guamense*.

Cycas micronesica

During surveys of the Orote Peninsula ERA and adjacent areas in 2009 and 2010, approximately 200 *C. micronesica* were recorded along the terrestrial portion of the ERA and the areas immediately inland (NAVFAC Marianas 2011a). *C. micronesica* plants were also observed to the southwest of the Orote Airfield during separate vegetation surveys in 2009 (NAVFAC Pacific 2010a) (see Figure 5-7). There has been widespread decline of *C. micronesica* populations in Guam due to the invasive cycad scale. The status of the *C. micronesica* population on Orote Peninsula is unknown, but JRM will be implementing forest enhancement projects in the future to benefit native species, such as *C. micronesica*. Additionally, as management tools become available, JRM will implement adaptive management actions to remove or control invasive insects, including feasible local controls of cycad scale.



Several *Cycas micronesica* of varying degrees of health have been observed during past surveys on Orote Peninsula.
(*Photo*: L. Shaughnessy)



One of a dozen *Heritiera longipetiolata* saplings near a large adult located southwest of the Orote Airfield.
(*Photo*: L. Shaughnessy)

Heritiera longipetiolata

Seven adult trees were recorded west of Kilo Wharf and east of Spanish Steps (BioSystems Analysis, Inc. 1989) and one individual was recorded just south of the San Luis Ponds. Based on survey data from 2005, numerous trees were recorded from Orote Island, Spanish Steps, the coastline between Kilo Wharf and Gab Gab Beach, and the area west of the San Luis Ponds (Williams 2007). During the surveys of the Orote Peninsula ERA and adjacent areas in 2009 and 2010, 16 large adult *H. longipetiolata* trees were recorded along the terrestrial portion of the ERA and the areas immediately inland. In addition, numerous younger *H. longipetiolata* trees were observed beneath the crown of each adult tree (NAVFAC Marianas 2011a). *H. longipetiolata* were also observed to the southwest of the Orote Airfield during separate vegetation surveys in 2009 (NAVFAC Pacific 2010a) (see Figure 5-7). During surveys in 2015, a single

H. longipetiolata tree was observed southwest of the Orote Airfield and had dozens of seedlings and saplings surrounding the adult tree (NAVFAC Marianas 2016a).

Tabernaemontana rotensis

The only record of *T. rotensis* on NBG Main Base is from a single individual southwest of the Orote Airfield (see Figure 5-7) (NAVFAC Pacific 2010a).

5.3 MARINE ENVIRONMENT

Refer to Section 5.1, *Current Operations and Land Use*, for an overview of Apra Harbor and a discussion of the assets and uses of Outer and Inner Apra Harbor. The marine information presented here is more detailed than for other parcels in JRM because more data are available for this area.

5.3.1 Joint Region Marianas-administered Submerged Lands

As specified in Chief of Naval Operations Instruction (OPNAVINST) 5090.1 , DON has a mandate to implement a program for the conservation of natural resources in nearshore areas (i.e., submerged lands) that are either titled to DON or are under DON access control. OPNAVINST 5090.1 and DoD Instruction (DoDI) 4715.03 (2011) define nearshore areas as those "waters and submerged lands adjoining the installation from the mean high water mark (i.e., the line on the shore established by the average of all high tides) to the boundaries of installation waterfront activities where DON controls access, and that are subject to the immediate authority of the Installation Commanding Officer or tenant command."

JRM-administered submerged lands extend 3 miles (4.8 kilometers) offshore from JRM terrestrial holdings in Guam (Figure 5-9). Therefore, submerged lands associated with NBG Main Base comprise approximately 30,867 acres (12,491 hectares), or one third of the total of JRM-administered submerged lands (85,364 acres [34,546 hectares]) in Guam, and approximately 16% of the total submerged lands surrounding Guam. The total shoreline length of Guam is approximately 150 miles (241 kilometers), with 25 miles (40 kilometers) of shoreline at NBG Main Base, or roughly 17% of Guam's shoreline.

Submerged lands at NBG Main Base were significantly altered during and immediately following World War II (WWII). During this period, dredging occurred in both Outer and Inner Harbor to support vessel movement and berthing. Large amounts of fill were used to construct port infrastructure, which covered reefs in areas on Inner Apra Harbor. Wetlands southeast of Inner Apra Harbor were also converted for agricultural use from the 1930s through the 1950s (NAVFAC Pacific 2015a). Today, maintenance dredging is performed as necessary in Inner Apra Harbor to maintain navigable depths.

The submerged lands at NBG Main Base cover a large area and a variety of habitat types. For this reason, and to better align management considerations, the description of the marine environment that follows for NBG Main Base is divided into the following geographical areas: Outer Harbor, Inner Harbor, Luminao/ Glass Breakwater, Orote Peninsula, Dadi, and the offshore environment (Figure 5-10). The Outer and Inner Harbor have received much more attention than locations outside the harbor, and there is much more detailed information available for Apra Harbor.

JRM-administered submerged lands include portions of Agat Bay, Orote Point, Apra Harbor, and Special Conservation Areas, including ERAs, Habitat Area of Particular Concern (HAPCs), and Marine Preserves, are summarized in Table 5-9. JRM-administered submerged lands at NBG Main Base are dually designated by Western Pacific Regional Fishery Management Council (WPRFMC) as Essential Fish Habitat (EFH) and includes Orote ERA and Jade Shoals which are identified as a HAPC. The northern portion of Sasa Bay and shallow marine areas in northern Outer Harbor near Cabras Island are owned and managed by GovGuam. The Sasa Bay Marine Preserve is a GovGuam-designated marine preserve. GovGuam owns and has management authority over the northern portion of Sasa Bay.

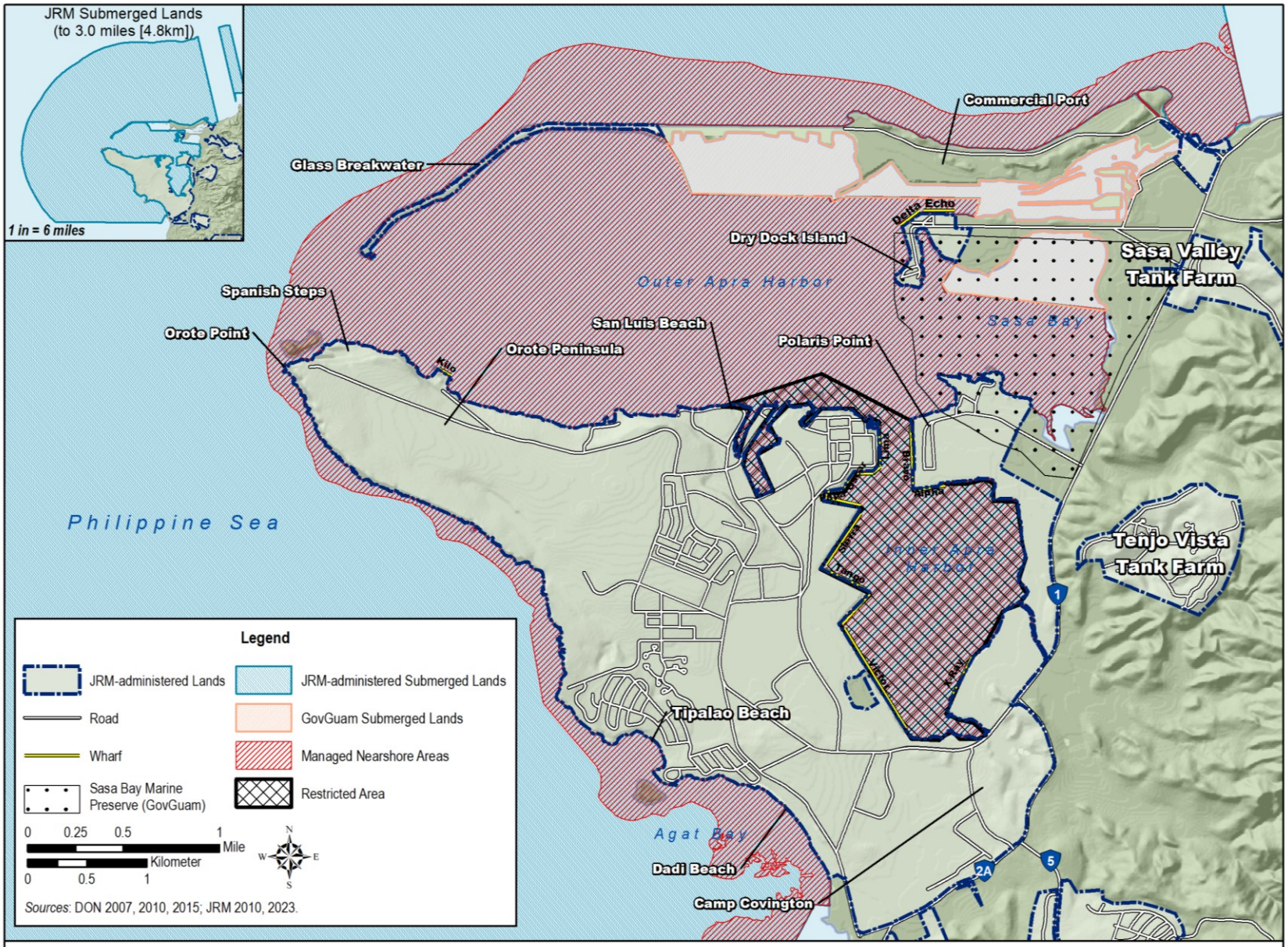


Figure 5-9
Submerged Lands Jurisdiction - Apra Harbor, Orote Peninsula, and Vicinity

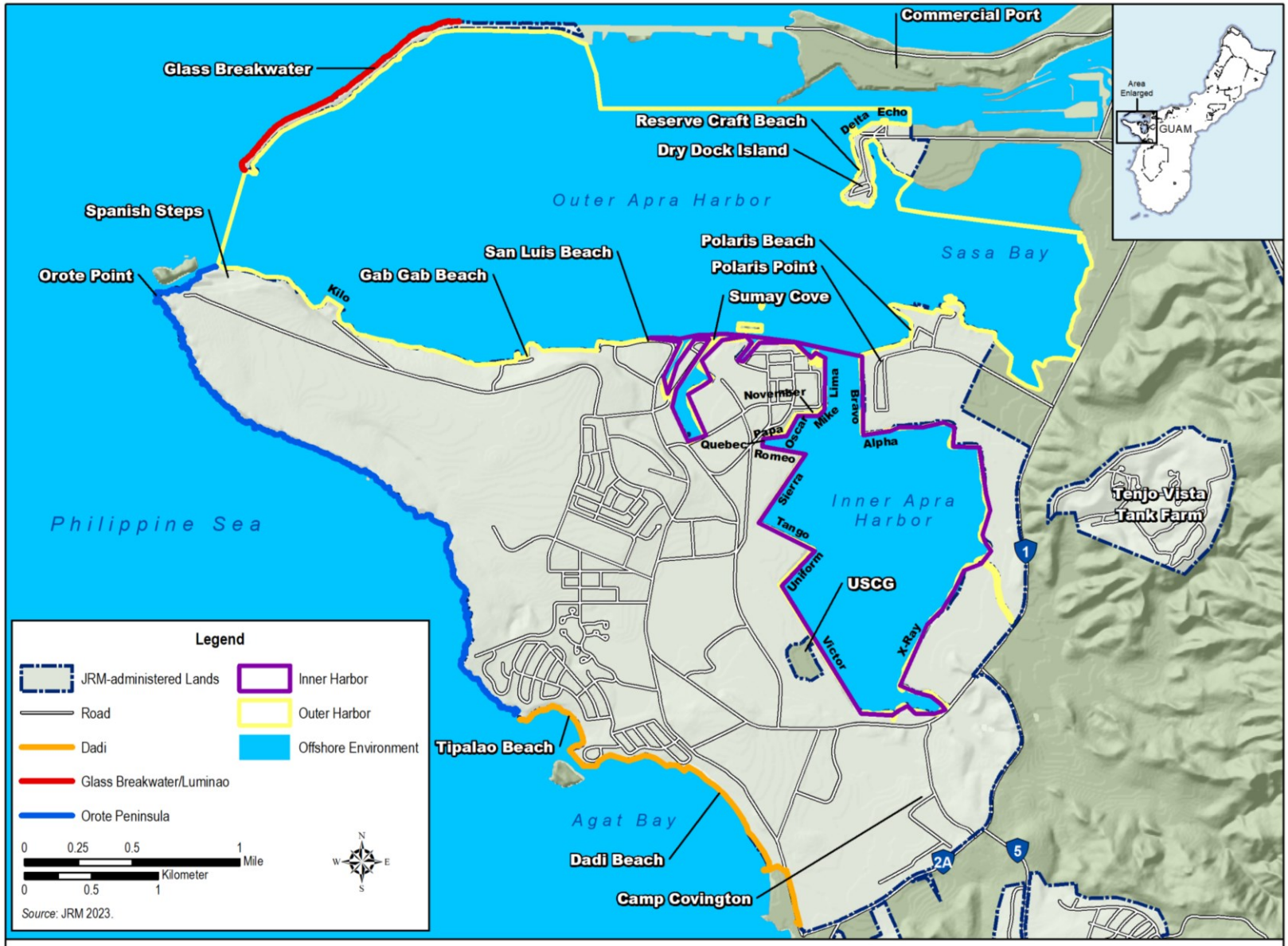


Figure 5-10
Marine Environments of NBG Main Base

Table 5-9. JRM-administered Submerged Lands of NBG Main Base

Installation (acres)	*Submerged Lands*	*DoD Designation*	*WPRFMC[(1)] Designation*
NBG Main Base (30,867)[(2)]	Outer Apra Harbor	--	Jade Shoals HAPC
	Inner Apra Harbor	--	--
	Sasa Bay	--	--
	Orote Peninsula	Orote Peninsula ERA	Orote Peninsula ERA HAPC

Notes: [(1)] Guam is also surrounded by WPRFMC EFH, which is dually designated on all JRM-administered submerged lands which extend 3 miles (4.8 kilometers) seaward from the coastline.
[(2)] The total includes 917 acres (371 hectares) of JRM-administered submerged lands offshore of Asan Bay (refer to Figure 4-9). These 917 acres (371 hectares) are not considered for proposed management actions addressed in this INRMP.

Key: DoD = Department of Defense; EFH = Essential Fish Habitat; ERA = Ecological Reserve Area; NBG = Naval Base Guam; HAPC = Habitat Area of Particular Concern; JRM = Joint Region Marianas; WPRFMC = Western Pacific Regional Fishery Management Council.

Source: JRM 2019.

5.3.2 Physical Environment

The Apra Harbor Watershed is discharged to the ocean from four main rivers with a drainage area of 13.65 square miles (35.35 square kilometers). The quantity, condition, and characteristics of these rivers and associated watersheds can lead to severe drainage and/or surface erosion problems in times of heavy precipitation (NAVFAC Pacific 1993). The Apra Harbor Watershed, which includes the subwatersheds of Sasa and Atantano, delivers freshwater inputs into the NBG Main Base marine environment on the eastern side of Inner Harbor and Sasa Bay (see Figure 5-4). In Guam, with the exception of river outfalls, all sediment is produced by marine organisms (Matson 2005). Coralline marine animals are a significant contributor to sediment in locations such as Apra Harbor (Adey and MacIntyre 1973). As a result of weak circulation and substantial sediment transport into the marine environment from the watershed, turbidity throughout the harbor is higher than outside the harbor. However, harbor turbidity is variable, ranging from clear conditions on the western extent near the mouth to highly turbid conditions in Sasa Bay (NAVFAC Pacific 2015b).

5.3.3 Outer Apra Harbor Marine Environment

5.3.3.1 Bathymetry and Currents

Outer Apra Harbor is bathymetrically complex with depths ranging from just a few feet deep on the top of shoals to greater than 150 feet (45 meters) in shallow bays. Outer Apra Harbor is a sunlit basin that generally increases in depth from Sasa Bay in the east to its greatest depths near the Outer Apra Harbor entrance to the west (Figure 5-11). A large number of pinnacles and shoals covered with coral and macroalgae rise from the depths of the basin. There are larger and more numerous bathymetric features in the southeastern Outer Harbor than toward the mouth of the harbor.

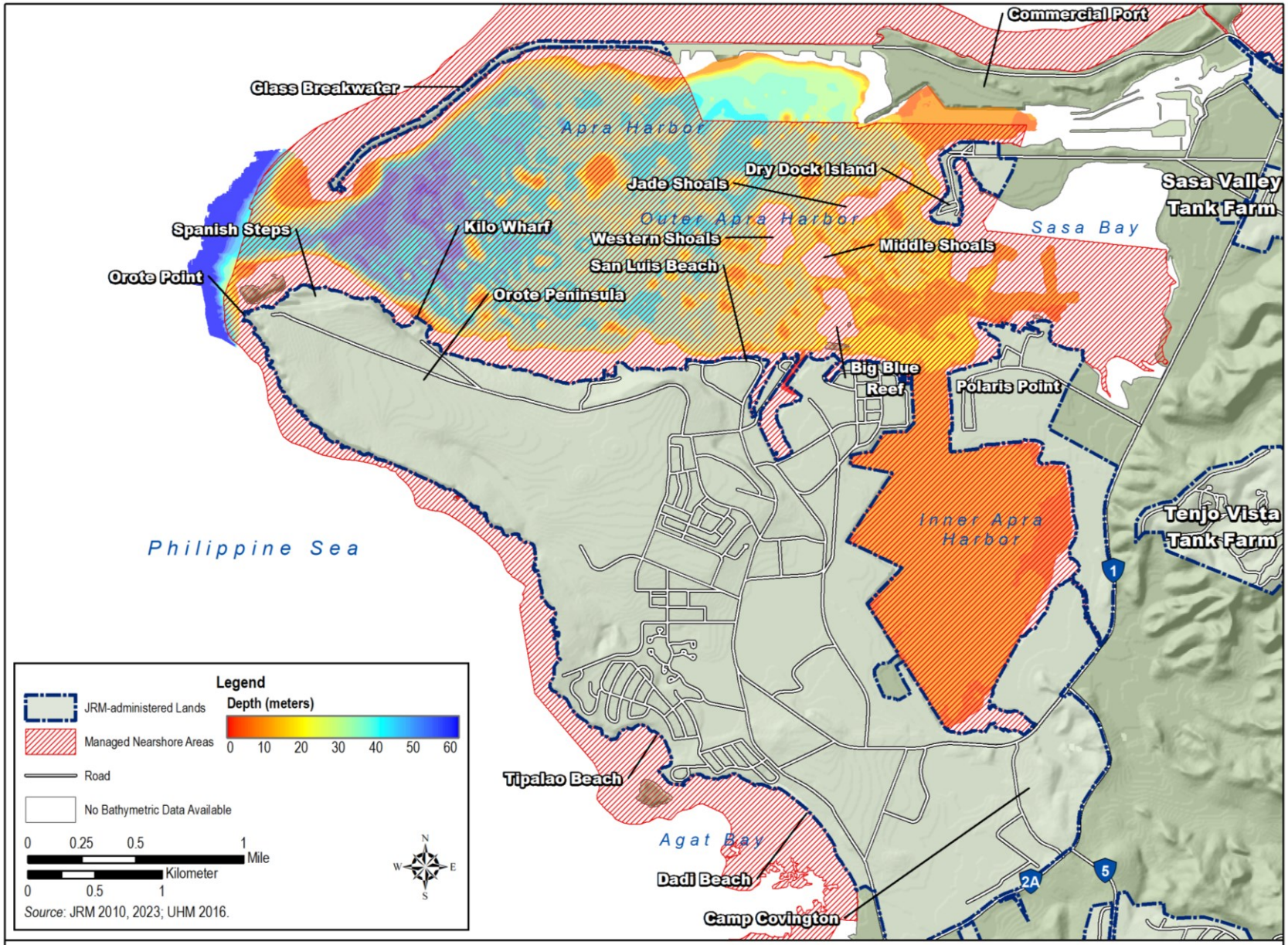


Figure 5-11
General Bathymetry of Apra Harbor and Inner Apra Harbor

Outer Apra Harbor has been altered, although not as drastically as Inner Apra Harbor. The tops of some pinnacles or shoals were removed or used for anchoring by Japanese and American forces during WWII and the turning basin on Inner Apra Harbor entrance channel was dredged during or soon after WWII. Areas that had previously been large reef flats at San Luis Shores, the Ship Repair Facility, and Polaris Point were filled in. The Drydock Island Peninsula was also created by a landfill process. Despite the alterations associated with WWII, much of the substrate is still bathymetrically complex and coral reef resources are exceptionally abundant (Smith et al. 2013; NAVFAC Pacific 2015c). Figure 5-11 depicts the general bathymetry of present day Apra Harbor.

Outer Apra Harbor was originally open on the north side. The construction of the Glass Breakwater to protect the harbor soon after the end of WWII reduced the water circulation and changed the harbor from a location subject to large waves to a relatively calm anchorage (Hammer 1947; Gailani et al. 2016). Currents within Apra Harbor are generally weak to moderate and have a circulation pattern that includes numerous clockwise eddies (Figure 5-12). Currents in the harbor are driven by tides and winds (Gailani et al. 2011). Outer Apra Harbor tidal currents can be about 0.2 to 0.3 knots (0.4 to 0.6 kilometers per hour). At Outer Apra Harbor entrance, speeds can be greater, with max flood speed of 1.5 knots (2.8 kilometers per hour), and max ebb up to 3 knots (5.6 kilometers per hour) (Smith et al. 2013). Typical bottom tidal currents are less than 0.16 feet per second (5 centimeters per second) (Gailani et al. 2011). Storm eddies may form in the harbor with both clockwise and counter-clockwise rotations and speeds of up to 1.5 knots (2.8 kilometers per hour) (Smith et al. 2013).

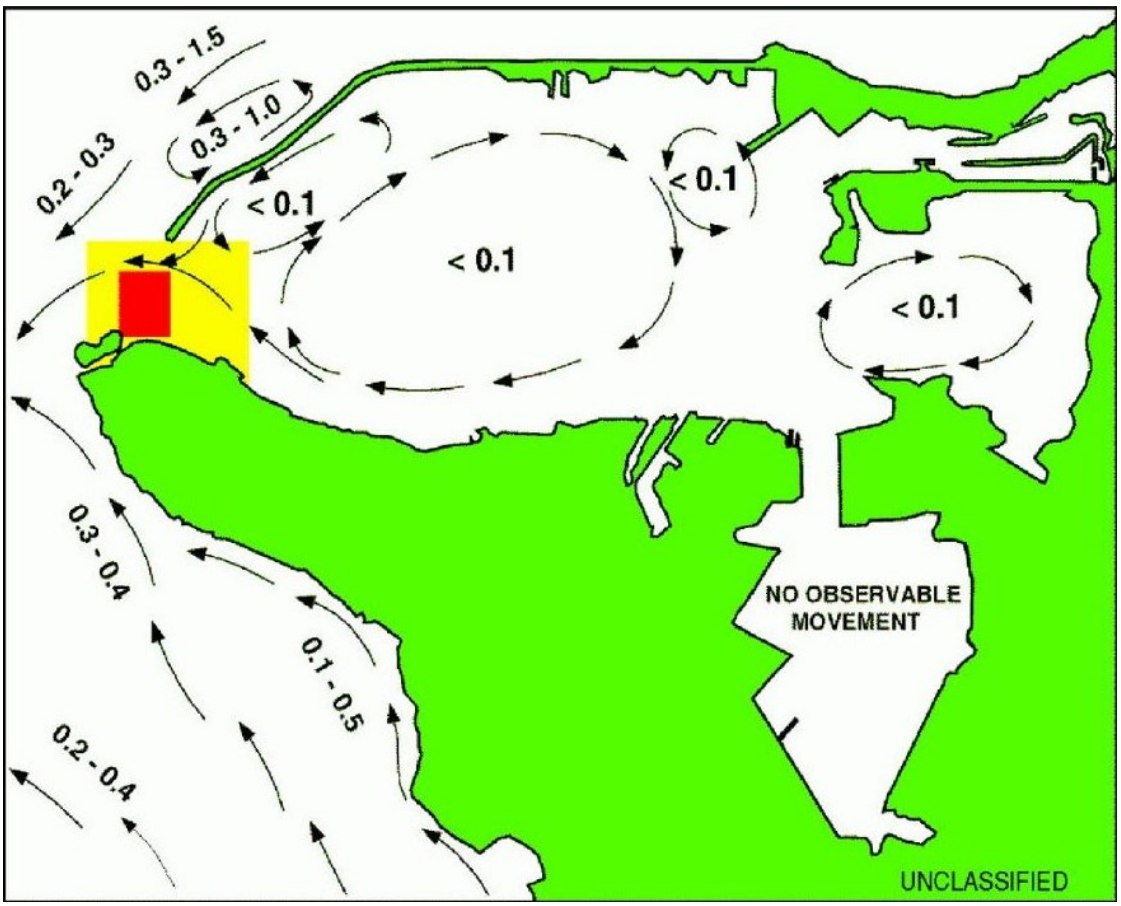


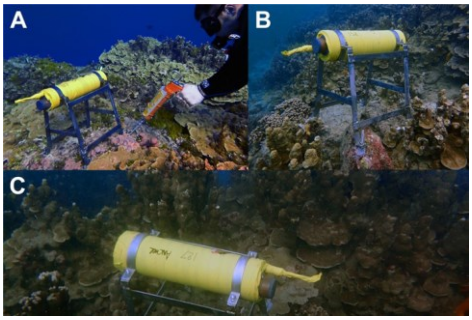
Figure 5-12. General Circulation of Outer Apra Harbor and Inner Apra Harbor

Notes: Red area indicates where eddies have been reported, yellow area indicates where tides cause current speeds to vary to a degree significantly affecting vessel navigation. Current speed is in knots. From Smith et al. 2013.

Current flow is not uniform with depth in Apra Harbor, and it changes with time. Naval oceanographic data shows that generally there is a surface current, a middle layer of higher variability, and a lower reverse layer. However, Apra Harbor is a low energy environment, and physical forcing from variable currents in the water column is low (Smith et al. 2013). A 2010 study by Sea Engineering and University of Guam (UOG) near Kilo Wharf found that currents were predominantly wind-driven, and occurred as a two-layer system. The surface layer flowed in the direction of the wind, and the deeper layer flowed in the opposite direction. The surface is defined by the upper 33 feet (10 meters), mid-depth is between 33 and 66 feet (10 to 20 meters), and bottom is below 66 feet (20 meters). During typical trade wind conditions, surface flow was to the west out of the harbor, while deeper flow was directed to the east, into the harbor. West wind conditions occurring in early October produced the opposite circulation pattern – surface flow to the east and deeper return flow to the west. Tide effects were small and acted by increasing the layer flow thickness in the ebb or flood direction. Currents in the vicinity of Kilo Wharf were found to be normally weak. During prevailing trade wind conditions, surface currents were typically 0.9 to 1.9 feet per second (0.3 to 0.6 centimeters per second) while bottom layer currents were typically less than 0.7 feet per second (0.2 centimeters per second) (Sea Engineering 2010).

5.3.3.2 Turbidity and Water Quality

The Apra Harbor Watershed, which includes the subwatersheds of Sasa and Atantano, delivers freshwater inputs into the NBG Main Base marine environment at the eastern side of Inner Apra Harbor and Sasa Bay (see Figure 5-4). Inner Apra Harbor drains into Outer Apra Harbor through the opening at Polaris Point.



SeaFET pH sensors mounted on custom-made stainless steel frames deployed in Apra Harbor: A. Orote Point; B. Middle Shoals; C. Anchor Reef
(*Source*: Schils et al. 2017)

Water quality sensors were deployed by Schils et al. (2017) at three locations from December 2014 to September 2016, to measure temperature, dissolved oxygen, potential of hydrogen, salinity/conductivity, chlorophyll, and turbidity (sensor locations marked on Figure 5-13): location N02 is Anchor Reef, a patch reef north of Polaris Point; location N06 is Middle Shoals, a patch reef; location N10 is Orote Point, a fringing reef. Schils et al. (2017) found that episodes of heavy rainfall lowered salinity levels for all three monitoring sites. Salinity levels at Anchor Reef, which is close to the mouth of Sasa Bay, were the most variable of the three monitoring sites and the recorded salinity minima correspond to tropical storm activity. Surface seawater temperatures on Outer Apra Harbor are typically 79–86 degrees Fahrenheit (°F) (26–30 degrees Celsius [°C]) (Smith et al. 2013). Temperature fluctuations are more pronounced at the eastern stations compared to those toward the mouth of the harbor.

Recorded potential of hydrogen values at Anchor Reef were lower (more acidic) than those at Orote Point. Both sites showed lowered potential of hydrogen values for the wet season than other times of the year. Continued or expanded monitoring of water properties is an important opportunity to collect data that will allow JRM to understand the marine environment and its dynamic patterns in Apra Harbor. In particular, measuring potential of hydrogen across time will allow DON to frame the acidity of Apra Harbor within the larger context of regional and global ocean acidification. Adding measurements of nutrient levels in the water could be useful since water quality is linked to coral reef health (Humphrey et al. 2008; Fabricius 2009; Redding et al. 2013), and a broader understanding of water quality in Apra Harbor inform management decisions.

In support of the Pacific Reef Assessment and Monitoring Program (Pacific RAMP), Brainard et al. (2012) conducted conductivity, temperature, and depth (CTD) casts in nearshore waters, including those along the

Orote ERA. The program was named Marianas Archipelago Reef Assessment and Monitoring Program (MARAMP) through 2012 and is now named the Pacific RAMP. In 2005 and 2007, optical refraction (i.e., turbidity) and nutrients were also measured, and CTD casts included locations in Apra Harbor. Compared to nearshore waters of the Orote ERA, temperature and salinity were higher in the harbor, while density was lower. Turbidity levels were measured through beam transmission attenuation, and Apra Harbor had the lowest transmission values of anywhere on the island. Compared to conditions around the rest of Guam, nutrient values (i.e., phosphate, chlorophyll, nitrite, and silicate) were higher inside Apra Harbor.

5.3.3.3 Marine Habitats

In 2005, National Oceanic and Atmospheric Administration's (NOAA's) National Centers for Coastal Ocean Science (NCCOS) developed habitat maps from aerial photography and prepared the Guam Coastal Atlas (NOAA NCCOS 2005) (Figure 5-13); however, these habitat maps are depth-limited. Acoustic imaging was collected by the NOAA's Pacific Islands Benthic Habitat Mapping Center (2012) and a series of benthic maps were generated that describe slope, substrate type, and rugosity (roughness). This mapping effort is a reasonable characterization of hard and soft substrate in Apra Harbor, but more detailed habitat mapping is required to understand the diversity, distribution, and fine structure of the benthic habitat in Apra Harbor (Figure 5-13).

In the past two decades, there have been broad scale resource inventories (Paulay et al. 1997, 2001, 2002), investigations into baseline conditions of Outer Apra Harbor (Raymundo et al. 2016; Schils et al. 2017), and resource assessments to support specific infrastructure improvement projects (i.e., military construction [MILCON] projects). A notable resource assessment was obtained to support environmental compliance for the Kilo Wharf Improvement Project (Schils et al. 2011). Numerous marine resource assessments were conducted to support a potential aircraft carrier pier construction for the Guam Military Relocation Environmental Impact Statement (EIS)/Overseas EIS (OEIS) (Dollar et al. 2009; Minton et al. 2009; NAVFAC Pacific 2011a; McManus and McManus 2012). Smith et al. (2013) provide a broad synthesis of marine resources in Apra Harbor. Relevant information from these sources is described in more detail below.

Data derived from all of the surveys, monitoring, and studies comprise the most comprehensive body of knowledge available on the status of marine resources in Apra Harbor, and are the most important supporting information for this section. Even with a sizeable array of information, gaps exist, and the Integrated Natural Resources Management Plan (INRMP) presents a tool for filling the gap needed to better manage the marine resources at NBG Main Base.

5.3.3.3.1 Bottom Habitat

Outer Apra Harbor is unique within the Mariana Islands and consequently has atypical benthic characteristics since there are no other harbors that are comparable in scale or structure in Guam or in the Marianas. Various types of coral reefs are found throughout Apra Harbor, but the type, distribution, and community composition is substantially different between Outer Apra Harbor and Inner Apra Harbor or reefs on the open coast of Guam. The differences are due to a number of factors that include substrate availability, depth, and water quality (e.g., sediment input, flushing rates, and circulation). Shallow water coral reef habitats on Outer Apra Harbor occur as fringing reefs, shoals, pinnacles, and as colonized artificial structures along the perimeter of Outer Apra Harbor. The bathymetry of southern Outer Apra Harbor is complex with pinnacles or shoals rising from the bottom. Shallow reef flats that support corals occur in Sasa Bay, San Luis, Gab Gab, and Spanish Steps. The combination of pinnacles, shoals, and deep water habitats can be characterized as a matrix of colonized patch reefs surrounded by soft bottom habitats (Figure 5-13).

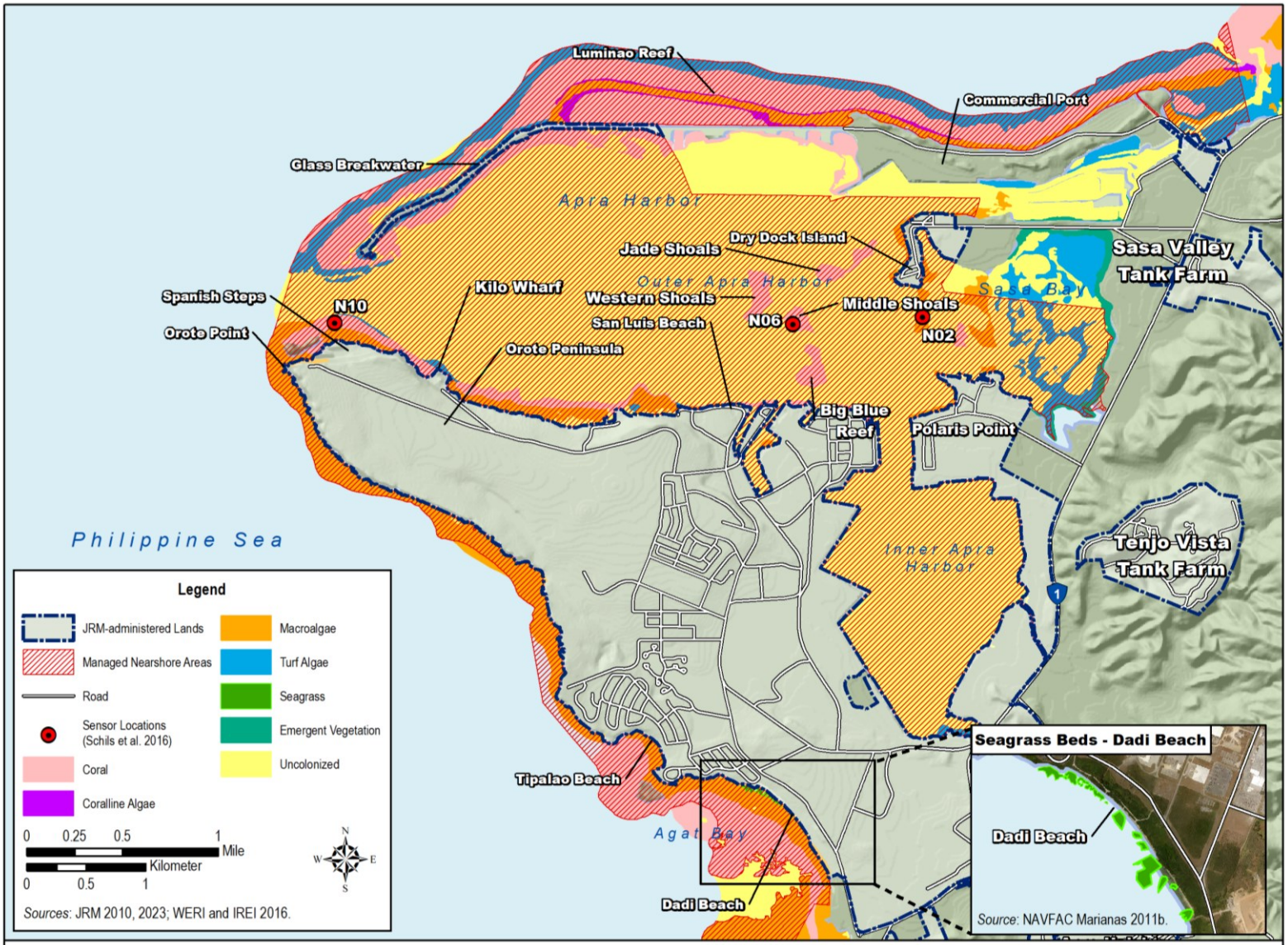


Figure 5-13
Benthic Habitats - Apra Harbor and Inner Apra Harbor

5.3.3.3.2 Soft Bottom – Sediment Contamination

Beginning soon after the end of WWII, commercial activities and NBG Main Base operations and maintenance released some chemicals in sediments that are now regulated by the U.S. Environmental Protection Agency (USEPA). Effects Range-Low (ER-L) and Effects Range-Median (ER-M) are measures of toxicity in marine sediment and are used by public agencies in the U.S. in deriving screening benchmarks for evaluating toxicity hazards, in particular from trace metals or organic chemicals. An ER-L is a "concentration below which effects are rarely observed or predicted among sensitive life stages and species of biota…" (U.S. Geological Survey [USGS] 2018). An ER-M is a "concentration above which effects are frequently or always observed among most species of biota…" (USGS 1998). The effects range values assist in evaluating the potential significance of elevated sediment concentrations, in conjunction with biological analyses. Therefore, in accordance with the Ocean Testing Manual (USEPA and U.S. Army Corps of Engineers [USACE] 1991) and/or Inland Testing Manual (USEPA and USACE 1998), one of the first steps in determining whether dredged material is suitable for ocean disposal and/or upland placement is to compare sediment concentrations against the ER-L or ER-M values. When an ER-L or ER-M is not available, sediment concentrations are compared to the laboratory analysis limits. In addition, Guam Environmental Protection Agency (Guam EPA) Phase III Report for Management of Contaminated Harbor Sediments (2000) outlines requirements and best management practices (BMPs) for handling dredging and dredge spoils which, in conjunction with federal requirements, are determined for each project through the permitting process.

In a 2006 sediment study (NAVFAC Pacific 2006), Aroclor-1260 was detected at a low level in Outer Apra Harbor sediment adjacent to the Ship Repair Facility, and tributyltin was detected at low levels in sediment of the channel connecting Inner and Outer Apra Harbor. Other contaminants, such as polychlorinated biphenyls (PCBs) (both individual congeners and other aroclors), chlorinated pesticides, organo-tins, phenols, and phthalates were either not detected or were estimated at concentrations below their respective reporting limits in sediment samples. In all areas, oil and grease and total recoverable petroleum hydrocarbons were below detection limits. Metals that have exceeded the ER-L but not ER-M levels have only been measured in front of Polaris Point. The most common metal to exceed ER-L is nickel. However, the 2006 sediment study reported that it "…is common for nickel to be found at concentrations greater than the ER-M in material determined to be suitable for ocean disposal."

In 2009, an additional sediment coring study was performed in the turning basin, directly in front of Polaris Point, and directly in front of the Ship Repair Facility (NAVFAC Pacific 2010b). For the majority of analytes, concentrations were either not detected or lower than ER-L values. Only three metals (copper, lead, and mercury), two polyaromatic hydrocarbon compounds (acenapthene and fluorine), four organochlorine pesticides (4,4'-Dichlorodiphenyltrichloroethane [DDT], total detectable chlordane, and total detectable DDTs), and total detectable PCBs exceeded ER-Ls in any of the samples. There were only two occurrences of a single analyte exceeding the ER-M value (4,4'-DDT).

The suitability of dredged material for ocean disposal and/or upland placement is determined in conjunction with biological evaluations. The Guam Coastal Management Program sampled marine organisms (e.g., soft corals, sponges, bony fishes, octopuses) in Guam harbors during a Harbor Sediments Project. From 1998 to 1999, a total of 156 samples of organisms were collected at the various harbors throughout Guam, including Outer Apra Harbor, and were examined for marine food chain contamination related to harbor sediment contamination. Mild increases in arsenic, copper, lead, mercury, tin, and PCBs were recorded in some organisms sampled at localized sites, mostly in Apra Harbor. Levels of contaminants in edible parts of organisms that are consumed were not significant or indicative of real health risks, except for copper and

zinc in oysters in Apra Harbor and Agana Boat Basin and arsenic in the Apra Harbor octopus. This study showed that Guam's harbor environment (excluding Inner Apra Harbor, which was not sampled) are generally clean. The study concluded that physical contact with sediment contaminants, at the levels observed, would not pose a notable health risk and the highest value of PCB's recorded from Guam samples was an order of magnitude below the U.S. Food and Drug Administration's food standard (Guam EPA 2000).

As supported by the conclusion of the 2009 sediment study (NAVFAC Pacific 2010b), results indicate that although some ER-L exceedances were observed for various trace metals and trace organics and ER-M exceedances were observed for one chlorinated pesticide, it is likely if sediments from the proposed Polaris Point or Ship Repair Facility Wharf dredge footprints were evaluated according to guidance outlined in the Ocean Testing Manual (USEPA and USACE 1991) and/or Inland Testing Manual (USEPA and USACE 1998) they would be deemed suitable for ocean disposal or upland placement, assuming a practicable beneficial use option was not available.

For safety reasons, harvest or collection of mollusks (e.g., octopuses, squid, clams, snails), crustaceans (e.g., lobsters, crabs), or echinoderms (e.g., sea cucumber, urchins) is not permitted on JRM-administered submerged lands at NBG Main Base. Figure 5-14 illustrates the designated fishing advisory area for JRM-administered submerged lands at NBG Main Base.

5.3.3.3.3 Coastal Habitat

The northern extent of Outer Apra Harbor is bound by the man-made Glass Breakwater, and has a limited amount of reclaimed sandy/rocky coastal habitat. However, the northern shoreline of Orote Peninsula, or the southern extent of Outer Harbor, has a much more natural sandy/rocky coastline. Along San Luis Shores and Polaris Point, there are remnant sheet pile walls that are decaying and the rock that was used as fill material forms the current rocky shoreline that sits on what was historically reef flat. The shoreline of Sumay Cove and Clipper Channel are primarily bordered by man-made structures. At the end of Sumay Cove, across from the Morale, Welfare and Recreation (MWR) facility, is a plot of land that was previously a filled wetland that has become overgrown with invasive plants. It is a candidate location for restoration projects, such as mangrove establishment. Significant mangrove forest habitats and reef flat are also found in Sasa Bay (AECOS, Inc. and Wil Chee Planning, Inc. 2009; NAVFAC Pacific 2015a). There is a healthy and flourishing mangrove community comprised of five mangrove species. The wetland adjacent to the east of the Sasa Bay is less extensive and supports fewer mangroves than the wetlands in the Atantano River Sub-watershed (NAVFAC Pacific 2015d).

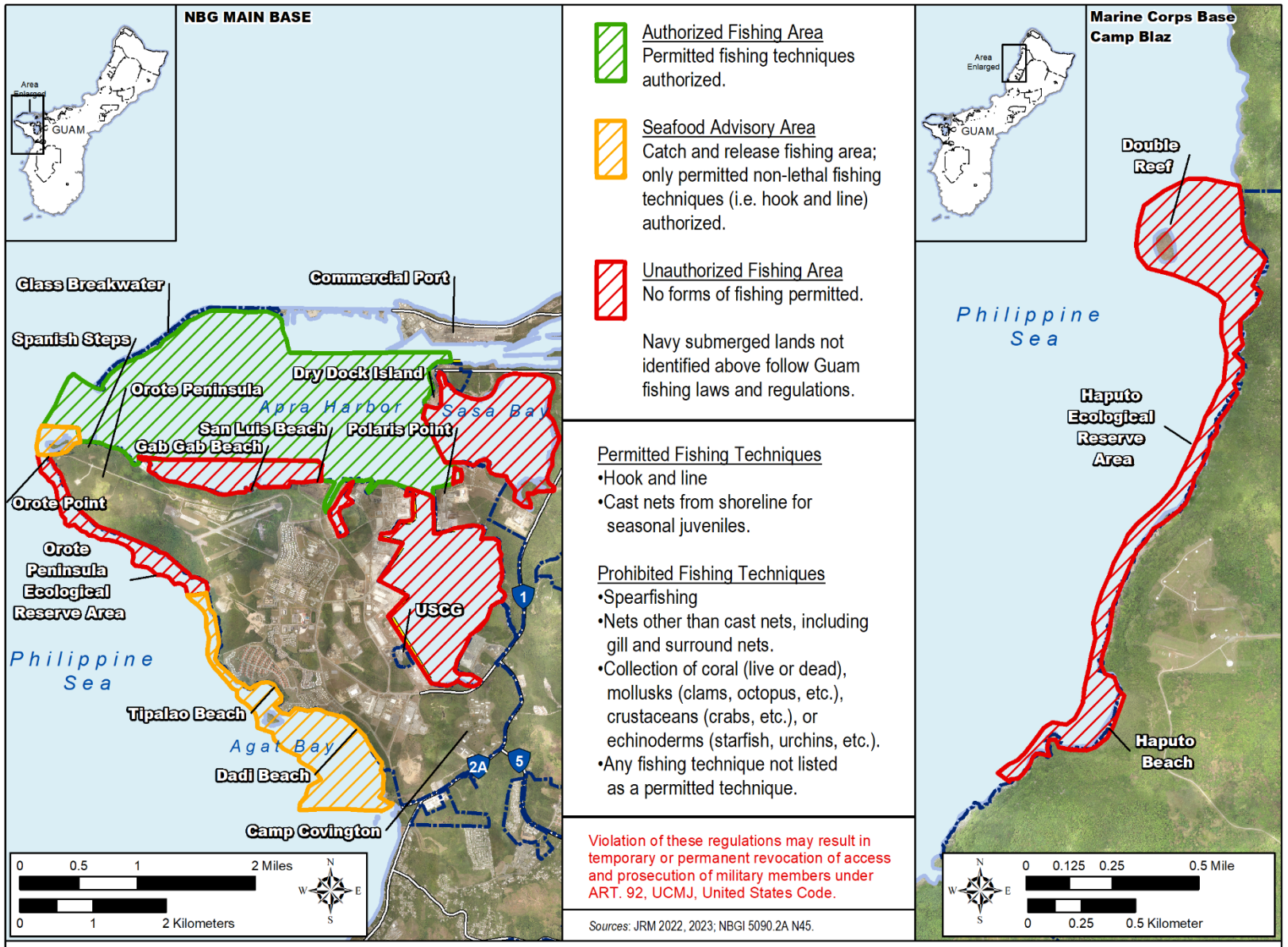


Figure 5-14
Fishing Areas with Specific Regulations near JRM-administered Submerged Lands on NBG Main Base

5.3.3.4 Marine Flora



Macroalgae habitat in Apra Harbor dominated by *Halimeda* spp. Several former patch reefs became *Halimeda* bioherms after the upper patch reef was dredged.
(*Photo*: D. Snyder)

Native Species

The diverse shallow water habitats of Apra Harbor were surveyed in 2010 in support of a proposed turning basin and wharf for an aircraft carrier (NAVFAC Pacific 2011a). Algae cover is a depth dependent phenomenon. Macroalgal cover on Outer Harbor shallow reef flats averaged 25%, but ranged from 3% to 68%. It was dominated by *Padina* sp., *Dictyota* sp., and *Halimeda opuntia*. On reef slopes, it averaged 16% on outward facing slopes, and 20% on inward facing slopes, varying among slope transects from 1% to 43%. Species on these slopes were often *Raflesia* sp., *Caulerpa verticillata*, and *Lobophora* sp. in higher-energy areas, and *Padina* sp., *Halimeda opuntia*, and *Halimeda* sp. in lower energy areas. Shallow rubble areas had less than 5% algal cover in species including *Dictyota* sp. and *Padina* sp. Reef flats and slopes in deep areas both tended to average approximately 40% in algal cover, dominated by species including *Dictyopteris repens* and *Caulerpa sertularioides*. Pinnacles averaged 43% algal cover, characterized by species such as *Caulerpa verticillata* and *Dictyopteris repens*.

Smith (2004) reported macroalgal cover near Kilo Wharf to be low, although in one area *Padina* sp. and *Halimeda* sp. were found to occur at 23% and 14% of the point-intercepts, respectively. Schils et al. (2011) surveyed the benthic community on the fringing reef (referred to as reef terrace) in the vicinity of Kilo Wharf (see Figure 5-13) at three depths. Macroalgal cover was highly variable throughout their study area, but green and red algae are prevalent. This dataset was focused on detecting changes as a result of in-water construction, thus indicator taxa were developed through statistical analysis of the community composition. Schils et al. (2011) reported no change in brown algae diversity after the construction, an increase in green algae from 9 to 13 taxa, and a similar increase in red algae from 7 to 15 after the construction.

A review by Bruno et al. (2014) suggests that macroalgae cover, classified as seaweed, on relatively pristine coral reefs on Pacific Islands could be as high as 22%. Macroalgae growth is strongly controlled by nutrient input and by herbivore grazing (Bruno et al. 2014). Outer Apra Harbor has greater nutrient input than most pristine reefs, and the herbivorous fish population is dramatically reduced. Given these conditions, Outer Apra Harbor has much less macroalgae than would be expected (Bruno et al. 2014).

Seagrass beds are not an extensive habitat in Apra Harbor. Only a limited amount of seagrass, *Halophila* sp. (possibly *Halophila japonica*), has been found in very low abundances on some deep flat and slope sites on Outer Apra Harbor (covering less than 0.5% of the substrate) (NAVFAC Pacific 2011b). Seagrass beds are considered EFH and are also designated as special aquatic sites under the CWA.

Non-native and Nuisance Species

The definitions of non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine flora in Guam are presented in Section 4.5.3, *Marine Flora*.

There are not yet reports of non-native or invasive marine flora on Outer Harbor. A nuisance marine species is native, but occasionally exhibits blooms or outbreaks or other undesirable characteristics. The green angel

hair algae (*Chaetomorpha* sp.) is a nuisance species that could occur in Outer Harbor based on its occurrence around Luminao, just outside Apra Harbor (Schils 2015).

5.3.3.5 Marine Invertebrates

Native Species

Paulay et al. (1997) reported on the results of an extensive study of species diversity within Apra Harbor. Using an informal sampling procedure, they found 60 species of sponges, 72 species of echinoderms, and 39 species of ascidians. Approximately 80% of the sponges, 18% of the echinoderms, and 72% of the ascidians were not found in Guam outside of Apra Harbor, an indication of the harbor's importance to Guam's overall biodiversity. The team additionally recorded 511 other invertebrate species, including 67 species of scleractinian corals and 34 species of non-scleractinian corals or anemones (gorgonians, soft corals, sea anemones and similar species in the groups Octocorallia, Actiniaria, Ceriantharia, Antipatharia, and Corallimorpharia). They found that particularly diverse habitats included the central shoals and mounds, the Sasa Bay mangrove, and the mooring and navigational buoys, the latter of which supported considerable flora and fauna. However, many of the species found on the buoys and not found elsewhere around Guam were believed to be non-native species.

Smith et al. (2013) provide a broad summary of marine resources of Apra Harbor. However, because coral reef habitats in Apra Harbor are highly diverse and Apra Harbor has unique characteristics relative to typical fringing reef formations in Guam, diversity and abundance of invertebrate communities varies greatly. Adequate quantitative evaluations of benthic invertebrate communities need to be based on like strata in order to be comparable. This concept had been unevenly applied throughout major recent assessment efforts, which include surveys conducted to support the 2010 EIS/OEIS for the U.S. Marine Corps (USMC) relocation from Okinawa to Guam and the Commonwealth of the Northern Mariana Islands (CNMI), and the Kilo Wharf expansion. However, a more consistent and spatially explicit approach to monitoring was conducted by UOG from 2014–2016 (Schils et al. 2017). Transects at NBG Main Base and Andersen AFB were established at a consistent depth. Utilizing these sites and establishing new ones is being targeted in future INRMP projects (see Section 5.4.2.1, *Marine Habitat Management*). These efforts have the potential to compliment both island- and region-wide monitoring as well as helping with targeting bleaching and reef stressors such as disease, invasive species, and crown-of-thorns seastar (COTS) (*Acanthaster planci*).

Benthic surveys were conducted extensively in the proposed aircraft carrier turning basin in the southeast portion of Apra Harbor by multiple groups, including Smith (2007), Dollar et al. (2009), Minton et al. (2009), and HDR (NAVFAC Pacific 2011a). Both Smith (2007) and Dollar et al. (2009) used *in situ* and photographic data sampling methods. However, Minton et al. (2009) showed an underestimate when sampling planar imagery. As a result, researchers worked collaboratively with regulatory agencies to develop an acceptable assessment approach, measuring 11 variables (NAVFAC Pacific 2011a). Using the refined assessment approach, sites previously evaluated by Dollar et al. (2009) were resurveyed adhering to methods comparable to Minton et al. (2009), and added additional sites for newly defined strata (NAVFAC Pacific 2011a). This effort identified 92 species of coral, none of which are ESA-listed. *Porites rus* and *Porites horizontalata* were the most abundant, together accounting for 66.5% of the observed colonies. Higher colony densities were found on the higher-energy, outward facing reef slopes. All other coral species were sporadically distributed. Stony coral cover across all transects averaged 14.5%. Of the 37 sponge taxa identified, the most common were *Clathria eurypa, Stylinos ruetzleri, Iotrochota ditrochota, Xestospongia carbornaria, Stylissa massa,* and *Liosina granularis*. Average sponge cover along all transects was 4.6%, although it exceeded 10% on several transects. Sponges can be considered an important habitat-defining group on Outer Apra Harbor (NAVFAC Pacific 2011a).



Area of virtually 100% coral cover between Kilo Wharf and Sumay Cove entrance.
(*Photo*: S. Smith).

Certain coral species, particularly *Porites rus* are tolerant of higher turbidity relative to other corals in Apra Harbor (Smith et al. 2013). The slow water circulation and turbidity may favor these species. *Porites rus* is a highly versatile species. Colonies can be massive, columnar, laminar, branching and encrusting, and single colonies can contain multiple growth forms (Veron 2000). Dollar et al. (2009) note that *Porites rus* is so prevalent in some portions of Outer Apra Harbor that it can form "supracolonies," which are a collection of colonies in close proximity that fuse as they grow in size. When this situation is repeated, it leads to a continuous living coral formation, composed of elements belonging to different generations. These conglomerate colonial structures, or supracolonies, may extend over tens or hundreds of square meters. Supracolonies have the form of vertical walls, such as off San Luis Shores, massive dome-shaped structures, and conical spires. In addition, colonies and supracolonies of *P. rus* can assume a variety of branching forms that occur in contiguous thickets covering large sections of the benthic surface. These supracolonies are major habitat-forming elements on Outer Apra Harbor coral reef habitat. The most severe problems impacting Guam's coral reefs include land use and coastal development, coral bleaching, COTS, and overfishing. While there is currently no known way to prevent bleaching when water temperatures rise, knowing the pattern of bleaching and limiting the effects of other stressors on coral reefs may aid in their recovery after bleaching. In addition, monitoring the extent of coral bleaching and subsequent mortality or recovery can help inform which coral species are more resistant to the impacts of bleaching.

Benthic surveys were conducted extensively in the vicinity of Kilo Wharf in support of the wharf expansion project in the early to mid-2000s. Surveys were conducted at multiple depth gradients laterally along the reef slope (terraces). Smith (2007) assessed benthic communities prior to construction and Schils et al. (2011) comprehensively evaluated the project impacts by comparing metrics before and after project activities. Coral community composition and impacts were assessed using functional group categories. Schils et al. (2011) found that live coral cover was variable: eastern sheltered sites averaged 59.5% at 9.8 feet (3 meters) and 65% at 32.8 feet (10 meters), while western exposed sites averaged 27.2% at 9.8 feet (3 meters) and 28.8% at 32.8 feet (10 meters). Coral recruitment was also quantified; in general, recruitment was greater toward the west, consistent with greater exposure to open ocean. This pattern was also observed in species richness, where a great number of the observed 48 coral species occurred toward the west. Eastern sheltered reefs were dominated by large colonies of *Porites rus*, which gave way to smaller *Pocillopora eydouxi, Acropora gemmifera*, and faviid colonies.

Severe coral bleaching events in 2013, 2014, 2016, and 2017 have degraded Guam's reefs. In 2015, El Nino–Southern Oscillation-related extreme low tides exposed reef flats for prolonged periods which led to further mortality (Raymundo et al. 2017). Comparing coral cover data from approximately 2011 through the extreme low tide impacts of 2015, Raymundo et al. (2017) estimated a 53% decline in staghorn

Acropora spp. in Guam. Of the 21 sites in the study, 6 are on JRM-administered submerged lands including 4 in Apra Harbor. The estimated mean mortality of staghorn *Acropora* spp. was 80% at Big Blue Shoals; 80% at Western Shoals; 30% at Dogleg; and 90% at Gab Gab (Raymundo et al. 2017). Within Apra Harbor, 2017 was the worst year for bleaching with impacts to corals located over 130 feet from the coastline.

Sessile macroinvertebrates (e.g., bivalves, anthozoids and polychaetes) were quantified along belt-transects in 2008 and 2009, and the most abundant and dominant non-scleractinian sessile invertebrates within survey sites were *Iotrochota protea*, *Rhabdastrella globostellata*, *Stylissa massa*, *Xestospongia exigua*, *Xestospongia* aff. *carbonaria*, and *Sinularia polydactyla.* Mobile macroinvertebrates were most abundant on reef flats, decreasing with depth. Dominant taxa were variable among habitats, most notably echinoderms and holothurians dominated the reef flats, while gastropods were especially abundant on the reef slopes (Schils et al. 2011).

In June 2017, NMFS issued a 90-day finding that determined that seven species of giant clam may be warranted for listing under the ESA (*Hippopus hippopus, Hippopus porcellanus, Tridacna costata, Tridacna derasa, Tridacna gigas, Tridacna squamosa, and Tridacna tevoroa*) (NMFS 2017a). Three species were not warranted for listing at the time of review (*Tridacna crocea, Tridacna maxima*, or *Tridacna noae*). At least three species of giant clams occur in Guam: *T. crocea, T. derasa,* and *T. maxima*. Of the three species, *T. derasa* is on the ESA 90-day finding. Elsewhere in Micronesia, *T. gigas*, *T. squamosa*, and *H. hippopus* are found, all of which are on the 90-day finding. Aside from federal protection, Guam regulations restrict or limit the harvest of giant clams (Public Law [PL] Section 12303, Commercial Harvest of Tridacnid Clams and PL Section 12304, Harvest of Tridacnid Clams [Giant Clams] for Personal Use). Giant clams occur on Outer Apra Harbor. Data from the UOG Monitoring on JRM-administered submerged lands during 2015-2016 found three locations on Outer Apra Harbor where clams occurred: a cluster of sightings on the reef slope northeast of Spanish Steps, the reef slope at Gab Gab, and the west side of Western Shoals. Only one observation was determined at the species level, and that was a *T. maxima* at Spanish Steps; all other observations were listed as *Tridacna* sp. The surveys for the proposed aircraft carrier wharf found bivalves of the genera *Arca*, *Chama*, *Isognomon*, *Lithophaga*, *Malleus*, *Pinctada*, *Pinna*, and *Spondylus* in and around the turning basin area of Outer Apra Harbor, but no giant clams (NAVFAC Pacific 2011a, 2011b). Mollusks were also found at sites off San Luis Shores. They were primarily *Lithophaga* sp., but a few unidentified mollusks occur in the data set (NAVFAC Pacific 2011a, 2011b). It is doubtful that they were giant clams, because the species are quite distinct and should be identifiable at least to genus.

Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine invertebrates in Guam are presented in Section 4.5.4, *Marine Invertebrates*. "Cryptogenic" is the term used to describe uncertainty whether a species is native or non-native. Cryptogenic species have obscure origins and distributions, or lack clear evidence of their introduction. These species are always data-poor, and there are few people with sufficient expertise to identify them.

There are not yet reports of invasive marine invertebrates on Outer Apra Harbor, though non-native species are numerous (Paulay et al. 2002). The harbor is the main point of entry for non-native species introduced by commercial shipping and military vessel traffic, and there are many non-native species, but the confluence of non-native and unique native species makes it difficult to distinguish native from non-native species in Apra Harbor.

Only 23% of the non-native marine species recognized in Guam have been found in natural habitats outside Apra Harbor (as opposed to man-made locations such as wharves and boat hulls). Of these, 6 are introduced and 14 are cryptogenic species (Paulay et al. 2002). Only the marine snail, *Tectus niloticus*, and the cryptogenic hydroids, *Pennaria disticha* and *Thyroscyphus fruticosus*, are relatively common outside Apra Harbor. Even within Outer Apra Harbor, non-native species are not abundant on natural substrata. Over half (46) of the recognized non-native species are restricted to artificial substrata (e.g., moorings), and even those that are not restricted are often most abundant on artificial bottoms. There is no indication that these non-native species are nuisance or invasive.

Among the nuisance marine species, there are records of COTS in Outer Apra Harbor (Smith et al. 2013), and there are no records of the coral-killing sponge, *Terpios hoshinota* (Schils et al. 2011). There have been no reports of major outbreaks of COTS in Apra Harbor between 2003 and 2012. A modest outbreak of COTS was reported in 2005 in the area west of Kilo Wharf to Orote Island (Smith et al. 2013). During surveys conducted in 2008–2010, no COTS were seen along 82-foot (25-meter) long transects covering the reef area from Kilo Wharf west to Orote Island and approximately 0.6 mile (1 kilometer) east of Kilo Wharf. Similarly, there were no COTS sightings during surveys for coral bleaching within Apra Harbor in 2017 (Timmers 2016). COTS were reported in low numbers at Gab Gab and San Luis beaches by Eyes of the Reef Marianas in early 2018 (Brown 2018).

5.3.3.6 Marine Fishes

Native Species

Taylor et al. (2009) observed a total of 119 fish species representing 28 families within the footprint of the proposed aircraft carrier wharf at Polaris Point and the turning basin and reefs to the northwest of Polaris Point. Analyses indicated that fish assemblages largely grouped along a depth/habitat gradient and diversity and biomass were greatest at sites of high coral cover. During Kilo Wharf monitoring efforts, 104 species of fish were recorded, and richness was positively correlated with depth and distance from the harbor entrance (Schils et al. 2011).

Results from the UOG marine monitoring effort on Outer Apra Harbor (Schils et al. 2017) recorded up to 73 species at a single monitoring site. The most speciose families of fishes were wrasses (Labridae including 33 wrasse and 15 parrotfishes), damselfishes (Pomacentridae, 24 species), surgeonfishes (Acanthuridae, 22 species), butterflyfishes (Chaetodontidae, 20 species), gobies (Gobiidae, 15 species), and squirrelfishes or soldierfishes (Holocentridae, 11 species). Large important fisheries species such as groupers (Epinephelinae), snappers (Lutjanidae), and emperors (Lethrinidae) were not commonly observed. Smaller fisheries species, such as parrotfishes and surgeonfishes (Acanthuridae), varied in abundance between monitoring sites. However, while performing in-water turtle tagging surveys (2015 and 2016), the free diver typically observed locally targeted fish species such as bluespine unicornfish (*Naso unicornis*) and bluefin trevally (*Caranx melampygus*) along Gab Gab reef and humphead wrasse (*Cheilinus undulatus*) and giant sweetlips (*Plectorhinchus albovittatus*) along fringing reefs fronting Dadi and Spanish Steps beaches (Hapdei 2017).

Schils et al. (2017) focused on a group of indicator species, butterflyfish that have an obligate relationship with coral, in Apra Harbor to make initial assessments of the coral community and to track indicator reef species' use of habitat within the harbor. Seven of the 20 species of butterflyfish observed are obligate coral-feeding species. *Heniochus lunulatus* and *H. chrysostomus* were most abundant at NBG Main Base sites. Schils et al. suggest that the two most common obligate coral-feeding species may be candidate indicator species that could be used to monitor coral reef health on these sites.

Detection of the presence or absence of species that specialize in the use of habitat or diet is a method for managers to assess the relative health of the coral reefs. There is a micropopulation of reef manta rays (*Manta alfredi*) in Guam. Hartup has observed multi-species spawning areas on which reef mantas feed (Hartup et al. 2013; Hartup 2017). Hartup has observed reef mantas feeding in one of these multi-species spawning areas on Outer Apra Harbor. Gray reef sharks (*Carcharhinus amblyrhynchos*) and blacktip sharks (*Carcharhinus limbatus*) have also been observed at this site as well (Hartup 2017).

In the past, saltwater fishing from NBG Main Base property has impacted marine resources, created safety risks, and conflicts among recreational use. The NBG Fishing Instruction (NBG Instruction 5090.2A N41 [Undated]) (Appendix F) applies to NBG Main Base shorelines and nearshore waters and sets policy that is consistent with other policies and management plans, conserves natural resources, and ensures safety for recreational users. Unauthorized fishing techniques include: (1) spearfishing, (2) nets other than cast nets, (3) harvest or collection of mollusks (e.g., octopuses, squid, clams, snails) crustaceans (e.g., lobsters, crabs) or echinoderms (e.g., sea cucumber, urchins), (4) explosives, (5) poisons, (6) intoxicating substances, (7) electrical devices, (8) snagging of fish by any method, (9) fish weirs or other trapping methods, (10) collection of coral, (11) any fishing technique not listed as a permitted fishing technique. Permitted fishing techniques include: (1) hook and line, and (2) cast nets from shoreline for seasonal juveniles. Authorized, unauthorized, and seafood advisory areas (catch and release only) for JRM-administered submerged lands at NBG Main Base are shown in Figure 5-14.

Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine fishes in Guam are presented in Section 4.5.5, *Marine Fishes*.

There are not yet reports of non-native or invasive marine fishes on Outer Harbor. A nuisance marine species is native, but occasionally exhibits population booms or other undesirable characteristics, and there are not yet reports of nuisance marine fish on Outer Harbor.

5.3.3.7 Marine Protected Species

Eight federal ESA-listed marine species are known to occur or potentially occur within the marine waters/submerged lands of NBG Main Base (Table 5-10, Figure 5-15). The following is a summary of known and potential occurrences of protected species in the JRM-administered submerged land areas. Because some records are not precise, their occurrences are approximated within the 3-mile (4.8-kilometer) JRM-administered submerged land boundary based on available records.



Partial bleaching on staghorn coral in Apra Harbor near Polaris Point. Bleaching restricted to the upper surfaces usually indicates UV intensity as the primary stressor. Recently dead surfaces are rapidly colonized by macroalgae.
(*Photo*: D. Snyder)

Table 5-10. Federal and Guam ESA-listed Threatened and Endangered Marine Species Recorded on JRM-administered Submerged Lands at NBG Main Base

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat[2]*	*Occurrence[3]*
Invertebrates (Corals)					
Coral/Acho Tasi	*Acropora globiceps*	T	--	Intertidal zone, upper reef slopes, and reef flats	Y
Coral/Acho Tasi	*Acropora retusa*	T	--	Shallow reef slope and back-reef areas	P
Coral/Acho Tasi	*Seriatopora aculeata*	T	--	Shallow reef slopes	P
Fish					
Oceanic whitetip shark/Haluu	*Carcharhinus longimanus*	T	--	Open ocean, usually well offshore	P
Giant manta ray/Afulu or Hafula or Fanihen Tasi	*Manta birostris*	T	--	Coastlines, oceanic island groups, and offshore pinnacles and seamounts	P
Scalloped hammerhead shark/ Haluun kiluus or Uluon matiyu na huluu	*Sphyrna lewini*	T[4]	--	Coastal seas from intertidal to depths of 1,640 feet (500 meters); nearshore nursery habitat includes bays and estuaries	Y
Reptiles					
Green sea turtle/Haggan	*Chelonia mydas*	E[5]	T	Nearshore waters and nesting beaches	Y
Hawksbill turtle/Haggan karai	*Eretmochelys imbricata*	E	E	Nearshore waters and nesting beaches	Y

Notes: [1] Chamorro names from GovGuam (2009), Kerr (1990, 2012), and Topping et al. (1975).
[2] Dominant adult habitat. Not necessarily inclusive of other life stages (e.g., egg/larvae/juvenile/breeding habitat).
[3] Occurrences approximated to JRM-administered submerged lands, but some fishery-based and acoustic-based records have imprecise locations.
[4] Indo-West Pacific Distinct Population Segment.
[5] Central West Pacific Distinct Population Segment.

Key: -- = not listed; E = endangered; P = potential for occurrence; ESA = Endangered Species Act; JRM = Joint Region Marianas; NBG = Naval Base Guam; SOGCN = Species of Greatest Conservation Need; T = threatened; Y = yes, known to occur.

Sources: Guam DAWR 2006; NMFS and USFWS 2007, 2016; GovGuam 2009; Kerr 2012, 2013; NMFS 2014a, 2014b, 2018a, 2018b; Brown 2015; USFWS 2015a; Lybolt 2015.

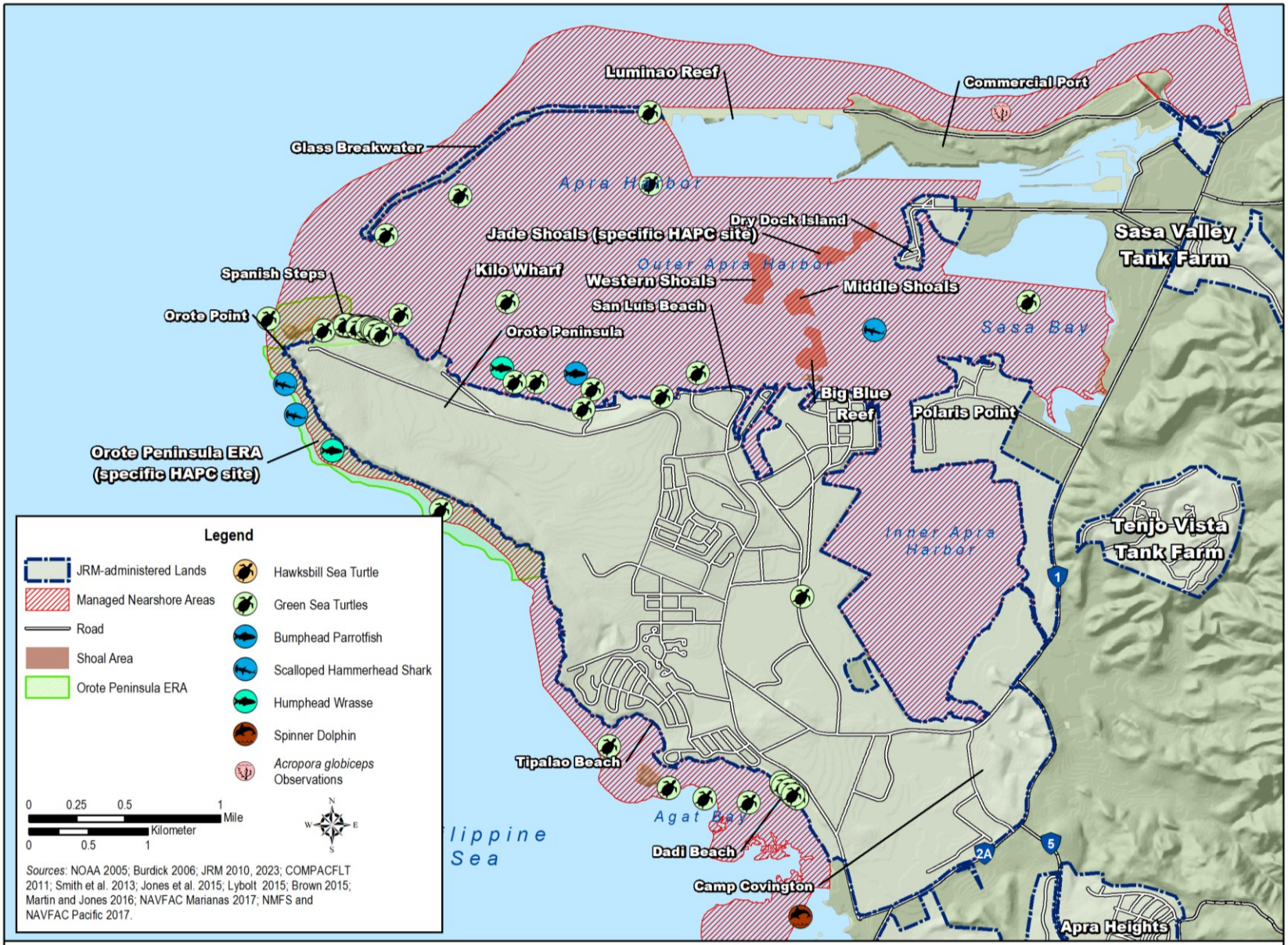


Figure 5-15
Protected Marine Species - NBG Main Base

Invertebrates – Corals

Three coral species that are known to occur in Guam (*Acropora globiceps*, *Acropora retusa*, and *Seriatopora aculeata*) were listed by NMFS as threatened under the ESA (NMFS 2014a). There are few records of occurrences for these three species in Guam waters. Based on 2016 records, there are 24 known occurrences of *A. globiceps*, two occurrences of *A. retusa*: one at the southernmost point of Guam and one on the southwest coast close to the only occurrence of *Seriatopora aculeata* (Brown 2015; Moribe 2017) (refer to Figure 4-6).

Acropora globiceps occurs on upper reef slopes and reef flats from very shallow locations down to 26 feet (8 meters), within relatively strong wave environments. Past confusion has occurred between the identification of *A. humilis* and *A. globiceps*. Coral scientists who conducted the surveys for the proposed aircraft carrier wharf in Apra Harbor in 2010 were aware of this issue at the time of the surveys and called it to DON's attention. None of the coral surveys associated with the proposed aircraft carrier wharf recorded this species.

There is only one location in Outer Apra Harbor where a federal ESA-listed coral species has been positively identified since the species were listed. In April 2015, several colonies of *Acropora globiceps* were encountered during a 40-minute non-systematic survey at Spanish Steps (Lybolt 2015). The colonies were seen in very shallow water less than 3.3 feet (1 meter) deep. Spanish Steps is just inside the tip of the Orote Peninsula which is a dynamic location that is exposed to some effect from the ocean outside the harbor. The area has high coral coverage of commonly seen species from Apra Harbor. A second colony was recorded from the reef crest south of Dadi Beach in September 2016. The single colony was approximately 10–15 inches (25-30 centimeters) across and was observed during a non-systematic survey of the nearshore area at Dadi Beach (NMFS and NAVFAC Pacific 2017).

Biological monitoring in the vicinity of Kilo Wharf also reported *A. globiceps* in Apra Harbor, but the degree of presence is unquantified (Schils et al. 2011) and that species has not been reported from that part of the harbor since the survey.

Fishes

The Indo-West Pacific DPS of the scalloped hammerhead shark (*Sphyrna lewini*) is ESA-listed as threatened (NMFS 2014b). The earliest confirmed record of a scalloped hammerhead in Guam was in 1968 and confirmed sightings remain rare to today (Kami 1971; NMFS 2014b; Adams 2018). Adult scalloped hammerhead sharks have been observed at multiple locations of Outer Apra Harbor, Sasa Bay, and the southernmost part of Inner Apra Harbor (NMFS 2015a) (see Figure 5-15). Juvenile scalloped hammerhead sharks have been observed near Sasa Bay. The species information suggests that Sasa Bay in Apra Harbor is a potential nursery area (NOAA 2005; NMFS 2015a). There is no proof that the site is used as a nursery, but there are several secondhand accounts of fishermen who have accidentally caught young-of-the-year hammerheads near Sasa Bay (NMFS 2015a; Resko 2018). If Apra Harbor acts as a nursery for this species, it would be reasonable to expect neonates, juveniles, and adult females to occur seasonally. They could conceivably use Inner Apra Harbor as habitat, but the amount of human activity and the lack of quality habitat may limit their presence in the area. JRM initiated an environmental DNA (eDNA) project in 2018 to assist with detection.

Two bony fishes occurring in the Mariana Archipelago are listed as federal species of concern and Guam-designated as SOGCN: the Napoleon or humphead wrasse (*Cheilinus undulatus*) and the bumphead parrotfish (*Bolbometopon muricatum*) (Guam DAWR 2006; NMFS 2015b, 2015c). Although neither humphead wrasse or bumphead parrotfish were observed during Kilo Wharf monitoring surveys (Schils et

al. 2011) or studies for proposed aircraft carrier wharf (NAVFAC Pacific 2011a, 2015c; Deakos et al. 2016), both species have been recorded within Apra Harbor, but in low numbers (Smith et al. 2013). The eDNA project would also include detection for these two species.

Sea Turtles

Green sea turtles are the most abundant and common sea turtle in Guam waters (Guam DAWR 2015; Martin et al. 2016). The seagrass beds and macroalgae of Agat Bay, Sasa Bay, and Apra Harbor provide important foraging and resting areas for green sea turtles (Guam DAWR 2006, 2015; Brindock 2015; Martin et al. 2016). Although they have been seen within all areas of Apra Harbor, based on data from 2004-2016, the highest density of sea turtle sightings has been in western Apra Harbor, particularly along the coast between Kilo Wharf and Gab Gab Reef (Figure 5-15). This is likely due to the large reef-wall environment that provides sufficient habitat and resources for large numbers of both species. Inversely, relatively few sea turtle sightings have been recorded in the eastern portions of the harbor (Smith et al. 2013; Brindock 2015; Jones et al. 2015). Inner Apra Harbor has limited habitat for green sea turtles; an individual green sea turtle was observed between Abo Cove and Victor Wharf during surveys conducted in 2008 (Smith et al. 2009).

Compared to green sea turtles, hawksbill turtles occur in low numbers in Guam waters and do not occur in large numbers anywhere within the Marianas (NMFS and USFWS 2007; Martin et al. 2016) except possibly around Rota. The waters of Rota have been recently shown to support hawksbill turtles in greater numbers than around Saipan (Summers et al. 2017). Sasa Bay and Apra Harbor provide important foraging and resting areas for hawksbill turtles and they have been seen within all areas of Apra Harbor (Kolinski 2001; Smith et al. 2009; Brindock 2015; Guam DAWR 2015; Jones et al. 2015; Martin and Jones 2016, 2017).

During sea turtle surveys and satellite tagging operations in July 2014, May 2015, and May 2016, a total of 11 subadult green sea turtles and three subadult hawksbill turtles were captured within Apra Harbor and equipped with satellite tags to track their movements (Brindock 2015; Jones et al. 2015). Tracking data revealed high site fidelity and limited movements for the green sea turtles as they either stayed within western Apra Harbor or moved to Agat Bay. Dive patterns suggest that both hawksbill and green sea turtles remain in deeper waters during the day and move nearshore during the night. Hawksbills spent more time in deeper waters than the greens, reaching depths of 330 feet (100 meters) or more. Green sea turtle average depth was less than 33 feet (10 meters) for day and night (Jones et al. 2015; Martin and Jones 2016, 2017).

In-water capture and tagging of resident sea turtles has been conducted by NOAA via an Interagency Agreement with JRM bi-annually since 2014 (NAVFAC Marianas and Andersen AFB 2023). From 2015–2022, surveys were conducted at various sites within Outer and Inner Apra Harbor and at Orote Point, Dadi Beach, Piti Bomb Holes, Double Reef, and Haputo (NOAA 2022). Out of all turtle encounters during the surveys, 263 turtles were observed but not captured, 29 turtles were captured but not outfitted with a satellite tag, and 65 turtles were captured and outfitted with a satellite tag. Out of the 357 turtles that were captured or observed, 272 (76.2%) were identified as green turtles, 41 (11.5%) as hawksbill turtles, and 44 (12.3%) as "unknown" species (but either green or hawksbill turtles) (NOAA 2022). The survey also showed high densities of both green and hawksbill turtles in the area of Gab Gab beach in Outer Apra Harbor (NOAA 2022). Since its commencement, the program has recorded a total of 503 green sea turtles and 55 hawksbill turtles around Guam from 2014–2022 (NAVFAC Marianas and Andersen AFB 2023). A summary of sea turtle observations and captures around NBG can be found in Table 5-11.

Sea turtle nesting surveys were conducted on NBG beaches in October 2022 and August 2023. A total of 28 nests (protected with wire mesh screening) and zero non-nesting emergences were observed (NAVFAC Marianas and NGB 2023). Out of all survey sites, turtle activity occurred solely at the Spanish Steps beach, and all activities were created by the green sea turtle; no evidence of hawksbill turtle activity was

documented. Vegetation removal was also executed at the Spanish Steps in late February of 2023 as invasive vines at the site can entangle female nesting turtles and impede hatchling emergence (NAVFAC Marianas and NGB 2023).

Table 5-11. Sea Turtle Observations and Captures Recorded within the vicinity of NBG (2014–2022)

Sea Turtle Species	*July 2014*		*May 2015*		*May 2016*		*May 2017[(a)]*		*June 2019[(a)]*		*July 2022[(a)]*	
	Obs	*Cap (Sat)*	*Obs*	*Cap (Sat)*	*Obs*	*Cap*	*Obs*	*Cap (Sat)*	*Obs*	*Cap (Sat)*	*Obs*	*Cap (Sat)*
Green	9	4 (4)	34	4 (7)	10	4 (3)	41	5 (19)	42	1 (8)	55	13 (5)
Hawksbill	0	0	2	0 (2)	0	0 (2)	2	0 (3)	11	1 (4)	6	1 (6)
Unknown	NA	NA	13	NA	12	NA	5	NA	2	NA	12	NA

Key: Cap = capture for tagging and physiological samples; NA = not available; Obs = observation; Sat = cap plus equipped with satellite tag.
Sources: Brindock 2015; Jones et al. 2015; Martin and Jones 2016, 2017; NOAA 2022[(a)]

Marine Mammals

Although marine mammals are frequently seen in the waters outside of Apra Harbor (Hill et al. 2014; Martin et al. 2016), there have been no observations recorded of any marine mammal species occurring within the harbor. This is probably due to the relatively high and constant level of human activity within the harbor. In 2016, a team from NMFS Pacific Islands Fisheries Science Center (PIFSC) tagged six short-finned pilot whales (*Globicephala macrorhynchus*) off Guam. One of the tags indicate that a pilot whale entered Outer Apra Harbor (Hill et al. 2017). It did not appear to go past Kilo Wharf. There is a single location in the tag track that is within the harbor. The error in the locations of other positions in the tag track could place the animal within or outside the harbor. There are several locations with sufficient certainty to state that the pilot whale appears to have lingered at the mouth of the harbor and the tip of the Orote Peninsula for some period. The rest of the locations on the tag tracks from the six pilot whales show that they swam around Guam and Rota staying relatively close to the islands and went to Galvez Bank and Santa Rosa Reef southwest of Guam (Hill et al. 2017).

5.3.4 Inner Apra Harbor Marine Environment

5.3.4.1 Bathymetry and Currents

Inner Apra Harbor is defined as the area from the mouth of the channel connecting the inner lagoon to Outer Apra Harbor back to where the wetland behind X-ray Wharf flows into Abo Cove. Like Outer Apra Harbor, Inner Apra Harbor is a heavily altered environment. The depth of Inner Apra Harbor is relatively uniform and has been maintained at depths required by various vessels (typically 22 to 40 feet [6.7 to 12.1 meters]), including submarines, since WWII. The bottom is primarily soft substrate with the exception of the hard substrate near the mouth of the channel to Outer Apra Harbor. Much of the shoreline has been filled and altered to support wharves with the exception of some of the eastern shoreline inhabited by mangroves and the shoreline south of X-ray Wharf. This means that much of the shoreline of Inner Apra Harbor is steep man-made structures.

In Inner Apra Harbor, the current flow pattern is caused by wind-driven wave action (Smith et al. 2013). Current movement is often less than 0.1 knots (0.19 kilometers per hour). Inner Apra Harbor is sufficiently shallow and restricted from Outer Apra Harbor such that the dynamics in Outer Apra Harbor have minimal bearing on the water movement of Inner Apra Harbor.

5.3.4.2 Turbidity and Water Quality

The Apra Harbor Watershed includes the subwatersheds of Sasa and Atantano, and it delivers freshwater into the NBG Main Base marine environment at the eastern side of Inner Apra Harbor and Sasa Bay (see Figure 5-4). As seen in Figure 5-4, the opening between Inner Apra Harbor and Outer Apra Harbor restricts water circulation. Turbidity in Inner Harbor is tightly coupled with freshwater input, which has a distinct seasonal weather pattern (i.e., monsoonal) that is punctuated with storm events. Due to weak circulation, the substantial sediment transport into the marine environment from the watershed and long residence time of water, turbidity throughout Inner Apra Harbor is higher than Outer Apra Harbor.

Additionally, dredging and construction in Apra Harbor and the adjacent watershed can contribute to the total amount of suspended sediment in Inner Apra Harbor, causing acute exposure of marine resources to increased turbidity levels. The infrastructure in Apra Harbor is being improved to support increased requirements placed on the U.S. Navy and the USMC in the Pacific, and many of the structures, which can date to WWII (Hammer 1947), require regular maintenance. Water quality measurements are regularly recorded in conjunction with infrastructure improvement projects (e.g., X-Ray Wharf).

5.3.4.3 Marine Habitats

There are ongoing efforts to better understand the spatial distribution of habitat in Apra Harbor (see Figure 5-13). Inner Apra Harbor is a less complex area of marine habitats, but it is also in some ways a more challenging area to characterize due to limited visibility and the more sparse and patchy distribution of marine resources.

In the past two decades, there have been broad scale resource inventories (Paulay et al. 1997, 2001, 2002) and investigations into baseline conditions of Inner Apra Harbor (Smith et al. 2008), and resource assessments to support specific infrastructure improvement projects (i.e., MILCON projects; the marine environment of Oscar and Papa Wharves was the focus of Donaldson et al. (2009). Numerous marine resource assessments were conducted to support a potential aircraft carrier pier for the Guam Military Relocation EIS/OEIS (Dollar et al. 2009; Minton et al. 2009; NAVFAC Pacific 2011a; McManus and McManus 2012). Some information from those reports included areas on Inner Apra Harbor as potential mitigation sites (NAVFAC Pacific 2011b, 2013c, 2015b, 2015d). Smith et al. (2013) provide a broad synthesis of marine resources on Apra Harbor, including Inner Apra Harbor.

Despite the abundance of available marine resources information, data gaps exist. Regardless, data derived from all of these efforts comprise the most comprehensive body of knowledge available on the status of marine resources on Apra Harbor, and are the most important supporting information for this section.

5.3.4.3.1 Bottom Habitat

Inner Apra Harbor is almost uniformly soft bottom habitat with the exception of hard bottom in the channel that connects the Inner and Outer Harbor, occasional scoured areas near piers, or shallow parts of the basin (see Figure 5-13). Inner Apra Harbor is subject to regular maintenance dredging and is no deeper than 40 feet (12 meters) in most locations. Coral reef habitats on Inner Apra Harbor occur as hard shoreline, occasional debris and rocks in the soft substrate, and artificial structures along the perimeter of the Harbor.

5.3.4.3.2 Coastal Habitat

Coastlines in Inner Apra Harbor are predominantly man-made structures (e.g., wharf faces) with estuarine wetlands on the east side and only limited rocky and/or sandy coastlines present. Mangrove forest is found along the eastern shore of Inner Apra Harbor, notably along the Atantano River Delta, and along the northern and eastern shorelines of Sasa Bay (AECOS, Inc. and Wil Chee Planning, Inc. 2009; NAVFAC

Pacific 2015a, 2015b). The largest concentration of mangroves in Guam is along the eastern shores of Apra Harbor. Mangroves are important habitat for juvenile and adult fish species, and their roots act as filters that trap sediment before it can be deposited in near shore habitat.

Abo Cove is an eastward extending finger of Inner Apra Harbor located near the NBG Main Gate. Three wetlands occur along the shore of the cove, and a large wetland extends inland, connected by a culvert under Marine Corps Drive to Abo Cove. The cove was once lined by a mangrove swamp and led inland to an extensive area of wetlands. Mangrove forest was probably a habitat that contributed meaningfully to the health of the coral reefs and reef flats that dominated Inner Apra Harbor area prior to the 1940s (see Figure 5-13). Due to development after WWII, the area of mangrove wetlands along Inner Apra Harbor has been significantly reduced. Mangrove restoration is major habitat improvement opportunity for NBG Main Base.

5.3.4.4 Marine Flora

Native Species

The dominant substrate on Inner Apra Harbor is soft bottom, which supports growth of algae. Smith et al. (2009) reported 19 species of macroalgae, in addition to turf algae, on Inner Apra Harbor. Among them, *Caulerpa verticillata,* is a green alga that copes well with increased levels of sedimentation and reduced salinities. Exceptionally large specimens of this alga were found in Abo Cove, probably a result of relatively low herbivore populations.

Seagrass beds are not an extensive habitat on Inner Apra Harbor. Only a limited amount of seagrass, *Halophila* sp. (possibly *Halophila japonica*), has been found in Abo Cove on Inner Apra Harbor (Smith et al. 2009). Seagrass beds are considered EFH and are also designated as special aquatic sites under the CWA.

Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine flora in Guam are presented in Section 4.5.3, *Marine Flora*.

There are not yet reports of non-native or invasive marine flora on Inner Apra Harbor. A nuisance marine species is native, but occasionally exhibits blooms or outbreaks or other undesirable characteristics, and there are not yet reports of nuisance marine flora on Inner Apra Harbor. The green angel hair algae (*Chaetomorpha* sp.) is present in Guam (Schils 2015), but it is not usually reported in low energy habitats such as Inner Apra Harbor.

5.3.4.5 Marine Invertebrates

Native Species

The section on Outer Apra Harbor reported on the results of an extensive study of species diversity within Apra Harbor and evidence suggests the harbor contains a unique assemblage of invertebrates (Paulay et al. 1997). Smith et al. (2013) provide a more recent broad summary of marine resources on Apra Harbor. Currently, there are monitoring efforts for specific sites on Inner Apra Harbor based on information needs for particular construction and maintenance projects. The transplant site for corals from X-ray Wharf has been monitored for 2 years (NAVFAC Pacific, in review 2017), and will likely continue to be monitored regularly for some time. Sites on Inner Apra Harbor could be considered for permanent transects in future monitoring plans.

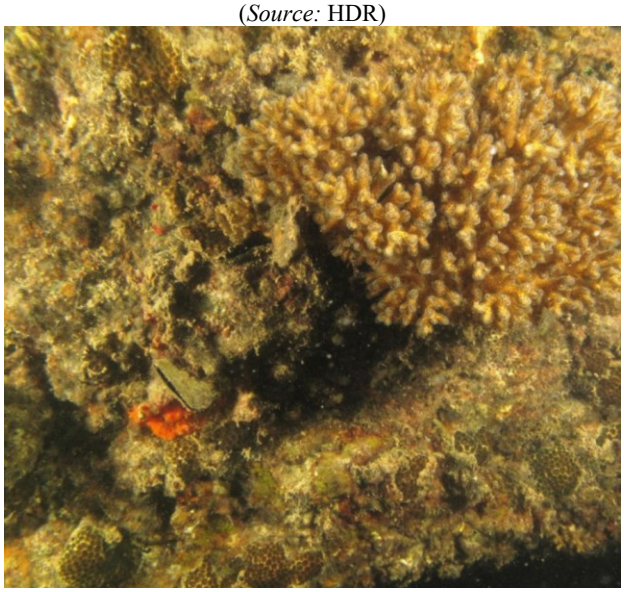
The habitat and bathymetry of Inner Apra Harbor is substantially different from Outer Apra Harbor. Inner Apra Harbor is a highly altered environment that supports coral growth primarily on the perimeter of the

harbor on man-made structures and the limited amount of hard substrate found close to the shoreline. There are no coral reefs in the main body of Inner Apra Harbor (Smith et al. 2013). Reef or reef-like areas are found in the mouth of the channel between the Outer and Inner Harbor. The substrate on the bottom of Inner Apra Harbor is unconsolidated sand or mud with occasional rocks or rubble, which support limited sponge growth, estimated to be less than 1% (Smith et al. 2013). Coral cover is much higher and more diverse on the wharves (Smith et al. 2008, 2013). The two areas of the Inner Apra arbor that have a more natural assemblage of sessile species are Abo Cove and the mangrove shoreline northeast of X-Ray Wharf. Past studies of Inner Apra Harbor have led UOG to recommend that Abo Cove as the only natural reef remnant on Inner Apra Harbor and should be protected. There are several restoration and enhancement projects that target Abo Cove in consideration or proposed as INRMP or mitigation projects that would preserve the integrity of that part of Inner Apra Harbor.

An investigation by UOG of Sierra, Tango, Uniform, and X-Ray Wharves found four to eight coral species on the wharf faces (Smith et al. 2008). The corals tended to occur primarily on the upper 10-13 feet (3-4 meters) of the wharf faces, probably due to turbidity limiting light penetration. X-ray Wharf is reported to be the most diverse wharf with eight species of coral reported by Smith et al. (2008) and 11 species or species complexes reported by Smith et al. (2013). This assemblage is more diverse than Abo Cove, which Smith et al. (2008) reported to have four coral species represented and NAVFAC Pacific (2011a) reported three coral species present.



***Porites* massive located in Outer Apra Harbor.**
(*Source:* HDR)



Corals common to Inner Apra Harbor include *Pocillopora damicornis* (top) and *Leptastrea purpurea*, which can form small brown honeycomb-like colonies that adhere to the substrate (seen below *P. damicornis*).
(*Source:* Smith et al. 2013).

The most common corals on Inner Apra Harbor are *Porites rus*, *Porites lutea* (aka *Porites* massive)[2]. Many experts no longer distinguish between massive *Porites* species - *Porites lutea*, *Porites australiensis*, *Porites*

[(2)] There is an ongoing issue related to identifying *P. lutea* based exclusively on on-site field observations. A number of scientists have switched to calling the species "*Porites* massive" when identifications are based entirely on field work (Khan 2010; Fenner 2017).

lobata, and others, *Leptastrea purpurea*, and *Pocillopora damicornis* (Smith et al. 2008, 2013; NAVFAC Pacific 2011a).

Inner Apra Harbor is subject to regular maintenance dredging (at an interval of roughly 5 to 8 years). Therefore, during this maintenance dredging, corals on Inner Apra Harbor are exposed to suspended sediment and oxygen depleted water as a result of the movement of large quantities of sediment by dredging equipment. DON employs BMPs to reduce negative effects to corals from dredging. In addition to dredging, wharf maintenance regularly impacts coral that is grown on the man-made structures. Because there are long intervals between major wharf repairs coral can grow to become large and can represent significant ecological function as EFH. Recent projects to refurbish or expand Uniform, Tango, and X-Ray Wharves have removed a large number of sizeable corals from Inner Apra Harbor.

In July 2015, a small coral translocation experiment that moved 96 corals from X-Ray Wharf before the wharf was expanded was placed on firm sandy substrates just west of Abo Cove in water depths between approximately 9 and 15 feet (2.7 and 4.5 meters). Limestone boulders ranging from 2.5 to 4 feet (0.75 to 1.2 meters) in diameter were procured from Smithbridge Quarry in Yigo, and placed on the shallow seafloor in 6 alternating clusters of 16 boulders each (Figure 5-16). Four species of coral were moved from X-Ray Wharf (*Pocillopora damicornis*, *Porites cylindrica*, *Porites rus*, and *Porites* sp. [massive]). Final results from 2 years of monitoring the translocated corals are not available at the time of writing, but initial results suggest at least partial survivorship of more than 90% of the colonies (NAVFAC Pacific, in review 2017). Results also suggest better health and survivorship of the translocated corals than reference corals of the same species that were growing on a nearby-submerged causeway. The limestone boulders are not only useful components of the relocation experiment, they are also surfaces that future invertebrates can recruit to or be moved to. They also add bathymetric complexity to the part of Inner Apra Harbor where they were placed.

The channel that passes from Outer to Inner Apra Harbor is a relatively narrow waterway (750 feet [230 meters] wide) that is intermediate in character between Inner Apra Harbor and Outer Apra Harbor. The characteristics of this area are similar to Inner Apra Harbor except at the transition zone to Outer Apra Harbor where natural coral reefs are present with live cover up to 25% (Marine Research Consultants 2005). Recent video surveys of the wharf faces, shoreline, and bottom (Shannon, in preparation n.d.) indicate that coral is present on the wharf faces and there is a clear gradient of coral presence on the sea floor starting from low cover close to Inner Apra Harbor and trending to higher cover near Outer Apra Harbor. The most abundant species in the area are *Porites rus*, *Pocillopora damicornis*, and a staghorn coral *Acropora* sp. (possibly *Acropora virgata*) (Marine Research Consultants 2005; Smith et al. 2013).

Upcoming projects to dredge the channel, large sections of Inner Apra Harbor, and repair or improve Lima, Mike, November, Oscar, Papa, Quebec, and Romeo Wharves will likely affect coral and other benthic resources on Inner Apra Harbor. Wharf faces and support structures that have been present for at least several years and are not scoured by vessel activities typically harbor thick communities of fouling organisms. The species of fouling organisms include corals. Changes from maintenance and construction projects will have an effect on the quantity and quality of fouling organisms and EFH in Inner Apra Harbor. Management and mitigation actions may be required to avoid, minimize, and offset impacts from these upcoming projects.

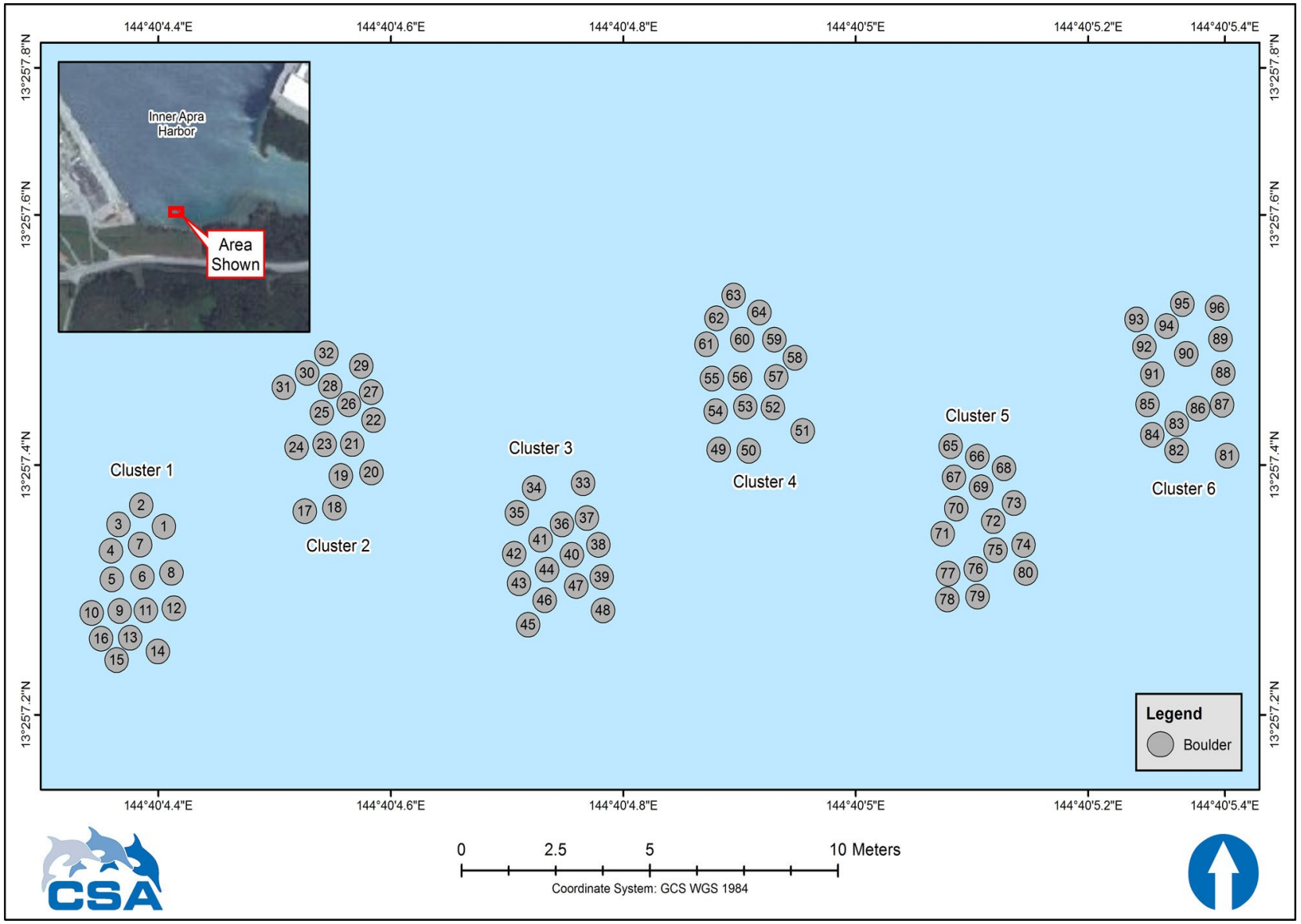
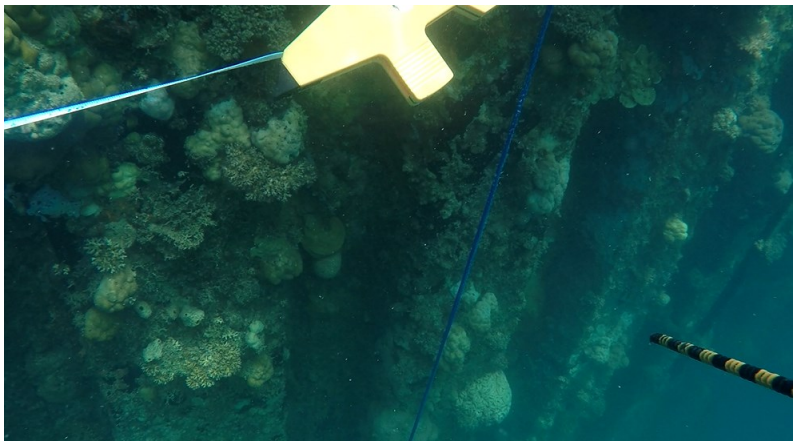


Figure 5-16. Location and Layout of the X-Ray Wharf Coral Translocation Experiment

Source: NAVFAC Pacific, in review 2017.

In July and August of 2017, NAVFAC conducted surveys of the wharf faces and the harbor bottom on the west side of Inner Apra Harbor. In front of Lima Wharf on the west side of the channel between Inner and Outer Apra Harbor, divers estimated approximately 700 coral colonies could be affected in an area that is planned for dredging. Many of the colonies are less than 3.9 inches (10 centimeters) across, very few were around 19.7 inches (50 centimeters) across, and none of the corals were more than 39.4 inches (1 meter) in their largest single dimension. The survey was during a period of elevated water temperatures which caused bleaching (NOAA 2017a). There was a high incidence of bleaching and disease among the corals in front of Lima Wharf; a subjective estimate is that 40 to 60% of colonies were affected. The approximate species composition of the approximately 700 corals in the area was 52% *Porites* sp. (massive), 21% *P. rus*, 13% *Astreopora* sp., <1% *Fungia* sp., <1% *Leptastrea* sp., <1% *Pocillopora* sp., <0.2% *Lobophyllia* sp., <0.01% *Pavona* sp., <0.01% *Porites cylindrica*, <0.01% *Favia* sp. (Timmers 2016).



Corals and sponges on the front of Lima Wharf near the security gate. (*Photo*: L. Shannon)

Depending on the amount of use and their location, wharf faces can support a range in the complexity and quality of the fouling community. Lima Wharf near the security gate at the mouth of Inner Apra Harbor has a dense population of moderate-size corals and other invertebrates on the wharf face. Oscar, Papa, and Romeo Wharves all support coral colonies of smaller size and lower species diversity (NAVFAC Pacific, in review 2017). These wharves have high levels of growth of macroalgae (*Dictyota* and other species) which can outcompete corals or prevent them from settling.

Quebec and Victor Wharves have exceptional coral growth for Inner Apra Harbor. There are many colonies of *Porites*, *Astreopora*, and *Lobophyllia* on the wharf faces reaching sizes over 91.7 inches (50 centimeters) in the greatest single dimension (NAVFAC Pacific, in review 2017). The large sizes are likely due to favorable sun exposure, limited vessel mooring at these sites, and the period of time since maintenance work on these wharves. The largest corals on wharf faces give a sense of the greatest level of ecological functionality of the corals present.

In the summer of 2015, prior to construction, X-Ray Wharf supported *Porites rus* that were up to 3.3 feet (1 meter) in diameter, *Porites* sp. (massive) up to about 29.5 inches (75 centimeters), *Porites cylindrica* up to about 11.8 inches (30 centimeters), and *Pocillopora damicornis* up to 13.8 inches (35 centimeters). All four of those species were plentiful and were transplanted for the X-Ray Wharf translocation experiment. Species that were also present but occurred less frequently were *Lobophyllia hataii* up to 9.8 inches (25 centimeters), *Leptastrea purpurea* up to 3.9 inches (10 centimeters), and *Pachyseris speciosa* up to 11.8 inches (30 centimeters) (NAVFAC Pacific, in review 2017).

Uniform and Tango Wharves are a contrast to some of the other wharf faces on Inner Apra Harbor. There is limited coral growth due primarily to recent wharf face improvements in 2012 and 2013. In summer of 2017, colonies of *Pocillopora* and *Leptastrea* smaller than 9.8 inches (25 centimeters) in greatest dimension were sparsely located on these wharf faces (NAVFAC Pacific, in review 2017). Turf algae was the primary plant cover and very little macroalgae was present.

While bivalves do occur on Inner Apra Harbor and can be the dominant species on some man-made structures such as Papa Wharf (Donaldson et al. 2009), no *Tridacna* clams have been observed.

Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i.* General issues for non-native, invasive, and nuisance marine invertebrates in Guam are presented in Section 4.5.4, *Marine Invertebrates*.

Numerous non-native or cryptogenic sponges and ascidians were reported on Inner Apra Harbor (Paulay et al. 1997). The study also searched for non-native or cryptogenic echinoderms and found none on Inner Apra Harbor. A nuisance marine species is native, but occasionally exhibits population booms or other undesirable characteristics. The extensive marine invertebrate fouling community could be considered a nuisance to the maintenance of efficient vessels (Paulay et al. 1997; Miller 2014), but this characteristic does not result from a population boom or other episodic process that characterizes nuisance species.

5.3.4.6 Marine Fishes

Native Species

Smith et al. (2008) recorded 62 species of fish on transects surveyed on Inner Apra Harbor, 59 of which are native to Guam. They noted that while this number indicates an impoverished fish fauna, the species seem representative of protected, turbid lagoons or bays of Guam. Donaldson et al. (2009) found results that were very similar to Smith et al. (2008). The area surveyed at Oscar and Papa Wharves was smaller than Smith et al. (2008), so it is not meaningful that they recorded 35 species of fish on their transects. They found that overall species richness was greater on or adjacent to mid-wall and top-wall transects at both wharves, where corals, hanging debris, and oyster shells provided shelter for various species, especially damselfish, cardinalfish, and juvenile butterflyfish species. Bottom-transects at both wharves had the lowest number of species and individuals (Donaldson et al. 2009).

Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine fishes in Guam are presented in Section 4.5.5, *Marine Fishes*.

Of the 62 species of fish Smith et al. (2008) recorded on transects surveyed on Inner Apra Harbor, at least three species appeared to be non-native or new records for Guam and the Mariana Islands. One, *Neopomacentrus violescens* (Pomacentridae – damselfishes), had been reported previously (Myers 1999; Myers and Donaldson 2003). The other two, *Amblygliphididon ternatensis* (Pomacentridae) and *Rhamdia cypselurus* (Apogonidae – cardinalfishes) had not been reported previously in the Mariana Islands. Donaldson et al. (2009) also observed the two Pomacentrid species in Inner Apra Harbor. It is not clear if any of these species have detrimental effects on the fish or coral community in Apra Harbor. There are not yet reports of non-native or invasive marine fishes on Inner Apra Harbor. It is not clear if any of the three new records of fish species have detrimental effects that would cause them to be considered invasive or nuisance species. A nuisance marine species is native, but occasionally exhibits population booms or other undesirable characteristics, and there are not yet reports of nuisance marine fishes on Inner Apra Harbor.

5.3.4.7 Marine Protected Species

Invertebrates – Corals

No federal ESA-listed corals have been observed on Inner Apra Harbor. Given what is known about the preferred habitat of the listed corals, Inner Apra Harbor is suboptimal.

Fishes

Adult scalloped hammerhead sharks (*Sphyrna lewini*) have been observed at multiple locations of Outer Apra Harbor, Sasa Bay, and the southernmost part of Inner Apra Harbor (NMFS 2015a). Juvenile scalloped hammerhead sharks have been observed near Sasa Bay. Observations of adults or juveniles are rare. The species information suggests that Sasa Bay in Apra Harbor is a potential nursery area (NOAA 2005; NMFS 2015a). There is no proof that the site is used as a nursery, but there are several secondhand accounts of fishermen who have accidentally hooked young-of-the-year hammerheads near Sasa Bay (NMFS 2015a; Resko 2018). If Apra Harbor acts as a nursery for this species, it would be reasonable to expect neonates, juveniles, and adult females to occur seasonally. They could conceivably use Inner Apra Harbor as habitat, but the amount of human activity and the lack of quality habitat may limit their presence in the area.

Sea Turtles

Inner Apra Harbor has limited habitat for green sea turtles and few sightings have been recorded. An individual green sea turtle was observed between Abo Cove and Victor Wharf during surveys conducted in 2008 (Smith et al. 2009). Sightings of green sea turtles did occasionally trigger mitigation actions during pile driving for the Uniform/Tango Wharf improvements in 2012 and 2013. Expectably, there were limited sightings during large-scale monitoring and tagging surveys conducted from 2015–2022 (NOAA 2022). While hawksbill turtles could occur within Inner Apra Harbor, they would be expected to occur even less than green sea turtles because of their low numbers and the lack of ideal habitat.

Marine Mammals

There have been no reports of any marine mammal species on Inner Apra Harbor.

5.3.5 Luminao/Glass Breakwater Marine Environment

5.3.5.1 Bathymetry and Currents

The bathymetry of Luminao and Glass Breakwater (north and east of Glass Breakwater) is steep and drops off into mesophotic and aphotic insular shelf zones. Luminao reaches down to approximately 40 feet (12.1 meters) and then drops off steeply.

As was stated in Section 4.5.1, *Physical Environment*, currents around Guam are heavily influenced by the North Equatorial Current (NEC), which is driven by the northeast and southeast trade winds. The NEC is strongest during the winter when the trade winds are greatest, but the average velocity is less than 9.8 feet per second (0.3 meters per second) (Tomczak and Godfrey 2003). To the west of Luminao, net flow is in a western direction from Hagatna Bay along shore (Wolanski et al. 2003). Guam is large enough to create a lee effect and eddies with a net eastward current flow, so current velocities can be slower than the NEC (Wolanski et al. 2003) (see Figure 5-12). Some influences such as tropical cyclones, El Nino, and ocean cyclonic eddies can also cause the reversal of dominant surface current flow (Eldredge 1983; Lagerloef et al. 1999; Wolanski et al. 2003).

5.3.5.2 Turbidity and Water Quality

Turbidity is tightly coupled with freshwater inputs, which have a distinct seasonal weather pattern (i.e., monsoonal) that is punctuated with cyclonic storm events. Luminao and Glass Breakwater are not adjacent or down current from major freshwater inputs. They are exposed to high wave energy which transports sediments away. Underwater visibility tends to be good at these locations.

Measurements of water and sediment quality on Luminao and Glass Breakwater would improve the understanding of the condition and stresses on resources at these locations, and add to existing temperature data.

5.3.5.3 Marine Habitats

Regarding Outer Apra Harbor, there are ongoing efforts to better understand the spatial distribution of habitat in Apra Harbor (see Figure 5-13). After attending to the harbor, JRM will turn its attention to habitat outside the harbor. Luminao and Glass Breakwater are logical places to perform habitat mapping.

In the past two decades, there have been broad scale resource inventories (Paulay et al. 1997, 2001, 2002), but relatively little effort has been invested into Luminao and Glass Breakwater. Numerous marine resource assessments were conducted to support a potential aircraft carrier pier for the Guam Military Relocation EIS/OEIS (Dollar et al. 2009; Minton et al. 2009; NAVFAC Pacific 2011a; McManus and McManus 2012). One of those reports included evaluating a potential mitigation site on the north side of Glass Breakwater (NAVFAC Pacific 2011b).

5.3.5.3.1 Bottom Habitat

Luminao is a barrier reef that extends west from Cabras Island creating the lagoon that became Apra Harbor. The Glass Breakwater was constructed atop a portion of Luminao. The habitat on Luminao and Glass Breakwater is typical fringing reef habitat, exposed to high wave action. These locations are important reference sites for Guam reefs in general because of the relatively good health of the coral communities and the high water circulation.

5.3.5.3.2 Coastal Habitat

The shoreline of Luminao is an artificial structure called Glass Breakwater which provides additional protection to Apra Harbor from the north. Glass Breakwater is composed of large boulders and, at the western extent, small sand deposits. There is a significant reef flat on Luminao and the amount of shallow substrate in clear water conditions is a distinct contrast to any other shallow water habitat on NBG Main Base.

5.3.5.4 Marine Flora

Native Species

Being exposed to high wave energy, seagrass beds are not present on Luminao or the north side of Glass Breakwater. In 2011, long-term monitoring sites were added on Luminao Reef, Cabras Island, and Orote Peninsula ERA across three depth strata (I. Williams et al. 2012). From these surveys, average macroalgae cover on Luminao and Glass Breakwater was approximately 25% and coral cover was relatively high (Williams et al. 2012).

Very little specific information on algae is available on Luminao and Glass Breakwater. Only one recent survey included macroalgae cover and diversity on the north side of Glass Breakwater (NAVFAC Pacific 2011a). Macroalgae percent cover ranged from a low of 7% to a high of 54%, and the average across five transects was 30% (±8.3 SE). Crustose coralline algae (CCA) had the highest average cover at 14% (±5.3 SE), followed by turf algae at 4% (±2.8 SE). Other less abundant species included *Halimeda* sp., *Peyssonnelia* sp., and cyanobacteria.

Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine flora in Guam are presented in Section 4.5.3, *Marine Flora*.

There are not yet reports of non-native or invasive marine flora on Luminao or Glass Breakwater. JRM has identified management strategies and actions to survey the areas to determine what species are present

including MHM-2 discussed in Section 5.4.2.1, *Marine Habitat Management* and MIS-2 discussed in Section 5.4.2.2, *Marine Invasive Species Management*. The nuisance marine angel hair algae (*Chaetomorpha* spp.) is a recurring problem with major blooms recorded on Luminao, Cocos, and Tanguisson (Schils 2015).

5.3.5.5 Marine Invertebrates

Native Species

Only one site on Luminao has been surveyed for marine invertebrates and coral cover was approximately 50%, dominated by acroporid species (Myers and Raymundo 2009). Additional site-specific data on coral and other invertebrates has not been reported; however, this site will continue to be monitored and a report will be completed once 10 years of quarterly monitoring surveys are completed.

As stated above in the Marine Flora section, surveys for the potential carrier wharf in Apra Harbor examined one site on the north side of Glass Breakwater (NAVFAC Pacific 2011a). Transects were established outside of the fringing reef at depths of 25–60 feet (7.6–18.2 meters). Stony coral percent cover ranged from 10% on the deepest transect to 79% on the shallowest transect, and averaged 33% (±12.0 SE) across all transects. In 2011, the Pacific RAMP included survey locations on Luminao Reef (and Cabras Island). From these surveys, coral cover averaged approximately 20%.

The total number of stony coral species identified in NAVFAC Pacific (2011a) on the five transects was 72 species. The most abundant stony coral species were *Leptastrea purpurea, Porites* sp., *Montipora* sp., *Favia* sp., *Porites pini*, and *Porites rus*. These six most abundant coral taxa composed 61% of the total stony corals identified. Size class data for the six most abundant coral taxa indicate the two species, *Leptastrea purpurea* and *Porites* sp., were the most abundant in the 5–10 centimeter and 10–20 centimeter size classes.

Severe coral bleaching events in 2013, 2014, and 2016 degraded Guam's reefs. In 2015, El Nino–Southern Oscillation-related extreme low tides exposed reef flats for prolonged periods which led to further mortality (Raymundo et al. 2017). Comparing coral cover data from approximately 2011 through the extreme low tide impacts of 2015, Raymundo et al. (2017) estimated that 80% of staghorn *Acropora* on Luminao was killed.

Sponge percent cover was very low on all transects on Glass Breakwater ranging from >0% to 2% (NAVFAC Pacific 2011b). Mobile invertebrates were infrequent as well. The urchin *Echinostrephus aciculatus* was the most frequently observed mobile invertebrate followed by the gastropod *Tectus niloticus* and several unidentified hermit crabs. The edible snail, introduced as a food source, was known as *Trochus niloticus* until a taxonomic name change in 2008 to *Tectus niloticus.* The name *Trochus* remains widely-known and is mentioned here to improve accessibility.

Giant clams *(Tridacna* spp.) were observed on Luminao. During surveys in 2010, HDR observed *Tridacna* clams on two of the five transects conducted on Luminao (NAVFAC Pacific 2011b). The observations were listed as *Tridacna* sp., so it is not known if the *Tridacna* species proposed for ESA listing are present on Luminao Reef or Glass Breakwater (NMFS 2017a).

Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine invertebrates in Guam are presented in Section 4.5.4, *Marine Invertebrates*.

As of the date of this INRMP, there have been no reports of non-native or invasive marine invertebrates on Luminao or Glass Breakwater. JRM has identified management strategies and actions to survey the areas to determine what invertebrate species are present including MHM-1 and MHM-5 discussed in Section 5.4.2.1, *Marine Habitat Management*. COTS is a native corallivorous seastar (it consumes scleractinian corals) that occasionally becomes a nuisance during outbreaks (Randall 1972; Lane 2012). It has been observed on Glass Breakwater and Luminao Reef (NAVFAC Pacific 2011b; Timmers 2016). Evidence of COTS feeding was also observed.

5.3.5.6 Marine Fishes

Native Species

Few fish studies have included Luminao Reef or the Glass Breakwater. In 2011, long-term monitoring sites were added on Luminao Reef, Cabras Island, and Orote Peninsula ERA across three depth strata (Williams et al. 2012), but results are not yet available. The bumphead parrotfish, a species of concern, has not been recorded on Luminao Reef or Glass Breakwater in any known recent survey.

Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Chapter 3, *Environmental Management Strategy and Mission Sustainability*, Section 3.5.3 *Regional Biosecurity Plan for Micronesia and Hawai'i.* General issues for non-native, invasive, and nuisance marine fishes in Guam are presented in Chapter 4, *Overview of Guam,* Section, 4.5.5 *Marine Fishes*.

There are not yet reports of non-native or invasive marine fishes on Luminao or Glass Breakwater, and JRM has identified management strategies and actions to survey the areas to determine what fish species are present including MHM-1 and MHM-5 discussed in 5.4.2.1, *Marine Habitat Management*. A nuisance marine species is native, but occasionally exhibits population booms or other undesirable characteristics, and there are not yet reports of nuisance marine fishes on Luminao or Glass Breakwater.

5.3.5.7 Marine Protected Species

Invertebrates – Corals

There are no records of *Acropora globiceps* on Luminao or Glass Breakwater, but there is a record on Cabras Island, just east of Luminao (Brown 2015). Closely related species that could be mistaken for *A. globiceps* are present on Luminao. Paulay et al. (2001) noted that *A. globiceps* was identified as *Acropora wardi* (also *wardii*) in Randall and Meyers (1983). Since then, coral experts agree that the differences between *A. wardi*, *A. globiceps*, and *Acropora humilis* have become better defined. For comparison, the 2009 presence/absence survey on the Orote Peninsula ERA reported *A. wardi* to be present on one of 59 stations and *Acropora humilis* was reported on 24 out of 59 stations (NAVFAC Marianas 2010b).

Acropora retusa usually occurs on upper reef slopes and tide pools ranging at depths of 1-15 feet (0.3-5 meters). Only two sightings of this species exist in Guam, both at depths of 50-66 feet (15-20 meters) (Brown 2015). There are no records of this species on Luminao, but the reef is the type of habitat that could support it. *Seriatopora aculeata* occurs at depths of 10-130 feet (3-40 meters). Its habitat preferences are largely unknown and there are no records of it on Luminao.

Fishes

Adult scalloped hammerhead sharks (*Sphyrna lewini*) have been observed nearby Luminao on Orote Peninsula and along the outer coastline of the Orote Peninsula near the Orote Airfield (NMFS 2015a; Adams 2018). The earliest confirmed record of a scalloped hammerhead in Guam was in 1968 and

confirmed sightings remain rare to today (Kami 1971; NMFS 2014b; Adams 2018). There are anecdotal reports of scalloped hammerheads on Luminao (Tibbatts 2017).

Sea Turtles

The shallows on Luminao Reef could support sea turtle resting or foraging; however, this part of the island had the fewest turtle sightings in the past five decades (Martin et al. 2016). Data collected from a large-scale, multi-year sea turtle tagging and observation survey that began in 2015 showed that although turtles are not found in high densities in this area, there is a particularly high ratio of hawksbill turtles compared to green turtles, and the turtles remained in those areas for the duration of the tag transmission period (NOAA 2022).

Marine Mammals

Marine mammals have been spotted offshore of Luminao and north to the Piti Floating Mine Neutralization Site. The list of species include spinner dolphins (*Stenella longirostris*), pantropical spotted dolphins (*Stenella atitenuata*), bottlenose dolphin (*Tursiops triuncatus*); sperm whale (*Physeter microcephalus*), dwarf sperm whale (*Kogia sima*), pygmy killer whale (*Feresa attenuata*), short-finned pilot whale (*Globicephala macrorhynchus*), false killer whale (*Pseudorca crassidens*), and melon-headed whale (*Peponocephala electra*) (Oleson and Hill 2010; NAVFAC Pacific 2012b; Hill et al. 2013b, 2014, 2016, 2017). Most of the species occur offshore and are discussed further in Section 5.3.8.3, *Marine Protected Species*. Spinner dolphins generally occur close to shore, and during marine mammal monitoring for Commander, U.S. Pacific Fleet (COMPACFLT), scientists observed a group of 15 spinner dolphins close to land in the Piti area just east of Cabras Island (Hill et al. 2015). Spinner dolphins are seen less in this area than other locations that are more protected and less populated by humans, such as southwest coast of Guam (Martin et al. 2016).

5.3.6 Orote Peninsula Marine Environment

Orote Peninsula is a prominent geographic feature, and also defines the habitat-zone on JRM-administered submerged lands (see Figure 5-10). The Orote Peninsula ERA extends along nearly the entire coastline of the Orote Peninsula (see Figures 5-2 and 5-10). Because these areas are nearly the same, data from the Orote Peninsula ERA generally applies to Orote Peninsula, and vice-versa.

5.3.6.1 Bathymetry and Currents

The bathymetry of the nearshore environment outside Apra Harbor contrasts significantly with the other areas on JRM-administered submerged lands on NBG Main Base. Reef flats are almost entirely absent from the area because there is no fringing reef. Instead, the steep cliffs extend down into the ocean and then taper out into a reef slope, most prominent at the northwest tip of the peninsula where tapering does not begin until a depth of 66 feet (20 meters). The cliff face has characteristic fissures that form a variety of distinctive cave features underwater. The seafloor is variable forming a nearly vertical sea cliff at the northwestern extent, and broad 30-degree terraces to the southeast. The terraces in this area are littered with large chunks of the cliff face that have broken off.

In the southwest portion of the island, net flow is northern from Facpi Point or northwestern from Agat Bay along shore. These westward currents converge out past the tip of Orote Peninsula with currents prevailing to the south moving from Hagatna Bay down the coast along Luminao and Glass Breakwater (Wolanski et al. 2003). Guam is large enough to create a lee effect and eddies that counter or reduce the effect of the NEC (Wolanski et al. 2003). Some influences such as tropical cyclones, El Nino, and ocean cyclonic eddies can also cause the reversal of dominant surface current flow (Eldredge 1983; Lagerloef et al. 1999; Wolanski et al. 2003). Currents along the Orote Peninsula can be much faster moving than those found off

the Glass Breakwater with rates as high as 0.5-meter per second (see Figure 5-12). They can also be more variable on a shorter time scale (Paulay et al. 2001; Wolanski et al. 2003).

5.3.6.2 Turbidity and Water Quality

Turbidity is tightly coupled with freshwater inputs, which have a distinct seasonal weather pattern (i.e., monsoonal) that is punctuated with cyclonic storm events. The southwest side of Orote Peninsula is not adjacent and/or down current from major freshwater inputs. It is exposed to open ocean to the west and therefore high wave energy, which transport sediments away laterally and/or longitudinally. Underwater visibility tends to be good on Orote Peninsula. Unsurprisingly, Orote Peninsula has cooler, cleaner water than Apra Harbor as measured by temperature, salinity, and turbidity (Brainard et al. 2012).



Effluent from this storm drain empties considerable quantities of freshwater and silt into the shallow waters in the southern part of the Orote Peninsula ERA during heavy rainfall.
(*Photo*: SWCA)

5.3.6.3 Marine Habitats

Regarding Outer Apra Harbor, there are ongoing efforts to better understand the spatial distribution of habitat on JRM-administered submerged lands (see Figure 5-10). After attending to the Harbor, JRM will turn its attention to habitat outside the Harbor.



Orote Peninsula
(*Photo*: D. Snyder)

In the past two decades, there have been broad scale resource inventories (Paulay et al. 2001; NAVFAC Marianas 2010c), but less effort has been invested on Orote Peninsula ERA than Apra Harbor. The Orote Peninsula ERA management unit consists of three general habitat types: cliff reef, reef slope, and reef drop off (Paulay et al. 2001). The reef slope on Orote Peninsula represents a small, unique transitional habitat between the very different marine environments of Apra Harbor and south Orote (Paulay et al. 2001). All three habitat types are characterized by abrupt transitions and steep slopes (Paulay et al. 2001).

5.3.6.3.1 Bottom Habitat

Bottom habitat along the seaward side of Orote Peninsula has two official designations: (1) as part of the Orote Peninsula ERA (see Section 5.1.6.2, *Orote Peninsula ERA* for details), and (2) as a HAPC (WPRFMC 2009). The seaward side bottom habitats on Orote Peninsula ERA are categorized as hardbottom rather than reef because the seafloor setting is primarily erosional due to high wave action. The Orote Peninsula is an important reference because of the relatively good health of the coral communities and the high water circulation.

Marine resources on Orote Peninsula ERA were initially evaluated in 1986 (USFWS 1986), and subsequently by Paulay et al. (2001), Smith et al. (2009), and NAVFAC Marianas (2010c). The current

general management plan for the ERA was finalized in 2010 (NAVFAC Marianas 2010b). As stated above, the Orote Peninsula ERA has no reef flats.

5.3.6.3.2 Coastal Habitat

Coastal habitats found along Orote Peninsula are characterized by steep cliffs that either plunge directly into the ocean or taper out as narrow rocky benches.

5.3.6.4 Marine Flora

Native Species

NOAA Coral Reef Ecosystem Division evaluated one site on Orote Peninsula ERA, and reported high algae cover from 2003-2007 (68% in 2003, declining through to 2007) (Brainard et al. 2012). The Coral Reef Ecosystem Division surveys report little to no CCA on Orote Peninsula.

Other surveys suggest Orote Peninsula may not be uniform with respect to algae. Smith et al. (2009) recorded 52 genera of marine algae on Orote Peninsula ERA. Orote may have a unique algae assemblage. New species records for Guam by Smith et al. (2009) included: *Amphiroa tribulus*, *Dictyosphaeria intermedia*, *Galaxaura divaricata*, *Gracilaria* cf. *millardetii*, *Haloplegma duperreyi*, *Hypnea saidana*, *Phyllodictyon anastomosans*, and *Tricleocarpa cylindrica*. *Pseudocodium okinawense* was described from a deep site on Orote Peninsula (250 feet [76 meters]), based on photographs taken before the specimen was lost (Faye et al. 2008). Smith et al. (2009) indicate that the point of Orote Peninsula differs hydrodynamically, geomorphologically, and biologically from other Orote Peninsula sites. The point features a well-developed reef assemblage characterized by a high coral cover, CCA cover, rich *Halimeda* stands and little turf algae cover. Shallow sites on Orote Peninsula ERA also had high CCA cover while the remaining stations were typified by high cover of turf algae and *Padina* (a dominant brown alga). Seagrass beds are not present on Orote Peninsula due to active surf and steep rocky terrain.

Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine flora in Guam are presented in Section 4.5.3, *Marine Flora*.

There are not yet reports of non-native or invasive marine flora on Orote Peninsula. JRM has identified management strategies and actions to survey the area to determine what species are present including MHM-2 discussed in 5.4.2.1, *Marine Habitat Management* and MIS-2 discussed in 5.4.2.2, *Marine Invasive Species Management*. Marine flora are not particularly abundant on Orote Peninsula (NAVFAC Pacific 2011a). There are not yet reports of nuisance marine flora on Orote Peninsula. The angel hair algae (*Chaetomorpha* spp.) may be present, but the relatively intense wave and currents make blooms unlikely.

5.3.6.5 Marine Invertebrates

Native Species

An assessment of coral colony size on Orote Peninsula suggests that recruitment is occurring and corals are replacing themselves. Coral diversity on Orote Peninsula is lower than other Guam fringing reefs, primarily due to the limited number of habitats types: cliff reef, reef slope, and reef drop off (Paulay et al. 2001). Smith et al. (2009) used the same survey sites as Paulay et al. (2001) to survey benthic communities on Orote Peninsula. Smith et al. (2008) recorded 200 species of stony corals, up from 156 species recorded by Paulay et al. (2001). In a different type of survey the mean number of coral species at each station on Orote Peninsula was 15.1 in 2008, up from 12.1 in 2001 (Smith et al. 2009). Coral cover ranged broadly, about 3–97% (Smith et al. 2009), and about 3–72% (Paulay et al. 2001).

Paulay et al. (2001) recorded 757 species of macroinvertebrates on Orote Peninsula. No other studies on Orote Peninsula have observed a similar number of species. Only 350 species of macroinvertebrates were recorded from biodiversity studies at the Orote Peninsula ERA in 2008 at the same sites Paulay et al. used (Paulay et al. 2001; Smith et al. 2009). A series of quantitative surveys of macroinvertebrates in 2008 (NAVFAC Marianas 2010c) found 42 species, up from 28 species in 2001 (Paulay et al. 2001). The biodiversity survey method is designed to maximize the list of species observed and may be an accurate depiction of maximum diversity on Orote Peninsula. The quantitative surveys are probably more representative of average macroinvertebrate diversity at any given location, because only those species that occur within randomly placed quadrats or transects are assessed. The two different assessment methods provide different diversity estimates and the trends between the two survey methods are contradictory. However, none of these differences are statistically significant and can be explained by observer interest, bias, experience, and sampling error.

The most common macroinvertebrates on Orote Peninsula ERA are the needle-spine sea urchin (*Echinostrephus aciculatus*) followed by the edible sea cucumber (*Holothuria edulis*) and the rock boring sea urchin (*Echinometra mathaei*) (NAVFAC Marianas 2010c). Smith et al. (2009) characterized the overall densities of macroinvertebrates on Orote Peninsula as low, with localized exceptions of some echinoid species. As with macroalgae, the northern tip of the Orote Peninsula has an invertebrate community that is measurably different from other places in the ERA, partially due to higher coral cover. Otherwise, the invertebrate communities are relatively homogenous (Smith et al. 2009).

Giant clams (*Tridacna* spp.) occur on Orote Peninsula ERA. During the 2010 surveys for mitigation sites that could be used for the proposed aircraft carrier wharf in Apra Harbor, HDR described *Tridacna* clams as relatively abundant at the tip of Orote Peninsula (Deakos et al. 2016). They were recorded on three of the five transects in that area. One of the observations was *Tridacna crocea*, but the other two were listed as *Tridacna* sp., so the species could conceivably be *Tridacna derasa*. Paulay et al. (2001) reported encountering *Tridacna maxima* at 6 of the 10 permanent monitoring stations on Orote Peninsula ERA, and Smith et al. (2009) report the same species at density from 0.8 to 2 organisms/100 square meters (1,076 square feet) on Orote Peninsula and in 7 out of 10 monitoring transects Orote Peninsula ERA.

Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine invertebrates in Guam are presented in Section 4.5.4, *Marine Invertebrates*.

Relatively few non-native species are likely, based on data from Paulay et al. (2002), and there are no reports of invasive marine invertebrates on Orote Peninsula. JRM has identified management strategies and actions to survey the area to determine what invertebrate species are present including MHM-1 and MHM-5 discussed in 5.4.2.1, *Marine Habitat Management*. The nuisance marine invertebrate, COTS, have been observed on Orote Peninsula ERA on multiple occasions (Smith et al. 2009; NAVFAC Marianas 2011b; Brainard et al. 2012; Timmers 2016). In the most recent quantitative report, the density was between 0.01 and 0.15 animals/100 square meters (1,076 square feet) (Brainard et al. 2012). Densities have been low, 0.002 COTS/square meters for Smith et al. (2009), equivalent to a density of eight individuals/acre (20



Crown-of-Thorns seastar (*Acanthaster planci*) at Spanish Steps on the Orote Peninsula.
(*Photo*: M. Lybolt)

individuals/hectare). Anecdotally, divers have noticed clusters of COTS appearing at the popular dive sites on Orote Peninsula ERA – Blue Hole, Barracuda Rock, and Crevice.

5.3.6.6 Marine Fishes

Native Species

Paulay et al. (2001) found 339 species of marine fishes on Orote Peninsula ERA. NAVFAC Marianas (2010b) recorded 427 species of fishes at the ERA, some not found elsewhere in Guam. Previous surveys were not as successful. USFWS (1986) recorded 227 marine fish species on Orote Peninsula ERA, and only 116 fish species were found 2 years later (USFWS 1988). In spite of the difference between years, little qualitative change in the health of the fish community has been observed. The families of wrasses (Labridae) and damselfishes (Pomacentridae) were the best represented. Other well represented families included triggerfish (Balistidae), surgeonfish (Acanthuridae), squirrelfish (Holocentridae), butterflyfish (Chaetodontidae), jack (Carangidae), and goatfish (Mullidae). The most abundant species in both surveys were the surge damselfish (*Chrysiptera leucopoma* aka *leucopomus* and *brownriggii*), damsel (*Pomachromis guamensis*), and the Chinese zebra goby (*Pterelectris* [=*Pogonoculius*] *zebra*) (USFWS 1986, 1988; Paulay et al. 2001; NAVFAC Marianas 2010c). Two species of sharks, the blacktip (*Carcharhinus melanopterus*) and the reef whitetip (*Triaenodon obeseus*), have been recorded on Orote Peninsula ERA (NAVFAC Marianas 2010c). While fishing is prohibited on Orote Peninsula ERA, there have been reports of illegal fishing. JRM is working on establishing a Conservation Law Enforcement Program, presented in Section 5.4.1.6, *Terrestrial Natural Resources Law Enforcement*, in order to improve management of the marine resources on Orote Peninsula ERA.

Burdick et al. (2008) reported that large parrotfishes, groupers, and wrasses are being targeted by spearfishers as the rise of 'trophy' fishing became more popular in the 1990s. The main families targeted by boat and shore fishermen in Guam from 2004 to 2006 include Acanthuridae, Carangidae, Lutjanidae, Lethrinidae, Mullidae, Siganidae, Kyphosidae, Scaridae, Scombridae, and Sphyraenidae (Burdick et al. 2008). Large-sized individuals are rare within on Orote Peninsula and were limited to emperors (*Lethrinus olivaceus*) and juvenile or young immature-phase female parrotfishes (*Chlorurus microrhinos*).

During surveys in 2009, the humphead wrasse, a species of concern, was found at 10 of 59 survey stations on Orote Peninsula ERA. These individuals were mainly juveniles or smaller females (NAVFAC Marianas 2010c). Adult males (terminal males) have been observed on Orote Peninsula ERA as recently as December 2016 (Brown 2017). The bumphead parrotfish, also a species of concern, has not been recorded on Orote Peninsula ERA during surveys or monitoring studies (USFWS 1986; NAVFAC Marianas 2010b). Martin et al. (2016) indicate that the section of the coast between the tip of the Orote Peninsula and Facpi Point could be an area of manta ray aggregation, although the density is much less than the northwest coast of Guam.

Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine fishes in Guam are presented in Section 4.5.5, *Marine Fishes*.

There are not yet reports of non-native or invasive marine fishes on Orote Peninsula. JRM has identified management strategies and actions to survey the area to determine what fish species are present including MHM-1 and MHM-5 discussed in 5.4.2.1, *Marine Habitat Management*. A nuisance marine species is native, but occasionally exhibits population booms or other undesirable characteristics, and there are not yet reports of nuisance marine fishes on Orote Peninsula.

5.3.6.7 Marine Protected Species

Invertebrates – Corals



ESA threatened *Acropora globiceps* at Spanish Steps on Orote Peninsula.
(*Photo*: M. Lybolt)

Acropora globiceps occurs on upper reef slopes and reef flats from very shallow locations down to 26 feet (8 meters), within relatively strong wave environments. There are no records of *A. globiceps* on Orote Peninsula ERA and the southern side of Orote Peninsula does not appear to be optimal habitat, but *A. globiceps* has been recorded at Dadi. Closely related species that could be mistaken for *A. globiceps* are present on Orote Peninsula. A 2009 presence/absence survey on Orote Peninsula ERA reported *Acropora wardi* to be present on 1 out of 59 biodiversity stations and *Acropora humilis* was reported on 24 out of 59 stations (NAVFAC Marianas 2010c). *A. globiceps* occurs on the point of Orote Peninsula (Lybolt 2015), but the point of Orote Peninsula is substantially different habitat than most Orote Peninsula ERA.

There are no records of *Acropora retusa* on Orote Peninsula ERA. The waters of Orote Peninsula ERA are unlikely to support this species due to the lack of shallow reef slope or tide pool habitat. Although Orote Peninsula ERA could conceivably support *S. aculeata*, there are no records of this species.

Fishes

In their 1986 survey of Orote Peninsula ERA (USFWS 1986), the USFWS noted that the scalloped hammerhead shark was "(previously reported) - known to occur but not observed." There is no indication as to the source of the 'previous report.' The scalloped hammerhead shark was not observed during 2008 surveys or previous monitoring studies in the vicinity of Orote Peninsula (NAVFAC Marianas 2010c). Single adult scalloped hammerhead sharks have been observed at the Blue Hole and Crevice dive sites in 2010 and 2015, respectively (Adams 2018). Adult scalloped hammerheads were observed on Orote Peninsula ERA and Apra Harbor (NMFS 2014b, 2015a). In early October 2017, a scalloped hammerhead (approximately 6 feet [1.8 meters]) was observed by divers at Spanish Steps (Tibbatts 2017).

Sea Turtles

Green and hawksbill turtles are frequently seen on Orote Peninsula ERA (Paulay et al. 2001; NAVFAC Marianas 2010c). Results from a large-scale turtle monitoring study from 2015–2022 showed that turtles are found in high densities on the west side of Orote Point, particularly green turtles, while few are found on the south side due to the lack of beach and other structures needed to support resting and foraging behavior (NOAA 2022). Tagging information indicates that turtles seen along the cliff of the Orote Peninsula ERA are in transit between Dadi/Agat Bay and Apra Harbor (NAVFAC Pacific 2011c; Jones et al. 2015; Martin and Jones 2017).

Sea turtle nesting surveys were conducted on NBG beaches in October 2022 and August 2023. A total of 28 nests (protected with wire mesh screening) and zero non-nesting emergences were observed (NAVFAC Marianas and NBG 2023). Out of all survey sites, turtle activity occurred solely at the Spanish Steps beach, and all activities were created by the green sea turtle; no evidence of hawksbill turtle activity was documented (NAVFAC Marianas and NBG 2023).

NBG implemented a nesting beach habitat enhancement program through the JRM INRMP which includes removal of invasive vegetation and marine debris, and trapping/removal of monitor lizards to prevent

predation at Spanish Steps (NAVFAC Marianas 2016b). Between September 2015 and October 2016, five monitor lizards were removed (three females, of which one had 11 eggs), one male, and one (sex unknown). The lizards were captured via noose traps and air rifle (NAVFAC Marianas 2016b). Noose traps were again deployed at Spanish Steps beach between October 17 and November 7, 2022. During this trapping period, (at least) five monitor lizards were captured; stomach contents did not contain evidence of hatchling predation. NBG began utilizing self-releasing screens in 2017 at Spanish Steps to prevent depredation of nests/hatchlings by monitor lizards. NBG also placed barricades (10- to 20-foot [3- to 6-meter] lengths) at six access points along Dadi Beach allowing pedestrian access while at the same time restricting vehicular access to protect sea turtle nests (NAVFAC Marianas 2016b). Vegetation removal was executed at the Spanish Steps in late February 2023 (NAVFAC Marianas and NBG 2023).

Marine Mammals

During nearshore marine mammal surveys conducted in 2015, cetaceans observed on Orote Peninsula included spinner dolphin (closer to Dadi), bottlenose dolphin, pantropical spotted dolphins, short-finned pilot whale, sperm whale, and dwarf sperm whale (Oleson and Hill 2010; NAVFAC Pacific 2012b; Hill et al. 2013b, 2015, 2016, 2017). Because of the deep water adjacent to Orote Peninsula, some marine mammals that are deep water species and rarely seen close to land can approach and be observed from land. During marine surveys in 2009, small groups of spinner dolphins and larger aggregations of short-finned pilot whales were observed infrequently near the survey stations (NAVFAC Marianas 2010c). In addition, sperm whales were observed 0.7 mile (1.1 kilometers) offshore of Orote Peninsula in February 2010 (Hill et al. 2012). That same month, two pods of sperm whales were photographed close to shore. Smith et al. (2009) also reported a sperm whale on Orote Peninsula ERA in 2008.

Most of the species occur offshore and are discussed further in Section 5.3.8.4, *Marine Protected Species*. Spinner dolphins regularly occur close to shore, but surveys did not record them in this area. Instead, they were seen frequently in Agat Bay.

5.3.7 Dadi Marine Environment

5.3.7.1 Bathymetry and Currents

Dadi is a beach located on the southwest side of NBG Main Base. The main beach area is approximately 0.6 mile (1 kilometer) long with a narrow sand and shell beach. The in-water substrate consists of a shallow reef flat about 0.1 mile (0.2 kilometer) wide. The bottom of near shore reef flat is soft sand that supports seagrass. Beyond the soft bottom, the area is bathymetrically complex at the meso-scale with many pits, dips, and ridges with hard bottom that supports coral.

In the southwest portion of the island, net flow is northern from Facpi Point or northwestern from Agat Bay along shore. Guam is large enough to create a lee effect and eddies that counter or reduce the effect of the NEC (Wolanski et al. 2003) (see Figure 5-12). Some influences such as tropical cyclones, El Nino, and ocean cyclonic eddies can also cause the reversal of dominant surface current flow (Eldredge 1983; Lagerloef et al. 1999; Wolanski et al. 2003). Currents along the reef slope of Dadi can be much faster moving than those found off Glass Breakwater with rates as high as 0.5 meters per second (see Figure 5-12). The shallow reef area is broad enough that it can be subject to movement caused by swell approaching the shore without plunging waves, because there is not a hard, shallow reef crest to break the waves like many of the other fringing reefs on the island.

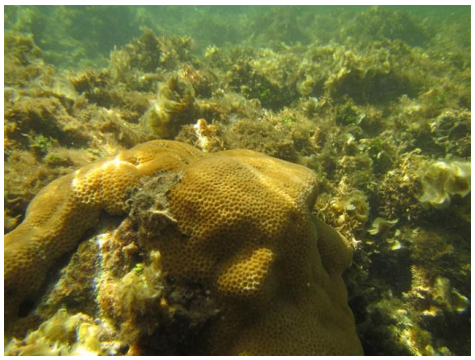
5.3.7.2 Turbidity and Water Quality

Turbidity is tightly coupled with freshwater inputs, which have a distinct seasonal weather pattern (i.e., monsoonal) that is punctuated with cyclonic storm events. Dadi is in the northern tip of the Agat Watershed.

The shore is low-lying enough to allow stormwater and sheeting runoff during rain events, but there is not significant feeding of the area by streams. The beach is exposed to open ocean to the west, but is sheltered by a reef flat and seagrass bed. Wave energy, which transports sediments away laterally and/or longitudinally is somewhat buffered. In the very nearshore, a moderate level of turbidity can occur. Otherwise, underwater visibility tends to be good on Dadi.

Measurements of water and sediment quality on Dadi would improve the understanding of the condition and stresses on resources at this location.

5.3.7.3 Marine Habitats



Dadi reef flat is dominated by macroalgae with sparse coral and seagrass.
(*Photo*: M. Lybolt)

Regarding Outer Apra Harbor, there are ongoing efforts to better understand the spatial distribution of habitat on JRM-administered submerged lands (see Figure 5-13). NBG Main Base is already in the process of getting improved habitat mapping and bathymetric data on Dadi (see Section 5.4.2.1, *Marine Habitat Management*).

In the past two decades, there have been broad scale resource inventories (Paulay et al. 2001; Smith et al. 2009; NAVFAC Marianas 2010c), but even less effort has been invested on Dadi than Orote Peninsula ERA. The effort of Paulay et al. in 2001 was primarily on the reef slope, and these sites were revisited by Smith et al. (2009). In 2009 and 2010, the surveys included biodiversity sites, a few of which were on Dadi. Aside from those surveys, attention has been on the seagrass beds on Dadi because they are an important resource for green sea turtles (NAVFAC Marianas 2011c).

5.3.7.3.1 Bottom Habitat

Bottom habitat on Dadi includes sandy soft bottom near shore that support seagrass beds (Porter et al. 2005; NAVFAC Marianas 2011c). On the reef flat and slope is an extended area of pavement and aggregate reef that supports up to 50% turf algae or coral cover (Porter et al. 2005). There is also a large sand channel that extends toward shore on the south end of Dadi (Smith et al. 2009).

5.3.7.3.2 Coastal Habitat

Dadi is a beach and rocky shoreline located on the southwest coast of NBG. The main beach area is an approximately 0.6-mile (1-kilometer) long sand and shell beach. In the mid-1940s, the Japanese constructed an elaborate interlocking system of pillboxes, strong points, and trenches on the north end of Dadi around the base of Orote Peninsula to defend the airfield. Freshwater seeps occur at various locations on Orote Peninsula, including Tipalao (Randall and Holloman 1974). The remains of this anti-landing defense network can still be seen below the southern end of the South Tipalao housing area (NAVFAC Marianas 2011c).

5.3.7.4 Marine Flora

Native Species

Seagrass beds found on Dadi Beach are dominated by two species: tape grass (*Enhalus acoroides*) and narrowleaf seagrass (*Halodule uninervis*) (see Figure 5-13) (NAVFAC Marianas 2011c). Tape grass was located exclusively in the northern section of the survey area. Narrowleaf seagrass was primarily located to the south of the tape grass but could also be found in small patches below the Japanese Fortifications near South Tipalao. The two species were somewhat disparate geographically, but isolated mixed patches

occurred around the interface of these species, in the vicinity of Tipalao Beach, and in a few isolated areas further south. The total area of seagrass cover was estimated to be 4.6 acres (1.9 hectares) (NAVFAC Marianas 2011c). Seagrass beds are considered EFH and are also designated as special aquatic sites under the CWA. Seagrass is also considered a benthic foraging essential feature for green turtle critical habitat.

Both Paulay et al. (2001) and Smith et al. (2009) found that shallow sites had CCA cover and species composition typical of shallow habitats. They also found that shallow water sites on Dadi were consistently more diverse than other sites on Orote Peninsula or Haputo ERAs. NBG Main Base conducted a seagrass mapping project in FY17 to monitor the extent and health of seagrass on Dadi.

Non-native and Nuisance Species

The definitions of non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine flora in Guam are presented in Section 4.5.3, *Marine Flora*.

There are not yet reports of non-native or invasive marine flora on Dadi. JRM has identified management strategies and actions to survey the area to determine what species are present including MHM-2 discussed in 5.4.2.1, *Marine Habitat Management* and MIS-2 discussed in 5.4.2.2, *Marine Invasive Species Management*. There are not yet reports of nuisance marine flora on Dadi, but the nuisance marine angel hair algae (*Chaetomorpha* spp.) is likely to be present based on their occurrence at similar habitats in Guam (Schils 2015).

5.3.7.5 Marine Invertebrates

Native Species

Surveys on Orote Peninsula ERA have not attempted to characterize or partition Dadi as a unique area of the Orote Peninsula. Several datasets exist on Dadi, but they were conveyed as overall trends about specific species or community elements rather than site- or station-specific information (Paulay et al. 2001; Smith et al. 2009). Both surveys found that the shallow areas of Dadi had much higher coral cover and colony sizes than deep sites. Shallow locations had 58 to 90% coral cover and very large mean colony sizes of 231 to 301 square inches (1,491 to 1,942 square centimeters). The coral colony size numbers are much larger than the results of Paulay et al. (2001), but Smith et al. (2009) explain this through methodological differences and loss of some permanent transect markers between the 2001 and 2008 study. Deep locations on Dadi had less than 9% coral cover and average colony size was between 20 and 24 inches (51 and 61 centimeters) (Smith et al. 2009).

Shallow locations on Dadi have similar species composition as other places on Orote Peninsula ERA. Better studies of the structure of the environment and greater detail of the invertebrate community will help to quantify Dadi's uniqueness on the Orote Peninsula/Agat Bay coastline. Paulay et al. (2001) and Smith et al. (2009) encountered the giant clam *Tridacna maxima* broadly distributed on Orote Peninsula ERA including sites on Dadi. Smith et al. (2009) report densities of *T. maxima* from 0.8 to 4 organisms per 100 square meters (1,076 square meters) on Dadi. *Tridacna derasa*, a species known in Guam, could be ESA-listed, but has not been specifically identified on Dadi.

Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine invertebrates in Guam are presented in Section 4.5.4, *Marine Invertebrates*.

Relatively few non-native species are likely on Dadi, based on data from similar habitat in Paulay et al. (2002), and there are no reports of invasive marine invertebrates on Dadi. There are not yet reports of non-native or invasive marine invertebrates on Dadi. JRM has identified management strategies and actions to survey the area to determine what invertebrate species are present including MHM-1 and MHM-5 discussed in 5.4.2.1, *Marine Habitat Management*. As in the Orote Peninsula section, the nuisance species, COTS, have been observed in the Orote ERA by Smith et al. (2009) and during DON surveys in the summer of 2017 (Timmers 2016). The area surveyed in 2017 included Dadi. There may have been a concentration of COTS in the area in the past. In 2003, towed diver surveys observed that the south end of Agat Bay contained one of the highest densities of COTS on the island – an average of 0.3 organisms/100 square meters (1,076 square feet) (Brainard et al. 2012).

5.3.7.6 Marine Fishes

Native Species

Past surveys have included Dadi as an integrated part of the Orote Peninsula ERA. Smith et al. (2009) noted broad similarity in the fish assemblage across Orote Peninsula ERA. Fish assemblages at reef flat stations tended to be distinct from bench upper slope stations, and this would be true of the sites for Dadi near the beach. The landscape of Dadi has some patches of habitat that are relatively unique. The stingray *Taeniura meyeni* was observed by Paulay et al. (2001) and Smith et al. (2009) on the large sandy bottom channel offshore of the southern part of Dadi. As described above in Section 5.3.3.3, *Marine Habitats,* a fishing advisory (catch and release only) has been issued for Dadi (see Figure 5-14).

Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i.* General issues for non-native, invasive, and nuisance marine fishes in Guam are presented in Section 4.5.5, *Marine Fishes*.

There are not yet reports of non-native or invasive marine fishes on Dadi. JRM has identified management strategies and actions to survey the area to determine what fish species are present including MHM-1 and MHM-5 discussed in 5.4.2.1, *Marine Habitat Management*. A nuisance marine species is native, but occasionally exhibits population booms or other undesirable characteristics, and there are not yet reports of nuisance marine fishes on Dadi.

5.3.7.7 Marine Protected Species

Invertebrates – Corals

Acropora globiceps was positively identified on Dadi in September 2016. At least one colony was observed during a 45–60 minute non-systematic swim (NMFS and NAVFAC Pacific 2017). The colony was relatively large, more than 7.9 inches (20 centimeters) across, and was bleaching on the distal ends of the branches. The colony occurred in less than 6.6 feet (2 meters) of water on the reef crest right near the large sand channel.



***Acropora globiceps* observed on Dadi.**
(*Photo*: J. Moribe)

Acropora retusa occurs on upper reef slopes and tide pools ranging at depths of 1-15 feet (0.3-5 meters). There are no records of this species being observed, but Dadi could conceivably support *A. retusa*. *Seriatopora aculeata* occurs at depths of 10-130 feet (3-40 meters). Its habitat preferences are largely unknown. The reef slope could conceivably support *S. aculeata*, but as of the publication of this INRMP, there are no records of this species within this area.

Fishes

The description of the occurrence of protected fishes on Orote Peninsula ERA probably applies to the reef slope on Dadi as well. As stated above, Smith et al. (2009) noted a relatively consistent base fish assemblage across the ERA. The shallows on Dadi are less likely to support the protected fish species because they prefer deeper habitat.

Sea Turtles

Green sea turtles are known to frequent the seagrass beds on Dadi Beach and Agat Bay (NOAA 2005; NAVFAC Pacific 2011c; Guam DAWR 2015; Jones et al. 2015; Hill et al. 2016; Martin and Jones 2016). Dominated by patch reef, Dadi Beach supports a high density of turtles, particularly green turtles.

During sea turtle surveys and satellite tagging operations in July 2014, May 2015, and November 2015, a total of 23 green sea turtles and two hawksbill turtles were captured from Agat Bay (Table 5-12) (NAVFAC Pacific 2011c; Jones et al. 2015; Martin and Jones 2016). All captured turtles had a suite of physiological data collected including length, mass, and skin samples for DNA and stable isotope analysis. A subset of these were also equipped with satellite tags. Standard captures included metal flipper tags and microchips injected subcutaneously into the rear flippers. Tracking data revealed high site fidelity and limited movements for green sea turtles between Agat Bay and Apra Harbor.

Table 5-12. Sea Turtle Observations and Captures Recorded at Agat Bay (2011, 2014, 2015)

Sea Turtle Species	Feb-Mar 2011[a]		July 2014[b]		May 2015[d]		Nov 2015[c]	
	Obs	Cap	Obs	Cap (Sat)	Obs	Cap (Sat)	Obs	Cap (Sat)
Green Sea Turtle (*Chelonia mydas*)	3	NA	5	2 (4)	15	2(7)	6	1 (7)
Hawksbill Turtle (*Eretmochelys imbricata*)	0	NA	0	1 (0)	0	0	0	1 (0)
Unknown	0	NA	0	0	1	0	9	0

Key: Cap = capture for tagging and taking of physiological samples; Feb = February; Mar = March; NA = not applicable; Nov = November; Obs = observation; Sat = capture for tagging, taking of physiological samples, and equipped with satellite tag.
Sources: [a] NAVFAC Pacific 2011c; [b] Jones et al. 2015; [c] Martin and Jones 2016; [d] Martin and Jones 2017.

Data collected from a large-scale sea turtle tagging and observation survey from 2015–2022 showed northern Dadi Beach has a high density of resident turtles, particularly of green turtles (NOAA 2022). This is likely due to the dominant patch reefs communities in the area that provide suitable resting and foraging habitat. During surveys conducted on NBG beaches from October 2022 to August 2023, there were no occurrences of green or hawksbill sea turtle nests on Dadi Beach (NAVFAC Marianas and NBG).

Marine Mammals

The marine mammals reported on Orote Peninsula or that aggregate in Agat Bay likely pass in front of Dadi. In particular, spinner dolphins could use the reef slope and some of the shallows above the large sand flat for resting. The part of the coast from the north tip of the Orote Peninsula south to Facpi Point is an area of moderate density for small delphinids (Martin et al. 2016).

Spinner dolphins have been reported in Agat Bay close to Dadi almost every year since COMPACFLT marine mammal monitoring has occurred in the Marianas (the effort formally started in 2010). Table 5-13 summarizes the sightings of spinner dolphins during small boat monitoring. Short-finned pilot whale have been reported offshore of Dadi and Agat Bay (Hill et al. 2015). Most species are reported off Orote Peninsula. This could be an actual pattern or just a reflection of bias in search effort or reporting. Tour operators regularly take tourists to view spinner dolphins on Dadi Beach. Since spinner dolphins rest during the day close to shore, these types of activities may impact the health of spinner dolphins and be viewed as harassment. NBG Main Base has proposed the establishment of a Conservation Law Enforcement Program, which would include enforcing regulations under the Marine Mammal Protection Act (MMPA) and could prevent disturbance and harassment from dolphin watching tours.

Table 5-13. Spinner Dolphin Sightings Recorded at Agat Bay during COMPACFLT Monitoring

Year	Number of Sightings	Group Size or Range of Group Size	Reference
2010	6	35-85	(Oleson and Hill 2010)
2011	4	3-35	(NAVFAC Pacific 2011c)
2012	1	20	(NAVFAC Pacific 2012b)
2013	1	25	(Hill et al. 2013b)
2014	1	24	(Hill et al. 2014)
2015	1 - near Agat Marina	9	(Hill et al. 2015)

Key: COMPACFLT = Commander, United States Pacific Fleet; NAVFAC = Naval Facilities Engineering Systems Command.

Sightings are usually within 0.6 mile (1 kilometer) of shore. The reduction in the number of sightings across time is not an indication of fewer dolphins. Small boat surveys for COMPACFLT monitoring are not

systematic in the way that areas are covered; therefore, sightings can be affected by how the field teams choose to search the Guam coastline for marine mammals.

5.3.8 Offshore Naval Base Guam Main Base Marine Environment

5.3.8.1 Bathymetry and Currents

The offshore waters around NBG Main Base drops off rapidly into mesophotic and aphotic insular shelf zones with distance from shore. There are no shoals, pinnacles, or sea mounts offshore of NBG Main Base. Within 3 miles (4.8 kilometers) of NBG Main Base, the water is approximately 4,950 feet (1,500 meters) deep.

As was stated in Section 4.5.1, *Physical Environment*, currents around Guam are heavily influenced by the NEC, which is driven by the northeast and southeast trade winds. Guam is large enough to create a lee effect and NBG Main Base and the offshore waters are in the lee of island. Some influences such as tropical cyclones, El Nino, and ocean cyclonic eddies can also cause the reversal of dominant surface current flow (Eldredge 1983; Lagerloef et al. 1999; Wolanski et al. 2003) moving water in an eastward direction, but these conditions are atypical.

5.3.8.2 Marine Habitats

The majority of the habitat offshore is open ocean (see Figure 5-13). The rapid drop off to the pelagic environment encourages species that are usually associated with being in deep water far offshore to occasionally come close to land.

Mesophotic coral ecosystems (MCE) extend from the nearshore area to offshore environments. Literature has generally defined MCEs as "light-dependent corals and associated communities typically found at depths ranging from 30–40 meters and extending to over 150 meters in tropical and subtropical regions" (Hinderstein et al. 2010). While there seems to be agreement in the existing literature as to the depth at which the upper MCEs occur, the depth at which the lower MCEs occur vary by location and site-specific environmental factors (Kahng et al. 2014). Little information is known in the current literature of the MCE presence around Guam. Hard coral has been observed in mesophotic depths (a maximum depth of 180 feet [55 meters]) around Guam, but the data is limited (Blyth-Skyrme et al. 2013). In the Marianas Archipelago, MCEs have been reported at depths greater than 492 feet (150 meters), but appreciable coral cover was documented to 328 feet (100 meters). Additionally, the highest coral cover of foliose and branching morphologies were found between 197 and 262 feet (60 and 80 meters) (Kahng et al. 2014). Also within the Marianas Archipelago, the highest mean hard coral cover was found between 197- and 262-feet (60- and 80-meter) depth ranges of Garapan Anchorage; a "notable observation at Saipan Anchorage was the presence of an extensive area of the branching coral *Euphyllia paraancora* [a previously proposed ESA species] in the southern part of the eastern anchorage area in ~ 60-80 meter depths;" and at Galvez Bank, located about 13 miles (22 kilometers) south-southwest of Guam, the highest mean cover of hard coral was documented between the 98–131 feet (30–40 meter) depth range, however, in the 197-foot (60-meter) depth range was where hard coral formed mesophotic reefs (Blyth-Skyrme et al. 2013). Sunlight attenuation is low beyond 213 feet (65 meters) and falls into the zone of mesophotic corals, which are typically outside the range of DON base activities or construction actions.

MCEs show a general pattern of a faunal break from an upper MCE to a lower MCE. The upper MCE can have higher species affinity with shallow water coral reefs while the lower MCE tends to have fairly distinct communities, and sometimes endemic species. Even though a study in the Gulf of Mexico found a faunal break from an upper MCE to a lower MCE at a depth of 197 feet (60 meters) due to community composition or genetic dissimilarity, the authors noted that research in the Pacific does not support an ecological divide

at that depth (Semmler et al. 2016). The upper MCE has been shown in some regions to serve as a refuge for shallow water species, as well as habitat for federal ESA-listed corals despite a large information gap (Sinniger et al. 2012; Pyle et al. 2016).

5.3.8.3 Marine Protected Species

Fishes

Effective March 1, 2018, NMFS listed the oceanic whitetip shark (*Carcharhinus longimanus*) as a threatened species under the ESA (NMFS 2018a). This species is found worldwide in tropical and subtropical waters and is known to occur in the pelagic environments near Guam. No systematic data exists that reports the occurrence of oceanic whitetip sharks in the offshore waters of NBG Main Base.

In January 2017, NMFS determined that the giant manta ray (*Manta birostris*) should be listed under ESA as threatened (NMFS 2017b). This species is found worldwide in tropical, subtropical, and temperate waters and is known to occur around Guam. No systematic data exists that reports the occurrence of giant manta rays in the offshore waters of NBG Main Base. During a marine mammal monitoring survey in 2012, a manta ray that was not identified to species was observed southwest of the Orote Peninsula. It was observed in 600 feet (182 meters) of water and was estimated to be 8.9 feet (2.7 meters) across (NAVFAC Pacific 2012b). The location where it was observed is estimated to be a little more than 3 miles (4.8 kilometers) from shore.



A hawksbill turtle (*Eretmochelys imbricata*) in Apra Harbor.
(*Photo*: D. Snyder)

Sea Turtles

Green sea turtles and other species of marine turtle that migrate through the area could be encountered in the offshore waters proximate to NBG Main Base. These species include leatherback, loggerhead, and olive ridley turtles, but very few records exist of these species being observed in offshore waters.

Marine Mammals

As indicated previously, spinner dolphins are the only species that occur very close to shore with any regularity. Some species have a regular pattern of occurring offshore. After spinner dolphins, the species that is observed most often in Guam is pantropical spotted dolphins (Hill et al. 2014). This species is seen offshore of NBG Main Base, but usually at distances greater than 3 miles (4.8 kilometers). Measures of the distance of sightings from shore were reported in COMPACFLT monitoring reports starting around 2014. Sightings of species other than spinner dolphins are listed by their general location in Table 5-14.

Table 5-14. Marine Mammal Sightings Other Than Spinner Dolphin at Agat Bay during COMPACFLT Monitoring

Year	*Common Name/Species*	*Number of Sightings*	*Group Size or Range of Group Size/Distance from Shore*	*Reference*
Offshore of Luminao/Glass Breakwater				
2010	Pantropical spotted dolphins/ *Stenella attenuata*	1	17 / much greater than 3 miles (4.8 kilometers)	(Oleson and Hill 2010)
2012	Pantropical spotted dolphins/ *Stenella attenuata*	1	6 / 3 miles (4.8 kilometers)	(NAVFAC Pacific 2012b)
	Sperm whale/ *Physeter microcephalus*	1	10 / 3 miles (4.8 kilometers)	(NAVFAC Pacific 2012b)
2013	Pantropical spotted dolphins (*Stenella attenuata*)	2	19 and 11 / 2-3 miles (1.2-1.8 kilometers)	(Hill et al. 2013b)

Table 5-14. Marine Mammal Sightings Other Than Spinner Dolphin at Agat Bay during COMPACFLT Monitoring

Year	*Common Name/Species*	*Number of Sightings*	*Group Size or Range of Group Size/Distance from Shore*	*Reference*
	Bottlenose dolphin/ *Tursiops truncatus*	1	8 / possibly within 1 mile (0.6 kilometers)	(Hill et al. 2013b)
	Short-finned pilot whale/ *Globicephala macrorhynchus*	1	29 / possibly within 1 mile (0.6 kilometers)	(Hill et al. 2013b)
	Pygmy killer whale/ *Feresa attenuata*	1	8 / possibly within 1 mile (0.6 kilometer)	(Hill et al. 2013b)
2014	Melon-headed whale/ *Peponocephala electra*	1	85 / 4.0 miles (6.5 kilometers)	(Hill et al. 2014)
2015	Pantropical spotted dolphins/ *Stenella attenuata*	2	90 and 13 / 3.7 and 4.0 miles (6 and 6.4 kilometers)	(Hill et al. 2016)
2016	Pantropical spotted dolphins/ *Stenella attenuata*	1	42 / 2.8 miles (4.5 kilometers)	(Hill et al. 2017)
	Dwarf sperm whale/ *Kogia sima*	1	3 / 1 mile (1.6 kilometers)	(Hill et al. 2017)
Orote Peninsula				
2010	Sperm whale/ *Physeter microcephalus*	1	9 / 0.7 mile (1.1 kilometers)	(Oleson and Hill 2010)
2012	Bottlenose dolphin/ *Tursiops truncatus*	1	7 / <0.5 mile (<0.8 kilometer)	(Hill et al. 2013a)
	Short-finned pilot whale/ *Globicephala macrorhynchus*	1	23 / >4 miles (>6.4 kilometers)	(NAVFAC Pacific 2012b)
2013	Short-finned pilot whale/ *Globicephala macrorhynchus*	1	17 / >3 miles (>4.8 kilometers)	(Hill et al. 2013b)
2014	Short-finned pilot whale/ *Globicephala macrorhynchus*	1	17 / 0.4 mile (0.64 kilometer)	(Hill et al. 2015)
2015	Pantropical spotted dolphins/ *Stenella attenuata*	1	76 / 1.1 miles (1.7 kilometers)	(Hill et al. 2016)
2016	Dwarf sperm whale/ *Kogia sima*	1	4 / 2.1 miles (3.3 kilometers)	(Hill et al. 2017)
2016	Pantropical spotted dolphins/ *Stenella attenuata*	2	31 and 5 / 1.2 and 3.8 miles (1.9 and 6.1 kilometers)	(Hill et al. 2017)
Dadi				
2015	Short-finned pilot whale/ *Globicephala macrorhynchus*	1	19 / 1.53 miles (2.46 kilometers)	(Hill et al. 2015)

In addition to small vessel surveys, the COMPACFLT monitoring effort has also deployed tags on marine mammals to remotely sense location and sometimes dive patterns. In 2013, four false killer whales were tagged off Rota. Track line of the tagged animals shows that they spent a significant amount of their time offshore of the west side of Guam. Many more of the positions were on the west side of the Mariana Islands than were over the Marianas Trench. Many of the positions were nearshore to Guam including off NBG Main Base.

Three short-finned pilot whales were also tagged in 2013 off Guam. The positions of these animals were close to the islands of Guam, Rota, Tinian, and Saipan. Locations were on all sides of the islands relatively close to shore. The only exception was one animal that ventured south to Santa Rosa Reef (Hill et al. 2013b). This pattern of staying close to the island is consistent with the six pilot whales that were tagged in 2016. They swam around Guam and Rota staying relatively close to the islands, but also went to Galvez Bank and Santa Rosa Reef southwest of Guam (Hill et al. 2017).

A pantropical spotted dolphin was tagged for the first time in 2016. The trackline shows more limited movement than the pilot whales. The tagged animal remained mostly on west side of Guam, although some excursion to southeast coast did occur (Hill et al. 2017). In general, the spotted dolphins remained more

distant from shore than the pilot whales. More animals will need to be tagged and compared quantitatively before a pattern can be established for spotted dolphins.

5.3.8.4 Marine Resources Monitoring



Monitoring and assessment for cryptic marine species.
(*Photo*: D. Snyder)

Multiple agencies acting cooperatively (principally GovGuam and UOG) established a long-term monitoring program for benthic communities using belt transect methods, and one of these sites is in Apra Harbor, at Western Shoals (Burdick and Brown 2011). To some extent, this was a precursor to the current DoD-sponsored effort to monitor marine resources in Apra Harbor at 10 permanent sites including Western Shoals (Schils et al. 2017). Both of these monitoring programs are specifically designed to detect change over time with high statistical confidence, and utilize multivariate statistical techniques to evaluate changes in select ecosystem indicators (McManus and McManus 2012). These monitoring designs are specifically built to integrate into and be directly comparable to existing broad scale island- and region-wide monitoring programs. Robust monitoring of this nature is critical for establishing context for NBG Main Base marine resources and any associated management actions. These data will be essential to evaluate the success of management actions and will also alert managers to local or broad changes that could trigger the need to update baseline assessments. This data set can be spatially expanded as needed to include additional target strata (e.g., depths, habitats) or specific geographic locations where management actions are taking place. Similarly, monitoring frequency can be adjusted as needed to capture planned, expected, or stochastic events. Maintaining the core survey effort is essential for putting the expanded efforts into context.

The Comprehensive Long-term Monitoring Program has continued by the partners. However, Western Shoals has not been surveyed since the initial surveys due to other emergent monitoring priorities caused by back-to-back bleaching events in the Marianas over the past 4 of 5 years. Burdick and Brown (2011) describe their initial findings which are consistent with the known baseline conditions with the variability that is expected when single strata are placed in the context of a larger area (i.e., Western Shoals compared to Apra Harbor). Previous survey data on stony corals at Western Shoals is available in Smith and Marx (2006) and Smith (2007). There is an ongoing Reef Resilience Assessment study currently in Guam that is headed by NOAA's Coral Reef Conservation Program. Work in the field commenced in July 2016. The surveys included 25 sites around Guam at two depths: 15 feet (4.5 meters) and 40 feet (12.1 meters). Sites include Orote Point and Luminao.

Schils et al. (2017) have reported their findings for 10 permanent sites in Apra Harbor; however, these data only represent a single year of data collection. JRM will coordinate with local and federal agencies to determine the best way to continue long-term marine resource monitoring in a cost effective and adaptive manner within JRM-administered submerged lands.

5.4 MANAGEMENT GOALS, OBJECTIVES, STRATEGIES, AND ACTIONS

JRM currently manages natural resources based on an ecosystem focused approach that involves the implementation of several ongoing management projects. These projects, which are further described in the following sections, provide examples of JRM's current efforts to manage and enhance natural resources in a manner consistent with the military mission. Appendix C lists management projects at NBG Main Base for FY 14–17. The following sections present management projects for NBG Main Base that have been

identified as necessary to achieve applicable goals and objectives identified in Chapter 3, *Environmental Management Strategy and Mission Sustainability*.

Management projects identified for NBG Main Base provide direct support for the military mission and the goal of "no net loss" in a number of ways. For example, projects that improve the baseline status of species or their habitat, show that populations are stable, or that habitat is improving or expanding may relieve restrictions on military training or operations, minimize costs and mitigation requirements, avoid workarounds, and/or streamline regulatory processes.

5.4.1 Terrestrial Ecosystem Management

NBG Main Base's native terrestrial habitats have been impacted by historical activities, introduction and spread of invasive and non-native species, effects of climate change, and the resulting loss of functions necessary to support healthy native habitats. Ecosystem functions have been disrupted by the extirpation of native animal and plant species, which has resulted in both economic and cultural impacts on the ecosystem services provided by native habitats. The occurrence of healthy native habitats on NBG Main Base is necessary to support sustainability of native species including federal and Guam ESA-listed species. JRM recognizes that restoration and enhancement of native habitats on lands that they manage is a long-term process, and that adaptive management is key to long-term success of the program.

Management projects are monitored and evaluated annually to ensure that they are meeting identified goals and objectives. JRM will establish mid-year coordination meetings with resource partners to discuss ongoing and planned projects, including prioritization, scope, methodology, issues or challenges, timelines, and performance evaluation criteria. These discussions are intended to facilitate improved coordination and information sharing to allow for course corrections, if necessary, to ensure an adaptive approach.

Terrestrial ecosystem management as described in the following sections is expected to: (1) improve the status of threatened and endangered species through habitat conservation and enhancement, and (2) promote health and sustainability of native forests. Healthy ecosystems will, in turn, relieve or reduce environmental constraints and allow for maximum operational flexibility for the installations and continued/managed access to important recreational areas.

A summary of the management projects and the estimated timeframe for completion is presented in Table 13-7, *Planned Implementation Summary of Projects at NBG Main Base* found in Chapter 13, *Planning, Integration, and Implementation*. Some of the projects described in this section are being accomplished through interactive partnerships with federal and territorial natural resource agencies (e.g., Guam DAWR), universities, and local organizations.

5.4.1.1 Terrestrial Habitat Management

The primary issues affecting terrestrial habitats on NBG Main Base are development and habitat fragmentation, invasive plant and invertebrate species, loss of seed dispersers, and damage by introduced ungulates. JRM has ongoing and planned projects to restore and enhance native terrestrial habitats on NBG Main Base. These projects focus on improving the quality and availability of appropriate habitat for listed species, as well as increasing the quality and health of existing native habitats, such as native limestone forests. Numerous related activities are required for native habitat improvement, such as control of ungulates and other invasive species, propagating and outplanting native plant species to improve diversity, and addressing forest health issues, such as improvement of seed dispersal. In order to achieve long-term goals, terrestrial habitat management requires successful daily and short-term management, coupled with long-term planning and investment. To ensure that JRM continues to meet the overriding goal of restoring

and enhancing terrestrial habitats for native species (including listed species) over the long-term, JRM site land managers and resource agencies will continue coordinating on natural resource management.

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial Habitat Management (THM) on NBG Main Base.

THM-1: FOREST ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-6; Goal #3, Objectives #1- 4; and Goal #4, Objective #2. This project supports the 2019 Guam Wildlife Action Plan (Guam DAWR 2019).

- *Strategy*: Protect and restore priority native habitats (i.e., limestone forest), prioritizing forested areas designated as Overlay Refuge, for the benefit of native flora and fauna, including protected species, by focusing on step-wise forest enhancement activities and by protecting species from direct and indirect threats.
- *Action*: Complete comprehensive surveys to identify locations of listed plant species in forested habitats within 5 years. Develop a monitoring program for listed plants found throughout NBG Main Base following the protocols for Global Positioning System (GPS) data collection used at Northwest Field and Finegayan.
- *Action*: Collect seeds of important native limestone forest plant species, including listed species from known locations on the installation, propagate in a nursery, and outplant in collaboration with resource partners.
- *Action*: Increase native forest acreage by planting, establishing, and monitoring select native tree species underneath tangantangan abutting native forest and by planting native tree species directly in pure tangantangan monostands.
- *Action*: Implement post-eradication monitoring of professionally eradicated ungulates from NBG Main Base to ensure the areas remains ungulate-free.
- *Action*: Conduct quarterly inspections (by foot and vehicle), including after typhoons or other major storm events, of the NBG Main Base perimeter fence to maintain its role as a barrier to ungulate immigration onto the installation.
- *Action*: Conduct repairs and routine maintenance of the perimeter fence, as needed.
- *Action*: Understand restoration potential for upland habitats and how ecosystems can help offset greenhouse gas emissions.
- *Action*: Assess below and above ground carbon stocks for upland vegetation over time.
- *Action*: Determine if translocation of Micronesian starlings to NBG Main Base is feasible. If determined to be feasible, install predator-proof nest boxes and translocate Micronesian starlings to NBG Main Base using BMPs learned from Andersen AFB nest box studies.

5.4.1.2 Terrestrial Exotic and Invasive Species Management

An invasive species is defined in Executive Order (EO) 13112, *Invasive Species*, as a species that is non-native (i.e., alien or exotic) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm, or harm to human health. Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions. Invasive species have had a catastrophic effect on the native flora and fauna of island ecosystems, particularly Guam. Attributes of island biota include small geographic ranges and population size, low reproductive rates, and lack of the ability to respond to invasive species and disturbed habitats. Islands typically have lower numbers of species than mainland areas, which results in fewer predators and competitors that could prohibit the establishment of invasive species. As a result of evolving in isolation,

island plants and animals have few defenses when exposed to introduced competitors and predators. These limitations in Guam have caused exotic and invasive species to replace native island species (Wiles et al. 2003).

Many of the native species in Guam are threatened due to introduced predators, such as the BTS and introduced ungulates, such as the Philippine deer, feral pig, and Asiatic water buffalo (carabao), which have significantly affected native vegetation communities. Feral populations of dogs and cats also pose threats to native wildlife populations. Secretary of the Navy Instruction (SECNAVINST) 6401.1B of September 29, 2006, prohibits dogs, cats, and other privately owned or feral animals from running at large on military installations. Several species of rats have colonized the island, preying on the eggs and young of native species and destroying native flora (i.e., seeds and seedlings). The continued widespread presence of the BTS, curious skink, and introduced amphibian species are of particular concern because of each species' potential negative impacts in Guam's native fauna. Examples of invasive species management approaches include the control of feral ungulates, the control of feral cats and dogs, and the removal of invasive plants to allow native species to flourish in degraded areas.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Exotic and Invasive Species Management (TIS) on NBG Main Base.

TIS-1: BROWN TREESNAKE INTERDICTION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #3-4; Goal #3, Objectives #1 and 4; Goal #4, Objectives #1-3; and Goal #7, Objective #3.

- *Strategy*: Maintain, develop, and implement actions to prevent the spread of BTS via the transportation network.
- *Action*: Annually review, update as needed, and develop BTS interdiction projects reflecting BMPs, adaptive management, and cost benefits.
- *Action*: Annually assess continuity and compliance of BTS interdiction activities across Biological Opinions (BO), DoD BTS interdiction operating instructions, and consistency with, and, to the benefit of other relevant JRM conservation actions.
- *Action*: Annually assess ongoing development of new/emergent management strategies and methodologies that reduce or eliminate the risk of BTS.
- *Action*: Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant long-term projects to benefit interdiction management objectives.

TIS-2: BROWN TREESNAKE SUPPRESSION

This project supports the following goals and objectives identified in Section 3.3.1, Goals and Objectives: Goal #1, Objectives #1-2; Goal #2, Objectives #1-4 and 6; Goal #3, Objectives #1 and 4; Goal #4, Objectives #1-3; and Goal #7, Objective #3. Actions listed are in accordance with the 2011 BTS MOA.

- *Strategy*: Suppress and control BTS numbers to support conservation goals for species and ecosystem recovery.
- *Action*: Develop an operational suppression implementation plan. The plan will identify and prioritize potential quality habitat site(s) for suppression actions. Site(s) must consider size, habitat, location, connectivity, synergistic effects, listed species benefits, ecological viability, and support regulatory and mission requirements. Suppression goals and activities will support USFWS recovery plan delisting requirements for threatened and endangered species.

- *Action*: Implement BTS suppression management actions in identified site(s) based on mission support impact and cost effectiveness. Data will be used to determine the minimum thresholds of BTS suppression activities needed to support conditions conducive to species persistence and recovery.
- *Action*: Through annual funding and partnerships, support development of tools and methods that improves monitoring, detection, and suppression in targeted habitat sites.
- *Action:* Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant projects to benefit long-term BTS suppression management actions.

TIS-3: BROWN TREESNAKE MANAGEMENT FOR THE RECOVERY OF PROTECTED SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, Goals and Objectives: Goal #1, Objectives #1-2; Goal #2, Objectives #1-4 and 6; Goal #3, Objectives #1 and 4; Goal #4, Objectives #1-3; and Goal #7, Objective #3. Actions listed are in accordance with the 2011 BTS MOA.

- *Strategy*: Suppress and control BTS numbers to support listed vertebrate species recovery.
- *Action*: Develop an operational suppression implementation plan. The plan will identify and prioritize potential quality habitat site(s) for suppression actions. Site(s) must consider size, habitat, location, connectivity, synergistic effects, listed species benefits, ecological viability, and support regulatory and mission requirements. Suppression goals and activities will support USFWS recovery plan delisting requirements for threatened and endangered species.
- *Action*: Implement BTS suppression management actions in identified site(s) based on mission support impact and cost effectiveness. Data will be used to determine the minimum thresholds of BTS suppression activities needed to support conditions conducive to species persistence and recovery.
- *Action*: Through annual funding and partnerships, support development of tools and methods that improve monitoring, detection, and suppression in targeted habitat sites.
- *Action:* Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant projects to benefit long-term BTS suppression management actions.

TIS-4: IMPLEMENTATION OF REGIONAL BIOSECURITY PLAN FOR MICRONESIA AND HAWAI'I

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #3; Goal #3, Objectives #1-2 and 4; Goal #4, Objectives #1-4; and Goal #7, Objective #1.

- *Strategy*: Implement appropriate recommendations within the RBP (DON 2015b) that will reduce the risk of introduction and spread of invasive species on NBG Main Base.
- *Action*: Develop standard language for biosecurity BMPs, update as necessary, to be included in project specifications that support prevention, such as vegetation management, and cleanliness standards for materials and equipment operating on the installation.
- *Action*: Conduct early detection surveys (EDS) for high-risk invasive species in training areas; at facilities for staging, storage, and movement of cargo/equipment and vehicles; and at other locations as deemed necessary.
- *Action*: Review and update, as appropriate, DoD Attachment M of the RBP every 3 years.
- *Action*: Develop, implement, and update (as necessary) a JRM biosanitation instruction to ensure cleanliness standards are adhered to for the movement of cargo and equipment.

- *Action:* Continue to develop high-risk invasive species protocols and implement control and/or eradication measurement when necessary (CRB and LFA Management Procedures [Version 4 Revised 02 August 2021]).

TIS-5: INVASIVE SPECIES MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #3 and 6; Goal #3, Objectives #1 and 4; and Goal #4, Objectives #1-3. This project supports conservation measures from the Reinitiation of the 2015 BO on the DON's Relocation of USMC from Okinawa to Guam and Associated Activities in Guam (USMC Relocation 2017 BO, which contains amendments to the 2015 BO) (USFWS 2017).

- *Strategy*: Control and eventually eradicate invasive plant and invertebrate species on NBG Main Base to protect and restore habitat.
- *Action*: Conduct research on the natural history of chain-of-love vine to determine the most cost effective and efficient means to reduce and control the species on Orote Peninsula. Implement base-wide eradication after method selection. After eradication, monitor for new growth and implement control/eradication when necessary.
- *Action*: Annually survey high-risk areas for LFA using established protocols. If LFA is detected on Main Base, implement proven control and eradication actions, followed by post-eradication monitoring.
- *Action*: Implement BMPs for CRB: (1) annually evaluate the need for comprehensive bio-sanitation of dead coconut trees and implement as necessary, (2) implement proper green waste management, (3) assist in release of landscape-level biocontrol agents for CRB, (4) implement awareness and reporting program in high-risk areas annually, and (5) implement long-term monitoring program and monitor coconut trees.
- *Action*: Survey and map locations of invasive insect infestations and compromised plants.
- *Action*: Use available management tools (i.e., as informed by management at Andersen AFB) to implement adaptive management actions to remove or control invasive insects, including, but not limited to, feasible local controls of cycad scale (e.g., hand applications to individual trees).
- *Action*: Develop a Hazard Analysis and Critical Control Point (HACCP) Plan and implement requirements for construction related to the USMC relocation.

TIS-6: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #2-4; Goal #3, Objectives #1 and 4; and Goal #4, Objectives #1-4. This project supports conservation measures from the BO for the Mariana Islands Training and Testing (MITT) Program (MITT BO) (USFWS 2015a).

- *Strategy*: Implement biosecurity conservation measures listed in the 2015 MITT BO from USFWS.
- *Action*: During training events, ensure 100% BTS canine inspection of aircraft and cargo/equipment departing for an off-island destination.
- *Action*: During training activities, establish snake-free quarantine areas (barriers) as deemed necessary for cargo/equipment traveling from Guam to the CNMI and locations outside of the MITT action area.
- *Action*: Ensure BTS awareness briefings for all military and contractor personnel prior to all MITT training activities.

- *Action*: Maintain invasive species rapid response capabilities to control and/or eradicate introduced, non-established, non-native invasive species sighted in vicinity of DoD training areas and facilities used for staging, storage, and movement of military personnel, cargo, and vehicles associated with training activities.
- *Action*: Ensure training event personnel conduct biosecurity self-inspections of all personal gear and hand carried items to avoid potential introduction of invasive species to and from Guam. Self-inspection will ensure the removal of soil accumulations, seeds, invertebrates, and vertebrates.
- *Action*: Ensure all training events adhere to the Armed Forces Pest Management Board Technical Guide No. 31 (AFPMB TG-31) cleanliness standards for all cargo/equipment, containers, and rolling stock arriving from off-island destinations and departing Guam for off-island destinations via inspections as deemed necessary.
- *Action*: Implement high-risk invasive species protocols for the control and/or eradication for high-risk species, as species are identified.

TIS-7: CONTROL FERAL DOGS AND CATS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1 and 4; and Goal #4, Objective #2.

- *Strategy*: Reduce threats to native species by implementing a control program for feral dogs and cats on NBG Main Base.
- *Action*: Conduct population surveys of areas of highest conservation concern, and/or human safety to determine locations and estimate numbers of feral dogs and cats, review accepted control measures, and coordinate with U.S. Army veterinarian and installation pest control personnel to control by authorized means if impacts to ESA-listed species or other native wildlife are identified.
- *Action*: In accordance with the interagency agreement between the USDA, APHIS Wildlife Services, and NAVFAC, measures will be implemented to control dog and cat populations on NMS. Trail cameras will be installed in areas identified as having feral dogs and cats. All animals will be trapped using live traps and transferred to a local pet shelter.
- *Action*: NAVFAC will provide population reports and data on population numbers, locations, and home ranges to APHIS Wildlife Services to ensure the most cost-effective wildlife management program is administered in NMS.
- *Action*: Include U.S. Navy installation feral dog and cat policy information in all installation outreach material presented to military and civilian personnel, housing residents, and contractors.

5.4.1.3 Terrestrial Protected Species Management

Management of terrestrial threatened and endangered species on JRM-administered lands includes implementing programs to protect species and coordinating efforts with the appropriate agencies. Key threats to threatened and endangered species that can lead to extirpation include:

- predation by BTS of native forest birds, lizards, and bats
- overgrazing, rooting, and trampling of plants and wildlife habitat by feral ungulates
- predation by feral cats, dogs, and pigs as well as predation by monitor lizards on birds, bats, and sea turtles
- human disturbance and poaching of sea turtles and Mariana fruit bats
- mortality or injury to native plants and wildlife due to natural stochastic events (e.g., typhoons)
- low reproductive success due to small population numbers
- habitat loss and fragmentation due to development

To address these key threats to listed species, JRM has conducted and continues to conduct numerous management and research projects to reduce BTS numbers at the local and landscape scale, control BTS at swiftlet caves at NMS, and to prevent their spread to other Pacific Islands through rigorous inspections and interdiction of outgoing cargo at DoD ports (i.e., Apra Harbor, Andersen AFB). Captive breeding programs conducted by Guam DAWR and mainland zoological institutions are maintaining populations of Guam rail and Guam kingfisher and are adding to the information needed for successful recovery of these species. Additional ecological research and monitoring is also being conducted by various agencies in Guam, including DoD, USDA, and USGS.

In accordance with section 7 of the ESA, a federal agency shall consult with the USFWS to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species. The DON will coordinate with the USFWS/Guam National Wildlife Refuge (NWR) for any federal action that is within Overlay Refuge lands and is identified as providing habitat for threatened or endangered species. In addition, the DON will avoid, as the mission allows, impacts on habitat suitable for threatened and endangered species, locally rare, and Guam-protected species.

Sensitive species are being managed by implementing specific management projects that enhance habitat for these species and by initiating specific strategies that address immediate needs of listed species on the installation. In addition, adherence to the goals set for threatened and endangered species management ensure that the installation remains in compliance with ESA and associated consultation requirements.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Protected Species Management (TPS) on NBG Main Base. Additional protection measures for terrestrial protected species are presented in Section 5.4.1.6, *Terrestrial Natural Resources Law Enforcement*.

TPS-1: ESA-LISTED SPECIES MONITORING

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; and Goal #3, Objectives #1-4.

- *Strategy*: Implement an ESA-listed species monitoring program to inform adaptive management actions and avoid sensitive areas during construction, operations, and training.
- *Action:* Conduct surveys to document distribution and abundance of ESA-listed invertebrates and plants focusing on newly listed species. NBG will prioritize areas that have not been recently surveyed for ESA-listed species. The monitoring program will update endangered species population distribution maps and GIS databases with data used to inform adaptive management of listed species.
- *Action*: Management actions described under THM-1 will benefit ESA-listed invertebrates and plants. Additional actions may be identified following baseline surveys for species.

TPS-2: SEA TURTLE POPULATION PROTECTION AND ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-6; Goal #3, Objectives #1-2 and 4; Goal #4, Objective #2; and Goal #6, Objectives #1-2.

- *Strategy*: Monitor and protect sea turtles on NBG Main Base to maintain habitat and improve nesting success.
- *Action*: Annually locate, protect, and evaluate 100% of sea turtle nests on NBG Main Base. Collect and maintain data on nest success, emergence success, and depredation for all nests. Monitor

long-term trends of spatial and temporal distribution of sea turtle nesting activity on NBG Main Base. Sea turtle nesting activity is monitored at nine beaches on NBG Main Base with monthly surveys during the non-nesting season and weekly/daily surveys (the frequency is site-specific) during the nesting season.

- *Action*: Manually remove the invasive vegetation at Spanish Steps beach to increase the likelihood of successful hatching of sea turtles and hatchling turtles successfully traversing the strand vegetation and beach to access the ocean. Removal of invasive vegetation will also enhance natural regeneration of native strand vegetation. Follow-up removal will be necessary at all sites due to sprouting from the seed bank.
- *Action*: Prevent monitor lizard depredation at nesting beaches by covering nests with wire mesh (to stop lizards from digging) to increase sea turtle hatchling success.
- *Action*: Implement NBG Main Base BMPs for ESA-listed species to ensure no adverse effects to ESA-listed species during DON activities, as have been developed for recent Biological Evaluations. Examples of BMPs include but are not limited to: (1) Designate observers to vigilantly observe activity sites for the presence of ESA-listed species, particularly during in-water activities; and (2) providing a contingency plan to avoid contamination of the marine environment from DON activities (DON 2013, 2015c).
- *Action*: Protect nesting female turtles and nests by limiting vehicle access to nesting beaches through placement of barriers on the beach access sites to Dadi Beach.
- *Action*: Participate in quarterly Haggan huddle meeting and share NBG data with agency partners.
- *Action*: Conduct beach profiling surveys to track shoreline erosion/accretion, as nesting habitat may be threatened by heavy rainfall and frequent typhoons.
- *Action*: Consider BTS traps, as reducing BTS presence will benefit habitat restoration for shorebirds that prey on ghost crabs, which target sea turtle eggs/hatchlings.
- *Action*: Fund a JRM sea turtle recovery coordinator position to coordinate sea turtle monitoring and recovery efforts across Navy lands and submerged lands and coordinate with INRMP partners (DoD, Territory agencies, NOAA Fisheries, and USFWS) to align JRM sea turtle actions with other efforts in the Marianas and improve coordination of sea turtle projects.
- *Action*: Continue nesting surveys (twice a week minimum during peak nesting season) and conduct additional surveys to identify additional nesting beaches or assess status of known nesting areas on JRM lands.
- *Action*: Mitigate any light pollution or predation that might be affecting nesting habitats.

TPS -3: MARIANA COMMON MOORHEN HABITAT ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #1 and 3-6; Goal #3, Objectives #1-2 and 4; and Goal #4, Objective #2.

- *Strategy*: Protect and enhance Mariana common moorhen population on NBG Main Base.
- *Action*: Conduct quarterly surveys for moorhen at NBG Main Base wetlands and ponds.
- *Action*: Maintain and monitor nesting platforms in wetlands and ponds where moorhen are known to occur. Nesting platforms will be monitored every 2 weeks.
- *Action*: Assess wetland vegetation at locations know to support moorhen, including the use of nesting platforms. Implement strategies, if feasible, and coordinate with partners.
- *Action*: Coordinate surveys efforts with partner agencies to conduct island-wide annual/bi-annual surveys.

- *Action*: Monitor active moorhen to determine if predation is occurring using trail cameras. If nest predation is observed, conduct predator control to reduce predation in the vicinity of wetlands/ponds.
- *Action*: Conduct annual assessment of surveys and nesting platform usage and provide annual report.

TPS-4: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal # 2, Objective #4; and Goal #3, Objectives #1-2 and 4. This project supports conservation measures from the 2015 MITT BO (USFWS 2015a).

- *Strategy*: Implement conservation measures listed in the 2015 MITT BO from USFWS.
- *Action*: Ensure no disturbance of sea turtle nests and nesting turtles via (1) conducting pre-exercise surveys no more than 6 hours prior to training activities; (2) directing landing crafts to areas determined to be clear of sea turtles and sea turtle nests; (3) restoring beach topography using hand tools after exercises, as necessary; (4) use of an environmental monitor on site during night-time landing and training activities; and (5) identifying any potential sea turtle nests and implementing a buffer zone based on criteria outlined in the BO.
- *Action*: Ensure no maneuver and navigation training occurs in Mariana moorhen habitat.
- *Action*: Ensure "No Wildlife Disturbance" and "No Training" on designated areas on Orote Point, Spanish Steps, Orote ERA, and other locations where listed species are known to occur.
- *Action*: Ensure all vehicular activities during training are restricted to designated and previously identified areas that do not contain listed species.
- *Action*: Vegetation removal shall be limited to the maintenance of existing bivouac areas that do not contain listed species or habitat. No new bivouac areas are proposed under MITT. Maneuver units will remain tactical and not establish support camps.
- *Action*: Ensure all training activities are consistent with the fire management plan in COMNAVMAR Instruction 3500.4A (Marianas Training Manual) (COMNAVMAR 2013).

TPS-5: MARIANA FRUIT BAT POPULATION MONITORING

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-4; Goal #3, Objectives #1 and 4.

- *Strategy*: Identify and monitor Mariana fruit bat populations on NBG Main Base to maintain and identify habitat relationships.
- *Action*: Conduct annual surveys for fruit bats on NBG Main Base.
- *Action*: Search for aggregating locations. If aggregations or new colony locations are detected, JRM will commence roost counts in accordance with established survey protocols. If changes in roost locations, colony size, or movement are detected, investigate potential threats or stressors that may be causing disturbance.

5.4.1.4 Migratory Bird Management

JRM installations manage and monitor the effects that both military readiness and non-readiness activities have on migratory bird species and populations. Relevant regulations and policies include the Military Readiness Rule (50 Code of Federal Regulations [CFR] 21.15); the 2014 Memorandum of Understanding (MOU) between the DoD and USFWS to Promote the Conservation of Migratory Birds; and EO 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*. Through the implementation of the

INRMP, proper management of migratory bird species and habitats, including the timely implementation of appropriate conservation practices, will help installations avoid or minimize impacts to migratory birds.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Migratory Bird Management (MIG) on NBG Main Base.

MIG-1: MONITORING AND ANALYSIS OF MBTA-LISTED BIRD SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1-2 and 4; and Goal #6, Objective #1.

- *Strategy*: Improve understanding of MBTA-listed bird habitat use on NBG Main Base and bird/mission interactions to avoid and minimize effects of takes on MBTA-listed birds.
- *Action*: Evaluate long-term data sets to identify migratory bird species of concern (referred to as "Mission Sensitive Species" in the DoD 2017 Guidance for Migratory Bird Management in Integrated Natural Resource Management Plans) for NBG Main Base and determine interrelatedness between these species and mission activities. These data will inform refinements to monitoring protocols and whether additional management actions for migratory birds are necessary for NBG Main Base.
- *Action*: Implement bird-safe building designs for new construction (e.g., facilities, utilities, alternative energy projects). For example, install bird-safe building glass to prevent collisions and ensure proper siting for wind energy. Review and update, if necessary, template design and construction specifications to include bird-safe building design guidelines (e.g., see 2016 USFWS Reducing Bird Collisions with Buildings and Building Glass Best Practices (USFWS 2016).
- *Action*: Continue annual monitoring of MBTA-listed birds on NBG Main Base.

MIG-2: CHECKLIST OF BMPS AND CONSERVATION MEASURES FOR MIGRATORY BIRDS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; and Goal #3, Objectives #1 and 4.

- *Strategy*: Identify BMPs, conservation measures, and other actions to avoid and minimize impacts to migratory birds.
- *Action*: Compile a complete list of BMPs and conservation measures within 2 years that should be reviewed by base planners prior to any proposed action on NBG Main Base. Based on the nature, scope, and location of a proposed action (e.g., buildings with glass windows, located within migratory bird habitat, etc.), planners and natural resources managers would consult the list of BMPs and conservation measures and incorporate appropriate measures into the proposed action to avoid and minimize impacts to migratory birds.

5.4.1.5 Terrestrial Natural Resources Educational Outreach

Conservation awareness is instrumental in creating conditions needed to manage natural resources. The JRM approach to awareness stresses education. It provides military personnel and the public with insights into installation natural environments and conservation challenges. The more educated people are about the unique and valuable natural resources on JRM-administered lands, the more responsibly they will act when using them. Education also promotes awareness of critical environmental projects and the rationale behind them. As activities such as habitat management, wildlife management, and land rehabilitation are generally accepted and understood, minimal effort is required to communicate conservation priorities to installation personnel, recreationists, and the general public. However, issues such as protection of sensitive areas for plant and wildlife species, invasive species management (ungulate management), wildfire suppression, and

restrictions on some recreational activities in JRM-administered lands require effective conservation communication to garner positive support and, perhaps more importantly, to avoid adverse reactions from various users. A conservation awareness program must be directed to both installation and external interests if it is to be effective.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Natural Resources Educational Outreach (TEDU) on NBG Main Base. These management projects are in parallel and in concert with those identified and discussed in Section 5.4.2.4, *Marine Natural Resources Educational Outreach*.

TEDU-1: ESA-LISTED SPECIES AND TERRESTRIAL RESOURCES OUTREACH

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7; Objectives #1-2. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Improve awareness among DoD personnel and the public of threats and stressors to terrestrial resources, including protected species, and the importance of conserving natural resources on NBG Main Base, in cooperative efforts with partners, such as GovGuam and USFWS.
- *Action*: Maintain the informational signs and interactive kiosks at NBG Main Base recreational beaches (including Gab Gab, San Luis, and Dadi Beaches).
- *Action*: Develop, update, and distribute multimedia for public education to incoming military personnel, contractors, schools, and other outreach opportunities that address appropriate behavior around threatened and endangered species and the consequence of introduced non-native plant and animal species. Outreach materials will be reviewed every 2 to 5 years.
- *Action*: Review and update, as needed, current outreach videos/media used during the orientation briefs viewed by 100% of new personnel upon arrival to Guam.

TEDU-2: JRM NATURAL RESOURCES STEWARDSHIP OUTREACH AND PUBLIC ENGAGEMENT PROGRAM

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7, Objectives #1-3.

- *Strategy*: Implement a comprehensive natural resources outreach program regarding the federal, territorial, and base environmental regulations and policies, as well as information about the importance of protecting and conserving JRM's natural resources.
- *Action*: Update a comprehensive Natural Resources Stewardship Outreach online training system for military and civilian personnel.
- *Action*: Create a JRM Environmental Public Engagement Plan to outline the areas where JRM can significantly increase their outreach with military personnel and the public about appropriate behavior toward threatened and endangered species and the importance of conserving natural resources within JRM-administered lands and submerged lands.
- *Action*: Conduct marine debris clean-ups a minimum of twice yearly on sea turtle nesting beaches.
- *Action*: Utilize partnerships with the USCG and SeaBees during joint training exercises to minimize costs and raise awareness within military personnel of the importance of maintaining the beaches to protect threatened and endangered species and other marine and terrestrial natural resources.
- *Action*: NBG Main Base will utilize annual high profile environmental days, such as Earth Day in April and the Ocean Conservancy's International Coastal Clean-up in September, to organize

clean-ups and provide natural resource outreach materials to military personnel and other participants.

- *Action*: Develop, update, and implement a biosecurity education and outreach program for contractor personnel, military personnel, and dependents.

5.4.1.6 Terrestrial Natural Resources Law Enforcement

JRM has established the following objectives for enforcement: (1) enforce laws and regulations pertaining to the implementation of the natural resources program, (2) integrate natural resources enforcement into the overall natural resources program, and (3) use enforcement personnel to enhance the natural resources program at JRM.

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial Natural Resources Law Enforcement (TLAW) on NBG Main Base.

TLAW-1: CONSERVATION LAW ENFORCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-3; Goal #2, Objectives #1-2 and 4; Goal #3, Objective #4; Goal # 6, Objectives #1-2; and Goal #7; Objectives #1-3.

- *Strategy*: Detect and deter unauthorized activity that negatively affects natural resources on NBG Main Base (e.g., poaching, off-roading) through conservation law enforcement.
- *Action*: Establish a Conservation Law Enforcement Program by hiring a Conservation Law Enforcement Officer, and by partnering with other agencies as applicable, to enforce natural resource laws, policies, and regulations on NBG Main Base. The Conservation Law Enforcement Officer will conduct outreach and enforce natural resource regulations.
- *Action*: Protect sea turtles from poaching on nesting beaches and submerged lands.

5.4.1.7 Terrestrial Geographic Information System and Data Management

Natural resources data are stored and maintained within a centralized JRM GIS database. The GIS database provides support for the entire environmental program and the training community. JRM uses the GIS for complex analyses such as project siting, data interpolations, and risk assessments.

GIS software enables installation staff to capture, store, update, manipulate, analyze, and display all forms of geographically referenced data and tabular information about natural and physical resources found on JRM-administered lands. The training of JRM staff and the allocation of their time to data entry, mapmaking, data analysis, and interpretation of the results determine the success of the installation GIS. Once fully developed, the installation GIS databases can be used for projects such as the following:

- providing maps with locations of species, vegetation communities, surface waters, and other areas of potential concern
- selecting suitable areas for construction activities
- planning land rehabilitation projects
- providing special maps for Environmental Awareness materials
- ensuring avoidance of threatened and endangered species habitats and other areas of special concern during construction projects
- identifying site options for use during National Environmental Policy Act (NEPA) evaluation of alternative sites
- calculating drainages and water flows
- determining wildlife habitat preferences

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial GIS and Data Management (TGIS) at NBG Main Base.

TGIS-1: TERRESTRIAL NATURAL RESOURCES GIS AND DATA MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-5; and Goal #3, Objectives #1 and 4.

- *Strategies*:
  - Identify data gaps in terrestrial natural resources GIS to assist in the development of future data collection efforts, surveys, and management actions.
  - Ensure that GIS information is available to installation subject matter experts and military personnel, biologists, planners, contractors, and others in a timely manner to assist with planning and decision-making.
- *Action*: Update and continuously maintain existing centralized GIS database to effectively inform and guide future management of terrestrial natural resources on NBG Main Base and meet natural resources goals and objectives. Readily available GIS data will be used to develop natural resources constraints maps for use in current and future NBG Main Base management and planning decisions.

5.4.1.8 Summary – Terrestrial Ecosystem Management

Implementation of the JRM INRMP program and the focused strategies and actions of the management projects for terrestrial resources provides a conservation benefit to the natural ecosystems within NBG Main Base by maintaining and enhancing the natural community structure, function, species diversity, and resiliency. Enhancing and restoring native habitats supports viable populations of native species and increases biodiversity. Projects that address invasive species prevention and early detection, as well as control, help to minimize the risk of introducing species both within and between islands. Data from regular monitoring of protected species informs management projects to enhance and restore habitat, reduce habitat fragmentation, buffer protected areas, implement new conservation strategies, and avoid and minimize impacts. Using this regional ecosystem-based approach for managing protected species and their associated ecosystems ensures that JRM remains in compliance with federal and territorial laws while supporting the operational functionality of the NBG Main Base mission.

Nineteen management projects addressing terrestrial natural resources management are proposed for implementation on NBG Main Base:

- Terrestrial Habitat Management – 1
  - THM-1: Forest Enhancement
- Terrestrial Exotic and Invasive Species Management – 7
  - TIS-1: Brown Treesnake Interdiction
  - TIS-2: Brown Treesnake Suppression
  - TIS-3: Brown Treesnake Management for the Recovery of Protected Species
  - TIS-4: Implementation of Regional Biosecurity Plan for Micronesia and Hawai‘i
  - TIS-5: Invasive Species Management
  - TIS-6: Mariana Islands Training and Testing Implementation of the Biological Opinion
  - TIS-7: Control Feral Dogs and Cats
- Terrestrial Protected Species Management– 5
  - TPS-1: ESA-listed Species Monitoring
  - TPS-2: Sea Turtle Population Protection and Enhancement
  - TPS-3: Mariana Common Moorhen Habitat Enhancement

  - TPS-4: Mariana Islands Training and Testing Implementation of the Biological Opinion
  - TPS-5: Mariana Fruit Bat Population Monitoring
- Migratory Bird Management – 2
  - MIG-1: Monitoring and Analysis of MBTA-listed Bird Species
  - MIG-2: Checklist of BMPs and Conservation Measures for Migratory Birds
- Terrestrial Natural Resources Educational Outreach – 2
  - TEDU-1: ESA-listed Species and Terrestrial Resources Outreach
  - TEDU-2: JRM Natural Resources Stewardship Outreach and Public Engagement Program
- Terrestrial Natural Resources Law Enforcement – 1
  - TLAW-1: Conservation Law Enforcement
- Terrestrial Geographic Information System and Data Management – 1
  - TGIS-1: Terrestrial Natural Resources GIS and Data Management

5.4.2 Marine Ecosystem Management

The mission of NBG Main Base is to support the forces of the U.S. Pacific Fleet, U.S. Pacific Air Forces, U.S. Marine Corps Forces, Pacific (MARFORPAC), and other commands and warfighters based in Guam. JRM-administered submerged lands at NBG Main Base offer a realistic training environment and provide significant recreational opportunities for military personnel and their families. These lands are presently influenced by natural and anthropogenic forces that drive the short- and long-term integrity of the resources. Monitoring surveys that allow for trend analysis and provide information on reef resiliency helps draw connections between various stressors and their impact on marine communities. Surveys can also help establish the status and condition of populations of native marine flora and fauna. This information allows JRM to design and implement adaptive management projects that avoid and minimize impacts to marine resources, including federal ESA-listed marine species and their habitats, while allowing mission-essential training, operations, and recreational use on JRM-administered lands.

Maintaining healthy marine communities supports the military mission by avoiding or alleviating potential training restrictions and/or restrictions on recreational access and use, allowing NBG Main Base to provide unimpeded support to DoD commands. The state of knowledge and the plans for managing marine resources on JRM-administered submerged lands differs from the management of terrestrial resources. The principal reason for the differences is that access to and direct knowledge of the marine resources by natural resource managers is extremely limited. Additionally, the cost and effort to obtain information about marine resources is typically much greater than that required for terrestrial resources. These restrictions could mean that evidence of the presence or the condition of resources may need to be inferred from indirect or infrequent measurements to a greater degree than is required on land. Therefore, the focus of this section of the INRMP for marine resources takes a different approach to the management of marine resources compared to terrestrial resources.

The content and projects described in the INRMP serve three purposes that are consistent with Overarching Goal #1, *Ensure Military Mission Sustainability and Environmental Compliance* (see Section 3.3.1, *Overarching Goals and Objectives*) but may not be held entirely in common with terrestrial resources:

- They serve the letter and spirit of the requirements of the Sikes Act for JRM to have a management plan for natural resources on its installation.
- They serve as a starting point for the basic characterization of information regarding the marine environment on JRM installations that is commonly understood between the DoD and resource agencies, and can be used for planning purposes for environmental compliance documents that will be prepared to support DoD actions.

- They may allow JRM and NMFS to come to agreement that the management projects that are planned in the INRMP are sufficient to preclude the need to designate critical habitat for federal ESA-listed species on JRM-administered submerged lands covered by the JRM INRMP and implementing actions to support their recovery.

The second item emphasizes the use of INRMP content and the results of INRMP projects to inform a basic understanding of marine resources in JRM-administered submerged lands. This understanding helps with planning costs, schedules, and requirements of proposed DoD projects, such as the type of NEPA document to be prepared, the presence of federal ESA-listed species, the type of natural resources consultations to expect, and the estimated quantity of resources and/or habitat that could be impacted. It is understood that additional detailed, site-specific studies are likely to be necessary for NEPA analyses and associated consultations.

The purpose of this section is to identify projects with specific strategies for NBG Main Base and to obtain workable and useful solutions for marine natural resources management. In accordance with OPNAVINST 5090.1 and the principles of adaptive ecosystem management, marine natural resources management goals, objectives, strategies, and actions were developed for NBG Main Base by an interdisciplinary team of ecologists, biologists, geologists, planners, and environmental scientists. Management of the JRM-administered submerged lands and associated marine resources in JRM: (1) protects and conserves threatened and endangered species through habitat conservation and enhancement, (2) promotes health and sustainability of coral reefs, (3) provides continued access to recreational areas, and (4) provides continued use and access to training areas ensuring no net loss to the military mission.

The overall strategy follows a cycle of: (1) understanding the spatial distribution and types of marine habitat on JRM-administered submerged lands, (2) characterizing the species and communities that occur in the various habitats, (3) determining the condition of the resources in the habitat, (4) determining how species that are present use or contribute to the habitat, and (5) managing the effects of stressors or threats on protected resources.

Adaptive management is intended to be an active part of all facets of the progression of resource management. Basic data collection to characterize a resource could be an endless process. Adaptive management will help to prioritize and focus effort to know when an emphasis needs to be on basic characterization, when responding to threats should be stressed, and what kind of balance between the two pursuits should be struck. Steps in the progression may be leaped past if conditions or information indicate a different step in the progression is needed. Adaptive management is not only depended on to determine what actions to take; it is also intended as a way to collaboratively review what is known about a resource so a collective agreement can be made on the next steps.

Similar to the terrestrial natural resources management program, the marine natural resources management program is divided into the following categories:

- Marine Habitat Management
- Marine Invasive Species Management
- Marine Protected Species Management
- Marine Natural Resources Educational Outreach
- Marine Natural Resources Law Enforcement
- Marine Natural Resources GIS and Data Management

As appropriate and applicable, all management projects will require evaluation or monitoring criteria, which are used to track the status of the management project, and whether the management project: (a) addresses

no net loss to the capability of NBG Main Base to support the military mission and (b) meets the identified goals and objectives. At a minimum, mid-year coordination meetings will be held with resource agencies to discuss ongoing and planned projects to include prioritization, scope, methodology, issues encountered, timelines, and evaluation or monitoring criteria; these factors will also be discussed at the annual INRMP Metrics meeting. These conversations are meant to facilitate information sharing and enable JRM and the Agencies to take an adaptive management approach to managing INRMP projects. This approach will mean that projects are managed more dynamically and will be more responsive to arising needs than a static 5-year plan would be. A summary of the management project and the estimated timeframe for completion is presented in Table 13-7, *Planned Implementation Summary of Projects at NBG Main Base* the INRMP Management Projects Implementation Table, found in Chapter 13, *Planning, Integration, and Implementation*.

Some of the management projects described in the following sections will be accomplished through interactive partnerships with federal and territorial natural resource agencies, universities, and local organizations. JRM natural resources management staff will establish partnerships based on the benefits to the regional ecosystem and the local environment.

5.4.2.1 Marine Habitat Management



Anchor from a dive boat in a reef near San Luis Ponds, Apra Harbor.
(*Photo*: D. Snyder)

Marine resources are inherently challenging to describe due to their inaccessibility and in many cases low detectability. The initial approach to marine resource assessment is to describe the baseline, answering the question "what is there?" This is typically done by scuba divers who record species richness and abundance within a study site that is representative of a larger area. Habitat mapping is often done in advance of baseline assessments to provide spatial context for "where" marine resources are distributed. Additionally, developing habitat maps initially helps to determine how to subdivide the study area into representative sections (i.e., strata) and how to extrapolate those baseline assessments into a larger context. However, baseline assessments are often not designed specifically to be repeatable. Repetition is critical to obtain sufficient statistical power that allows for the detection of change over time in various metrics. Monitoring designs typically increase statistical power by designing surveys that are repeatable with very high precision. Both baseline assessments and monitoring programs are essential for marine resource managers, who must first understand what resources are present and how they are distributed, and then how military operations and corresponding management actions affect those resources through time. When monitoring detects substantial changes in marine resource communities, the management actions may be adjusted.

Interagency efforts to develop consistent methods for evaluating impacts to nearshore marine resources and determining suitable mitigations that offset lost ecological functions and services are supported by DON, NMFS, USFWS, USEPA, and USACE. Standardized methods that agencies can agree on are expected to benefit processes associated with NEPA, interagency consultations (e.g., ESA), CWA Section 404 permitting, and natural resources management. Interim results from the interagency effort are expected in the near term for consideration, but repeatable processes that are agreed on by all agencies are expected to be established over the next 5 to 10 years.

Management projects in offshore areas are primarily focused on outreach and education and monitoring associated with testing and training given that the resources are mobile and wide-ranging and the logistical

challenges of managing those resources. Divers cannot easily access marine resources below 98 to 131 feet (30 to 40 meters). Autonomous and remotely operated vehicles can be used to observe and assess resources at greater depths, but implementing management projects remotely is challenging enough with the current state of technology; therefore, autonomous/remotely operated vehicles are not a practical solution for most potential INRMP management projects.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Marine Habitat Management (MHM) on NBG Main Base.

MHM-1: CORAL HABITAT ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-6; Goal #3, Objectives #1-2 and 4; Goal #5, Objective #1; and Goal #6, Objectives #1-2.

- *Strategy*: Enhance coral habitat by monitoring health and acute impacts and through focused reef restoration efforts.
- *Action*: Establish long-term monitoring programs to track changes in the health of corals and water quality that are compatible with existing monitoring programs in Guam and the region. JRM has programmed for active/continuous remote monitoring of water quality parameters at select locations.
- *Action*: Continue ongoing work with regulatory partners and local subject matter experts to identify priority resilience indicators. Using the same or similar methods to Maynard et al. (2015), synchronize data sets for at least one meaningful monitoring period to allow JRM sites to be compared to other sites within the Guam Coral Reef Resilience Assessment. Existing monitoring data from survey efforts will continue to inform this process (Schils et al. 2017). The measures for assessing resilience include: macroalgae percent cover (to be obtained as coarse level data in the benthic habitat mapping project), coral community (available for some sites from past studies), bleaching resistance, coral recruitment and connectivity, coral diversity (available for some sites from past studies), herbivorous fish community (available for some of Apra Harbor from past studies), herbivore average functional group biomass, temperature variability, land-based sources of pollution, and accessibility due to wave exposure.
- *Action*: Using the results obtained above, further refine priority sites (e.g., those that have high resilience factor) for targeted management actions. Examples of targeted management actions, include but are not limited to actions that improve water quality (e.g., reduce land base sources of pollution or runoff, wetland/mangrove enhancement), fisheries management and enforcement (see MLAW-1), no anchoring areas, outreach, and targeted reef restoration actions (e.g., macroalgae control, outplanting of coral recruits). JRM is already taking steps to address a number of these actions which are described further below.
- *Action*: JRM has programmed for annual monitoring to include pre, during, and post monitoring around bleaching events, coral disease, and active intervention during COTS outbreaks on NBG submerged lands. JRM is working with partners locally to align monitoring strategies and adapt as necessary. Monitoring methodology will be coordinated with the Guam Coral Reef Response team, an interagency effort between NOAA, USFWS, National Park Service, Guam DAWR, Bureau of Statistics and Plans, Guam EPA, UOG, and recently U.S. Navy. Utilize monitoring results to develop and prioritize response actions (e.g., implement control efforts in a timely manner using best available methods such as bile salts or sodium bisulphate if COTS outbreaks are detected, minimize harmful activities at sensitive sites during coral bleaching events to reduce local stress to corals).

- *Action*: Develop protocol for immediate assessment and response to reef damage caused by unanticipated events such as vessel groundings and anchor damage. The protocol will outline responsible parties, coordination process, and initial reef damage assessment requirements. This protocol will inform the long-term response plan. Conduct an in-person workshop for DoD personnel and stakeholders to present the incident response plan, including how incidents can be assessed and managed.
- *Action*: JRM will coordinate with local partners and subject matter experts (SMEs) to determine appropriate locations and methods for coral population enhancement and restoration efforts. JRM will align projects with the proposed Guam Restoration Strategy (in development). This may include projects that include sexual propagation that collect gametes, settle them on tiles, and eventually outplant new colonies, but can also include outplanting colonies, clones, or asexual propagation from fragments, or other restoration strategies such as algal removal.
- *Action*: Reduce adverse impacts from commercial and recreational boating to coral reef habitat and EFH due to improper vessel anchoring by installing and maintaining mooring buoys at 19 locations within JRM-administered submerged lands: Outer Apra Harbor (15) and the south side of Orote Peninsula (4). Proposed locations are shown in Figure 5-17.
- *Action*: Participate in bi-annual Guam Coral Reef Task Force and the reef restoration working group.
- *Action*: Develop protocol for immediate assessment and response to reef damage caused by natural disasters/events such as typhoons, tsunamis, heat waves, extreme flooding, and earthquakes.
- *Action:* Provide awareness on shallow mooring systems buoy locations to the local fishing community.
- *Action:* Provide educational workshops, outreach materials, and/or signage on fishing best practices.



Figure 5-17. Location of Proposed Mooring Buoys within Outer Apra Harbor and the south side of Orote Peninsula at NBG Main Base

MHM-2: MARINE FLORA MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objectives #1 and 3-5; and Goal #3, Objective #1.

- *Strategy:* Survey and monitor sub-tidal areas for submerged aquatic vegetation, including seagrass and macroalgae.
- *Action*: Collaborate with aquaculture experts and potential partners to determine feasibility and capacity for growing or acquiring native herbivorous fish and invertebrates (e.g., sea urchins) for release on JRM-administered submerged lands in order to help control overgrowth of macroalgae.
- *Action*: Monitor and assess seasonal changes to health of seagrass beds at Dadi. Survey information will include: species identification, abundance description, mapping of each species via GIS including existing aerial photograph verification, and assessment of ecosystem health. Follow-up surveys will be conducted annually during wet and dry seasons to monitor health of existing seagrass beds.
- *Action*: Measure and monitor carbon sequestration rates of seagrass beds at Dadi Beach Reef Flat.
- *Action:* Develop a seagrass restoration plan for Dadi Beach reef flat.
- *Action:* Restore seagrass beds at Dadi Beach, if feasible. Seagrass provides coastal resiliency by stabilizing sediments in the seafloor. Seagrass is the primary food source for resident green and hawksbill turtles at NBG.

MHM-3: EVALUATE MANGROVE FUNCTIONALITY IN THE ATANTANO WATERSHED

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objectives #1, 3-5 and 7; and Goal #3, Objectives #1 and 4.

- *Strategy*: Conduct studies to evaluate functional aspects of the mangrove habitat in Inner Apra Harbor.
- *Action*: Establish a Sediment Elevation Table to evaluate mangrove sediment trapping functionality on the southeast side of Inner Apra Harbor.
- *Action*: Census the fish and in-water invertebrate species that use the mangrove swamp for stages of ontogeny in their life cycle.
- *Action*: Census the epibionts that grow on the mangrove roots such as tunicates, sponges, and algae.
- *Action*: Measure productivity of the mangroves to determine growth rates.
- *Action*: Delineate the current boundaries of mangrove distribution and track changes over time.
- *Action*: Evaluate the flow dynamics of water through the culvert under the road adjacent to Abo Cove and in the wetland behind the road.
- *Action*: Enhance the structure of the mangroves, as appropriate.
- *Action*: Measure and monitor carbon sequestration rates of mangrove wetlands at NBG.
- *Action:* Manage/restore/sustain mangroves along the NBG coastline. Mangroves reduce wave action, stabilize sediments/coastline, and protect establishments along the shoreline from storm surges.
- *Action:* Conduct studies to monitor sediment and nutrient loads in time and space for managing stressors' inputs to the coastal and coral reef areas. Utilize a Soil and Water Assessment Tool (SWAT) model to simulate flow, soil erosion, sediment, and nutrient transport, and for evaluating the effect of climate change, land use change, and BMP applications.

MHM-4: AVOID AND MINIMIZE ADVERSE EFFECTS OF DON ACTIVITIES ON MARINE RESOURCES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-4; Goal #3, Objective #4; and Goal #6, Objective #1.

- *Strategy*: Avoid and minimize impacts to sensitive resources during in-water infrastructure improvement projects as well as during operations.
- *Action*: Develop and implement consistent BMPs to address impacts to water quality during DON activities. Examples of BMPs that could be triggered by water quality include but are not limited to: (1) limiting dredge activity on a day when environmental conditions encourage suspended sediment to remain suspended in the water column longer or move farther in the harbor than under typical conditions; (2) managing the timing of activities that disturb sediment so they would not contribute to decreased water quality after large rain events have flushed upland sediments into the nearshore marine environment; or (3) avoid work during coral spawning periods. These BMPs will be incorporated into the construction and design template specifications.
- *Action*: Implement NBG Main Base BMPs for ESA-listed species to ensure no adverse effects to ESA-listed species during DON activities, as have been developed for recent Biological Evaluations. Examples of BMPs include but are not limited to: (1) Designate observers to vigilantly observe activity sites for the presence of ESA-listed species, particularly during in-water activities; and (2) providing a contingency plan to avoid contamination of the marine environment from DON activities (DON 2013, 2015c).

- *Action*: Provide operators with more granularity on marine resource constraints (i.e., sensitive habitat areas).
- *Action*: Ensure the established environmental review process is implemented to evaluate the effects of actions on marine resources prior to implementing new activities.
- *Action*: Conduct long-term monitoring at Mound 9, which includes monitoring the success rates of relocated corals by species and substrate.
- *Action*: Re-assess and re-evaluate hard-bottom sites in Outer Apra Harbor that can be used for coral transplantation projects.

MHM-5: MARINE RESOURCES DATA ANALYSIS AND COORDINATION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objectives #1 and 3-4; Goal #3, Objective #4; and Goal #7, Objective #3.

- *Strategy*: Establish long-term partnership with NMFS PIFSC to improve communication, collaboration, and information sharing to ensure the most up-to-date NOAA Pacific RAMP data are analyzed and available to inform JRM INRMP adaptive management strategies.
- *Action*: Develop an agreement with NMFS PIFSC to address critical data needs from tri-annual NOAA Pacific RAMP surveys for sites within JRM-administered submerged lands to evaluate trends over time and inform management actions. JRM will work with NMFS PIFSC to develop a scope, to determine an acceptable cycle for data analysis (e.g., within 12-18 months of survey completion), and to identify data categories and survey locations to prioritize for analysis. At a minimum, the analysis would include a summary of findings from coral, algal, benthic, and fish surveys within JRM-administered submerged lands and associated figures.

MHM-6: MARINE HABITAT MAPPING EFFORTS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objectives #1 and 3-5; Goal #3, Objectives #1 and 4; Goal #5, Objective #1; and Goal #7, Objective #3.

- *Strategy*: Classify and delineate benthic mapping and characterization in the nearshore waters of JRM-administered submerged lands at NBG Main Base, focusing on information gaps.
- *Action*: Provide baseline data for monitoring changes in coral reef and marine benthic communities that are compatible with existing monitoring programs in Guam and the region.
- *Action*: Obtain high resolution habitat maps of submerged habitat to inform priorities as well as avoidance and minimization measures during DON activities.
- *Action*: Work with NOAA NCCOS to classify and delineate benthic habitats in the nearshore waters of submerged lands at NBG Main Base using side scan or multibeam sonar. Results from this project will be used to map threatened and endangered species (e.g., sea turtles, corals, and scalloped hammerhead shark), EFH, and indicator of health.
- *Action*: Work with NOAA NCCOS to perform mapping projects of previously mapped locations/installations every 5 years to study/monitor temporal and spatial changes in habitat.

MHM-7: U.S. NAVY DIVER TRAINING FOR SUBMERGED NATURAL RESOURCES MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1 and 2; Goal #2, Objective #4; Goal #3, Objective #4; and Goal #7, Objective #3.

- *Strategy*: Ensure that NAVFAC Marianas marine resource specialists are capable of participating in rapid assessment surveys of marine resources with other federal and territorial agencies when necessary.
- *Action*: NAVFAC Marianas marine resources specialists will complete Navy Diver Training (Navy prerequisite for conducting in-water work) to obtain the qualifications necessary to actively monitor and report on the health of marine resources on JRM-administered submerged lands.

MHM-8: ACOUSTIC TELEMETRY NETWORK

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; and Goal #3, Objectives #1-2 and 4.

- *Strategy*: Determine presence/absence of individuals, movement patterns, habitat utilization, foraging locations, home range size, and site fidelity for indicator species and protected species.
- *Action*: Deploy acoustic tags for indicator species and protected species to determine geospatial and temporal patterns of habitat use, residency, and movement patterns in waters of Apra Harbor and adjacent inshore habitats.

5.4.2.2 Marine Invasive Species Management

An invasive species is defined in EO 13112 as a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm, or harm to human, animal, or plant health. Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions. As with terrestrial ecosystems, marine invasive species can have a significant effect on the native marine species of island ecosystems.

Marine invasive species control and removal efforts are mandated by similar federal, DoD, and JRM regulations as terrestrial invasive species. DON funded the development of the RBP for Micronesia and Hawai‘i. The RBP is a multi-disciplinary effort of federal and regional scientists and experts to address pathways and encourage a more holistic approach to evaluating and managing terrestrial, marine, and freshwater invasive species risks within Micronesia and Hawai‘i. DON/JRM will implement necessary and appropriate DoD recommendations of the RBP (refer to Volume I, Attachment M, U.S. DoD Biosecurity Recommendations).

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Marine Invasive Species Management (MIS) on NBG Main Base.

MIS-1: IMPLEMENTATION OF REGIONAL BIOSECURITY PLAN FOR MICRONESIA AND HAWAI‘I

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #3; Goal #3, Objectives #1-2 and 4; Goal #4, Objectives #1-4; and Goal #7, Objective #1.

- *Strategy*: Implement recommendations within the RBP (DON 2015b) that are applicable to JRM (Volume I, Attachment M, *U.S. DoD Biosecurity Recommendations*) that would avoid and minimize: (1) new invasive species incursions into Guam’s marine waters and (2) the transfer of invasive species from Guam to Hawai‘i and other parts of Micronesia.
- *Action*: Develop and maintain a Marine Invasive Species Management Plan for NBG Main Base. This plan would include, but not be limited to, the following:
    1) Establish a watchlist and effective monitoring program for high-risk non-native marine species that are known or thought to pose significant ecological, economic, social, or

cultural impacts to Guam and the CNMI, focusing on species that are not established or widely distributed in the region. The watch list will be coordinated and consistent with the Guam Marine Biosecurity Action Plan (Miller 2014) Appendix C on potential marine invasive species.

2) Develop early detection and response protocols for new incursions by a few focal non-native marine species for Guam and the CNMI.
3) Develop standard language to be included in contract specifications that provides BMPs to lessen the risk of marine invasive species being transported to project sites.

- *Action*: JRM will work with appropriate U.S. Navy commands to determine if updates are warranted for Navy hull husbandry standards (Naval Sea Systems Command S9086-CQ-STM-010) (U.S. Navy 2006) and ballast water requirements (*Note: The U.S. Navy adopts USCG standards*).
- *Action*: Implement JRM Marine Invasive Species Management Plan, perform MIS baseline surveys for all installations and implement necessary actions/protocols based on baseline results.
- *Action:* Create a marine invasive species database for JRM submerged lands.

MIS-2: FEDERAL AND TERRITORIAL COORDINATION AND COLLABORATION FOR MARINE INVASIVE SPECIES PREVENTION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #4; Goal #4, Objective #4; and Goal #7, Objective #3.

- *Strategy*: Develop partnerships to improve coordination and collaboration with other federal and Guam agency staff, industry, and non-governmental organizations and seek opportunities to synergize funding, resources, and efforts to accomplish common goals (i.e., those outlined in the 2014 Guam Marine Biosecurity Action Plan).
- *Action*: Participate in the quarterly Guam Invasive Species Advisory Council meetings and coordinate regularly with the territorial marine invasive species coordinator once hired.
- *Action*: Develop partnerships to improve coordination and collaboration with other Pacific Island governments as well, such as Palau, FDM, CNMI, New Zealand, and Australia.

5.4.2.3 Marine Protected Species Management

Management of marine threatened and endangered species on JRM-administered submerged lands includes implementing programs to protect species and coordinating efforts with the appropriate agencies. An INRMP is a primary tool for the DoD to fulfill its obligation to support section 7(a)(1) of the ESA which states that all federal departments and agencies shall seek to conserve listed species and shall use their authorities to further the purpose of the ESA.

In accordance with section 7(a)(2) of the ESA, a federal agency shall consult with NMFS to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species. In addition, DON avoids impacts on habitat suitable for federal and Guam ESA-listed species, as the mission allows. Federal ESA-listed species in JRM-administered submerged lands will continue to be managed by implementing specific management strategies that enhance habitat for these species and by initiating specific strategies that address immediate conservation needs of listed species on the installation.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Marine Protected Species Management (MPS) on NBG Main Base. Additional protection measures for marine protected species are presented in Section 5.4.2.5, *Marine Natural Resources Law Enforcement*.

MPS-1: SCALLOPED HAMMERHEAD SHARK STUDY

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; and Goal #3, Objectives #1-2 and 4. This project supports conservation measures from the ESA section 7 Consultation BO and Conference Report for the U.S. Military MITT Activities (NMFS 2020).

- *Strategy*: Conduct surveys to determine the temporal and spatial abundance, distribution, and habitat use of the threatened scalloped hammerhead shark within Apra Harbor.
- *Action*: Monitor shark population movements, habitat use, and behavior through capture and acoustic or satellite tagging efforts or other appropriate methods.

MPS-2: SEA TURTLE POPULATION PROTECTION AND ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1-2 and 4; and Goal #7, Objective #3.

- *Strategy*: Monitor sea turtle activity and determine habitat use in the marine waters of JRM-administered submerged lands and adjacent Guam waters.
- *Action*: Examine distribution, movement, and habitat use of sea turtles on JRM-administered submerged lands around Guam (focus on Apra Harbor). Up to 300 Passive Integrated Transponder tags will be attached to turtles captured by JRM. Of the turtles captured and fitted with Passive Integrated Transponder tags, 34 will be outfitted with GPS satellite telemetry or archival tags to monitor movement and collect data on habitat use (i.e., habitat type, depth, time at depth); drifters will be deployed to examine dispersal of hatchlings.
- *Action*: Continue to coordinate efforts with U.S. Pacific Fleet as long as their complementary sea turtle monitoring efforts continue.
- *Action*: Reduce in-water debris by supporting and/or facilitating cleanups of in-water debris several times per year.
- *Action*: Determine the status of Fibropapillomatosis (tumor disease) in the resident sea turtle population.
- *Action*: Understand the impacts of climate change on resident sea turtles (e.g., sedimentation, reef degradation, ocean acidification) and nesting sea turtles (e.g., genetic analysis).
- *Action*: Implement and coordinate water quality monitoring and ecosystem monitoring to evaluate runoff and implement action to mitigate effects of erosion.
- *Action*: Continue in-water surveys and conduct additional surveys within JRM submerged lands to identify additional foraging/resting areas.

MPS-3: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 4; Goal #3, Objectives #1-2 and 4; and Goal #4, Objective #2. This project supports conservation measures from the ESA section 7 Consultation BO and Conference Report for the U.S. Military MITT Activities (NMFS 2020).

- *Strategy*: Implement conservation measures listed in the 2020 MITT BO from NMFS.
- *Action*: Ensure no impact to coral or hard substrates during MITT training activities occurring within or adjacent to reef habitats by implementing appropriate avoidance measures.

5.4.2.4 Marine Natural Resources Educational Outreach



Marine debris in Apra Harbor.
(*Photo*: M. Lybolt)

Conservation awareness is instrumental in creating conditions needed to manage natural resources. The JRM approach to awareness stresses education. It provides military personnel and the public with insights into installation natural environments and conservation challenges. Education promotes awareness of threats and stressors to marine resources and threatened and endangered species. Activities such as habitat management, natural resources management, and submerged lands rehabilitation can be assisted by increasing the public's awareness of the importance of conserving the natural resources within JRM-administered submerged lands. However, issues such as protection of sensitive marine areas for fish and wildlife species, invasive species management, and restrictions on some recreational activities within JRM-administered submerged lands, require effective outreach with the public and military personnel in order to garner support and, perhaps more importantly, to avoid adverse reactions from various user impacts. An outreach program focused on minimizing impacts to marine resources and protecting ESA-listed marine species must be directed to both installation and external stakeholders to be effective.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Marine Natural Resources Educational Outreach (MEDU) on NBG Main Base. These management projects are in parallel and in concert with those identified and discussed in Section 5.4.1.5, *Terrestrial Natural Resources Educational Outreach*.

MEDU-1: ESA-LISTED SPECIES AND MARINE RESOURCES OUTREACH

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7, Objectives #1-2. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Implement a targeted outreach program to improve awareness among DoD personnel and the public of threats and stressors to marine resources, including protected species, and the importance of conserving natural resources on NBG Main Base through cooperative efforts with partners such as GovGuam and USFWS.
- *Action*: Maintain informational signs and interactive kiosks at NBG Main Base recreational beaches (including Gab Gab, San Luis, and Dadi Beaches).
- *Action*: Develop, update, and distribute multimedia for public education to incoming military personnel, contractors, schools, and other outreach opportunities that address appropriate behavior around threatened and endangered species and the consequence of introduced non-native plant and animal species. Outreach materials will be reviewed every 2 to 5 years.
- *Action*: Review and update, as needed, current outreach videos/media utilized during the orientation briefs viewed by 100% of new personnel upon arrival to Guam.
- *Action*: Coordinate with the dive shops to help promote environmental education and awareness to reduce negative recreational impacts on JRM-administered submerged lands.

MEDU-2: JRM NATURAL RESOURCES STEWARDSHIP OUTREACH AND PUBLIC ENGAGEMENT PROGRAM

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7, Objectives #1-3.

- *Strategy*: Implement a comprehensive natural resources outreach program regarding the federal, territorial, and base environmental regulations and policies, as well as information about the importance of protecting and conserving JRM's natural resources.
- *Action*: Update a comprehensive Natural Resources Stewardship Outreach online training system for military and civilian personnel, on an as needed basis to reflect changes in best science and management practices.
- *Action*: Continue to work with JRM Environmental Outreach and Educational Program coordinator to significantly increase their outreach with military personnel and the public about appropriate behavior toward threatened and endangered species and the importance of conserving natural resources within JRM-administered lands and submerged lands.
- *Action*: Conduct marine debris clean-ups several times a year on sea turtle nesting beaches.
- *Action*: Utilize partnerships with the USCG and SeaBees during joint training exercises, and during joint training exercises to minimize costs and to raise awareness within military personnel of the importance of maintaining the beaches to protect threatened and endangered species and other marine natural resources.
- *Action*: Continue to use annual high profile environmental days, such as Earth Day in April and the Ocean Conservancy's International Coastal Clean-up in September, to organize clean-ups and provide natural resource outreach materials to military personnel and other participants.
- *Action*: Update outreach materials (signage, pamphlets, videos, etc.) for the public and military personnel about the importance of using reef-safe sunscreen to minimize impacts on the reefs and to educate military personnel and other participants about the importance of disposing trash properly and distribute this information at marine debris clean-up events.
- *Action*: Develop, update, and implement a biosecurity education and outreach program for contractor personnel, military personnel, and dependents.

5.4.2.5 Marine Natural Resources Law Enforcement

JRM has established the following objectives for enforcement: (1) enforce laws and regulations pertaining to the implementation of the natural resources program, (2) integrate natural resources enforcement into the overall natural resources program, and (3) use enforcement personnel to enhance the natural resources program at JRM.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Marine Natural Resources Law Enforcement (MLAW) on NBG Main Base.

MLAW-1: CONSERVATION LAW ENFORCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-3; Goal #2, Objectives #1-2 and 4; Goal #3, Objectives #4; Goal # 6, Objectives #1-2; and Goal #7; Objectives #1-3.

- *Strategy*: Detect and deter unauthorized activity that negatively affects natural resources on NBG Main Base (e.g., poaching, littering, improper vessel anchoring, illegal fishing) through conservation law enforcement.

- *Action*: Establish a Conservation Law Enforcement Program by hiring a Conservation Law Enforcement Officer, and by partnering with other agencies as applicable, to enforce natural resource laws, policies, and regulations on NBG Main Base. The Conservation Law Enforcement Officer will conduct outreach and enforce natural resource regulations.
- *Action*: Protect sea turtles from poaching on nesting beaches and submerged lands.

MLAW-2: RECREATIONAL ACCESS TRACKING AND ECOLOGICAL RESERVE AREA VISITOR USE PLAN

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1 and 3; Goal #2, Objectives #3-4; Goal #3, Objective #4; and Goal #6, Objectives #1-2.

- *Strategy*: Monitor impacts from outdoor recreation and visitor use through surveys and develop an outdoor Recreation and Visitor Use Plan.
- *Action*: Determine the pressure on marine resources from the various forms of recreation, JRM will gather information on recreational usage and types of impacts on marine resources by recreational usage (fishing, diving, beach activities, boating, poaching).
- *Action*: Establish a regular monitoring program to inform the development of a Recreation and Visitor Use Plan. This plan will inform the Conservation Law Enforcement Program and will evaluate the feasibility of implementing previous ERA management recommendations (NAVFAC Marianas 2011b), such as boat permits.

5.4.2.6 Marine Geographic Information System and Data Management

Natural resources data are stored and maintained within a centralized JRM GIS database using GIS data collection standards. The GIS database also provides support for the entire environmental program and the training community. JRM uses GIS for complex analyses such as project siting, data interpolations, and risk assessments.

GIS software enables installation staff to capture, store, update, manipulate, analyze, and display all forms of geographically referenced data and tabular information about natural and physical resources found on JRM-administered submerged lands. The training of JRM staff and the allocation of their time to data entry, mapmaking, data analysis, and interpretation of the results determines the success of the installation GIS. Once fully developed, the installation GIS databases can be used for projects such as the following:

- providing maps with bathymetric contours and locations of species, marine habitat, EFH, and other areas of potential concern
- providing special maps for Environmental Awareness materials
- ensuring avoidance of threatened and endangered species habitats and other areas of special concern during construction projects
- identifying site options for use during NEPA evaluation of alternative sites
- calculating drainages and water flows
- determining species habitat preferences

To meet the goals and objectives of the INRMP, the following management project was identified for Marine GIS and Data Management (MGIS) on NBG Main Base.

MGIS-1: MARINE NATURAL RESOURCES GIS AND DATA MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-5; and Goal #3, Objectives #1 and 4.

- *Strategies*:
  - Identify data gaps in marine natural resources GIS to assist in the development of future data collection efforts, surveys, and management actions.
  - Ensure that GIS information is available to installation SMEs and military personnel, biologists, planners, contractors, and others in a timely manner to assist with planning and decision-making.
- *Action*: Update and continuously maintain existing centralized GIS database to effectively inform and guide future management of marine natural resources on NBG Main Base and meet natural resources goals and objectives. Readily available GIS data will be used to develop natural resources constraints maps for use in current and future JRM management and planning decisions for NBG Main Base.
- *Action:* Create a marine invasive species database for JRM submerged lands.

5.4.2.7 Summary – Marine Ecosystem Management

Implementation of the JRM INRMP program and the focused strategies and actions of the management projects for marine resources provides a conservation benefit to the marine ecosystem at NBG Main Base by maintaining and enhancing marine community structure, function, species diversity, and resiliency. Inventorying and monitoring help maintain and improve the local scientific knowledge of coral reef ecosystems and their resilience to environmental stressors, guide adaptive management solutions, and aid in avoidance and minimization of potential impacts to sensitive resources. Furthermore, proactive invasive species prevention, early detection, and control reduces the risk of intra- and inter-island species introductions. Using this regional ecosystem-based approach for managing protected species and their associated ecosystems ensures that JRM remains in compliance with federal and territorial laws while supporting the operational functionality of the NBG Main Base mission.

Eighteen management projects addressing marine natural resources management are proposed for implementation on NBG Main Base:

- Marine Habitat Management – 8
  - MHM-1: Coral Habitat Enhancement
  - MHM-2: Marine Flora Management
  - MHM-3: Evaluate Mangrove Functionality in the Atantano Watershed
  - MHM-4: Avoid and Minimize Adverse Effects of DON Activities on Marine Resources
  - MHM-5: Marine Resources Data Analysis and Coordination
  - MHM-6: Marine Habitat Mapping Efforts
  - MHM-7: U.S. Navy Diver Training for Submerged Natural Resources Management
  - MHM-8: Acoustic Telemetry Network
- Marine Invasive Species Management – 2
  - MIS-1: Implementation of Regional Biosecurity Plan for Micronesia and Hawai‘i
  - MIS-2: Federal and Territorial Coordination and Collaboration for Marine Invasive Species Prevention
- Marine Protected Species Management – 3
  - MPS-1: Scalloped Hammerhead Shark Study
  - MPS-2: Sea Turtle Population Protection and Enhancement
  - MPS-3: Mariana Islands Training and Testing Implementation of the Biological Opinion
- Marine Natural Resources Educational Outreach – 2
  - MEDU-1: ESA-listed Species and Marine Resources Outreach
  - MEDU-2: JRM Natural Resources Stewardship Outreach and Public Engagement Program

- Marine Natural Resources Law Enforcement – 2
  - MLAW-1: Conservation Law Enforcement
  - MLAW-2: Recreational Access Tracking and Ecological Reserve Area Visitor Use Plan
- Marine Geographic Information System and Data Management – 1
  - MGIS-1: Marine Natural Resources GIS and Data Management

6 NAVAL BASE GUAM NAVAL MUNITIONS SITE

6.1 CURRENT OPERATIONS AND LAND USE

In 1944, the United States (U.S.) Navy began construction of a facility for ordnance storage in Guam, which would later become Naval Munitions Site (NMS), also known as the Naval Magazine and the Munitions Annex. The need for quantities of ammunition and the ability to store it safely and efficiently was seen as part of a front line for national defense during the Korean War. Additional ammunition magazines were constructed during the latter part of the Korean War, and by February 1954, over 18,500 tons of ammunition were stored at NMS. During the height of the Vietnam War (1960s and early 1970s), there was a major increase of stored ordnance at NMS, making it a major ammunition supply point (Aaron 2011). In July 1995, some of the facility's functions were relocated to the Naval Magazine at Lualualei, Hawai'i. Today, NMS retains only those functions necessary to support mobilization and regional contingencies for the Pacific Fleet.

6.1.1 Land Ownership and Management

NMS is managed by Navy Munitions Command, Pacific East Asia Division, Unit Guam, Naval Base Guam (NBG). Located on mountainous terrain in south-central Guam, NMS encompasses approximately 8,645 acres (3,499 hectares). The majority of the NMS boundary is not fenced or marked with signage, and unauthorized access through these unsecured areas remains a problem.

6.1.2 Naval Munitions Site Assets and Uses

NMS provides support to units of the Pacific Fleet operating in the Western Pacific through receiving, renovating, maintaining, storing, and issuing ammunition, explosives, and expendable ordnance materials. NMS has the primary responsibility of providing ordnance support for the Seventh and Fifth Fleets and is the single transportation service for point-to-point ammunition hauling between military installations in Guam. Magazines at NMS provide more than 250,000 square feet (23,226 square meters) of storage space for ordnance materials. Munitions handling buildings, motor pools, mess halls, and related support buildings are also located within NMS. Observation towers inside NMS enhance site security during the movement of munitions into and out of the facility. NMS Emergency Detonation Site is used to dispose of ordnance from military installations in Guam (Figure 6-1). Public access to authorized locations within NMS is managed under the Joint Region Marianas (JRM) Public Access Plan. In addition, annual visitation to important cultural sites and annual events (e.g., Liberation Day, All-Saints Day) is coordinated through the JRM Public Affairs Office.



Mount Jumullong Manglo is the second highest peak on Guam. It is an important hike for locals to honor Good Friday.
(*Photo*: L. Shaughnessy)

Fena Valley Reservoir is an artificial lake that lies entirely within NMS boundaries, and it currently serves as the primary water source for NBG and southern Guam. The reservoir provides 10–12 million gallons per day (gpd) to the U.S. Department of the Navy (DON) and Guam Waterworks Authority (SWCA and Tom Nance Water Resource Engineering [TNWRE] 2007). Any water generated in excess of the DON and Guam Waterworks Authority flows over the spillway into the Maagas River. Naval Facilities Engineering Systems Command (NAVFAC) Marianas operates the Fena Water Treatment Plant located just below the downstream toe of the dam.

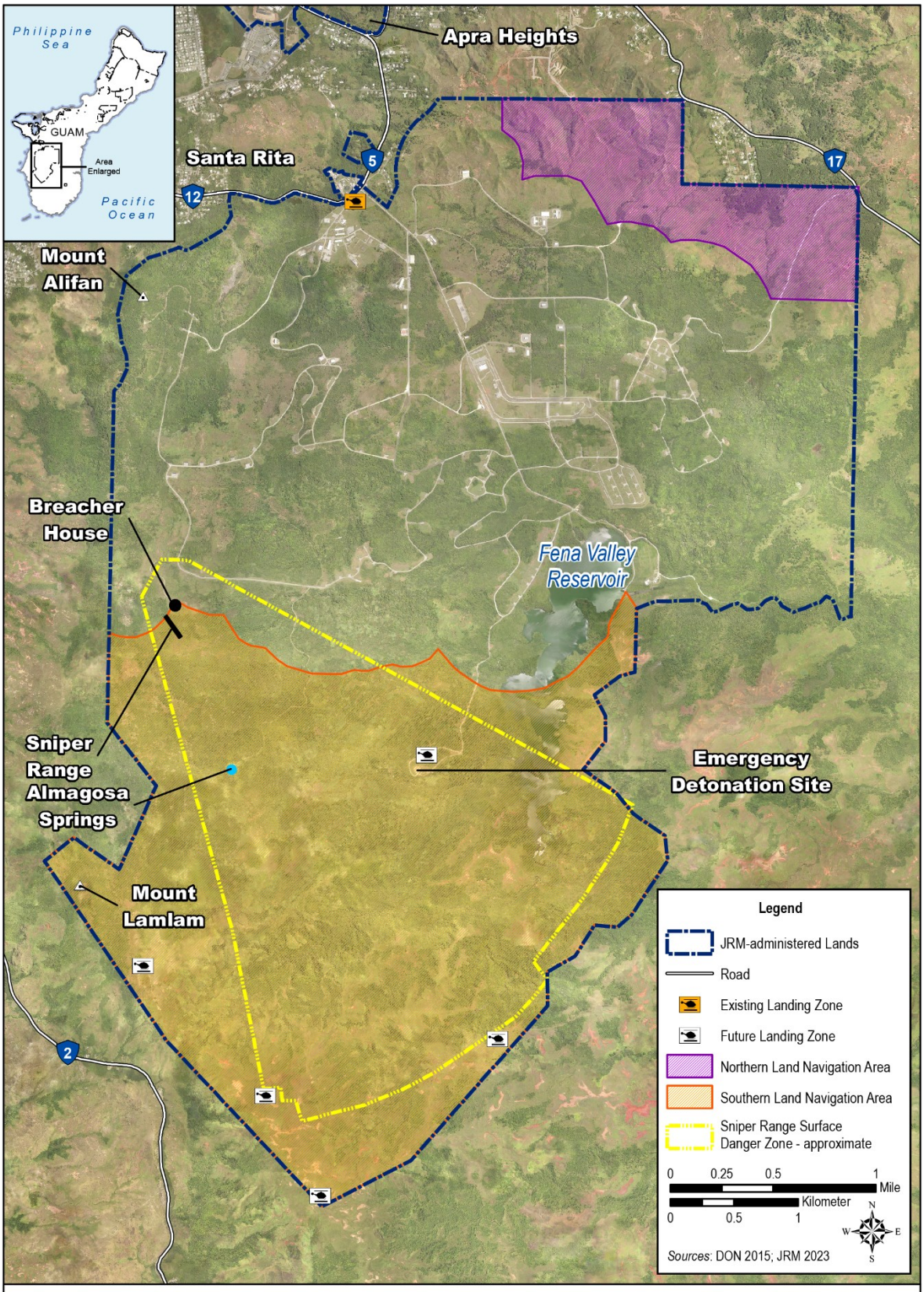


Figure 6-1
Overview of NMS

Detailed information about the reservoir appears in Section 6.2.2, *Hydrology*. In addition to the water supply pumped from the reservoir, water from the Almagosa and Bonya Springs is also captured and treated for drinking water use at the Fena Water Treatment Plant (SWCA and TNWRE 2007). In 1952, DON constructed a cofferdam at the pool where the Maagas River, also known as the Lost River, reemerges from limestone cliffs near the spillway at Fena Dam to create a supplemental water supply source (SWCA and TNWRE 2007). This source was never developed, but remnants of the cofferdam remain.

6.1.3 Training Areas

NMS supports ground and air-ground training, primarily for Special Forces personnel, within the 3,357-acre (1,359-hectare) Southern Land Navigation Area and the 508-acre (206-hectare) Northern Land Navigation Area (see Figure 6-1). As outlined in the 2014 Mariana Islands Training and Testing (MITT) Biological Assessment (BA) training activities that occur on NMS include the following:

- Combat Search and Rescue
- Urban Warfare Training, Non-combatant Evacuation Operations/Humanitarian Assistance Operations/Disaster Relief Operations
- Personnel Insertion/Extraction
- Parachute Insertion and Embassy Reinforcement
- Direct Action (Combat Close Quarters)
- Direct Action (Breaching)
- Intelligence/Surveillance/Reconnaissance (ISR)
- Urban Warfare Training, Maneuver (Convoy and Land Navigation)
- Field Exercise Training and Force Protection
- Anti-terrorism
- Land Demolitions (Unexploded Ordnance [UXO]) Discovery/Disposal

Training in urban warfare, breaching, and non-combatant evacuation operations occur at the Breacher House (see Figure 6-1). Sniper qualification training is conducted at the Sniper Range (DON 2014). Helicopter firefighting training occurs occasionally near the Fena Valley Reservoir spillway (U.S. Fish and Wildlife Service [USFWS] 1998); this ensures that military resources are prepared to provide water drops in case the Government of Guam (GovGuam) requests assistance during wildfires (DON 2014).

Future training activities, as part of the Guam Military Relocation, include maneuver training (convoy and land navigation), combat search and rescue, and field training exercises. These training activities will occur in the Southern and Northern Land Navigation Areas (DON 2017). Additional details on duration and frequency of these activities appear in the 2010 Guam Military Relocation Environmental Impact Statement (EIS)/Overseas EIS (OEIS) and the 2015 MITT EIS/OEIS.

U.S. Marine Corps (USMC) training exercises addressed in the 2015 Biological Opinion (BO) on the DON's Relocation of U.S. Marine Corps from Okinawa to Guam and Associated Activities in Guam, and in the 2017 Reinitiation of the 2015 BO, include company-level patrolling, jungle training, land navigation, and air-ground operations. Terrain flight, ground threat reaction, defensive maneuvering, and external load training will also occur at NMS. Ground threat reaction training requires a tactical flight maneuver area or route (similar to terrain flight routes) where ground-based electromagnetic radiation threat simulators are placed. Defensive maneuvers are also conducted along a route over land or water. Finally, confined area landing training operations will also occur at NMS (USFWS 2017). Due to repeated use during maneuver training, foot trails will be established within the Southern Land Navigation Area (USFWS 2017).

NMS access for certain training activities occurs via helicopter and/or MV-22 tilt-rotor aircraft at designated landing zones (see Figure 6-1). Personnel, hand-carried supplies, and equipment are airlifted to particular training sites because no vehicles are allowed. Helicopter and MV-22 tilt-rotor aircraft operations at NMS also include terrain flight, ground threat reaction, defensive maneuvering, confined area landing, and external load training. Training for terrain flights occurs only within the southern portion of NMS, south of the southern extent of Fena Valley Reservoir. Once aircraft cross into NMS, below Fena Valley Reservoir (training restriction line), pilots are then authorized to conduct low-level terrain flights, 50-200 feet (15-61 meters) above ground level (AGL), within the southern NMS. Low-level terrain flights do not occur over munition bunkers, the main NMS, the area to the east of the munition bunkers, over Fena Valley Reservoir, or over Almagosa Springs (USFWS 2017). Confined area landing training consists of one pass of the landing zone for orientation, a downwind approach, followed by the landing and takeoff (USFWS 2017).

The central portion of NMS, outside the designated Northern and Southern Land Navigation Areas, is particularly sensitive to wildlife disturbance. All aviation training is conducted so that aircraft approach the southern portion of NMS over the Talofofo River watershed and Fena Valley Reservoir at heights of 1,000 feet (305 meters) or greater AGL. Flights may go up the Ugum River at altitudes of 1,000 feet (305 meters) or greater AGL until they reach 9,843 feet (3,000 meters) from the mouth of the river at Highway 4, at that point aircraft can conduct low-level terrain flights. Military training units work in close coordination with JRM MITT operations to define authorized training restrictions, which may include prohibition of training in sensitive locations. JRM works closely with NBG biologists to identify areas to avoid wildlife disturbance but still be consistent with obtaining combat readiness and training requirements. Proper designation of these areas within the overlay National Wildlife Refuge (NWR) boundary signs (see Section 6.1.5.1, *Overlay Refuge Lands*) helps ensure that bivouacs and training operations do not cause additional disturbance to protected species (USFWS 2017).

6.1.4 Explosive Safety Quantity Distance Arcs

Explosive Safety Quantity Distance (ESQD) arcs are safety zones placed around areas where munitions are being stored or handled. The arcs are calculated based upon the type and volume of explosives involved. These arcs limit access and activities within them to protect personnel from harm in the case of an accident. The extent of the ESQD arcs on NMS limits development and activities within the site (Figure 6-2). ESQD arcs encompass approximately 70 percent (%) of NMS. The facilities located within these ESQD arcs include ordnance storage magazines, ordnance operating and support buildings, the Fena Valley Reservoir Dam and appurtenances, and an extensive network of roads.

6.1.5 Special Conservation Areas

6.1.5.1 Overlay Refuge Lands

The majority of NMS is designated as Overlay Refuge (Figure 6-3), which is described in Section 3.5.3, *Guam National Wildlife Refuge Comprehensive Conservation Plan*. Management actions relevant to the Overlay Refuge on NMS are described in Section 6.3.1*, Terrestrial Ecosystem Management*.

6.1.5.2 Government of Guam Conservation Areas

The GovGuam-designated 2,854-acre (1,155-hectare) Bolanos Conservation Area and 662-acre (244-hectare) Cotal Conservation Area lie immediately adjacent to the southern and northern borders of NMS (Figure 6-3).

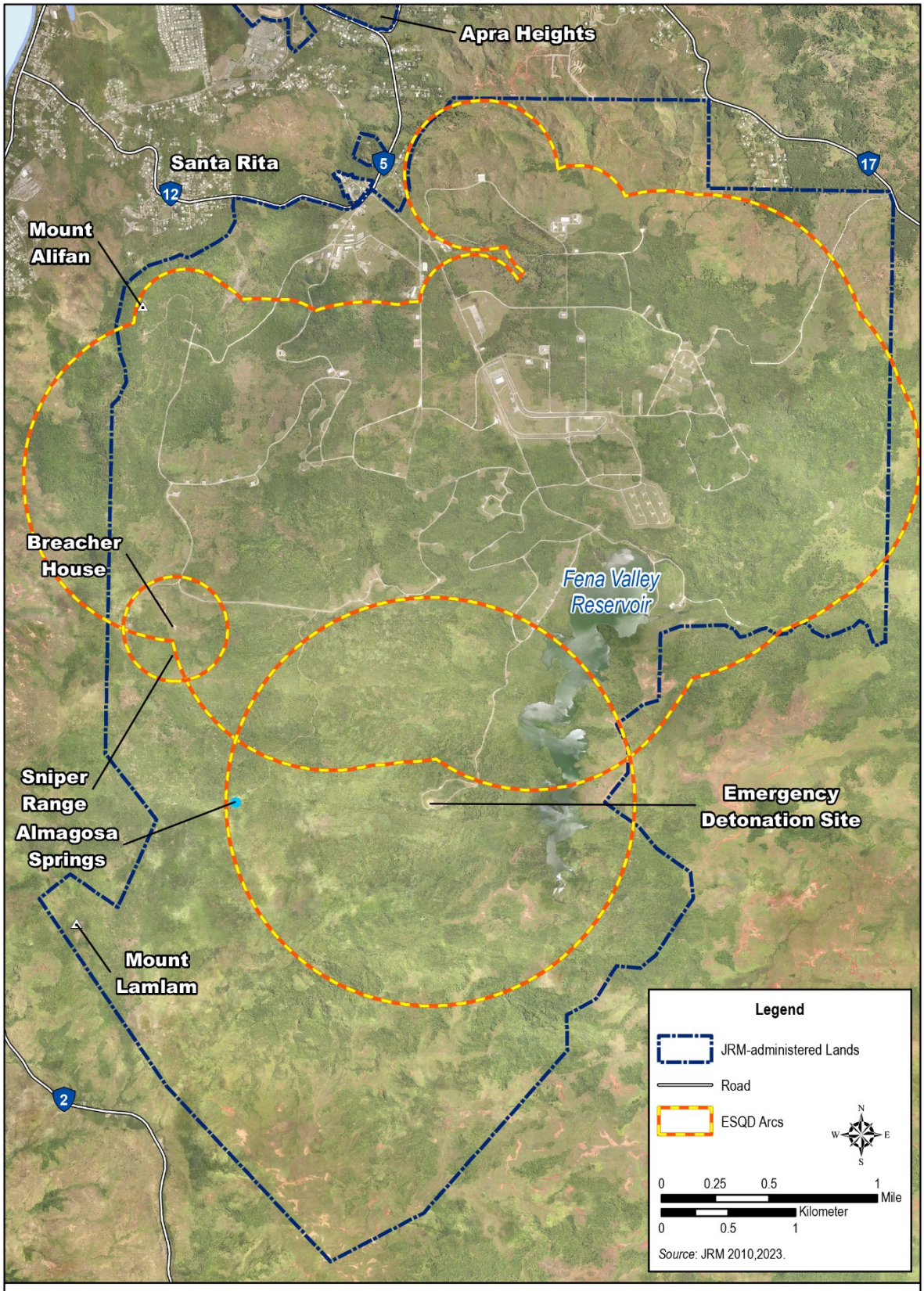


Figure 6-2
ESQD Arcs on NMS

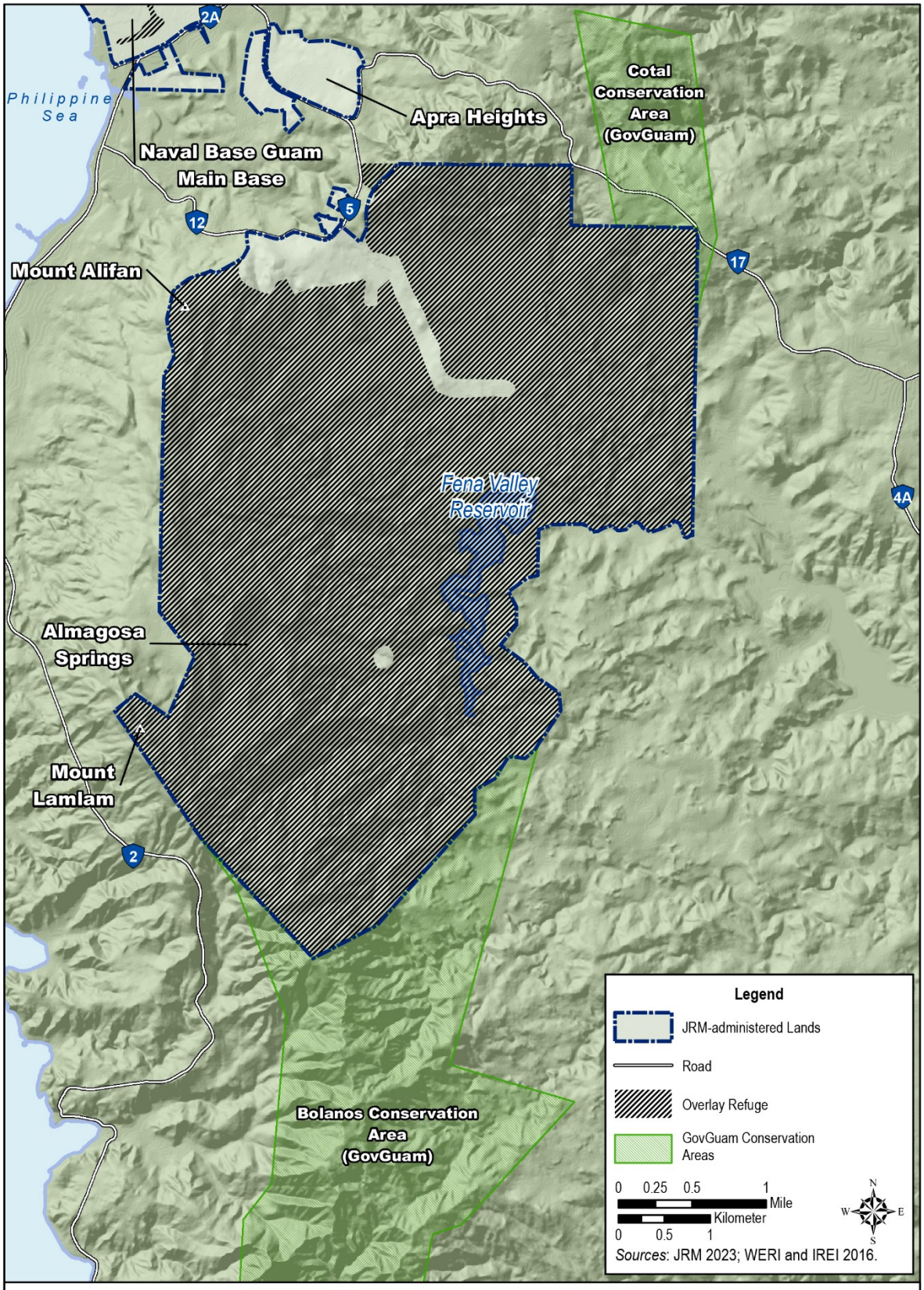


Figure 6-3
Overlay Refuge Lands on NMS and Adjacent GovGuam Conservation Lands

Both areas were established in 1999 for conservation of habitat for the potential restoration of Species of Greatest Conservation Need (SOGCN), as identified in Guam's Comprehensive Wildlife Conservation Strategy (Guam Division of Aquatic and Wildlife Resources [Guam DAWR] 2006) and 2019 Guam Wildlife Action Plan (Guam DAWR 2019). DON is considering installing signs between NMS and GovGuam lands to discourage trespassing. DON maintains existing signage around the three caves within NMS known to provide habitat for federal Endangered Species Act (ESA)-listed Mariana swiftlets (*Aerodramus bartschi*).

6.2 TERRESTRIAL ENVIRONMENT

6.2.1 Geology, Topography, and Soils

6.2.1.1 Geology

Geologic Units

NMS is located in what Tracey et al. (1964) referred to as the southern structural province of Guam. The complex geology is predominantly volcanic in origin and underlain by highly weathered basalts and tuff-derived sedimentary rocks. Because of alternative periods of submergent and emergent sea levels, massive outcrops of limestone representing ancient reefs are scattered over the area. The western boundary of NMS coincides with a range of low mountains oriented on a north-to-south axis, including Mount Alifan, Mount Almagosa, Mount Humuyong Manglo, and Mount Lamlam at a height of 1,334 feet (407 meters) above mean sea level (MSL) (Figure 6-4). This range lies on the Bolanos structural block, which consists of rock from the Miocene-aged Umatac Formation. The Umatac Formation is composed of east-dipping (5-10 degrees) volcanic rocks, including flow basalts and tuff breccia or tuff-derived conglomerate, sandstone, and shale (Gingerich 2003; Taborosi 2006). Portions of the range have alternated between periods of submergence and emergence as evidenced by the presence of the Alifan Limestone (DON 2009).

Within NMS, two distinct areas of limestone (Taborosi 2006) are present on an otherwise predominantly volcanic terrain: cockpit karst of the central NMS area and the southern mountain limestone that caps the ridgeline along the base western boundary. Taborosi (2006) defines cockpit karsts as "numerous sinkholes separated by limestone ridges and hills." These two areas are easily differentiated by the general distribution of soils; interaction with the hydrologic cycle causes phenomena important to land drainage patterns and wetlands formation.

Karst Geology

Rainfall percolates through interconnecting voids and aquifers in soluble karst topography and does not run off into discrete channels. The most typical dissolution features evident on the karst surface are sinkholes (topographically closed depressions that drain internally). These form by either dissolution or collapse of underground voids. While a majority of sinkholes in Guam are located in the limestone plateau in the northern half of the island, the greatest concentration of sinkholes on southern Guam (some 197 identified) occurs just north of Fena Valley Reservoir (Taborosi 2004; JRM 2013), on and off DON property. Some sinkholes may support hydrophitic vegetation. The cockpit karst formations within NMS are noteworthy because they abut volcanic uplands.

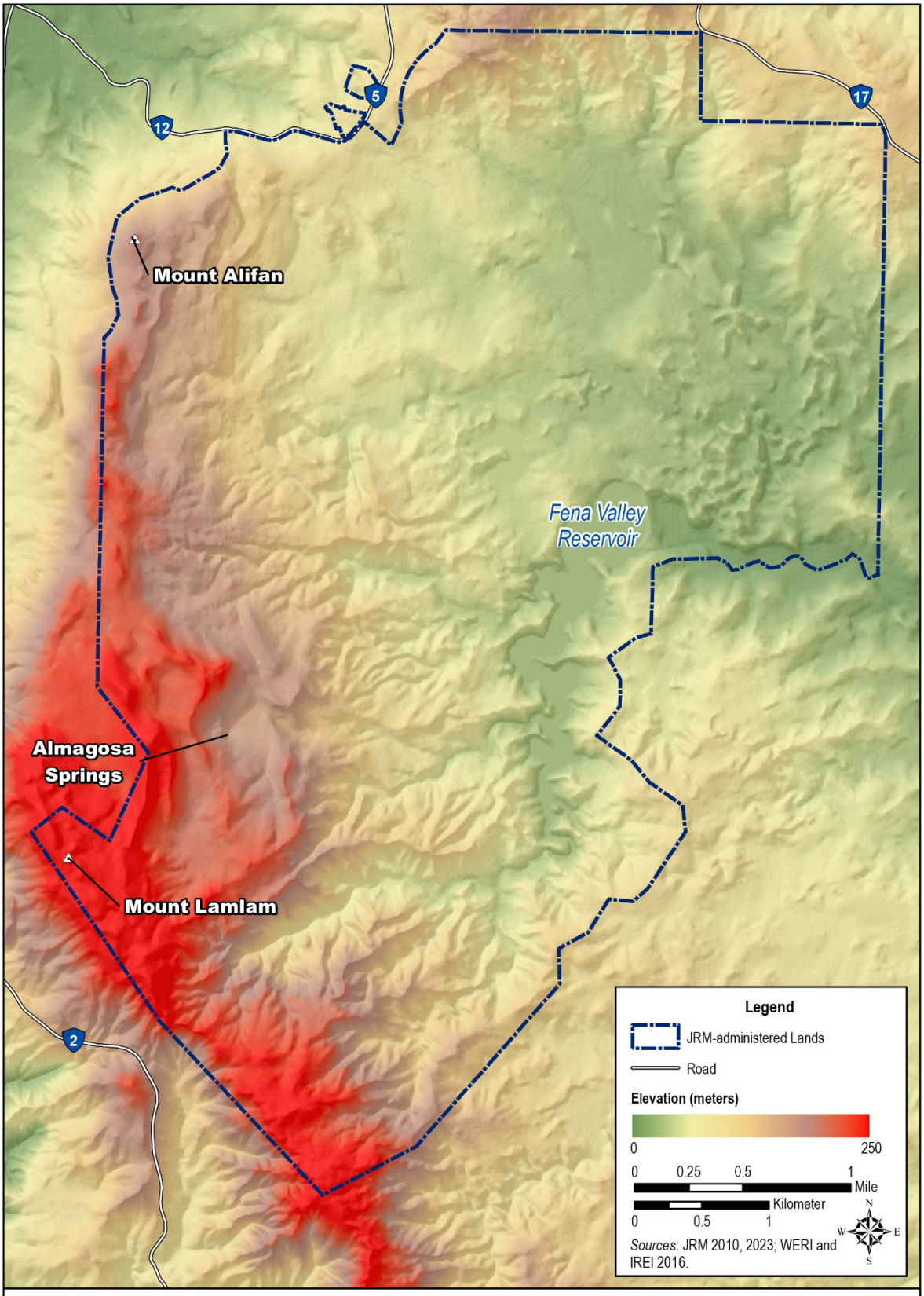


Figure 6-4
Topographic Features on NMS

Streams that develop on the volcanic terrain encounter limestone barriers on their way to the sea, directing water flow under and through the karst. An example is the "Lost River" below the confluence of the Maemong and Bonya Rivers, where the surface channel disappears as flow slides under a huge limestone cap resting upon highly weathered volcanic ash. The stream reappears at the toe of a vertical escarpment just upstream of the confluence of the Maagas River and the spillway below Fena Dam.

Seismology

The Talofofo Fault Zone crosses NMS in a northwest-southeast direction. Several smaller faults cross the site in a north-south direction. NMS is not in an area vulnerable to liquefaction, nor is it in danger of tsunami inundation (Water and Environmental Research Institute of the Western Pacific [WERI] 2008). For more details on seismic activity in Guam, see Section 4.2.1.3, *Seismology*.

6.2.1.2 Topography

NMS is located in southern Guam, which is a mountainous upland with many rivers that form wide valleys and plains near the coast (see Figure 6-4). The western boundary of NMS coincides with a range of low mountains oriented on a north-to-south axis. This range includes Mount Alifan, Mount Almagosa, Mount Lamlam, and Mount Jumullong.



NMS is located in the southern region of Guam and is characterized by mountains and hills intersected with riparian valleys.
(*Photo*: L. Shaughnessy)

6.2.1.3 Soils

Soils within NMS originate on bottomland, volcanic plateaus, and limestone plateaus. Akina-Agfayan soils dominate dissected volcanic mountains and plateaus with patches of gently to strongly sloping Akina-Togcha-Ylig soils on plateaus and basins. Soils within the limestone uplands and escarpments in the central NMS consist of shallow, well-drained Ritidian-Rock Outcrop-Guam series. Refer to Table 4-1 for details of soil classifications. Bottomland soils within the principal drainages in the central NMS are level to nearly level and relatively deep, poorly drained Inarajan-Inarajan Variant soils (U.S. Department of Agriculture [USDA] 1988) (Figure 6-5). There are differences in erosion and infiltration patterns between limestone and volcanic areas. Rainfall on highly weathered volcanic terrain (saprolites) produces run-off that erodes the surface into a stream distribution network: swales, gulches, and valleys develop that direct surface flow to streams that connect to form larger aquatic features on the way to discharge at the coast (JRM 2013). These streams produce occasional flooding in riparian corridors, resulting in ephemeral wetlands and a water table of varying depths.

6.2.2 Hydrology

6.2.2.1 Surface Water

The Fena Valley Reservoir covers approximately 200 acres (81 hectares) and is the largest freshwater body in Guam (Figure 6-6). Impounded by construction of the Fena Dam in 1951, the Fena Valley Reservoir receives surface water from the Imong, Almagosa, and Maulap Rivers. Scott (1993) reported depths of the Fena Valley Reservoir up to 65 feet (20 meters) in the wet season and less than half that level during the dry season. The reservoir originally had a maximum storage capacity of about 2.3 billion gallons or 8,365 acre-feet (925 hectare-meters) (SWCA and TNWRE 2007). Since then, the reservoir has lost approximately 17% of its designed storage capacity due to sediment accumulation from the surrounding watershed (Marineau and Wright 2017).

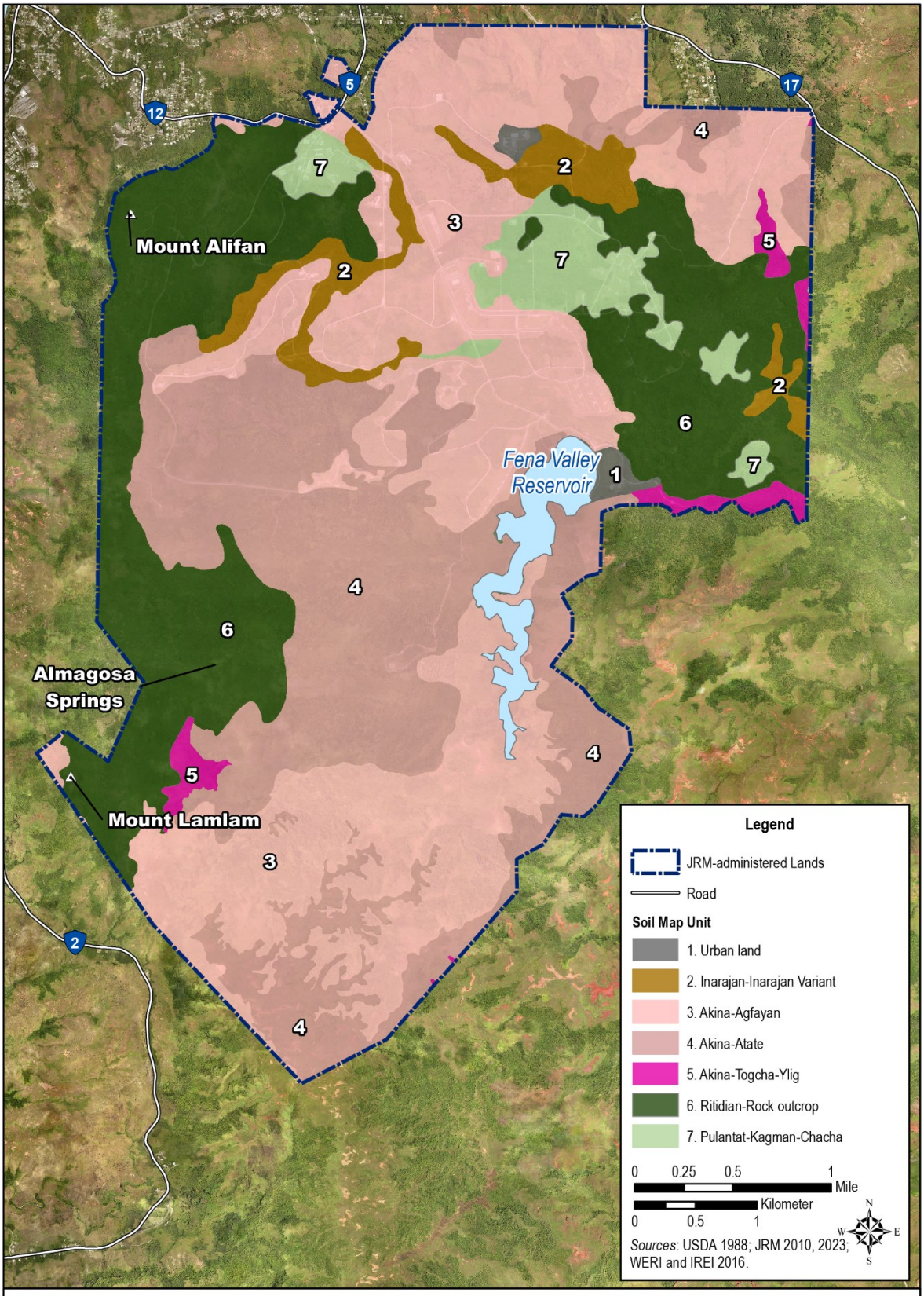


Figure 6-5
Soils on NMS

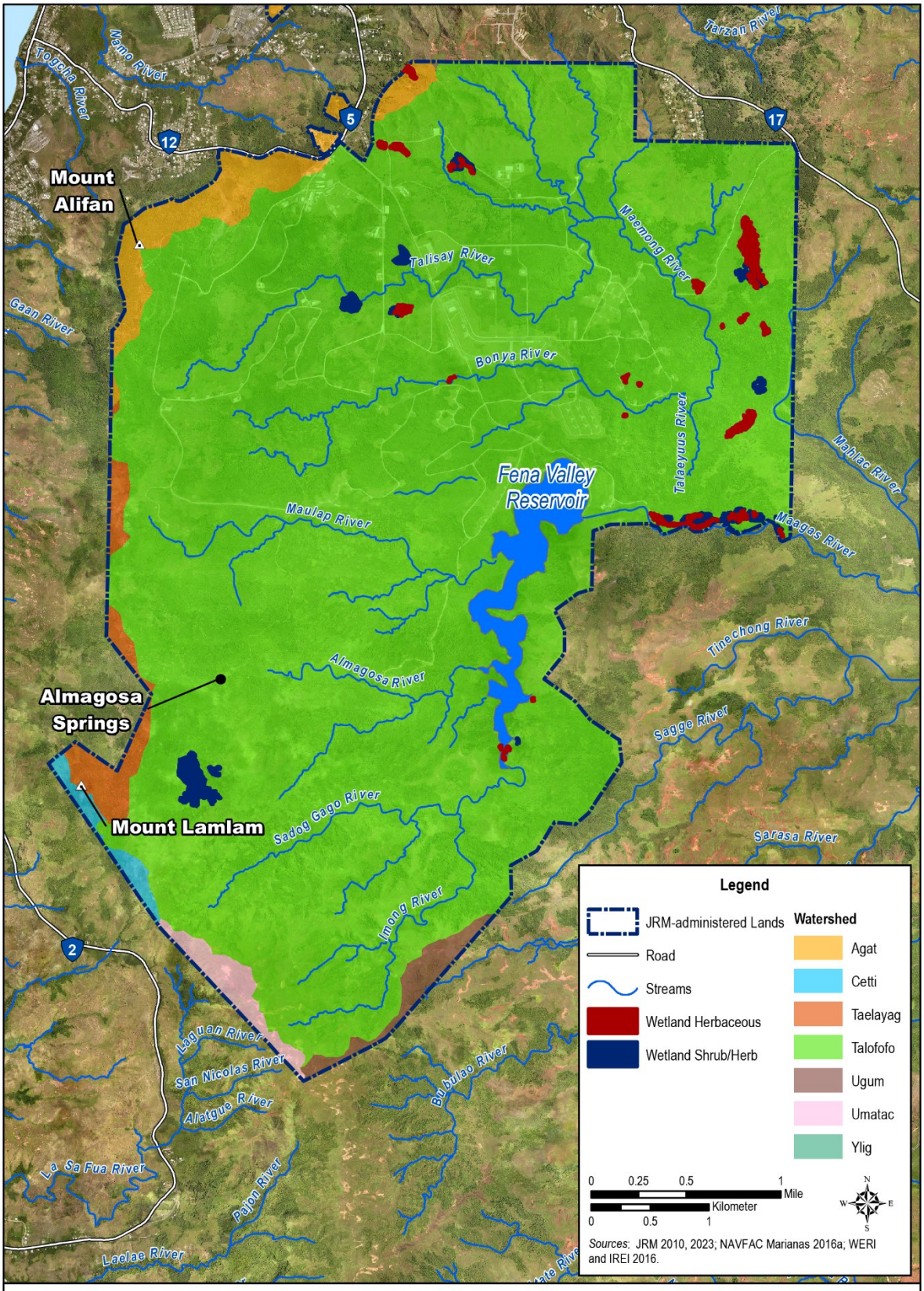


Figure 6-6
Surface Waters, Wetlands, and Watersheds on NMS

Nine perennial waterways drain NMS (see Figure 6-6). As stated above, three of them (Imong, Almagosa, and Maulap) flow into the Fena Valley Reservoir. Sadog Gagu in the south of NMS converges with the Imong River before it flows into Fena Valley Reservoir. Bonya, Talisay, and Maemong perennial rivers converge with the Maagas River before it meets the Talofofo River east of NMS. The Maagas River, also known as the Lost River, disappears underground and resurfaces again adjacent to its confluence with the Talofofo River. The Mahlac River flows southeast out of NMS eventually joining the Maagas River. The Mahlac, Bonya, Talisay, Maemong, and Maagas Rivers have more gentle gradients than the streams flowing into Fena Valley Reservoir, which results in broad river basins. The U.S. Geological Survey (USGS) actively monitors stream flow at its gauging stations located at the Fena Dam spillway and on the Maulap, Almagosa, and Imong Rivers.

Erosion not only leads to soil loss but also to excessive siltation of stream habitats within the Talofofo River basin and coastal habitat in Talofofo Bay; this likely has contributed to the 17% loss in storage capacity of Fena Valley Reservoir. An analysis of land cover change in the Talofofo watershed from 1973 to 2001 (Wen et al. 2009) demonstrates an increase in barren lands. Erosion is exacerbated by ungulate activity (e.g., grazing, rooting, and rubbing) from feral pigs (*Sus scrofa*), Philippine deer (*Rusa marianna*), and Asiatic water buffalo (carabao) (*Bubalus bubalis*) and by naturally occurring and intentionally set grass fires.

6.2.2.2 Groundwater

Groundwater on NMS occurs in volcanic rocks and older limestone with low permeability. The water table occurs at elevated levels in places and discharges as springs where the groundwater intersects the ground surface. Groundwaters maintain the base flow of streams during periods of drought. Southern Guam is comprised of emerged volcanic soils that have no effective permeability for water well development. Springs from within the limestone or at the interface between limestone and volcanic soils are already captured and form pools (Almagosa and Bonya Springs), flow into Fena Valley Reservoir, or go downstream to the coast (SWCA and TNWRE 2007).

6.2.3 Vegetation Communities

Vegetation communities identified on NMS are shown in Table 6-1 and described below. Detailed descriptions of vegetation community types are found in Section 4.4.1, *Vegetation Communities*. Figures 6-7, 6-8, and 6-9 depict the terrestrial vegetation communities occurring on NMS. Three categories of non-vegetated areas on NMS (barren areas, developed areas, and open water) make up 9% of the total area on NMS. Barren areas are described as non-vegetated areas of soil, sand, or rock. Developed areas include human occupied or otherwise highly disturbed areas such as lawns, buildings, roads, and parking lots. Open water includes natural and man-made sources of open water (NAVFAC Marianas 2016a). Three vegetation communities—savanna, ravine forest, and *Vitex* forest—comprise approximately 75% of the vegetated, undeveloped areas of NMS (Table 6-1). The greatest threats to native vegetation communities on NMS are fire, feral ungulates, and invasive plants. Plants also face dispersal challenges because most native forest birds in Guam have been extirpated, and Mariana fruit bats (*Pteropus mariannus mariannus*) within NMS are quite rare.

Casuarina forest makes up less than 1% of the vegetated, undeveloped area on NMS. *Casuarina* is a sparse forest or woodland composed mainly, if not entirely, of ironwood (*Casuarina equisetifolia*), also known as Australian pine (NAVFAC Marianas 2016a). This species tolerates dry and salty or exposed conditions. *Casuarina* forests often have very little understory.

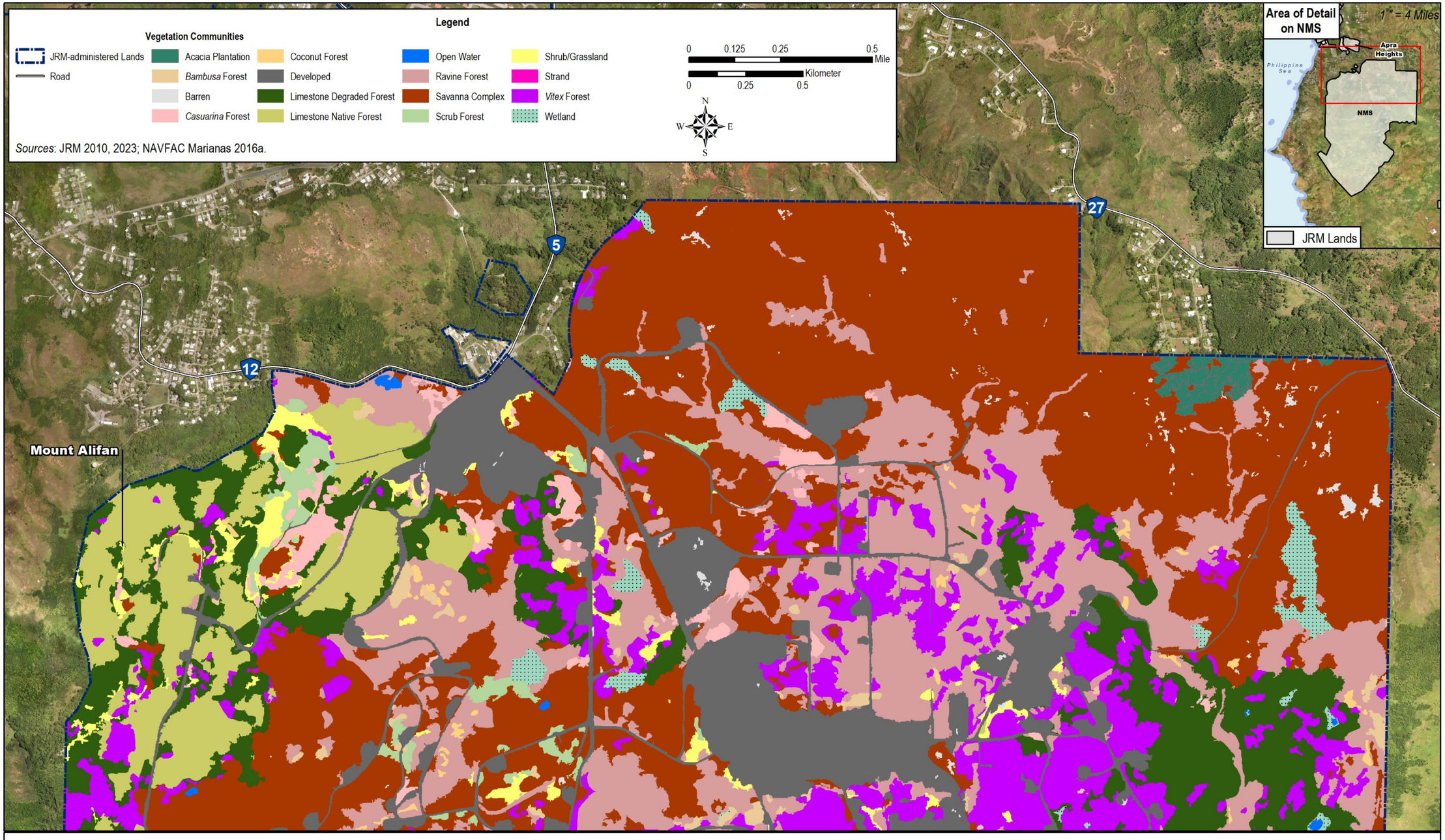


Figure 6-7
Vegetation Communities on Northern NMS

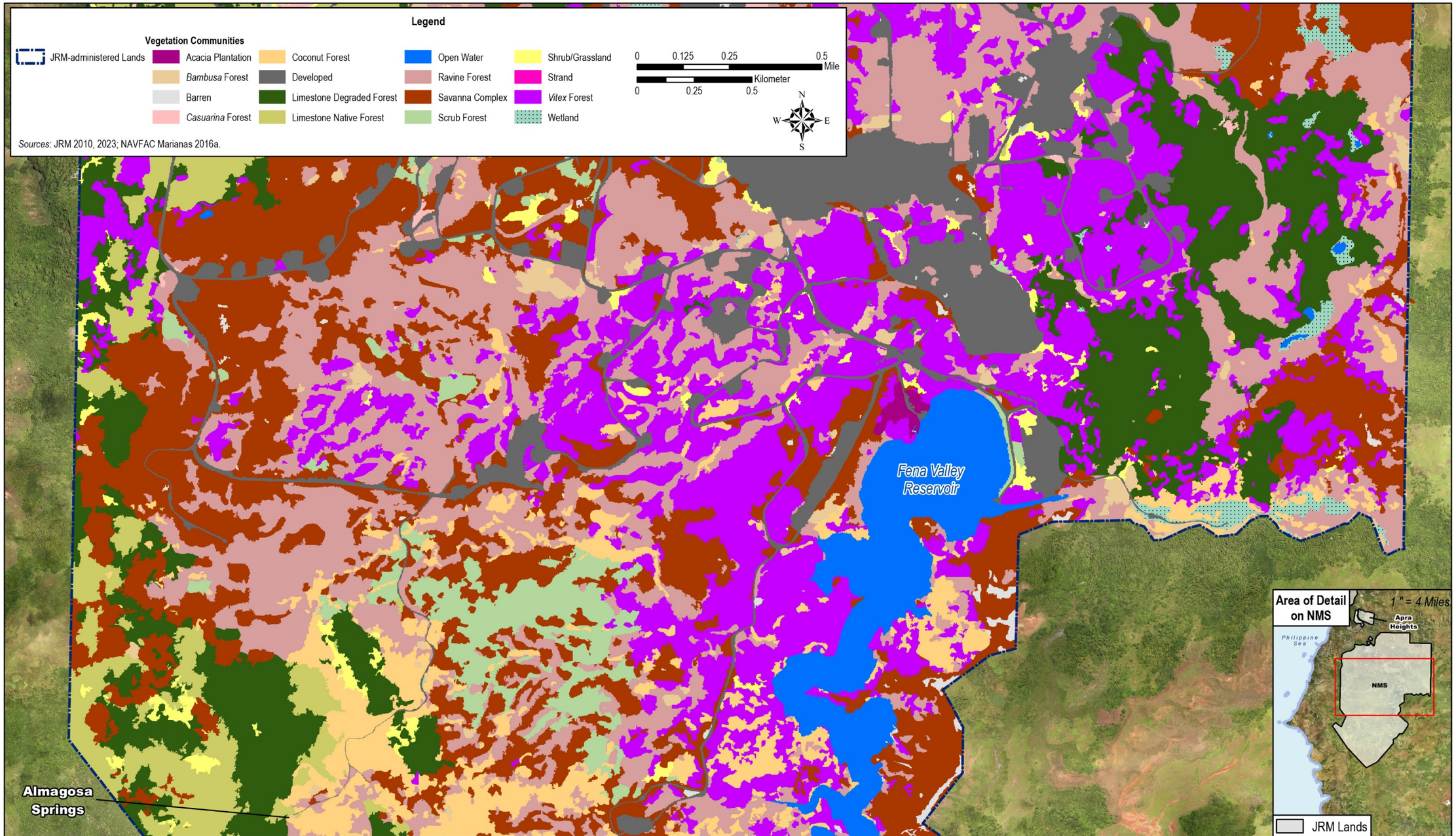


Figure 6-8
Vegetation Communities on Central NMS

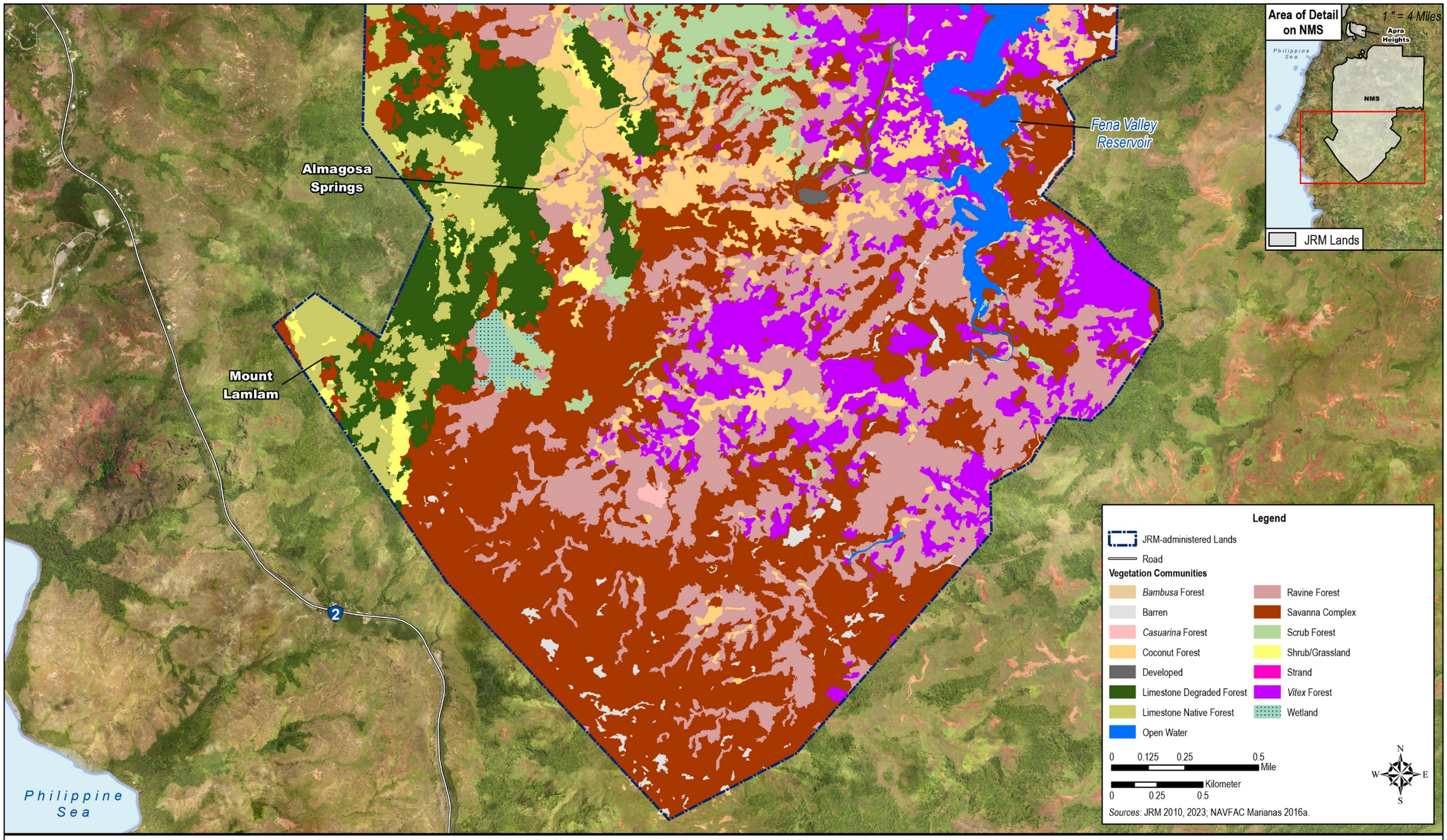


Figure 6-9
Vegetation Communities on Southern NMS

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Approximately 4% of vegetated, undeveloped areas of NMS are comprised of stands dominated almost exclusively by the coconut palm (*Cocos nucifera*) (NAVFAC Marianas 2016a). These stands may have minimal understory or may support a relatively diverse understory of mixed native and non-native shrubs, herbs, or ferns. The coconut palm occurs throughout the world's tropics and subtropics, but its arrival in the Marianas is not known to be natural or human introduced (Raulerson and Rinehart 1991). Regardless of its arrival, humans have established coconut plantations to maximize the food source. Several acres of coconut plantations still exist within NMS (DON 2009; NAVFAC Marianas 2016a). Some of the coconut forest stands seen today are remnants of previous coconut plantations, but others are likely due to natural dispersion (NAVFAC Pacific 2010).

Table 6-1. Vegetation Communities on NMS

Vegetation Community	*Area (acres)*	*% of Total Area*	*% of Vegetated, Undeveloped Area*
Casuarina Forest	57.3	0.7	0.7
Coconut Forest	313.9	3.6	4.0
Limestone Degraded Forest	762.0	8.8	9.7
Limestone Native Forest	418.2	4.8	5.3
Ravine Forest	1,857.3	21.5	23.7
Scrub/Shrub	163.0	1.9	2.1
Grassland			
Savanna Complex	2,897.4	33.5	36.9
Other Shrub/Grassland	104.6	1.2	1.3
Wetland			
Herbaceous Wetland	30.0	0.3	0.4
Shrub/Herb Wetland	42.5	0.5	0.5
Non-native Forest			
Acacia Plantation	26.7	0.3	0.3
Bambusa Forest	59.5	0.7	0.8
Pimenta Forest	10.6	0.1	0.1
Vitex Forest	1,099.5	12.7	14.0
Other Non-native Forest	3.7	<0.1	<0.1
Non-vegetated Categories			
Barren	55.3	0.6	NA
Developed	544.0	6.3	NA
Open Water	200.7	2.3	NA
Total	**8,646.2**		

Key: < = less than; % = percent; NA = not applicable; NMS = Naval Munitions Site.
Source: NAVFAC Marianas 2016a.

Limestone forests, both native and degraded, make up approximately 15% of the vegetated, undeveloped land on NMS and occur on elevated limestone terraces, plateaus, and slopes (NAVFAC Marianas 2016a). Limestone native forests are relatively undisturbed on shallow limestone soils dominated by native tree and shrub species. There is little disturbance to the forest floor from non-native ungulate grazing or rooting. Large canopy-emergent trees including dukduk (*Artocarpus mariannensis*) or joga (*Elaeocarpus joga*) may be present. *Merrilliodendron megacarpum* and a few other species are dominant in small areas. Within NMS, limestone forests occur on Alifan limestone ridges in the west and the Bonya limestone in the central and eastern portions. Trees that typically dominate in limestone native forests at NMS include *Pandanus* spp., nunu (*Ficus* spp.), *Meiogyne cylindrocarpa*, *Aglaia mariannensis*, and *Premna serratifolia* (NAVFAC Marianas 2016a). Some of these limestone forest communities have been significantly disturbed by

clearing, invasive plants, and introduced animal species (NAVFAC Marianas 2016a) and, thus, are regarded as degraded. Degraded limestone forest communities are typically dominated by the non-native invasive tree *Vitex parviflora* and in some areas, the bay rum tree (*Pimenta racemosa*). This plant community has one or more of the following characteristics: (1) dominated by a variety of non-native woody species, (2) substantial forest clearings, or (3) dominated by pago (*Hibiscus tiliaceus*), a tree species usually indicative of disturbance in Guam's limestone forests. The most common non-native tree species found in these forests are *V. parviflora* and tangantangan (*Leucaena leucocephala*). Although dominated by disturbance and non-native species, native tree species are still present in these forests and usually include one or more of the following: *P. serratifolia*, kafu (*Pandanus tectorius*), *M. cylindrocarpa*, and *A. mariannensis* (NAVFAC Marianas 2016a).



Kafu (*Pandanus tectorius*) stand within limestone native forests seen from a hilltop on NMS.
(*Photo*: L. Shaughnessy)

Ravine forest communities are abundant in NMS, comprising approximately 24% of the vegetated, undeveloped areas of NMS, primarily in the south-central portion of the installation. Ravine forest occurs primarily on the slopes covered by volcanic substrate and continues downward into riparian areas of the rivers, drainages, and intervening ridges. Kafu, pahong (*Pandanus dubius*), pago, the native betelnut palm (*Areca catechu*), and coconut palm are dominant within ravine forest. The invasive tree *V. parviflora* dominates many ravine forest areas at NMS, particularly drier sites. Ravine swamps are often present on argillaceous limestone soils, bottomlands, and in depressional areas. These areas of wetlands dominated by shrubs or trees are included within the ravine forest vegetation community. In most cases, the wetlands dominated by woody species were not separated out as distinct plant communities due to the lack of data about the spatial limits of these areas. Pago and *Pandanus* spp. are the most common woody plants associated with these communities, where they often form dense thickets. Extensive areas of disturbed ravine forest are also present in NMS, especially in areas subject to low-intensity ground fires and past human disturbance (DON 2009; NAVFAC Marianas 2016a).

M. megacarpum is the dominant native plant within the ravine valley slopes surrounding Mount Almagosa in the southern NMS. This species comprised more than 63% of the relative density of trees during the 2009 vegetation survey. The overall relative density of native species along the Sadog Gagu River, located in the southern tip of NMS, was approximately 33%, which is lower than the densities observed in ravine forest transects in the northern areas of NMS (NAVFAC Pacific 2010).

Scrub/Shrub vegetation community is characterized by the predominance of low-stature woody vegetation that may be a mixture of native and non-native species. This community makes up 2% of the undeveloped area of NMS. The vegetation may be a secondary thicket of woody species but may also include some interspersed herbaceous vegetation. The woody vegetation is too low or sparse to be characterized as forest. The low-stature character may be caused by human disturbance or physical conditions, such as fire, soil saturation, or poor soils.



Badlands result from human-set wildland fires and destruction of vegetation by ungulates. The exposed red soil makes them conspicuous across the NMS landscape.
(*Photo*: L. Shaughnessy)

Savanna complex and shrub/grassland are the two grassland communities present on NMS. They are the installation's most widespread vegetation community, comprising approximately 38% of the vegetated, undeveloped area of NMS. Savanna and grassland areas are typically dominated by swordgrass (*Miscanthus floridulus*), a large grass species. It is present in large open areas on NMS, particularly in the north and south (see Figures 6-7 through 6-9), often with patches of woody vegetation scattered throughout. In some areas, wild cane (*Saccharum spontaneum*) is a secondary dominant species. Barren areas, sometimes called badlands and sometimes mapped as barren, are often interspersed with savanna grasslands. Erosion in these areas is particularly evident within NMS (NAVFAC Marianas 2016a). Large barren areas are the result primarily of human-set wildland fires and destruction of vegetation by ungulates. Since 1998, the DON has implemented vegetation-based management actions to address erosion within NMS, including large scale planting of grass cover and trees in affected areas. Dueñas, Camacho & Associates, Inc. (2013) examined the effectiveness of various treatments through experimental planting in plots throughout NMS and concluded that barren areas should be replanted with *Paspalum notatum, Sphagneticola trilobata,* or *Vetiveria zizanoides* as groundcover treatments to reduce erosion. In 2017, approximately 0.5 acre (0.2 hectare) of *V. zizanoides* was planted in a barren area of NMS, southwest of Fena Valley Reservoir.

NAVFAC Marianas (2016a) distinguishes between two types of wetland communities—herbaceous communities and shrub/herb communities. Herbaceous wetlands are dominated by herbaceous species and, in most cases, are floristically simple, with only a few plant species being dominant (i.e., tall reed [*Phragmites karka*]). In some areas, other grasses (*Poaceae*) and sedges (*Cyperaceae*) may also be common. In shrub/herb wetland, the plant communities are subject to permanent or periodic inundation or prolonged soil saturation. These communities are located in low places that are poorly drained and support volcanic soils. Pago is the woody species usually associated with these wetlands. NAVFAC Marianas (2016a) categorizes large areas of wetlands as ravine forest vegetation community because these wetlands are found in ravine forests and are dominated by shrubs or trees; as a result, they are not mapped as separate wetland communities in Table 6-1 and Figures 6-7 through 6-9.

Wetland delineations were conducted on JRM-administered lands in 2008 (AECOS, Inc. and Wil Chee Planning, Inc. 2009). NMS has the greatest area of wetlands on JRM-administered lands (DON 2009). Based on past wetland surveys, NMS has approximately 100 discrete wetlands totaling over 1,149 acres (465 hectares) (AECOS, Inc. and Wil Chee Planning, Inc. 2009; NAVFAC Marianas 2014a, 2015). Portions of the Fena Valley Reservoir shoreline support wetland plant communities, especially when high water levels inundate vegetated shorelines. During lower water levels, much of the shoreline consists of steep cliffs (AECOS, Inc. and Wil Chee Planning, Inc. 2009). As the water depth increases within the reservoir, floating aquatic plants replace rooted wetland vegetation. Karriso, *Ceratopteris thalictroides*, pago, coconut palm, *Pandanus* spp., *Urochloa mutica, Cyperus difformis*, and betelnut palm are rooted plants commonly found around Fena Valley Reservoir. Floating aquatic flora found in Fena Valley Reservoir includes *Egeria densa,* hydrilla (*Hydrilla verticillata*), curly pondweed (*Potamogeton crispus*), and bladderwort (*Utricularia* spp.). Introduced hydrilla has occasionally overwhelmed Fena Valley Reservoir and restricted sunlight to native plants (Guam DAWR 2006).

The Talisay, Maemong, Bonya, Mahlac, Maagas, Maulap, Almagosa, Sadog Gagu, and Imong Rivers flow through portions of NMS. Riparian wetlands border many of these streams. Water current is a major limiting factor in the development of plant communities in these running water habitats. Storm events and flash floods strongly influence water depth and current velocity in Guam's streams (DON 2009).

Acacia plantations consist of areas within NMS that were planted with species of *Acacia* to control erosion. *Pimenta* forests consist of small areas on somewhat dry limestone ridges and slopes in northern NMS, which are dominated by the bay rum tree. Few other woody plants grow in areas dominated by this species. Bamboo forests are dense monocultures of the non-native *Bambusa vulgaris* and are typically found in small areas within ravine forests adjacent to streams or wet areas. Areas categorized as non-native forests are often exclusively dominated by non-native tree species (e.g., teak [*Tectona* spp.], *Tabebuia* spp., *Acacia* spp.). These non-native forest types make up just over 1% of the total undeveloped, vegetated areas on NMS.

Vitex forest, which forms a monotypic canopy, comprises approximately 14% of the vegetated, undeveloped area of NMS. While *Vitex* forest can be considered a form of degraded limestone forest, as it moves into an area, it outcompetes native and non-native species, becoming the dominant large tree within the area (NAVFAC Marianas 2016a).

6.2.4 Terrestrial Wildlife

6.2.4.1 Mammals

Native Species

The only native mammal species found on NMS is the Mariana fruit bat. The fruit bat is federal ESA-listed as threatened and Guam ESA-listed as endangered and is discussed below under Section 6.2.5, *Terrestrial Protected Species*.

Non-native Species



Carabao (*Bubalus bubalis*) cause significant soil disturbance while wallowing, which results in erosion and creates openings for non-native invasive weeds.
(*Photo*: L. Shaughnessy)

Philippine deer, feral pigs, and Asiatic water buffalo (carabao) were introduced to Guam by the Spanish in the 1600s and 1700s. Feral populations of each are still present throughout most of the island's undeveloped lands. These three species have significantly impacted natural ecosystems on NMS by causing extensive soil erosion, stream and reef siltation, loss of native plant and animals species, and degradation of native species' habitat. Deer grazing on native tree seedlings is suspected to adversely affect native tree regeneration and cause erosion. Feral pigs and Asiatic water buffalo (carabao) cause significant soil disturbance while foraging and wallowing, which also cause erosion and create openings for non-native invasive weeds (DeNicola 2015). In addition, these species also damage facilities within NMS, including destruction of chain link fences and erosion of protective soil covering ordnance storage bunkers and around

utility poles; Asiatic water buffalo (carabao) have been known to damage vehicles. The primary mortality for these species is through illegal poaching and natural causes.

Based on 2009 surveys, which estimated 55 individuals, JRM Natural Resource Specialists estimated the Asiatic water buffalo (carabao) population to be approximately 150 animals in fall 2017 (Vogt 2017b). This estimate is an extrapolation based on demographic surveys showing that approximately 10% of the population are yearling calves, implying an approximate 10% annual growth rate.

In 2016, a cooperative agreement was entered into with White Buffalo, Inc. for field-based feral pig and deer control, eradication, and research operations on JRM-administered lands in Guam. Operations ran from October 2021 to November 2023. During the first year, White Buffalo removed three pigs from within the Alifan Conservation Fence #1 and 41 deer from within the NMS Conservation Fence #1 (NAVFAC Marianas 2022a). During the second year, only one deer was found within the NMS Conservation Fence #2. No pigs were detected within Alifan Conservation Fence #1 or within NMS Conservation Fence #2. A third site, NMS Conservation Fence #4, was included in year two eradication work, and 21 deer and 13 pigs were removed from the area (NAVFAC Marianas 2022a).

There have been no recent surveys of small mammals within NMS, although rodents are known to occur. Non-native mammal species on NMS include rats (*Rattus* spp.), house mouse (*Mus musculus*), musk shrew (*Suncus murinus*), feral dogs (*Canis familiaris*), and feral cats (*Felis catus*). The black rat (*R. rattus*) is likely the most common introduced small mammal species within NMS (Wiewel et al. 2009). Various species of rats are a major obstacle to recovery of species on Pacific Islands (Atkinson 1985). The musk shrew may be a significant predator of native geckos and skinks in Guam (Fritts and Leasman-Tanner 2001), although, presumably, its numbers are kept low by brown treesnake (BTS) (*Boiga irregularis*) predation (Wiewel et al. 2009).

The presence of non-native mammals within NMS provides avenues for the transmission of leptospirosis, a seriously debilitating bacterial disease that passes by the urine of feral mammals onto vegetation, eventually entering water bodies (ponds, lakes, streams, and stormwater) (Wiewel et al. 2009). Leptospirosis is a serious human health risk and is transmitted to humans through open wounds and through mucous membranes.

Management strategies and actions for ungulate control are further described in Section 6.3, *Management Goals, Objectives, Strategies, and Actions*.

6.2.4.2 Birds

Native Species

Many of the native bird species that historically occurred in Guam, including NMS, have been extirpated due to the presence of the BTS. Standardized avian surveys have been conducted on NMS since 2008. Surveys are conducted by NAVFAC Marianas personnel at two sites (helicopter landing zone and Fena spillway) approximately every 2 weeks during the peak migration and residency of wintering birds (September 1 through April 30) and approximately every 4 weeks during the remainder of the year (May 1 through August 30), resulting in approximately 40-45 surveys per year. Based on these surveys through August 2017 and those conducted for other projects or studies on the installation, 20 species have been documented, 15 of which are protected under the Migratory Bird Treaty Act (MBTA) (Table 6-2) (Eggleston 2009; NAVFAC Pacific 2010, 2013; Brindock 2012; DON 2015a; NAVFAC Marianas 2016b, 2017a; Wenninger 2016). The white-throated ground dove (*Alopecoenas xanthonurus*), Mariana swiftlet, Mariana common moorhen (*Gallinula chloropus guami*), and migratory shore birds are Guam-designated as SOGCN. The white-throated ground dove is listed as threatened under the Guam ESA. Two of these

species are protected by both the federal ESA and Guam ESA (Mariana common moorhen and Mariana swiftlet), discussed below in Section 6.2.5, *Terrestrial Protected Species*.

While the majority of avian species on NMS are native to the region, most are seasonal visitors that migrate annually to winter or summer destinations. Migratory birds either spend the winter in Guam or migrate through during the spring and fall to breeding areas to the north and south. The wetlands, riparian areas, open grassy fields, and mowed areas on NMS provide seasonal foraging habitat for migratory avian species. The majority of migratory birds observed from September through April were shorebirds. The dominant species were Pacific golden plovers (*Pluvialis fulva*), tattlers (*Tringa* spp.), and ruddy turnstones (*Arenaria interpres*). Although yellow bitterns (*Ixobrychus sinensis*) are considered migratory, they are a year-round breeding resident in Guam and are able to persist despite the presence of BTS.

Micronesian starlings (*Aplonis opaca*) do not currently occur on NMS; however, given recent success with nest boxes on Andersen Air Force Base (AFB), NBG is considering options for expanding the starlings' range by installing nest boxes on NMS.

Table 6-2. Bird Species Recorded on NMS

Common Name/ Chamorro Name(1)	***Scientific Name***	***Non-native Breeding Resident***	***Listed under MBTA***
Pacific golden plover/Dulili	*Pluvialis fulva*	Common non-breeding visitor	Y
Wood sandpiper/ Dulili	*Tringa glareola*	Common non-breeding visitor	Y
Common sandpiper/Dulili	*Actitis hypoleucos*	Common non-breeding visitor	Y
Pectoral sandpiper/ Dulili	*Calidris melanotos*	Common non-breeding visitor	Y
Common snipe/None	*Gallinago gallinago*	Common non-breeding visitor	Y
Grey-tailed tattler/None	*Tringa brevipes*	Common non-breeding visitor	Y
Wandering tattler/Dulili	*Tringa incana*	Common non-breeding visitor	Y
Ruddy turnstone/Dulili	*Arenaria interpres*	Common non-breeding visitor	Y
White tern/Chunge	*Gygis alba*	Common native breeding resident	Y
Eastern cattle egret/Chuchuko	*Bubulcus coromandus*	Common non-breeding visitor	Y
Yellow bittern/ Kakkak	*Ixobrychus sinensis*	Common native breeding resident	Y
Little egret/ Chuchuko	*Egretta garzetta*	Common non-breeding visitor	Y
Mariana common moorhen(2)/Pulattat	*Gallinula chloropus guami*	Uncommon native breeding resident	Y
Mariana swiftlet/ Chachaguak or Yayaguak(2)	*Aerodramus bartschi*	Uncommon native breeding resident	Y
Black drongo/ Salin Taiwan	*Dicrurus macrocercus*	Common introduced breeding resident	N
Black francolin/None	*Francolinus francolinus*	Common introduced breeding resident	N
Eurasian tree sparrow/Gagapale	*Passer montanus*	Common introduced breeding resident	N

Table 6-2. Bird Species Recorded on NMS

Common Name/ Chamorro Name[1]	*Scientific Name*	*Non-native Breeding Resident*	*Listed under MBTA*
Island collared dove/Palumat	*Streptopelia bitorquata*	Common introduced breeding resident	N
White-throated ground dove[2]/ Paluman apaka (male) and Paluman fache (female)	*Alopecoenas xanthonurus*	Uncommon native breeding resident	Y
King quail/ Bengbeng	*Excalfactoria chinensis*	Common introduced breeding resident	N

Notes: [1] Common and scientific names based on Gill and Donsker (2017). Chamorro names from GovGuam (2009), Liske-Clark (2015), Topping et al. (1975), and USFWS (2015a).
[2] Guam DAWR unpublished data.
Key: MBTA = Migratory Bird Treaty Act; N = no, does not occur; NMS = Naval Munitions Site; Y = yes, known to occur.
Sources: Eggleston 2009; NAVFAC Pacific 2010, 2011, 2013; Brindock 2012, 2013; Guam DAWR 2015; NAVFAC Marianas 2015, 2016b, 2017a; Wenninger 2016; Gill and Donsker 2017.

Non-native Species

Based on the standardized bi-weekly and monthly avian surveys through August 2017, as well as those conducted for other projects or studies on NMS, five non-native, introduced species have been documented within NMS proper (Eggleston 2009; NAVFAC Pacific 2010, 2011, 2013; Brindock 2012, 2013; NAVFAC Marianas 2015, 2016b, 2017a; Wenninger 2016) (see Table 6-2). The island collared dove (*Streptopelia bitorquata*) and black francolin (*Francolinus francolinus*) were the most commonly observed non-native species on NMS. The black drongo (*Dicrurus macrocercus*) and Eurasian tree sparrow (*Passer montanus*) are found primarily in the developed areas of NMS, and the king quail (also known as blue quail) (*Excalfactoria chinensis)* is a rare resident in the southern NMS within the savanna complex (NAVFAC Pacific 2010, 2013).

6.2.4.3 Reptiles and Amphibians

Twenty-one species (4 native, 16 non-native, and 1 naturalized) have been documented as occurring on NMS (Table 6-3).

Table 6-3. Reptile and Amphibian Species Recorded on NMS

Common Name/ Chamorro Name[1]	*Scientific Name*	*Residence Status*
Brown treesnake/Kolepbla	*Boiga irregularis*	Non-native
Curious skink/Gualiek halumtano	*Carlia ailanpalai*	Non-native
Common snapping turtle/Haggan	*Chelydra serpentina*	Non-native
Greenhouse frog/Kairo	*Eleutherodactylus planirostris*	Non-native
Pacific blue-tailed skink/Gualiek halumtano	*Emoia caeruleocauda*	Native
Crab-eating frog/Kairo	*Fejervarya cancrivora*	Non-native
Mutilating gecko/Achiak	*Gehyra mutilate*	Non-native
House gecko/Achiak	*Hemidactylus frenatus*	Non-native
Gunther's Amoy frog/Kairo	*Sylvirana guentheri*	Non-native
Mourning gecko/Achiak	*Lepidodactylus lugubris*	Native
Moth skink/Gualiek halumtano	*Lipinia noctua*[2]	Native
Eastern dwarf tree frog/Kairo	*Litoria fallax*	Non-native
Chinese three-keeled pond turtle/Haggan	*Mauremys reevesii*	Non-native

Table 6-3. Reptile and Amphibian Species Recorded on NMS

Common Name/ Chamorro Name[1]	*Scientific Name*	*Residence Status*
Pacific slender-toed gecko/Achiak	*Nactus pelagicus*[1]	Native
Chinese soft-shelled turtle/Haggan	*Pelodiscus sinensis*	Non-native
Hong Kong whipping frog/Kairo	*Polypedates braueri*	Non-native
Marine toad/Kairo	*Rhinella* (=*Bufo*) *marina*	Non-native
Three-toed box turtle/Haggan	*Terrapene carolina triunduis*	Non-native
Red-eared slider/Haggan	*Trachemys scripta elegans*	Non-native
Brahminy blind snake/Ulo attilong	*Ramphotyphlops braminus*	Non-native
Monitor lizard/Hilitai	*Varanus tsukamotoi*	Native

Notes: [1] Common and scientific names based on Gill and Donsker (2017). Chamorro names from GovGuam (2009), Liske-Clark (2015), Topping et al. (1975), and USFWS (2015a).

Sources: Rodda and Fritts 1996; Leberer 2003; Christy et al. 2007; Cota 2008; Pregill and Steadman 2009; NAVFAC Pacific 2010, 2013; Zug 2013; USGS 2018.

Native Species

The native Pacific blue-tailed skink (*Emoia caeruleocauda*), mutilating gecko (*Gehyra mutilata*), mourning gecko (*Lepidodactylus lugubris*), and monitor lizard (*Varanus tsukamotoi*) can be found in most habitats (NAVFAC Pacific 2010, 2013). The federal ESA-listed Slevin's skink (*Emoia slevini*) and Guam ESA-listed endangered moth skink (*Lipinia noctua*) and Pacific slender-toed gecko (*Nactus pelagicus*) are discussed below in Section 6.2.5, *Terrestrial Protected Species*.

Non-native Species

Sixteen introduced, non-native reptile and amphibian species are documented within NMS (see Table 6-3). Soft-shelled turtles (*Pelodiscus sinensis*) have been observed in Fena Valley Reservoir. These introduced species may pose a threat to the native aquatic fish and invertebrate species (Leberer 2003). In addition to this species, Leberer (2003) identified four other species of non-native freshwater turtles introduced to Guam in the past 30 years, including the common snapping turtle (*Chelydra serpentina*) and red-eared slider (*Trachemys scripta elegans*).

The introduced curious skink (*Carlia ailanpalai*) and Indo-Pacific house gecko (*Hemidactylus frenatus*) are found in all habitats, although the house gecko, as its name implies, is more common within developed areas; both are considered the most abundant skink and gecko species in Guam.

The occurrence of the Brahminy blind snake (*Ramphotyphlops braminus*) was among the first reptiles collected in the Mariana Islands (summarized by Rodda et al. (1991). It was recorded in Guam during a survey effort in 1996 (Rodda and Fritts 1996). Due to the secretive nature of blind snakes and their tendency to remain under leaf litter or other cover, typical reptile sampling methods employed in all other survey efforts on NMS (i.e., sticky traps on trees and visual observations) are not effective in detecting blind snakes. Blind snakes may be more common than previous reptile surveys suggest.

The continued widespread presence of the BTS, curious skink, and other non-native reptile and amphibian species is of concern because of each species' potential adverse impacts in Guam's native fauna. Of particular concern is the potential for introduced reptile and amphibian species to serve as additional food sources for the BTS (NAVFAC Pacific 2010).

Although Guam has no native amphibian species, as would be expected, the non-native amphibian species listed in Table 6-3 are found in wet habitats, particularly wetlands, riparian areas, and ravine forest with associated wetlands.

6.2.4.4 Freshwater Fishes

Native Species

Although there have been few surveys of freshwater ecosystems in Guam, the nature of aquatic communities and dynamics are reasonably well understood. However, there remains some disagreement on species-level identification of native fishes and crustaceans. All of the native fish species occurring within the rivers in Guam are diadromous, requiring access to both saltwater and freshwater during their life cycles. Native diadromous species in the families Angullidae (eels), Eleotridae (sleepers), Gobiidae (gobies), and Kuhliidae (flagtails) inhabit the Talofofo River and penetrate far upstream into its tributaries within NMS, including the Maagas River and the Lost River (Concepcion and Nelson 1999; Fitzsimons et al. 2002; Guam DAWR 2006). Japanese eels (*Anguilla japonica*) occur in Fena Valley Reservoir (DON 2009) and in streams within NMS.

Non-native Species

In an effort to control the growth of pondweed and bladderwort in shallow waters of Fena Valley Reservoir, two species of tilapia (*Oreochromis mossambicus* and *Coptodon zillii*) were introduced into the reservoir by Guam DAWR between 1956 and 1968 (BioSystems Analysis, Inc. 1989). Mosquito fish (*Gambusia affinis*) and guppies (*Poecilia reticulata*) were also introduced for mosquito control. During the 1960s, other species, including peacock cichlid (*Cichla ocellaris*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), and channel catfish (*Ictalurus punctatus*) were introduced to increase angling opportunities (Maciolek 1984; Nico and Walsh 2011). Additionally, other aquatic species have been introduced to the reservoir over the years (Guam DAWR 2006). The impacts of these introduced fishes on native aquatic insects and other invertebrates are unknown (Englund 2011); however, they may pose a threat to native fishes and invertebrates within downstream waters (DON 2009). Recent stock assessments of fishes in Fena Valley Reservoir are not available. It should be noted that recreational fishing is not permitted in NMS.

6.2.4.5 Invertebrates

Native Species

The Guam tree snail (*Partula radiolata*) and the fragile tree snail (*Samoana fragilis*) are the only native tree snail known to occur in NMS. They are federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. Section 6.2.5, *Terrestrial Protected Species* provides further detail.

Coconut crabs (*Birgus latro*) and land hermit crabs (*Coenobita brevimanus*) occur on NMS. Land hermit crabs rely on borrowed shells for protection throughout their lives, often using the shell of the African land snail (*Achatina fulica*). Known as the largest terrestrial arthropod, coconut crabs initially borrow shells but then develop their own hard exoskeleton. Coconut and land hermit crabs are omnivorous and nocturnal and eat foods such as fruits, seeds, plants, rotting wood, dead insects, and carrion. Threats to these species include rats, feral pigs, dogs, monitor lizards, and humans (JRM 2013).

Amphidromous atyid shrimp, palaemonid prawns, and neritid snails are among the conspicuous invertebrate families inhabiting streams within NMS. Leberer and Cai (2003) collected *Atyoida pilipes* and *Caridina mertoni* shrimp within the Ugum River at its confluence with the Talofofo River. They noted that

atyid shrimp are ubiquitous in virtually all Guam's rivers. These prawns and shrimp were incorrectly cited in the 2010 Guam Military Relocation EIS/OEIS (DON 2010) as being non-native species. Paulay et al. (2003) listed three freshwater crabs in the family Varunidae (*Orcovita mollitia*, *Ptychognathus* sp., and *Varuna litterata*) from Guam. These species are all amphidromous, with a marine larval stage, and a freshwater adult stage.

Amphidromy is a type of diadromous life history strategy of fishes and invertebrates, which spend most of their lives in freshwater. However, their larvae must reach the sea for early development before returning to streams to complete their growth to maturity (McDowall 1988). This is important to the Integrated Natural Resources Management Plan (INRMP) in that aquatic ecosystems must be managed in such a way as to maintain open migratory pathways within NMS streams to sustain populations of native amphidromous species (Ford and Kinzie, III 1982; Fitzsimons et al. 2002). Kerr (2013) provided a checklist of aquatic mollusks found in Guam and identified 19 gastropods in Guam streams and rivers, 9 of which possess amphidromous life cycles. Only 6 of the 19 species are non-native and may have been introduced to Guam through the aquarium trade. Table 6-4 lists the freshwater macrofauna reported within or likely to occur within NMS. Englund (2011) examined aquatic insects in the Maulap River upstream of Fena Valley Reservoir near the 'Detonation Pit' and concluded this was among the highest quality stream habitats sampled during his study, with 13 species of aquatic insects collected during 1.5 hours of sampling. All of the aquatic insects collected by Englund (2011) within NMS were determined to be native species.

Table 6-4. Freshwater Macrofauna Recorded on NMS

Common Name/ Chamorro Name(1)	*Scientific Name*	*Diadromous*	*Residence Status*
Fishes			
Japanese eel/Hasule	*Anguilla japonica*	Y	Native
Dark-margined flagtail/ Atinget	*Kuhlia marginata*	Y	Native
Jungle flagtail/Atinget	*Kuhlia rupestris*	Y	Native
Goby/Macheng	*Sicyopterus macrostetholepis*	Y	Native
Goby/Macheng	*Stiphodon elegans*	Y	Native
Goby/Macheng	*Stiphodon percnopterygonius*	Y	Native
Goby/Macheng	*Awaous guamensis*	Y	Native
Sleeper/None	*Eleotris* sp.	Y	Native
Peacock cichlid/None	*Cichla ocellaris*	N	Non-native
Redbelly tilapia/Talapiha	*Coptodon zillii*	N	Non-native
Mozambique tilapia/ Talapiha	*Oreochromis mossambicus*	N	Non-native
Philippine catfish/Ito	*Clarias batrachus*	N	Non-native
Channel catfish/Ito	*Ictalurus punctatus*	N	Non-native
Western mosquitofish/ None	*Gambusia affinis*	N	Non-native
Guppy/None	*Poecilia reticulata*	N	Non-native
Green swordtail/None	*Xiphophorus helleri*	N	Non-native
Smallmouth bass/None	*Micropterus dolomieu*	N	Non-native
Largemouth bass/None	*Micropterus salmoides*	N	Non-native
Crustaceans			
Atyid shrimp/Uhang	*Atyoida pilipes*	Y	Native
Atyid shrimp/Uhang	*Caridina mertoni*	Y	Native
Tahitian prawn/Uhang	*Macrobrachium lar*	Y	Native
Forest ghost crab/Naot or apotalang or atopalang	*Ocypode cordimanus*	Y	Native

Table 6-4. Freshwater Macrofauna Recorded on NMS

Common Name/ Chamorro Name[(1)]	*Scientific Name*	*Diadromous*	*Residence Status*
Freshwater crab/Naot or apotalang or atopalang	*Varuna litterata*	Y	Native
Freshwater crab/Atopalang	*Orcovita mollitia*	Y	Native
Freshwater crab/Naot or apotalang or atopalang	*Ptychognathus* sp.	Y	Native
Mollusks			
Freshwater nerite/None	*Neritina pulligera*	Y	Native
Freshwater nerite/None	*Neritodryas subsulcata*	Y	Native
Crown nerite/None	*Clithon corona*	Y	Native
Dubious nerite/None	*Clithon oualaniensis*	Y	Native
Bat snail/None	*Neritina auriculata*	Y	Native
Petit's nerite/None	*Neritina petitii*	Y	Native
Variegated nerite/None	*Neritina variegata*	Y	Native
Lineated nerite/None	*Septaria lineata*	Y	Native
Porcelain nerite/None	*Septaria porcellana*	Y	Native
Quilted melania/None	*Tarebia granifera*	N	Native
Red-rimmed melania/None	*Melanoides tuberculata*	N	Native
Freshwater thiarid snail/ Akaleha	*Stenomelania plicaria*	N	Native
Green pond snails/Akaleha	*Lymnaea viridis*	N	Native
River snail/Akaleha	*Sinotaia magniciana*	N	Non-native
Physid snails/Akaleha	*Physidae*	N	Non-native
Ram's snails/Akaleha	*Planorbidae*	N	Non-native
Pagoda tiara/Akaleha	*Thiara scabra*	N	Non-native
Dark apple snail/Akaleha	*Ampullaria conica*	N	Non-native
Golden apple snail/ Akaleha	*Pomacea canaliculata*	N	Non-native

Note: [(1)] Chamorro names from GovGuam (2009), Kerr (2012), Liske-Clark (2015), Topping et al. (1975), and USFWS (2015a).
Key: N = no, is not diadromous; NMS = Naval Munitions Site; Y = yes, is diadromous.
Sources: Maciolek 1984; Concepcion and Nelson 1999; Fitzsimons et al. 2002; Leberer and Cai 2003; Paulay et al. 2003; Guam DAWR 2006; DON 2009, 2010; Nico and Walsh 2011; Kerr 2013.

Non-native Species

African land snails (*A. fulica*), coconut rhinoceros beetles (CRB) (*Oryctes rhinoceros*), two species of scarab beetles (*Protaetia pryeri* and *P. orientalis*), Erythrina gall wasps (*Quadrastichus erythrinae*), cycad scale (*Aulacaspis yasumatsui*), New Guinea flatworm (*Platydemus manokwari*), and over 26 species of ants are non-native invertebrates found in Guam. These species are known threats to native palms, native *Cycas micronesica*, native ifit and Erythrina trees, native tree snails, and other native species. However, the extent of their distribution within NMS and impacts on native species are unknown.

The little fire ant (LFA) (*Wasmannia auropunctata*) has been detected in at least four areas of NMS due to infestations occurring adjacent to the property borders, and presents a threat to native invertebrate and vertebrate species. Accidentally introduced to northern Guam in 2011, it is slowly expanding its range despite extensive efforts to control it.

6.2.5 Terrestrial Protected Species

Twelve federal ESA-listed species are known to occur on NMS, with an additional five species having the potential to occur (Table 6-5). In addition, nine Guam ESA-listed species are known to occur or may occur.

There are no native freshwater aquatic species listed as threatened or endangered within NMS. Table 6-5 and Figure 6-10 provide a summary of the occurrence and location of federal and Guam ESA-listed species within NMS. The discussion that follows provides a summary of each.

Table 6-5. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Recorded Species on NMS

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat*	*Occurrence*
Mammals					
Mariana fruit bat/Fanihi	*Pteropus mariannus mariannus*	T	E	Limestone native and coconut forests	Y
Birds					
Common moorhen/Pulattat	*Gallinula chloropus guami*	E	E	Wetland (herbaceous, mangrove, and shrub/herb)	Y
Mariana swiftlet/ Chachaguak or Yayaguak	*Aerodramus bartschi*	E	E	Mahlac Cave, Fachi Cave, and Maemong Cave	Y
Reptiles					
Slevin's skink/Gualiek halumtano	*Emoia slevini*	E	E	Limestone native forest	PU[2]
Moth skink/Gualiek halumtano	*Lipinia noctua*	--	E	Limestone native forest	Y
Pacific slender-toed gecko/Achiak	*Nactus pelagicus*	--	E	Limestone native forest	Y
Invertebrates					
Guam tree snail/Akaleha	*Partula radiolata*	E	E	Vitex and ravine forests	Y
Fragile tree snail	*Samoana fragilis*	E	E	Vitex and ravine forests	Y
Plants					
None/Siboyas halumtano	*Bulbophyllum guamense*	T	--	Limestone native forest	Y
Tree fern/Satsa	*Sphaeropteris lunulata*	--	E	Ravine forest and savanna complex	P
None/Fadang	*Cycas micronesica*	T	--	Limestone native and degraded forests, ravine forest, and savanna complex summits	Y
None/None	*Dendrobium guamense*	T	--	Limestone native forest and limestone coastal scrub	Y
None/None	*Hedyotis megalantha*	E	--	Savanna complex	PU
None/Ufa halumtano	*Heritiera longipetiolata*	E	E	Limestone native forest	Y
None/None	*Maesa walkeri*	T	--	Limestone native and degraded forests and savanna complex	Y
None/Seyaihagona or Maisa ulu	*Nervilia jacksoniae*	T	--	Limestone native and degraded forests	Y
Safford's Leafflower/None	*Phyllanthus saffordii*	E	--	Savanna complex	PU
None/ Biringenas halumtano	*Solanum guamense*	E	--	Limestone native forest, limestone coastal scrub, and roadsides	PU

Table 6-5. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Recorded Species on NMS

Common Name/ Chamorro Name(1)	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat*	*Occurrence*
None/None	*Tabernaemontana rotensis*	T	--	Limestone native and degraded forests	Y
None/None	*Tinospora homosepala*	E	--	Limestone native forest and limestone coastal scrub	PU
None/None	*Tuberolabium guamense*	T	--	Limestone native forest and limestone coastal scrub	Y

Note: (1) Chamorro names from GovGuam (2009), Topping et al. (1975), Safford (2009), and USFWS 2015a.
(2) Historic occurrence.
Key: -- = not listed; E = endangered; ESA = Endangered Species Act; NMS = Naval Munitions Site; P = potential for occurrence; PU = potential for occurrence, but unlikely; T = threatened; Y = yes, known to occur.
Sources: Schreiner and Nafus 1996; Guam DAWR 2006; GovGuam 2009; Safford 2009; USFWS 2011, 2015a; NAVFAC Pacific 2013; NAVFAC Marianas 2014b, 2016b, 2017b, 2023a; DON 2015a.

6.2.5.1 Mammals

Mariana Fruit Bat

Mariana fruit bat is federal ESA-listed as threatened and Guam ESA-listed as endangered. Mariana fruit bats have suffered declining populations within NMS and elsewhere in Guam due to multiple factors. Historically, humans have harvested bats for food. According to Morton and Wiles (2002), this impact has been exacerbated by the increasing human population in Guam and the increasing availability of firearms. They noted that poaching within NMS likely caused bats to become more sensitive to human presence. Poachers hunting for deer within NMS often set fires that can destroy bat roosting and foraging habitat. Predation by BTS over the past six decades, particularly on unattended juvenile bats, is also a likely cause of population decline (Morton and Wiles 2002). These impacts frustrate recovery efforts despite the bat's legal protection under the federal and Guam ESA. USFWS (2009) identified habitat fragmentation and loss due to urbanization and expansion of military installations as a threat to bat populations. Direct human disturbance of roosting sites caused by increased military activities and unauthorized entry into protected areas can lead to the dispersal of bats (Morton and Wiles 2002). NAVFAC Marianas (2017c) also identified habitat degradation by feral ungulates as a likely factor limiting roosting and foraging opportunities. Management strategies and actions of the INRMP to protect and conserve Mariana fruit bats include protection and enhancement of their forested habitats, control and suppression of BTS, continued monitoring of bat populations, and control of wildland fires and ungulates.

Monthly census of fruit bats occurred on NMS between 1963 and 1968 and the number of observations dropped from 53 bats per 100 acres to approximately five bats per 100 acres (Perez 1972). In the late 1980's, Wiles (1987) estimated as many as 25-50 fruit bats occupied the interior forested regions of NMS and Talofofo. Between 1985 and 1999, there were only 38 confirmed sightings of Mariana fruit bats in the upper Talofofo River watershed; 23 of these occurred at or near Fena Valley Reservoir.

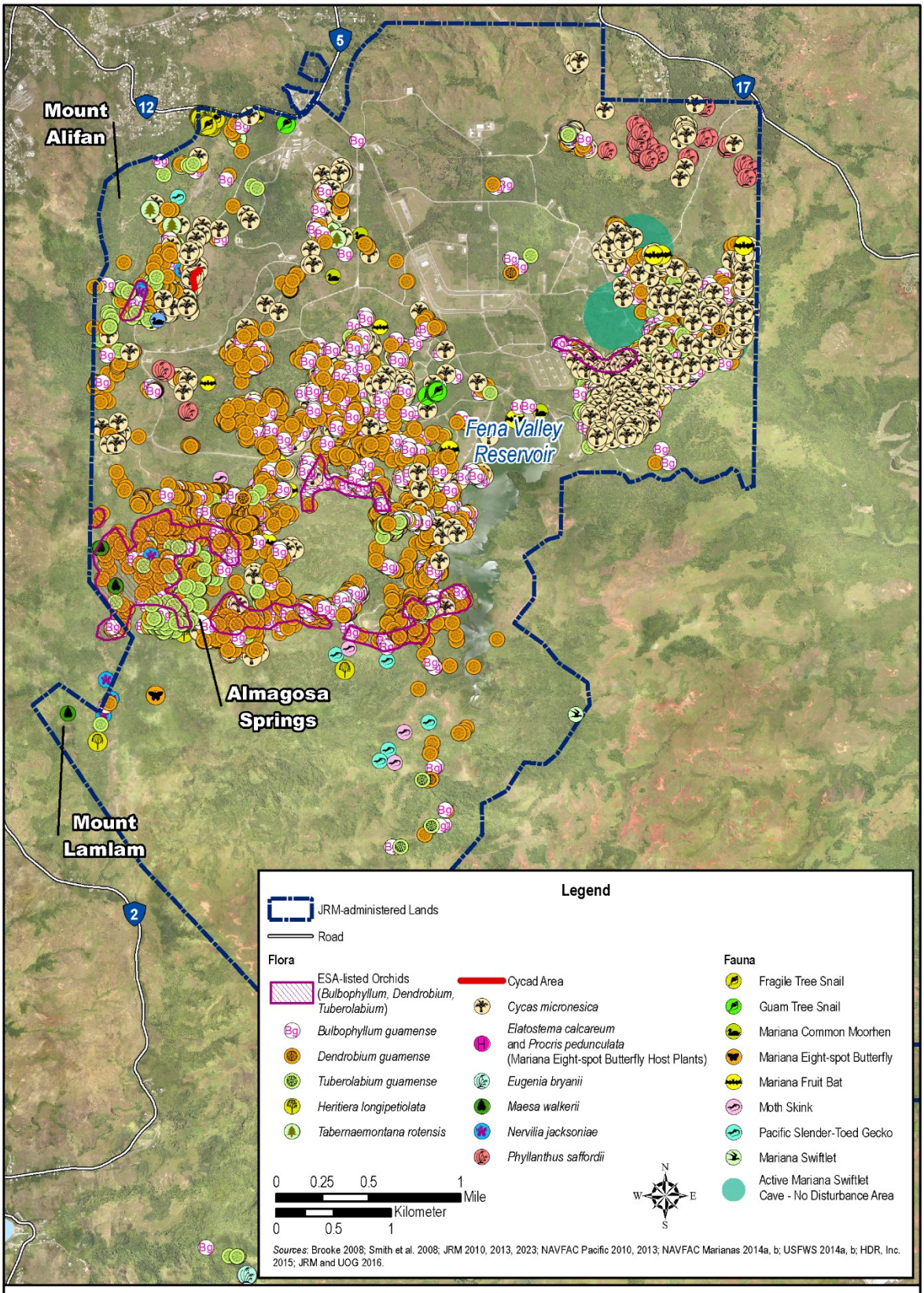


Figure 6-10
Protected Terrestrial Species on NMS

In 2010, three sightings of the same individual Mariana fruit bat were reported within NMS (NAVFAC Pacific 2010). Seven observations of one Mariana fruit bat in flight, each on a different day, were recorded at NMS between May 10 and June 22, 2012 (NAVFAC Pacific 2013).

The most recent surveys on NMS were conducted in 2022, which resulted in 49 unique fruit bat detections (U.S. Navy 2023a). After a reconnaissance survey in April 2023, a roosting colony was confirmed in the area north of Cross Island Road estimating a population size of 75–100 individuals (U.S. Navy 2023a). In June of the same year, the roost yielded over 200 bats (U.S. Navy 2023b).

6.2.5.2 Birds

Mariana Swiftlet

Mariana swiftlet is federal and Guam ESA-listed as endangered. Once considered common in Guam, Mariana swiftlet began a significant decline in the 1960s (Brindock 2015). It inhabits three limestone caves within NMS: Mahlac, Maemong, and Fachi (see Figure 6-10). During *T. guamense* surveys in 2019 and 2020 within the Bolanos Conservation Area in Utmac (southern Guam, outside of DoD lands), an incidental observation of a new Mariana swiftlet cave was documented (Guam Plant Extinction Protection Program 2021). These are the only known roosting locations for this species in Guam, except for an additional unconfirmed report of a few birds near Janum Point in northern Guam (Guam DAWR 2006). The DON, USFWS, and Guam DAWR have been monitoring the swiftlet population at these caves for over 30 years.

The method of conducting visual arrival surveys of birds entering and exiting the caves has been used for more than 20 years with up to four evening cave entrance surveys per year (Gorreson et al. 2023). A group of observers from various local and federal agencies arrive 60 minutes prior to sunset, conduct an in-cave count of birds and nests, then position themselves at cave entrances and count arriving and exiting birds until they are unable to detect birds due to low-light/complete darkness. Arrival surveys of birds cannot account for two sources of uncertainty (Brindock 2010): 1) the extent to which swiftlets may repeatedly enter and exit caves and be "double-counted"; and 2) how many birds remain in the cave during a survey to roost or attend nests (although counters generally survey the roosting area before conducting entrance counts to tally birds remaining in the cave). Additional uncertainty arises from the difficulty of counting in low light conditions while birds rapidly fly in and out of a cave, often in groups, as well as regularly circling within the visual sample area. A swiftlet colony can also be readily disturbed and numerous birds might fly from the cave at once, thereby adding to the difficulty of visually tracking individuals. Surveyors that enter the cave for a count of birds and nests in the cave before the cave entrance count may risk additional disturbance to the colony. Because conditions and observers change over time, the reliability and replicability of population estimates across counts is difficult to assess.

The Mariana swiftlet maintained a small population of about 400 to 500 birds during the 1980s and 1990s. Despite populations being low overall, those within the Mahlac Cave increased dramatically between 1998 and 2010 to an estimated 1,400 birds (Sabol et al. 2011). The same study estimated nearly 400 swiftlets in Maemong Cave and nearly 200 in Fachi Cave. Mariana swiftlet population estimates for Mahlac, Fachi, and Maemong Caves from 1986 through 2017 are shown in Figure 6-11. Brindock (2015) suggests that predation by BTS, disturbance, decrease in prey from habitat alteration (deforestation), typhoons, and disease are factors that may currently be limiting the population in Guam. BTS traps were initially deployed outside of Mahlac Cave in 2000; a decrease in the number of snakes observed at the caves during visual surveys correlates with an increase in the population of swiftlets (Figure 6-12). Trapping started at Maemong Cave in 2011 and at Fachi Cave in 2012 (Klug et al. 2014). The population at Maemong appears to have increased between 2012 and 2016. No change has been seen in the population size at Fachi. The

population of Mariana swiftlet in 2010 was estimated to be between 900 and 1,100 birds; in 2016, the population was estimated to be between 1,550 and 1,600 birds (Figure 6-11). Surveys between 2010 and 2017 had shown a slight increase in the overall NMS Mariana swiftlet population (Figure 6-11). Estimated population size on NMS from 2018 to 2023, based on visual surveys are as follows: 2018, 1,090 birds; 2019, 1,280 birds; 2020, 1,130 birds; 2021, 931 birds; 2022, 834 birds; and 2023, 1,105 birds.

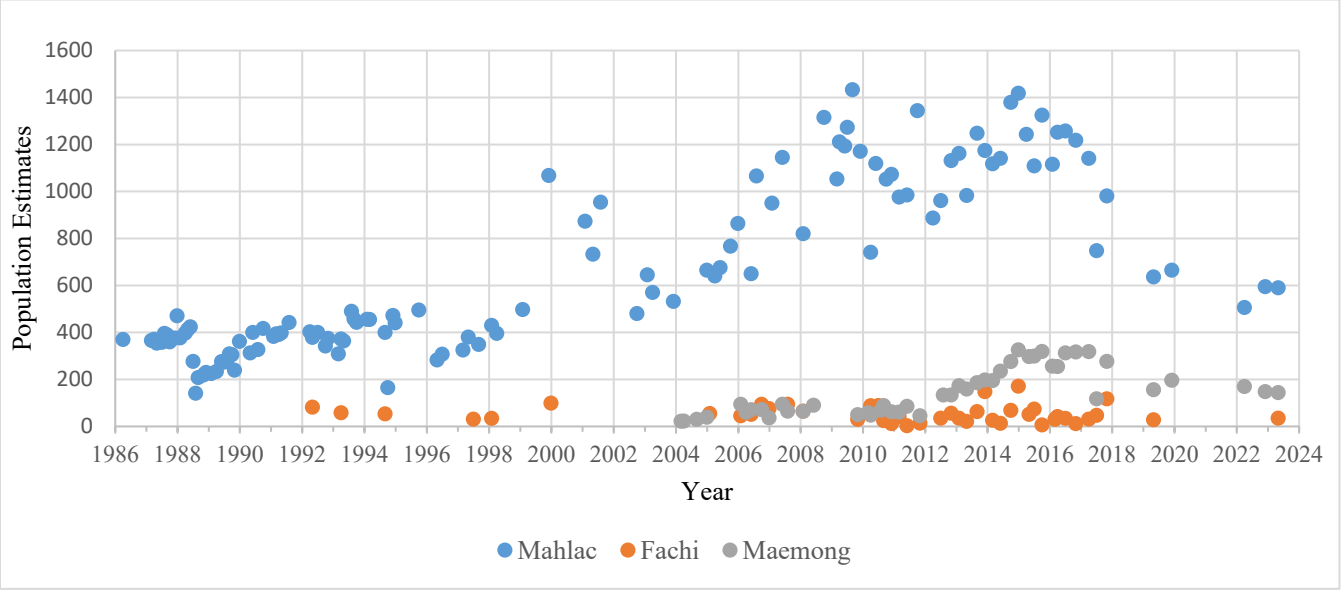


Figure 6-11. Individual Mariana Swiftlet Population Estimates Recorded at Mahlac, Fachi, and Maemong Caves, NMS (1986-2023)

Sources: NAVFAC Marianas 2016c; Vogt 2017a; Gorrenson et al. 2023

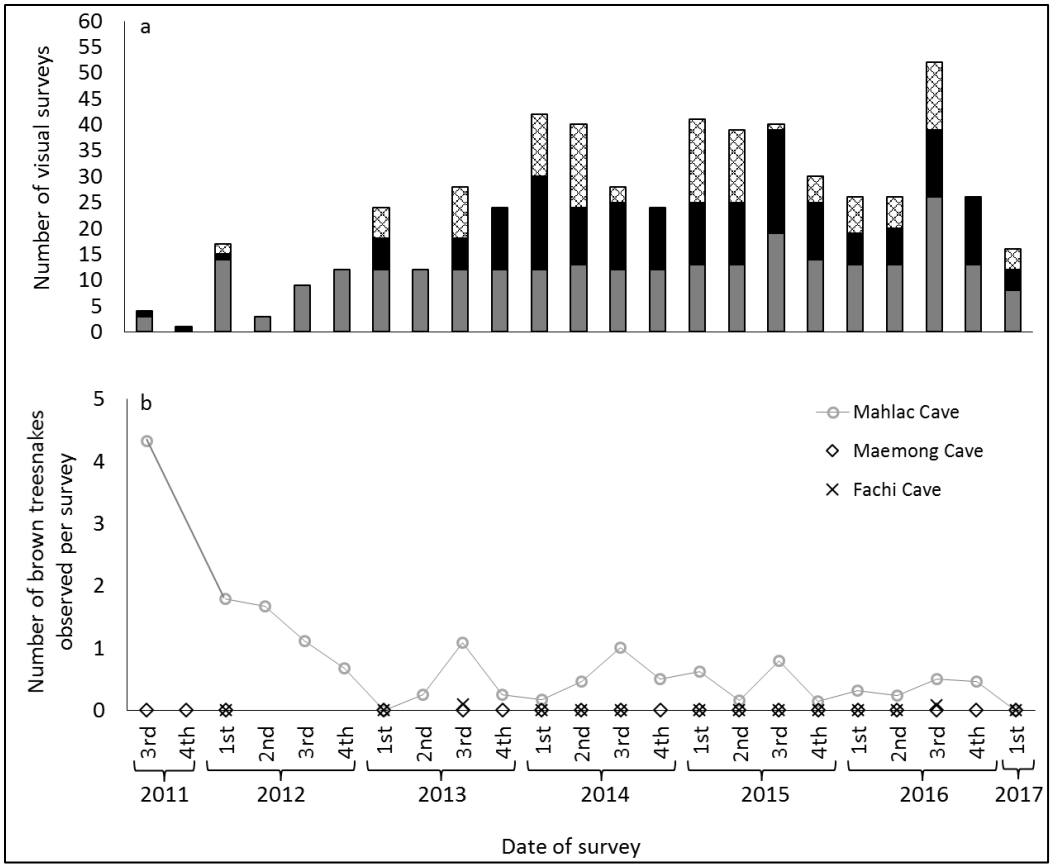


Figure 6-12. Number of Surveys Conducted/Quarter for Mariana Swiftlet Caves (a) and Number of BTS Observed per Survey at Mariana Swiftlet Caves as a Function of Survey Date (b)

Notes: (a) Gray = Mahlac, black = Maemong, hatching = Fachi. (b) 1st quarter = January–March; 2nd quarter = April–June; 3rd quarter = July–September; 4th quarter = October–December.
Source: Lujan 2017

Starting in 2018, the DON has funded work to develop thermal and near-infrared videography in low-light or completely dark settings, holding the greatest promise for producing accurate counts of swiftlets at roost and nest locations within caves (Brindock 2010; Johnson et al. 2018). Importantly, photo documentation can be reviewed post-count period to assess accuracy, and computer vision algorithms can be developed to efficiently process imagery for rapid count estimation. This allows for high confidence and replicability across counts and minimizes human disturbance during counts (Gorresen et al. 2023).

Cave-specific estimates of colony size for 2019, 2022, and 2023 demonstrated that Mahlac Cave harbored about 77% of the known swiftlet population in Guam, and an equivalent proportion (80%) of active nests. The average estimated colony size for the three occupied caves based on counts conducted using near-infrared and thermal videography are as follows: Mahlac Cave, 577; Maemong Cave, 157; and Fachi, 31 (Gorresen et al. 2023), a significantly smaller number than visual surveys from the same time period. Additional work focused on the comparison of the two different methods is planned as well as the continued improvements to camera designs and development of algorithms to assist in counting and tracking the movement of birds.

Mariana Common Moorhen

Mariana common moorhen is federal and Guam ESA-listed as endangered. Although Guam DAWR surveys in 1988 found 66 birds on Fena Valley Reservoir, USFWS (1992) subsequently reported a downward trend in moorhen numbers. Surveys conducted in 2001 (later reported by Takano and Haig (2004) encompassed three wetlands on NMS including Fena Valley Reservoir, Fena Dam spillway, and the Naval Magazine Pond (a flooded depression with scattered emergent vegetation located in an area lying on the north side of Almagosa Springs Road). These surveys were conducted during the dry season when moorhens were expected to be more concentrated on perennial wetlands and, therefore, easier to count. Of the 90 birds estimated to be in Guam during the survey, 38 were located on wetlands in NMS. The majority of those birds, 33, were using the Fena Valley Reservoir. Since 2001, eutrophication of Fena Valley Reservoir following a typhoon resulted in the loss of hydrilla, a water plant used by moorhens as a nesting habitat. The moorhen population at the reservoir declined further after the loss of the plant (USFWS 2009). Brooke and Grimm (2008) reported only two common moorhen observations within Fena Valley Reservoir between July 2005 and December 2008. The DON conducted 28 surveys along the reservoir shoreline and spillway between September 2013 and August 2014 and did not find any Mariana common moorhen at that time (Brindock 2014; NAVFAC Marianas 2015). Figure 6-13 illustrates the decline in moorhen observations at Fena Valley Reservoir between 1987 and 2013.

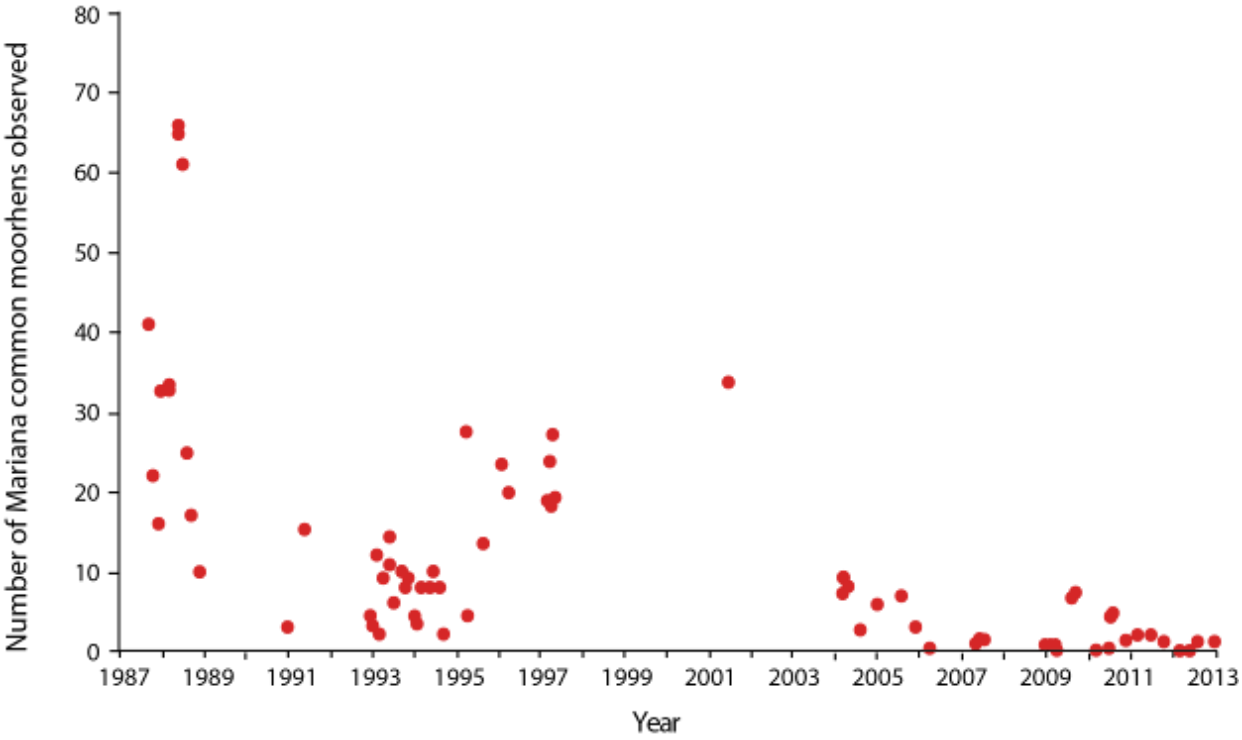


Figure 6-13. Number of Mariana Common Moorhens Recorded at Fena Valley Reservoir, 1987-2013

Source: NAVFAC Marianas 2014a.

It was unclear whether the decline in moorhens observed at the reservoir from 1987 to 2013 represented an overall decline in abundance or the movement of moorhens to other wetland habitats. Another possible stressor on the moorhen population that may have contributed to this decline includes predation of moorhen eggs and chicks by BTS and feral cats and dogs (Stinson et al. 1991; USFWS 1992; Takano and Haig 2004).

NAVFAC Marianas (2015) also cited potential predation pressure on moorhens by introduced catfish and turtles and by the native anguillid eel.

In 2014, NAVFAC Marianas contracted construction of numerous artificial nesting platforms to simulate hydrilla in Fena Valley Reservoir in an attempt to attract more Mariana common moorhen. No moorhens, however, have been observed using the platforms since they were installed (Vogt 2017c). NAVFAC Marianas (2015) reported moorhen sightings at nine small perennial wetland sites within NMS during the 2014 dry season; only two birds were recorded during wet season surveys. In the 2015 dry season, no moorhens were observed within NMS, and only three moorhens were observed during the wet season (NAVFAC Marianas 2016b). Vogt (2017c) indicated that NAVFAC Marianas would continue experimentation with artificial nesting platforms to enhance habitat for moorhen in Fena Valley Reservoir.

6.2.5.3 Reptiles

Skinks and Geckos

Moth skinks and Pacific slender-toed geckos are Guam ESA-listed endangered species. The moth skink is also Guam-designated as SOGCN. Both species were captured on NMS during 2010 surveys, but their distribution and abundance are unknown due to the variability of information presented in reports. During herpetofauna surveys on NMS in 2008, five moth skinks were captured (DON 2010). Additionally, five geckos were recorded, two individuals were captured using glue-boards, and three were observed during visual surveys (DON 2010). The Pacific slender-toed gecko is rarely seen.

Slevin's skink is the only endemic reptile to the Mariana Islands. It is both a federal and Guam ESA-listed endangered species and Guam-designated as SOGCN. The species still occurs on Cocos Island (USFWS 2015b) but has not been verified in the wild on the main island of Guam since 1945.

6.2.5.4 Invertebrates

Tree Snails

The Guam tree snail and the fragile tree snail are the only native tree snails known to still occur on NMS. They are ESA-listed as endangered, Guam ESA-listed as endangered, and Guam-designated as SOGCN. Mount Alifan was the only area within NMS surveyed during early partulid tree snail surveys by Crampton (1925) and Hopper and Smith (1992). The Guam tree snail was detected in the west-central highlands near Mount Alifan along with two other species, the humped tree snail (*P. gibba*) and the newly described Mount Alifan tree snail (*P. salifana*). The Mount Alifan tree snail was subsequently found and verified by Abbott in 1945 and by Langford in 1946 (Hopper and Smith 1992). It was considered an endemic species only known from Mount Alifan. Extensive surveys by Hopper and Smith (1992) in 1989 failed to detect any living partulid tree snails at this location. With no record of the Mount Alifan tree snail since 1945, it is now considered extinct (Hopper and Smith 1992; Smith et al. 2008). Surveys conducted in 2008 found two populations of Guam tree snails along Kitts Road on NMS (Smith et al. 2008) (see Figure 6-10). Surveys conducted in 2009 in NMS found dead, weathered shells of humped tree snails in the Almagosa Springs area. The humped tree snail is considered locally extirpated. Surveys conducted in 2020 and 2021 discovered a high-density population of 1,896 fragile tree snails in the northwest corner of NMS (NAVFAC Marianas 2021). The island of Guam has no federal ESA-listed or candidate freshwater invertebrates (Englund 2011).

6.2.5.5 Plants

Of the 12 federal ESA-listed plant species that have the potential to occur on NMS (see Table 6-5), eight have been recorded. Table 6-6 shows the results of surveys conducted in 2017 targeting 14 federal ESA-listed species, three of which are Guam ESA-listed species. *Eugenia bryanii*, *Hedyotis megalantha*, *Phyllanthus saffordii*, *Psychotria malaspinae*, *Solanum guamense*, and *Tinospora homosepala* were not observed during surveys, and, as such, are not discussed further.

Table 6-6. Number of Federal ESA-listed Threatened and Endangered Plant Species Recorded on NMS

Common Name/ Chamorro Name(1)	*Species*	*Federal Status*	*Guam Status*	*Total*
None/Siboyas halumtano	*Bulbophyllum guamense*	T	--	**27,076**
None/Fadang	*Cycas micronesica*	T	--	**932**
None/None	*Dendrobium guamense*	T	--	**17,361**
None/Aaban or Aabang	*Eugenia bryanii*	E	--	**0**
None/None	*Hedyotis megalantha*	E	--	**0**
None/Ufa halumtano	*Heritiera longipetiolata*	E	E	**0**
None/None	*Maesa walkeri*	T	--	**7**
None/Seyaihagon or Maisa ulu	*Nervilia jacksoniae*	T	--	**384**
Safford's Leafflower/None	*Phyllanthus saffordii*	E	--	**983**
None/Aplokating-palaoan	*Psychotria malaspinae*	E	--	**0**
None/Biringenas halumtano	*Solanum guamense*	E	--	**0**
None/None	*Tabernaemontana rotensis*	T	--	**31**
None/None	*Tinospora homosepala*	E	--	**0**
None/None	*Tuberolabium guamense*	T	--	**12,301**

Note: (1) Chamorro names from GovGuam (2009); Safford (2009); Topping et al. (1975); and USFWS (2015a).
Key: -- = not listed; E = endangered; ESA = Endangered Species Act; NMS = Naval Munitions Site; T = threatened.
Sources: Safford 2009; DON 2017. NAVFAC Marianas 2023a, 2022b.

Bulbophyllum guamense

Bulbophyllum guamense is a federal ESA-listed threatened epiphytic orchid that forms mats on branches of trees in coastal lowland/limestone forests and is known from widely distributed occurrences on the southern Mariana Islands of Guam and Rota (Ames 1914; Raulerson and Rinehart 1992; Costion and Lorence 2012). In Guam, *B. guamense* was known from clifflines encircling the island and on the slopes of Mount Lamlam and Mount Almagosa. In 1992, this species was reported to occur in large, mat-like formations on trees "all over the island" (Raulerson and Rinehart 1992). In 2014, USFWS (2014) reported only four known occurrences (three in Guam and one on Rota) totaling fewer than 250 individuals in Guam, and fewer than 30 individuals on Rota. *B. guamense* is vulnerable to the effects of habitat loss due to urbanization, agricultural development, and by predation pressure from non-native invertebrates (USFWS 2014). In 2015, USFWS listed *B. guamense* as threatened (USFWS 2015b). Surveys conducted in 2019 through 2023 found a total of 12,722 *B. guamense* individuals at NMS (NAVFAC Marianas 2023a).

Sphaeropteris lunulata

The tree fern *Sphaeropteris lunulata* was observed in NMS during vegetation surveys conducted in 1989 (BioSystems Analysis, Inc. 1989). This tree fern is not a federal ESA-listed species, but is Guam ESA-listed as endangered and Guam-designated as SOGCN.

Cycas micronesica

Cycas micronesica is Guam's only native gymnosperm and one of only two native *C. micronesica* species within the U.S. (NAVFAC Marianas 2017a). It is known to occur in the forest and savanna ecosystems of Guam, Rota, Palau, and Yap (Raulerson 2006; USFWS 2015b) and has been reported on Pagan (Pratt 2011). *C. micronesica* was not known historically from Tinian but was planted there in the early 2000s in an effort to conserve the species. In Guam, *C. micronesica* is severely impacted by Asian cycad scale, the non-native cycad blue butterfly (*Luthrodes pandava*), and non-native ungulates (Marler and Lawrence 2012). This species is federal ESA-listed as threatened and Guam-designated as SOGCN. Although more numerous in the northern portion of Guam, *C. micronesica* is found in NMS.



Ravine forests on NMS support a variety of protected plant species, including *Cycas micronesica* and *Dendrobium guamense*. (*Photo*: L. Shaughnessy)

Dendrobium guamense

Dendrobium guamense, a federal ESA-listed threatened epiphyte in the orchid family (Orchidaceae), is known in limestone forests from Guam, Rota, and Tinian. *D. guamense* populations were decreasing in Guam and both the species and its habitat are adversely affected by habitat loss and destruction from agricultural activities, urbanization, non-native species interactions, fires, typhoons, and predation by non-native invertebrates. In 2015, USFWS listed *D. guamense* as threatened (USFWS 2015b). Surveys conducted in 2019 through 2023 documented 6,376 individuals at NMS within vitex and ravine forests (NAVFAC Marianas 2023a).

Heritiera longipetiolata

Heritiera longipetiolata is a large, federal ESA-listed endangered tree in the hibiscus family, reaching heights of up to 40 feet (12 meters). It occurs in moist native forest on limestone cliffs, particularly on coastal cliffs with windy conditions (Raulerson and Rinehart 1991). Only four individuals were observed in NMS. In 2015, USFWS listed *H. longipetiolata* as threatened (USFWS 2015b).

Maesa walkeri

Maesa walkeri is a federal ESA-listed threatened shrub in the primrose family (Primulaceae) found only on Rota and Guam within the forest ecosystem (USFWS 2015b). Following listing of the species, subsequent surveys on Mount Lamlam discovered 45 individuals (NAVFAC Marianas 2017b). Surveys at NMS in 2017 discovered eight mature adults, but no recruitment was noted (NAVFAC Marianas 2017b). The only

known *Maesa walkeri* in Guam occur in the NMS. Potential physical disturbance includes trampling by soldiers and vehicles, ungulate grazing, loss of seed dispersers, invasive plants and insects, and destruction by the creation of roads and trails or the placement of bivouacs.

Nervilia jacksoniae

Nervilia jacksoniae is a small, federal ESA-listed threatened herb in the orchid family (Orchidaceae) and is found only in the Mariana Islands (USFWS 2017). Threats to *N. jacksoniae* include habitat loss and destruction from development, damage due to ungulates (wallows, digging, and browsing), predation from invasive slugs, and damage from fire events. At the time of listing, it was known from two occurrences totaling fewer than 200 individuals in Guam and 13 occurrences of 320 individuals on Rota (USFWS 2015b). Surveys at NMS in 2017 discovered 205 mature individuals within three survey areas (NAVFAC Marianas 2017b). Surveys of the limestone forest in NMS to determine the full extent of the species have not been completed. The only known *N. jacksoniae* in Guam occur in the NMS. Figure 6-10 shows the known distribution of *N. jacksoniae* within NMS.



Approximately 205 *Nervilia jacksoniae* orchids were found in NMS during the 2017 surveys for listed plant species.
(*Photo*: University of Guam)

Phyllanthus saffordii

Phyllanthus saffordii is a federal ESA-listed endangered woody endemic shrub. During surveys of ESA-listed threatened plant species in the NMS, 279 *Phyllanthus saffordii* (226 mature and 53 juvenile) were observed (NAVFAC Marianas 2022b). However, the population in Guam is decreasing from initial numbers observed in Guam, and is at risk, due to continued habitat loss and destruction from agriculture, urban development, non-native animals and plants, fires, and typhoons, and direct damage by recreational vehicles. The effects of climate change will likely further exacerbate many of these threats in the future.

Tabernaemontana rotensis

Tabernaemontana rotensis is a small- to medium-sized, federal ESA-listed threatened tree in the dogbane family (Apocynaceae) that grows in the forest ecosystem (USFWS 2015b). It is endemic to Guam and Rota. In 2004, 250 individuals were located in Guam. In 2007, more than 21,000 individuals were found throughout Andersen AFB in Guam, with a population structure representing seedlings, juveniles, and mature adults. Targeted surveys at NMS in 2017 discovered one mature individual within three survey areas (NAVFAC Marianas 2017b). In cumulative surveys conducted in 2019 through 2023, 19 total *T. rotensis* were discovered (NAVFAC Marianas 2023a, 2023b). Although it was found to be more numerous than previously thought, the species is still at risk due to habitat loss and destruction from non-native plants and animals, wildland fires, development, and training (USFWS 2015b).

Tuberolabium guamense

Tuberolabium guamense is a federal ESA-listed threatened epiphytic orchid that grows in low positions on trees and shrubs and in the canopy of limestone native forest (Raulerson and Rinehart 1992; Zarones et al. 2015). *Tuberolabium guamense* forms roots that elevate it from the trunk or branch surface. Leaves are oblong and leathery, and the plant produces clusters of small white flowers. Plants flower from September through October in Guam and Rota and have been observed in fruit in November and February on Rota (Raulerson and Rinehart 1992; Zarones et al. 2015). Surveys at NMS in 2017 recorded 291 individuals

within three survey areas (NAVFAC Marianas 2017b). Ongoing surveys beginning in 2019 have recorded 3,540 individuals within two survey areas at NMS (NAVFAC Marianas 2023a).

6.3 MANAGEMENT GOALS, OBJECTIVES, STRATEGIES, AND ACTIONS

JRM currently manages natural resources based on an ecosystem focused approach that involves the implementation of several ongoing management projects. These projects, which are described in the following sections, provide examples of JRM's current efforts to manage and enhance natural resources in a manner consistent with the military mission. Appendix C lists management projects at NMS for Fiscal Year (FY) 14–17. The following sections present management projects for NMS that have been identified as necessary to achieve applicable goals and objectives identified in Chapter 3, *Environmental Management Strategy and Mission Sustainability*.

Management projects identified for NMS provide direct support for the military mission and the goal of "no net loss" in a number of ways. For example, projects that improve the baseline status of species or their habitat show that populations are stable or that habitat is improving or expanding may relieve restrictions on military training or operations, minimize costs and mitigation requirements, avoid workarounds, and/or streamline regulatory processes.

6.3.1 Terrestrial Ecosystem Management

NMS's native terrestrial habitats have been impacted by historical activities, introduction and spread of invasive and non-native species, effects of climate change, and the resulting loss of functions necessary to support healthy native habitats. Ecosystem functions have been disrupted by the extirpation of native animal and plant species, which has resulted in both economic and cultural impacts on the ecosystem services provided by native habitats. The occurrence of healthy native habitats on NMS is necessary to support sustainability of native species, including federal and Guam ESA-listed species. JRM recognizes that restoration and enhancement of native habitats on lands that they manage is a long-term process, and that adaptive management is key to long-term success of the program.

Management projects are monitored and evaluated annually to ensure that they are meeting identified goals and objectives. JRM will establish mid-year coordination meetings with resource partners to discuss on-going and planned projects, including prioritization, scope, methodology, issues or challenges, timelines, and performance evaluation criteria. These discussions are intended to facilitate improved coordination and information sharing to allow for course corrections, if necessary, to ensure an adaptive approach. Terrestrial ecosystem management, as described in the following sections, is expected to: (1) improve the status of threatened and endangered species through habitat conservation and enhancement, and (2) promote health and sustainability of native forests. Healthy ecosystems will, in turn, relieve or reduce environmental constraints and allow for maximum operational flexibility for the installations and continued/managed access to important recreational areas.

A summary of the management projects and the estimated timeframe for completion is presented in Table 13-7, *Planned Implementation Summary of Projects at NBG Main Base*, found in Chapter 13, *Planning, Integration, and Implementation*. Some of the projects described in this section are being accomplished through interactive partnerships with federal and territorial natural resource agencies (e.g., Guam DAWR), universities, and local organizations.

6.3.1.1 Terrestrial Habitat Management

JRM has ongoing and planned projects to restore and enhance native terrestrial habitats. These projects focus on improving the quality and availability of appropriate habitat for listed species, as well as increasing

the quality and health of existing native habitats, such as limestone native forests. Numerous related activities are required for native habitat improvement, such as control of ungulates and other invasive species, propagating and outplanting native plant species to improve diversity, and addressing forest health issues, such as improvement of seed dispersal.

In order to achieve long-term goals, Terrestrial Habitat Management (THM) requires successful daily and short-term management coupled with long-term planning and investment. To ensure that JRM continues to meet the overriding goal of restoring and enhancing terrestrial habitats for native species (including listed species) over the long term, JRM site land managers and resource agencies will continue coordinating on natural resource management.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for THM on NMS.

THM-1: WATERSHED MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2 and Goal #2, Objectives #7-8.

- *Strategy*: Protect and restore habitats and manage the land to reduce sediment run-off for the benefit of the Southern Guam Watershed.
- *Action*: Reduce sediment run-off by planting 800 feet (244 meters) of *V. zizanoides* buffer strips along base of badland hills on NMS every 2 years.
- *Action*: Identify priority areas with high erosion rates to implement additional grass planting at Fena Valley Reservoir.
- *Action*: Determine feasibility of using coconut fiber wattles to protect stream banks and reduce sedimentation delivery into stream channels.

THM-2: FOREST ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-6; Goal #3, Objectives #1-4; and Goal #4, Objective #2. This project supports the 2019 Guam Wildlife Action Plan (Guam DAWR 2019).

- *Strategy*: Protect and restore priority native habitats (i.e., limestone native forest) for the benefit of native flora and fauna, including protected species, by focusing on step-wise forest enhancement activities and by protecting species from direct and indirect threats.
- *Action*: Construct and maintain ungulate exclusion fences in priority areas using appropriate materials and specifications for the region. Approximately 75-100 acres (30-40 hectares) per year will be fenced until all the areas shown in Figure 6-14 are complete.
- *Action*: Eradicate ungulates from within ungulate exclusion areas to allow forest regeneration. Multiple techniques will be used to eradicate ungulates including trapping and active shooting using a professional ungulate control company or agency. Ungulates will be eradicated within 12-18 months of fence completion for each management area.

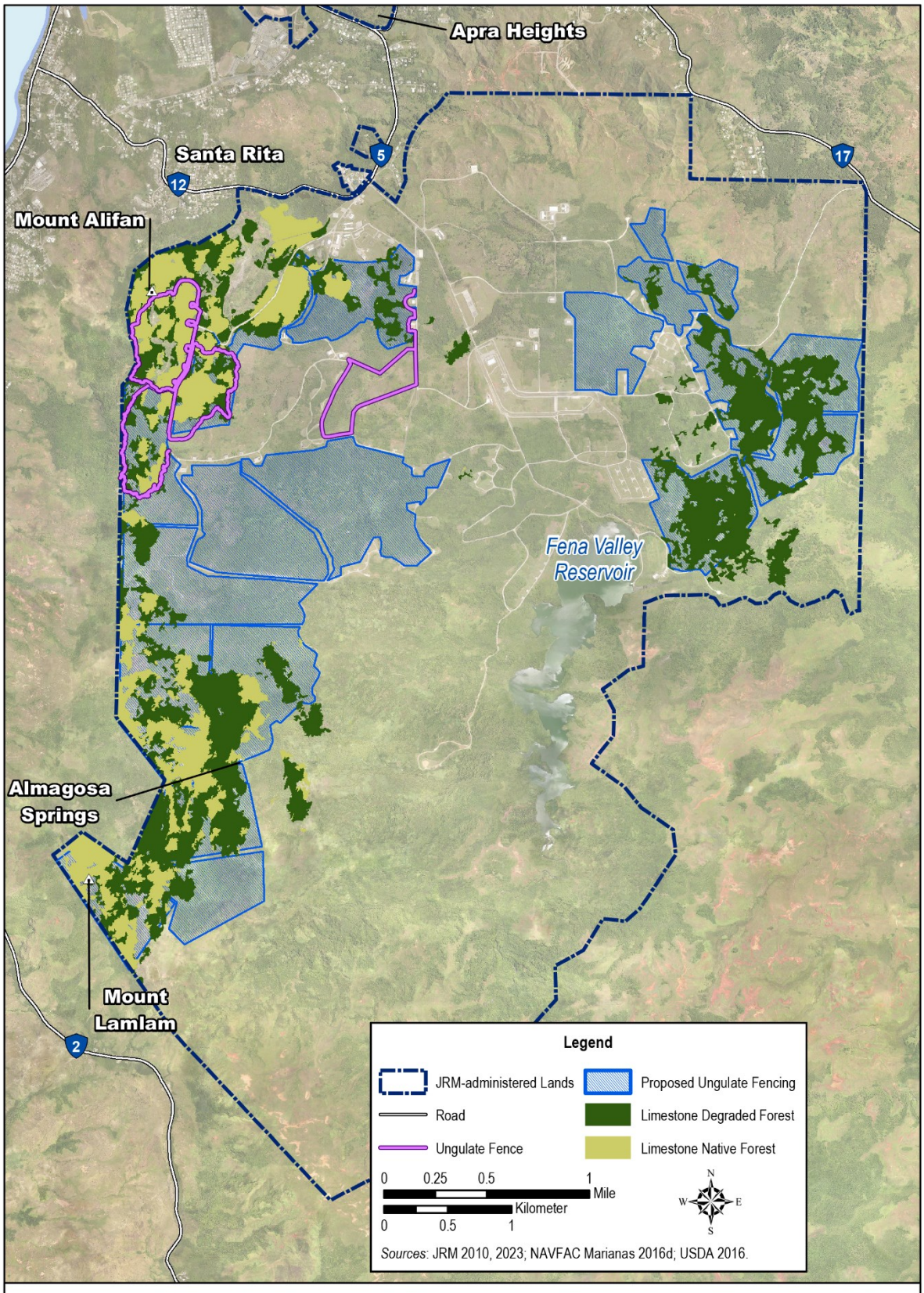


Figure 6-14
Ungulate Fencing on NMS

- *Action*: Survey and map locations of non-native and invasive plants and develop a targeted removal and maintenance strategy within fenced forest enhancement areas. Surveys and mapping of invasive plants will occur prior to or concurrently with fence installations. Invasive plant removal will occur following ungulate eradication.
- *Action*: Collect seeds from existing populations of native trees on NMS, propagate in a nursery, and outplant within forest enhancement areas once ungulates are eradicated. Federal permits will be obtained prior to collection of seeds from listed plants. Seed collection will occur prior to or concurrently with ungulate removal. Outplanted trees will be monitored and maintained to ensure successful establishment.
- *Action*: Develop performance metrics and monitor fenced management areas to evaluate effectiveness of forest enhancement actions.
- *Action*: Complete comprehensive surveys to identify locations of listed plant species in ungulate management areas and develop a monitoring program to detect species response.
- *Action*: Determine if translocation of Micronesian starlings to NMS is feasible. If determined to be feasible, install predator-proof nest boxes and translocate Micronesian starlings to NMS using best management practices (BMPs) learned from Andersen AFB nest box studies.

THM-3: MANAGING WILDLAND FIRES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-8; Goal #3, Objectives #1-2 and #4; Goal #5, Objective #2; and Goal #7, Objective #2.

- *Strategy*: Protect and restore natural resources on NMS by reducing habitat degradation (i.e., soil erosion and vulnerability to invasive plant establishment) resulting from wildland fires.
- *Action*: Rehabilitate and restore degraded areas through implementation of the 2015 NBG Wildlands Fire Management Plan.
- *Action*: Control problem fuels (i.e., swordgrass) in strategic locations to disrupt the spread of wildland fires in savanna/grasslands.
- *Action*: Determine effectiveness of direct seeding of scarified *Acacia* seed on a small-scale site that has been mowed and treated with herbicide (e.g., simulate conditions following a wildland fire).
- *Action*: Expand the establishment of shaded fuel breaks in areas where non-fire fuel reduction (e.g., mechanical cutting and herbicide applications) have proven effective as a temporary solution.
- *Action*: To ensure adequate annual maintenance, place selected firebreaks in higher maintenance standards to prevent erosion.
- *Action*: Develop a wildland fire monitoring and reporting system that includes basic fire data such as the location of the wildland fires, acreage burned, resources expended, and impacts to natural resources and ecosystem services.
- *Action*: Install wildland fire danger signs at strategic locations on NMS. Fire danger warning signs that include daily fire danger condition and the appropriate phone number to call to report wildland fires.
- *Action*: Develop an after-action reporting system that facilitates site assessments that support restoration and rehabilitation projects.
- *Action*: Confer on the roles and responsibilities of NBG Environmental Division and NBG Federal Fire Health and Safety Code that facilitate Health and Safety Code response capacity to continue effective water bucket drops on wildland fires.

- *Action*: Establish a working group of agencies and departments involved in wildland fire prevention, detection, and suppression to initiate a dialog on improving cooperation in wildland fire management.
- *Action*: Review and update the existing mutual aid agreement with Guam Fire Department to reflect the current DON organizational structure and responsibilities. Guam Department of Agriculture Division of Forestry and Soil Resources will be included in any wildland fire mutual aid agreement because of their complementary capabilities and responsibilities.
- *Action*: Evaluate and adjust the roles and responsibilities of DON personnel in wildland fire management. Responsibilities will be reflected in the installation instructions.

6.3.1.2 Terrestrial Exotic and Invasive Species Management

An invasive species is defined in Executive Order (EO) 13112, *Invasive Species*, as a species that is non-native (i.e., alien or exotic) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions. Invasive species have had a catastrophic effect on the native flora and fauna of island ecosystems, particularly Guam. Attributes of island biota include small geographic ranges and population size, low reproductive rates, and lack of the ability to respond to invasive species and disturbed habitats. Islands typically have lower numbers of species than mainland areas, which results in fewer predators and competitors that could prohibit the establishment of invasive species. As a result of evolving in isolation, island plants and animals have few defenses when exposed to introduced competitors and predators. These limitations in Guam have caused exotic and invasive species to replace native island species (Wiles et al. 2003).

Many of the native species in Guam are threatened due to introduced predators, such as the BTS, and introduced ungulates, such as the Philippine deer, feral pig, and Asiatic water buffalo (carabao), which have significantly affected native vegetation communities. Feral populations of dogs and cats also pose threats to native wildlife populations. Secretary of the Navy Instruction (SECNAVINST) 6401.1B dated September 29, 2006, prohibits dogs, cats, and other privately owned or stray animals from running at large on military installations. Several species of rats have colonized the island, preying on the eggs and young of native species and destroying native flora (i.e., seeds and seedlings). The continued widespread presence of the BTS, curious skink, and introduced amphibian species are of particular concern because of each species' potential negative impacts in Guam's native fauna. Examples of invasive species management approaches include the control of feral ungulates, the control of feral cats and dogs, and the removal of invasive plants to allow native species to flourish in degraded areas.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Exotic and Invasive Species Management (TIS) on NMS.

TIS-1: BROWN TREESNAKE INTERDICTION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #3-4; Goal #3, Objectives #1 and 4; Goal #4, Objectives #1-3; and Goal #7, Objective #3.

- *Strategy*: Maintain, develop, and implement actions to prevent the spread of BTS via the transportation network
- *Action*: Annually review, update as needed, and develop BTS interdiction projects reflecting BMPs, adaptive management, and cost benefits.

- *Action*: Annually assess continuity and compliance of BTS interdiction activities across BOs, Department of Defense (DoD) BTS interdiction operating instructions, and consistency with, and, to the benefit of other relevant JRM conservation actions.
- *Action*: Annually assess ongoing development of new/emergent management strategies and methodologies that reduce or eliminate the risk of BTS.
- *Action*: Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant long-term projects to benefit interdiction management objectives.

TIS-2: BROWN TREESNAKE SUPPRESSION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-4 and 6; Goal #3, Objectives #1 and 4; Goal #4, Objectives #1-3; and Goal #7, Objective #3. Actions listed are in accordance with the 2011 BTS MOA.

- *Strategy*: Suppress and control BTS numbers to support conservation goals for species and ecosystem recovery.
- *Action*: Develop an operational suppression implementation plan. The plan will identify and prioritize potential quality habitat site(s) for suppression actions. Site(s) must consider size, habitat, location, connectivity, synergistic effects, listed species benefits, ecological viability, and support regulatory and mission requirements. Suppression goals and activities will support USFWS recovery plan delisting requirements for threatened and endangered species.
- *Action*: Implement BTS suppression management actions in identified site(s) based on mission support impact and cost effectiveness. Data will be used to determine the minimum thresholds of BTS suppression activities needed to support conditions conducive to species persistence and recovery.
- *Action*: Through annual funding and partnerships, support development of tools and methods that improves monitoring, detection, and suppression in targeted habitat sites.
- *Action:* Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant projects to benefit long-term BTS suppression management actions.

TIS-3: BROWN TREESNAKE MANAGEMENT FOR THE RECOVERY OF PROTECTED SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-4 and 6; Goal #3, Objectives #1 and 4; Goal #4, Objectives #1-3; and Goal #7, Objective #3. Actions listed are in accordance with the 2011 BTS MOA.

- *Strategy*: Suppress and control BTS numbers to support listed vertebrate species recovery.
- *Action*: Annually conduct BTS suppression management actions outside of Mariana swiftlet-occupied caves and conduct visual surveys and removal efforts inside Mariana swiftlet-occupied caves. Data collected from these efforts will be used as part of a larger research program aimed at understanding the swiftlet's response to BTS control, swiftlet population dynamics, and factors affecting swiftlet cave occupancy. In-cave BTS visual surveys and removal efforts will be implemented in compliance with the 2024 BO for BTS Control within Mariana Swiftlet Occupied Caves, Naval Base Guam (2023-0133592).
- *Action*: Develop and deploy camera systems in Mariana swiftlet-occupied caves to document spatial and temporal interactions of BTS and swiftlets to determine predation pressure, as well as to gain a practical understanding of how snakes access nests, setting the stage for better control

efforts targeted at BTS in and around swiftlet-occupied caves. Work will be implemented in compliance with Recovery permit #ES003483.

- *Action*: Create 3-dimensional digital morphologic maps of Mariana swiftlet-occupied and unoccupied caves to identify characteristics of Mariana swiftlet roosting and nesting areas. Digital maps will also be used to assess whether certain morphologic features (e.g., bumpy calcite crystal surfaces, smooth solution pockets, crevices, etc.) may allow for snakes to reach swiftlets. In addition, unoccupied Mariana swiftlet caves will be mapped. Morphologic maps from the unoccupied caves will be evaluated to look for features similar to areas occupied by swiftlets to identify caves that may be suitable for future occupancy by swiftlets. Work will be implemented in compliance with Recovery permit #ES003483.
- *Action*: Annually evaluate BTS suppression efforts in and around Mariana swiftlet caves assessing current methodologies and operational schedules. Maintaining annual funding and management practices for long-term recovery efforts.

TIS-4: CONTROL FERAL DOGS AND CATS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1 and 4; and Goal #4, Objective #2.

- *Strategy*: Reduce threats to native species by implementing a control program for feral dogs and cats on NBG Munitions Site.
- *Action*: Conduct population surveys of areas of highest conservation concern, and/or human safety to determine locations and estimate numbers of feral dogs and cats, review accepted control measures, and coordinate with U.S. Army veterinarian and installation pest control personnel to control by authorized means if impacts to ESA-listed species or other native wildlife are identified.
- *Action*: In accordance with the interagency agreement between the USDA, APHIS Wildlife Services, and NAVFAC, measures will be implemented to control dog and cat population on NMS. Trail cameras will be installed in areas identified as having feral dogs and cats. All animals will be trapped using live traps and transferred to a local pet shelter.
- *Action*: NAVFAC will provide population reports and data on population numbers, locations, and home ranges to APHIS Wildlife Services to ensure the most cost-effective wildlife management program is administered in NMS.
- *Action*: Include U.S. Navy installation feral dog and cat policy information in all installation outreach material presented to military and civilian personnel, housing residents, and contractors.

TIS-5: IMPLEMENTATION OF REGIONAL BIOSECURITY PLAN FOR MICRONESIA AND HAWAI‘I

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #3; Goal #3, Objectives #1-2 and 4; Goal #4, Objectives #1-4; and Goal #7, Objective #1.

- *Strategy*: Implement appropriate recommendations within the Regional Biosecurity Plan (RBP) (DON 2015b) that will reduce the risk of introduction and spread of invasive species on NMS.
- *Action*: Develop standard language for biosecurity BMPs, update as necessary, to be included in project specifications that support prevention, such as vegetation management, and cleanliness standards for materials and equipment operating on the installation.
- *Action*: Conduct early detection surveys (EDS) for high-risk invasive species in training areas; at facilities for staging, storage, and movement of cargo/equipment and vehicles, and at other locations as deemed necessary.

- *Action*: Review and update, as appropriate, DoD Attachment M of the RBP every 3 years.
- *Action*: Develop, implement, and update (as necessary) a JRM biosanitation instruction to ensure cleanliness standards are adhered for the movement of cargo and equipment.
- *Action:* Continue to develop high-risk invasive species protocols and implement control and/or eradication measurement when necessary.

TIS-6: INVASIVE SPECIES MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #3 and 6; Goal #3, Objectives #1 and 4; and Goal #4, Objectives #1-3.

- *Strategy*: Implement appropriate surveys, management, and control measures for invasive plant and invertebrate species that will reduce the risk of introduction and spread of invasive species on NMS.
- *Action*: Annually survey high-risk areas for LFA using established protocols. If LFA is detected on NMS, implement proven control and eradication actions, followed by post-eradication monitoring.
- *Action*: Implement BMPs for CRB: (1) annually evaluate the need for comprehensive bio-sanitation of dead coconut trees and implement as necessary, (2) implement proper green waste management, (3) assist in release of landscape-level biocontrol agents for CRB, (4) implement awareness and reporting program in high-risk areas, and (5) implement long-term monitoring program and monitoring coconut trees.
- *Action*: Control the spread of established invasive plants (i.e., *Cestrum diurnum,* bay rum tree*, V. parviflora*) by removing young plants in new locations and removing dense stands of mature plants that dominate areas of NMS.
- *Action*: Using available management tools (i.e., as informed by management at Andersen AFB), implement adaptive management actions to remove or control invasive insects, including, but not limited to, feasible local controls of cycad scale (e.g., hand applications to individual trees).

TIS-7: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #2-4; Goal #3, Objectives #1 and 4; and Goal #4, Objectives 1-4. This project supports conservation measures from the 2015 MITT BO (USFWS 2015b).

- *Strategy*: Implement biosecurity conservation measures listed in the 2015 MITT BO from USFWS.
- *Action*: During training events, ensure 100% BTS canine inspection of aircraft and cargo/equipment departing for an off-island destination.
- *Action*: Ensure BTS awareness briefings for all military and contractor personnel prior to all MITT training activities.
- *Action*: Maintain invasive species rapid response capabilities to control and/or eradicate introduced non-established, non-native invasive species sighted in vicinity of DoD training areas and facilities used for staging, storage, and movement of military personnel, cargo, and vehicles associated with training activities.
- *Action*: Ensure training event personnel conduct biosecurity self-inspections of all personal gear and hand carried items to avoid potential introduction of invasive species to and from Guam. Self-inspection will ensure the removal of soil accumulations, seeds, invertebrates, and vertebrates
- *Action*: Ensure all training events adhere to the Armed Forces Pest Management Board Technical Guide No. 31 (AFPMB TG-31) cleanliness standards for all cargo/equipment, containers, and rolling stock arriving from off-island destinations via inspections as deemed necessary.

- *Action*: Implement high-risk invasive species protocols for the control and/or eradication for high-risk species, as species are identified.

6.3.1.3 Terrestrial Protected Species Management

Management of terrestrial threatened and endangered species on JRM-administered lands includes implementing programs to protect species, and coordinating efforts with the appropriate agencies. Key threats to threatened and endangered species that can lead to extirpation include:

- predation by BTS of native forest birds, lizards, and bats
- overgrazing, rooting, and trampling of plants and wildlife habitat by feral ungulates
- predation by feral cats, dogs, and pigs, as well as predation by monitor lizards on birds, and bats
- human disturbance and poaching of Mariana fruit bats
- mortality or injury to native plants and wildlife due to natural events (e.g., typhoons)
- low reproductive success due to small population numbers
- habitat loss and fragmentation due to development

To address these key threats to listed species, JRM has conducted and continues to conduct numerous management and research projects to reduce BTS numbers at the local and landscape scale, control BTS at swiftlet caves on NMS, and to prevent their spread to other Pacific Islands through rigorous inspections and interdiction of outgoing cargo at DoD ports (e.g., Apra Harbor, Andersen AFB). Captive breeding programs conducted by Guam DAWR and mainland zoological institutions are maintaining populations of Guam rail (*Gallirallus owstoni*) and Guam kingfisher (*Todiramphus cinnamominus*) and are adding to the information needed for successful recovery of these species. Additional ecological research and monitoring is also being conducted by various agencies in Guam, including DoD, USDA, and USGS.

In accordance with section 7 of the ESA, a federal agency shall consult with the USFWS to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species. The DON shall coordinate with the USFWS/Guam NWR for any federal action that is within Overlay Refuge lands and is identified as providing habitat for threatened or endangered species. In addition, the DON will avoid, as the mission allows, impacts on habitat suitable for threatened and endangered species, and locally rare, and Guam-listed species.

Sensitive species at JRM are being managed by implementing specific management projects that enhance habitat for these species and by initiating specific strategies that address immediate needs of listed species on the installation. In addition, adherence to the goals set for threatened and endangered species management ensure that the installation remains in compliance with ESA and associated consultation requirements.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Protected Species Management (TPS) on NMS. Additional protection measures for terrestrial protected species are presented in Section 6.3.1.6, *Terrestrial Natural Resources Law Enforcement*.

TPS-1: ESA-LISTED SPECIES MONITORING

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; and Goal #3, Objectives #1-4.

- *Strategy*: Implement an ESA-listed species monitoring program to inform adaptive management actions and avoid sensitive areas during operations and training.

- *Action*: Conduct surveys to document distribution and abundance of ESA-listed terrestrial vertebrates, invertebrates, and plants, focusing on newly listed species. NMS will prioritize areas that have not been recently surveyed for ESA-listed species. The monitoring program will update endangered species population distribution maps and Geographic Information System (GIS) databases with data used to inform adaptive management of listed species.
- *Action*: Management actions described under THM-2 will benefit ESA-listed species. Additional actions may be identified following baseline surveys for species.

TPS-2: PROTECTION OF LISTED INVERTEBRATES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1-2 and 4; and Goal #4, Objective #2. This project supports conservation measures from the 2015 MITT BO (USFWS 2015b).

- *Strategy*: Protect and enhance populations of ESA-listed tree snails and butterflies at NMS.
- *Action*: Identify, monitor, and protect (e.g., avoidance, fencing) known locations of ESA-listed tree snails and butterflies and habitat to detect changes in population size over time within areas of targeted ungulate management.
- *Action*: Conduct predator monitoring (e.g., platydemus, rat-chewed shells) and control along with standardized snail counts.
- *Action*: Propagate and outplant ESA-listed species known to occur on JRM lands inside ungulate fenced areas.

TPS-3: PERFORM MOTH SKINK AND PACIFIC SLENDER-TOED GECKO SURVEYS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2 and Goal #3, Objectives #1-2 and 4.

- *Strategy*: Improve understanding of distribution of Guam ESA-listed moth skink and Pacific slender-toed gecko on NMS.
- *Action*: Identify focus areas and conduct a baseline survey to determine locations of Guam ESA-listed moth skink and Pacific slender-toed gecko on NMS. These surveys should be conducted prior to and following ungulate eradication in ungulate management areas.

TPS-4: MONITOR AND MAINTAIN MARIANA SWIFTLET POPULATION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1-2 and 4; and Goal #4, Objectives #1-2.

- *Strategy*: Protect and maintain Mariana swiftlet population on NMS.
- *Action*: Conduct simultaneous visual and videographic quarterly surveys (four surveys per cave per year) at Maemong, Mahlac, and Fachi Caves to monitor the swiftlet population size at each cave as well as assess accuracy of survey methods.
- *Action*: Improve current videography and algorithm-based technologies to monitor the swiftlet population size, trends, and nest/chick survival rates.
- *Action*: Within 5 years, consider and assess the replacement of visual surveys with videography and algorithm bases surveys.
- *Action*: Within 10 years, evaluate reproductive success, foraging habitat use, and nesting habitat selection aligned with the priority actions identified in the USFWS Recovery Plan (USFWS 2019).
- *Action*: Perform in-cave monitoring of BTS activities and their removal on a quarterly basis.

- *Action*: Control BTS in and around Mariana swiftlet caves (via trapping, bait stations, and hand capture) to facilitate population growth and maintain a viable swiftlet population. BTS traps are to be placed in the forest at Mahlac, Fachi, and Maemong Caves. Monitor traps and ensure they are resupplied weekly.

TPS-5:MARIANA MOORHEN MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-6; Goal #3, Objectives #1-2 and 4; and Goal #4, Objective #2.

- *Strategy*: Protect and enhance Mariana common moorhen population on NMS.
- *Action*: Conduct quarterly surveys for moorhen at known use wetlands and ponds at NMS.
- *Action*: Maintain and monitor nesting platforms in accessible NMS wetlands and ponds.
- *Action*: Assess wetland vegetation at locations known to support moorhens, including the use of nesting platforms. Implement vegetation enhancement strategies, if feasible, and coordinate with partners.
- *Action*: Monitor active moorhen nesting platforms to determine if predation is occurring using trail cameras. If nest predation is observed, conduct predator control to reduce predation in the vicinity of wetlands/ponds.
- *Action*: Coordinate survey efforts with partner agencies to conduct island-wide annual/bi-annual surveys.
- *Action*: Conduct annual assessment of surveys and nesting platform usage and provide annual report.

TPS-6: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal # 2, Objective #4; and Goal #3, Objectives #1-2 and 4. This project supports conservation measures from the 2015 MITT BO (USFWS 2015b).

- *Strategy*: Implement conservation measures listed in the 2015 MITT BO from USFWS.
- *Action*: Ensure no maneuver and navigation training occurs in riparian habitat to minimize disturbance to Mariana moorhen.
- *Action*: Ensure "No Wildlife Disturbance" and "No Training" on designated areas in the NMS, i.e. Mariana swiftlet caves and other locations where listed species are known to occur.
- *Action*: Ensure all vehicular activities during training are restricted to designated and previously identified areas that do not contain listed species.
- *Action*: Ensure helicopter overflights as part of training activities are restricted throughout the NMS below 500 feet AGL and fixed-wing aircraft are restricted below 1,000 feet AGL to minimize visual and noise disturbance for Mariana moorhen, Mariana swiftlets, and Mariana fruit bats and to reduce the potential for aircraft strike.
- *Action*: Ensure all training activities are consistent with the fire management plan in COMNAVMAR Instruction 3500.4A (Marianas Training Manual) (COMNAVMAR 2013).
- *Action*: Vegetation removal shall be limited to the maintenance of existing bivouac areas that do not contain listed species or habitat. No new bivouac areas are proposed under MITT. Maneuver units will remain tactical and not establish support camps.

TPS-7: MARIANA FRUIT BAT POPULATION MONITORING

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-4; Goal #3, Objectives #1 and 4.

- *Strategy*: Identify and monitor Mariana fruit bat populations on NMS to maintain and identify habitat relationships.
- *Action*: Conduct annual surveys for fruit bats on NMS.
- *Action*: Search for fruit bat aggregating locations. If aggregations or new colony locations are detected, roost counts will commence in accordance with established survey protocols. If changes in roost locations, colony size, or movement are detected, investigate potential threats or stressors that may be causing disturbance.

6.3.1.4 Migratory Bird Management

JRM installations manage and monitor the effects that both military readiness and non-readiness activities have on migratory bird species and populations. Relevant regulations and policies include the Military Readiness Rule (50 Code of Federal Regulations [CFR] 21.15); the 2014 Memorandum of Understanding (MOU) between the DoD and USFWS to Promote the Conservation of Migratory Birds; and EO 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*. Through the implementation of the INRMP, proper management of migratory bird species and habitats, including the timely implementation of appropriate conservation practices, will help installations avoid or minimize impacts to migratory birds.

To meet the goals and objectives of the INRMP, the following management project has been identified for Migratory Bird Management (MIG) on NMS.

MIG-1: MONITORING OF MBTA-LISTED BIRD SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1-2 and 4; and Goal #6, Objective #1.

- *Strategy*: Improve understanding of MBTA-listed bird habitat use on NMS and bird/mission interactions to avoid and/or minimize effects of takes on MBTA-listed birds.
- *Action*: Evaluate long-term data sets to identify migratory bird species of concern (referred to as "Mission Sensitive Species" in the DoD 2017 Guidance for Migratory Bird Management in Integrated Natural Resource Management Plans) for NMS and determine interrelatedness between these species and mission activities. These data will inform refinements to monitoring protocols and identify whether additional management actions for migratory birds are necessary for NMS.
- *Action*: Implement bird-safe building designs for new construction (e.g., facilities, utilities, alternative energy projects). For example, install bird-safe building glass to prevent collisions and ensure proper siting for wind energy. Review and update, if necessary, template design and construction specifications to include bird-safe building design guidelines (e.g., see Reducing Bird Collisions with Buildings and Building Glass Best Practices (USFWS 2016).
- *Action*: Continue annual monitoring of MBTA-listed birds on NMS to improve understanding of MBTA-listed bird habitat use and bird/mission interactions.

6.3.1.5 Terrestrial Natural Resources Educational Outreach

Conservation awareness is instrumental in creating conditions needed to manage natural resources. The JRM approach to awareness stresses education. It provides military personnel and the public with insights into installation natural environments and conservation challenges. The more educated people are about the

unique and valuable natural resources on JRM-administered lands, the more responsibly they will act toward using them. Education also promotes awareness of critical environmental projects and the rationale behind them. As activities such as habitat management, wildlife management, and land rehabilitation are generally accepted and understood, minimal effort is required to communicate conservation priorities to installation personnel, recreationists, and the general public. However, issues such as protection of sensitive areas for plant and wildlife species, invasive species management (ungulate management), wildfire suppression, and restrictions on some recreational activities in JRM-administered lands require effective conservation communication to get positive support and, perhaps more importantly, to avoid adverse reactions from various users. A conservation awareness program must be directed to both installation and external interests if it is to be effective.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Natural Resources Educational Outreach (TEDU) on NMS.

TEDU-1: ESA-LISTED SPECIES AND TERRESTRIAL RESOURCES OUTREACH

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #4; Goal #3, Objectives #4; Goal #4, Objectives #1 and 4; Goal #6, Objective #1; and Goal #7, Objectives #1-2. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Improve awareness among DoD personnel and the public of threats and stressors to terrestrial resources, including protected species, and the importance of conserving natural resources on NMS in cooperative efforts with partners, such as GovGuam and USFWS.
- *Action*: Develop, update, and distribute multimedia for public education to incoming military personnel, contractors, schools and at other outreach opportunities that address appropriate behavior around threatened and endangered species and the consequence of introduced non-native plant and animal species. Outreach materials will be reviewed every 2 to 5 years.
- *Action*: Review and update, as needed, current outreach videos/media used during the orientation briefs viewed by 100% of new personnel upon arrival to Guam.
- *Action*: Continue to coordinate the dissemination of information on environmentally sensitive resources in no training areas with range scheduling personnel on NMS.

TEDU-2: JRM NATURAL RESOURCES STEWARDSHIP OUTREACH AND PUBLIC ENGAGEMENT PROGRAM

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1; and Goal #7, Objectives #1-3.

- *Strategy*: Implement a comprehensive natural resources outreach regarding the federal, territorial, and base environmental regulations and policies, as well as information about the importance of protecting and conserving JRM's natural resources.
- *Action*: Update a comprehensive Natural Resources Stewardship Outreach online training system for military and civilian personnel.
- *Action*: Create a JRM Environmental Public Engagement Plan to outline the areas where JRM can significantly increase their outreach with military personnel and the public about appropriate behavior toward threatened and endangered species and the importance of conserving natural resources within JRM-administered terrestrial and submerged lands.
- *Action*: Develop, update, and implement a biosecurity education and outreach program for contractor personnel, military personnel, and dependents.

6.3.1.6 Terrestrial Natural Resources Law Enforcement

JRM has established the following objectives for enforcement: (1) enforce laws and regulations pertaining to the implementation of the natural resources program; (2) integrate natural resources enforcement into the overall natural resources program; and (3) use enforcement personnel to enhance the natural resources program at JRM.

To meet the goals and objectives of the INRMP, the following management project has been identified for Terrestrial Natural Resources Law Enforcement (TLAW) on NMS.

TLAW-1: CONSERVATION LAW ENFORCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-3; Goal #2, Objectives #4; Goal #3, Objectives #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1; and Goal #7; Objectives #1-3.

- *Strategy*: Detect and deter unauthorized activity that negatively affects natural resources on NMS (e.g., poaching, off-roading) through conservation law enforcement.
- *Action*: Establish a Conservation Law Enforcement Program by hiring a Conservation Law Enforcement Officer and by partnering with other agencies as applicable, to enforce natural resource laws, policies, and regulations on NMS. The Conservation Law Enforcement Officer will conduct outreach and enforce natural resource regulations.

6.3.1.7 Terrestrial Geographic Information System and Data Management

Natural resources data are stored and maintained within a centralized JRM GIS database. The GIS database provides support for the entire environmental program and the training community. JRM uses the GIS for complex analyses such as project siting, data interpolations, and risk assessments.

GIS software enables installation staff to capture, store, update, manipulate, analyze, and display all forms of geographically referenced data and tabular information about natural and physical resources found on JRM-administered lands. The training of JRM staff and the allocation of their time to data entry, mapmaking, analysis of data, and interpretation of the results determine the success of the installation GIS. Once fully developed, the installation GIS databases can be used for projects such as the following:

- providing maps with locations of species, vegetation communities, surface waters, and other areas of potential concern
- selecting suitable areas for construction activities
- planning land rehabilitation projects
- providing special maps for Environmental Awareness materials
- ensuring avoidance of threatened and endangered species habitats and other areas of special concern during construction projects
- identifying site options for use during National Environmental Policy Act (NEPA) evaluation of alternative sites
- calculating drainages and water flows
- determining wildlife habitat preferences

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial GIS and Data Management (TGIS) on NMS.

TGIS-1: TERRESTRIAL NATURAL RESOURCES GIS AND DATA MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-3; Goal #2, Objectives #1-2 and 4; Goal #3, Objectives #4; Goal #6, Objective #1; and Goal #7, Objectives #1-3.

- *Strategies*:
  - Identify data gaps in terrestrial natural resources GIS to assist in the development of future data collection efforts, surveys, and management actions.
  - Ensure that GIS information is available to installation subject matter experts and military personnel, biologists, planners, contractors, and others in a timely manner to assist with planning and decision-making.
- *Action*: Update and continuously maintain existing centralized GIS database to effectively inform and guide future management of terrestrial natural resources on NMS and meet natural resources goals and objectives. Readily available GIS data can be used to develop natural resources constraints maps for use in current and future JRM management and planning decisions for NMS.

6.3.1.8 Summary – Terrestrial Ecosystem Management

Implementation of the JRM INRMP program and the focused strategies and actions of the management projects for terrestrial resources provides a conservation benefit to the natural ecosystems within NMS by maintaining and enhancing the natural community structure, function, species diversity, and resiliency. Enhancing and restoring native habitats supports viable populations of native species and increases biodiversity. Furthermore, proactive invasive species prevention, early detection, and control reduces the risk of intra- and inter-island species introductions. Data from regular monitoring of protected species is used to implement better management projects to enhance and restore habitat, reduce habitat fragmentation, buffer protected areas, implement new conservation strategies, and avoid and minimize impacts. Using this regional ecosystem-based approach for managing protected species and their associated ecosystems ensures that JRM remains in compliance with federal and territorial laws while supporting the operational functionality of the NMS mission.

Twenty-two management projects addressing terrestrial natural resources management are proposed for implementation on NMS:

- Terrestrial Habitat Management – 3
  - THM-1: Watershed Management
  - THM-2: Forest Enhancement
  - THM-3: Managing Wildland Fires
- Terrestrial Exotic and Invasive Species Management – 7
  - TIS-1: Brown Treesnake Interdiction
  - TIS-2: Brown Treesnake Suppression
  - TIS-3: Brown Treesnake Management for the Recovery of Protected Species
  - TIS-4: Control Feral Dogs and Cats
  - TIS-5: Implementation of Regional Biosecurity Plan for Micronesia and Hawai‘i
  - TIS-6: Invasive Species Management
  - TIS-7: Mariana Islands Training and Testing Implementation of the Biological Opinion
- Terrestrial Protected Species Management – 7
  - TPS-1: ESA-listed Species Monitoring
  - TPS-2: Protection of Listed Invertebrates

  - TPS-3: Perform Moth Skink and Pacific Slender-toed Gecko Surveys
  - TPS-4: Monitor and Maintain Mariana Swiftlet Population
  - TPS-5: Restoration of Mariana Common Moorhen Population
  - TPS-6: Mariana Islands Training and Testing Implementation of the Biological Opinion
  - TPS-7: Mariana Fruit Bat Population Monitoring
- Migratory Bird Management – 1
  - MIG-1: Monitoring of MBTA-listed Bird Species
- Terrestrial Natural Resources Educational Outreach – 2
  - TEDU-1: ESA-listed Species and Terrestrial Resources Outreach
  - TEDU-2: JRM Natural Resources Stewardship Outreach and Public Engagement Program
- Terrestrial Natural Resources Law Enforcement – 1
  - TLAW-1: Conservation Law Enforcement
- Terrestrial Geographic Information System and Data Management – 1
  - TGIS-1: Terrestrial Natural Resources GIS and Data Management

7 APRA HEIGHTS, SASA VALLEY AND TENJO VISTA TANK FARMS, NAVAL COMPUTER AND TELECOMMUNICATIONS STATION BARRIGADA, AND BARRIGADA TRANSMITTER SITE

7.1 APRA HEIGHTS

7.1.1 Current Operations and Land Use

Located southeast of Naval Base Guam (NBG) Main Base and northwest of NBG Naval Munitions Site (NMS) on Route 5, Apra Heights (243 acres [98 hectares]) comprises two family housing neighborhoods (Apra View and Apra Palms), community support facilities, and the Santa Rita Naval Administrative/Office Complex (Figure 7-1). Community support facilities include the McCool Elementary/Middle School (K-8) and shops. Southern High School is located just outside the southern boundary of the installation.

7.1.2 Geology, Topography, and Soils

7.1.2.1 Geology

Apra Heights is located on volcanic rock units. One fault runs through the southeastern corner of Apra View Family Housing (refer to Figure 4-4). Apra Heights is not in an area vulnerable to liquefaction, nor is it in danger of tsunami inundation (Water and Environmental Research Institute of the Western Pacific [WERI] 2008). Apra Heights is susceptible to the seismic activity described in Section 4.2.1.3, *Seismology*.

7.1.2.2 Topography

Apra Heights is located just south of NMS in hilly terrain.

7.1.2.3 Soils

The site is underlain by volcanic upland soils, primarily Akina-Agfayan soils, with some areas of Akina-Atate soils along the northern, eastern, and southeastern portions of the property (Figure 7-2); the descriptions of each soil type are summarized in Table 4-1. The Akina series consists of well drained, moderately slowly permeable soils (United States [U.S.] Department of Agriculture [USDA] 1988).

7.1.3 Hydrology

7.1.3.1 Surface Water

Apra Heights is located in the Apra and Agat drainage basins (Figure 7-3). The Aplacho River runs through the northern portion of Apra View Family Housing (Figure 7-3). Based on previous vegetation mapping and surveys of the southern and western portions of Apra View Family Housing, areas of herbaceous wetlands, dominated by the native, tall reed (*Phragmites karka*), occur within the central portion of the undeveloped western area (Naval Facilities Engineering Systems Command [NAVFAC] Pacific 2013). Refer to Section 7.1.4, *Vegetation Communities*, for further discussion.

7.1.3.2 Groundwater

Due to the underlying volcanic rock units with their low porosity and permeability, groundwater is not retained within the Apra Heights area.

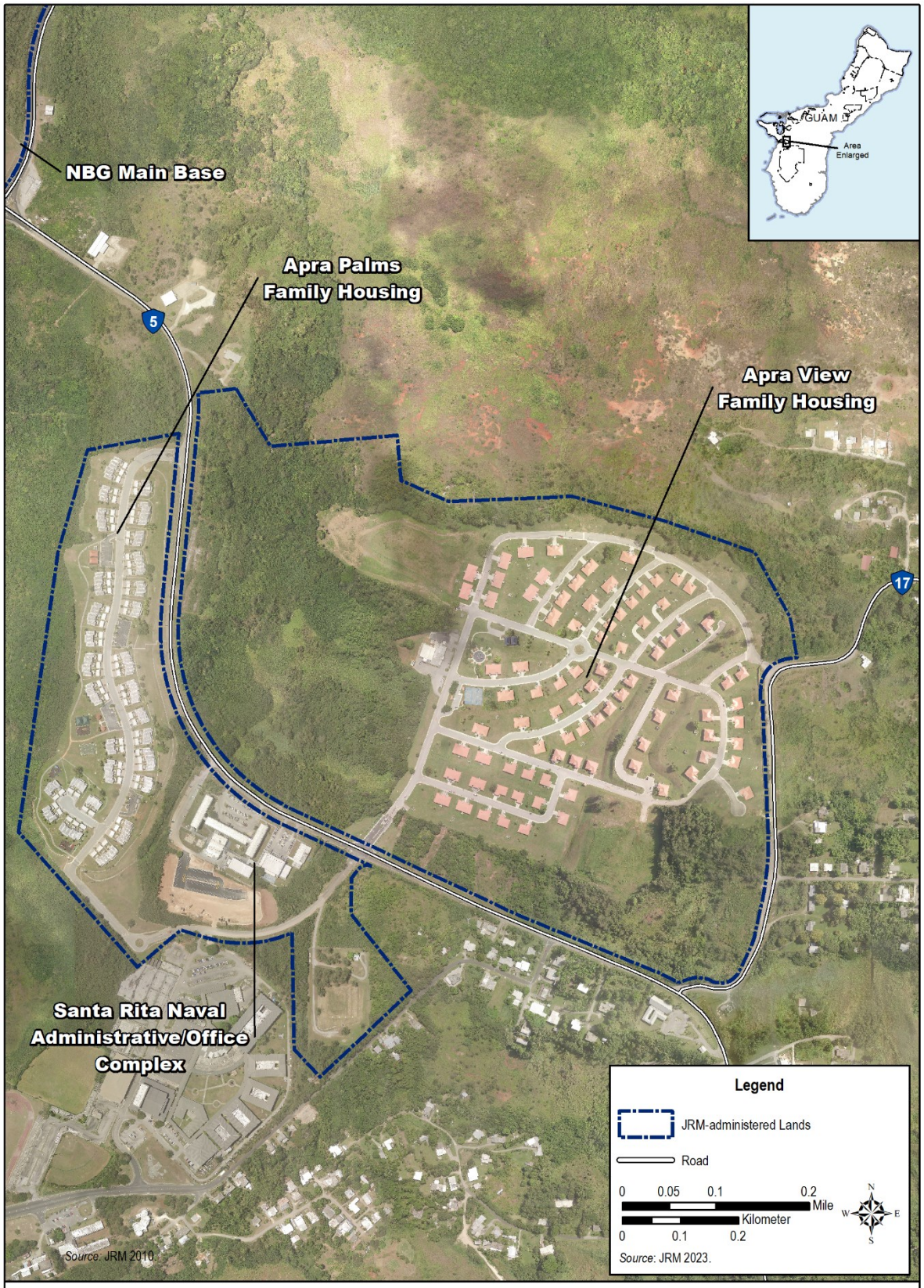


Figure 7-1
Overview of Apra Heights

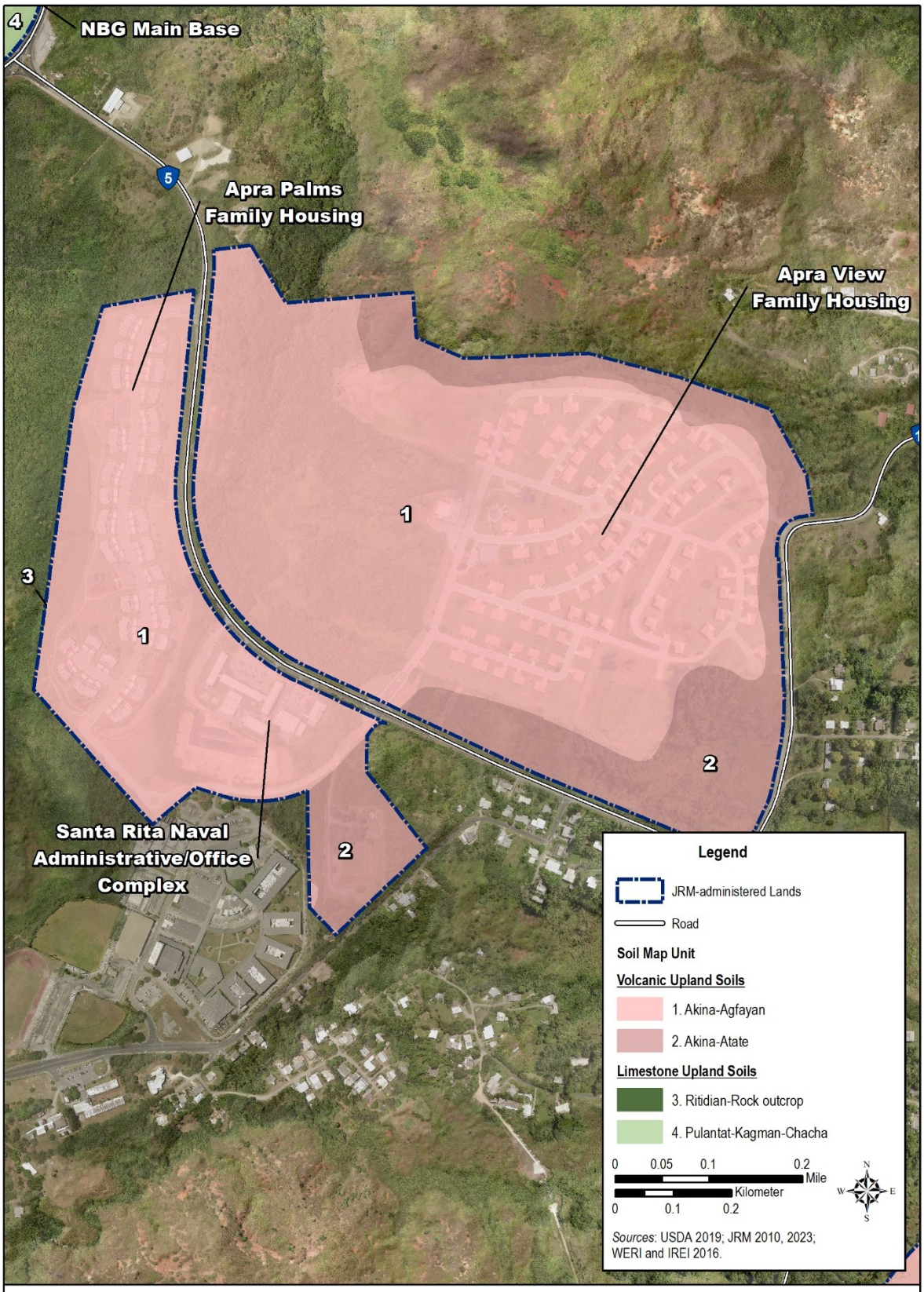


Figure 7-2
Soils - Apra Heights

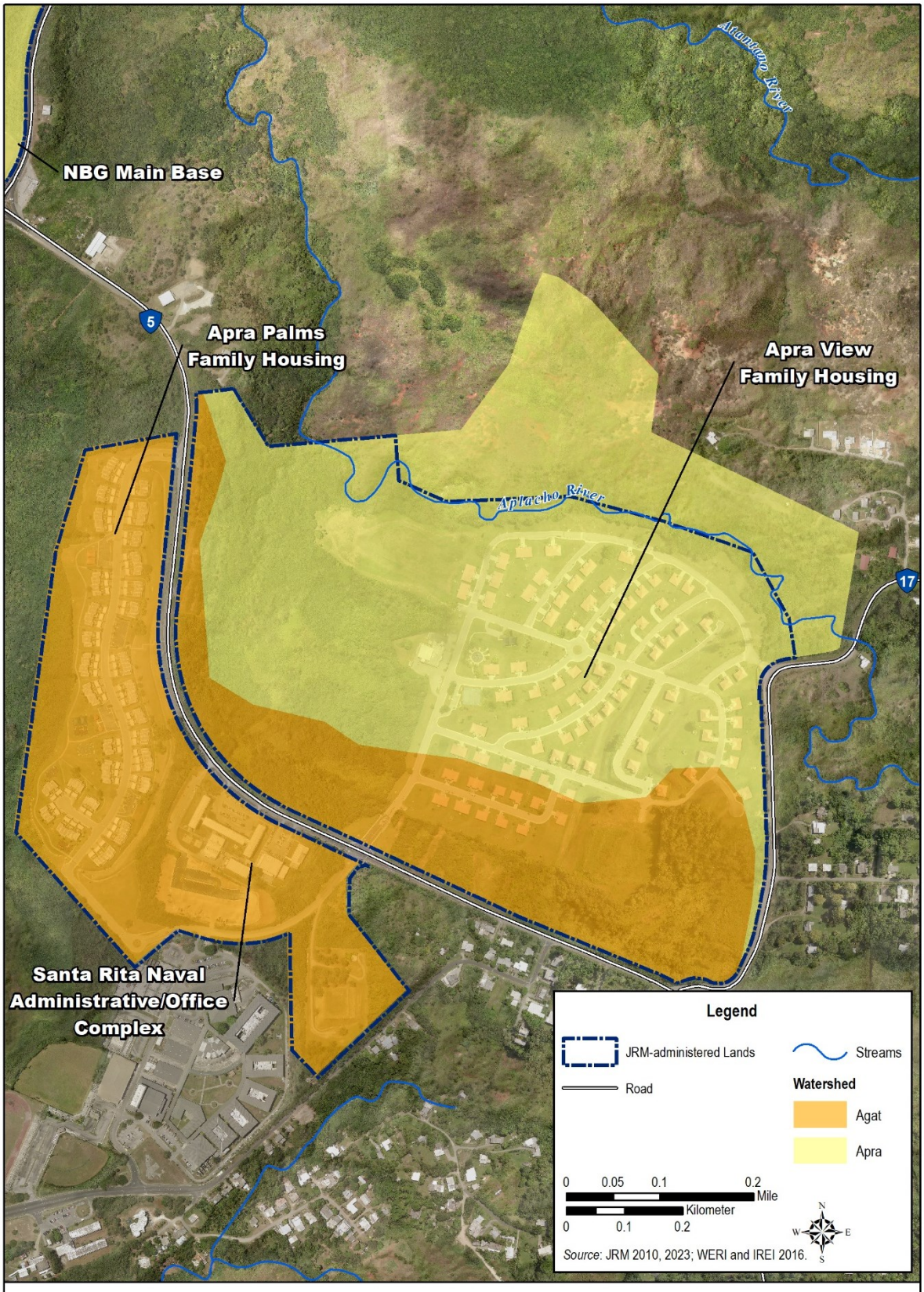


Figure 7-3
Surface Waters and Watersheds - Apra Heights

7.1.4 Vegetation Communities

The 2015 U.S. Department of the Navy (DON)-funded study to update the vegetation classifications for Joint Region Marianas (JRM)-administered lands (NAVFAC Marianas 2016) described in Section 4.4.1, *Vegetation Communities*, did not re-map the small parcels of JRM-administered lands discussed in this chapter. The most recent vegetation mapping developed for Apra Heights is from an assessment of forest conditions by the U.S. Forest Service (USFS) (2014) and uses classifications from a USFS mapping effort performed in 2006 (USFS 2006). For purposes of this Integrated Natural Resources Management Plan (INRMP), the classification system used in the DON 2015 report was applied, where applicable, to the 2014 USFS vegetation mapping available for Apra Heights.

Almost half (47 percent [%]) of the Apra Heights property is developed (i.e., buildings, roads, and landscaped areas) or barren (Table 7-1 and Figure 7-4). Vegetation within the remaining undeveloped areas is primarily scrub forest dominated by non-native woody species interspersed with areas of scrub/shrub. Biological surveys conducted in support of the Guam and Commonwealth of the Northern Mariana Islands (CNMI) Military Relocation identified herbaceous wetlands dominated by tall reed in the areas mapped as scrub/shrub (NAVFAC Pacific 2013). North of the Aplacho River is an area of shrub/grassland. Other areas in the Apra Heights housing area have secondary growth and consist primarily of non-native species (NAVFAC Pacific 2013).

Table 7-1. Vegetation Communities on Apra Heights

Vegetation Community	*Area (acres)*	*% of Total Area*	*% of Vegetated, Undeveloped Area*
Other Shrub/Grassland	19.4	6.8	12.9
Scrub/Shrub	36.8	13.0	24.4
Scrub Forest	94.4	33.3	62.7
Non-vegetated Categories			
Barren	5.0	1.7	NA
Developed	128.2	45.2	NA
Total	**283.8**		

Key: % = percent; NA = not applicable.
Source: USFS 2014.

7.1.5 Terrestrial Wildlife

7.1.5.1 Mammals

In 2015, a single Mariana fruit bat (*Pteropus mariannus mariannus*) was observed in the Aplacho River ravine flying in an east-northeast direction behind the housing area (Guam Division of Aquatics and Wildlife Resources [Guam DAWR] 2017a). The Mariana fruit bat is federal Endangered Species Act (ESA)-listed as threatened, Guam-listed as endangered, and Guam-designated as Species of Greatest Conservation Need (SOGCN).

Although no mammal surveys have been conducted within Apra Heights, it is expected that the common, non-native small mammals found throughout Guam would occur, including Norway rat (*Rattus norvegicus*), black rat (*Rattus rattus*), Polynesian rat (*Rattus exulans*), house mouse (*Mus musculus*), and musk shrew (*Suncus murinus*) (Wiles 2005; Wiewel et al. 2009). In addition, feral pigs (*Sus scrofa*), feral dogs (*Canis lupus familiaris*), and cats (*Felis catus*) are also expected to occur. Philippine deer (*Rusa marianna*) may occasionally wander into the area from neighboring forested lands.

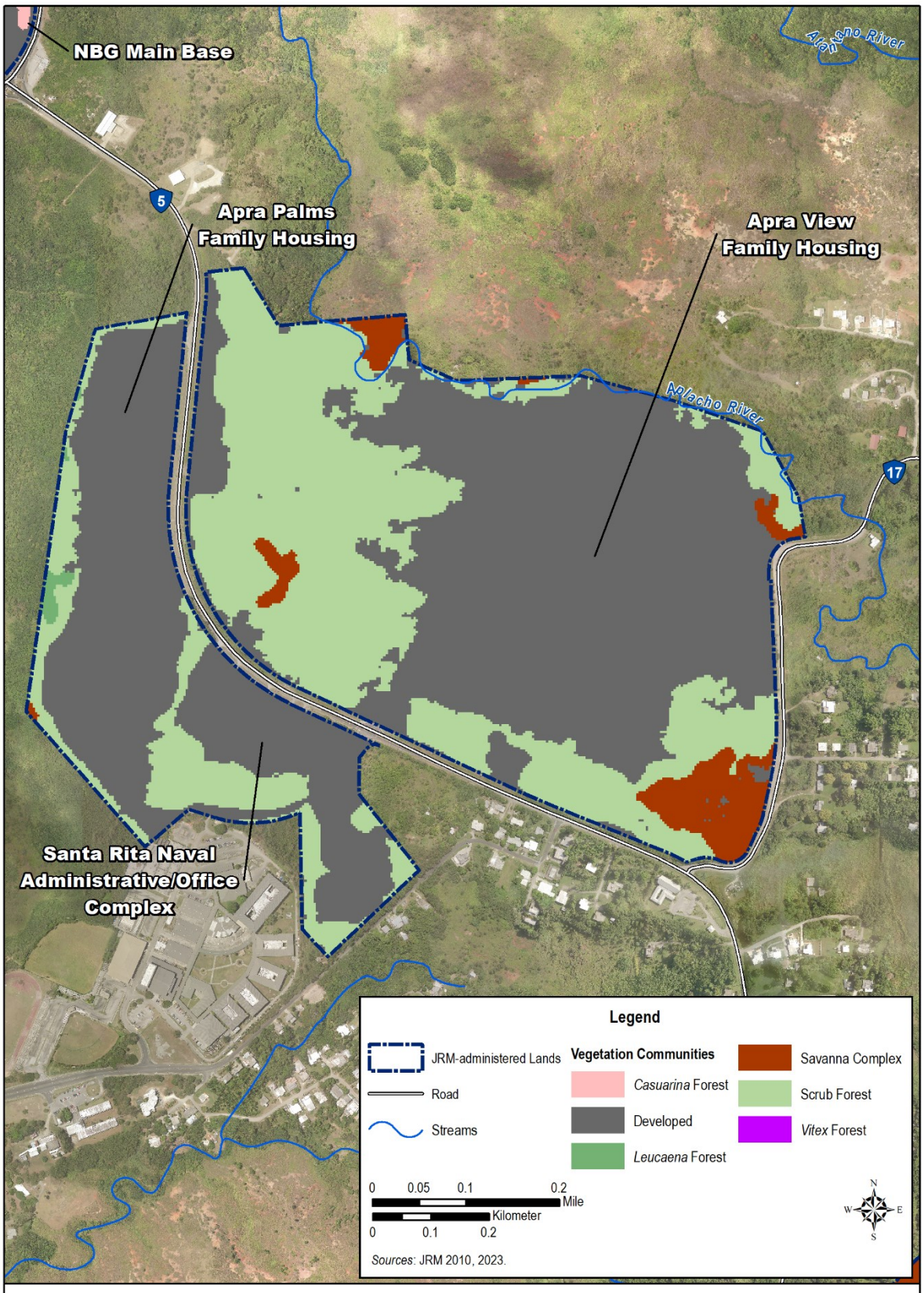


Figure 7-4
Vegetation Communities - Apra Heights

7.1.5.2 Birds

Although no bird surveys have been conducted within Apra Heights, it is expected that the common bird species found throughout Guam would occur, including non-native Eurasian tree sparrow (*Passer montanus*), black drongo (*Dicrurus macrocercus*), and island collared dove (*Streptopelia bitorquata*). Migratory Bird Treaty Act [MBTA]-listed species, including Eastern cattle egret (*Bubulcus coromandus*), Pacific golden plover (*Pluvialis fulva*), bristle-thighed curlew (*Numenius tahitiensis*), whimbrel (*Numenius phaeopus*), and the native yellow bittern (*Ixobrychus sinensis*) have been observed on mowed, open fields in these areas from 2010-2015 (Guam DAWR 2017b). The Pacific golden plover is Guam-designated as SOGCN.

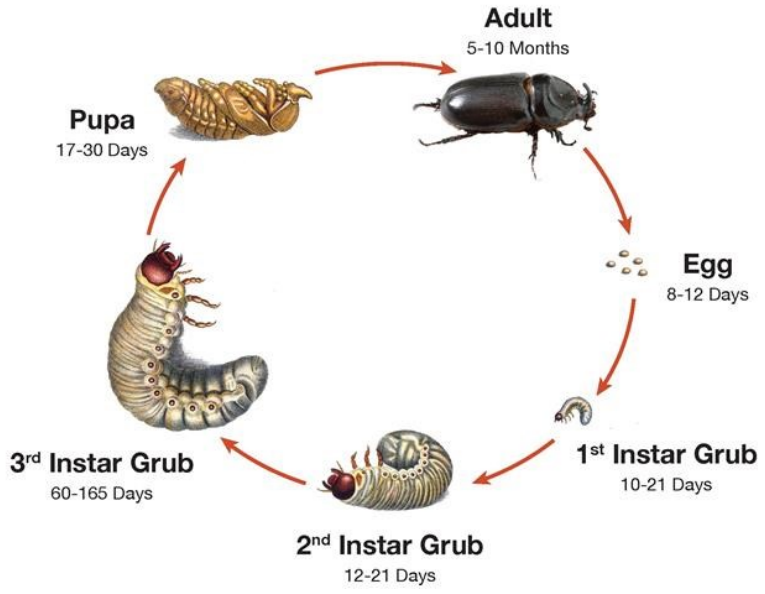
7.1.5.3 Reptiles and Amphibians

Based on a January 2013 survey along one transect within the western undeveloped portion of Apra View Family Housing, two species of reptiles and two species of amphibians are known to occur: native Pacific blue-tailed skink (*Emoia caeruleocauda*), non-native curious skink (*Carlia ailanpalai*), marine toad (*Rhinella* [=*Bufo*] *marina*), and greenhouse frog (*Eleutherodactylus planirostris*). Although the brown treesnake (BTS) (*Boiga irregularis*) was not recorded, it was assumed present since it has been so ubiquitous in the past and this species can be very cryptic (NAVFAC Pacific 2013). In addition, the native monitor lizard (*Varanus tsukamotoi*) occurs in Apra Heights.

7.1.5.4 Invertebrates

There have been no systematic surveys for invertebrates within Apra Heights other than a survey conducted during a 2013 study of tree snails (NAVFAC Marianas 2014a). Guam tree snails (*Partula radiolata*) are known to occur in Apra Heights, and are discussed further in Section 7.1.6, *Terrestrial Protected Species*.

The coconut rhinoceros beetle (CRB) (*Oryctes rhinoceros*) was first detected in Guam in the Tumon Bay area on September 12, 2007 and was considered to have spread island-wide by 2010 (Smith and Moore 2008). Best management practices (BMPs) are implemented to help curb the spread of and damage from CRB.



Life cycle of the coconut rhinoceros beetle (*Oryctes rhinoceros*)
(*Source:* Bedford 1980).

7.1.6 Terrestrial Protected Species

7.1.6.1 Invertebrates

Guam Tree Snail

The only listed species known to occur within the Apra Heights property is the federal ESA-listed endangered Guam tree snail. The Guam tree snail was listed under the ESA by the U.S. Fish and Wildlife Service (USFWS) in October 2015 (USFWS 2015a). Surveys conducted in March 2013, within the undeveloped portion of Apra View Family Housing, recorded 88 Guam tree snails in two areas (Figure 7-5). The eastern location consisted of a population of 10 individuals (host plant not identified in the report). The western location consisted of two populations approximately 100 feet (30 meters) apart: 5 individuals on the non-native host plant custard apple (*Annona reticulata*) and 73 individuals on the native host plant noni (*Morinda citrifolia*) (NAVFAC Marianas 2014a).



Guam tree snail (*Partula radiolata*) on noni (*Morinda citrifolia*).
(*Photo*: NAVFAC Marianas 2014a)



The noni (*Morinda citrifolia*) tree is a host plant for the endangered Guam tree snail (*Partula radiolata*).
(*Photo:* L. Gutierrez)

7.2 SASA VALLEY AND TENJO VISTA TANK FARMS

7.2.1 Current Operations and Land Use

Sasa Valley and Tenjo Vista Tank Farms are located east of Marine Corps Drive (Route 1) and south of the village of Piti. Defense Fuel Support Point Guam, under NBG, operates the Sasa Valley (428 acres [173 hectares]) and Tenjo Vista Tank Farms (231 acres [93 hectares]) that provide storage, transfer, and pumping capability for petroleum, oil, and lubricants (POL) for both DON and U.S. Air Force (USAF) (Figure 7-6). Tenjo Vista Tank Farm houses thousands of gallons of F-76 military diesel fuel in seven underground storage tanks. The Sasa Valley Tank Farm comprises a lower and upper complex. The lower complex includes administration and security, a pump house, electrical substation, seven POL storage tanks, a truck fueling station, and supporting POL processing equipment. The upper complex contains 20 underground storage tanks with a combined storage capacity of approximately 42 million gallons (159 million liters), including the following:

- six tanks store JP-8 jet fuel for Andersen Air Force Base (AFB);
- six tanks store JP-5 aircraft fuel for DON aircraft carriers;
- three tanks store F-76 diesel fuel for DON vessels; and
- five tanks store marine fuel oil for DON vessels.

JP-8 fuel is pumped to Andersen AFB, while the other products are delivered via gravity flow to other Guam Defense Logistics Agency Defense Energy Support Center facilities/piers. The Tank Farms are directly connected to Delta and Echo piers, located on Drydock Island in Outer Apra Harbor, to support DON fueling operations (NAVFAC Marianas 2015; NAVFAC Marianas and Andersen AFB 2015; NBG 2016).

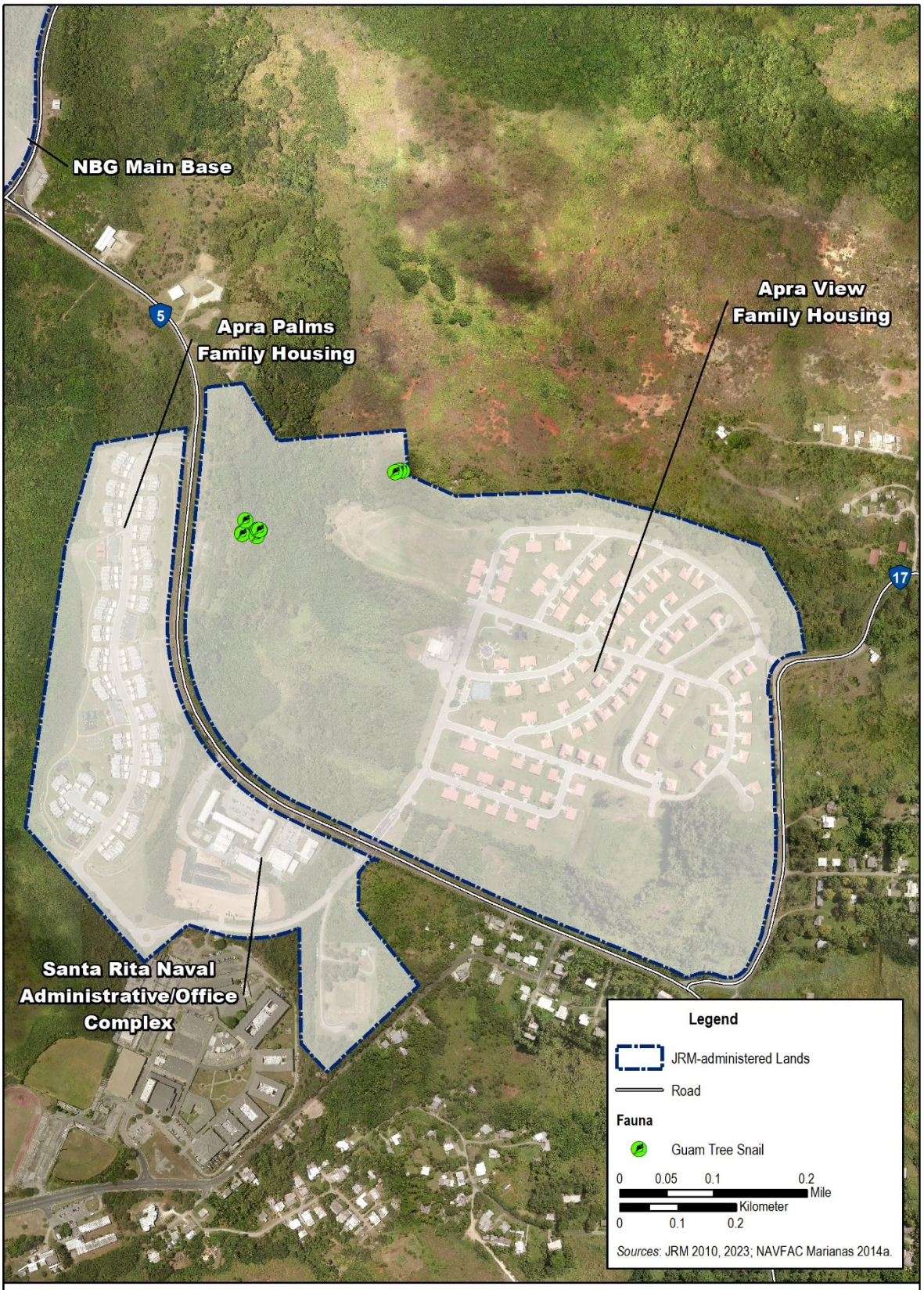


Figure 7-5
Protected Species - Apra Heights



Figure 7-6
Overview of Sasa Valley and Tenjo Vista Tank Farms

7.2.1.1 Special Conservation Areas

As discussed in Section 3.5.3, *Guam National Wildlife Refuge Comprehensive Conservation Plan*, Overlay Refuge lands were established in 1994. With the exception of the administration area at the main entrance to the Sasa Valley Tank Farm, all of the remaining lands within the Sasa Valley and Tenjo Vista Tank Farms are Overlay Refuge lands (refer to Figure 3-3). Recognizing that the primary purpose of lands within the Overlay Refuge is to support DON's national defense mission, they provide a commitment by DON and USFWS for a coordinated program centered on the following:

- Protection of threatened and endangered species and other native flora and fauna;
- Maintenance of native ecosystems; and
- Conservation of native biological diversity in cooperation with Guam DAWR (2006).

7.2.2 Geology, Topography, and Soils

7.2.2.1 Geology

The upland (eastern) portion of Sasa Valley Tank Farm is located in volcanic rock units and the lowlands (western) portion is located in limestone units and reef beach/alluvium deposits. The upland (eastern) portion of Tenjo Vista Tank Farm is located in volcanic rock units and the lowlands (western) portion is located in limestone units.

Two southwest-northeast trending faults lie within the eastern portion of Sasa Valley Tank Farm; no faults occur within Tenjo Vista Tank Farm (refer to Figure 4-4). Nearby faults make both installations susceptible to earthquakes (refer to Section 4.2.1.3, *Seismology*).

7.2.2.2 Topography

Both Sasa Valley and Tenjo Vista Tank Farms are located at the base of and within the steep hills of western Guam.

7.2.2.3 Soils

Soils within the higher elevation, eastern portion of Sasa Valley are primarily volcanic upland soils of the Akina series consisting of well drained, moderately slowly permeable soils (Figure 7-7); the descriptions of each soil type are summarized in Table 4-1. The western portion of Sasa Valley and the majority of Tenjo Vista lie near sea level and consist of poorly to well-drained limestone upland soils of plateaus and hills, and poorly drained bottomland soils common to coastal plains (USDA 1988) (Figure 7-7).

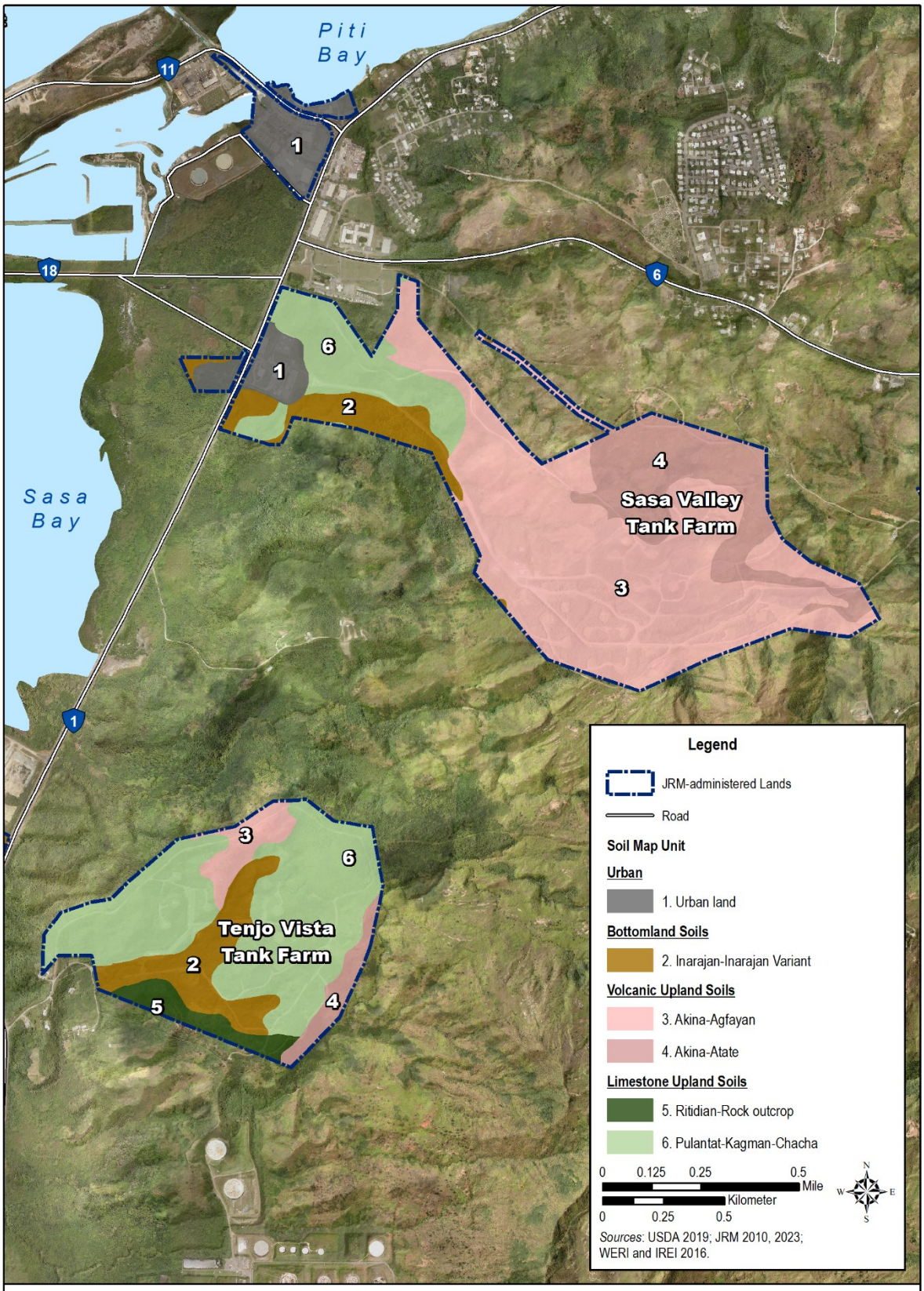


Figure 7-7
Soils - Sasa Valley and Tenjo Vista Tank Farms

7.2.3 Hydrology

7.2.3.1 Surface Water

Sasa Valley Tank Farm

The Sasa Valley Tank Farm is located in the Apra and Piti-Asan drainage basins (Figure 7-8). The dominant surface water feature of Sasa Valley is the perennial Sasa River, which runs east to west across almost the entire length of the Sasa Valley parcel (Figure 7-8). A total of 15 natural and man-made wetland areas, covering approximately 57 acres (23 hectares), have been identified within the Sasa Valley Tank Farm (AECOS, Inc. and Wil Chee Planning, Inc. 2009; NAVFAC Marianas and Andersen AFB 2015). Most of these wetlands are associated with the Sasa River, particularly along the western portion. Additional scattered wetlands not directly associated with the Sasa River are found along the southwestern and northeastern boundary of the Tank Farm. The majority of the wetlands are seasonally flooded, forested wetlands with limited areas of open water. In addition, a southern tributary of the Masso River, along with associated wetlands, extends into the north-central portion of the Sasa Valley Tank Farm (Figure 7-8). For further details regarding the extent and nature of wetlands within the Sasa Valley parcel, refer to NAVFAC Marianas and Andersen AFB (2015). For further details on the role of these wetlands as a natural habitat, see Section 7.2.4, *Vegetation Communities.*

Tenjo Vista Tank Farm

The Tenjo Vista Tank Farm is located in the Apra drainage basin (Figure 7-8) and occupies an area of low hills drained by multiple small feeder streams into the Guatali River. This river runs east to west across the central portion of the Tenjo Vista Tank Farm (Figure 7-8). A total of nine natural and man-made wetland areas, covering approximately 16 acres (6.5 hectares), have been identified within the Tenjo Vista Tank Farm (AECOS, Inc. and Wil Chee Planning, Inc. 2009; NAVFAC Marianas and Andersen AFB 2015). Most of these wetlands are associated with the Guatali River and its associated drainages. As with Sasa Valley, the majority of the wetlands are seasonally flooded, forested wetlands with limited areas of open water. For further details regarding the extent and nature of wetlands within the Tenjo Vista parcel, refer to NAVFAC Marianas and Andersen AFB (2015). For further details on the role of these wetlands as a natural habitat, see Section 7.2.4, *Vegetation Communities.*

7.2.3.2 Groundwater

Due to the underlying volcanic rock units with their low porosity and permeability, groundwater is not retained within the majority of the Sasa Valley Tank Farm. The western portion of Sasa Valley and most of Tenjo Vista are located within non-volcanic areas classified as a basal (if connected to the ocean and underlain by seawater or volcanic basement units) groundwater zone (WERI and Island Research and Education Initiative [IREI] 2016).

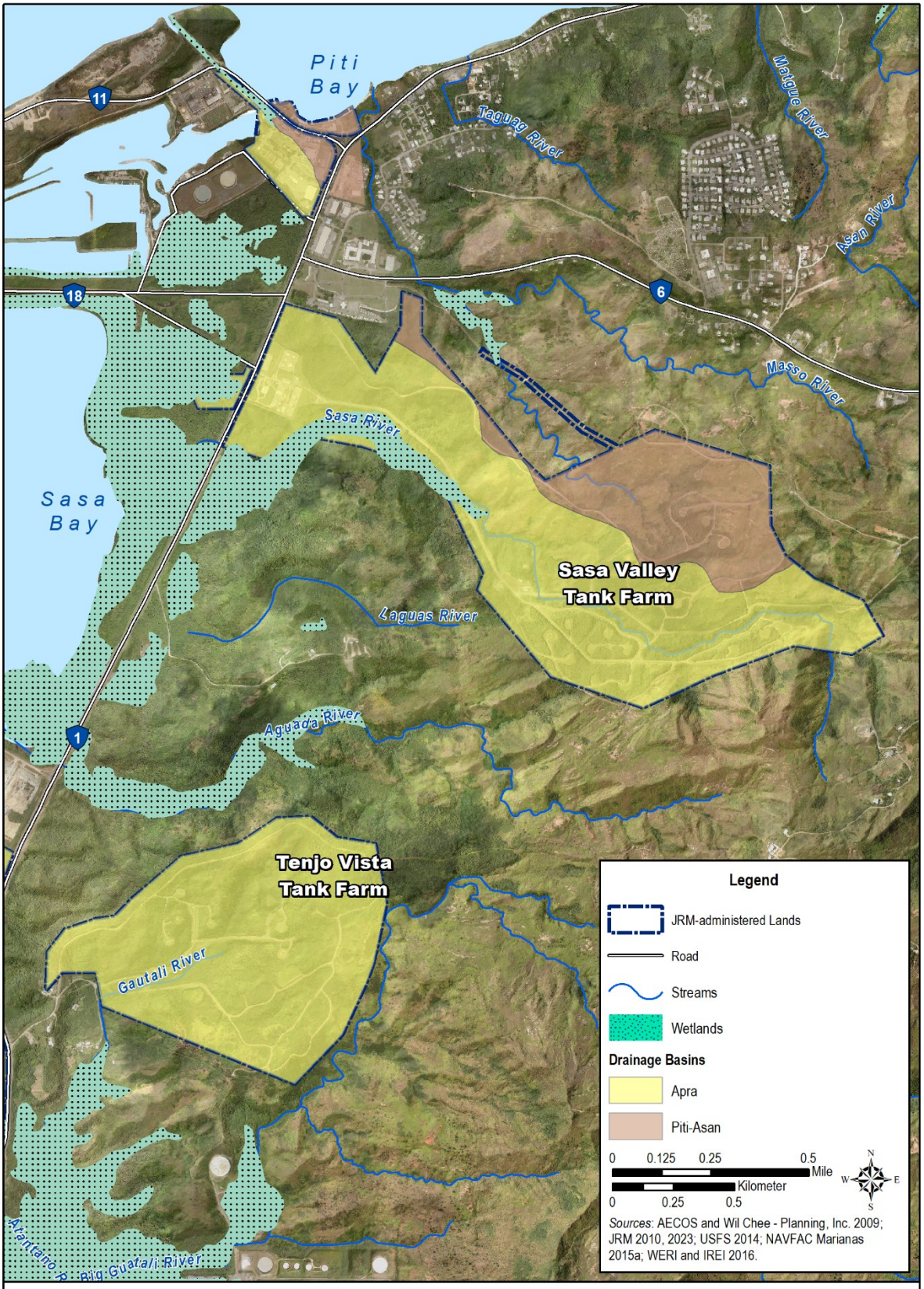


Figure 7-8
Surface Waters, Wetlands, and Drainage Basins - Sasa Valley and Tenjo Vista Tank Farms

7.2.4 Vegetation Communities

7.2.4.1 Sasa Valley Tank Farm

Approximately 15% of the Sasa Valley Tank Farm is developed (i.e., buildings, roads, and landscaped areas) or barren (Table 7-2 and Figure 7-9). Vegetation within the remaining undeveloped areas is primarily scrub forest along the western and southern portions of the parcel, and other shrub/grassland dominating the northern area. Overall, 13% of the Tank Farm is classified as wetlands, with three types occurring: palustrine emergent wetlands, palustrine forested wetlands, and palustrine scrub/shrub wetlands. The most common type of wetland found in Sasa Valley Tank Farm is palustrine forested wetlands dominated by pago (*Hibiscus tiliaceus*), followed by palustrine scrub/shrub wetlands dominated by tall reed (AECOS, Inc. and Wil Chee Planning, Inc. 2009; NAVFAC Marianas and Andersen AFB 2015).

Sasa Valley Tank Farm contains several acres of habitat (e.g., scrub/shrub, grassland, etc.) that are subject to frequent wildland fires that originate on adjacent privately owned lands. Wildland fires traversed the area in 2012, 2014, and 2016. As a result, eroded sediments were carried into Sasa River and Sasa Bay (Outer Apra Harbor), and into the Masso River on Government of Guam (GovGuam) lands that empties into Masso Bay (Piti). The extensive grasslands to the north and east of Sasa Valley Tank Farm can contribute to the onset of an intense, fast-moving fire front, potentially endangering the 31 fuel storage tanks and numerous fuel pipelines.

Table 7-2. Vegetation Communities on Sasa Valley Tank Farm

Vegetation Community	*Area (acres)*	*% of Total Area*	*% of Vegetated, Undeveloped Area*
Other Shrub/Grassland	99.9	23.3	27.3
Wetlands	56.8	13.3	15.5
Scrub Forest	169.3	39.6	46.3
Scrub/Shrub	31.5	7.4	8.6
Leucaena Forest	7.7	1.8	2.1
Ravine Forest	0.3	0.1	0.1
Non-vegetated Categories			
Barren	0.7	0.2	NA
Developed	61.8	14.4	NA
Open Water	<0.1	<0.1	NA
Total	**428.0**		

Key: < = less than; % = percent; NA = not applicable.
Source: USFS 2014.

7.2.4.2 Tenjo Vista Tank Farm

Approximately 10% of the Tenjo Vista Tank Farm is developed (i.e., buildings, roads, and landscaped areas) or barren (Table 7-3 and Figure 7-9). The majority (65%) of the vegetation within the undeveloped areas is scrub forest, with some shrub/grassland along the eastern boundary and patches of shrub/grassland and scrub/shrub along the southern boundary and north-central area. Wetlands occur on approximately 7% of the site, most of which are palustrine scrub/shrub wetlands dominated by tall reed or palustrine forested wetlands dominated by pago (AECOS, Inc. and Wil Chee Planning, Inc. 2009; NAVFAC Marianas and Andersen AFB 2015).

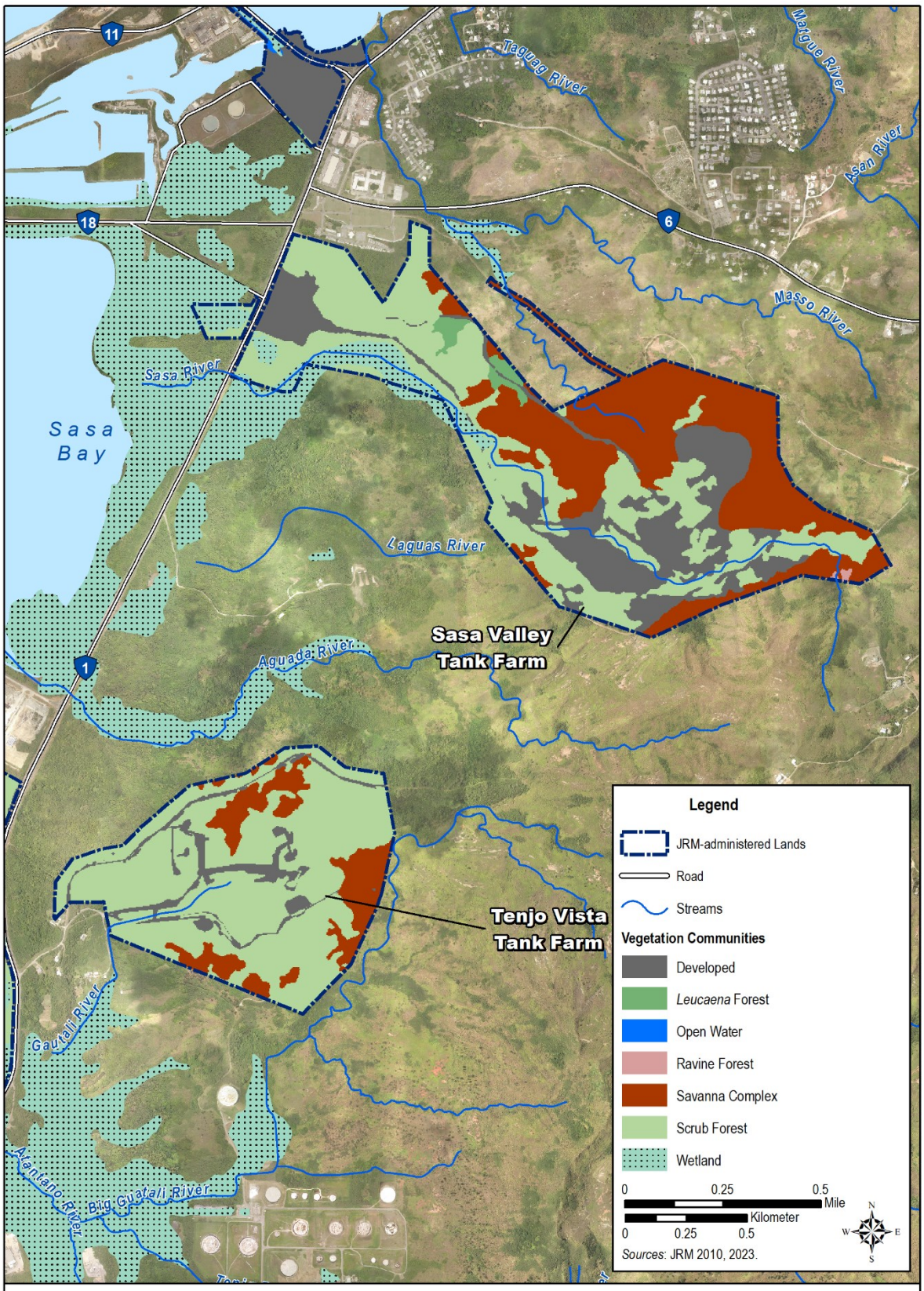


Figure 7-9
Vegetation Communities - Sasa Valley and Tenjo Vista Tank Farms

Table 7-3. Vegetation Communities on Tenjo Vista Tank Farm

Vegetation Community	*Area (acres)*	*% of Total Area*	*% of Vegetated, Undeveloped Area*
Other Shrub/Grassland	18.4	8.0	8.8
Wetlands	15.7	6.8	7.5
Scrub Forest	156.9	68.0	75.1
Scrub/Shrub	17.9	7.8	8.6
Non-vegetated Categories			
Barren	0.2	0.1	NA
Developed	21.6	9.4	NA
Total	**230.7**		

Key: % = percent; NA = not applicable.
Source: USFS 2014.

7.2.5 Terrestrial Wildlife

7.2.5.1 Mammals

Although no mammal surveys have been conducted within either the Sasa Valley or Tenjo Vista sites, it is expected that the common, non-native small mammals found throughout Guam would occur, including feral dogs, cats, Norway rat, black rat, Polynesian rat, house mouse, and musk shrew (Wiles 2005; Wiewel et al. 2009). In addition, feral pigs and Philippine deer are also expected to occur since the habitat in these sites is suitable to support these species. Mariana fruit bats are occasionally reported in the area. The fruit bat is federal ESA-listed as threatened and Guam ESA-listed as endangered and is discussed below in Section 7.2.6.1, *Mammals*.

7.2.5.2 Birds

Recent wetland habitat surveys for Mariana common moorhen (*Gallinula chloropus guami*) were conducted by NAVFAC Marianas (2014a); however, no moorhen were recorded from either location within Sasa Valley or Tenjo Vista (refer to Section 7.2.6.2, *Birds*). Habitat in the Tank Farms is suitable to support the native yellow bittern (an MBTA-listed species), non-native Eurasian tree sparrow, black drongo, and island collared dove, so these ubiquitous and adaptable species are expected to occur at these sites.

7.2.5.3 Reptiles and Amphibians

Although no reptile and amphibian surveys have been conducted within either the Sasa Valley or Tenjo Vista sites, based on the habitat types found within each site, the following species are expected to occur: the native Pacific blue-tailed skink and mourning gecko (*Lepidodactylus lugubris*); the native monitor lizard; and the non-native curious skink, BTS, house gecko (*Hemidactylus frenatus*), marine toad, barking frog (*Hyla gratiosa*), crab-eating frog (*Fejervarya limnocharis*), and greenhouse frog.

7.2.5.4 Invertebrates

There have been no systematic surveys for invertebrates within the Sasa Valley or Tenjo Vista Tank Farm areas. However, a single federal ESA-listed Guam tree snail was incidentally found in Sasa Valley Tank Farm during a moorhen survey. This species is discussed in further detail below in Section 7.2.6.3, *Invertebrates*.

The CRB was first detected in Guam in the Tumon Bay area on September 12, 2007 and was considered to have spread island-wide by 2010. BMPs are implemented to help curb the spread of and damage from the CRB.

7.2.6 Current Operations and Land Use

7.2.7 Terrestrial Protected Species

Three federal ESA-listed species have been observed or recorded on the Sasa Valley or Tenjo Vista sites: one mammal, one bird, and one tree snail. The species are also listed under the Guam ESA.

7.2.7.1 Mammals

Mariana Fruit Bat

The Mariana fruit bat is federal ESA-listed as threatened and Guam-listed as endangered and Guam-designated as SOGCN. Although it is very rare, local residents have reported sightings of fruit bats in this area, leading Guam DAWR to speculate that the habitat found in the Sasa Valley and Tenjo Vista areas supports bat roosting and foraging (Guam DAWR 2017c).

7.2.7.2 Birds

Mariana Common Moorhen

The Mariana common moorhen is federal ESA-listed as endangered and Guam-listed as endangered and Guam-designated as SOGCN. Dry and wet season surveys for the moorhen were conducted in April-May and September 2014, respectively, at 15 wetlands in Sasa Valley and 9 wetlands in Tenjo Vista; however, no moorhens were detected (NAVFAC Marianas 2014a).

The wetlands were also assessed for the presence of or potential to support open water, which would indicate suitable habitat for the moorhen. Only one wetland in Sasa Valley supported open water during the survey (NAVFAC Marianas 2014a, 2014b). One wetland at Tenjo Vista is currently marked with a sign "Moorhen Habitat – Do Not Disturb" and historically has been reported to contain ponded water (Figure 7-10) (AECOS, Inc. and Wil Chee Planning, Inc. 2009; NAVFAC Marianas 2014a, 2014b). It is not known when the "Moorhen Habitat" sign was erected at Tenjo Vista and if the area once supported moorhens. NAVFAC Marianas (2014a) stated that the site appeared promising for supporting moorhens, given the potential for ponded water and the close proximity to a known population of moorhens at the Tri-Star Tank Farm immediately to the south. Ritter and Savidge (1999) also mentioned the use of the Tenjo Vista ponds by moorhen.

7.2.7.3 Invertebrates

Guam Tree Snail

The Guam tree snail is federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. The Guam tree snail was listed as endangered by the USFWS in October 2015 (USFWS 2015a). In 2021, a large population was documented in multiple locations throughout the Sasa Valley Tank Farm as shown in Figure 7-10 (Island Eco Services 2021). During this survey, a total of 992 individuals were recorded.

Fragile Tree Snail

The fragile tree snail is federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. During 2021 surveys at the Sasa Valley Tank Farm, a large population was documented in multiple locations near the eastern end of the Sasa Valley Tank Farm boundaries as shown in Figure 7-10 (Island Eco Services 2021). During this survey, a total of 240 individuals were recorded; prior to this survey, the species had not been documented in the area.

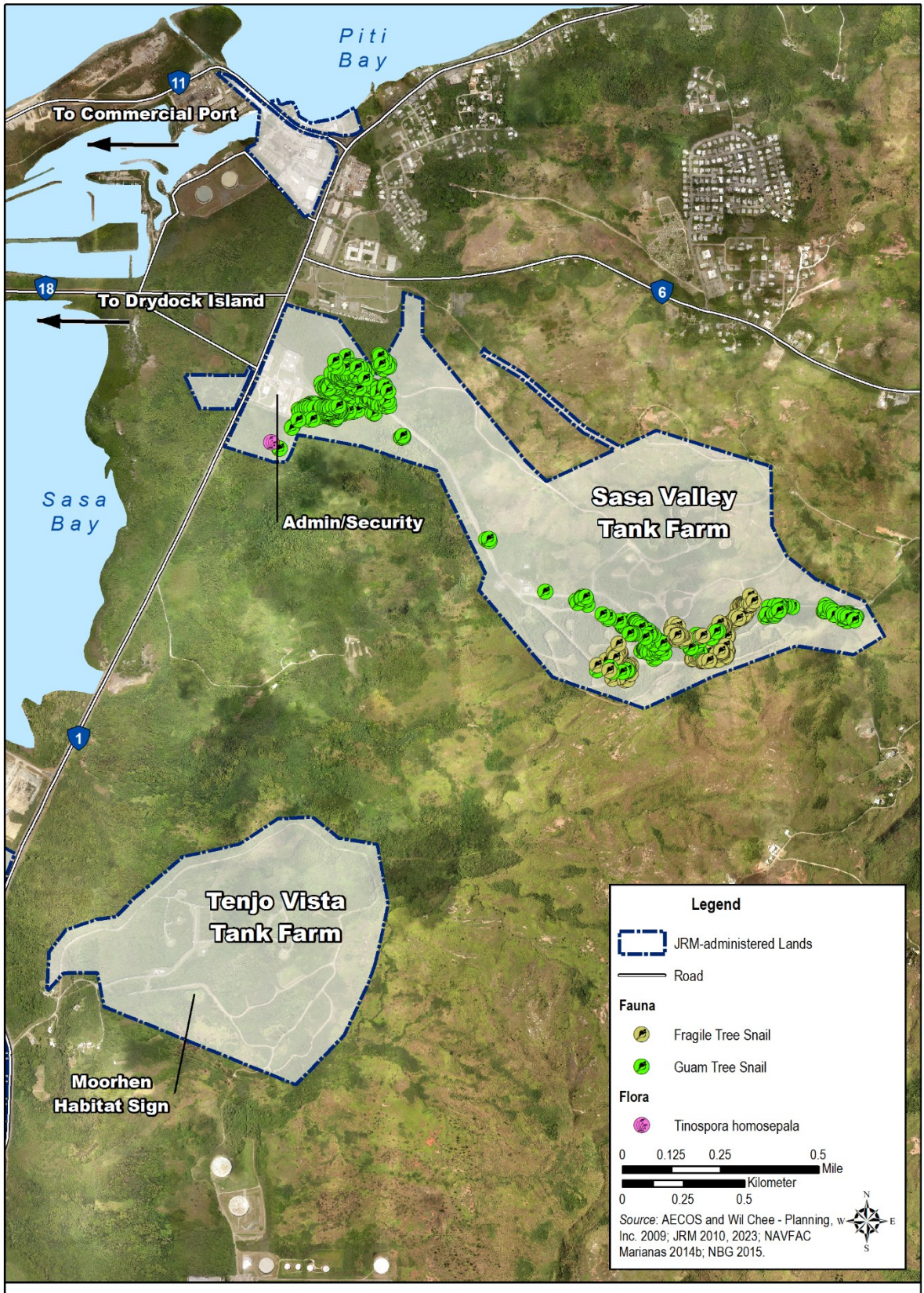


Figure 7-10
Protected Species - Sasa Valley and Tenjo Vista Tank Farms

7.2.7.4 Plants

Tinospora homosepala

Tinospora homosepala is federal ESA-listed as endangered. During 2021 surveys at the Sasa Valley Tank Farm, a population of 120 mature plants were documented near Marine Corps Drive (Island Eco Services 2021). Prior to this survey, the species had not been documented in the area.

7.3 NAVAL COMPUTER AND TELECOMMUNICATIONS STATION BARRIGADA AND BARRIGADA TRANSMITTER SITE

7.3.1 Naval Computer and Telecommunications Station Barrigada

The 1,366-acre (553-hectare) Naval Computer and Telecommunications Station (NCTS) Barrigada site supports high-frequency transmitting activities for all Department of Defense (DoD) activities in Guam. A 1.2-mile (2-kilometer) radius electromagnetic radiation protection zone is designated around the transmitting antennas at NCTS Barrigada to preclude electromagnetic radiation problems. It is also the headquarters for the Space and Naval Warfare Systems Command (SPAWAR) Systems Center Pacific, Detachment Guam; the Army Reserve Center; as well as supporting military training operations. A Military Operations on Urban Terrain (MOUT) area, the former Fleet Hospital warehouse, and the former Admiral Nimitz Golf Course are also located at NCTS Barrigada (Figure 7-11) (NBG 2016). The golf course is closed and is currently designated an archaeological area while DON conducts cultural resource consultations with the Guam Historic Preservation Office (HPO) under the National Historic Preservation Act (NHPA). However, operations supporting specific mission requirements are authorized, including use as a high-altitude – low opening drop zone. For specific training activities, mission planners are provided a map of no-training areas to ensure known archaeological sites are avoided. In addition, any proposed natural resource management efforts would be reviewed with the NBG cultural resource manager prior to implementation.

On 25 April 2017, the Finding of No Significant Impact was signed for the permanent stationing and operation of the Terminal High-Altitude Area Defense (THAAD) ballistic missile defense battery. As of 2023, THAAD has since been relocated. The THAAD defense system is powered by batteries and requires uninterrupted operation of numerous generators. The batteries emit electromagnetic radiation and require an exclusion zone in front of the radar.

Military training activities that occur on NCTS Barrigada are associated with Mariana Islands Training and Testing (MITT) operations (DON 2014, 2015a), which have replaced all Mariana Islands Range Complex (MIRC) activities (DON 2010a). These activities include (DON 2014):

- *Urban Warfare Training* – Military units conduct training activities in the MOUT area including use of force, breaching doors and obstacles, and in close quarters combat (Figure 7-11); blanks and simunitions (simulated munitions) are used; helicopters and tilt-rotor aircraft provide support.
- *Non-combatant Evacuation/Humanitarian Assistance/Disaster Relief Operations* – Military units evacuate non-combatants from hostile or unsafe areas or provide humanitarian assistance in times of disaster. Blanks and simunitions are used; helicopters and tilt-rotor aircraft provide support.
- *Personnel Parachute Insertion/Extraction* – Military personnel train for covert insertion and extraction into target areas using helicopters and fixed-wing aircraft (insertion only); insertions are conducted within the designated Drop Zone within NCTS Barrigada (Figure 7-11).
- *Maneuver* – Personnel participate in land navigation and convoy training.

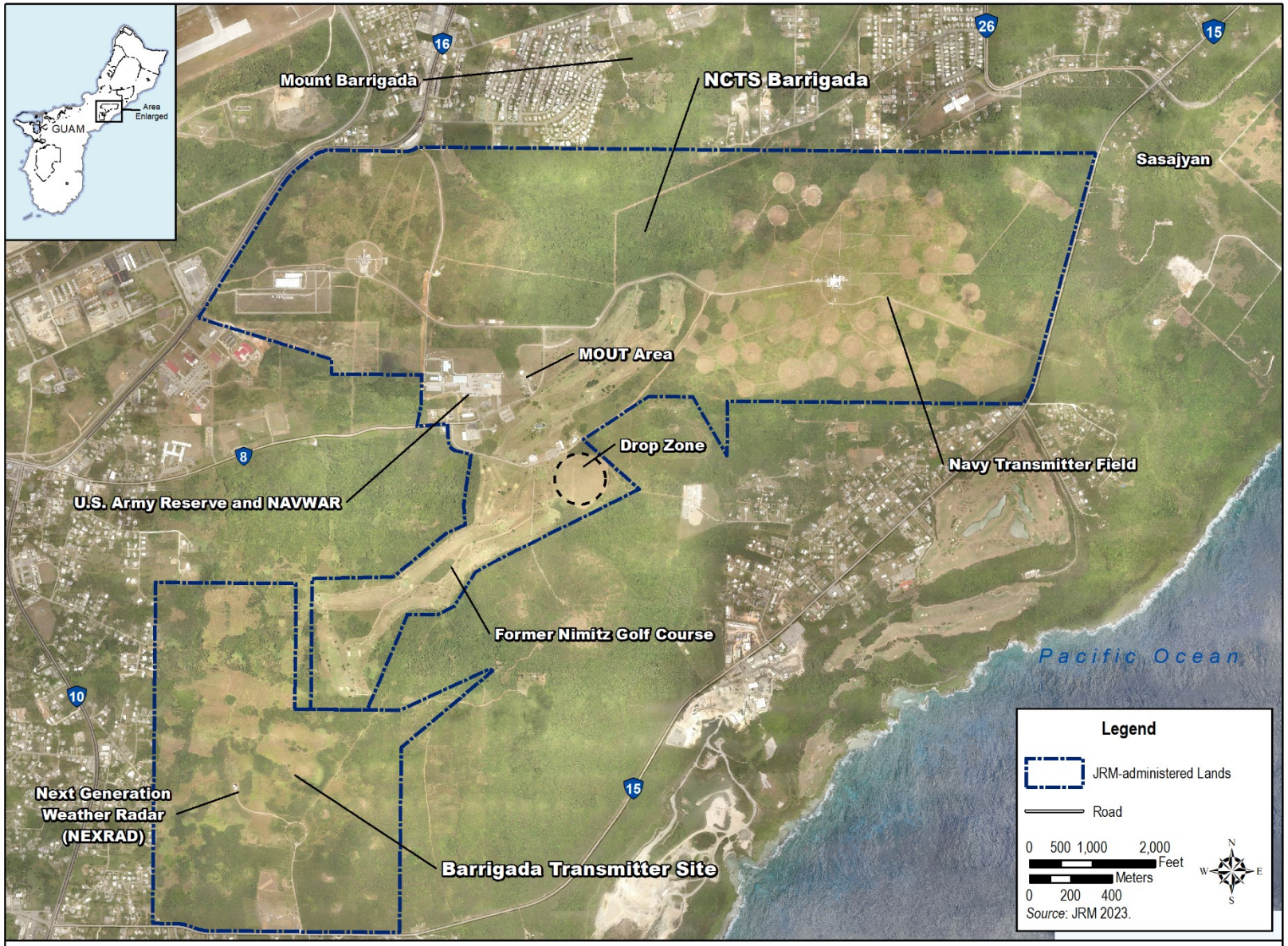


Figure 7-11
Overview of NCTS Barrigada and Barrigada Transmitter Site

- *Force Protection* – Units train in force protection operations to increase the physical security of military personnel and to reduce their vulnerability to attacks.

7.3.1.1 Barrigada Transmitter Site

The 432-acre (175-hectare) Barrigada Transmitter Site (previously known as Air Force Barrigada or Air Force Communications Annex Barrigada) supports a Next-Generation Radar high-resolution weather radar operated by Andersen AFB (see Figure 7-11).

7.3.2 Geology, Topography, and Soils

7.3.2.1 Geology

The Barrigada parcels are located in limestone rock units. There are no faults running through either Barrigada parcel, although the Tamuning-Yigo fault lies a couple of miles to the north (refer to Figure 4-4).

7.3.2.2 Topography

The Barrigada parcels are located on relatively flat land on top of the northern Guam limestone plateau. Elevations range from approximately 240 feet (73 meters) to 500 feet (152 meters) above mean sea level (MSL). The most prominent feature is Mount Barrigada which rises in the north-central part of NCTS Barrigada with a maximum height of roughly 600 feet (183 meters), just north of the site boundary.

7.3.2.3 Soils

Both Barrigada parcels are underlain with limestone upland soils (Figure 7-12); the descriptions of each soil type are summarized in Table 4-1. The three types of soils found at the Barrigada parcels are all well drained, slowly permeable soils that are shallow over limestone, typically on plateaus (USDA 1988). The Ritidian-Rock Outcrop soils within the parcels are associated with Mount Barrigada.

7.3.3 Hydrology

7.3.3.1 Surface Water

<u>NCTS Barrigada</u>

NCTS Barrigada is located primarily in the Hagatna and Mangilao drainage basins (Figure 7-13). There are two surface water features on NCTS Barrigada: a man-made pond associated with the closed golf course and a 0.9-acre (0.4-hectare) emergent wetland within the southern area near the border with the Barrigada Transmitter Site (Figure 7-13). This southern wetland was confirmed to meet U.S. Army Corps of Engineers (USACE) wetland criteria during a 2010 wetlands study in support of the Guam and CNMI Military Relocation Environmental Impact Statement (EIS)/Overseas EIS (OEIS) (NAVFAC Pacific 2010a). This wetland is seasonally ponded and does not support permanent surface water.

<u>Barrigada Transmitter Site</u>

Barrigada Transmitter Site is located in the Hagatna drainage basin (Figure 7-13). A wetland study was conducted at the Barrigada Transmitter Site in May 2010 that resulted in the delineation of seven palustrine emergent wetlands within the Barrigada Transmitter Site boundaries and one palustrine emergent wetland located between the NCTS Barrigada and Barrigada Transmitter Site property boundaries (Figure 7-13) (NAVFAC Pacific 2010a). All of these wetland areas are seasonally ponded and do not support permanent surface water. The delineated wetlands on the Barrigada Transmitter Site total approximately 2.4 acres (1.0 hectare). The wetland located between the properties is approximately 1.1 acres (0.4 hectare).

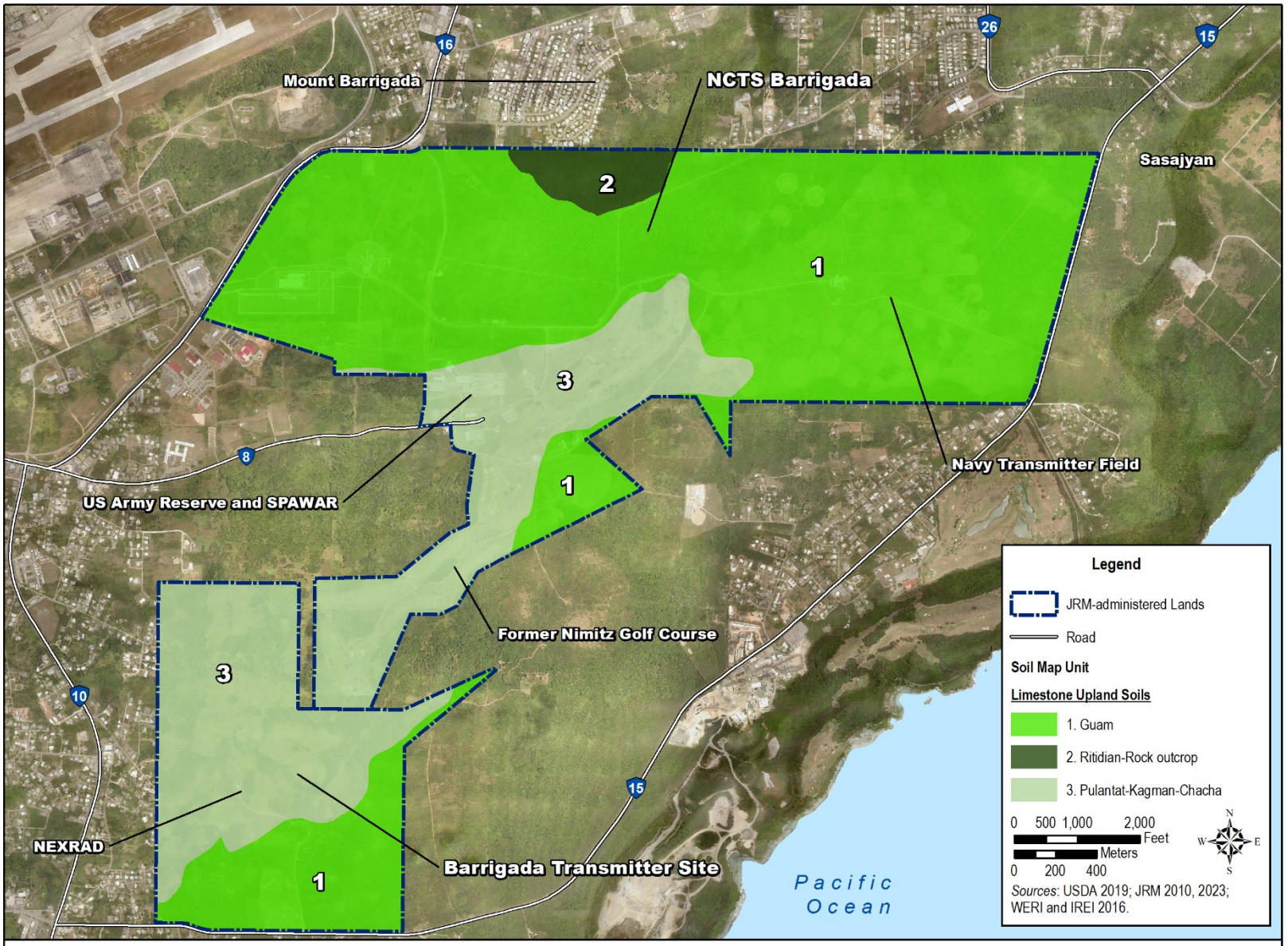


Figure 7-12
Soils - NCTS Barrigada and Barrigada Transmitter Site

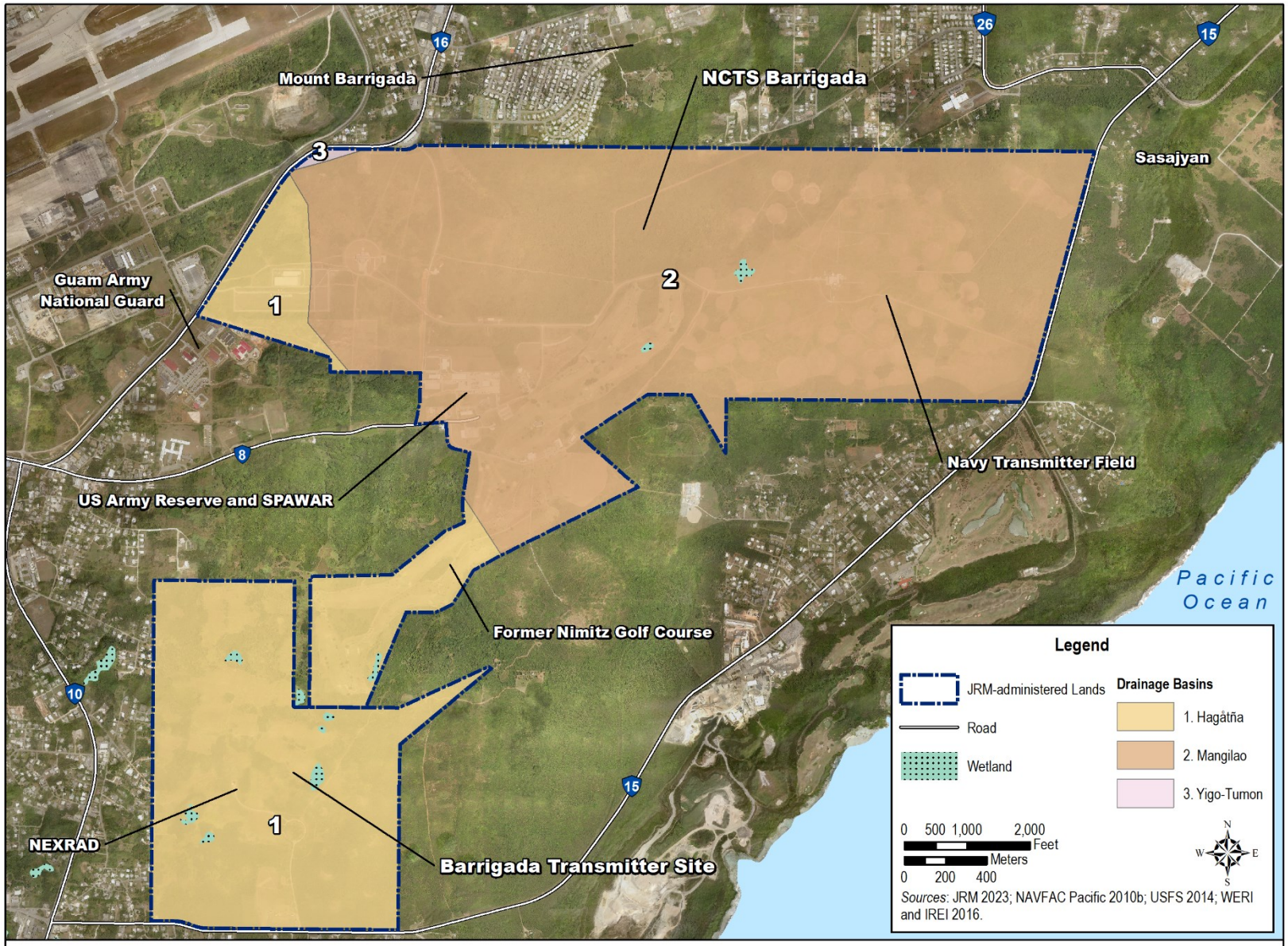


Figure 7-13
Wetlands and Drainage Basins - NCTS Barrigada and Barrigada Transmitter Site

7.3.3.2 Groundwater

NCTS Barrigada

NCTS Barrigada is underlain by very permeable limestone in the Mangilao and Hagatna sub-basins of the Northern Guam Lens Aquifer (NGLA) (refer to Figure 4-10). Refer to Section 4.3.2, *Groundwater*, for further discussion of the NGLA.

Barrigada Transmitter Site

Barrigada Transmitter Site lays south of and draws water from the southern extent of the NGLA. The Transmitter Site is underlain by the Hagatna Sub-basin (refer to Figure 4-10). The Hagatna Sub-basin is very permeable limestone located within non-volcanic areas classified as a basal groundwater zone (WERI and IREI 2016). Refer to Section 4.3.2, *Groundwater,* for further discussion of the NGLA.

7.3.4 Vegetation Communities

7.3.4.1 NCTS Barrigada

Approximately 30% of the NCTS Barrigada property is developed (i.e., buildings, roads, and landscaped areas) or barren (Table 7-4 and Figure 7-14). The shrub/grassland areas within the eastern portion of the parcel are associated with the transmitter/antenna field and are routinely mowed. Vegetation within the undeveloped areas is primarily scrub forest dominated by the native plants, banyan or nunu (*Ficus* spp.), pago, *Ochrosia* (=*Neisosperma*) *oppositifolia*, and *Meiogyne cylindrocarpa*; and the non-native woody species custard apple and *Triphasia trifolia*. The area of scrub forest is heavily impacted by feral pigs (NAVFAC Pacific 2010a, 2013), decreasing the potential for vegetation to grow and leading to erosion of barren lands. The open water (golf course pond) and palustrine emergent wetland found in the southern area of the site were discussed above in Section 7.3.3.1, *Surface Water*.

Table 7-4. Vegetation Communities on NCTS Barrigada

Vegetation Community	*Area (acres)*	*% of Total Area*	*% of Vegetated, Undeveloped Area*
Leucaena Forest	67.1	4.9	7.1
Other Shrub/Grassland	285.2	20.9	30.0
Open Water (golf course pond)	0.2	<0.1	<0.1
Palustrine Emergent Wetland	1.2	0.1	0.1
Scrub Forest	407.9	29.9	43.0
Scrub/Shrub	187.7	13.7	19.8
Non-vegetated Categories			
Barren	3.0	0.2	NA
Developed	414.1	30.3	NA
Total	**1,366.4**		

Key: < = less than; % = percent; NA = not applicable; NCTS = Naval Communications and Telecommunications Station.
Source: USFS 2014.

7.3.4.2 Barrigada Transmitter Site

Although the Barrigada Transmitter Site is largely undeveloped, the majority of the site has been heavily disturbed and is dominated by non-native tangantangan (*Leucaena leucocephala*) and the native pago (Table 7-5 and Figure 7-14). Some areas classified as shrub/grassland are fallow agricultural fields with a heavy cover of invasive vine species including mile-a-minute vine (*Mikania micrantha*), chain-of-love vine (*Antigonon leptopus*), and the native *Stictocardia tiliifolia* (NAVFAC Pacific 2010a, 2013).

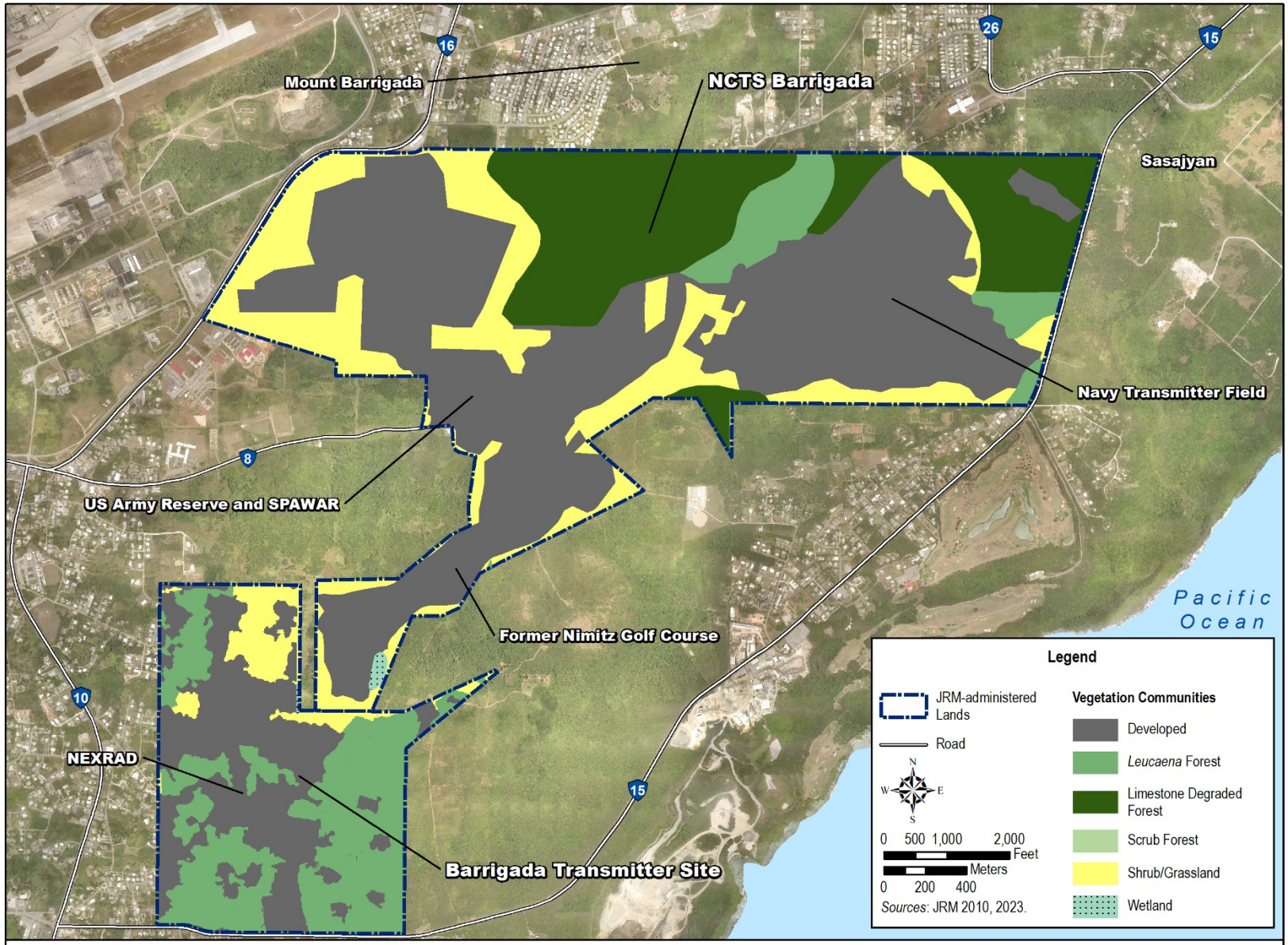


Figure 7-14
Vegetation Communities - NCTS Barrigada and Barrigada Transmitter Site

Table 7-5. Vegetation Communities on Barrigada Transmitter Site

Vegetation Community	*Area (acres)*	*% of Total Area*	*% of Vegetated, Undeveloped Area*
Leucaena Forest	196.6	45.5	47.9
Other Shrub/Grassland	105.9	24.5	25.8
Wetland	4.0	0.9	1.0
Scrub Forest	43.3	10.0	10.6
Scrub/Shrub	60.6	14.0	14.8
Non-vegetated Categories			
Barren	4.0	0.9	NA
Developed	17.8	4.1	NA
Total	**432.2**		

Key: % = percent; NA = not applicable.
Source: USFS 2014.

7.3.5 Terrestrial Wildlife

7.3.5.1 Mammals

Although no mammal surveys have been conducted within either Barrigada site, it is expected that the common, non-native small mammals found throughout Guam would occur, including Norway rat, black rat, Polynesian rat, house mouse, and musk shrew (Wiles 2005; Wiewel et al. 2009). In addition, feral pigs and Philippine deer are known to occur on both sites, where they have caused extensive damage to the vegetation (NAVFAC Pacific 2010b, 2013). Mariana fruit bats are occasionally reported from the area, and are discussed below in Section 7.3.6.1, *Protected Species.*

7.3.5.2 Birds

NCTS Barrigada

During a transect survey in February 2008, seven bird species were observed at NCTS Barrigada, three of which are native and listed under the MBTA (Table 7-6) (NAVFAC Pacific 2010b). The only native breeding species was the yellow bittern; all other breeding species are non-native species. Two species (Pacific golden plover and Eastern cattle egret) are common winter residents in Guam. The Pacific golden plover is Guam-designated as SOGCN. Mariana common moorhen are occasionally observed in the area, and are discussed below in Section 7.3.6.1.2, *Birds.*

Table 7-6. Bird Species Recorded on NCTS Barrigada and Barrigada Transmitter Site

Common Name/ Chamorro Name[(1)]	*Scientific Name*	*Residence Status*	*Listed under MBTA*	*NCTS Barrigada*	*Barrigada Transmitter Site*
Yellow bittern/Kakkak	*Ixobrychus sinensis*	Common native breeding resident	Y	Y	N
Pacific golden plover/Dulili	*Pluvialis fulva*	Common non-breeding visitor	Y	Y	N
Eastern cattle egret/Chuchuko	*Bubulcus coromandus*	Common non-breeding visitor	Y	Y	N
Little egret/Chuchuko	*Egretta garzetta*	Uncommon non-breeding visitor	Y	N	Y
Black-winged stilt/None	*Himantopus himantopus*	Uncommon non-breeding visitor	Y	N	Y
Island collared dove/Pulumat	*Streptopelia bitorquata*	Common introduced breeding resident	N	Y	Y
White-throated ground dove/Paluman apaka (male) and Paluman fache (female)	*Alopecoenas xanthonurus*	Uncommon native breeding resident	N	N	Y
Micronesian starling/Sali	*Aplonis opaca*	Uncommon native breeding resident	N	N	Y
Black drongo/Salin Taiwan	*Dicrurus macrocercus*	Common introduced breeding resident	N	Y	N
Eurasian tree sparrow/Gagapale	*Passer montanus*	Common introduced breeding resident	N	Y	N
Black francolin/None	*Francolinus francolinus*	Common introduced breeding resident	N	Y	Y

Notes: [(1)] Common and scientific names based on Gill and Donsker (2017). Chamorro names from GovGuam (2009), Liske-Clark (2015), Topping et al. (1975); and USFWS (2015b).
Key: MBTA = Migratory Bird Treaty Act; N = no; NCTS = Naval Communications and Telecommunications Station; Y = yes.
Sources: NAVFAC Pacific 2010b, 2013.

Barrigada Transmitter Site

During a transect survey in February 2008 and through incidental observations during a Mariana common moorhen survey in December 2012 (see Table 7-6) (NAVFAC Pacific 2010b, 2013), four bird species were observed at the Barrigada Transmitter Site, two of which are native and listed under the MBTA. No native breeding species were observed; all breeding species are non-native species. The little egret (*Egretta garzetta*) and black-winged stilt (*Himantopus himantopus*) are uncommon winter migrants and were incidentally observed in December 2012 at the wetland in the southwest corner of the site (see Figure 7-13). At the time of the surveys, the area supported a substantial area of shallow open water; 2 days after the surveys, the water had receded (NAVFAC Pacific 2013). During wintering months, the Barrigada Transmitter Site is known to harbor migratory birds, including plovers, egrets, whimbrel, and yellow bittern (Guam DAWR 2017d). In 2014, the native white-throated ground dove (*Alopecoenas xanthonurus*) was observed at this site, and the native Micronesian starling (*Aplonis opaca*) was found in 2016 (Guam DAWR 2017e). The white-throated ground dove and Micronesian starling are Guam-listed as endangered and Guam-designated as SOGCN.

7.3.5.3 Reptiles and Amphibians

NCTS Barrigada

Based on visual surveys and glue-board trapping conducted along three transects in February 2008 and October 2009, seven reptile species (three native, one naturalized, and three non-native) and three non-native amphibian species have been observed at NCTS Barrigada (Table 7-7) (NAVFAC Pacific 2010b).

Table 7-7. Reptile and Amphibian Species Recorded on NCTS Barrigada and Barrigada Transmitter Site

Common Name/ Chamorro Name[(1)]	*Scientific Name*	*Residence Status*	*NCTS Barrigada*	*Barrigada Transmitter Site*
Curious skink/Gualiek halumtano	*Carlia ailanpalai*	Non-native	Y	Y
Pacific blue-tailed skink/Gualiek halumtano	*Emoia caeruleocauda*	Native	Y	Y
Mutilating gecko/Achiak	*Gehyra mutilata*	Native	Y	Y
House gecko/Achiak	*Hemidactylus frenatus*	Non-native	Y	Y
Mourning gecko/Achiak	*Lepidodactylus lugubris*	Native	Y	Y
Monitor lizard/Hilitai	*Varanus tsukamotoi*	Native	Y	Y
Brown treesnake/Kolepbla	*Boiga irregularis*	Non-native	Y	Y
Greenhouse frog/Kairo	*Eleutherodactylus planirostris*	Non-native	Y	N
Hong Kong whipping frog/Kairo	*Polypedates megacephalus*	Non-native	Y	N
Marine toad or Cane toad/Kairo	*Rhinella* (=*Bufo*) *marina*	Non-native	N	Y

Notes: [(1)] Common and scientific names based on Gill and Donsker (2017). Chamorro names from GovGuam (2009), Liske-Clark (2015), Topping et al. (1975); and USFWS (2015b).
Key: N = no; NCTS = Naval Communications and Telecommunications Station; Y = yes.
Sources: NAVFAC Pacific 2010b, 2013.

Barrigada Transmitter Site

Based on visual surveys and glue-board trapping along one transect in February 2008 and two transects in January 2013, five reptile species (one native, one naturalized, and three non-native) and one non-native amphibian species have been observed at the Barrigada Transmitter Site (see Table 7-7) (NAVFAC Pacific 2010b, 2013). Although not detected during the 2008 survey effort, native monitor lizards and mutilating geckos were also likely present at Barrigada Transmitter Site (NAVFAC Pacific 2010b).

7.3.5.4 Invertebrates

NCTS Barrigada

Butterfly surveys were conducted in September 2009 and January 2010 within one transect located northeast of the transmitter field near the northeastern boundary of the property. Four butterfly species were identified during the surveys: blue-banded king crow (*Euploea eunice*), blue moon (*Hypolimnas bolina*), common Mormon (*Paplio polytes*), and common evening brown (*Melanitis leda*). None of the species are considered endangered or threatened, and all are fairly well distributed throughout Guam and the Northern Mariana Islands.

Tree snail surveys conducted in October and November 2009 within the same transect as for butterfly species did not observe any live partulid tree snails or their shells. Shells of the introduced giant African snail (*Lissachatina fulica*) and both live individuals and shells of the introduced cinnamon bun snail

(*Satsuma mercatoria*) were seen on the transect. In addition, live introduced New Guinea flatworms (*Platydemus manokwari*) were also observed (NAVFAC Pacific 2010a). This flatworm is known to feed on juvenile partulid tree snails, and is believed to be the primary threat to the continued existence of partulid tree snails in Guam, the Mariana Islands, and potentially Oceania (Hopper and Smith 1992).

Barrigada Transmitter Site

There are no records of any surveys for invertebrate species within the Barrigada Transmitter Site. The CRB was first detected in Guam in the Tumon Bay area on September 12, 2007 and was considered to have spread island-wide by 2010. BMPs are implemented to help curb the spread of and damage from CRB.

7.3.6 Terrestrial Protected Species

7.3.6.1 NCTS Barrigada

Five federal ESA-listed species have been recorded on NCTS Barrigada: one mammal, one invertebrate, and three plants (Table 7-8 and Figure 7-15). Three are also Guam ESA-listed species.

7.3.6.1.1 Mammals

Mariana Fruit Bat

Mariana fruit bat is federal ESA-listed as threatened and Guam ESA-listed as endangered. Mariana fruit bats have suffered declining populations within NCTS Barrigada and elsewhere in Guam. In 2013, one Mariana fruit bat was observed between Barrigada Hill (a historic colony site) and NCTS Barrigada pipeline road. The individual roosted on a dukduk tree (*Artocarpus mariannensis*) between the pipeline and the golf course perimeter road (Guam DAWR 2017f).

7.3.6.1.2 Birds

Mariana Common Moorhen

The Mariana common moorhen is federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. An active nest was observed at the golf course pond during the September 2014 wet season survey, and one adult and four chicks were observed (NAVFAC Marianas 2014b). The nest was built upon and used again during May-June 2015 (dry season) when two adult, three juvenile, and five moorhen chicks were observed. The following October (wet season), the nest was not active, but four adult and two juvenile moorhens were observed (NAVFAC Marianas 2016).

Table 7-8. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded on NCTS Barrigada

Common Name/ Chamorro Name[(1)]	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat*	*Occurrence*
Mammals					
Mariana fruit bat/Fanihi	*Pteropus mariannus mariannus*	T	E	Limestone native and coconut forests	P
Birds					
Mariana common moorhen/Pulattat	*Gallinula chloropus guami*	E	E	Wetland (artificial)	Y
Invertebrates					
Guam tree snail/Akaleha	*Partula radiolata*	E	E	Limestone native and ravine forests	Y
Plants					
None/Siboyas halumtano	*Bulbophyllum guamense*	T	--	Limestone native and degraded forests	Y
None/Fadang	*Cycas micronesica*	T	--	Limestone native and degraded forests	Y
None/Ufa halumtano	*Heritiera longipetiolata*	E	E	Limestone native forest	Y

Notes: [(1)] Chamorro names from GovGuam (2009), Topping et al. (1975), and USFWS (2015a).
Key: -- = not listed; E = endangered; NCTS = Naval Communications and Telecommunications Station; P = potential for occurrence; T = threatened, Y = yes, known to occur.
Sources: GovGuam 2009; NAVFAC Pacific 2010b; NAVFAC Marianas 2014a, 2016; USFWS 2014, 2015b; Marine Corps Activity Guam (MCAG) 2017; Guam DAWR 2017d, 2017e, 2017f.

7.3.6.1.3 Invertebrates

Guam Tree Snail

The Guam tree snail is federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. Tree snails were incidentally observed on *Ochrosia* (=*Neisosperma*) *oppositifolia* during vegetation surveys conducted in 2008 at NCTS Barrigada (Figure 7-15). Tree snail surveys conducted in October and November 2009 within one transect located northeast of the transmitter field, near the northeastern boundary of the property, did not observe any Guam tree snails or their shells.

7.3.6.1.4 Plants

Bulbophyllum guamense

Bulbophyllum guamense is federal ESA-listed as threatened. The one occurrence record for this species is based on USFWS geospatial data collected and analyzed in support of the proposed listing of 23 species from Guam and the CNMI (USFWS 2014). The only information regarding this occurrence is that it is a pre-1994 record.

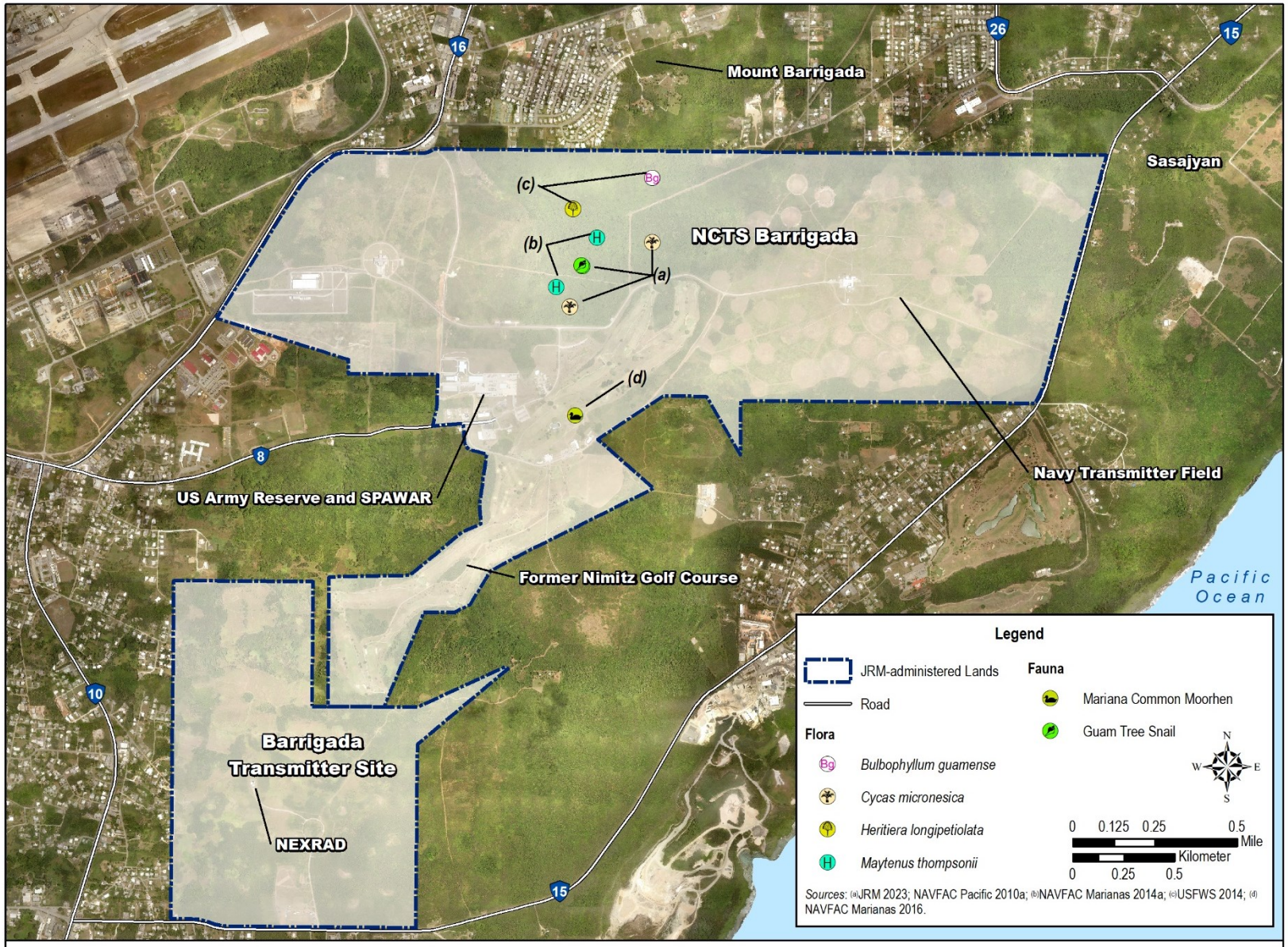


Figure 7-15
Protected Species and Butterfly Host Plants - NCTS Barrigada and Barrigada Transmitter Site

Tabernaemontana rotensis

Tabernaemontana rotensis is a moderate-sized tree and grows in limestone forests. It is federal ESA-listed as threatened and considered Guam-designated as SOGCN by Guam DAWR. The highest concentrations of this species in Guam were found on Andersen AFB where over 21,000 individual *T. rotensis* were mapped at 265 locations (NAVFAC Pacific 2010b).

Cycas micronesica

Cycas micronesica is federal ESA-listed as threatened and Guam-designated as SOGCN. Surveys conducted in 2008 at NCTS Barrigada observed numerous *C. micronesica* along two of the vegetation transects located within the scrub forest within the center of the property (see Figure 7-15) (NAVFAC Pacific 2010b). The species was found in densities of 190 individuals per acre on one transect and 31 individuals per acre on the second. Specimens were not in good health and were often topped by epiphytes, such as bird's nest fern (*Asplenium nidus*). Previous surveys found *C. micronesica* to be among the dominant species in the limestone forest at NCTS Barrigada (BioSystems Analysis, Inc. 1989). Marler and Lawrence (2012) found that *C. micronesica* populations declined dramatically across Guam in response to the 2003 accidental introduction of the invasive cycad scale (*Aulacaspis yasumatsui*).

Heritiera longipetiolata

Heritiera longipetiolata is federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. The one occurrence recorded for this species is based on the USFWS 2014 Geographic Information System (GIS) data in support of the proposed listing of 23 species from Guam and the CNMI. The only information regarding this occurrence is that it is a pre-1994 record.

Maytenus thompsonii

Although not a listed species, luluhut (*Maytenus thompsonii*) is a host plant for the federal ESA-listed endangered Mariana wandering butterfly (*Vagrans egistina*). A plant that is relatively common in native and degraded limestone forests, *M. thompsonii,* was observed along two vegetation transects within the center of the property (see Figure 7-15).

7.3.6.2 Barrigada Transmitter Site

To date, no federal or Guam-listed species or host plants for federal ESA-listed butterflies have been observed on Barrigada Transmitter Site (BioSystems Analysis, Inc. 1989; NAVFAC Pacific 2010b, 2013; NAVFAC Marianas 2014b). This site has been heavily disturbed, and the vegetation is dominated by non-native tangantangan and shrub/grasslands that are or were agricultural fields.

7.4 MANAGEMENT GOALS, OBJECTIVES, STRATEGIES, AND ACTIONS

JRM currently manages natural resources based on an ecosystem-focused approach that involves the implementation of several ongoing management projects. These projects, which are described in the following sections, provide examples of JRM's current efforts to manage and enhance natural resources in a manner consistent with the military mission. Appendix C lists management projects at Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site for FYs 14-17. The following sections present management projects for Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site that have been identified as necessary to achieve applicable goals and objectives identified in Chapter 3, *Environmental Management Strategy and Mission Sustainability*.

Management projects identified for Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site provide direct support for the military mission and the goal of "no net loss" in a number of ways. For example, projects that improve the baseline status of species or their habitat, show that populations are stable, or that habitat is improving or expanding may relieve restrictions on military training or operations, minimize costs and mitigation requirements, avoid workarounds, and/or streamline regulatory processes.

7.4.1 Terrestrial Ecosystem Management

The native terrestrial habitats on Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site have been impacted by historical activities, introduction and spread of invasive and non-native species, effects of climate change, and the resulting loss of functions necessary to support healthy native habitats. Ecosystem functions have been disrupted by the extirpation of native animal and plant species, which has resulted in both economic and cultural impacts on the ecosystem services provided by native habitats. The occurrence of healthy native habitats on Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site is necessary to support sustainability of native species including federally and locally listed threatened and endangered species. JRM recognizes that restoration and enhancement of native habitats on lands that they manage is a long-term process, and that adaptive management is key to long-term success of the program.

Management projects will be monitored and evaluated annually to ensure they are meeting identified goals and objectives. JRM will establish mid-year coordination meetings with resource partners to discuss ongoing and planned projects, including prioritization, scope, methodology, issues or challenges, timelines, and performance evaluation criteria. These discussions are intended to facilitate improved coordination and information sharing to allow for course corrections, if necessary, to ensure an adaptive approach.

Terrestrial habitat management as described in the following sections is expected to: (1) improve the status of threatened and endangered species through habitat conservation and enhancement, and (2) promote health and sustainability of native forests. Healthy ecosystems will, in turn, relieve or reduce environmental constraints and allow for maximum operational flexibility for the installations and continued/managed access to important recreational areas.

A summary of the management projects and the estimated timeframe for completion is presented in Table 13-9, Planned Implementation Summary of Projects at Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site and found in Chapter 13, Planning, Integration, and Implementation. Some of the projects described in this section will be accomplished through interactive partnerships with federal and territorial natural resource agencies (e.g., Guam DAWR), universities, and local organizations.

7.4.1.1 Terrestrial Habitat Management

JRM has ongoing and planned projects to restore and enhance native terrestrial habitats. These projects focus on improving the quality and availability of appropriate habitat for listed species, as well as increasing the quality and health of existing native habitats, such as native limestone forests. Numerous related activities are required for native habitat improvement, such as control of ungulates and other invasive species, propagating and outplanting native plant species to improve diversity, and addressing forest health issues, such as improvement of seed dispersal.

In order to achieve long-term goals, terrestrial habitat management requires successful daily and short-term management, coupled with long-term planning and investment. To ensure that JRM continues to meet the overriding goal of restoring and enhancing terrestrial habitats for native species (including listed species) over the long-term, JRM site land managers and resource agencies will continue coordinating on natural resource management.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Habitat Management (THM) for Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site.

THM-1: WATERSHED MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; and Goal #2, Objectives #3 and 7-8.

- *Strategy*: Stabilize eroding stream banks and wetland areas at Sasa Valley Tank Farm and Apra Heights housing areas to reduce siltation entering Outer and Inner Apra Harbor.
- *Action*: Assess streambank erosion of the Sasa River and Aplacho River on JRM-administered lands and identify methods for controlling and stabilizing soils at eroding sites to promote plant growth through bioengineering, removal of invasive species, and planting.
- *Action*: Identify metrics that will be used to monitor success at each site. Monitoring will take place at regular intervals and after typhoons or heavy rains.
- *Action*: Adaptively manage sites to maintain streambanks.

THM-2: FIRE PREVENTION AND MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1-2; Goal #2, Objectives #3 and 6; and Goal #5, Objective #2.

- *Strategy*: Reduce savanna grasslands and wildland fires by planting and maintaining *Acacia* trees.
- *Action*: Annually remove 10 or more acres (4 or more hectares) of tallgrasses (i.e., swordgrass) by mowing and herbicide application of new growth to maintain low structure native grasses following the 2015 NBG Wildlands Fire Management Plan.
- *Action*: Reforest 10 acres (4 hectares) with *Acacia* plantings at Sasa Valley Tank Farm. This planted site is designated as a "protected" resource area and "must suppress fire area," and will be maintained as a natural forested area in perpetuity.
- *Action*: Routinely mow and apply herbicide to remove tall grasses to prevent wildland fires from destroying newly planted or immature *Acacia* trees in accordance with the protocols for this site in the NBG Wildlands Fire Management Plan. Project will follow protocols for planting in the Forest Service Cetti Bay Implementation Plan.

- *Action*: Once established, monitor the health of the trees annually by a randomized sampling plan of the planted trees. Should tree survival fall below 80%, DON will take reasonable efforts to maintain the tree stocking at 240-300 trees/acre.

7.4.1.2 Terrestrial Exotic and Invasive Species Management

An invasive species is defined in Executive Order (EO) 13112, *Invasive Species*, as a species that is non-native (i.e., alien or exotic) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm, or harm to human health. Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions. Invasive species have had a catastrophic effect on the native flora and fauna of island ecosystems, particularly Guam. Attributes of island biota include small geographic ranges and population size, low reproductive rates, and lack of the ability to respond to invasive species and disturbed habitats. Islands typically have lower numbers of species than mainland areas, which results in fewer predators and competitors that could prohibit the establishment of invasive species. As a result of evolving in isolation, island plants and animals have few defenses when exposed to introduced competitors and predators. These limitations in Guam have caused exotic and invasive species to replace native island species (Wiles et al. 2003).

Many of the native species in Guam are threatened due to introduced predators, such as the BTS, and introduced ungulates, such as the Philippine deer, feral pig, and Asiatic water buffalo (carabao) (*Bubalus bubalis*) which have significantly affected native vegetation communities. Feral populations of dogs and cats also pose threats to native wildlife populations. Secretary of the Navy Instruction (SECNAVINST) 6401.1B, dated September 29, 2006, prohibits dogs, cats, and other privately owned or stray animals from running at large on military installations. Several species of rats have colonized the island, preying on the eggs and young of native species and destroying native flora (i.e., seeds and seedlings). The continued widespread presence of the BTS, curious skink, and introduced amphibian species are of particular concern because of each species' potential negative impacts in Guam's native fauna. Examples of invasive species management approaches include the control of feral ungulates, the control of feral cats and dogs, and the removal of invasive plants to allow native species to flourish in degraded areas.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Exotic and Invasive Species Management (TIS) for Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site.

TIS-1: BROWN TREESNAKE INTERDICTION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #3-4; Goal #3, Objectives #1 and 4; Goal #4, Objectives #1-3; and Goal #7, Objective #3.

- *Strategy*: Maintain, develop, and implement actions to prevent the spread of BTS via the transportation network.
- *Action*: Annually review, update as needed, and develop BTS interdiction projects reflecting BMPs, adaptive management, and cost benefits.
- *Action*: Annually assess continuity and compliance of BTS interdiction activities across Biological Opinions (BO), DoD BTS interdiction operating instructions, and consistency with, and, to the benefit of other relevant JRM conservation actions.
- *Action*: Annually assess ongoing development of new/emergent management strategies and methodologies that reduce or eliminate the risk of BTS.

- *Action*: Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant long-term projects to benefit interdiction management objectives.

TIS-2: BROWN TREESNAKE SUPPRESSION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-4 and 6; Goal #3, Objectives #1 and 4; Goal #4, Objectives #1-3; and Goal #7, Objective #3. Actions listed are in accordance with the 2011 BTS MOA.

- *Strategy*: Suppress and control BTS numbers to support conservation goals for species and ecosystem recovery.
- *Action*: Develop an operational suppression implementation plan. The plan will identify and prioritize potential quality habitat site(s) for suppression actions. Site(s) must consider size, habitat, location, connectivity, synergistic effects, listed species benefits, ecological viability, and support regulatory and mission requirements. Suppression goals and activities will support USFWS recovery plan delisting requirements for threatened and endangered species.
- *Action*: Implement BTS suppression management actions in identified site(s) based on mission support impact and cost effectiveness. Data will be used to determine the minimum thresholds of BTS suppression activities needed to support conditions conducive to species persistence and recovery.
- *Action*: Through annual funding and partnerships, support development of tools and methods that improves monitoring, detection, and suppression in targeted habitat sites.
- *Action:* Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant projects to benefit long-term BTS suppression management actions.

TIS-3: BROWN TREESNAKE MANAGEMENT FOR THE RECOVERY OF PROTECTED SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-4 and 6; Goal #3, Objectives #1 and 4; Goal #4, Objectives #1-3; and Goal #7, Objective #3. Actions listed are in accordance with the 2011 BTS MOA.

- *Strategy*: Suppress and control BTS numbers to support listed vertebrate species recovery.
- *Action*: Develop an operational suppression implementation plan. The plan will identify and prioritize potential quality habitat site(s) for suppression actions. Site(s) must consider size, habitat, location, connectivity, synergistic effects, listed species benefits, ecological viability, and support regulatory and mission requirements. Suppression goals and activities will support USFWS recovery plan delisting requirements for threatened and endangered species.
- *Action*: Implement BTS suppression management actions in identified site(s) based on mission support impact and cost effectiveness. Data will be used to determine the minimum thresholds of BTS suppression activities needed to support conditions conducive to species persistence and recovery.
- *Action*: Through annual funding and partnerships, support development of tools and methods that improves monitoring, detection, and suppression in targeted habitat sites.
- *Action:* Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant projects to benefit long-term BTS suppression management actions.

TIS-4: INVASIVE SPECIES MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #3 and 6; Goal #3, Objective #1 and 4; and Goal #4, Objectives #1-3. This project supports conservation measures from the Reinitiation of the 2015 BO on the DON's Relocation of USMC from Okinawa to Guam and Associated Activities in Guam (USMC Relocation 2017 BO, which contains amendments to the 2015 BO) (USFWS 2017).

- *Strategy*: Control and eventually eradicate invasive plant and invertebrate species to protect and restore habitat.
- *Action*: Control and monitor the entire infested area with repeated applications of ant bait and long-term barrier treatments to prevent ants from entering the area again from adjacent private property that is LFA positive.
- *Action*: Implement BMPs for CRB: (1) annually evaluate the need for comprehensive bio-sanitation of dead coconut trees and implement as necessary, (2) implement proper green waste management, (3) assist in release of landscape-level biocontrol agents for CRB, (4) implement awareness and reporting program in high-risk areas, and (5) implement long-term monitoring program and monitor coconut trees.
- *Action*: Develop a Hazard Analysis and Critical Control Point (HACCP) Plan and implement requirements for construction related to the USMC relocation.

TIS-5: IMPLEMENTATION OF REGIONAL BIOSECURITY PLAN FOR MICRONESIA AND HAWAI'I

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #3; Goal #3, Objectives #1-2 and #4; Goal #4, Objectives #1-4; and Goal #7, Objective #1.

- *Strategy*: Implement appropriate recommendations within the Regional Biosecurity Plan (RBP) (DON 2015c) that will reduce the risk of introduction and spread of invasive species.
- *Action*: Develop standard language for biosecurity BMPs, update as necessary, to be included in project specifications that support prevention, such as vegetation management, and cleanliness standards for materials and equipment operating on the installation.
- *Action*: Conduct early detection surveys (EDS) for high-risk invasive species in training areas; at facilities for staging, storage, and movement of cargo/equipment and vehicles, and at other locations as deemed necessary.
- *Action*: Review and update, as appropriate, DoD Attachment M of the RBP every 3 years.
- *Action*: Develop, implement, and update (as necessary) a JRM biosanitation instruction to ensure cleanliness standards are adhered for the movement of cargo and equipment.
- *Action:* Continue to develop high-risk invasive species protocols and implement control and/or eradication measurement when necessary.

TIS-6: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #2-4; Goal #3, Objectives #1 and 4; and Goal #4, Objectives #1-4. This project supports conservation measures from the BO for the MITT Program (2015 MITT BO) (USFWS 2015b).

- *Strategy*: Implement biosecurity conservation measures listed in the 2015 MITT BO from USFWS.

- *Action*: During training events, ensure 100% BTS canine inspection of aircraft and cargo/equipment departing for an off-island destination.
- *Action*: Ensure BTS awareness briefings for all military and contractor personnel prior to all MITT training activities.
- *Action*: Maintain invasive species rapid response capabilities to control and/or eradicate introduced non-established, non-native invasive species sighted in vicinity of DoD training areas and facilities used for staging, storage, and movement of military personnel, cargo, and vehicles associated with training activities.
- *Action*: Ensure training event personnel conduct biosecurity self-inspections of all personal gear and hand carried items to avoid potential introduction of invasive species to and from Guam. Self-inspection will ensure the removal of soil accumulations, seeds, invertebrates, and vertebrates.
- *Action*: Ensure all training events adhere to the Armed Forces Pest Management Board Technical Guide No. 31 (AFPMB TG-31) cleanliness standards for all cargo/equipment, containers, and rolling stock arriving from off-island destinations and departing Guam for off-island destinations via inspections as deemed necessary.
- *Action*: Implement high-risk invasive species protocols for the control and/or eradication for high-risk species, as species are identified.

TIS-7: CONTROL FERAL DOGS AND CATS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1 and 4; and Goal #4, Objective #2.

- *Strategy*: Reduce threats to native species by implementing a control program for feral dogs and cats in Apra Heights.
- *Action*: Conduct population surveys of areas of highest conservation concern, and/or human safety to determine locations and estimate numbers of feral dogs and cats, review accepted control measures, and coordinate with U.S. Army veterinarian and installation pest control personnel to control by authorized means if impacts to ESA-listed species or other native wildlife are identified.
- *Action*: In accordance with the interagency agreement between the USDA, APHIS Wildlife Services, and NAVFAC, measures will be implemented to control dog and cat population. Trail cameras will be installed in areas identified as having feral dogs and cats. All animals will be trapped using live traps and transferred to a local pet shelter.
- *Action*: NAVFAC will provide population reports and data on population numbers, locations, and home ranges to APHIS Wildlife Services to ensure the most cost-effective wildlife management program is administered.
- *Action*: Include U.S. Navy installation feral dog and cat policy information in all installation outreach material presented to military and civilian personnel, housing residents, and contractors.

7.4.1.3 Terrestrial Protected Species Management

Management of terrestrial threatened and endangered species on JRM-administered lands includes implementing programs to protect species and coordinating efforts with the appropriate agencies. Key threats to threatened and endangered species that can lead to extirpation include:

- Predation by BTS of native forest birds, lizards, and bats;
- Overgrazing, rooting, and trampling of plants and wildlife habitat by feral ungulates;
- Predation by feral cats, dogs, and pigs, as well as predation by monitor lizards on birds, and bats
- Human disturbance and poaching of Mariana fruit bats;

- Mortality or injury to native plants and wildlife due to natural events (e.g., typhoons);
- Low reproductive success due to small population numbers; and
- Habitat loss and fragmentation due to development.

To address these key threats to listed species, JRM has conducted, and continues to conduct, numerous management and research projects to reduce BTS numbers at the local and landscape scale, control BTS at swiftlet caves at NMS, and to prevent their spread to other Pacific Islands through rigorous inspections and interdiction of outgoing cargo at DoD ports (i.e., Apra Harbor and Andersen AFB). Captive breeding programs conducted by Guam DAWR and mainland zoological institutions are maintaining populations of Guam rail and Guam kingfisher, and are adding to the information needed for successful recovery of these species. Additional ecological research and monitoring is also being conducted by various agencies in Guam, including DoD, USDA, and U.S. Geological Survey (USGS).

In accordance with section 7 of the ESA, a federal agency shall consult with the USFWS to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species. The DON will coordinate with the USFWS/Guam National Wildlife Refuge (NWR) for any federal action that is within Overlay Refuge lands and is identified as providing habitat for threatened or endangered species. In addition, the DON will avoid, as the mission allows, impacts on habitat suitable for threatened and endangered species, and locally rare and Guam-listed species.

Sensitive species are being managed by implementing specific management projects that enhance habitat for these species and by initiating specific strategies that address immediate needs of listed species on the installation. In addition, adherence to the goals set for threatened and endangered species management ensure that the installation remains in compliance with ESA and associated consultation requirements.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Protected Species Management (TPS) for Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site. Additional protection measures for terrestrial protected species are presented in Section 7.5.1.6, *Terrestrial Natural Resources Law Enforcement*.

TPS-1: ESA-LISTED SPECIES MONITORING

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-4; and Goal #3, Objectives #1-2 and 4. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Implement a federal ESA-listed species monitoring program to inform adaptive management actions and avoid sensitive areas during construction, operations, and training.
- *Action*: Conduct surveys to document distribution and abundance of federal ESA-listed invertebrates and plants, focusing on newly listed species in 2015. JRM will prioritize areas that have not been recently surveyed for federal ESA-listed species. The monitoring program will update endangered species population distribution maps and GIS databases with data used to inform adaptive management of listed species.
- *Action*: Conduct Mariana fruit bat surveys at Sasa Valley, and Tenjo Vista.

TPS-2: MARIANA COMMON MOORHEN MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #1 and 3-6; Goal #3, Objectives #1-2 and 4; Goal #4, Objective #2.

- *Strategy*: Protect and Enhance Mariana common moorhen population on NCTS Barrigada and Sasa Valley and Tenjo Vista Tank Farms.
- *Action*: Conduct quarterly surveys for moorhen at NCTS Barrigada pond.
- *Action*: Maintain and monitor nesting platforms at NCTS Barrigada pond.
- *Action*: Assess wetland vegetation at locations known to support moorhen, including the use of nesting platforms. Implement vegetation enhancement strategies, if feasible, and coordinate with partners.
- *Action*: Participate in partner agency island-wide annual/bi-annual Mariana common moorhen surveys.
- *Action*: Monitor active moorhen nesting platforms to determine if predation is occurring using trail cameras. If nest predation is observed, conduct predator control to reduce predation in the vicinity of wetlands/ponds.
- *Action*: Assess Sasa Valley and Tenjo Vista Tank Farm wetlands annually for presence of Mariana common moorhen and implement management actions (nesting platforms, vegetation assessments, and predator control) as feasible.
- *Action*: Conduct annual assessment of surveys and nesting platform usage and provide annual report.

TPS-3: MARIANA FRUIT BAT POPULATION MONITORING

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-4; Goal #3, Objectives #1 and 4.

- *Strategy*: Identify and monitor Mariana fruit bat populations at Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site to maintain and identify habitat relationships.
- *Action*: Conduct annual surveys for fruit bats at Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site.
- *Action*: Search for aggregating locations. If aggregations or new colony locations are detected, roost counts will commence in accordance with established survey protocols. If changes in roost locations, colony size, or movement are detected, investigate potential threats or stressors that may be causing disturbance.

7.4.1.4 Migratory Bird Management

JRM installations manage and monitor the effects that both military readiness and non-readiness activities have on migratory bird species and populations. Relevant regulations and policies include the Military Readiness Rule (50 Code of Federal Regulations [CFR] 21.15); the 2014 Memorandum of Understanding (MOU) between the DoD and USFWS to Promote the Conservation of Migratory Birds; and EO 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*. Through the implementation of the INRMP, proper management of migratory bird species and habitats, including the timely implementation of appropriate conservation practices, will help installations avoid or minimize impacts to migratory birds.

To meet the goals and objectives of the INRMP, the following management project was identified for Migratory Bird Management (MIG) for Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site.

MIG-1: MONITORING OF MBTA-LISTED BIRD SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-4; and Goal #3, Objectives #1-2 and 4.

- *Strategy*: Improve understanding of MBTA-listed bird habitat use and bird/mission interactions to avoid and minimize effects of takes on MBTA-listed birds.
- *Action*: Identify migratory bird species of concern (referred to as "Mission Sensitive Species" in the DoD 2017 Guidance for Migratory Bird Management in Integrated Natural Resource Management Plans) and determine interrelatedness between these species and mission activities. These data will inform refinements to monitoring protocols and whether additional management actions for migratory birds are necessary.
- *Action*: Implement bird-safe building designs for new construction (e.g., facilities, utilities, alternative energy projects). For example, install bird-safe building glass to prevent collisions and ensure proper siting for wind energy. Review and update, if necessary, template design and construction specifications to include bird-safe building design guidelines (e.g., see Reducing Bird Collisions with Buildings and Building Glass Best Practices (USFWS 2016).
- *Action*: Continue annual monitoring of MBTA-listed birds to improve understanding of MBTA-listed bird habitat use and bird/mission interactions.

7.4.1.5 Terrestrial Natural Resources Educational Outreach

Conservation awareness is instrumental in creating conditions needed to manage natural resources. The JRM approach to awareness stresses education. It provides military personnel and the public with insights into installation natural environments and conservation challenges. The more educated people are about the unique and valuable natural resources on JRM-administered lands, the more responsibly they will act when using them. Education also promotes awareness of critical environmental projects and the rationale behind them. As activities such as habitat management, wildlife management, and land rehabilitation are generally accepted and understood, minimal effort is required to communicate conservation priorities to installation personnel, recreationists, and the general public. However, issues such as protection of sensitive areas for plant and wildlife species, invasive species management (ungulate management), wildfire suppression, and restrictions on some recreational activities on JRM-administered lands require effective conservation communication to garner positive support and, perhaps more importantly, to avoid adverse reactions from various users. A conservation awareness program must be directed to both installation and external interests if it is to be effective.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Natural Resources Educational Outreach (TEDU) for Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site.

TEDU-1: ESA-LISTED SPECIES AND TERRESTRIAL RESOURCES OUTREACH

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and #4; Goal #6, Objective #1; and Goal #7, Objectives #1-2. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Improve awareness among DoD personnel and the public of threats and stressors to terrestrial resources, including protected species and the importance of conserving natural resources, in cooperative efforts with partners such as GovGuam and USFWS.
- *Action*: Develop, update, and distribute multimedia for public education to incoming military personnel, contractors, schools, and at other outreach opportunities that address appropriate behavior around threatened and endangered species and the consequence of introduced non-native plant and animal species. Outreach materials will be reviewed every 2 to 5 years.
- *Action*: Review and update, as needed, current outreach videos/media used during the orientation briefs and viewed by 100% of new personnel upon arrival to Guam.

TEDU-2: JRM NATURAL RESOURCES STEWARDSHIP OUTREACH AND PUBLIC ENGAGEMENT PROGRAM

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and #4; Goal #6, Objective #1; and Goal #7, Objectives #1-3.

- *Strategy*: Implement a comprehensive natural resources outreach program regarding the federal, territorial, and base environmental regulations and policies, as well as information about the importance of protecting and conserving JRM's natural resources.
- *Action*: Update a comprehensive Natural Resources Stewardship Outreach online training system for military and civilian personnel.
- *Action*: Create a JRM Environmental Public Engagement Plan to outline the areas where JRM can significantly increase their outreach with military personnel and the public about appropriate behavior toward threatened and endangered species and the importance of conserving natural resources within JRM-administered terrestrial and submerged lands.
- *Action*: JRM will utilize annual high profile environmental days, such as Earth Day in April, to organize clean-ups and provide natural resource outreach materials to military personnel and other participants.
- *Action*: Develop, update, and implement a biosecurity education and outreach program for contractor personnel, military personnel, and dependents.

7.4.1.6 Terrestrial Natural Resources Law Enforcement

JRM has established the following objectives for enforcement: (1) enforce laws and regulations pertaining to the implementation of the natural resources program, (2) integrate natural resources enforcement into the overall natural resources program, and (3) use enforcement personnel to enhance the natural resources program at JRM.

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial Natural Resources Law Enforcement (TLAW) for Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site.

TLAW-1: CONSERVATION LAW ENFORCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-3; Goal #2, Objectives #1-2 and 4; Goal #3, Objectives #4; Goal #6, Objective #1; and Goal #7; Objectives #1-3.

- *Strategy*: Detect and deter unauthorized activity that negatively affects natural resources (e.g., poaching, off-roading) through conservation law enforcement.
- *Action*: Establish a Conservation Law Enforcement Program by hiring a Conservation Law Enforcement Officer, and by partnering with other agencies (as applicable), to enforce natural resource laws, policies, and regulations on JRM-administered lands. The Conservation Law Enforcement Officer will conduct outreach and enforce natural resource regulations.

7.4.1.7 Terrestrial Geographic Information System and Data Management

Natural resources data are stored and maintained within a centralized JRM GIS database. The GIS database also provides support for the entire environmental program and the training community. JRM uses GIS for complex analyses such as project siting, data interpolations, and risk assessments.

GIS software enables installation staff to capture, store, update, manipulate, analyze, and display all forms of geographically referenced data and tabular information about natural and physical resources found on JRM-administered lands. The training of JRM staff and the allocation of their time to data entry, mapmaking, data analysis, and interpretation of the results determines the success of the installation GIS. Once fully developed, the installation GIS databases can be used for projects such as the following:

- providing maps with locations of species, vegetation communities, surface waters, and other areas of potential concern
- selecting suitable areas for construction activities
- planning land rehabilitation projects
- providing special maps for Environmental Awareness materials
- ensuring avoidance of threatened and endangered species habitats and other areas of special concern during construction projects
- identifying site options for use during National Environmental Policy Act evaluation of alternative sites
- calculating drainages and water flows
- determining wildlife habitat preferences

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial GIS and Data Management (TGIS) for Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site.

TGIS-1: TERRESTRIAL NATURAL RESOURCES GIS AND DATA MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-5; and Goal #3, Objective #1 and 4.

- *Strategies*:
  - Identify data gaps in terrestrial natural resources GIS to assist in the development of future data collection efforts, surveys, and management actions.
  - Ensure that GIS information is available to installation subject matter experts (SMEs) and military personnel, biologists, planners, contractors, and others in a timely manner to assist with planning and decision-making.
- *Action*: Update and continuously maintain existing centralized GIS database to effectively inform and guide future management of terrestrial natural resources at Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site, and meet natural

resources goals and objectives. Readily available GIS data can be used to develop natural resources constraints maps for use in current and future JRM management and planning decisions.

7.4.1.8 Summary – Terrestrial Resources Ecosystem Management

Implementation of the JRM INRMP program and the focused strategies and actions of the management projects for terrestrial resources provides a conservation benefit to the natural ecosystems within Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site by maintaining and enhancing the natural community structure, function, species diversity, and resiliency. Enhancing and restoring native habitats supports viable populations of native species and increases biodiversity. Furthermore, proactive invasive species prevention, early detection, and control reduces the risk of intra- and inter-island species introductions. Data from regular monitoring of protected species can be used to implement better management projects to enhance and restore habitat, reduce habitat fragmentation, buffer protected areas, implement new conservation strategies, and avoid and minimize impacts. Using this regional ecosystem-based approach for managing protected species and their associated ecosystems ensures that JRM remains in compliance with federal and territorial laws while supporting the operational functionality of the mission for Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site.

Seventeen management projects addressing terrestrial natural resources management are proposed for implementation at Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, and Barrigada Transmitter Site:

- Terrestrial Habitat Management – 2
  - THM-1: Watershed Management
  - THM-2: Fire Prevention and Management
- Terrestrial Exotic and Invasive Species Management – 7
  - TIS-1: Brown Treesnake Interdiction
  - TIS-2: Brown Treesnake Suppression
  - TIS-3: Brown Treesnake Management for the Recovery of Protected Species
  - TIS-4: Invasive Species Management
  - TIS-5: Implementation of Regional Biosecurity Plan for Micronesia and Hawai‘i
  - TIS-6: Mariana Islands Training and Testing Implementation of the Biological Opinion
  - TIS-7: Control Feral Dogs and Cats
- Terrestrial Protected Species Management – 3
  - TPS-1 ESA-listed Species Monitoring
  - TPS-2: Mariana Islands Training and Testing Implementation of the Biological Opinion
  - TPS-3: Mariana Fruit Bat Population Monitoring
- Migratory Bird Management – 1
  - MIG-1: Monitoring of MBTA-listed Bird Species
- Terrestrial Natural Resources Educational Outreach – 2
  - TEDU-1: ESA-listed Species and Terrestrial Resources Outreach
  - TEDU-2: JRM Natural Resources Stewardship Outreach and Public Engagement Program
- Terrestrial Natural Resources Law Enforcement – 1
  - TLAW-1: Conservation Law Enforcement
- Terrestrial Geographic Information System and Data Management – 1
  - TGIS-1: Terrestrial Natural Resources GIS and Data Management

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8 ANDERSEN AIR FORCE BASE

8.1 CURRENT OPERATIONS AND LAND USE

Andersen Air Force Base (AFB) was opened in 1944 as a B-29 bomber staging base in World War II (WWII) and has since served supporting operations in the Asia and South Pacific regions. Since 2009, it has been jointly operated with Naval Base Guam (NBG) under the Joint Region Marianas (JRM) military command. Andersen AFB is a strategically located forward operating base and is vital to the security of the United States (U.S.). Andersen AFB's mission is expanding to support the defense strategy specified in the 2014 Quadrennial Defense Review (QDR) and the 2018 National Defense Strategy (Department of Defense [DoD] 2014, 2018). The QDR is congressionally mandated and directs DoD to review its strategy, programs, and resources. The QDR report delineates a national defense strategy that is consistent with the most recent National Security Strategy by defining force structure, modernization plans, and a budget to allow the military to successfully execute the full range of missions within that strategy.

The 2010 QDR evaluated global U.S. military strategy and priorities (DoD 2010), and called for development of additional training capabilities for unit, combined, and joint forces in the Western Pacific. These additional training capabilities would assure readiness of U.S. forces to carry out military operations as well as humanitarian assistance, disaster relief, and maritime security to maintain regional stability.

The 2014 QDR confirmed the U.S. military's continued commitment to rebalance the Asia-Pacific region, which is increasingly central to U.S. political, economic, and security interests (DoD 2014). The 2014 QDR stated that many of the U.S. forces returning from combat in Iraq and Afghanistan would return to assigned stations in the Asia-Pacific region, rebalancing the forces and providing readiness to support U.S. Indo-Pacific Command (USINDOPACOM) missions. These forces will resume bilateral and multilateral training exercises and pursue increased training opportunities to support the stability of the region.

The 2018 National Defense Strategy identifies an objective to maintain a favorable balance of power in the Pacific region. The strategy highlights achieving peace through strength, which requires a Joint Force to deter conflict through preparedness for war. The ultimate goal of the strategy in the Pacific is to establish transparency and non-aggression with China, which can only be achieved through prioritizing preparedness (DoD 2018).

The 36th Wing (36 WG) is the host unit to U.S. Air Force (USAF), U.S. Army, U.S. Department of the Navy (DON), and U.S. Marine Corps (USMC) Active forces along with USAF Reserve and Air National Guard. The Wing's mission is to provide the highest quality peacetime and wartime support from its strategic Pacific location. Guam serves as a stopping point for numerous aircraft en route to Japan, Korea, and other Indo-Asian Pacific locations. Andersen AFB accommodates family housing as well as a live-fire training range complex as specified in the 2015 Record of Decision for the Final Supplemental Environmental Impact Statement (EIS) for Guam and Commonwealth of the Northern Mariana Islands (CNMI) Military Relocation (DON 2015a) and in the MITT 2020 Supplemental Environmental Impact Statement (EIS).

8.1.1 Land Ownership and Management



Munitions storage igloos on Andersen AFB.
(*Photo*: L. Shaughnessy)

Andersen AFB is located in Yigo at the northern tip of Guam (Figure 8-1) and covers approximately 15,400 acres (6,232 hectares). Ownership of Andersen AFB lands was transferred to the DON in 2009 during transition of Andersen AFB to operate under JRM command. The main operations area of the base is in the eastern third of the installation at approximately 600 feet (183 meters) above sea level. This area includes the main active airfield and an array of operations, maintenance, and community support facilities. The central third of the installation is a Munitions Storage Area (MSA). The western third is Northwest Field (NWF), which is the main Contingency Readiness Group cantonment, various field exercises, bivouacs, and is the permanent location of the Pacific Air Forces Regional Training Center. Two active hunting areas are located south of NWF. Several Special Conservation Areas (i.e., areas designated for the conservation of natural resources) are found on or adjacent to Andersen AFB.

8.1.2 Andersen Air Force Base Assets and Uses

8.1.2.1 Andersen Main Base

Andersen Main Base consists of about 11,018 acres (4,459 hectares) and is administered by the 36 WG. The main base is used for airfield operations and training, headquarters, munitions storage, and Explosive Ordnance Disposal (EOD) training. As an operational airfield, the main base includes operations, administration, maintenance, housing, and community support facilities. The 36 WG supports all U.S. military aircraft and personnel transiting the Mariana Islands Range Complex (MIRC) (DON 2010, 2015b).

8.1.2.2 Northwest Field

NWF is an WWII-era airfield that includes two runways that have historically been used for both aircraft and ground-based operations. Presently, approximately 280 acres (113 hectares) of land are cleared near the eastern end of both runways for parachute drop training. The south runway is used for training of short field and vertical lift aircraft and often supports various types of ground maneuver training. Helicopter units use other paved surfaces for confined area landing, simulated amphibious ship helicopter deck landings, and insertions and extractions of small maneuver teams (Pacific Air Forces 2006; DON 2010).

About 3,562 acres (1,442 hectares) in NWF are available for maneuver training, field exercises, and bivouacs. These activities consist of camp/tent setup, survival skills, land navigation, day/night tactical maneuvers and patrols, blank ammunition and pyrotechnics firing, treatment and evaluation of casualties, fire safety, weapons security training, perimeter defense/security, field equipment training, and chemical attack/response (DON 2010). The establishment of an Intelligence/Surveillance/Reconnaissance (ISR) Strike Project on Andersen AFB was terminated in 2020, however infrastructure upgrades to the North Ramp have commenced.

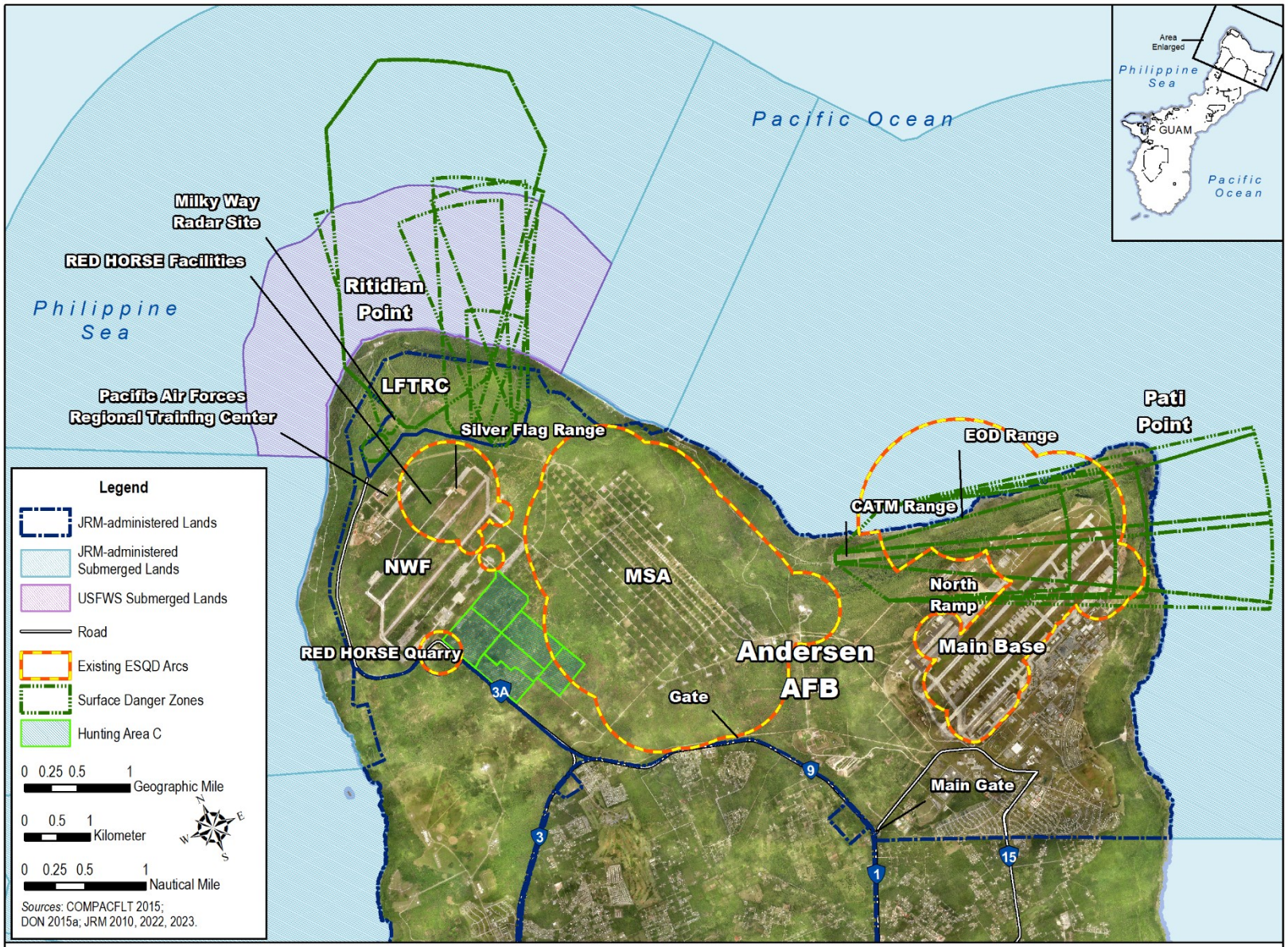


Figure 8-1
Overview of Andersen AFB

8.1.2.3 Munitions Storage Areas

Andersen AFB has two MSAs with a total of 144 munitions storage igloos (126 igloos in MSA I and 18 igloos in MSA II). The current total munitions storage capacity at Andersen AFB is 384,000 square feet (35,675 square meters). A third MSA is located near the North Ramp and is utilized by the Marine Corps. MSA II is part of an historic district and contains architectural resources eligible for listing in the National Register of Historic Places. Activities planned for Andersen AFB will require 664,000 square feet (61,688 square meters) of operational munitions storage floor space, resulting in a storage capacity shortfall of 280,000 square feet (26,01 square meters). The 36 WG is in the process of addressing the anticipated storage shortfall while considering existing environmental constraints (JRM and Andersen AFB 2016).

8.1.2.4 Tarague Basin Combat Arms and Training Maintenance Range

The Tarague Basin Combat Arms and Training Maintenance (CATM) Range (29.5 acres [11.9 hectares]) located east of Pati Point beach in the Tarague Basin supports training with pistols, rifles, machine guns up to 7.62 millimeters, and inert mortars up to 60 millimeters. Training is also conducted with the M203 40-millimeter grenade launcher using inert training projectiles only (DON 2010). A Surface Danger Zone (SDZ) associated with the CATM (refer to Figure 9-1) extends to the east of the range, with a ricochet area of 1,975 acres (799 hectares) and a secondary danger area of 1,011 acres (409 hectares).



Tarague Basin Combat Arms and Training Maintenance Range lies in the north of Andersen AFB in Tarague basin.
(*Photo*: L. Shaughnessy)

8.1.2.5 Explosive Ordnance Disposal Range

The EOD Range, small arms firing ranges, and associated safety zones are located on the shore near Tarague Beach. The locations of the Explosive Safety Quantity Distance (ESQD) arcs are shown on Figure 8-1. EOD operations have been in existence since 1961 and are conducted in accordance with the U.S. Environmental Protection Agency (USEPA) and Guam Environmental Protection Agency (Guam EPA) regulations. EOD and small arms firing operations affect only the immediate locations of detonation or firing. Explosions at the EOD pit and on the CATM range are conducted on hardtop surfaces or within fire control pits, and fires resulting from these explosions are rare and negligible. Land-based detonations at the EOD Range were the subject of consultations between Andersen AFB and U.S. Fish and Wildlife Service (USFWS), which were concluded in August 2004 (DON 2009; National Marine Fisheries Service [NMFS] 2010). The Pacific Islands Fish and Wildlife Office concurred with the Andersen AFB determination that the Pati Point EOD Range would not adversely affect Endangered Species Act (ESA)-listed species. The 554th RED HORSE Squadron Demolition Team and 736th Security Forces Squadron and other units periodically hold EOD training events at this location, following notification to the public through the Andersen Public Affairs office.

Increased security conditions at the location afford the Mariana fruit bat (*Pteropus mariannus mariannus*) and green sea turtle (*Chelonia mydas*) greater protection when they frequent this area of Tarague Basin.

8.1.3 Training Areas

Training activities approved at Andersen AFB, subject to the conservation recommendations in the USFWS Biological Opinion (BO) for the Mariana Islands Training and Testing Program (MITT), the NMFS ESA section 7 Consultation BO and Conference Report, and the MITT EIS, include USAF combat search and rescue, urban warfare training, non-combatant evacuation operations, personnel insertion/extraction, embassy reinforcement, direct action combat (close quarters and breaching), ISR, urban warfare training, maneuver (convoy land navigation), field training exercise, force protection, anti-terrorism, seize airfield, airfield expeditionary, and land demolitions (improvised explosive device and unexploded ordnance [UXO]) (USFWS 2015a; NMFS 2020; Naval Facilities Engineering Systems Command [NAVFAC] Pacific 2020). USMC training activities on Andersen AFB include training activities on the Live-fire Training Range Complex. Table 8-1 provides a summary of training areas associated with Andersen AFB (refer to Figure 8-1 for training area locations).

8.1.4 Danger Zones

ESQD arcs on Andersen AFB are associated with all MSAs, the EOD, and small arms firing ranges (see Figure 8-1). The arcs shown on Figure 8-1 are the Inhabited Building Distance arcs, within which buildings that are routinely inhabited are not permitted for safety reasons. Smaller diameter public road and highway ESQD arcs (not shown on Figure 8-1) are generated from the munitions operation site.

SDZs are also found within Andersen AFB (see Figure 8-1) and extend outwards and offshore from small arms firing ranges and related activities. SDZs encompass portions of a range in the horizontal plane that are endangered by firing a particular weapon. They include areas between the firing line and the target line, an impact area, a ricochet trajectory area, and a secondary danger area. In addition, the SDZ may also include a weapon back-blast area. The SDZ must be located completely within the boundaries of U.S. government-owned or -leased properties. Due to limited access, biological surveys and related conservation activities may be restricted to irregular, brief periods of time when ranges are not in use and free of UXO.

8.1.5 Special Conservation Areas

Andersen AFB has several areas designated for conservation of natural resources. Table 8-2 provides a summary of the acreages for the largest areas and Figure 8-2 displays the locations.

Table 8-1. Summary of Training Areas on Andersen AFB

Training Area[1]	*Description**
Main Base	• Used for aviation. Is a working airfield and has a full array of operations, maintenance, and community support facilities. Supports all U.S. military aircraft and personnel transiting the MIRC. Facilities are available for cargo staging and inspection.
Northwest Field	• Traditionally used for vertical and short field landings. Eastern end of both runways used for parachute drop training. • Planned expansion of the CDZ will open up portions of NWF airborne/DZLZ training activities. • Helicopter units have used other paved surfaces for confined area landing, simulated amphibious ship helicopter deck landings, and infil/exfil of small maneuver teams. • Other training exercises include camp/tent setup, survival skills, land navigation, day/night tactical maneuvers and patrols, blank ammunition and pyrotechnics firing, treatment and evaluation of casualties, fire safety, weapons security training, perimeter defense/security, field equipment training, and chemical attack/response. • Used for the RED HORSE Squadron and its Silver Flag training unit, the Commando Warrior training program, and the Combat Communications squadron.
Tarague Basin (CATM Range)	• Tarague Basin is used for the CATM small arms range. The CATM range supports training with pistols, rifles, machine guns up to 7.62 millimeters, and inert mortars up to 60 millimeters. Training is also conducted with the M203 40-millimeter grenade launcher using inert training projectiles only.
Tarague Basin (EOD Range)	• The RED HORSE Squadron and Security Squadron use the EOD Range for training and disposal of UXO on an as needed basis.

Note: [1] Refer to Figure 8-1 for locations of all training areas.
Key: AFB = Air Force Base; CATM = Combat Arms and Training Maintenance; CDZ = Cargo Drop Zone; DZLZ = Drop Zone/Landing Zone; EOD = Explosive Ordnance Disposal; infil/exfil = infiltration/exfiltration; MIRC = Mariana Islands Range Complex; NWF = Northwest Field; RED HORSE = Rapid Engineer Deployable Heavy Operations Repair Squadron Engineers; U.S. = United States; UXO = unexploded ordnance.
Sources: DON 2010, 2015b; U.S. Army 2015.

Table 8-2. Special Conservation Area Acreage on Andersen AFB

Special Conservation Areas	*Terrestrial Lands (acres)*	*Submerged lands (acres)*	*Managed Nearshore Areas (acres)*
Overlay Refuge Lands[1]	8,941.20	--	--
MCB Camp Blaz Forest Enhancement Area[2]	*654.32*	--	--
MCB Camp Blaz NWF Ungulate Control Area[2]	*596.18*	--	--
Pati Point Nature Area	713.30	--	--
Ungulate Exclosures (Tarague Fences 1 and 2)	10.21	--	--
HMU	137.58	--	--
Guam Micronesian Kingfisher MOA Recovery Habitat	3,853.30	--	--
Andersen AFB Marine Resources Preserve	--	10,672.55	1,340.67
Total Special Conservation Area Land	**14,906.09**	**10,672.55**	**1,340.67**

Notes: [1] Overlay Refuge lands include some that are designated as other conservation areas. The sum of acres for all conservation areas does not equal the total area of land designated as conservation land.
[2] These sites are located within the Overlay Refuge, and their areas are not included in the total of Conservation Lands.
Key: AFB = Air Force Base; HMU = Habitat Management Unit; MCB = Marine Corps Base; MOA = Memorandum of Agreement; NWF = Northwest Field.
Sources: NAVFAC Marianas GIS data, JRM 2023.

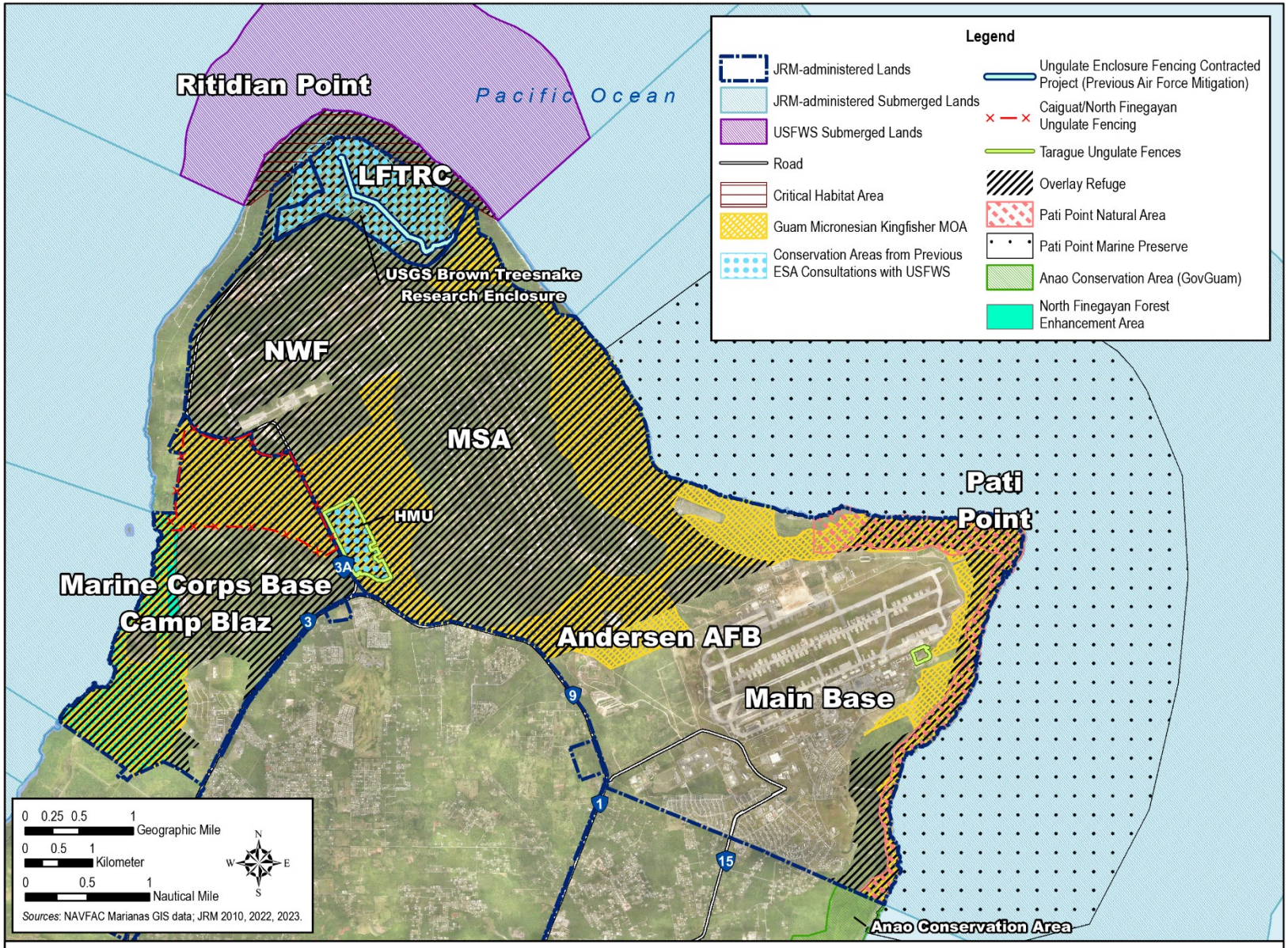


Figure 8-2
Special Conservation Areas on Andersen AFB

8.1.5.1 Overlay Refuge Lands

Overlay Refuge lands were established in 1994 and provide a commitment by the DoD and USFWS for a coordinated program with Guam Division of Aquatics and Wildlife Resources (Guam DAWR). The program is centered on the protection of threatened and endangered species and other native flora and fauna, the maintenance of native ecosystems, and the conservation of native biological diversity. The program does recognize that the primary purpose of Overlay Refuge lands is to support the national defense mission of the USAF (Government of Guam [GovGuam] et al. 1993; USAF and USFWS 1994).

Approximately 8,941.20 (3,618.78 hectares) of Overlay Refuge lands are designated on Andersen AFB (Figure 8-2). These lands are currently managed by JRM and were originally identified as providing important habitat for federal ESA-listed threatened and endangered species (e.g., Mariana crow [*Corvus kubaryi*], Guam kingfisher [*Todiramphus cinnamominus*], Guam rail [*Gallirallus owstoni*], and *Serianthes nelsonii*) as well as other Guam native species. The Overlay Refuge lands on Andersen AFB consist primarily of limestone degraded forest (2,240 acres [906.5 hectares]), *Vitex* Forest (2,260 acres [914.59 hectares]), and limestone native forest (1,738 acres [703.34 hectares]). Altogether, these three vegetation communities cover 43.9 percent (%) of the AFB lands.

8.1.5.2 Pati Point Nature Area and Andersen Air Force Base Marine Resources Preserve

The Andersen AFB Marine Resources Preserve was established in 1973 to protect the coastal resources surrounding the northeastern portion of the base (Stevens 1973). Adjacent to the Marine Resources Preserve is the Pati Point Nature Area, which is intended to protect the coastal marine environment. GovGuam established Pati Point Marine Preserve on May 16, 1997 by Guam Public Law (PL) 24-21 (JRM 2013). Pati Point Marine Preserve covers nearly the same areas as the Andersen AFB Marine Preserve (4,819 acres [1,950 hectares]) and the Pati Point Nature Area (713 acres [288 hectares]) (see Figure 8-2). Underwater surveys done in 2011 confirmed the effectiveness of the Preserve in protecting the coastal marine environment around Pati Point (Williams et al. 2012).

8.1.5.3 Habitat Management Unit

The Habitat Management Unit (HMU) is approximately 148 acres (60 hectares) and was established to enhance native habitat based on the 2002 Area 50 Restoration Plan (NAVFAC Marianas and Andersen AFB 2017a). The plans for the HMU included the removal and exclusion of ungulates and other introduced predators such as rats, shrews, and cats; additionally, a brown treesnake (BTS) (*Boiga irregularis*) barrier was erected along the fenceline with the intention of eradicating snakes as a conservation measure to improve foraging habitat for Mariana fruit bats and Mariana crows (NAVFAC Marianas and Andersen AFB 2017a). Since it was established, the HMU has been used by various agencies as a test site for control and monitoring programs focused on the removal of invasive species and habitat restoration.



Outward appearance of the HMU perimeter barrier.
(*Source:* NAVFAC Marianas and Andersen AFB 2017a)

8.1.5.4 Guam Kingfisher Memorandum of Agreement Recovery Habitat

As mentioned in Section 4.4.3.2, *Birds*, a Memorandum of Agreement (MOA) was signed between DON and USFWS to establish Recovery Habitat for the Guam kingfisher. A modification to the MOA was signed in December 2015, identifying total 5,211 acres (2,108 hectares) (3,853 acres [1,559 hectares] within Andersen AFB) of habitat that will be protected such that the land is suitable for the kingfisher. The MOA also requires habitat protection to offset any impacts to the habitat brought on as a result of the Guam Military Relocation (DON and USFWS 2015a, 2015b).

8.2 TERRESTRIAL ENVIRONMENT

8.2.1 Geology, Topography, and Soils

8.2.1.1 Geology

Geologic Units

Andersen AFB is situated on a plateau that is composed of old (Barrigada) and young (Mariana) limestone bedrock (Figures 8-3 and 8-4). Cavities and sinkholes occur in the porous limestone karst, including a large sinkhole (Installation Restoration Program [IRP] Site 66) on the northeastern portion of the installation located approximately 700 by 900 feet (213 by 274 meters) from the coastline. Rainwater easily percolates through the porous limestone (Gingerich 2003). Beaches are found along the coastline where cliffs retreat. The beaches are comprised of deep, poorly draining beach/reef deposits, which generally consist of beach sand and fragments of coral, coralline algae, mollusks, *Halimeda* algae, echinoid spines, and shells of benthic foraminifera (Water and Environmental Research Institute [WERI] and Island Research & Education Initiative [IREI] 2016).



Andersen AFB is composed of limestone bedrock. Undisturbed karst environment hinders the access of ungulates and supports the persistence of limestone native forests.
(*Photo*: L. Shaughnessy)

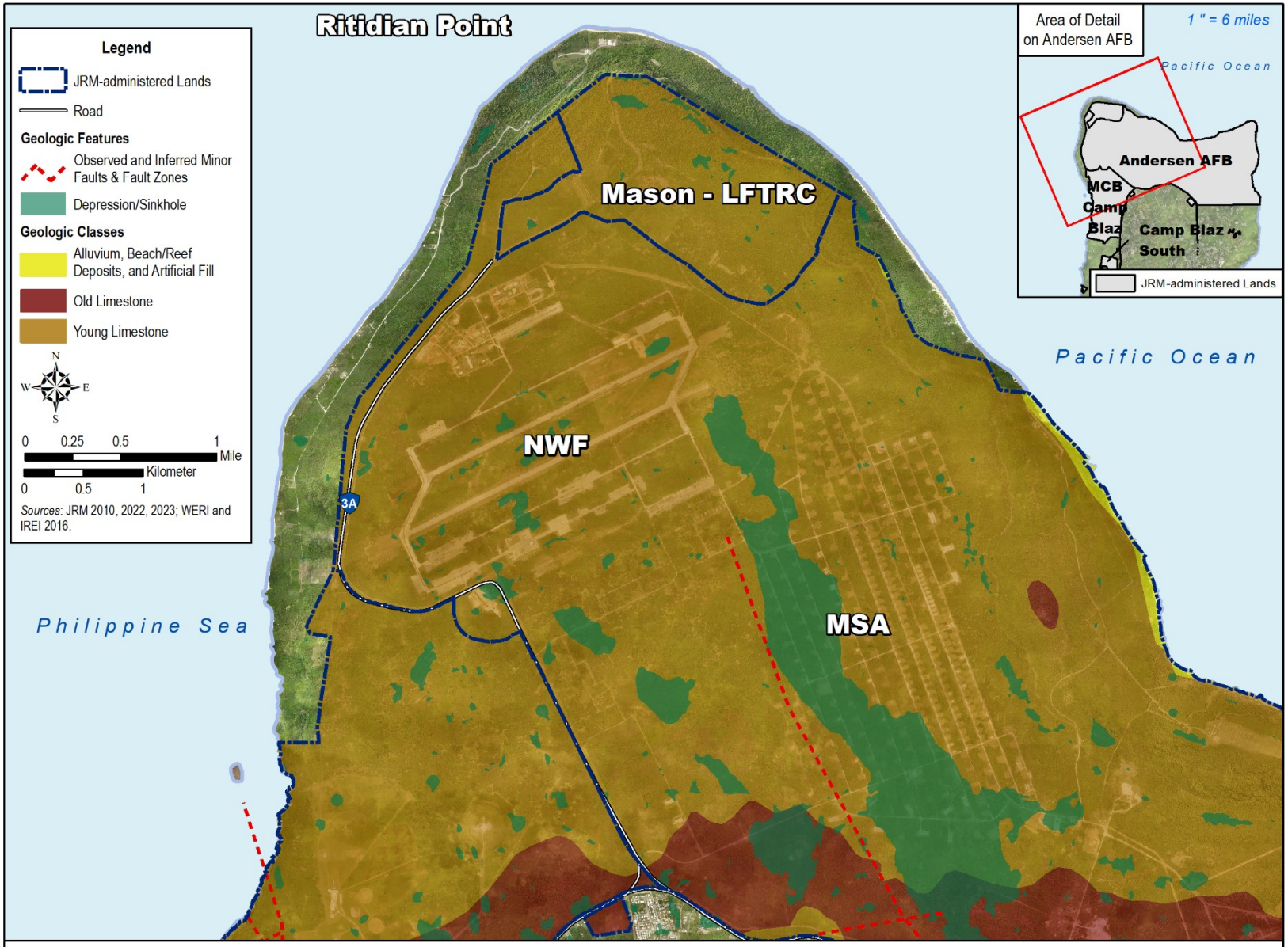


Figure 8-3
Geological Features on Western Andersen AFB

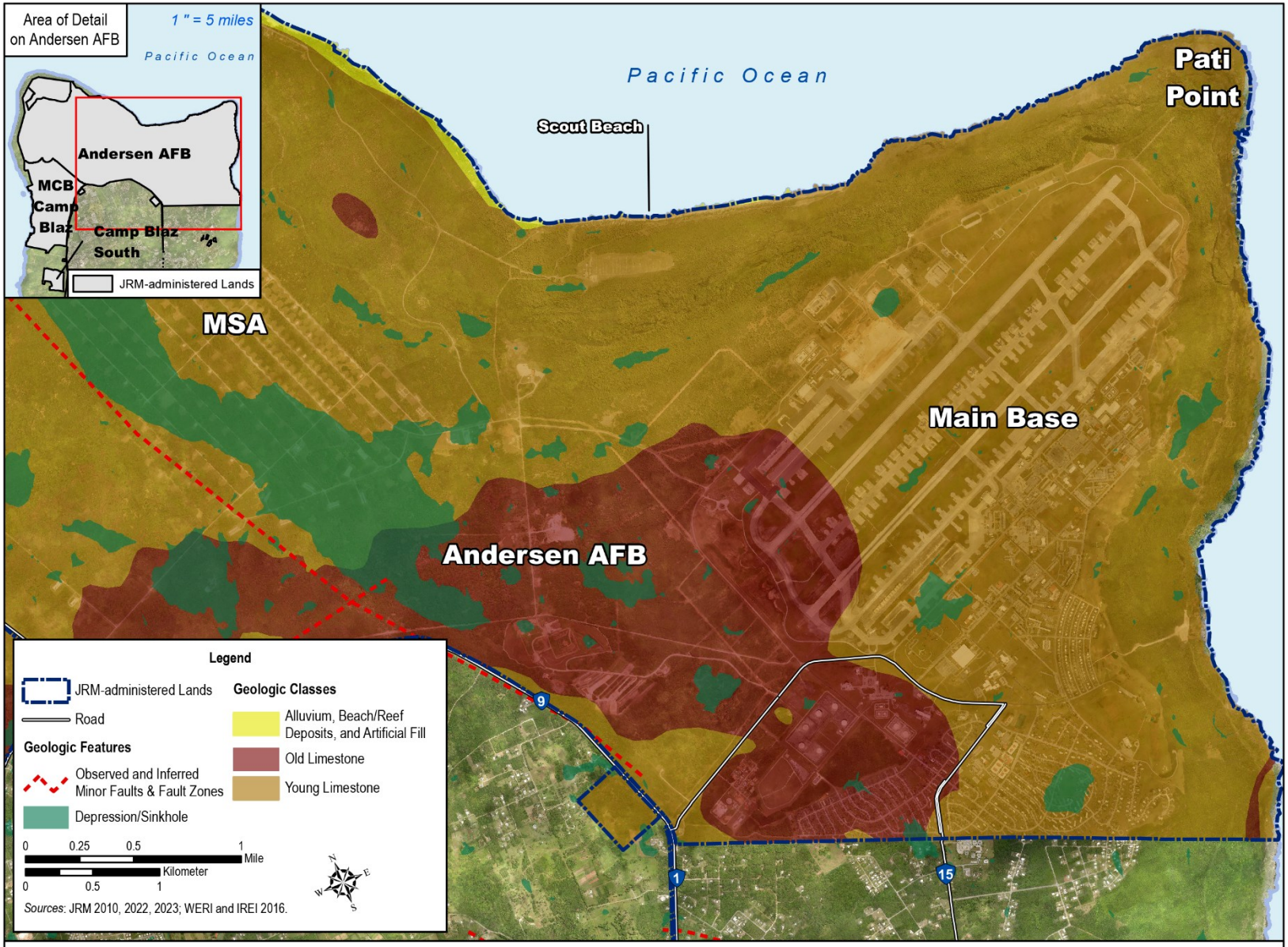


Figure 8-4
Geological Features on Eastern Andersen AFB

Seismology

Andersen AFB overlies a minor fault line and is susceptible to earthquake events. However, the overall likelihood for landslides to occur on northern Guam is generally low due to the lack of steep areas with soil vulnerable to slipping in seismic events. The Guam Hazard Mitigation Plan reports that the northern portion of Andersen AFB has a high-risk of liquefaction (Guam Homeland Security 2014). According to the Guam Hazard Mitigation Plan, the areas in Guam determined to be susceptible to a large tsunami include all landmasses below 16 feet (5 meters) in mean sea elevation. The low-lying coastal areas around Andersen AFB are susceptible to tsunami inundation (Guam Homeland Security 2014).

8.2.1.2 Topography

Andersen AFB is situated in Guam's northern limestone plateau. The plateau's elevation ranges from 295 to 590 feet (90 to 180 meters) above mean sea level (MSL) with steep cliffs surrounding the plateau on the north, east, and west. A coastal lowland terrace extends between 300 to 900 feet (90 to 270 meters) from the bottom of the cliffs to the ocean.

8.2.1.3 Soils

Andersen AFB land is dominated by shallow, well-drained limestone upland soils on the limestone plateau and cliffs and well-drained coastal limestone sands (Figures 8-5 and 8-6); a description of each soil type is provided in Table 4-1 in Section 4.2.3, *Soils*.



Steep cliffs surround the northern limestone plateau on the north, east, and west sides.
(*Photo*: L. Shaughnessy)



Coastal lowland terraces stretch outward from the cliffs to the ocean on Andersen AFB.
(*Photo*: L. Shaughnessy)

8.2.2 Hydrology

8.2.2.1 Surface Water

Andersen AFB is located in the Agafa Gamas and Andersen drainage basins (refer to Figure 4-8a). No natural surface water resources such as lakes or streams occur on Andersen AFB because of the high permeability of the limestone bedrock; however, Jocson et al. (2002) note that temporary ponding, even on the high permeability limestone plateau, can occur during prolonged heavy rains and typhoon events. Rainfall typically percolates into limestone cavities or is channeled into dry wells located throughout Andersen AFB. Stormwater runoff from impervious surfaces is currently directed via concrete-lined culverts to underground injection control wells, which are permitted and regulated by Guam EPA (DON 2015c).

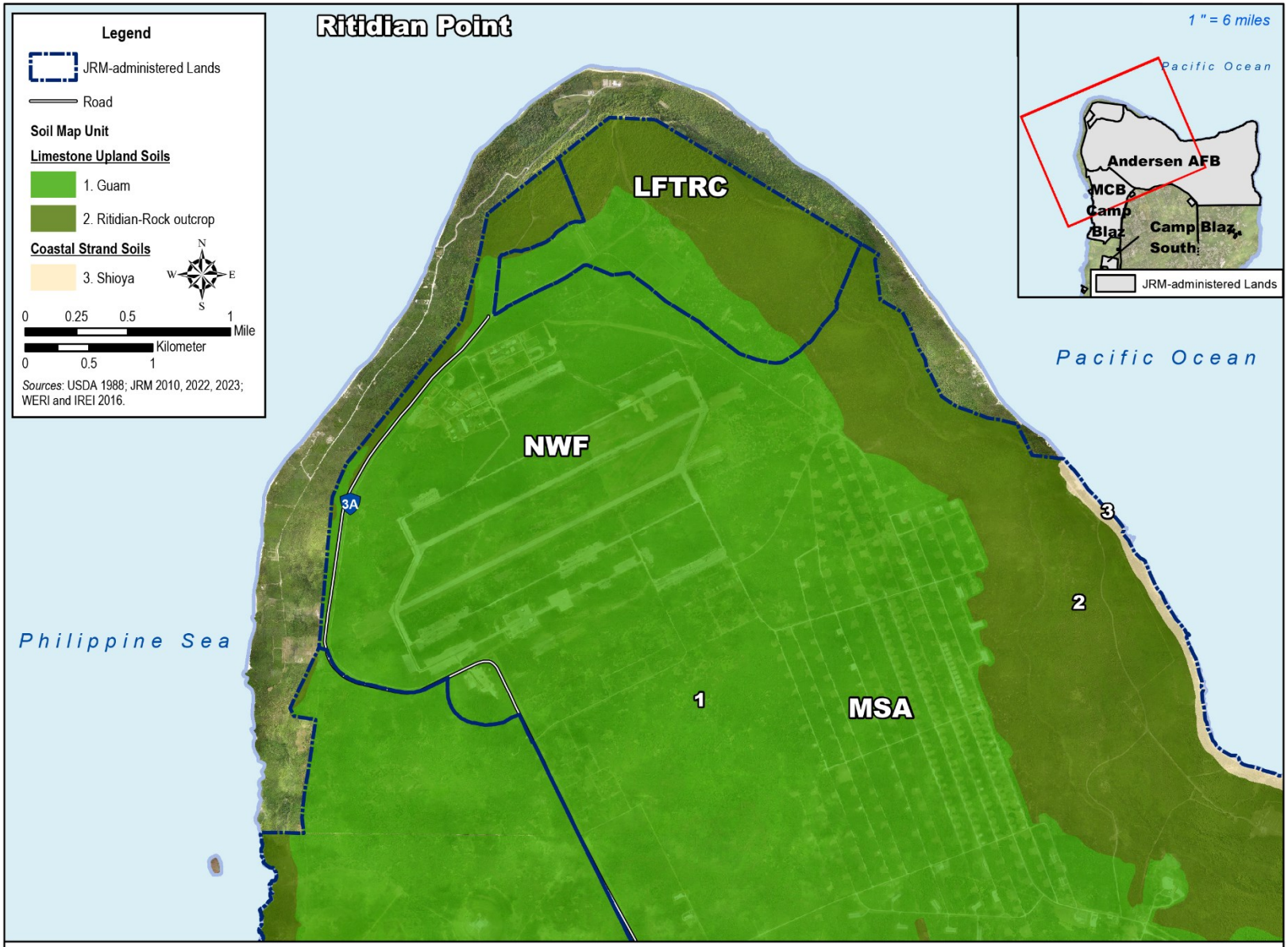


Figure 8-5
Soils on Western Andersen AFB

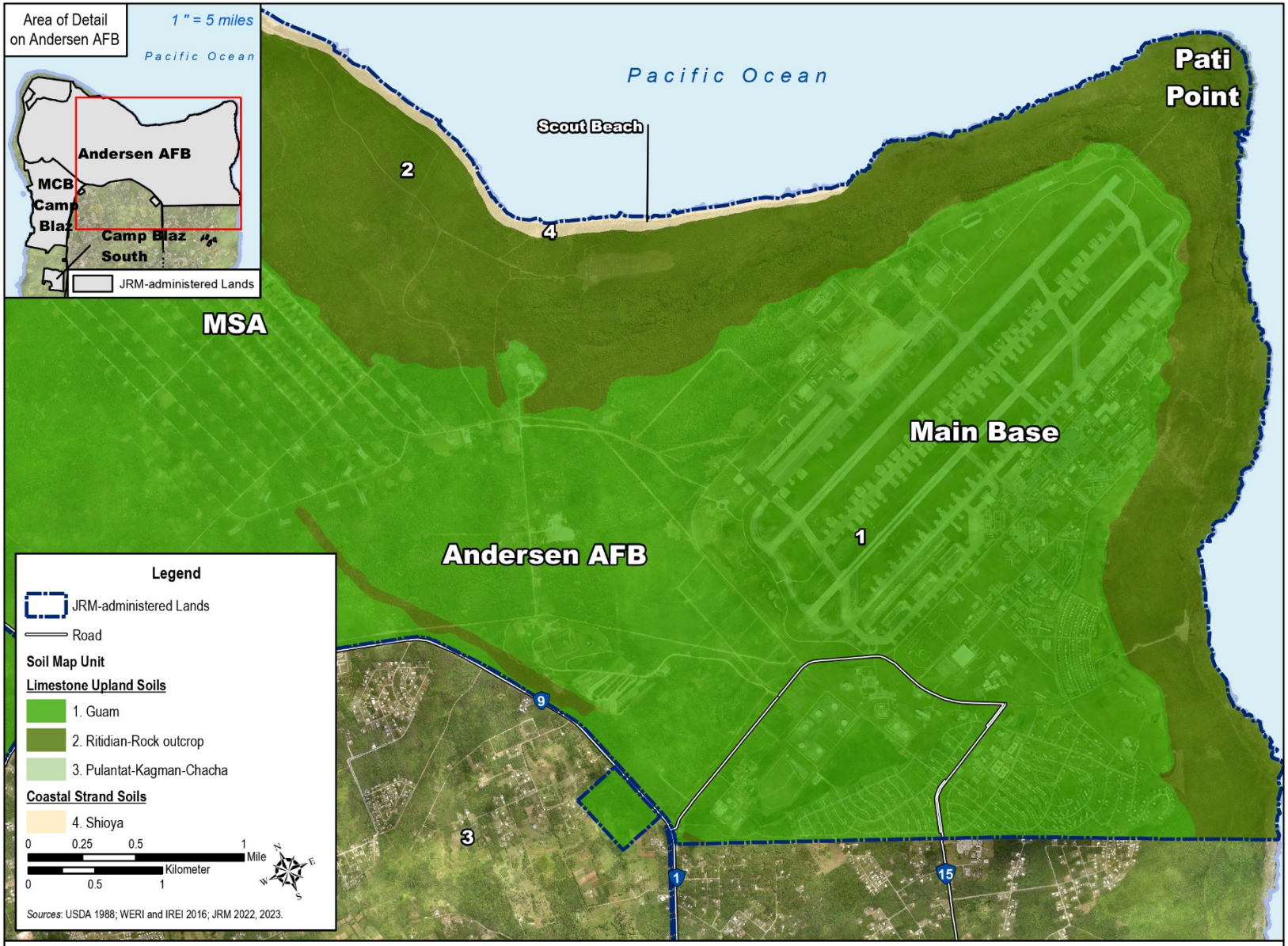


Figure 8-6
Soils on Eastern Andersen AFB

8.2.2.2 Groundwater

Andersen AFB overlies the northern portion of the Northern Guam Lens Aquifer (NGLA), an island karst aquifer located in uplifted young, highly conductive limestone that covers the northern half of Guam (Jocson et al. 2002). Andersen AFB is located atop the three northern sub-basins: the Finegayan Sub-basin lies under the western third of the base; the Agafa Gumas Sub-basin lies under the central portion of the base (which includes NWF); and the Andersen Sub-basin lies under the eastern portion of the base (refer to Figure 4-10) (Gingerich 2003). A potable water well field on Andersen AFB, south and southeast of the MSA, is proposed for development as a result of the Guam Military Relocation (DON 2015c).

Groundwater is encountered at around sea level, which averages around 450 feet (137 meters) below the ground surface under the limestone plateau upon which most of the base sits. Approximately 100 dry wells have been drilled to facilitate the flow of stormwater into the underlying groundwater basins. To prevent potential pollution and contamination of the groundwater from stormwater, Andersen AFB has implemented a Stormwater Pollution Prevention Plan (DON 2010). Andersen AFB's water supply comes from groundwater wells on Marine Corps Base Camp Blaz (MCBCB) Urban Training Complex.

8.2.3 Vegetation Communities

Andersen AFB is located primarily on a limestone plateau, but there are also substantial areas of rocky and sandy coastal strands, lowland forest, coastal terraces, and vertical cliffs. The classification system used to describe the vegetation on Andersen AFB is described in Section 4.4.1, *Vegetation Communities.* The base has the largest area of limestone native forest on JRM-administered lands, with over 2,500 acres (1,012 hectares), generally along the northern and eastern coastal plateau (NAVFAC Marianas 2016a). These communities are typically dominated by one or more of the following: banyan (*Ficus* spp.), *Ochrosia* (=*Neisosperma*) *oppositifolia*, *Aglaia mariannensis*, *Meiogyne cylindrocarpa*, *Premna serratifolia*, *Eugenia reinwardtiana*, and *Pandanus tectorius*. Also dominant or prominent in some areas are *Macaranga thompsonii* and *Pisonia grandis*. Edges of limestone native forest often contain or are dominated by the tree/shrub *Ochrosia mariannensis*. Table 8-3 provides the vegetation communities found on Andersen AFB, the acreage of each type, and the percentage of undeveloped areas; Figures 8-7 to 8-9 identify the locations of vegetation communities.



The slopes of the plateau on Andersen AFB support limestone native forest and include species such as *Cycas micronesica*, *Meiogyne cylindrocarpa*, and *Aglaia mariannensis*.
(*Photo*: L. Shaughnessy)

Table 8-3. Vegetation Communities on Andersen AFB

Vegetation Community	*Area (acres)*	*% of Total Area*	*% of Vegetated, Undeveloped Area*
Casuarina Forest [(1)]	121.1	0.8	1.1
Coconut Forest [(1)]	318.0	2.1	3.0
Limestone Coastal Scrub	415.0	2.7	4.0
Limestone Degraded Forest [(1)]	3,288.7	21.4	31.5
Limestone Native Forest	2,541.7	16.5	24.4
Non-native Forest			
Leucaena Forest [(1)]	52.9	0.3	0.5
Vitex Forest [(1)]	2,790.3	18.1	26.7
Other Shrub/Grassland	863.8	5.6	8.4
Strand	46.5	0.3	0.4
Non-vegetated categories			
Barren	54.5	0.4	NA
Developed	4,886.3	31.8	NA
Total	**15,378.8**		

Note: [(1)] Categorized as a type of degraded forest.
Key: % = percent; AFB = Air Force Base; NA = not applicable.
Sources: U.S. Forest Service 2006; NAVFAC Marianas 2016b.

Approximately 55% of the vegetated, undeveloped areas of Andersen AFB are dominated primarily by degraded forest communities (NAVFAC Marianas 2016b). In some cliffline areas, and on the plateau away from the cliffline, the forest is substantially disturbed from prior clearing, ungulate damage, and/or invasive plant encroachment. These forested areas are either mapped as degraded limestone forest, or they are dominated by the non-native and invasive *Vitex parviflora* and are mapped as *Vitex* forest. Other degraded areas have dominant species that might include the native pago (*Hibiscus tiliaceus*) or *P. tectorius*. While native, pago and *P. tectorius* can become invasive, forming dense stands and crowding out other natives.

Other invasive plants found in Andersen AFB include the small trees/shrubs custard apple (*Annona reticulata*), *Mikania micrantha,* and *Passiflora suberosa*, as well as the herbaceous ground covers *Chromolaena odorata*, and *Bidens pilosa*. Coastal areas, which include rocky and sandy substrates, have a variety of shrubs and herbs. In some areas behind coastal strands are large stands of coconut (*Cocos nucifera*). Rocky coastal areas are often dominated by the native shrub *Pemphis acidula*.

Large stands of the endemic *Cycas micronesica* are present in areas of both native and degraded limestone forest. As with NBG Telecommunications Site (TS), most of these *C. micronesica* plants show signs of infestation by cycad scale (*Aulacaspis yasumatsui*) and are in very poor condition.

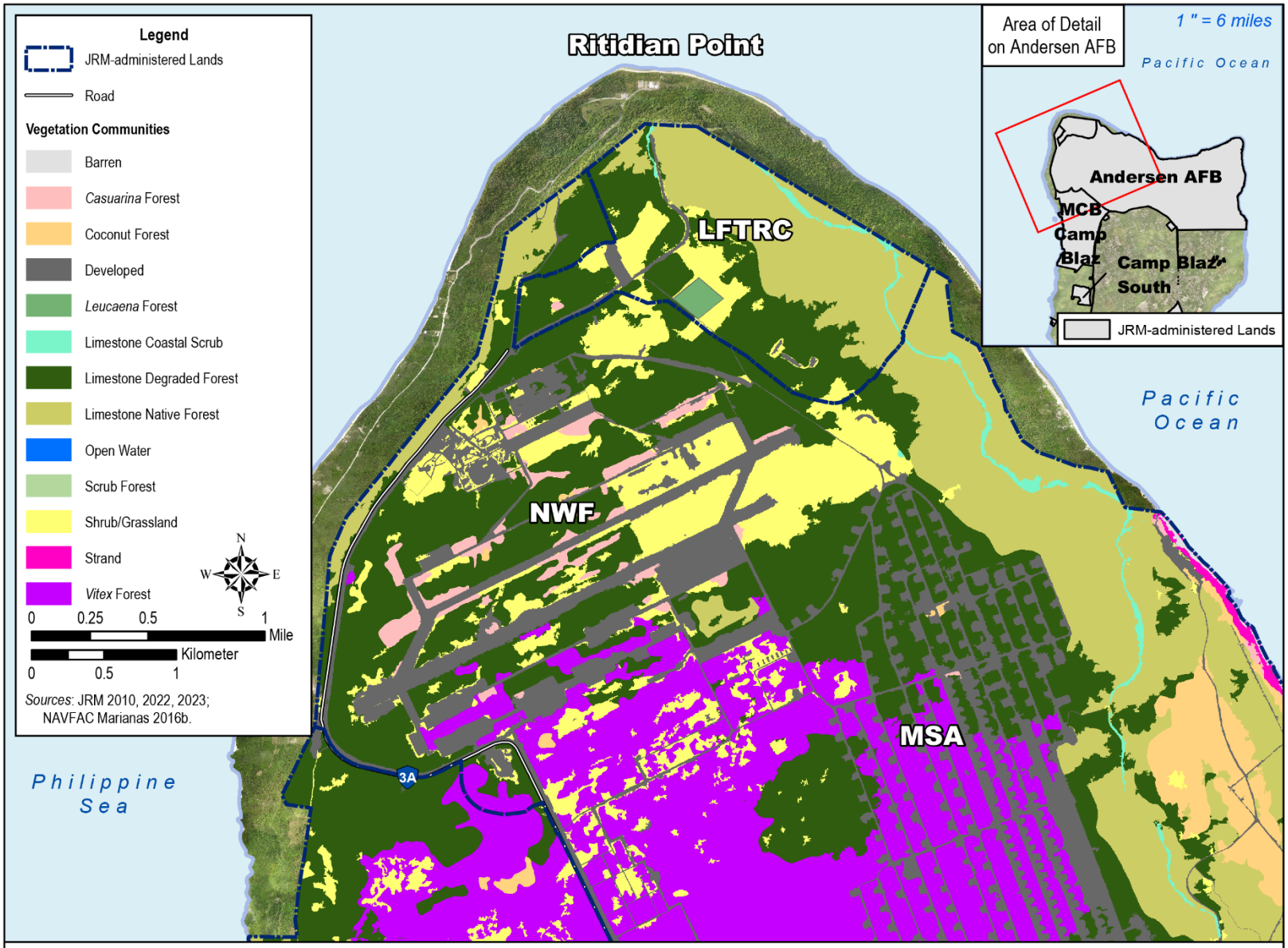


Figure 8-7
Vegetation Communities on Western Andersen AFB

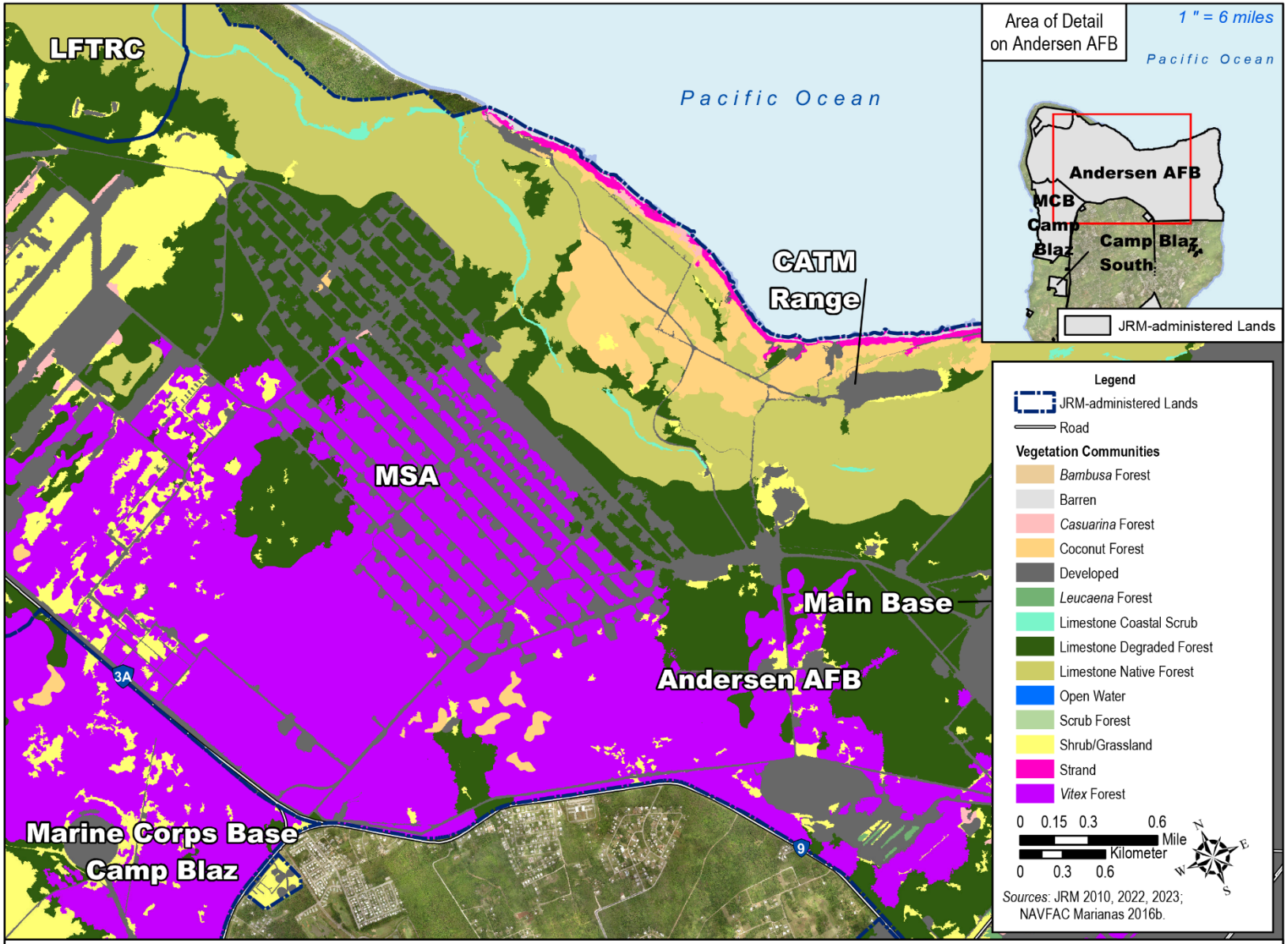


Figure 8-8
Vegetation Communities on Central Andersen AFB

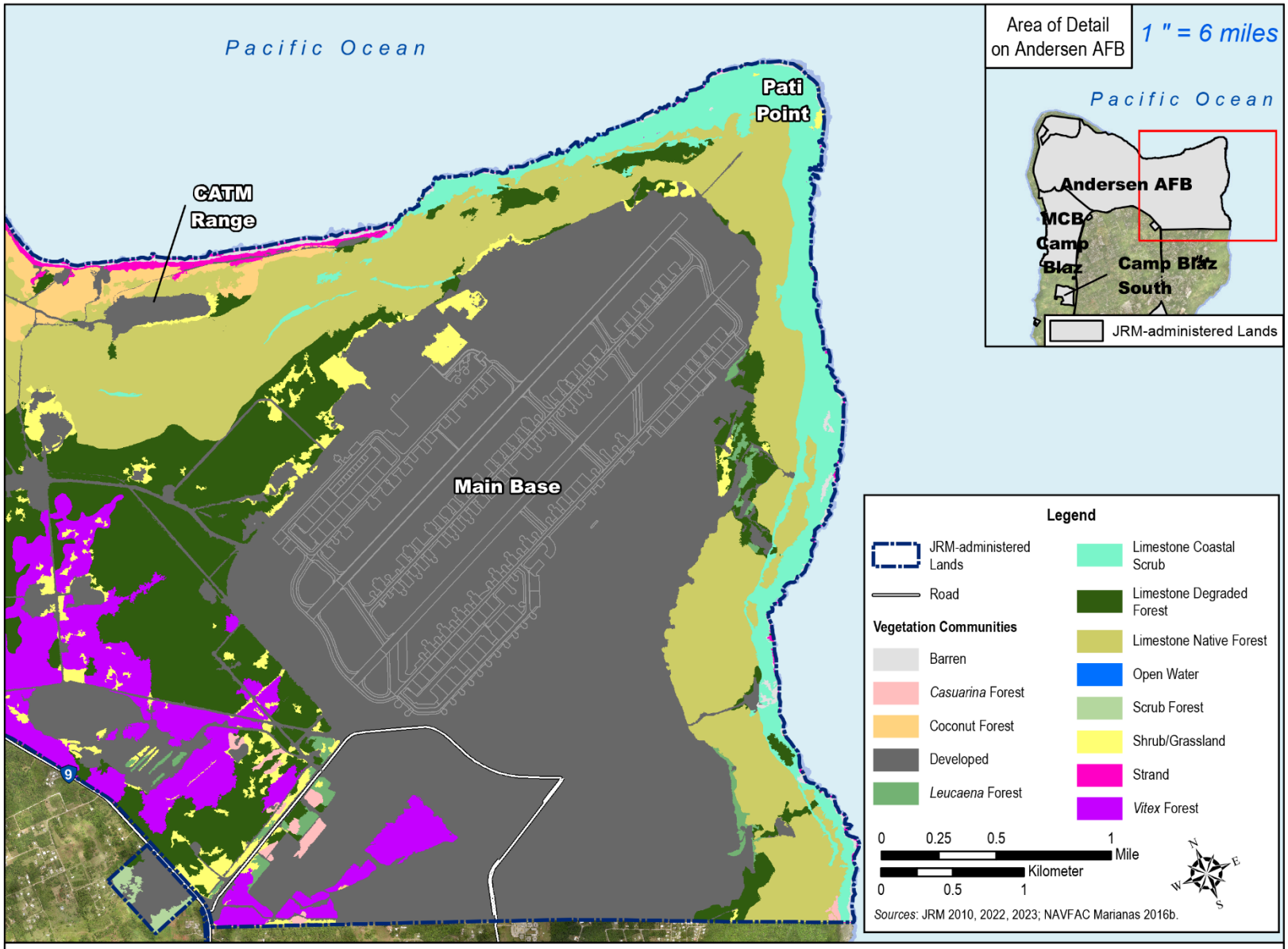


Figure 8-9
Vegetation Communities on Eastern Andersen AFB

8.2.4 Terrestrial Wildlife

8.2.4.1 Mammals

Native Species

The only native mammal currently occurring in Guam is the Mariana fruit bat, which is discussed below in Section 8.2.5, *Terrestrial Protected Species*.

Non-native Species

Feral pigs and Philippine deer are known to negatively affect the native ecosystems on Andersen AFB (DON 2015d). They cause extensive habitat damage by rooting and digging, create browse lines and impair regeneration of native plants, promote proliferation of browse-resistant plant species, and have the potential to threaten sea turtle nests. U.S. Department of Agriculture (USDA) conducts feral ungulate control on Andersen AFB. Ungulate removal numbers by year and location are summarized in Table 8-4.



Feral pig (*Sus scrofa*) behaviors such as rooting and digging prevent native plant regeneration and proliferation.
(*Photo*: L. Shaughnessy)

Table 8-4. Summary of Ungulate Removal on Andersen AFB (Oct 2014–Sept 2023)

Fiscal Year	*Period*	*Feral Pigs*							*Philippine Deer*							*Total*
		TB	*Upi*	*RP*	*NWF*	*Main A/B*	*MSA*	*Total*	*TB*	*Upi*	*RP*	*NWF*	*Main A/B*	*MSA*	*Total*	*Feral Pigs/ Philippine Deer*
2014	Oct–Sept	97	18	23	2	-	-	*140*	14	30	24	1	-	-	*69*	**209**
2015	Oct–Sept	158	30	2	21	-	-	*211*	62	81	6	1	-	-	*150*	**361**
2016	Oct–Sept	179	18	0	0	-	-	*197*	395	58	0	0	-	-	*453*	**650**
2017	Oct–Sept	113	20	-	-	-	-	*133*	252	176	-	-	-	-	*428*	**561**
2018	Oct–Sept	70	-	-	-	-	-	*70*	564	-	-	-	-	-	*564*	**634**
2019	Oct–Sept	41	-	-	-	-	-	*41*	288	-	-	-	-	-	*288*	**329**
2020	Oct–Sept	67	6	-	22	24	0	*119*	159	44	-	306	113	0	*622*	**741**
2021	Oct–Sept	119	88	1	152	53	14	*427*	233	112	-	296	191	389	*1,221*	**1,648**
2022	Oct–Sept	83	10	-	110	165	55	*423*	172	146	-	825	206	576	*1,925*	**2,348**
2023	Oct–Sept	63	40	-	69	4	60	*236*	192	84	-	410	139	365	*1,190*	**1,426**
Total		**990**	**230**	**26**	**376**	**246**	**129**	**1,997**	**2,331**	**731**	**30**	**1,839**	**649**	**1,330**	**6,910**	**8,907**

Key: - = No ungulate removal performed; Main A/B = Main Base; MSA=Munitions Storage Area; NWF= Northwest Field; Oct = October; RP = Ritidian Point; Sept = September; TB = Tarague Basin.

Sources: DeNicola 2015; USAF 2017, 2020, 2021 2022, 2023.

In 2016, a cooperative agreement was entered into with White Buffalo, Inc. for field-based feral pig and deer control, eradication and research operations on JRM-administered lands in Guam. Operations ran from October 2021 to November 2023. During the first year, White Buffalo removed 306 deer and 139 pigs from the Northwest Field and 4 deer and 28 pigs from Tarague Basin (NAVFAC Marianas 2022). During the second year, 276 deer and 49 pigs were removed from the Northwest Field and 6 deer and 31 pigs were removed from Tarague Basin. A third site, Main A/B, was included in year two eradication work, and 25 deer and 41 pigs were removed from the area (NAVFAC Marianas 2022).

Andersen AFB maintains an active hunting program to fulfill requirements under the Sikes Act (as amended), Executive Orders (EOs) 13112 and 13443, the ESA, Migratory Bird Treaty Act (MBTA), and other mandates. The program is growing, with the number of recreational hunters having almost tripled in 2017 (Hartzell 2018b). The program is currently on hold due to build-up of AFB; however, an active Volunteer Conservation Officer Program allows officers an opportunity to recreationally hunt upon completion of 6 hours of monthly program duties. Hunting areas labeled 'C' are designated as special hunting areas (see Figure 8-1). Additional hunting areas may be authorized, as appropriate. The hunting regulations on Andersen AFB include 36 WG Instructions 32-7005 and -7003, Guam hunting regulations (9 Guam Administrative Rule 11), 10 U.S. Code (USC) 2671, and Chief of Naval Operations Instruction (OPNAVINST) 5090.1C .

While only a few small mammal surveys have been conducted on Andersen AFB, it is expected that the common non-native small mammals found throughout Guam would be present on Andersen AFB, including the Norway rat (*Rattus norvegicus*), black rat (*Rattus rattus*), Polynesian rat (*R. exulans*), house mouse (*Mus musculus*), and musk shrew (*Suncus murinus*) (Wiles 2005; Wiewel et al. 2009). Feral populations of domesticated animals such as dogs (*Canis lupus familiaris*) and cats (*Felis catus*) occur on Andersen AFB and pose threats to native wildlife populations (NAVFAC Marianas 2017a). Dogs are opportunistic feeders and have been known to prey on native waterbirds in Hawai'i (Young et al. 2011), including Hawaiian coot (*Fulica americana alai*), Hawaiian moorhen (*Gallinula chloropus sandvicensis*), and Hawaiian stilt (*Himantopus mexicanus knudseni*) (Bergman et al. 2009). Cats hunt regardless of food availability (Loss et al. 2013). Cats on Andersen AFB have been known to prey on native skinks (Lardner et al. 2013). Feral cats destroyed an experimental population of Guam rail within the MSA (NAVFAC Marianas 2013).

8.2.4.2 Birds

Native Species

Most avian species on the installation are native to the region; however, many are seasonal visitors that use coastal, grassy, or other open habitats to forage during their annual migration. Migratory birds either spend the winter in Guam or migrate through during the spring and fall to breeding areas to the north and south.

Sea birds that have the potential to occur on Andersen AFB either during migration or as year-round residents include black noddy (*Anous minutus*), brown noddy (*Anous stolidus*), brown booby (*Sula leucogaster*), red-footed booby (*Sula sula*), white tern (*Gygis alba*), great frigatebird (*Fregata minor*), sooty tern (*Onychoprion fuscatus*), and the white-tailed tropicbird (*Phaethon lepturus*). Previous surveys (USAF 2009) reported that black noddies, brown noddies, white terns, and brown boobies were commonly observed on Andersen AFB. White terns are still observed on Andersen AFB in the developed portion of main base (Hartzell 2018a). Shorebirds that have the potential to migrate through or occur in coastal areas of Andersen AFB include the whimbrel (*Numenius phaeopus*) and several species of sandpipers and plovers. Wading birds that have the potential to migrate through or reside on Andersen AFB include Eastern cattle egret (*Bubulcus coromandus*), intermediate egret (*Ardea intermedia*), Pacific reef heron (*Egretta sacra*), and yellow bittern (*Ixobrychus sinesis*). Pacific reef herons have been observed foraging on the exposed reef on Andersen AFB. These sea birds, shorebirds, and wading birds are protected by the MBTA. The white-tailed tropicbird, Pacific reef heron, brown booby, and all migratory shorebirds are also considered Guam Species of Greatest Conservation Need (SOGCN) (Guam Division of Aquatic and Wildlife Resources [DAWR] 2006).

Migratory bird surveys conducted on Andersen AFB in the fall of 2011 identified several shorebird and wading bird species present on the base. The Pacific golden plover (*Pluvialis fulva*) was the most commonly

observed bird during those surveys, followed by the ruddy turnstone (*Arenaria interpres*). Other species observed included wood sandpiper (*Tringa glareola*), wandering tattler (*T. incana*), grey-tailed tattler (*T. brevipes*), sharp-tailed sandpiper (*Calidris acuminata*), Pacific reef heron, whimbrel, and ruff (*Calidris pugnax*). Table 8-5 summarizes the bird species present on Andersen AFB and Appendix E provides a listing of the extirpated bird species.

Additional discussion may be found in Section 8.2.5, *Terrestrial Protected Species* and in Section 4.4.2.2, *Birds*.

Table 8-5. Bird Species Recorded on Andersen AFB

Common Name/ Chamorro Name[(1)]	***Scientific Name***	***Residence Status***	***Listed under MBTA***
Micronesian starling/Sali	*Aplonis opaca*	Uncommon native breeding resident	N
Yellow bittern/Kakkak	*Ixobrychus sinesis*	Common native breeding resident	Y
Ruddy turnstone/Dulili	*Arenaria interpres*	Common non-breeding visitor	Y
Tattler spp.[(2)]	*Tringa* spp.	Common non-breeding visitor	Y
Wood sandpiper/Dulili	*Tringa glareola*	Common non-breeding visitor	Y
Sharp-tailed sandpiper/Dulili	*Calidris acuminata*	Common non-breeding visitor	Y
Pacific golden plover/Dulili	*Pluvialis fulva*	Common non-breeding visitor	Y
White tern/Chunge	*Gygis alba*	Common breeding resident	Y
Eastern cattle heron/Chuchuko	*Bubulcus coromandus*	Common non-breeding visitor	Y
Pacific reef heron, reef egret/Chuchuko atilong [(3)]	*Egretta sacra*	Uncommon non-breeding resident	Y
Little egret/Chuchuko	*Egretta garzetta*	Uncommon non-breeding visitor	Y
Whimbrel/Kalalang	*Numenius phaeopus*	Uncommon non-breeding visitor	Y
Black-winged stilt/None	*Himantopus himantopus*	Uncommon non-breeding visitor	Y
Ruff/None	*Calidris pugnax*	Uncommon non-breeding visitor	Y
Island collared dove/Palumat	*Streptopelia bitorquata*	Common introduced breeding resident	N
Black drongo/Salin Taiwan	*Dicrurus macrocercus*	Common introduced breeding resident	N
Eurasian tree sparrow/Gagapale	*Passer montanus*	Common introduced breeding resident	N
Great frigate bird/Payaya	*Fregata minor*	Occasional non-breeding resident	Y
Black francolin/None	*Francolinus francolinus*	Common introduced breeding resident	N

Notes: [(1)] Common and scientific names based on Gill and Donsker (2017). Chamorro names from GovGuam (2009), Liske-Clark (2015), Topping et al. (1975), and USFWS (2015a).
[(2)] Wandering and grey tattlers were combined into one category since they are undistinguishable from each other in non-breeding plumage.
[(3)] The Pacific reef egret is uncommon.
Key: AFB = Air Force Base; MBTA = Migratory Bird Treaty Act; N = no; Y = yes
Sources: NAVFAC Marianas 2013; DON 2015b.

Non-native Species



Black francolin (*Francolinus francolinus*)
(*Photo*: Wikipedia)

Four non-migratory introduced bird species occur on Andersen AFB and include black drongo (*Dicrurus macrocercus*), Eurasian tree sparrow (*Passer montanus*), black francolin (*Francolinus francolinus*), and island collared dove (*Streptopelia bitorquata*). Introduced birds pose a risk to native bird species because of their potential to displace or compete with native species or transmit diseases. The black francolin and island collared dove are game species per Guam regulation, but the current hunting instruction excludes them from being hunted on Andersen AFB. Black drongo are a conspicuous and aggressive avian species that can contribute to a decline in native bird species (USAF 2009). Roadside and forest bird surveys conducted from 2008 through 2010 at NWF, North Ramp, and a proposed utility corridor along Route 9, identified black francolin, island collared dove, black drongo, and Eurasian tree sparrow (NAVFAC Pacific 2010). The black francolin was the most commonly observed species on this portion of Andersen AFB at that time.

Feral chickens (*Gallus gallus*) are less of a threat to wildlife than dogs and cats, but as generalist feeders, they have the potential to prey on small native wildlife, including skinks and geckos. They also have the potential to spread avian diseases, which may affect both current native bird colonies and the recolonization efforts on Andersen AFB of extirpated native birds (Gottdenker et al. 2005).

8.2.4.3 Reptiles and Amphibians

Native Species



Pacific blue-tailed skink (*Emoia caeruleocauda*)
(*Photo*: L. Shaughnessy)

Herpetological surveys have been performed intermittently around Andersen AFB. While some species may not have been seen during particular surveys, nine species of reptiles and amphibians were documented during the 2008-2009 herpetofauna surveys performed in NWF, North Ramp, and proposed utility corridors on Andersen AFB (NAVFAC Pacific 2010). Of these, the following three species are native: Pacific blue-tailed skink (*Emoia caeruleocauda*), moth skink (*Lipinia noctua*) (a Guam ESA-listed endangered species), and mutilating gecko (*Gehyra mutilata*).

Monitor lizards (*Varanus tsukamotoi*) are native and endemic to the Mariana Islands (Weijola et al 2020). Their remains have been found in pre-historic strata in Guam (Pregill and Steadman 2009) and are different from congeners in Palau (Crombie and Pregill 1999). Biosecurity programs are in place to slow or prevent the spread of this

species. They are typically found in the more forested habitats or associated edges but have also been observed in more developed areas.

Hawksbill turtles (*Eretmochelys imbricata*) and green sea turtles are federal and Guam ESA-listed as endangered. They are known historically to nest on beaches on Andersen AFB (USAF 2009). Sea turtles are discussed further in Section 8.2.5, *Terrestrial Protected Species*.

Non-native Species

During the 2008-2009 herpetofauna surveys discussed above, six introduced species were documented. These include curious skink (*Carlia ailanpalai*), house gecko (*Hemidactylus frenatus*), BTS, Brahminy blind snake (*Ramphotyphlops braminus*), marine toad (*Rhinella* [=*Bufo*] *marina*), and greenhouse frog (*Eleutherodactylus planirostris*) (NAVFAC Pacific 2010).



The Brahminy blind snake (*Ramphotyphlops braminus*) is small, lives in the soil, and can easily be mistaken for an earthworm.
(*Photo*: L. Shaughnessy)

The continued widespread presence of the curious skink, the BTS, and other non-native reptile and amphibian species is of concern because of each species' potentially deleterious impacts in Guam's native fauna. Of particular concern is the potential for introduced species to serve as additional food sources for the BTS (NAVFAC Pacific 2010). Rodda et al. (1999) reported a change in the diet of BTS between 1989 and 1999 in response to the disappearance of prey species, notably Guam's native birds. Research conducted on arboreal BTS since 1989 has demonstrated that small lizards (geckos and skinks equally) and their eggs appear to be the most common prey consumed. Larger BTS that were captured while foraging on the ground were found to have mostly consumed the curious skink, which tend to spend their time on the ground. Marine toads can be heard calling, and their carcasses are often seen on roads. Table 8-6 summarizes the occurrence of reptiles and amphibians on Andersen AFB.

Table 8-6. Reptile and Amphibian Species Recorded on Andersen AFB

Common Name/Chamorro Name[(1)]	*Scientific Name*	*Residence Status*
Brown treesnake/Kolepbla	*Boiga irregularis*	Non-native
Marine toad or Cane toad/Kairo	*Rhinella* (=*Bufo*) *marina*	Non-native
Curious skink/Gualiek halumtano	*Carlia ailanpalai*	Non-native
Green sea turtle/Haggan	*Chelonia mydas*	Native
Greenhouse frog/Kairo	*Eleutherodactylus planirostris*	Non-native
Pacific blue-tailed skink/Gualiek halumtano	*Emoia caeruleocauda*	Native
Hawksbill turtle/Haggan karai	*Eretmochelys imbricata*	Native
Mutilating gecko/Achiak	*Gehyra mutilata*	Native
House gecko/Achiak	*Hemidactylus frenatus*	Non-native
Mourning gecko/Achiak	*Lepidodactylus lugubris*	Native
Moth skink/Gualiek halumtano	*Lipinia noctua*	Native
Brahminy blind snake/Ulo attilong	*Ramphotyphlops braminus*	Non-native
Monitor lizard/Hilitai	*Varanus tsukamotoi*	Native

Note: [(1)] Common and scientific names based on Gill and Donsker (2017). Chamorro names from GovGuam (2009), Liske-Clark (2015), Topping et al. (1975), and USFWS (2015a).
Key: AFB = Air Force Base.
Source: NAVFAC Pacific 2010.

8.2.4.4 Invertebrates

Native Species

The Mariana eight-spot butterfly (*Hypolimnas octocula marianensis*) and the Mariana wandering butterfly (*Vagrans egistina*) are both federal ESA-listed as endangered. The Mariana eight-spot butterfly does occur on Andersen AFB, and is discussed further in Section 8.2.5, *Terrestrial Protected Species.* The Mariana wandering butterfly has not been seen since 1979 and is considered extirpated from Guam (USFWS 2015a).

Four other native butterfly species were documented within forested areas on Andersen AFB during 2009-2010 butterfly surveys: lemon emigrant (*Catopsilia pomona*), monarch (*Danaus plexippus*), blue-banded king crow (*Euploea eunice*), and blue moon (*Hypolimnas bolina*) (NAVFAC Pacific 2010). These species are fairly well distributed throughout Guam and portions of the Mariana Islands. Other native butterfly species documented on Andersen AFB include the three-spot grass yellow (*Eurema blanda*) and the tiny grass blue (*Zizula hylax*) (Schreiner and Nafus 1997; USAF 2009).

The native, federal ESA-listed Guam tree snail (*Partula radiolata*) is present in Tarague Basin and other on-base locations and is discussed in further detail in Section 8.2.5, *Terrestrial Protected Species*.

Other terrestrial invertebrates that occur on Andersen AFB include the nocturnal, native land hermit crab (*Coenobita brevimanus*) and the coconut crab (*Birgus latro*), both of which begin their life at sea and spend their adult life on land. Land hermit crabs rely on borrowed shells throughout their lives, often using the shell of the giant African snail (*Achatina fulica*). Threats to these species include humans and introduced predators such as, rats, feral pigs, dogs, as well as native species such as monitor lizards. Coconut crabs are a culturally important species and a local delicacy in Guam. They are considered a game species and are regulated by GovGuam due to being overharvested (JRM 2013). Coconut crab hunting is still technically permitted under Section 7, Coconut Crab Hunting Regulations and procedures, of 36 WG Instruction 32-7003 (December 2000); however, permits were administratively stopped in recent years. Andersen AFB will not issue Coconut Crab Collecting Permits (36th Air Base Wing Form 26-A) until it is determined that such take does not endanger the continued existence of the resident coconut crab population, given the full range of impacts (e.g., impact by high feral swine densities).

Non-native Species

Non-native butterflies documented on Andersen AFB include the common mormon (*Papilio polytes*) and the cycad blue or plains cupid (*Luthrodes pandava*).

Shells of the introduced giant African snail and the rosy wolf snail (*Euglandina rosea*), as well as both live snails and empty shells of the introduced cinnamon bun snail (*Satsuma mercatoria*), were observed during 2009 and 2016 tree snail surveys (NAVFAC Pacific 2010, 2017). Additionally, the introduced New Guinea flatworms (*Platydemus manokwari*), a major predator of native invertebrates, were observed across the base. During the 2016 surveys, the tropical American lined tree snail (*Drymaeus multilineatus*) was observed in the MSA on Andersen AFB.



Tropical American lined tree snail (*Drymaeus multilineatus*)
(*Photo*: L. Shaughnessy)

The little fire ant (LFA) (*Wasmannia auropunctata*) represents a serious threat to native invertebrate and vertebrate species; however, it is not yet known to occur on Andersen AFB. Accidentally introduced to northern Guam in 2011, it is slowly expanding its range in Guam despite extensive efforts to control it.

The greater banded hornet (*Vespa tropica*) was first identified in Guam in July 2016, based on collected specimens from Dededo (Rosario et al. 2016). This species is native to China, Japan, Malaysia, Hong Kong, Singapore, India, and the Philippines. Banded hornets usually nest underground, in tree hollows, or similar confined spaces and are known to attack the nests of the local boonie bees (*Ropalidia marginata*) in order to obtain the larvae to feed their own larvae (Rosario et al. 2016).

8.2.5 Terrestrial Protected Species

Six federal ESA-listed endangered species are known to occur on Andersen AFB. These include three plant species (*Heritiera longipetiolata*, *S. nelsonii*, and *Eugenia bryanii*) and three animal species (green sea turtle, Mariana eight-spot butterfly, and Guam tree snail). Five federal ESA-listed threatened plants are known to occur on Andersen AFB: *Bulbophyllum guamense* (Johnson 2016a), *Cycas micronesica*, *Dendrobium guamense*, *Tabernaemontana rotensis*, and *Tuberolabium guamense*. Of these, *H. longipetiolata*, *S. nelsonii*, Mariana fruit bat, green sea turtle, and Guam tree snail are listed as endangered under the Guam ESA. The Micronesian starling is also listed as endangered under the Guam ESA. *C. micronesica* and *T. rotensis* are both designated as Guam SOGCN (Guam DAWR 2006).

Potential habitat is present on the installation for nine other federal ESA-listed endangered, threatened, or candidate species, some of which might already be extinct. Table 8-7 summarizes the protected species in Guam and their occurrence on Andersen AFB.

Table 8-7. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded on Andersen AFB

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat*	*Occurrence*
Mammals					
Mariana fruit bat/Fanihi	*Pteropus mariannus mariannus*	T	E	Limestone native and coconut forests	Y
Birds					
Mariana common moorhen/Pulattat	*Gallinula chloropus guami*	E	E	Wetland (herbaceous, mangrove, and shrub/herb)	PU[3]
Micronesian starling/Sali	*Aplonis opaca*	--	E	All habitat types	Y
Reptiles					
Green sea turtle/Haggan	*Chelonia mydas*	E[2]	T	Open water and strand	Open water and strand: Y
Hawksbill turtle/Haggan karai	*Eretmochelys imbricata*	E	E	Open water and strand	Open water: Y; strand: PU[3]
Tide-pool skink/ Gualiek halumtasi	*Emoia atrocostata*	--	E	Strand and wetland	PU[3]
Azure-tailed skink/ Gualiek halumtano	*Emoia cyanura*	--	E	Forest edge	PU[3]
Slevin's skink/ Gualiek halumtano	*Emoia slevini*	E	E	Limestone native forest	PU[3]
Moth skink/ Gualiek halumtano	*Lipinia noctua*	--	E	Limestone native and degraded forests.	Y
Pacific slender-toed gecko/ Gualiek or Achiak	*Nactus pelagicus*	--	E	Limestone native forest	Y
Micronesian gecko/ Gualiek	*Perochirus ateles*	--	E	Limestone native forest	PU[3]
Invertebrates					
Humped tree snail/Akaleha	*Partula gibba*	E	E	Limestone native forest	PU[3]
Guam tree snail/Akaleha	*Partula radiolata*	E	E	Limestone native forest and strand	Y
Mariana eight-spot butterfly/Ababbang	*Hypolimnas octocula marianensis*	E	--	Limestone native forest	Y
Plants					
None/Siboyas halumtano	*Bulbophyllum guamense*	T	--	Limestone native and degraded forests	Y
None/Fadang	*Cycas micronesica*	T	--	Limestone native and degraded forests	Y
None/None	*Dendrobium guamense*	T	--	Limestone native forest and limestone coastal scrub	Y
None/Aagan or aabang	*Eugenia bryanii*	E	--	Limestone coastal scrub	Y
None/Ufa halumtano	*Heritiera longipetiolata*	E	E	Limestone native forest	Y
None/None	*Maesa walkeri*	T	--	Limestone native and degraded forests	PU[3]
None/Seyaihagon or Maisa ulu	*Nervilia jacksoniae*	T	--	Limestone native and degraded forests	P
None/Aplokating-palaoan	*Psychotria malaspinae*	E	--	Limestone native forest and limestone coastal scrub	P
Fire tree/Hayun lago	*Serianthes nelsonii*	E	E	Limestone native and degraded forests	Y
None/Biringenas halumtano	*Solanum guamense*	E	--	Coastal limestone cliffs and terraces	PU

Table 8-7. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded on Andersen AFB

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat*	*Occurrence*
None/None	*Tabernaemontana rotensis*	T	--	Limestone native and degraded forests	Y
None/None	*Tinospora homosepala*	E	--	Limestone native forest and limestone coastal scrub	PU[3]
None/None	*Tuberolabium guamense*	T	--	Limestone native forest and limestone coastal scrub	Y

Notes: [1] Chamorro names from GovGuam (2009), Topping et al. (1975), Safford (2009), and USFWS (2015a).
[2] Central West Pacific Distinct Population Segment.
[3] Historical occurrence.

Key: -- = not listed; AFB = Air Force Base; E = endangered; ESA = Endangered Species Act; P = potential for occurrence; PU = potential for occurrence, but unlikely; T = threatened; Y = yes, known to occur.

Sources: Schreiner and Nafus 1997; Guam DAWR 2006; GovGuam 2009; Safford 2009; NAVFAC Pacific 2010, 2013; NAVFAC Marianas 2014, 2016a; USFWS 2014a, 2015a; NAVFAC Marianas and Andersen AFB 2015, 2017b.

8.2.5.1 Mammals

Mariana Fruit Bat

Mariana fruit bats are federal ESA-listed as threatened, Guam ESA-listed as endangered, and Guam-designated as SOGCN. Their population has been in a steady decline since the early part of the 20th century (NAVFAC Marianas 2017a). In 1972, the Mariana fruit bat population on Andersen AFB consisted of 500 to 600 individuals. By 1978, the number of fruit bats on all of Guam had been reduced to 50 individuals (Wheeler and Aguon 1978), and in 1984, they were federal ESA-listed as endangered (USFWS 1994a, 2015b). Between 1980 and 1981, the fruit bat population in Guam grew to almost 1,000 bats divided into two main colonies on Pati Point, likely the result of immigration from Rota (Wiles 1987a, 1987b). Between 1981 and 1987, fruit bats roosted in at least 19 locations along the northern coast of Andersen AFB between Lafac Point and Ritidian Point (Wiles 1987c). Except for the increase in the early 1980s, the overall population trend of this species has continued its decline. In 2006, Janeke et al. (2006) estimated fewer than 100 fruit bats at Pati Point. A survey conducted on Andersen AFB from June 2007 until April 2008 indicated counts from 31 to 54 bats with an average count of 40 (Andersen AFB 2008). A count in May 2010 recorded only 10 bats at the Pati Point colony (JRM 2013). Surveys in 2011 found two to three bats below Pati Point, but the colony is no longer present, and surveys have not found that the colony has relocated (JRM et al. 2012).

Beginning in 2014, the collaborative fruit bat monitoring project between the UOG and Andersen AFB began using base-wide counts to estimate fruit bat populations. Surveys conducted in 2014 and 2015 estimated the population of Andersen AFB fruit bats at 24 (NAVFAC Marianas 2015a). The 2015 survey estimated the Andersen AFB population at 45 fruit bats, and eight surveys conducted at Pati Point yielded two fruit bat sightings (NAVFAC Marianas and Andersen AFB 2017c). In one rare instance (in November 2015), a colony of fruit bats temporarily inhabited the HMU southwest of NWF (NAVFAC Marianas and Andersen AFB 2017c). Surveys conducted that year included the HMU as a survey site in hopes of recording this new population; however, most fruit bat sightings were recorded that year in southwestern and eastern Andersen AFB (Figures 8-10 and 8-11). There were only a few observations of fruit bats at northern Andersen AFB near Ritidian Point (Figure 8-12). In 2018, bat numbers were estimated to be approximately 60 on Andersen AFB. Subsequent years showed a steady increase in population, and the estimated number of bats on Andersen AFB in 2022 was approximately 106 (U.S. Navy 2023).

The fruit bat survey conducted in 2022 was the 9th year of annual, large-scale, base-wide fruit bat surveys conducted on Andersen AFB. These surveys are crucial as they provide a method to better understand fruit bat diet and habitat use and quantify population recovery metrics for bats residing on base.

8.2.5.2 Birds

Micronesian Starling

The Micronesian starling is Guam ESA-listed as endangered and Guam-designated as SOGCN. They are found in the forests north of the flightline, east of the golf course, in the housing areas, and in an area to the south of Andersen AFB (DON 2010). The species is also present on beach strand areas along the southeastern portion of Guam, parts of Hagatna, and Cocos Island.

The starling has adapted to nesting in the housing area as well as on buildings and other man-made structures and is important for dispersal of native plant seeds (Caves et al. 2013). As with the other Guam bird species, the principal cause of decline is due to predation by BTS. Starlings have persisted on Andersen AFB, where BTS control has been ongoing for decades.

In 1996, conservation staff at Andersen AFB initiated a volunteer program to protect nesting of Micronesian starlings by installing nest boxes (JRM 2013). The nest boxes were not predator-resistant, and data on nesting success were not collected; by the early 2000s efforts ceased. However, JRM continued the development of a predator proof nest box in 2015 with Micronesian starlings used as surrogates for Guam kingfishers (Savidge 2016).

A 3-year monitoring project, from August 2019 to May 2023, was developed to track nesting activity, fledgling survival, abundance, demography, and genetic composition of starlings on Andersen AFB prior to and during BTS control (NAVFAC Marianas 2023c). Over 1,000 nests were monitored over the course of the project, and results showed slightly higher nest success rates in nest boxes versus natural nests. Over half of the documented mortality was caused by BTS. Nine surveys were conducted during the project and as of 2023, the starling population on Andersen AFB has increased to over 1,600 birds (NAVFAC Marianas 2023c).

White-throated Ground Dove

The white-throated ground dove (*Alopecoenas xanthonurus*), a Guam ESA-listed endangered species, is considered to have been extirpated from the island by the BTS as of the late 1980s (Guam DAWR 2006). However, since then, it has been seen in a few rare instances on Andersen AFB: in 2003, two male white-throated ground doves were sighted on the installation (Guam DAWR 2006) and an individual was heard during 2011 surveys (DON 2015b). In April 2023, an anecdotal observation was made of one individual near a road in Tarague by Air Force personnel (M. Burt, personal communications, 12 December 2023). These occurrences, along with a few others, are likely visitors from the nearby island of Rota.

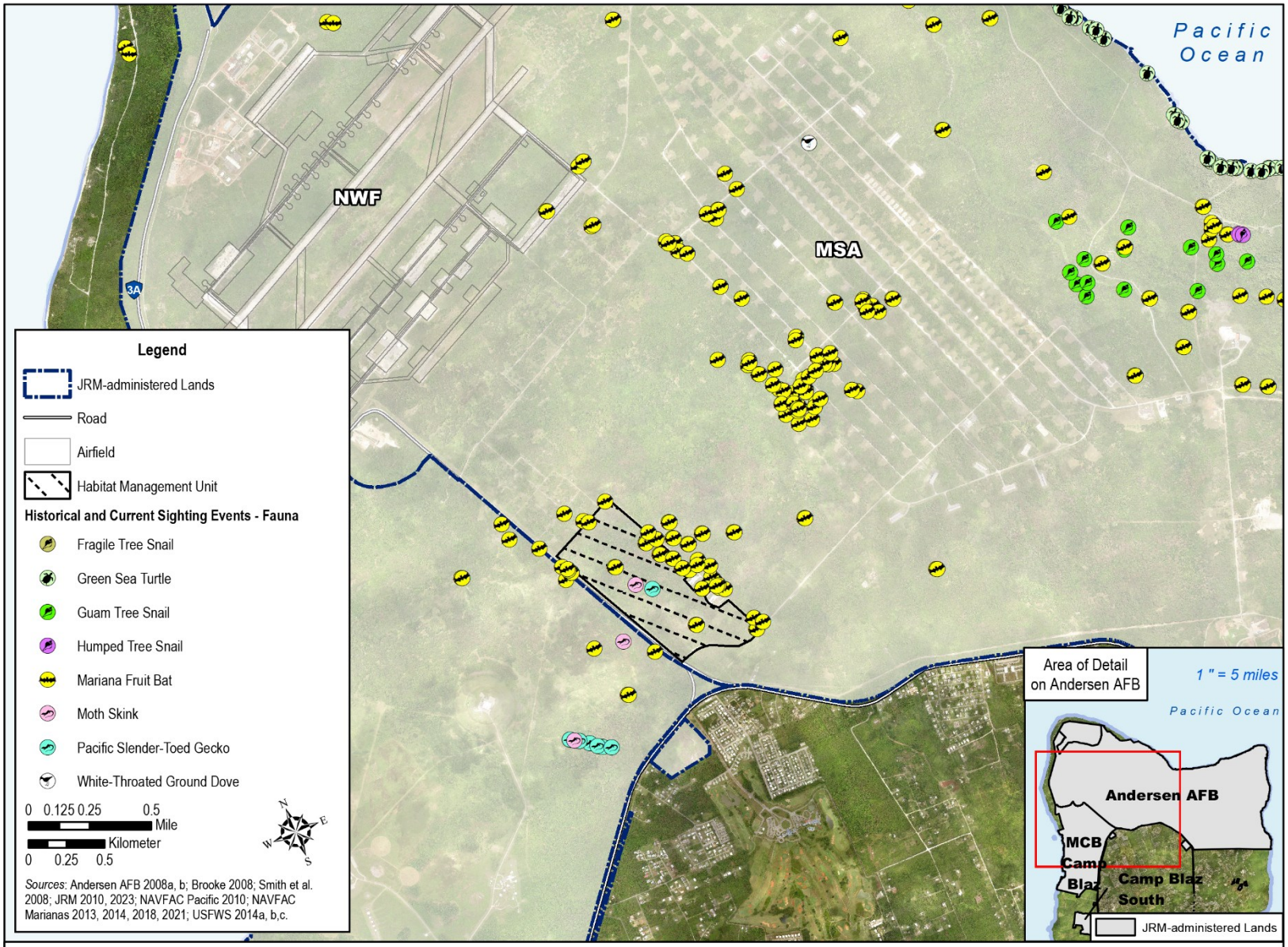


Figure 8-10
Protected Terrestrial Species Recorded on Southwestern Andersen AFB

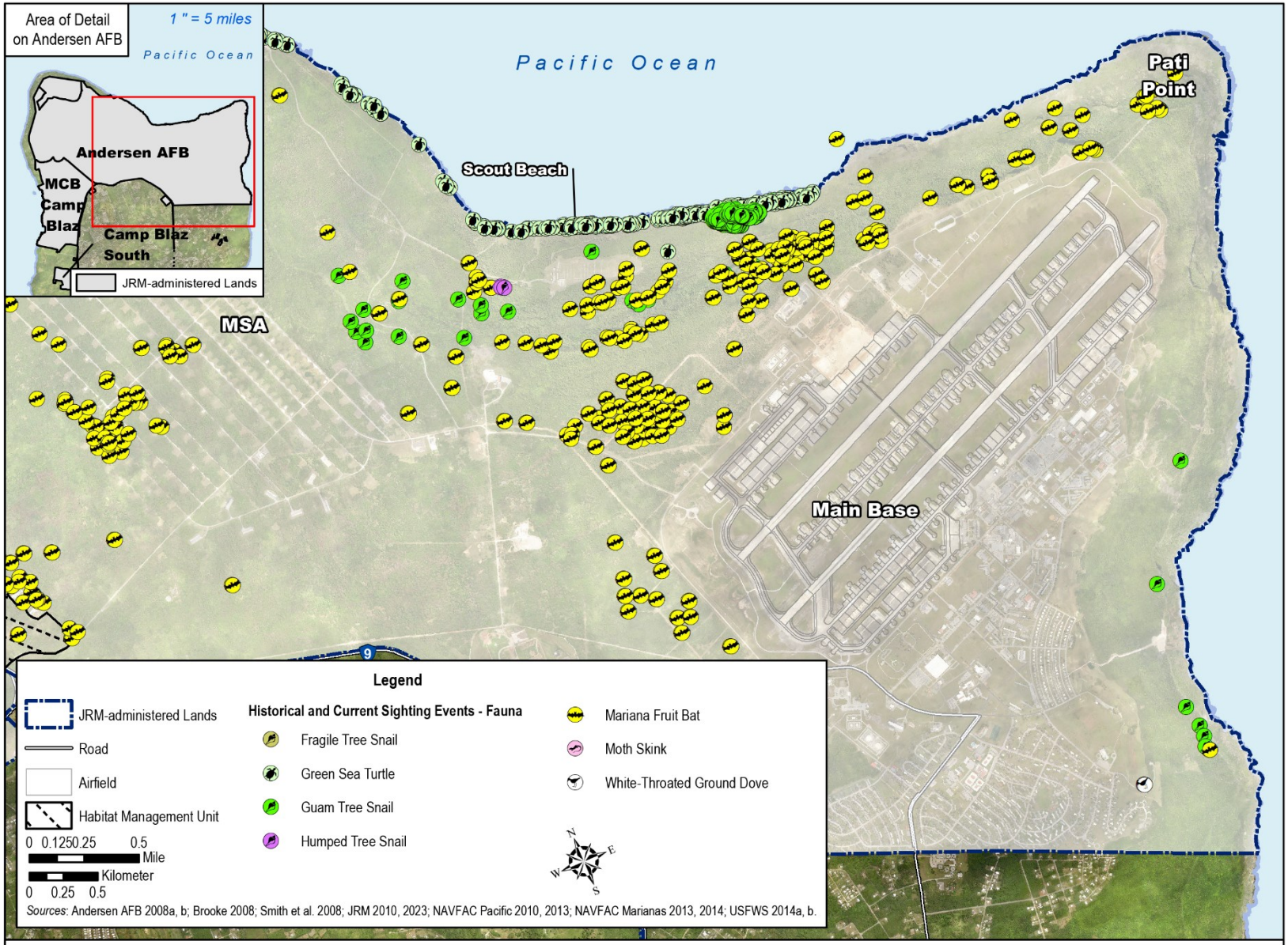


Figure 8-11
Protected Terrestrial Species Recorded on Eastern Andersen AFB

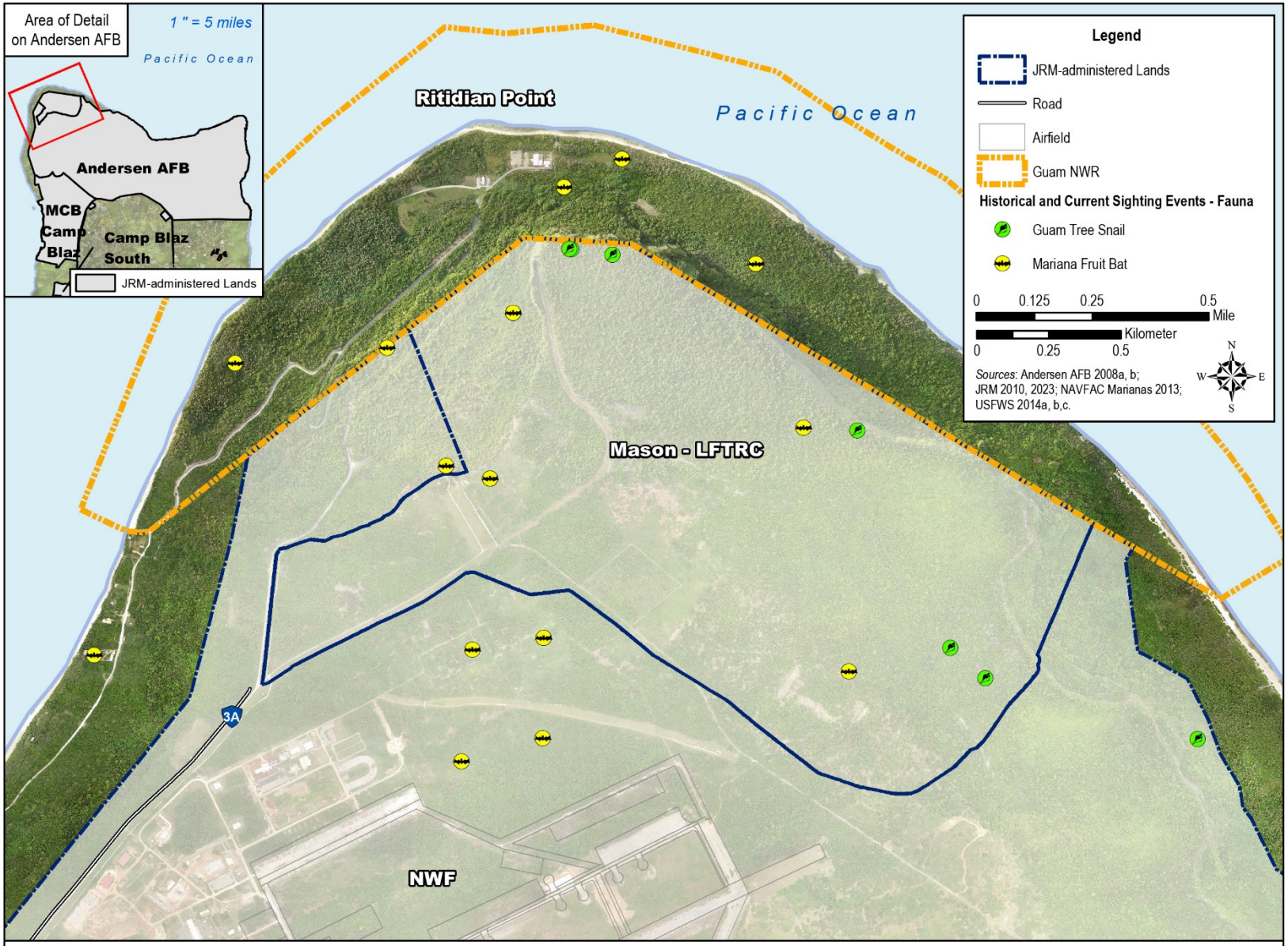


Figure 8-12
Protected Terrestrial Species Recorded on Northern Andersen AFB

8.2.5.3 Reptiles and Amphibians

Green Sea Turtle

The Central West Pacific Distinct Population Segment (DPS) of the green sea turtle is federal ESA-listed as endangered. In Guam, green sea turtles are Guam ESA-listed as endangered. Green sea turtles are known to nest on five beaches within Anderson AFB: Tarague, EOD, Scout, Sirena, and Pati. The first green sea turtle nesting activity on Andersen AFB was recorded in 1984; however, the first organized surveys were not conducted until 2005 by DAWR (Staman 2015). From 2018 to present, sea turtle surveys occur on a weekly basis of five times per week during nesting season and three times per week during non-nesting season, equating to at least 200 surveys per year. The 2022 Sea Turtle Management Plan for Andersen AFB, Guam, provides detailed historical sea turtle nesting data collected from 1984 to 2022 (NAVFAC Marianas and Andersen AFB 2023).

During the nesting season, typically from February through September or October in Guam, female green sea turtles emerge from the sea to lay an average of 110 to 130 eggs per clutch in large sandpit nests near vegetation above the high water line. After incubating for 45 to 80 days, 2-inch (5-centimeter) turtle hatchlings emerge from the nest and return to the ocean. An individual female can lay as many as seven clutches of eggs in successive 10 to 12 day intervals over a several-month season (Davis 1992). However, individual green sea turtles do not nest every year, and the frequency of nesting in Guam is unknown but estimated at 3 to 4 years at a rookery in Yap (NAVFAC Marianas and Andersen AFB 2017d). Green sea turtles will return to the same beach, if possible.

From March 2014 through December 2022, surveys recorded 733 green sea turtle nests and 171 non-nesting emergences during nine distinct nesting seasons on Andersen AFB beaches, with a total of 904 nesting emergences (Tarague, Scout, Sirena, Pati, and EOD) (Table 8-8) (NAVFAC Marianas and Andersen AFB 2023). All beaches on Andersen AFB were surveyed consistently throughout the survey years except for EOD beach, which was not accessible until January 2015. The lower number of nests recorded in 2014 reflects the inaccessibility of EOD beach during the survey period. While a small number of turtles nest on Pati, Scout, Sirena, and Tarague beaches, EOD beach is emerging as the predominant area for nesting activity. Hatching success from 564 eggs was determined to be 98% (Horeg 2017). Decreased human presence, ease of beach access for nesting, and greater surface area of shoreline vegetation could account for the difference in nesting success between EOD beach and Pati, Scout, Sirena, and Tarague (NAVFAC Marianas and Andersen AFB 2017b).

The 2022 season observed the second highest recorded number of emergences and nests since consistent monitoring of all five beaches (including EOD) began in 2015, with 150 total emergences constituting 125 nests and 25 non-nesting emergences. There also appeared to be a nesting site preference throughout the nesting seasons, where most nesting occurred on EOD beach (724 out of 904 emergences). In addition, nesting occurred on all five beaches on Andersen AFB, consistent with 2016, 2019, 2020 and 2021 nesting seasons. Shoreline vegetation was the most preferred nesting habitat throughout all seasons, although there has been a significant increase in beach forest preference since 2020. In 2022, field technicians tagged four nesting green sea turtles. In total, 24 nesting turtles have been tagged since 2015. Of the 24, four had been satellite tagged and successfully tracked to their foraging grounds in the Philippines and islands east of Taiwan during the 2019 and 2020 nesting seasons (Figure 8-13). Based on data collected in 2022, average hatching success was 86.5%, and average hatchling emergence success was 84.5%. Ghost crab and strawberry crab predation was found to be the most significant factor contributing to nest damage.

In 2010, turtle-friendly lights were installed at the Tarague Parking Lot area, and fluorescent lights at the Sirena pavilion were painted yellow to reduce the mask brightness. Later in 2012, all lighting at Tarague

was replaced with turtle-friendly lights. In 2016, a timer was installed at the volleyball court to reduce light pollution on nesting beaches (NAVFAC Marianas and Andersen AFB 2017d). All lighting installed at Andersen AFB recreational areas must abide by sea turtle-friendly lighting standards as indicated in the Best Management Practices of the 2022 Sea Turtle Management Plan (NAVFAC Marianas and Andersen AFB 2023).

Table 8-8. Green Sea Turtle Nests and Non-Nesting Emergences Recorded on Andersen AFB Beaches (2014 to 2022)

Year	*Location*	*# True Nests*	*# False Nests*
2014	Sirena, Scout, Tarague	14	2
2015	EOD, Sirena	49	9
2016	EOD, Pati, Sirena, Scout, Tarague	83	9
2017	EOD, Pati, Sirena, Tarague	39	11
2018	EOD, Pati, Scout, Tarague	50	12
2019	EOD, Pati	118	29
2020	EOD, Pati, Sirena, Scout, Tarague	92	23
2021	EOD, Pati, Sirena, Scout, Tarague	163	51
2022	EOD, Pati, Sirena, Scout, Tarague	125	25
	Totals:	**733**	**171**

Note: [1]EOD Range was not surveyed in 2014.
Key: AFB = Air Force Base; EOD = Explosive Ordnance Disposal.
Source: NAVFAC Marianas & Andersen AFB 2023.

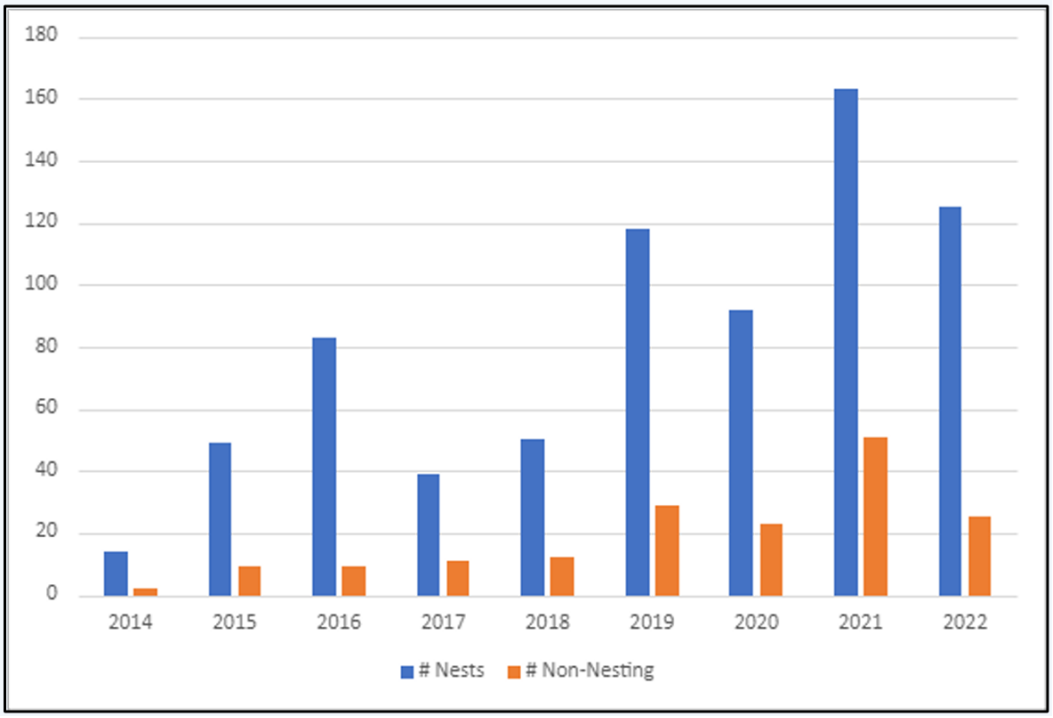


Figure 8-13. Green Sea Turtle Emergences Recorded on Andersen AFB Beaches (2014 – 2022)

Note: EOD beach was not surveyed in 2014.
Source: NAVFAC Marianas & Andersen AFB 2023.

Hawksbill Turtle

Hawksbill turtles are federal and Guam ESA-listed as endangered. They have nested on beaches in northern and central Guam in the past, but there have been no recent recordings of the species nesting on Andersen AFB (NAVFAC Marianas and Andersen AFB 2023). Hawksbill turtles are known to use habitat in the offshore waters of Andersen AFB (NAVFAC Marianas and Andersen AFB 2017b). The last recorded nestings in the area were three unconfirmed sightings in 1984 between Urunao and Tarague (NAVFAC Marianas and Andersen AFB 2023). The last sighting of a hawksbill turtle on Andersen AFB occurred in 1997 at the EOD beach; it was a desiccated specimen, and the cause of death was unknown.

Skinks and Geckos

Neither the moth skink nor the Pacific slender-toed gecko (*Nactus pelagicus*) is a federal ESA-listed species, but GovGuam lists both species as Guam ESA-endangered and the moth skink designated as SOGCN. Although not frequently encountered, moth skinks have been observed occasionally on Andersen AFB. During herpetofauna surveys on Andersen AFB in 2008, one moth skink was captured in a glue-board trap, on a transect paralleling Route 9, near the solid waste landfill (DON 2010). Both the skink and gecko have been observed just south of the Andersen AFB border in northeastern Finegayan, and, therefore, are known to inhabit in the area (NAVFAC Pacific 2010). From May through October 2010, 251 individual sightings of the slender-toed gecko within the Andersen AFB HMU were documented from 17 separate observation dates, and the species has been observed frequently since then (DON 2015c).

Amphibians

There are no protected amphibian species at Andersen AFB.

8.2.5.4 Invertebrates

Mariana Eight-spot Butterfly

The Mariana eight-spot butterfly is federal ESA-listed as endangered. A number of surveys over the years have recorded the presence of the Mariana eight-spot butterfly on Andersen AFB (Figures 8-14 and 8-15) (University of Guam [UOG] 2007; Rubinoff and Haines 2012; NAVFAC Marianas 2013; NAVFAC Marianas and Andersen AFB 2015). During surveys conducted in 2011, 7 adult butterflies, 96 larvae, and 35 eggs were observed with 38% of host plant patches occupied by the species (NAVFAC Marianas 2013). Surveys conducted in the dry season (March) of 2013 yielded seven chrysalides and 40 eggs, and surveys conducted in the wet season (July and August) yielded observation of one adult and 60 eggs (NAVFAC Marianas 2014). A number of adult Mariana eight-spot butterflies were observed during field surveys conducted in June 2014. Eggs, fragments of recently hatched eggs, and extensive caterpillar feeding damage were observed in various locations within limestone native forest during field surveys on Andersen AFB in April 2015 (NAVFAC Marianas and Andersen AFB 2015).

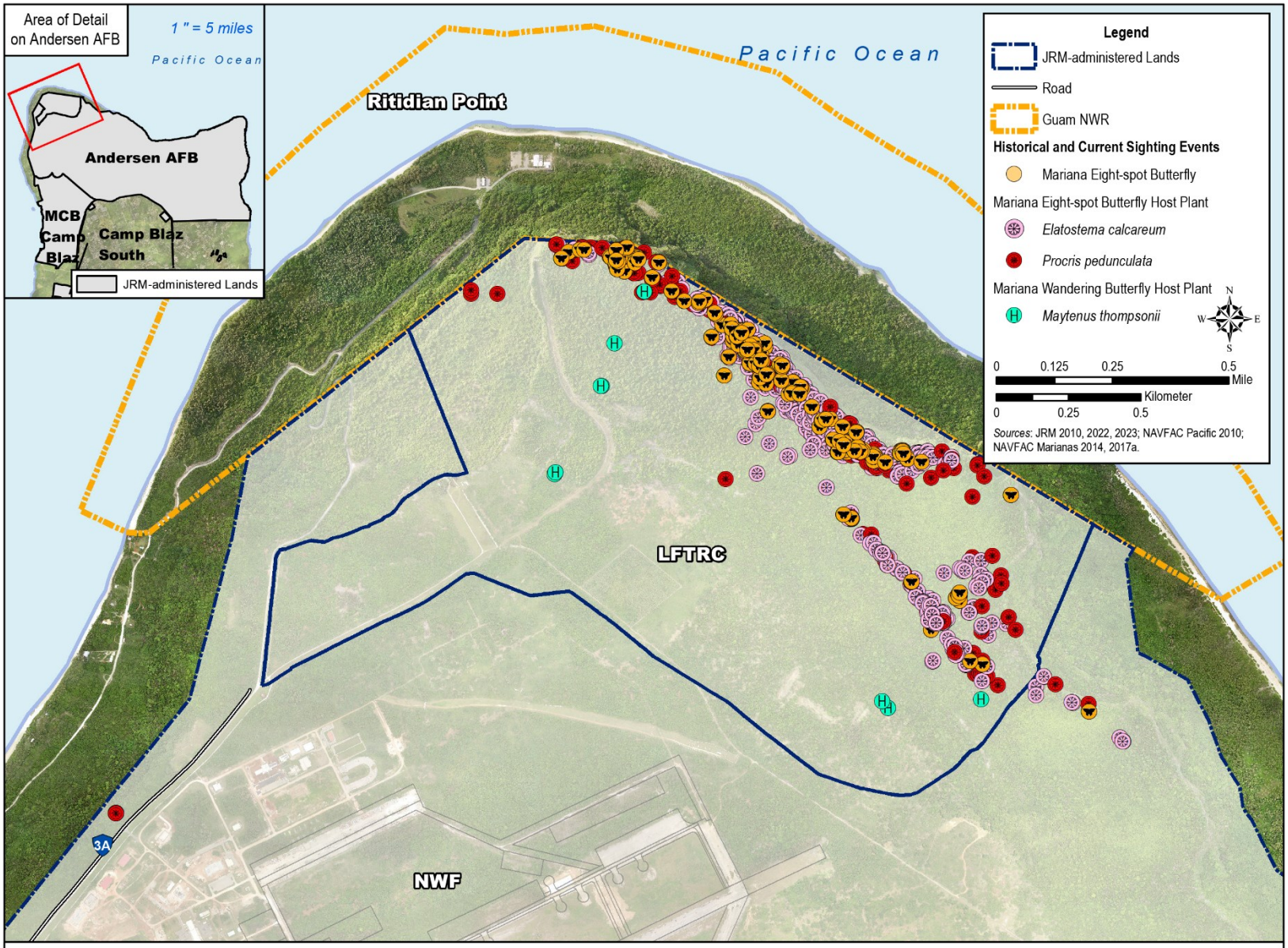


Figure 8-14
Protected Terrestrial Species Recorded on Northern Andersen AFB

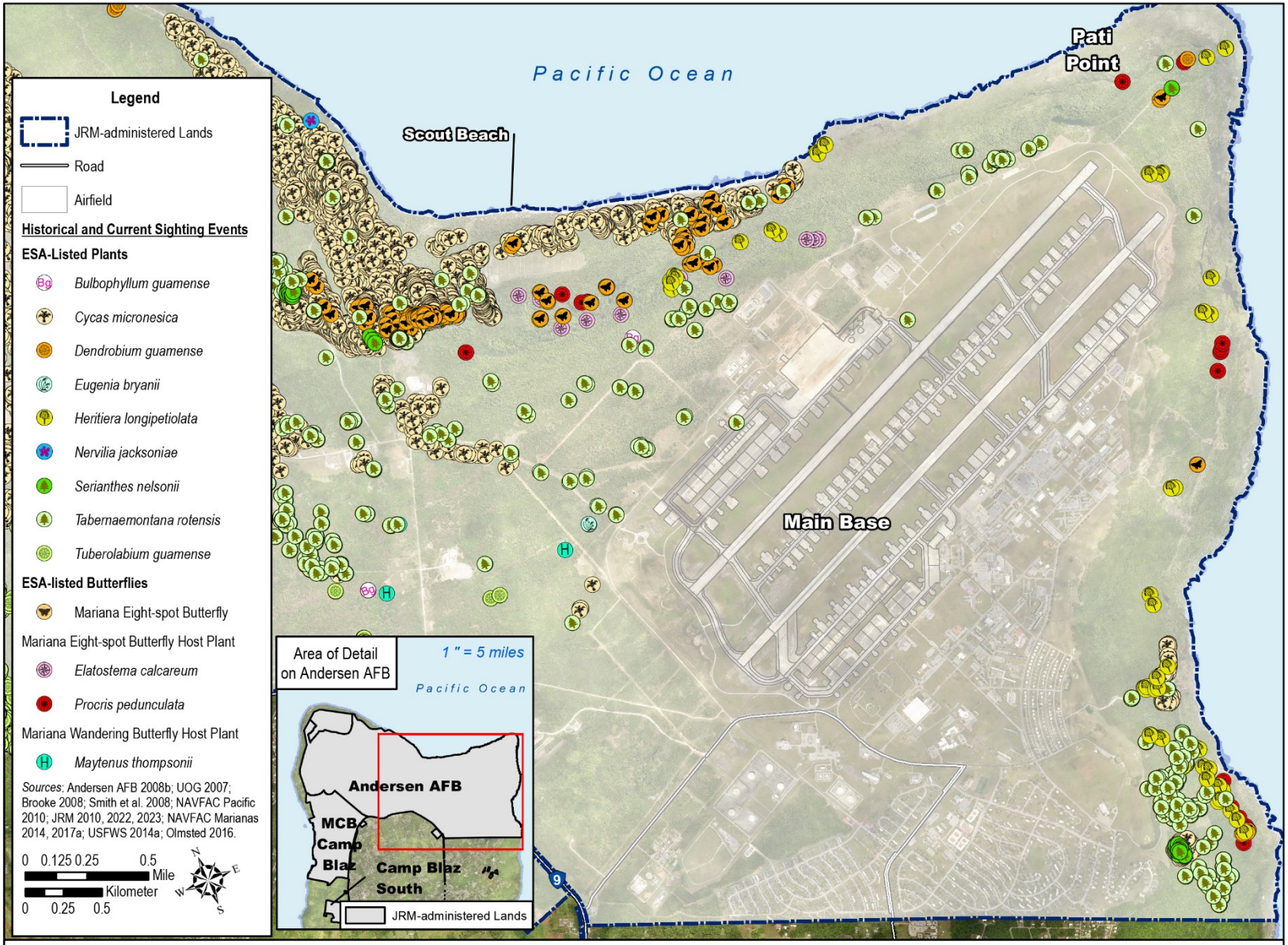


Figure 8-15
Protected Terrestrial Species Recorded on Eastern Andersen AFB

Tree Snails

The humped tree snail, Guam tree snail, and fragile tree snail are federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. In 1920, humped and Guam tree snails were observed during surveys in the Tarague Basin, on land now under the control of Andersen AFB (Crampton 1925). In 1989, areas of Andersen AFB known to support tree snails historically were resurveyed, but no living partulid snails were observed (Hopper and Smith 1992). In October and November 2011, 49 live tree snails were observed in coastal strand habitat at the eastern end of Tarague Basin; 29 of the 49 tree snails observed were recorded as fragile tree snails and 20 were recorded as Guam tree snails (NAVFAC Marianas 2013). Surveys conducted in August 2013 confirmed the continued presence of tree snails in the Tarague Basin area but found only Guam tree snails; additionally, the previous recording of the fragile tree snails was determined to have been misidentified juvenile Guam tree snails (NAVFAC Marianas 2014, 2015a). Consequently, no substantiated records of extant fragile tree snail presence exist for Andersen AFB. During surveys conducted from 2022 to 2023, a second colony of the Guam tree snail was inadvertently discovered adjacent to the Palm Tree Golf Course. Analysis of snail data plots at both the Tarague and the golf course colony show a general decline in snails during the survey period with a rapid drop in numbers following typhoon Mawar in May of 2023, although, the golf course colony has slightly expanded in dispersion since the typhoon (NAVFAC Marianas 2023a).



The Guam tree snail (*Partula radiolata*) is present in Tarague Basin.
(*Photo*: B. Holland and D. Rubinoff)

Although Guam tree snails are present in Guam National Wildlife Refuge (NWR) (lands that are just outside of Andersen AFB), surveys have confirmed that this northern population does not cross over into installation land and is restricted to the NWR land (NAVFAC Marianas and Andersen AFB 2015; NAVFAC Marianas 2016b).

Guam tree snails use a wide variety of host plants, including coconut, *C. micronesica, Flagellaria indica*, *Hernandia sonora*, *Mammea odorata*, noni (*Morinda citrifolia*), *O. mariannensis*, and *O. oppositifolia*. While they are not limited by host plants, they are found in moist and shaded forest (NAVFAC Marianas 2013), a characteristic that generally limits them to limestone native forests. Historical and current presence of tree snails on Andersen AFB are shown in Figures 8-10, 8-11, and 8-12.

8.2.5.5 Plants

There are 16 federal ESA-listed plant species that may be present on JRM in Guam. *C. micronesica* and *T. rotensis* are Guam-designated as SOGCN (Guam DAWR 2006). Locations of protected plants on Andersen AFB can be seen in Figures 8-15, 8-16, 8-17, and 8-18. Due to the high presence of ungulates at AFB Northwest Field (NWF), recruitment of tree species may be low, and the spread of invasive species elevated.

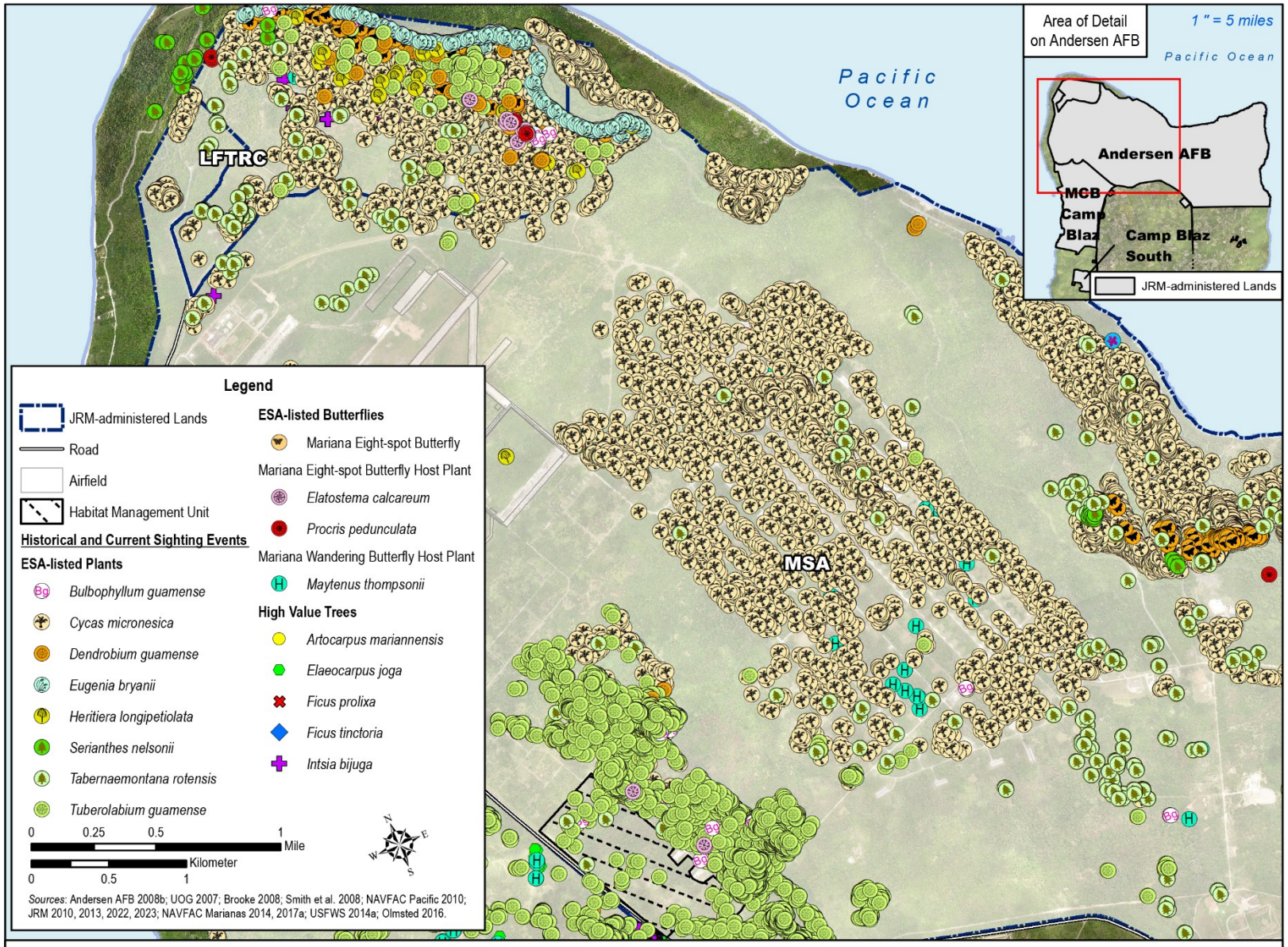


Figure 8-16
Protected Terrestrial Species Recorded on Southwestern Andersen AFB

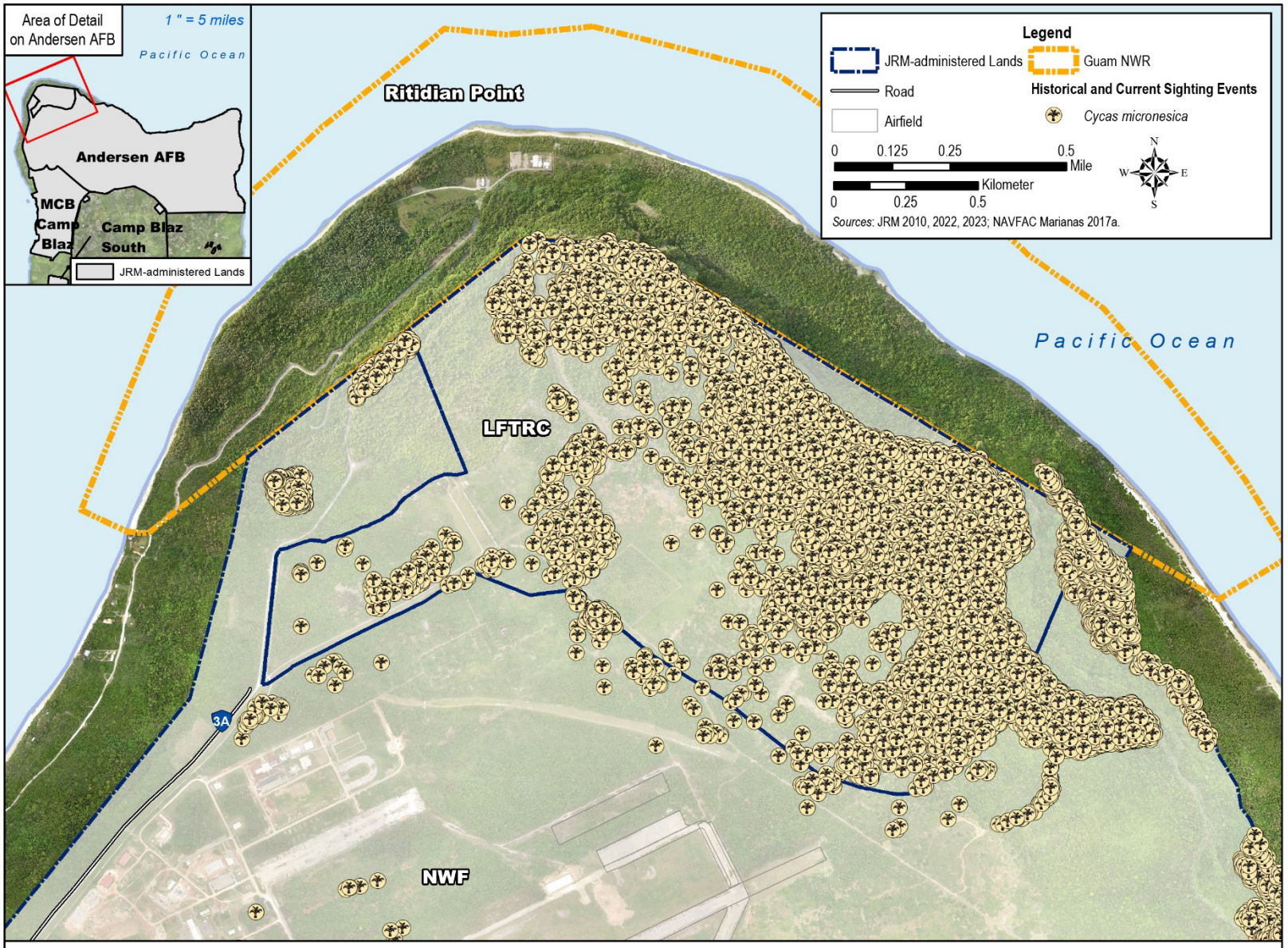


Figure 8-17
Protected Terrestrial Species Recorded on Northern Andersen AFB

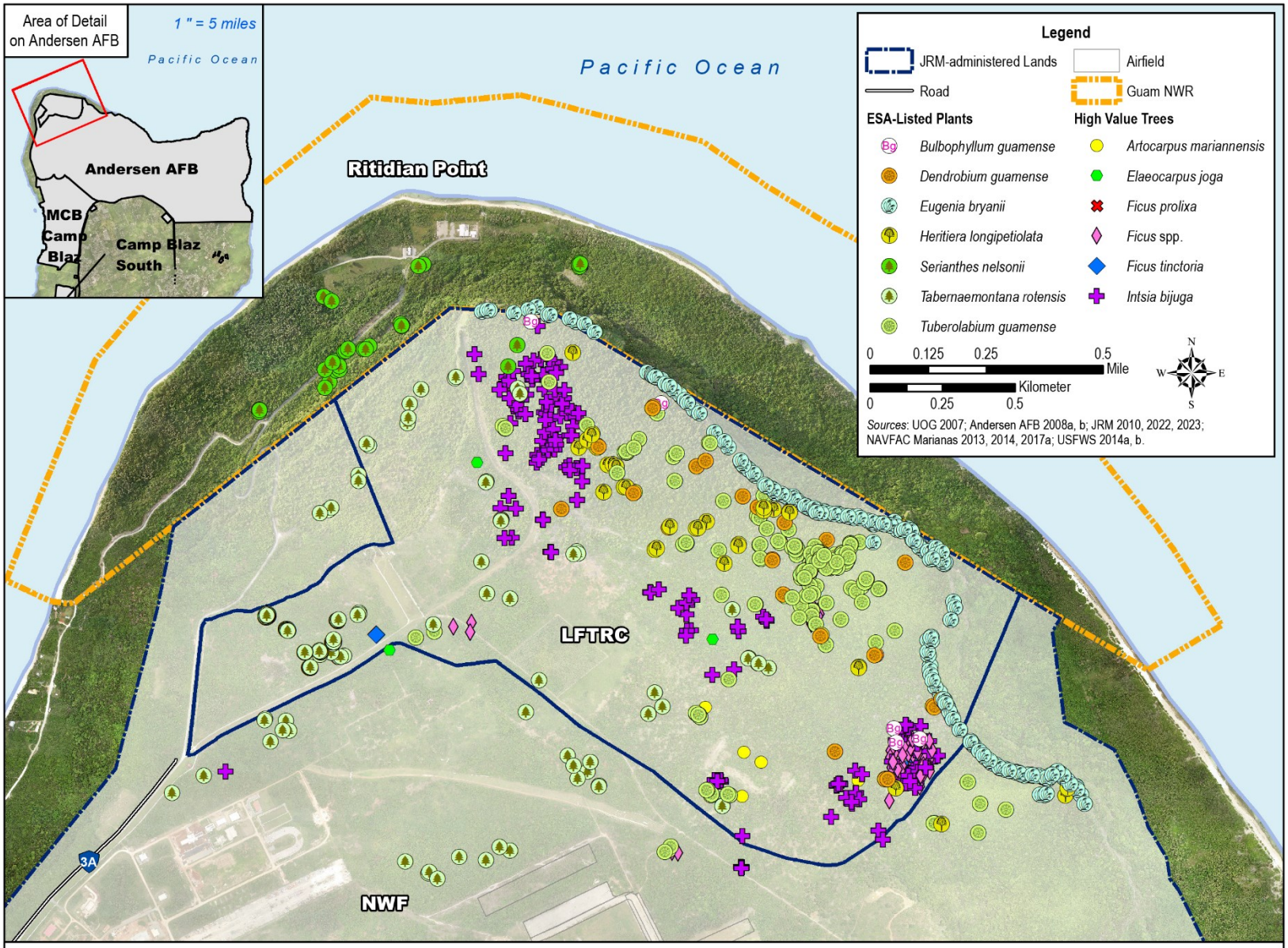


Figure 8-18
Protected Terrestrial Species Recorded on Northern Andersen AFB

Psychotria malaspinae

While *P. malaspinae* historically occurred on Andersen AFB, there are no recent records of the species. *P. malaspinae* is a federal ESA-listed endangered shrub in the coffee family also known from a handful of occurrences prior to 2010, one of which consisted of two individuals in NWF (USFWS 2014a, 2014b). There is much debate over the taxonomic status of *P. malaspinae,* and the distinction between *P. malaspinae* and *P. hombroniana* var. *malaspinae* may only be resolved through genetic testing, which is underway with UOG guidance (USFWS 2015b).

Cycas micronesica

C. micronesica is federal ESA-listed as threatened and Guam-designated as SOGCN. It is found in limestone forests throughout Andersen AFB and is listed as endangered because of the cycad scale that is devastating the species (Marler and Lawrence 2012; USFWS 2014a). During recent surveys on Andersen AFB in 2016 and 2017, over 18,000 *C. micronesica* were recorded (NAVFAC Marianas 2017a). A majority of the *C. micronesica* observed were in poor condition (NAVFAC Marianas 2017b), largely due to infestation by the cycad scale, and several were also observed dead (NAVFAC Marianas 2016a). Surveys conducted from October 2022 through February 2023 at Andersen AFB resulted in the observation of 1,020 *C. micronesica* (NAVFAC Marianas 2023b).



A majority of the *Cycas micronesica* observed in Andersen AFB are in poor condition.
(*Photo*: L. Shaughnessy)

Dendrobium guamense

D. guamense is federal ESA-listed as threatened. It is an epiphytic orchid that forms clumps on tree branches of coastal lowland/limestone forests. Recent surveys identified occurrences in the limestone native forests, north and northeast of NWF and in the limestone native forests at Pati Point (NAVFAC Marianas 2017a). *D. guamense* was not observed during plant and invertebrate surveys conducted from October 2022 through February 2023 at Andersen AFB.

Heritiera longipetiolata

H. longipetiolata is federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. It is a large endemic tree found on Andersen AFB in crevices of tower karst in limestone native forests. A 2007 study documented the species as occurring at numerous locations on Andersen AFB, primarily in the central portion of the base and near the limestone cliffs in the northeast and southeast corners (UOG 2007). *H. longipetiolata* was not observed during plant and invertebrate surveys conducted from October 2022 through February 2023 at Andersen AFB.

Eugenia bryanii

E. bryanii is federal ESA-listed as endangered. It is a perennial shrub in the myrtle family and is endemic to Guam. Historically, *E. bryanii* is located on windy exposed coastal clifflines and in lowland/limestone forests along the Pigua River. Surveys in 2016 and 2017 identified over 600 individuals along the coastal cliffs in the limestone native forests north and northeast of NWF (see Figure 8-18) (NAVFAC Marianas 2017a). *E. bryanii* was not observed during plant and invertebrate surveys conducted from October 2022 through February 2023 at Andersen AFB.

Serianthes nelsonii

S. nelsonii is federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. It is endemic to limestone forests of Guam and Rota and is one of the largest native trees in the Mariana Islands. Principal risks of extinction include a limited range, a minimal number of individuals, and a lack of recruitment (Marler and Cascasan 2015; Marler 2017). A recovery plan was developed and published by the USFWS in 1994 to outline management strategies in order to recover and protect the species (USFWS 1994b). The recovery plan is supplemented by 5-year reviews, and the latest review was published in 2017 (USFWS 2017a). The U.S. Navy also produced a management plan for the tree, which it updates periodically (Andersen AFB 2014). Only 33 individuals are known from Guam and Rota (Marler 2017) with only one adult *S. nelsonii* is known to occur in Guam, specifically on MCB Camp Blaz at Ritidian Point.

Monitoring studies from 2012 to 2015 were conducted to better understand the ecology and conservation of the species. Weekly visits to the adult tree were conducted to observe plant behavior and maintain the site (Marler and Cascasan 2015). The biweekly visits to the adult tree in Guam were also conducted to observe plant behavior, apply insecticides, and maintain the site. During the 2013 study period, 374 seedlings emerged under the adult tree; however, nearly 30% of these died in less than 15 days (Marler and Cascasan 2015). Surveyors observed widely contrasting seedling emergence for each month of the year. In 2014, the number of seedlings to emerge under the adult tree increased to 488. Marler and Musser (2015) evaluated four treatments and monitored the survival of these 488 seedlings. Insecticide, fertilizer, and supplemental lighting treatments did not significantly impact survival rate. However, the fourth treatment (Ridomil Gold fungicide) did increase seedling survival rate, suggesting that in addition to previously recognized problems of predation by insects and ungulates, microorganisms in the soil may be reducing seedling survival (Marler and Musser 2015). As of 2016, the health of the lone tree in Guam continues to decline, showing a recent decrease in canopy cover and no natural regeneration to sustain a wild population. Only one older juvenile tree (out of the 67 trees outplanted in 1999-2000) persists in the Tarague Basin (USFWS 2017a). Nursery trials have been conducted to generate plants and increase the understanding of horticulture and ecology of *S. nelsonii* (Marler et al. 2015; NAVFAC Marianas 2015b; Marler 2017). *S. nelsonii* seedlings can be successfully raised in nurseries if proper horticultural methods are applied (Marler and Cascasan 2015; Marler et al. 2015; Marler 2017), suggesting that these new techniques may be of great value to recovery of the species. *S. nelsonii* was not observed during plant and invertebrate surveys conducted from October 2022 through February 2023 at Andersen AFB.

Tabernaemontana rotensis

T. rotensis is federal ESA-listed as threatened and Guam-designated as SOGCN. It is a small to medium-sized tree endemic to Guam and Rota and found in limestone forests. Surveys conducted in 2005 and 2006 found 21,000 individuals on Andersen AFB (UOG 2007). Surveys conducted in 2016 and 2017 confirmed existence of additional individuals (NAVFAC Marianas 2017a). Marler et al. (2015) conducted research on seedling emergence at different light levels from seeds stored for different periods at different temperature and humidity levels. They found that 80% of *T. rotensis* seedlings emerged in full sunlight, while only 63% emerged in 25% ambient light. This research is a valuable addition to future management and propagation of the species. Surveys conducted from October 2022 through February 2023 at Andersen AFB resulted in the observation of 25 *T. rotensis* individuals (NAVFAC Marianas 2023b).

Tuberolabium guamense

T. guamense is federal ESA-listed as threatened. It is an epiphytic orchid found in limestone forests. When the species was listed, it was known from a single occurrence in Guam and six occurrences on Rota; however, it was recognized that more individuals might be found scattered across native forests in Guam

(USFWS 2015b). Surveys conducted in 2016 identified 4,278 individuals in the limestone forests on Andersen AFB (Olmsted 2016). As of 2022, a total of 24,276 *T. guamense* individuals have been documented at NWF by UOG surveys and there are an estimated 7,040 within the HMU (UOG 2022).

8.3 MARINE ENVIRONMENT

Refer to Section 8.1, *Current Operations and Land Use*, for an overview of Andersen AFB and a discussion of the assets and uses of Andersen AFB.

8.3.1 Joint Region Marianas-administered Submerged Lands

The total shoreline length of Guam is approximately 150 miles (241 kilometers), of which about 9% (13 miles [31 kilometers]) is found within Andersen AFB. JRM-administered submerged lands extend 3 miles (5 kilometers) offshore of Andersen AFB (Figure 8-19) and encompass approximately 37,869 acres (15,325 hectares), 44% of the total of JRM-administered submerged lands (85,364 acres [34,546 hectares]) surrounding Guam. This submerged land includes the 713-acre (289-hectare) Andersen AFB Marine Resources Preserve (MRP) (Figure 8-19). In 1973, the USAF established the Andersen AFB MRP to protect marine habitats and marine resources. Guam PL 24-21 established the Pati Point Marine Preserve in 1997, along with four other marine preserves around Guam (Burdick et al. 2008). Enforcement within these preserves by GovGuam began in 2001.

The seaward boundary of the preserve extends to the 600-feet (183-meters) submerged contour (approximately 1.2 miles [2 kilometers] from shore), and the inland boundary of the preserve extends landward 32 feet (10 meters) from the mean high tide mark, or to the nearest edge of a public right-of-way, whichever comes first. The Pati Point Marine Preserve and Andersen AFB MRP overlap in the nearshore area and approximately 32 feet (10 meters) along the onshore area. The entire coastline boundary of Pati Point Marine Preserve borders Andersen AFB. In addition to its inclusion in a Marine Protection Area, the area around Pati Point derives further protection from the limited accessibility due to its proximity to Andersen AFB (Brainard et al. 2012). Within Pati Point Marine Preserve, the following actions are prohibited: all fishing except using hook-and-line from shore, shell collecting, and gleaning and removal of sand or rocks.

8.3.2 Physical Environment

The submerged lands offshore of Andersen AFB are relatively natural and undisturbed. No significant military construction activity has occurred in these waters or at the coastline, which is primarily comprised of steep limestone cliffs around Pati Point and on the eastern side of Andersen AFB. On the northern side of Andersen AFB, west of Pati Point, the cliffs are fronted by sandy beaches. Surface seawater temperatures off of Andersen AFB typically range between 80.8-86.2 degrees Fahrenheit (°F) (27.1-30.1 degrees Celsius [°C]). However, during 2013, 2014, and 2016, water temperatures offshore of Guam were elevated above normal. This elevation was due to prolonged El Nino conditions, which caused environmental degradation that included prolonged coral bleaching (Harvey 2016).

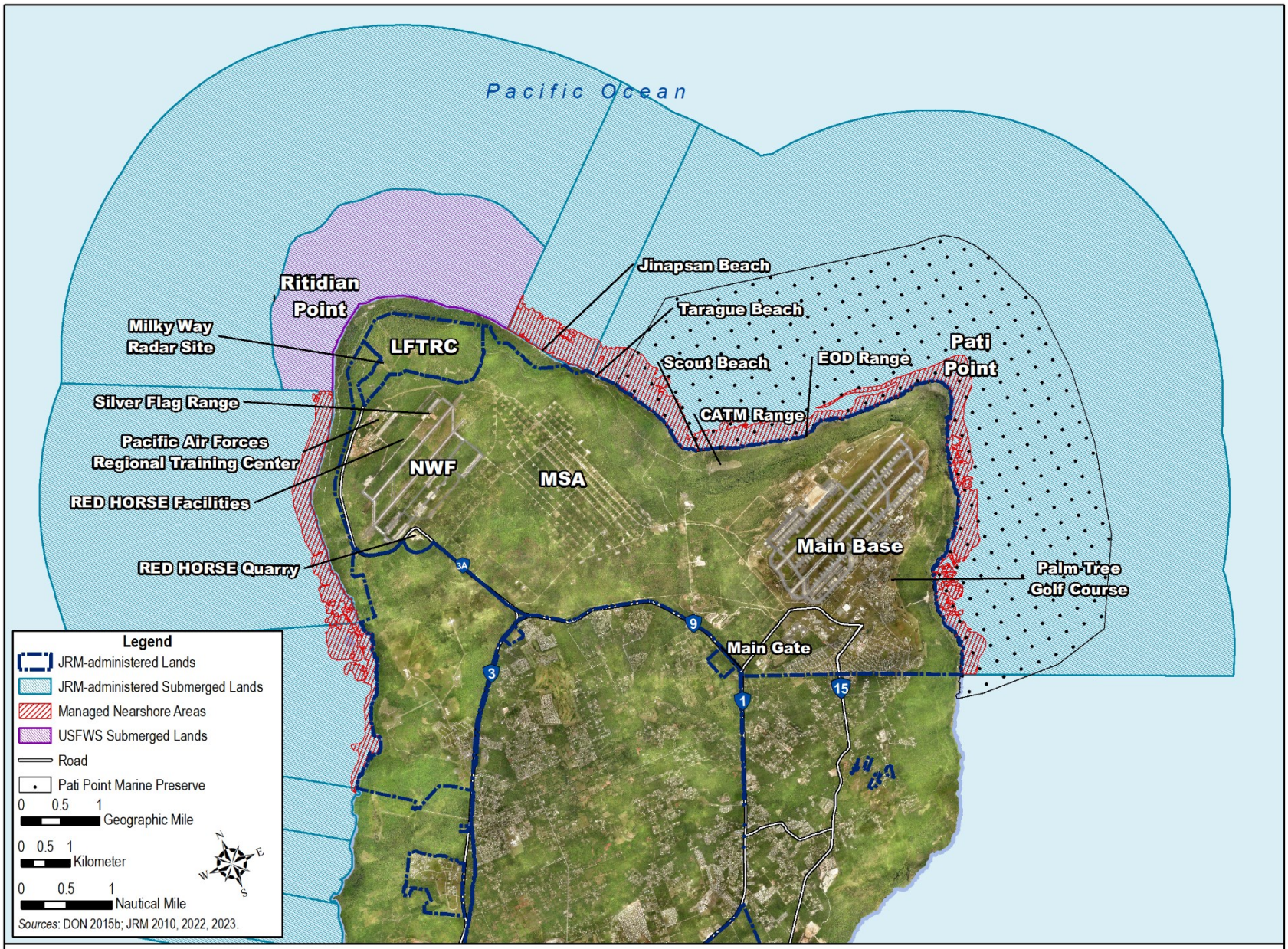


Figure 8-19
JRM-administered Submerged Lands of Andersen AFB

8.3.2.1 Bathymetry and Currents

The coastline of Andersen AFB is backed by steep cliffs inland, and includes relatively narrow sand beaches primarily on the northern coast, with volcanic or limestone rock outcrops at various locations along the beach. Schils et al. (2017) and Schils and Houk (2017) surveyed underwater habitats at eight sites at or in proximity to Andersen AFB; all of these sites had fringing coral reefs out to approximately 200 feet (60 meters) from shore. Closest to shore is a hard reef flat pavement with encrusting corals, which reaches approximately 16-30 feet (5-10 meters) deep. Further out, a shallower reef crest is formed by terraced algal pools, onto which waves typically break.

The reef crest and flat are incised with deeper channels perpendicular to shore; these channels can funnel wave energy and create hazardous conditions, but they also support high coral cover. Seaward of the reef crest, the bathymetry abruptly drops off. However, the submerged shelf offshore of Andersen AFB is wider and shallower compared to other JRM-administered submerged lands around Guam, reaching 328 feet (100 meters) depth approximately 1.2 miles (2 kilometers) from shore (Figure 8-20). The northwesterly flow of the North Equatorial Current bathes the island of Guam, impinging upon the eastern side of the island and flowing north and south around it. Therefore, nearshore currents offshore Andersen AFB generally flow northward along the coast on the east side of the island south of Pati Point, and then west along the northern coast of the island west of Pati Point (Wolanski et al. 2003). During El Nino events, the North Equatorial Current may slow or switch direction (Lagerloef et al. 1999), which changes the direction and strength of nearshore currents. Regional-scale modeling of currents and biological connectivity shows very complex dynamics in space and time (Kendall and Poti 2015).

The mean diurnal tidal range in Guam is 2.35 feet (0.72 meters). As such, other than the entrance to Outer Apra Harbor, tidal currents are unlikely to be significant. MSL is reduced significantly during El Nino events, which causes very shallow corals to become exposed during very low tides, leading to coral death (Widlanski et al. 2015).

8.3.2.2 Turbidity and Water Quality

The JRM-administered submerged lands offshore Andersen AFB are not adjacent or down current from any streams, which are concentrated on the southern volcanic portion of Guam. Best management practices (BMPs) related to stormwater management and infrastructure on Andersen AFB, in combination with the natural filtration provided by the limestone, help to maintain the quality of the water discharging through seeps.

In 2003, 2005, and 2007 Brainard et al. (2012) conducted conductivity, temperature, and depth casts in nearshore waters, including those along the shore of Andersen AFB. The program was known as Mariana Archipelago Reef Assessment and Monitoring Program (MARAMP) through 2012 and is presently named the Pacific Reef Assessment and Monitoring Program (Pacific RAMP). In 2005 and 2007, optical refraction (i.e., turbidity) was measured at several sites in this region, and nutrients were also measured at one site in 2005 and at two sites in 2007.

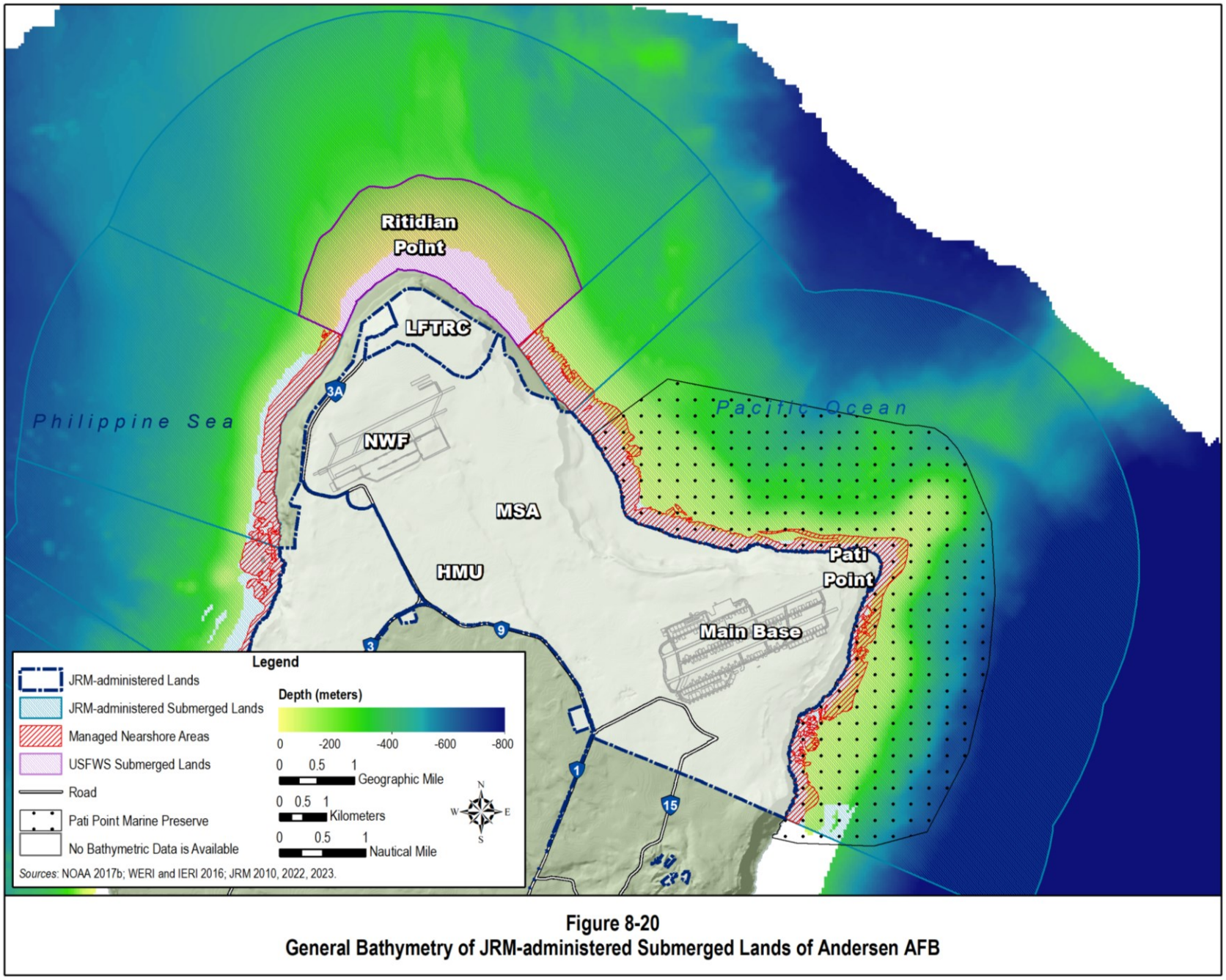


Figure 8-20
General Bathymetry of JRM-administered Submerged Lands of Andersen AFB

Compared to nearshore open waters at other sites around Guam, waters were cooler and more saline in 2003, particularly at the southeastern reaches of JRM-administered submerged lands on Andersen AFB. In 2005, waters off of Andersen AFB were lower in salinity and more moderate in temperature compared to other sites around the island, and the site analyzed on the north side of the island, within JRM-administered submerged lands on Andersen AFB, contained generally low chlorophyll-a and nutrients. In 2007, there was a marked difference between water temperature and salinity on the east side of the island (south of Pati Point) as compared to the north and west sides of the island (west of Pati Point), with warmer and fresher water on the east. Turbidity was very low in all measurements of this region.

In 2007, nitrate, phosphate, and silicate were elevated offshore the east of Andersen AFB as compared with other locations around Guam, while nitrite was slightly elevated at the site on the north side of Andersen AFB. Chlorophyll-a was low at both sites as reflected in low chlorophyll-a estimates from the Moderate Resolution Imaging Spectroradiometer satellite (ranging from about 0.04-0.08 micrograms per liter) (National Oceanic and Atmospheric Administration [NOAA] 2017a). These findings suggest that nutrients offshore Andersen AFB are somewhat elevated, yet are not generally causing phytoplankton blooms (elevated populations of algae in the water column); instead, nutrients may be taken up by macroalgae, which are abundant offshore Andersen AFB (see Section 8.3.4, *Marine Flora*).

Marine resources offshore on Andersen AFB are likely subjected, to some degree, to the array of stressors in the marine environment that are described in Section 4.5.7, *Stressors on the Marine Environment of Guam.* However, with low levels of development onshore and limited recreational access due to surf hazards, many local-scale stresses such as sedimentation, trampling, and sunscreen pollution are lower than at more heavily developed and frequented locations in Guam. These overall conditions should provide for improved coral resilience to climate impacts (Carilli et al. 2009) and acute events such as typhoon strikes. However, some emerging stressors, such as the possible inhibition of gamete or larval development, which may be imposed by endocrine disruptors (such as sunscreen or other personal care products), are still understudied (Downs et al. 2016). A project was developed by JRM in 2017 to implement a public outreach project about the importance of using reef-safe sunscreen in order to help protect Guam's coral reefs (see Section 8.4.2.4, *Marine Natural Resources Educational Outreach*).

8.3.2.3 Waves and Storms

The most consistent wave energy impacting Guam is caused by the northeast trade winds, which drive generally small, choppy, and short-period waves onto the exposed JRM-administered submerged lands on Andersen AFB (Brainard et al. 2012). In addition, typhoons generally approach Guam from the east, and thus the JRM-administered submerged lands offshore Andersen AFB are regularly exposed to large and energetic typhoon-driven waves.

Coral bleaching, caused by elevated sea surface temperatures, is often mitigated when cooler waters are driven up onto coral reefs by surface wave-driven mixing, or deeper internal waves that impinge upon reef slopes (Wall et al. 2015). Corals around Andersen AFB are expected to benefit from this type of wave-driven cooling more than corals at sheltered sites around Guam, and may therefore survive better during bleaching events compared to other sites on the island. Understanding and predicting coral bleaching around Guam will be improved with continued monitoring of coral status and physical conditions before, during, and after coral bleaching events. The Guam Coral Reef Response Team developed "canary sites" where rapid reconnaissance surveys are conducted if NOAA issues a warning for predicted coral bleaching; Ritidian Point is the designated canary site for northern Guam (Hoot and Burdick 2017). The current status of coral bleaching within JRM-administered submerged lands on Andersen AFB is unknown.

8.3.3 Marine Habitats

8.3.3.1 Bottom Habitat

Portions of the Andersen AFB MRP and JRM-administered submerged lands on Andersen AFB around the northeastern corner of Guam stand out as areas with overall reef conditions that are among the best when compared to conditions around the other populated southern Mariana Islands. This region contains seagrass, and shallow-water and deep-water coral ecosystems (Brainard et al. 2012), along with some regions dominated by coralline algae and turf algae (Figure 8-21). Benthic morphology is illustrated in Figure 8-22.

The coral reefs off Andersen AfB are generally fringing reefs (Schils and Houk 2017; Schils et al. 2017). Low diversity encrusting corals occur on the relatively shallow reef flat nearest shore, and a coralline algal reef crest forms a buffer to wave energy farther from shore. This crest and reef flat are cut by channels perpendicular to shore to form a spur and groove habitat, with corals growing on the sides of the grooves and sand and rubble in the bottom. Most of the coral habitat is found on the seaward side of the reef crest, on both shallow and deeper fore-reef habitats, which tend to host different assemblages of corals.

Because of the exposed nature of the reefs off Andersen AFB, and thus strong wave and current conditions, these reefs have not been surveyed as extensively as reefs in more protected regions around Guam. However, with the relatively low levels of human impacts, and healthier fish populations than other areas of Guam, it is critical for JRM to effectively manage and protect these healthy marine ecosystems.

8.3.3.2 Coastal Habitat

The northeast and southern coasts of Andersen AFB are largely inaccessible by road and backed by steep cliffs. The eastern coast is backed by a more moderate (averaging about 45 degree) slope, with road access to most of this section of coastline. Because this area is much more easily accessed by road, the eastern coastline experiences the greatest human impact. The western edge of the installation does not extend to the coastline. Andersen AFB currently provides a volunteer marine patrol to help reduce human impacts to Tarague Basin marine coastal and nearshore species and habitats. The volunteer patrol may be expanded in the near future to increase public awareness and reduce undeliberate damage.

8.3.4 Marine Flora

8.3.4.1 Native Species

Marine flora serve as a very important aspect of the coral reef ecosystem. Turf algae are a small, filamentous assemblage of many algal species that serve as primary food sources for many reef grazers. Macroalgae are assemblages of large fleshy and/or calcified species with a wide range of growth forms. These algae can grow out of control without enough grazers or with excess nutrient enrichment. Crustose coralline algae (CCA) are often recognized as important “building blocks” of coral reefs. This type of algae serves as cement over and between fragments of dead coral and sand, providing a stronger foundation for the coral reef. CCA is also an important substrate onto which coral larvae preferentially settle (Heyward and Negri 1999). Cyanobacteria (sometimes called blue-green algae) often cause unsightly blooms in Guam (e.g., Thacker and Paul 2001 and references therein) and may indicate nutrient pollution (Albert et al. 2005).

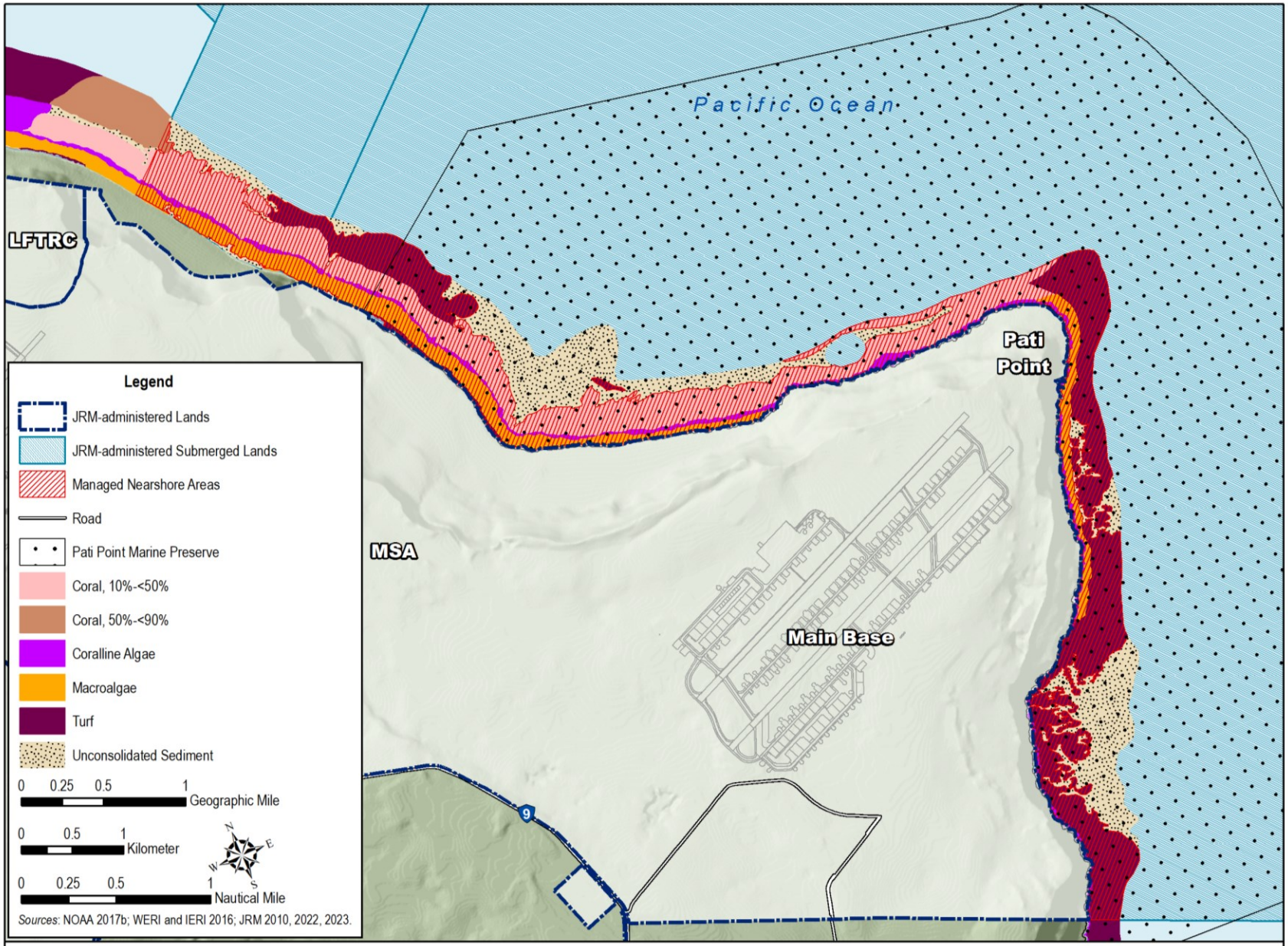


Figure 8-21
Benthic Habitats Offshore Andersen AFB

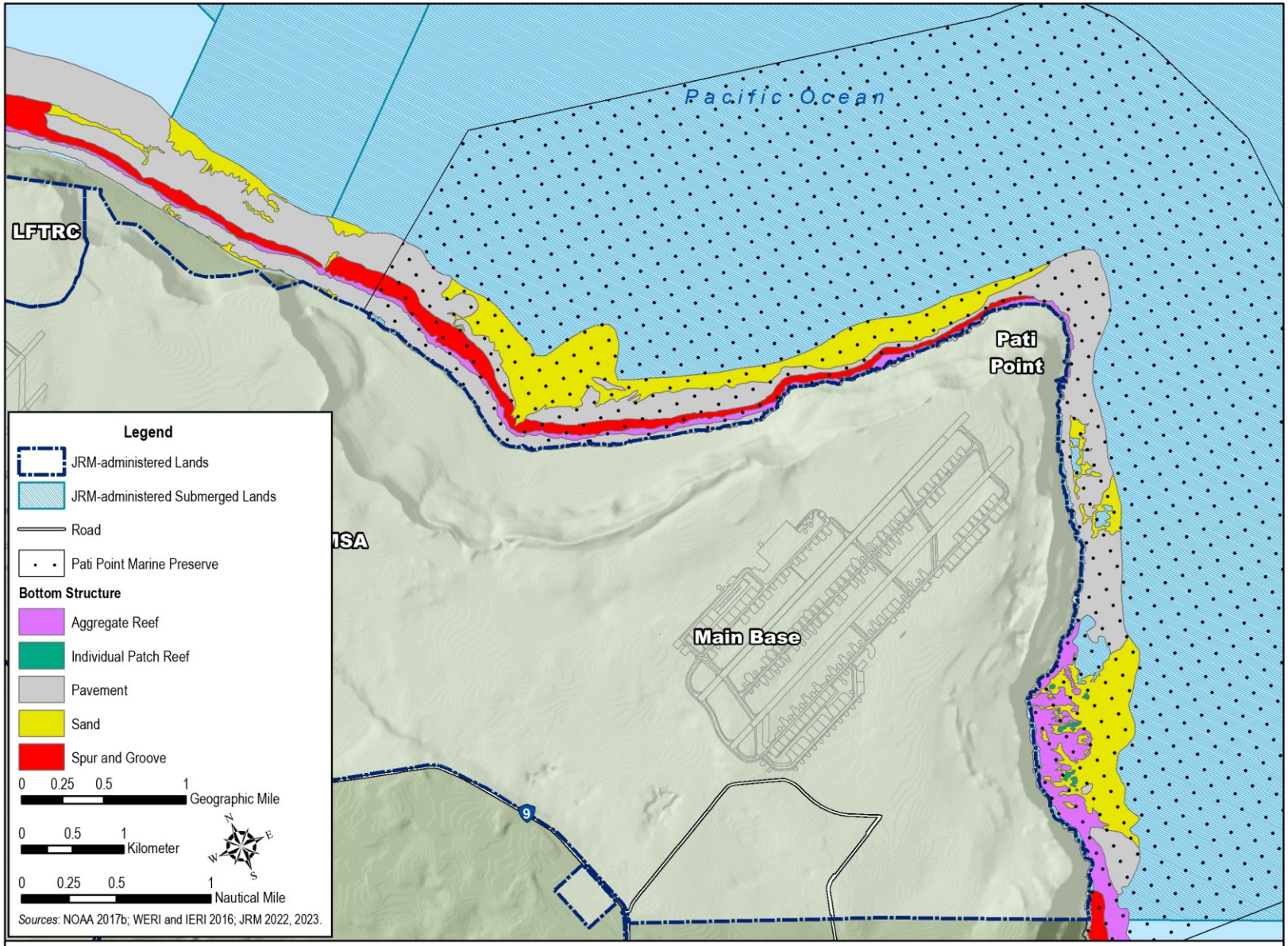


Figure 8-22
Benthic Morphology Offshore Andersen AFB

Turf algae, CCA, and cyanobacteria were all common around Guam in 2003 and 2005, while CCA was reduced at some sites around the island in 2007 (Brainard et al. 2012). In 2003, turf and macroalgae cover ranged between 10 to 60%, while CCA ranged between 10 to 30%. In 2005, there was an increase in turf and macroalgae cover to 30-75% and a decrease in CCA to 1-10% cover. In 2007, turf and macroalgae decreased again to 10-50% cover, while CCA was about the same at 0-8% cover. Pacific RAMP 2007 surveys indicated that the greatest density of coralline algal disease (coralline lethal orange disease) around Guam was found off Jinapsan Point (to the northwest of Tarague Beach) (Brainard et al. 2012). During the 2003, 2005, and 2007 surveys, macroalgae and turf algae cover was highest around Pati Point, with more than 75% macroalgal cover and approximately 30% macroalgal cover at some sites distant from Andersen AFB (Brainard et al. 2012). The 2011 Pacific RAMP surveys within Pati Point Marine Preserve indicated CCA levels were 9% and macroalgae cover was approximately 24% (Williams et al. 2012).

All locations around Guam had relatively abundant calcified green *Halimeda* and *Neomeris* algae in 2003-2007 Pacific RAMP surveys; however, the northeast coastline had some unique marine flora communities in 2003 and 2005. In 2003, only three sites around Guam contained *Halimeda opuntia* and *Portieria hornemannii*, two of which were on the north coast off Andersen AFB. In 2005, these three sites were also the only sites around the island containing a species of the red alga *Galaxaura* sp. and lacking species of the calcified red algae *Amphiroa* sp. Tsuda (2004) reported 270 algal species in Guam, with 7 Cyanophyta, 88 Chlorophyta, 30 Phaeophyta, and 145 Rhodophyta.

Schils et al. (2017) and Schils and Houk (2017) surveyed multiple sites around Andersen AFB and classified all as fringing reefs; they found that turf algae was the dominant cover, with an average of approximately 60% cover in this region. While some authors separate turf algae and macroalgae into separate categories, others combine them into the same functional group because they are grazed upon by herbivores and compete with corals (Vermeij et al. 2010).

Healthy coral reefs require a certain balance with macroalgae cover. Eutrophication can lead to detrimental effects of cyanobacteria, resulting in low dissolved oxygen and sunlight. Too much macroalgae can decrease substrate needed for coral larvae to settle and for further growth of established coral colonies to occur. The 75% macroalgal cover observed during some surveys around Pati Point may be normal in this environment, however, this high amount of algae cover may instead reflect increased nutrient discharges to the coastal zone, encouraging algal growth or reduced herbivory due to overfishing. Further surveys, including routine assessments of algal cover during and outside of seasonal blooms, are required to determine normal and sustainable algal cover around Andersen AFB or to determine whether intervention is warranted to reduce algal dominance.

Three species of seagrasses occur in Guam: *Enhalus acoroides*, *Halodule uninervis,* and *Halophila minor* (Tsuda 2004), but no reports describing seagrass beds off Andersen AFB have been identified (NOAA 2009).

8.3.4.2 Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine flora in Guam are presented in Section 4.5.3, *Marine Flora*.

There are no reports of non-native or invasive marine flora on Andersen AFB. A nuisance marine species is native but occasionally exhibits blooms or outbreaks or other undesirable characteristics; however, to date, no nuisance marine flora have been reported on Andersen AFB. The green angel hair algae

(*Chaetomorpha* sp.) is a nuisance species that could occur on Andersen AFB (Schils 2015), but the relatively strong waves and currents make blooms unlikely.

8.3.5 Marine Invertebrates

8.3.5.1 Native Species

Corals

The benthic communities to both the west and south of Pati Point generally support different coral reef habitats when compared to each other. Live hard coral cover from 2003-2007 towed-diver surveys was higher west of Pati Point than south of it, with mean coral cover of 30% west of Pati Point and 14% south of it. The Pacific RAMP Benthic Condition Index in both 2005 and 2007 was medium for the area west of Pati Point and high south of Pati Point. The Benthic Condition Index took into account the ratio of crustose coralline red algae to macroalgae, coral cover, the frequency of stressed-coral observations, and crown-of-thorns seastar (COTS) (*Acanthaster planci*) observations. Benthic habitats were also characterized differently northwest and southeast of Pati Point. South of the point, irregular pavement flats and areas of high rugosity habitat with rocky pillars and boulders were observed. In contrast, the habitat west of Pati Point was more sheltered and consisted of rolling fringing reefs with lower rugosity (Brainard et al. 2012). These observed differences in benthic habitats and coral communities south and west of Pati Point could be the result of wave energy forces. Both episodic storm and trade wind waves affect Guam from the east (Brainard et al. 2012), possibly hindering coral recruitment or dislodging adult colonies. Similarly, as noted above, other physical oceanographic conditions on either side of Pati Point such as temperature, salinity, and nutrients can vary (Brainard et al. 2012), which may serve to control differences in coral communities.

Schils et al. (2017) and Schils and Houk (2017) found that two sites around Pati Point appeared to be distinct from others just west and south of that area. Corals that were more abundant within Pati Point included genera with affinities to groundwater seeps reported elsewhere in the southern and northern Mariana Islands: *Psammocora*, *Millepora*, *Coscinaraea*, and *Echinophyllia.* Based on this 2017 survey, it suggests the potentially distinct assemblages at Pati Point were probably a consequence of differing natural environmental regimes rather than management regimes, because benthic communities are not actively managed in this area. This conclusion is supported from a snapshot spatial profile of water quality, which highlighted anomalously low salinity levels in the waters associated with the two previously mentioned sites near Pati Point.

Schils et al. (2017) and Schils and Houk (2017) also noted that reefs just west and south of Pati Point have high condition scores; however, they cautioned not to attribute high condition scores to the management status associated with Pati Point Marine Preserve. Groundwater discharge has been shown to promote unique (coral) diversity, yet limit coral cover on the reefs in the northern Mariana Islands (Houk and van Woesik 2008; Houk and Starmer 2010).

Ritidian Point, the northernmost tip of Guam and northwest of Andersen AFB and a Habitat Area of Particular Concern, had moderate values for Benthic, Fish, and Coral Reef Condition in 2003-2007 (Brainard et al. 2012). Still, the coral reefs around Ritidian Point were in notably better condition relative to some other locations around the populated southern islands of Guam, Rota, Tinian, and Saipan (Brainard et al. 2012). Ritidian Point is not included in the JRM-administered submerged lands on Andersen AFB; however, the good condition of the coral reefs there, as well as offshore of Andersen AFB and MCB Camp Blaz may have a reciprocating positive effect on the coral reef ecosystem between these three regions.

In 2005, the highest coral cover observed on JRM-administered submerged lands was Jinapsan Point and within the large bay to the east, where interpolated live coral cover values of up to 63% were recorded. The highest generic diversity was also seen near Jinapsan Point in the northern region, an area in which the 2003 Pacific RAMP surveys found That *Favia* spp. corals were dominant (Brainard et al. 2012). The 2007 Pacific RAMP survey found the highest incidence of coral disease in the northern region of Guam near Jinapsan Point; however, observations of disease prevalence in this area were still relatively low at approximately 3% (Brainard et al. 2012). Coral diseases are still not well understood, and further monitoring including rapid response to outbreaks of disease is important.

Amesbury et al. (1995a, 1995b, 1995c, 1995d) recorded 39 species of corals offshore Andersen AFB. This represents only 13% of the approximately 300 species of corals recorded from Guam, which may have been due to reduced observer expertise or effort. Schils et al. (2017) and Schils and Houk (2017) found that sites they surveyed off of Andersen AFB had high coral species richness, with *Acropora*, *Montipora*, *Astreopora*, and massive species of *Porites* contributing most to coral cover.

Overall, based on the 2014-2015 field surveys from Schils et al. (2017), coral condition along the north and northeast coast of Andersen AFB appeared to be based on relatively natural environmental regimes. Human and natural stressors observed on the northwest coast may be having a detrimental effect on coral growth there, which could result in a negative spillover effect to the north and northeast.

Other Invertebrates

Jinapsan Point had the most abundant giant clams (*Tridacna* spp.) of all Pacific RAMP sites in 2003 (Brainard et al. 2012). Their 2005 survey results suggested that giant clams were relatively abundant near Pati Point and near Jinapsan Point. Their 2007 towed-diver surveys also showed similar results around the island. The two surveys completed in the north region, between Pati and Jinapsan Points, had the highest mean densities of giant clams (Brainard et al. 2012).

Pacific RAMP 2003 surveys found the north region between Pati and Jinapsan Points to have the third highest densities of sea cucumbers around Guam, dominated by species from the genus *Stichopus* (Brainard et al. 2012). Sea cucumbers were significantly reduced during the 2005 Pacific RAMP surveys, and rebounded slightly during the 2007 surveys (Brainard et al. 2012).

Amesbury et al. (1995a, 1995b, 1995c, 1995d) reported 35 species of macro-invertebrates within JRM-administered submerged lands on Andersen AFB. In their comparisons, they noted this as a rather modest number, but that the majority of shallow-water marine invertebrates are cryptic or nocturnal, which results in many missed species during surveys. Schils et al. (2017) and Schils and Houk (2017) recorded 16,387 mobile invertebrates in their surveys. The following made up 90% of all invertebrates they observed: alpheid shrimp, hermit crabs, two sea urchins (*Echinostrephus aciculatus* and *Echinometra mathaei*), a vermivorous cone snail (*Conus sponsalis*), nudibranch (*Thuridilla gracilis*), corallivorous gastropod (*Drupella cornus*), and the seastar (*Linckia multifora*).

Schils and Houk further noted that arthropods were the dominant mobile invertebrates for all but two sites and that Pati Point East was dominated by mollusks. The three most common phyla during their surveys were Arthropoda, Echinodermata, and Molluska. The four most commonly observed taxa within Andersen AFB waters were two arthropods (alpheid shrimps and hermit crabs), sea urchin (*E. aciculatus*), and a mollusk (*Cerithium zonatum*). They emphasized that the rock-boring snapping shrimp (*Alpheus schmitti*) were by far the most abundant mobile invertebrates, which accounted for 42% of all of their observations (Schils and Houk 2017; Schils et al. 2017). These recent marine resource surveys noted that mobile invertebrate species diversity was fairly equal between Andersen AFB and NBG, but over twice as many

specimens were encountered on Andersen AFB, compared to NBG (Schils and Houk 2017; Schils et al. 2017).

Biodiversity of coral reefs is dominated by invertebrates that rely on coral for food and habitat. Additionally, some invertebrates are coral predators. Dominance and diversity of these invertebrates can provide indicators of changes in communities, which can ultimately affect coral reef ecosystems. Logistical constraints may hamper accurate data acquisition of mobile invertebrates; for example, the requirement for night dives and the occurrence of intermittent storm events causing broken coral and fragments of mollusks.

8.3.5.2 Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine invertebrates in Guam are presented in Section, 4.5.4, *Marine Invertebrates*.

To date, there is no evidence of non-native or invasive marine invertebrates on Andersen AFB. However, the non-native *Tectus niloticus* is abundant in Guam and is almost certainly present on Andersen AFB (Paulay et al. 2002).

COTS are considered native to Guam waters, and outbreaks of this nuisance species have occurred off Andersen AFB. During November 1968-August 1969, dive teams surveyed all waters around Guam and participated in control efforts to remove COTS. During this time, large aggregations of COTS were found in the JRM-administered submerged lands off Andersen AFB (Chesher 1969a). Corals in very shallow water, large *Porites* coral heads in moderate swell conditions, and reefs with strong swell were generally the only survivors because the seastar were unable to maintain traction in these conditions (Chesher 1969a, 1969b). Coral reefs off Andersen AFB, particularly around Pati Point, may have enjoyed significant protection from COTS due to relatively high wave activity. While sites on the leeward side of Guam lost up to 99% of living corals, the impact of the outbreak in the late 1960s was not as severe off Andersen AFB (Chesher 1969a, 1969b). Around Guam, more than 20,000 COTS were removed or killed in-situ to control the outbreak (Chesher 1969a, 1969b). Since that time, other COTS outbreaks have occurred at lower densities. COTS have now eaten many of their preferred prey species and are switching to non-preferred prey (Burdick 2018). While the cause for COTS outbreaks is still under investigation, Timmers et al. (2012) found that outbreaks do not appear to be related to increased dispersal between islands, but instead are more likely caused by island-scale factors; this suggests that local management of COTS outbreaks is an important focus. The current status of COTS within JRM-administered submerged lands off Andersen AFB is unknown.

The nuisance marine species *Terpios hoshinota,* a coral-killing sponge, has been observed at many sites in Guam, but was not observed by Bryan (1973) who surveyed the island. Outbreaks of this sponge do not appear to have had a lasting negative impact on the reef community at this time, and may occur undetected on Andersen AFB. Plucer-Rosario (1987) found that *Terpios hoshinota* sponges grew fastest in the absence of living coral tissue, suggesting that *Terpios hoshinota* may be less effective at killing healthy coral as previously thought. Reimer et al. (2011) suggest that *Terpios hoshinota* may have serious outbreaks that kill and outcompete corals over short periods, but do not necessarily cause a permanent loss of coral on reefs.

8.3.6 Marine Fishes

8.3.6.1 Native Species

Hook-and-line fishing from shore is allowed for all species in Pati Point Marine Preserve. Trolling is allowed only for pelagic fishes, such as tunas (Scombridae) and billfishes (Scomberesocidae), in all the

preserves seaward from the reef margin. The 36 WG Instruction 32-7003 (December 2000) outlines the fishing regulations for Andersen AFB. Fishing special access permits cost $10.00 and are valid for a 1-year period from the date of issue; onshore hook-and-line fishing from Tarague Beach to Pati Point Beach is permitted during all hours. Trolling may be conducted from the reef margin seaward, but only for pelagic fish. The taking of any type of marine life, dead or alive, by any method other than by pole fishing from the shoreline is prohibited. Onshore pole fishing is allowed from the west end of Andersen AFB at Tarague Beach (except in the authorized swimming area) to Pati Point recreational beach. Spearfishing, net fishing, and chumming are prohibited in JRM-administered submerged lands on Andersen AFB. The possession of spears, spearguns, or nets, within 65 feet (20 meters) inland of the mean high tide mark signifies the intent to use fishing gear, and any violators are prosecuted. This possession information is in the process of being updated by Andersen AFB and revisions are anticipated by 2019.

Andersen AFB has a Marine Patrol Volunteer Conservation Officer program, which is a joint program between Andersen AFB and Guam DAWR. The purpose of the program is to collect fishermen activity data and sea turtle nesting activity data on Andersen AFB beaches and at the Pati Point Marine Preserve. The Marine Patrol Volunteer Conservation Officer program is designed as a tool for the education of the general public who visit and use the resources and facilities at these locations. Information developed by the program helps inform Conservation Law Enforcement Program needs.

Pacific RAMP surveys in 2005 and 2007 assessed the Pati Point Marine Preserve as being in superior condition, and the benthic and fish communities received a high ranking in their Coral Reef Condition Index. Biomass values for large fishes were highest in the northwest region and near Pati Point (Brainard et al. 2012). Pacific RAMP surveys in 2011 and 2014 also indicated high total fish biomass off of Pati Point (Heenan et al. 2015). Amesbury et al. (1995a, 1995b, 1995c, 1995d) recorded 221 fish species in 40 families off Andersen AFB. This is approximately 25% of the total recorded fish fauna from Guam and underestimates the diversity of some cryptic groups (Amesbury et al. 1995a, 1995b, 1995c, 1995d).

The Pacific RAMP 2003 towed-diver survey found the highest biomass of large fishes around Pati Point, with three reef sharks (*Carcharhinidae*) recorded in this area. Additionally, the Fish Condition Index for Guam, Rota, Tinian, and Saipan, which uses Pacific RAMP 2005 and 2007 data only, showed that the fish community around Pati Point was in good condition relative to other areas around the populated southern islands (Brainard et al. 2012). Parrotfishes (*Scaridae*) and other fish families that are heavily exploited around Guam were commonly observed around Pati Point, and one whitetip reef shark (*Triaenodon obesus*) was observed in 2005. Parrotfish are herbivorous and important in maintaining the balance of macroalgae in the coral reef ecosystem. The Fish Condition Index value for the area around and south of Pati Point increased from medium in 2005 to high in 2007, and the index for the survey area west of Pati Point in the north region increased from low in 2005 to medium in 2007 (Brainard et al. 2012). The improvement west of Pati Point was caused by an increase in large-fish biomass that, in turn, was largely a result of observations of several sharks, which were rarely seen elsewhere around the populated southern islands.

Underwater visual surveys around Guam in 2011 indicated that the north coast of Andersen AFB contained the most fish biomass of any region around Guam, with most sites exceeding 100 grams of fish per cubic meter (3 ounces per square yard) (Williams et al. 2012). Pati Point Marine Preserve had notably more frequent sightings of fish taxa of particular interest, such as sharks, jacks, humphead wrasse (*Cheilinus undulatus*), and large emperors, than other parts of Guam (Williams et al. 2012). NMFS completed Guam and CNMI Pacific RAMP surveys in 2017.

Fish species that use corals exclusively for shelter or food are of considerable importance. These obligate coral-dwelling or feeding species coevolved with corals for obligatory habitat use (Donaldson 1989, 1990) or feeding (e.g., Reese 1981, 1991; Harmelin-Vivien and Bouchon-Navaro 1983; Roberts et al. 1988;

Pratchett et al. 2014). The distribution and abundance of these fishes should be correlated with the distribution and abundance of corals at any given site (Crosby and Reese 1996; Crosby et al. 2013). It was noted that by monitoring changes in the distribution and abundance of butterflyfishes, and changes in their behavior that could be observed relatively easily, one could effectively detect changes in a coral reef system. An increase in the abundance of butterflyfishes, the detection of changes in how and where they are distributed, and corresponding changes in their behavior, could indicate a relatively healthy coral reef system when compared against a previous survey. A decrease and corresponding change in patterns of distribution and behavior would be indicative of a relatively unhealthy system, or at least one that is undergoing change.

In their recent surveys, Schils et al. (2017) and Schils and Houk (2017) used indicator species from two families of fishes, the butterflyfishes (*Chaetodontidae*) and the hawkfishes (*Cirrhitidae*), to explore reef condition. They identified certain species of butterflyfishes found within the depth range of their surveys as obligate coral-feeding species (Myers 1999; see also Pratchett et al. 2014). Schils et al. (2017) and Schils and Houk (2017) found that 7 of the 21 total species of butterflyfishes they recorded were obligate coral-feeding species (Myers 1999): *Chaetodon bennetti*, *Heniochus. lunulatus*, *C. melannotus*, *C. ornatissimus*, *C. quadrimaculatus*, *C. reticulatus*, and *H. chrysostomus*. Most common on Andersen AFB sites were *C. reticulatus, H. lunulatus* and *C. quadrimaculatus*. Schils et al. (2017) and Schils and Houk (2017) suggested these seven most common coral-feeding species found may be candidate indicator species used to monitor coral reef health at these sites. Additionally, they found one species of hawkfish, *Neocirrhites armatus*, which is also considered an obligate coral-dwelling fish (Donaldson 1989, 1990). This species occurs almost exclusively between branches of *Pocillopora* shrub corals, mainly *P. eydouxi* (Donaldson 1989, 1990). *P. eydouxi*, in turn, is found commonly on exposed reef terraces (Veron 2000). Schils et al. (2017) and Schils and Houk (2017) found this hawkfish species was relatively abundant at only one site east of Pati Point, present in very small numbers at another, and was absent from the other sites they surveyed. This is unusual given that this species favors exposed reef terraces at depths where *P. eydouxi* corals are found.

8.3.6.2 Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine fishes in Guam are presented in Section, 4.5.5, *Marine Fishes*.

To date, there is no evidence of non-native or invasive or nuisance marine fish offshore Andersen AFB. A nuisance marine species is native, but occasionally exhibits blooms, outbreaks, or other undesirable characteristics.

8.3.7 Marine Protected Species

Federal ESA-listed marine species have been recorded within the marine waters/submerged lands of Andersen AFB (Table 8-9; Figures 8-23 and 8-24). The following is a summary of known and potential occurrences of protected species in the JRM-administered submerged land areas. Marine protected species occurrences are approximated within the 3 miles (5 kilometers) of JRM-administered submerged lands, but some fishery-based and acoustic-based records have imprecise locations. Further details on each species can be found in Appendix E.

Table 8-9. Federal and Guam ESA-listed Threatened and Endangered Marine Species Recorded on JRM-Administered Submerged Lands on Andersen AFB

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat[2]*	*Occurrence[3]*
Invertebrates (Corals)					
Coral/Acho Tasi	*Acropora globiceps*	T	--	Intertidal zone, upper reef slopes, and reef flats	Y
Coral/Acho Tasi	*Acropora retusa*	T	--	Shallow reef slope and back-reef areas	P
Coral/Acho Tasi	*Seriatopora aculeata*	T	--	Shallow reef slopes	P
Fish					
Oceanic whitetip shark/Haluu	*Carcharhinus longimanus*	T	--	Open ocean, usually well offshore	PU
Giant manta ray/Afula or Hafula or Fanihen Tasi	*Manta birostris*	T	--	Coastlines, oceanic island groups, and offshore pinnacles and seamounts	P
Scalloped hammerhead shark/Haluun kiluus or Ulon matiyu na huluu	*Sphyrna lewini*	T[4]	--	Coastal seas from intertidal to depths of 1,640 feet (500 meters); nearshore nursery habitat includes bays and estuaries	Y
Reptiles					
Green sea turtle/Haggan	*Chelonia mydas*	E[5]	T	Offshore waters and nesting beaches	Y
Hawksbill turtle/Haggan karai	*Eretmochelys imbricata*	E	E	Offshore waters and nesting beaches	Y
Marine Mammals					
Fin whale/ Salungai or Bayena	*Balaenoptera physalus*	E	--	Generally near the 656 feet (200 meters) isobaths	P
Humpback whale/ Salungai or Bayena	*Megaptera novaeangliae*	E[6]	--	Coastline to 5,906 feet (1800 meters) isobaths	P
Sei whale/ Salungai or Bayena	*Balaenoptera borealis*	E	--	Offshore, prefers deeper waters	P
Sperm whale/ Salungai or Bayena	*Physeter macrocephalus*	E	--	Deep waters generally >3,281 feet (>1000 meters) depth	Y

Notes: [1] Chamorro names from GovGuam (2009), Kerr (1990, 2012), and Topping et al. (1975).
[2] Dominant adult habitat. Not necessarily inclusive of other life stages (e.g., egg/larvae/juvenile/breeding habitat).
[3] Occurrences approximated to JRM-administered submerged lands, but some fishery-based and acoustic-based records have imprecise locations.
[4] Indo-West Pacific Distinct Population Segments.
[5] Central West Pacific Distinct Population Segments.
[6] Western North Pacific Distinct Population Segments.

Key: -- = not listed; AFB = Air Force Base; E = endangered; ESA = Endangered Species Act; N = no, does not occur; P = potential for occurrence; PU = potential for occurrence, but unlikely; T = threatened; Y = yes, known to occur.

Sources: Guam DAWR 2006, 2015; GovGuam 2009; USFWS 2011; Kerr 2012; Hill et al. 2013, 2014; NMFS 2014a, 2014b; DON 2015b; Hill et al. 2015; Jones et al. 2015; Brown 2015; Lybolt 2015; Hill et al. 2016; NMFS 2018a, 2018b.

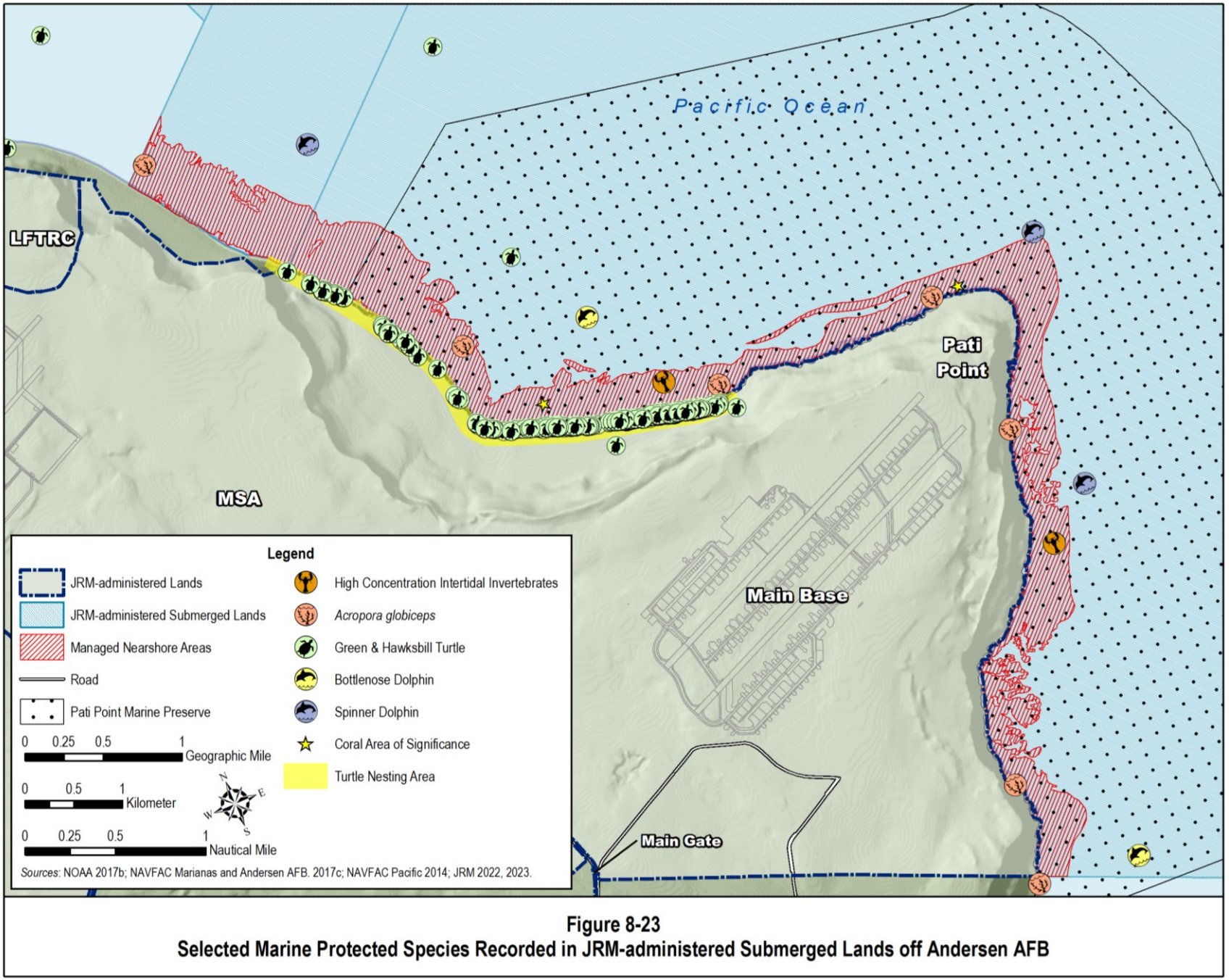


Figure 8-23
Selected Marine Protected Species Recorded in JRM-administered Submerged Lands off Andersen AFB

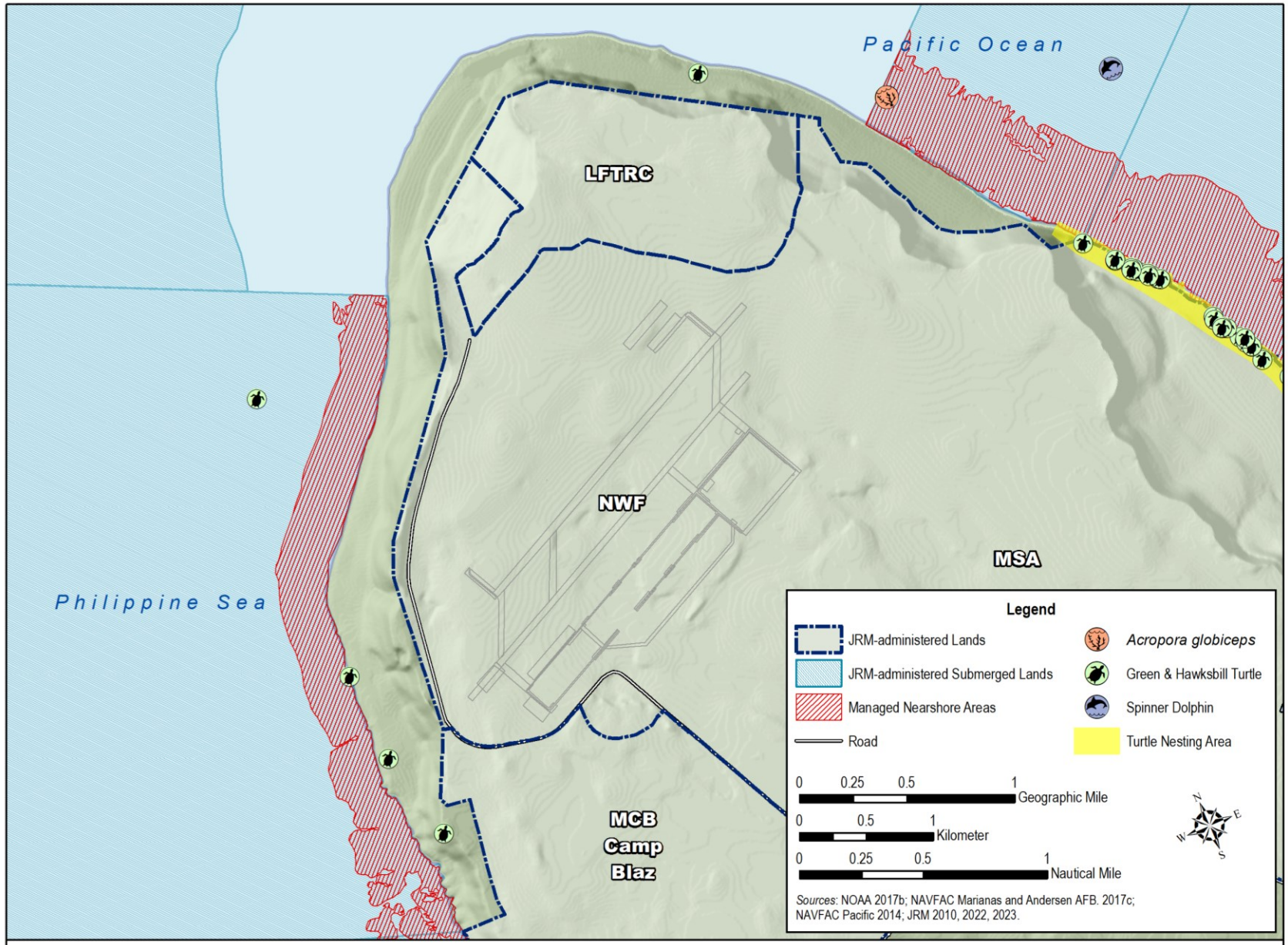


Figure 8-24
Selected Marine Protected Species Recorded in Andersen AFB Northwest Field Submerged Lands

8.3.7.1 Invertebrates – Corals

Three coral species (*Acropora globiceps*, *A. retusa*, and *Seriatopora aculeata*) were recently listed by NMFS as threatened under the ESA and are found in Guam waters (NMFS 2014a). Only *A. globiceps* has been found within the marine waters of Andersen AFB (refer to Figure 4-6) (NMFS 2014a).

8.3.7.2 Fishes

Scalloped Hammerhead Shark

The federal ESA lists six DPS for the scalloped hammerhead (*Sphyrna lewini*) (NMFS 2014b). Scalloped hammerhead sharks within the Indo-West Pacific DPS are federal ESA-listed as threatened and known to occur in the Mariana Archipelago. The International Union for Conservation of Nature Red List considers this shark endangered. Scalloped hammerheads are the second largest hammerhead shark species and reach a length of at least 13 feet (4 meters). Observations of scalloped hammerheads offshore Andersen AFB have not been recorded. Scalloped hammerheads are found worldwide in tropical and temperate seas; therefore, these sharks could occur within JRM-administered submerged lands of Andersen AFB. However, there are limited shallow soft bottom habitats offshore Andersen AFB, which are their preferred locations when they move inshore.

Humphead Wrasse and Bumphead Parrotfish

Two bony fishes occurring in the Mariana Archipelago are listed as species of concern by NMFS and Guam-designated as SOGCN: the Napoleon or humphead wrasse (*Cheilinus undulatus*) and the bumphead parrotfish (*Bolbometopon muricatum*) (Guam DAWR 2006; NMFS 2015b, 2015a). The 2012 NOAA status review of the humphead wrasse concluded that there was a low overall risk of extinction for this fish in the foreseeable future, with relatively low certainty and little available information (NMFS 2015b). Despite its natural rarity and depressed abundance in certain areas, this no-to-low overall risk of extinction is based primarily on the species' sustained widespread distribution throughout most of its known range, and its recent effective protection from exploitation at a variety of localities under both U.S. and foreign jurisdiction (NMFS 2015b). Graham et al. (2015) reported that between 2003-2011, an average of 0.055 humphead wrasse were observed per 108,000 square feet (10,000 square meters) of survey area around Guam. Several humphead wrasse were observed at sites on the north coast of Andersen AFB during the 2014 Pacific Islands Fisheries Science Center (PIFSC) surveys, the most of any location around Guam.

No bumphead parrotfish were sighted during the 2007 Pacific RAMP surveys (Brainard et al. 2012). In 2012, NOAA determined that the bumphead parrotfish (*Bolbometopon muricatum*) did not warrant federal ESA listing because the species still occupies its historical range, although at a lower and declining abundance but with biological characteristics and management measures that support the population above the viability threshold. This parrotfish remains a federal species of concern (NMFS 2020). Fenner (2014) cites evidence that bumphead parrotfish were common in Guam in the 1960s, but by the 1970s, they were targeted by fishermen, and now they are rarely sighted.

8.3.7.3 Sea Turtles

Green Sea Turtle and Hawksbill Turtle

Two species of sea turtles have been sighted in JRM-administered submerged lands off Andersen AFB: green sea turtle and hawksbill turtle. Martin et al. (2016) report data on sea turtle observations around Guam from semimonthly aerial surveys conducted by Guam DAWR. They found an eightfold increase in turtle observations island-wide since the 1960s, but this trend was driven by increases in turtles in the south of Guam. The area offshore of Andersen AFB typically had a low to moderate number of turtle observations

throughout this time period, but there were more observations on the north coast of the island west of Pati Point than other regions around Guam, excluding the southern region (Martin et al. 2016).

In 2016, Andersen AFB natural resource personnel tagged a green sea turtle during nesting at Andersen AFB to ensure that nesting turtle populations there were assessed in ongoing Guam sea turtle migration research (NAVFAC Marianas and Andersen AFB 2017b). Nesting green sea turtle's migration paths have since been successfully satellite tagged and tracked by the NOAA PIFSC (Figure 8-25). As shown in Figure 8-25, three nesting green sea turtles tagged in 2019 and 2020 on EOD Beach were tracked to the Philippines and an island east of Taiwan (NAVFAC Marianas and Andersen AFB 2023). Since 2016, a total of 19 sea turtles have been tagged (NAVFAC Marianas and Andersen AFB 2023). Information on trends in sea turtle nesting success on Andersen AFB is included in Section 8.2.5.3, *Reptiles and Amphibians*.

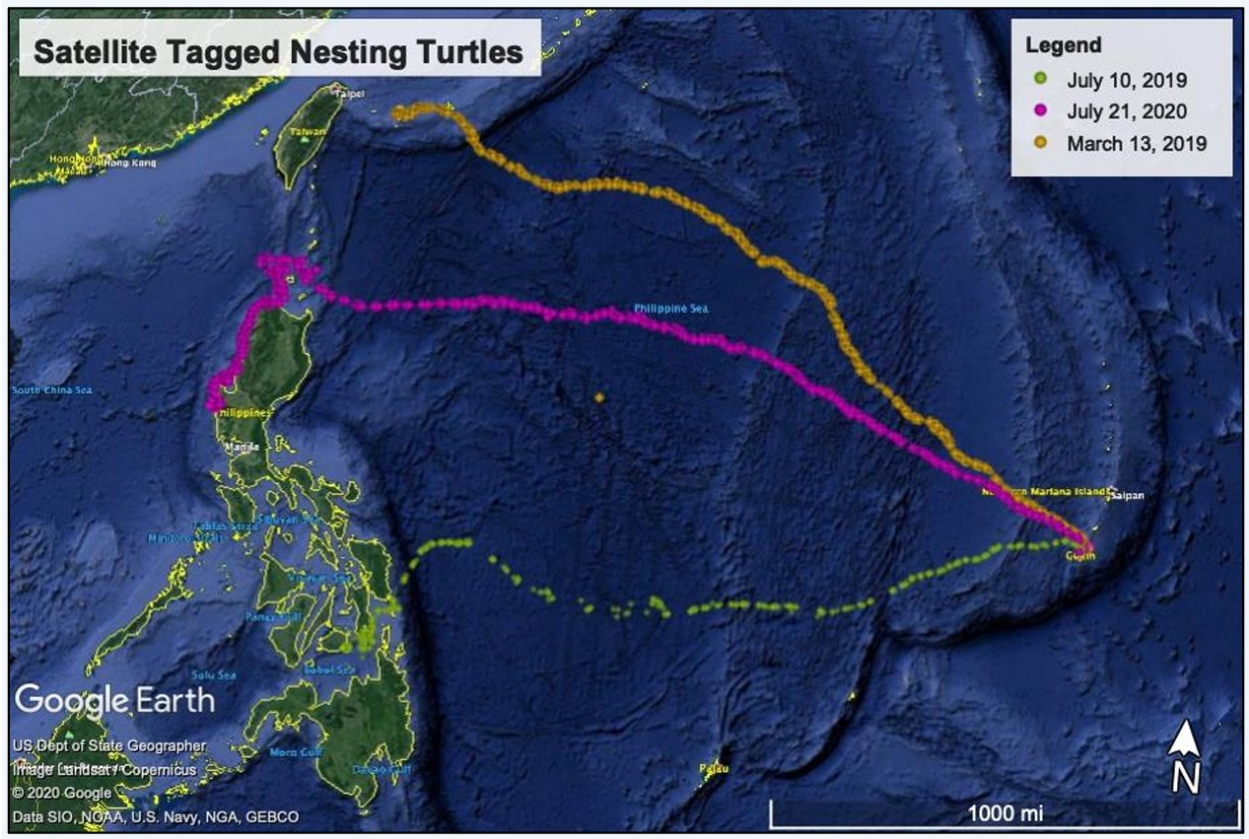


Figure 8-25. Migration Pattern of Satellite Tagged Green Sea Turtle from Andersen AFB
Source: NAVFAC Marianas and Andersen AFB 2023

8.3.7.4 Marine Mammals

All marine mammals are protected under the Marine Mammal Protection Act (MMPA). Andersen AFB is a challenging location to monitor for marine mammals because the northeastern end of the island is the windward face that receives the prevailing trade winds. The winds can create sea conditions that are not conducive to small boat operations and reduce the visibility of marine mammals. Despite these conditions limiting survey efforts, a number of marine mammal sightings have been made offshore of Andersen AFB. This is partially because shore-based efforts of monitoring marine species have been explored by the Pacific Fleet's Marine Species Monitoring Program (Deakos et al. 2016). The list of species seen off Andersen AFB include spinner dolphins (*Stenella longirostris*), pantropical spotted dolphins (*Stenella attenuata*), bottlenose dolphin (*Tursiops truncatus*), short-finned pilot whale (*Globicephala macrorhynchus*), false killer whale (*Pseudorca crassidens*), and melon-headed whale (*Peponocephala electra*) (Hill et al. 2012, 2013, 2014, 2016; NAVFAC Pacific 2014; Deakos et al. 2016).



Shore-station surveys for marine mammals and sea turtles using Big Eye binoculars from Andersen AFB. (*Photo*: J. Aschettino)

In the second year of Fleet monitoring in the Mariana Islands (NAVFAC Pacific 2011), the NMFS team observed spinner dolphins twice offshore Andersen AFB; one sighting was on the north side between Ritidian and Pati Points (45 animals) and the other was on the east side, south of Pati Point (14 animals) (Hill et al. 2012). As with virtually all spinner dolphin sightings, the groups were very close to shore. In 2011, the sightings were in less than 330 feet (100 meters) water depth. In 2012, a group of 18 spinner dolphins was observed by the NMFS team in the same area between Ritidian and Pati Points. The other sightings that year were north and west of Andersen AFB. There were two sightings of pantropical spotted dolphins at 3.14 miles (5.05 kilometers) of 35 animals and at 7.6 miles (12.3 kilometers) of 22 animals offshore; a sighting of short-finned pilot whale at 4.34 miles (7.98 kilometers) observed 30 animals offshore (Hill et al. 2013). Observation of the spinner dolphins between Ritidian and Pati Points continued in 2013, with a group of 34 animals sighted in the same general area as 2011 and 2012. A second separate group was sighted south of Pati Point within an hour on the same day in 2013 (Hill et al. 2013).

In September 2015, NMFS tagged a bottlenose dolphin off Rota that roamed between Rota and northern Guam over 10 days. The track line from the tag shows the animal visiting the shoreline of Guam off MCB Camp Blaz and Ritidian Point (Hill et al. 2016). During that same survey in August and September, NMFS observed several species off Andersen AFB. Consistent with the previous 3 years, there was a group of three spinner dolphins in the nearshore area between Ritidian and Pati Points. NMFS observed a group of 25 false killer whales offshore, 2.7 miles (4.4 kilometers) northeast of Ritidian Point. There were also two sightings of pantropical spotted dolphins north and west of Ritidian Point comprising 25 and 59 animals, 2.6 miles (4.2 kilometers) and 4.2 miles (6.7 kilometers), respectively, from shore (Hill et al. 2016).

As previously stated, sea conditions can be a challenge for surveying marine mammals off Andersen AFB, but the cliffs provide good vantage points for viewing the ocean. The Pacific Fleet's Marine Species Monitoring Program conducted two studies using big-eye binoculars and theodolites to spot marine mammals from the cliffs. There were two sites used for the surveys, one on the north side of Pati Point and one on the east side. In May 2013, the first year of the survey, there were 15 spinner dolphin sightings close to shore on the east side of Pati Point and 2 spinner dolphin sightings on the north side over a 5-day survey period. There were also several unidentified cetacean or dolphin sightings and one short-finned pilot whale sighting 3.1 miles (5 kilometers) from shore north of Pati Point (NAVFAC Pacific 2014). In March 2015, surveys were repeated at the same locations; however, sea states were higher in 2015 than 2013, which made spotting marine species more difficult. There were four spinner dolphin sightings close to shore on the east side of Pati Point and no spinner dolphin sightings on the north side over the 5-day survey period. As in 2013, there were several unidentified cetacean and dolphins sightings. There were also sightings of a pod of melon-headed whale 6.2 miles (10 kilometers) from shore east of Pati Point and two bottlenose dolphin sightings less than 330 feet (100 meters) from shore – one on each side of the Point (Deakos et al. 2016).

Martin et al. (2016) found that the region south of Pati Point on the east coast was one of two regions around Guam that had the highest observations of small delphinids from the 1960s to 2012. This indicates that the JRM-administered submerged lands on Andersen AFB are an important region for small marine mammals.

Spinner Dolphins

Spinner dolphins are frequently sighted around Guam during NMFS PIFSC's cetacean surveys (Hill et al. 2014, 2015, 2016). During the 2015 NMFS PIFSC cetacean survey, spinner dolphins were sighted in proximity to Andersen AFB. Spinner dolphins were sighted within JRM-administered submerged lands on Andersen AFB during earlier surveys in 2013 as well (Hill et al. 2014).

Bottlenose Dolphins

Deakos et al. (2016) sighted bottlenose dolphins around Guam in 2015. Satellite tags deployed in 2015 and visual observations in 2014 and 2016 confirmed that bottlenose dolphins use the waters off the west coast of Guam (Hill et al. 2015, 2016, 2017). There are no known observations of bottlenose dolphins within JRM-administered submerged lands on Andersen AFB

Pantropical Spotted Dolphins

During NMFS PIFSC's 2013, 2014, 2015, and 2016 cetacean surveys, pantropical spotted dolphins were sighted around Guam (Hill et al. 2014, 2015, 2016, 2017). Satellite tags showed that, in 2015 and 2016, individuals from this species frequented waters off the west coast of Guam (Hill et al. 2016, 2017). During the 2015 NMFS PIFSC cetacean survey, pantropical spotted dolphins were sighted approximately 3 miles (5 kilometers) from the northern coast of Guam near the limit of JRM-administered submerged lands on Andersen AFB; these animals could have transited through these submerged lands (Hill et al. 2016).

Short-finned Pilot Whales

During NMFS PIFSC's 2013, 2014, 2015, and 2016 cetacean surveys, short-finned pilot whales were sighted around Guam. Deakos et al. (2016) also sighted one pantropical spotted dolphin off the northeast coast of Guam in 2015. Satellite tags deployed in 2013, 2015, and 2016 also showed that individuals from this species used waters in the JRM-administered submerged lands on Andersen AFB on multiple occasions (Hill et al. 2014, 2015, 2016, 2017; Martin et al. 2016).

Rough-toothed Dolphins

During the 2013 and 2014 NMFS PIFSC cetacean surveys, rough-toothed dolphins (*Steno bredanensis*) were sighted near Aguiguan and Saipan, with six of the individuals being confirmed in photo-identification catalogs (Hill et al. 2014, 2015). There are no confirmed sightings on JRM-administered submerged lands on Andersen AFB, but these animals could have transited through these submerged lands.

False Killer Whales

During the 2015 NMFS PIFSC cetacean survey, a group of false killer whales were sighted off the north side of Guam near Ritidian Point, and these animals could have transited through JRM-administered submerged lands on Andersen AFB (Hill et al. 2016). False killer whales were also sighted near Guam during the 2014 NMFS PIFSC cetacean survey (Hill et al. 2015).

Pygmy Killer Whales

A group of 11 pygmy killer whales *Feresa attenuata*) were sighted off the southwest side of Guam during the 2015 NMFS PIFSC cetacean survey, with 9 individual whales being recognized from encounters in previous years (Hill et al. 2014, 2015, 2016). There are no confirmed sightings on submerged lands, but these animals could have transited through JRM-administered submerged lands on Andersen AFB.

Blue Whales

Acoustic equipment has recorded the presence of blue whales (*Balaenoptera musculus*) in the Western Pacific waters around Guam; however, it is not known if they were near Andersen AFB (Klinck et al. 2015, 2016; Oleson et al. 2015).

Fin Whales

Acoustic equipment has recorded the presence of fin whales (*Balaenoptera physalus*) in the Western Pacific waters around Guam; however, it is not known if they were near Andersen AFB (Klinck et al. 2015, 2016; Oleson et al. 2015).

Humpback Whales

Acoustic equipment has recorded the presence of many humpback whales (*Megaptera novaeangliae*) in the Western Pacific waters around Guam and the CNMI, especially in the waters south of Guam and southeast of Tinian (Klinck et al. 2015, 2016; Oleson et al. 2015). According to NMFS, humpback whales occurring in Guam are part of the Western North Pacific DPS. One humpback whale was sighted 9 miles (15 kilometers) off the northeast coast of Saipan in 2007 (Fulling et al. 2011), and more recently in 2015, four humpback whale mom/calf pairs and four other humpback whales were sighted off the west coasts of Saipan and Tinian (Hill et al. 2016). There are no confirmed sightings of humpback whales within JRM-administered submerged lands on Andersen AFB, but these animals could have transited through these submerged lands.

Sei Whales

Sei whales (*Balaenoptera borealis*) were sighted during the 2007 Mariana Islands Sea Turtle and Cetacean Survey. All confirmed sightings of sei whales were south of Saipan (approximately 15 degrees [°] North), with concentrations in the southeastern portion of the CNMI (Fulling et al. 2011). This is an indication that this species could transit in and around Andersen AFB. Acoustic equipment has recorded the presence of sei whales in the Western Pacific waters around Guam; however, it is not known if they were near Andersen AFB (Klinck et al. 2015, 2016; Oleson et al. 2015).

Sperm Whales

During a small boat survey around Guam and Saipan in February and early March of 2010, there were two sperm whale (*Physeter macrocephalus*) sightings: (1) a group of nine animals off Orote Point, Guam, inshore from the 1,640 feet (500 meters) isobath; and (2) a group of six animals northwest of Saipan in waters greater than 3,281 feet (1,000 meters) deep (Ligon et al. 2011). A group of 10 sperm whales was also sighted during small boat surveys off western Guam in waters approximately 3,940 feet (1,200 meters) deep in March 2012 (NAVFAC Pacific 2011). The sperm whale was the most frequently sighted cetacean (21 sightings) during the 2007 survey, with acoustic detections almost three times higher (61) than visual detections in the field (Fulling et al. 2011). Passive-acoustic glider surveys in 2014 and 2015 confirmed the presence of sperm whales around Guam (Klinck et al. 2015, 2016). This is an indication that they may occur around Andersen AFB.

Blainville's Beaked Whales

Passive-acoustic glider surveys in 2014 and 2015 confirmed the presence of Blainville's (*Mesoplodon densirostris*) beaked whales around and to the south of Guam and between Rota and Tinian (Klinck et al. 2015, 2016). During the 2015 NMFS PIFSC cetacean survey, a single group of Blainville's beaked whales (one adult male with three or four females/juvenile males) were sighted off of Rota (Hill et al. 2016). Blainville's beaked whales were also seen near Rota during the NMFS PIFSC cetacean survey in 2014 (Hill et al. 2015). There are no confirmed sightings on JRM-administered submerged lands off Andersen AFB, but these animals could have transited through these submerged lands.

Risso's Dolphins

Passive-acoustic glider surveys in 2014 and 2015 confirmed the presence of Risso's dolphin (*Grampus griseus*) around and to the south of Guam and to the east of Saipan (Klinck et al. 2015, 2016). There are no confirmed sightings on JRM-administered submerged lands off Andersen AFB, but these animals could have transited through these submerged lands.

Common Minke Whales

Passive-acoustic glider surveys in 2015 confirmed the complex, amplitude-modulated calls of the common minke whale (*Balaenoptera acutorostrata*) during a survey near the Mariana Trench southeast of Guam (Klinck et al. 2016). There are no confirmed sightings on JRM-administered submerged lands off Andersen AFB, but these animals could have transited through these submerged lands.

Killer Whales

Passive-acoustic glider surveys in 2014 confirmed the presence of killer whales (*Orcinus orca*) around and to the south of Guam (Klinck et al. 2015). There are no confirmed sightings on JRM-administered submerged lands off Andersen AFB, but these animals could have transited through these submerged lands.

Bryde's Whales

Three Bryde's whales (*Balaenoptera edeni*) were sighted between Rota and Guam during the 2015 NMFS PIFSC cetacean survey, with species identification confirmed by photos (Hill et al. 2016). There are no confirmed sightings on JRM-administered submerged lands off Andersen AFB, but these animals could have transited through these submerged lands.

Melon-headed Whales

A group of melon-headed whales (*Peponocephala electra*) were sighted off the east coast of Guam during a Guam shore survey in 2015 (Deakos et al. 2016). As noted previously, there was a sighting of a pod of melon-headed whale 6.2 miles (10.0 kilometers) from shore east of Pati Point in 2015 (Deakos et al. 2016).

Cuvier's Beaked Whales

In the 2014 NMFS PIFSC cetacean survey, a confirmed sighting of a Cuvier's beaked whale (*Ziphius cavirostris*) occurred 12 miles (19 kilometers) off the west coast of Saipan in 5,600-feet (1,700-meter) deep water (Hill et al. 2015). There are no confirmed sightings on JRM-administered submerged lands off Andersen AFB, but these animals could have transited through these submerged lands.

8.3.8 Marine Resources Monitoring

Multiple agencies acting cooperatively (principally GovGuam and UOG) established a long-term monitoring program for benthic communities using belt transect methods (Burdick and Brown 2011). In some ways, this was a precursor to the current DoD-sponsored effort to monitor marine resources in JRM-administered submerged lands off Andersen AFB at 10 permanent sites including Pati Point (Schils and Houk 2017; Schils et al. 2017). Both of these monitoring programs are specifically designed to detect change over time with high statistical confidence, and utilize multivariate statistical techniques to evaluate changes in select ecosystem indicators (McManus and McManus 2012). These monitoring designs are specifically built to integrate into and be directly comparable to existing broad scale island- and region-wide monitoring programs. Robust monitoring of this nature is critical for establishing context for Andersen AFB marine resources and any associated management actions. The data set gathered is essential to evaluate the success of management actions and alert managers to local or broad changes that could trigger the need to update baseline assessments. This data set can be spatially expanded as needed to include additional target strata (e.g., depths, habitats) or specific geographic locations where management actions are taking place. Similarly, monitoring frequency can be adjusted as needed to capture planned, expected, or stochastic events. Maintaining the core survey effort is essential for putting the expanded efforts into context.

The Guam Comprehensive Long-term Coral Reef Monitoring Program has had to use their resources on emergent needs such as coral bleaching monitoring; however, Burdick and Brown (2011) described their initial findings consistent with the known baseline conditions, with the variability that is expected when single strata are placed in the context of a larger area. There is an ongoing NOAA-led collaborative Reef Resilience Assessment study currently in Guam. Field work commenced in July 2016. The surveys included 25 sites around Guam at two depths: 15 feet (5 meters) and 40 feet (12 meters). Sites include Jinapsan Beach, Tagua, Pati Point, and Latte Point, which are located in JRM-administered submerged lands off of Andersen AFB.

Schils et al. (2017) and Schils and Houk (2017) have provided a report describing their findings for 10 permanent sites in JRM-administered submerged lands off Andersen AFB; however, these data only represent a single year of data collection. The real value of this effort is realized when there are multiple years of data to compare and describe trends in benthic composition, coral community dynamics, fish assemblages, mobile invertebrates, and water quality. JRM will obtain feedback from the relevant territorial and federal agencies on which aspects should be continued for long-term marine resources monitoring within JRM-administered submerged lands and how frequently the survey should be conducted, as well as potential changes in type of data collection, location of sites, depth of sites, and new technologies that can be utilized to increase efficiency.

8.4 MANAGEMENT GOALS, OBJECTIVES, STRATEGIES, AND ACTIONS

JRM currently manages natural resources based on an ecosystem-focused approach that involves the implementation of several ongoing management projects. These projects, which are further described in the following sections, provide examples of JRM's current efforts to manage and enhance natural resources in a manner consistent with the military mission. Appendix C lists management projects on Andersen AFB for Fiscal Years (FY) 14-17. The following sections present management projects for Andersen AFB that are identified as necessary to achieve applicable goals and objectives identified in Chapter 3, *Environmental Management Strategy and Mission Sustainability*.

Management projects identified for Andersen AFB provide direct support for the military mission and the goal of "no net loss" in a number of ways. For example, projects that improve the baseline status of species or their habitat show that populations are stable, or that habitat is improving or expanding, may relieve restrictions on military training or operations, minimize costs and mitigation requirements, avoid workarounds, and/or streamline regulatory processes.

8.4.1 Terrestrial Ecosystem Management

Andersen AFB's native terrestrial habitats have been impacted by historical activities, introduction and spread of invasive and non-native species, effects of climate change, and the resulting loss of functions necessary to support healthy native habitats. Ecosystem functions have been disrupted by the extirpation of native animal and plant species, which have resulted in both economic and cultural impacts on the ecosystem services provided by native habitats. The occurrence of healthy native habitats on Andersen AFB is necessary to support sustainability of native species, including federal and Guam ESA-listed species. JRM recognizes that restoration and enhancement of native habitats on lands that they manage is a long-term process, and that adaptive management is key to long-term success of the program.

Management projects are monitored and evaluated annually to ensure that they are meeting identified goals and objectives. JRM will establish mid-year coordination meetings with resource partners to discuss ongoing and planned projects, including prioritization, scope, methodology, issues or challenges, timelines, and performance evaluation criteria. These discussions are intended to facilitate improved coordination and information sharing to allow for course corrections, if necessary, to ensure an adaptive approach.

Terrestrial ecosystem management as described in the following sections is expected to: (1) improve the status of threatened and endangered species through habitat conservation and enhancement, and (2) promote health and sustainability of native forests. Healthy ecosystems will, in turn, relieve or reduce environmental constraints and allow for maximum operational flexibility for the installations and continued/managed access to important recreational areas.

A summary of the management projects and the estimated timeframe for completion is presented in Table 13-10, *Planned Implementation Summary of Projects at Andersen AFB* found in Chapter 13, *Planning, Integration, and Implementation*. Some of the projects described in this section are being accomplished through interactive partnerships with federal and territorial natural resource agencies (e.g., Guam DAWR), universities, and local organizations.

8.4.1.1 Terrestrial Habitat Management

JRM has ongoing and planned projects to restore and enhance native terrestrial habitats. These projects focus on improving the quality and availability of appropriate habitat for listed species, as well as increasing the quality and health of existing native habitats, such as limestone native forests. Numerous related activities are required for native habitat improvement, such as control of ungulates and other invasive

species, propagating and outplanting native plant species to improve diversity, and addressing forest health issues, such as improvement of seed dispersal. The 2017 Restoration Plan for the HMU (NAVFAC Marianas and Andersen AFB 2017a) and the 2018 Conceptual Limestone Forest Restoration and Enhancement Plan serve as management tools to help guide site-specific restoration and enhancement efforts on Andersen AFB.

In order to achieve long-term goals, Terrestrial Habitat Management (THM) requires successful daily and short-term management, coupled with long-term planning and investment. To ensure that JRM continues to meet the overriding goal of restoring and enhancing terrestrial habitats for native species (including listed species) over the long-term, JRM site land managers and resource agencies will continue coordinating on natural resource management.

To meet the goals and objectives of the Integrated Natural Resources Management Plan (INRMP), a suite of management projects was identified for THM on Andersen AFB.

THM-1: FOREST ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-6; Goal #3, Objectives #1 and 4; and Goal #4; Objective #2. This project supports conservation measures from the reinitiation of the 2015 BO for the DON's Relocation of USMC from Okinawa to Guam and Associated Activities in Guam (USMC Relocation 2017 BO, which contains amendments to the 2015 BO) (USFWS 2017b).

- *Strategy*: Protect and restore priority native habitats (i.e., limestone forest) for the benefit of native flora and fauna, including protected species, by focusing on step-wise forest enhancement activities and by protecting species from direct and indirect threats.
- *Action*: Propagate native forest species and plant nursery grown plants or seeding species in the wild. Young plants will be managed for approximately 3 years until they become established.
- *Action*: Develop a monitoring program for listed plants found throughout JRM-administered lands following the protocols for GPS data collection used at NWF and Finegayan. Known locations will be monitored and new surveys will be conducted to identify additional locations.
- *Action*: Conduct surveys to map locations and abundance of non-native invasive plants and rank occurrences by invasive plant species standards.
- *Action*: Implement control/eradication for top ranked invasive plant species and monitor to prevent recurrence.
- *Action*: Monitor vegetation, vertebrate, and invertebrate communities in fenced ungulate control areas prior to fencing and after removal to track invasive plants and monitor understory growth, increased groundcover, increased canopy cover, increased species diversity, and increased number of forest tree seedlings and saplings.
- *Action*: Construct ungulate fencing as a barrier to feral pigs and deer immigration in priority habitats.
- *Action*: Construct ungulate fencing surrounding the Live-fire Training Range Complex.
- *Action*: Eradicate pigs and deer within fenced ungulate exclusion areas and control ungulates outside of fenced areas on Andersen AFB to protect threatened and endangered species and associated habitat.

- *Action*: Maintain the HMU BTS Barrier to prevent snakes from immigrating into the HMU. Fence maintenance will include: maintaining both sides of the fence to exclude vegetation within a minimum of 3 feet (1 meter) of the barrier; painting the barrier every 2 years with rust-proofing paint to increase the life of the barrier; power washing the base of the barrier annually to prevent debris from building up and developing breaches in the fence at ground level; conducting inspections on a weekly basis; and completing routine mechanical repair and maintenance of the barrier as needed on an annual basis.

THM-2: URBAN FORESTRY DATA BASE, MAINTENANCE, AND REPLACEMENT OF TREES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1 and Goal #2, Objectives #3 and 6.

- *Strategy*: Ensure that management of urban trees on Andersen AFB is compatible with JRM INRMP goals and objectives.
- *Action*: Continue to implement the integrated grounds maintenance program to minimize the amounts of chemicals and water needed to maintain grounds and landscaped areas in healthy and attractive conditions.
- *Action*: Collaborate with technical specialists from local agencies to develop an Urban Forestry Plan for JRM that includes specifications for soil types, planting requirements, watering and fertilizer regimens, pest control, disease treatments, and other maintenance practices.
- *Action*: Develop and maintain an urban forestry database to catalog existing trees and provide a schedule for their maintenance.
- *Action*: Continue to manage urban forest resources for disease, damage, and replacement.
- *Action*: Plant native trees along the cliff tops to provide native seed rain for passive native forest recovery.
- *Action*: Review the status of actions prescribed under Management of Andersen AFB Urban Forest Resources at the annual INRMP review meeting and initiate actions based on the review to ensure that actions are implemented as prescribed, pending available funding.

8.4.1.2 Terrestrial Exotic and Invasive Species Management

An invasive species is defined in EO 13112, *Invasive Species*, as a species that is non-native (i.e., alien or exotic) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm, or harm to human health. Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions. Invasive species have had a catastrophic effect on the native flora and fauna of island ecosystems, particularly Guam. Attributes of island biota include small geographic ranges and population size, low reproductive rates, and lack of the ability to respond to invasive species and disturbed habitats. Islands typically have lower numbers of species than mainland areas, which results in fewer predators and competitors that could prevent the establishment of invasive species. As a result of evolving in isolation, island plants and animals have few defenses when exposed to introduced competitors and predators. These limitations in Guam have caused exotic and invasive species to replace native island species (Wiles et al. 2003).

Many of the native species in Guam are threatened due to introduced predators, such as the BTS, and introduced ungulates such as the Philippine deer, feral pig, and Asiatic water buffalo (carabao) (*Bubalus bubalis*), which have significantly affected native vegetation communities. Feral populations of dogs and cats also pose threats to native wildlife populations. Secretary of the Navy Instructions (SECNAVINST)

6401.1B of September 29, 2006, prohibits dogs, cats, and other privately owned or stray animals from running at large on military installations. Several species of rats have colonized the island, preying on the eggs and young of native species and destroying native flora (i.e., seeds and seedlings). The continued widespread presence of the BTS, curious skink, and introduced amphibian species are of particular concern because of each species' potential negative impacts in Guam's native fauna. Examples of invasive species management approaches include the control of feral ungulates, the control of feral cats and dogs, and the removal of invasive plants to allow native species to flourish in degraded areas.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Exotic and Invasive Species Management (TIS) on Andersen AFB.

TIS-1: BROWN TREESNAKE INTERDICTION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1-2; Goal #2, Objectives #3-4; Goal #3, Objectives #1 and 4; and Goal #4, Objectives #1-3. This project supports conservation measures from the MOA for the Conservation of Guam Micronesian Kingfisher Recovery Habitat in Northern Guam (2015 Guam Micronesian Kingfisher MOA) (DON and USFWS 2015a)

- *Strategy*: Maintain, develop, and implement actions to prevent the spread of BTS via the transportation network.
- *Action*: Annually review, update as needed, and develop existing BTS interdiction projects reflecting BMPs, adaptive management, and cost benefits.
- *Action*: Annually assess continuity and compliance of BTS interdiction activities across BOs, DoD BTS interdiction operating instructions, and consistency with, and, to the benefit of other relevant JRM conservation actions.
- *Action*: Annually assess ongoing development of new/emergent management strategies and methodologies that reduce or eliminate the risk of BTS.
- *Action*: Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant long-term projects to benefit interdiction management objectives.
- *Action*: Consult with the USDA Animal and Plant Health Inspection Service (APHIS) Wildlife Services National Wildlife Research Center in Fort Collins to determine the most effective and least disruptive control strategies. Resulting research requirements will be finite projects that assist in the development of snake control techniques and in the management of Mariana fruit bat roosts through the adaptive management strategy.

TIS-2: BROWN TREESNAKE SUPPRESSION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-4 and 6; Goal #3, Objectives #1 and 4; Goal #4, Objectives #1-3; and Goal #7, Objective #3. Actions listed are in accordance with the 2011 BTS MOA.

- *Strategy*: Suppress and control BTS numbers to support conservation goals for species and ecosystem recovery.
- *Action*: Develop an operational suppression implementation plan. The plan will identify and prioritize potential quality habitat site(s) for suppression actions. Site(s) must consider size, habitat, location, connectivity, synergistic effects, listed species benefits, ecological viability, and support regulatory and mission requirements. Suppression goals and activities will support USFWS recovery plan delisting requirements for threatened and endangered species.

- *Action*: Implement BTS suppression management actions in identified site(s) based on mission support impact and cost effectiveness. Data will be used to determine the minimum thresholds of BTS suppression activities needed to support conditions conducive to species persistence and recovery.
- *Action*: Through annual funding and partnerships, support development of tools and methods that improves monitoring, detection, and suppression in targeted habitat sites.
- *Action:* Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant projects to benefit long-term BTS suppression management actions

TIS-3: BROWN TREESNAKE MANAGEMENT FOR THE RECOVERY OF PROTECTED SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-4 and 6; Goal #3, Objectives #1 and 4; Goal #4, Objectives #1-3; and Goal #7, Objective #3. Actions listed are in accordance with the 2011 BTS MOA.

- *Strategy*: Suppress and control BTS numbers to support listed vertebrate species recovery.
- *Action*: Maintain annual funding and project goals to ensure long-term viability of the HMU as a primary research site for development and testing of methods and schedules for BTS eradication. Ensuring that research requirements are finite and sequential to assist in the development of snake control techniques that will assist in the management and recovery of threatened and endangered species (e.g., Mariana fruit bat, Guam kingfisher, Guam rail). This includes establishing a mechanism to expeditiously repair damages to the HMU BTS barrier and collaborating with reintroduction planning teams to support reintroduction projects.
- *Action*: Annually conduct BTS suppression management actions adjacent to the fruit bat colony to determine fruit bat response to BTS control. BTS suppression activities will be consistent with an established BO.
- *Action*: Through annual funding and partnerships, support development of tools and methods that improves monitoring, detection, and suppression in targeted habitat sites.
- *Action:* Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant projects to benefit long-term BTS suppression management actions

TIS-4: INVASIVE SPECIES MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1-2; Goal #2, Objectives #2-4; Goal #3, Objective #1 and 4; and Goal #4, Objectives #1-3. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017b).

- *Strategy*: Remove and control invasive species that threaten the survival of listed species and other native plants or animals, negatively impact tourism and agriculture, and/or cause human life or safety issues.
- *Action*: Initiate eradication of feral cats and rats the year prior to rail releases and monitor while rails are present. Removal of mammalian predators will be ongoing as they are not excluded by the existing BTS fence. Predator control may include, but is not limited to, trapping, shooting, and baiting. The 2017 Restoration Plan for the HMU (NAVFAC Marianas and Andersen AFB 2017a) will be used to guide eradication and management actions.

- *Action*: Annually survey high-risk areas for LFA using established protocols. If LFA is detected on Andersen AFB, implement proven control and eradication actions, followed by post-eradication monitoring.
- *Action*: Implement BMPs for CRB: (1) annually evaluate the need for comprehensive bio-sanitation of dead coconut trees and implement as necessary, (2) implement proper green waste management; (3) assist in release of landscape-level biocontrol agents for CRB, (4) implement awareness and reporting program in high-risk areas annually, and (5) implement long-term monitoring program and monitor coconut trees.
- *Action*: Survey and map locations of invasive insect infestations and compromised plants.
- *Action*: Develop, test, and prioritize adaptive management actions to remove or control invasive insects, including, but not limited to, feasible local controls of cycad scale (e.g., hand applications to individual trees).
- *Action*: Develop a Hazard Analysis Critical Control Point (HACCP) Plan and implement requirements for construction related to the USMC relocation.
- *Action*: As management tools become available, implement adaptive management actions to remove or control invasive insects, including, but not limited to, feasible local controls of cycad scale (e.g., hand applications to individual trees).

TIS-5: IMPLEMENTATION OF REGIONAL BIOSECURITY PLAN FOR MICRONESIA AND HAWAI'I

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #3; Goal #3, Objectives #1-2 and 4; Goal #4, Objectives #1-4; and Goal #7, Objective #1.

- *Strategy*: Implement appropriate recommendations within the Regional Biosecurity Plan (RBP) (DON 2015e) that will reduce the risk of introduction and spread of invasive species on Andersen AFB.
- *Action*: Develop standard language for biosecurity BMPs, update as necessary, to be included in project specifications that support prevention, such as vegetation management, and cleanliness standards for materials and equipment operating on the installation.
- *Action*: Conduct early detection surveys (EDS) for high-risk invasive species in training areas; at facilities for staging, storage, and movement of cargo/equipment and vehicles, and at other locations as deemed necessary.
- *Action*: Review and update, as appropriate, DoD Attachment M of the RBP every 3 years.
- *Action*: Develop, implement, and update (as necessary) a JRM biosanitation instruction to ensure cleanliness standards are adhered for the movement of cargo and equipment.
- *Action:* Continue to develop high-risk invasive species protocols and implement control and/or eradication measurement when necessary.

TIS-6: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1; Objectives #1-2; Goal #2, Objectives #2-4; Goal #3, Objectives #1 and 4; and Goal #4, Objectives #1-4. This project supports conservation measures from the BO for the MITT Program (2015 MITT BO) (USFWS 2015a).

- *Strategy*: Implement biosecurity conservation measures listed in the 2015 MITT BO from USFWS.
- *Action*: During training events, ensure 100% BTS canine inspection of aircraft and cargo/equipment departing for an off-island destination.

- *Action*: During training activities, establish snake-free quarantine areas (barriers) as deemed necessary for cargo/equipment traveling from Guam to CNMI and locations outside of the MITT action area.
- *Action*: Ensure BTS awareness briefings for all military and contractor personnel prior to all MITT training activities.
- *Action*: Maintain invasive species rapid response capabilities to control and/or eradicate introduced non-established, non-native invasive species sighted in vicinity of DoD training areas and facilities used for staging, storage, and movement of military personnel, cargo, and vehicles associated with training activities.
- *Action*: Ensure training event personnel conduct biosecurity self-inspections of all personal gear and hand carried items to avoid potential introduction of invasive species to and from Guam. Self-inspection will ensure the removal of soil accumulations, seeds, invertebrates, and vertebrates.
- *Action*: Ensure all training events adhere to the Armed Forces Pest Management Board Technical Guide No. 31 (AFPMB TG-31) cleanliness standards for all cargo/equipment, containers, and rolling stock arriving from off-island destinations and departing Guam for off-island destinations via inspections as deemed necessary.
- *Action*: Implement high-risk invasive species protocols for the control and/or eradication for high-risk species, as species are identified.

TIS-7: CONTROL FERAL DOGS AND CATS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1 and 4; and Goal #4, Objective #2.

- *Strategy*: Reduce threats to native species by implementing a control program for feral dogs and cats on Andersen AFB.
- *Action*: Conduct population surveys of areas of highest conservation concern, and/or human safety to determine locations and estimate numbers of feral dogs and cats, review accepted control measures, and coordinate with U.S. Army veterinarian and installation pest control personnel to control by authorized means if impacts to ESA-listed species or other native wildlife are identified.
- *Action*: In accordance with the interagency agreement between the USDA, APHIS Wildlife Services, and NAVFAC, measures will be implemented to control dog and cat populations. Trail cameras will be installed in areas identified as having feral dogs and cats. All animals will be trapped using live traps and transferred to a local pet shelter.
- *Action*: NAVFAC will provide population reports and data on population numbers, locations, and home ranges to APHIS Wildlife Services to ensure the most cost-effective wildlife management program is administered.
- *Action*: Include U.S. Navy installation feral dog and cat policy information in all installation outreach material presented to military and civilian personnel, housing residents, and contractors.

8.4.1.3 Terrestrial Protected Species Management

Management of terrestrial threatened and endangered species on JRM-administered lands includes implementing programs to protect species, and coordinating efforts with the appropriate agencies. Key threats to threatened and endangered species that can lead to extirpation include the following:

- predation by BTS of native forest birds, lizards, and bats
- overgrazing, rooting, and trampling of plants and wildlife habitat by feral ungulates

- predation by feral cats, dogs, and pigs, as well as predation by monitor lizards on birds, bats, and sea turtles
- human disturbance and poaching of sea turtles and Mariana fruit bats
- mortality or injury to native plants and wildlife due to natural stochastic events (e.g., typhoons)
- low reproductive success due to small population numbers
- habitat loss and fragmentation due to development

To address these key threats to listed species, JRM has conducted and continues to conduct numerous management and research projects to reduce BTS numbers at the local and landscape scale, control BTS at swiftlet caves at Naval Munitions Site (NMS), and to prevent their spread to other Pacific Islands through rigorous inspections and interdiction of outgoing cargo at DoD ports (i.e., Apra Harbor, Andersen AFB). Captive breeding programs conducted by Guam DAWR and mainland zoological institutions are maintaining populations of Guam rail and Guam kingfisher and are adding to the information needed for successful recovery of these species. Additional ecological research and monitoring is also being conducted by various agencies in Guam, including DoD, USDA, and USGS.

In accordance with section 7 of the ESA, a federal agency shall consult with the USFWS to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any threatened or endangered species. The DON will coordinate with the USFWS/Guam NWR for any federal action that is within Overlay Refuge lands and is identified as providing habitat for threatened or endangered species. In addition, the DON will avoid, as the mission allows, impacts on habitat suitable for threatened and endangered species, and locally rare, and Guam ESA-listed species.

Sensitive species are being managed by implementing specific management projects that enhance habitat for these species and by initiating specific strategies that address immediate needs of listed species on the installation. In addition, adherence to the goals set for threatened and endangered species management ensure that the installation remains in compliance with ESA and associated consultation requirements.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Protected Species Management (TPS) on Andersen AFB. Additional protection measures for terrestrial protected species are presented in Section 8.4.1.6, *Terrestrial Natural Resources Law Enforcement*.

TPS-1: SEA TURTLE POPULATION PROTECTION AND ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-5; Goal #3, Objectives #1-2 and 4; Goal #4, Objective #2; Goal #6, Objective #1-2; and Goal #7, Objectives #1-2.

- *Strategy*: Monitor and protect sea turtles on Andersen AFB to maintain habitat and improve nesting success.
- *Action*: Conduct surveys to monitor long-term trends of spatial and temporal distribution of sea turtle nesting activity on Andersen AFB.
- *Action*: Protect sea turtle nests from ungulates and monitor lizard predation through screening and monitoring.
- *Action*: Implement shoreline vegetation management to increase the likelihood of successful hatching of sea turtles and hatchling turtles successfully traversing the strand vegetation and beach to access the ocean. Removal of invasive vegetation will enhance natural regeneration of native strand vegetation.

- *Action*: Incorporate outreach and education program that includes two annual beach clean-ups along Tarague Beach, public presentations to schools and incoming families, and information to recreational beach visitors through signage and outreach materials.
- *Action*: Fund a JRM sea turtle recovery coordinator position to coordinate sea turtle monitoring and recovery efforts across Navy lands and submerged lands and coordinate with INRMP partners (DoD, Territory agencies, NOAA Fisheries, and USFWS) to align JRM sea turtle actions with other efforts in the Marianas and improve coordination of sea turtle projects.
- *Action*: Continue nesting surveys (twice a week minimum during peak nesting season) and conduct additional surveys to identify additional nesting beaches or assess status of known nesting areas on JRM lands.
- *Action*: Mitigate any light pollution or predation that might be affecting nesting habitats.

TPS-2: MARIANA FRUIT BAT POPULATION PROTECTION AND ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1-2; Goal #2, Objectives #1 and #3-4; and Goal #3, Objectives #1 and #4. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017b).

- *Strategy*: Monitor Mariana fruit bat population status on Andersen AFB to maintain and identify habitat relationships.
- *Action*: Continue base-wide surveys annually in May/June to obtain abundance estimates using established base-wide survey protocols to allow for evaluation of trends over time, adjusting frequency if necessary.
- *Action*: Search for aggregating locations. If aggregations or new colony locations are detected, Andersen AFB will commence roost counts in accordance with established survey protocols. If changes in roost locations, colony size, or movement are detected, investigate potential threats or stressors that may be causing disturbance.
- *Action*: Collect ejecta and fecal samples for diet analysis and genetic testing according to established protocols and use data from dietary analysis to inform forest enhancement activities (e.g., outplanting and establishment of beneficial native flora).
- *Action*: Perform vegetation surveys in areas known to be used by fruit bats, specifically focused on distribution and density of important food trees, such as *F. prolixa*.
- *Action*: Provide new information from monitoring efforts to partners in fruit bat management during bi-annual project review meetings and INRMP annual review process.
- *Action*: Conduct spatial and temporal analysis to understand patterns in fruit bat activity (e.g., by vegetation type or season) and provide guidance for development planning and fruit bat management.
- *Action*: Conduct pre-construction surveys for fruit bats within construction footprints one week prior to vegetation clearing activities.

TPS-3: MOTH SKINK AND PACIFIC SLENDER-TOED GECKO SURVEYS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1-2; and Goal #3, Objectives #1 and 4.

- *Strategy*: Develop better understanding of occurrence and distribution of Guam ESA-listed moth skinks and Pacific slender-toed geckos on Andersen AFB.

- *Action*: Survey the distribution and abundance of the moth skink and Pacific slender-toed gecko on Andersen AFB.
- *Action*: Consider potential reintroduction sites for protected reptile species in appropriate locations (e.g., Tarague Basin) when adequate fencing and predator control can be provided.

TPS-4: PROTECTION OF LISTED INVERTEBRATES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-6; and Goal #3, Objectives #1-2 and 4. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017b).

- *Strategy*: Monitor and conduct surveys for listed tree snails, butterfly, and plant species on Andersen AFB.
- *Action*: Conduct additional surveys of tree snail, butterfly, and listed plant species to identify new locations.
- *Action*: Conduct pre-construction surveys for ESA-listed species within construction footprints.
- *Action*: Locate and protect the host plants for Mariana eight-spot butterfly.
- *Action*: Propagate and plant host plants for Mariana eight-spot butterfly within forest enhancement sites and on the back side of berms of the Live-fire Training Range Complex.
- *Action*: Raise and disperse butterfly larvae to host plants.
- *Action*: Translocate listed butterflies from construction footprints at NWF and monitor host plants for one year.
- *Action*: Conduct studies that assess the impacts of parasitoids and develop methods for control of parasitoids.

TPS-5: CONSERVATION OF LISTED PLANT SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-6; Goal #3, Objectives 1-2 and 4; and Goal #4, Objective #2. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017b).

- *Strategy*: Conserve and monitor existing *C. micronesica* within *C. micronesica* ungulate exclusion plots and *S. nelsonii,* particularly the mature *S. nelsonii* at Ritidian Point, on Andersen AFB.
- *Action*: Protect and conduct monthly monitoring of the mature *S. nelsonii* at Ritidian Point and all other *S. nelsonii* planted on Andersen AFB.
- *Action*: Continue to monitor and implement conservation methods on existing populations of *C. micronesica* within pre-existing fenced plots.
- *Action*: Perform an annual health evaluation as a metric to track success of conservation actions.
- *Action*: Conduct non-native plant removal and chemical and mechanical protection from invasive insects as needed.
- *Action*: Install and maintain ungulate proof fencing.
- *Action*: Install mechanisms to protect plants during a typhoon.
- *Action*: Pollinate plants manually and perform propagation and outplanting of plants.
- *Action*: Conduct pre-construction surveys for ESA-listed species within construction footprints at NWF.

- *Action*: Translocate ESA-listed species within construction footprints that cannot be avoided into protected habitat or Forest Enhancement sites.
- *Action*: Maintain and monitor translocated plants for one year to ensure at least 50% survival.
- *Action*: Propagate and outplant ESA-listed species known to occur on JRM lands inside ungulate fenced areas.
- *Action*: Propagate *S. nelsonii* seedlings to help meet recovery plan goals and provide guidance on best practices for outplant and care of *S. nelsonii* on partner-managed lands.

TPS-6: SUPPORT RECOVERY PLANNING USING SURROGATE NATIVE SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #3; and Goal #3, Objectives #1-4. This project supports and is consistent with the Revised Recovery Plan for the Sihek or Guam Micronesian Kingfisher, *Recovery Action #2*.

- *Strategy*: As part of recovery planning efforts, determine the optimum level of BTS suppression and control measures needed to reduce mortality prior to reintroduction of the Guam Kingfisher using Micronesian starlings as a surrogate species. This project will also support expansion of Micronesian starlings across the landscape throughout Andersen AFB.
- *Action*: Expand the local range of Micronesian starlings on Andersen AFB by placing predator proof nesting boxes at increasing distances from existing nest sites in conjunction with BTS suppression efforts.
- *Action*: Monitor choice and use of nest boxes, success of fledging, survivorship, and foraging range.

TPS-7: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1-2 and 4; and Goal #4, Objective #2. This project supports conservation measures from the 2015 MITT BO (USFWS 2015a).

- *Strategy*: Implement conservation measures listed in the 2015 MITT BO from USFWS.
- *Action*: Ensure "No Wildlife Disturbance" and "No Training" in designated areas to include Tarague Beach and other locations where listed species are known to occur.
- *Action*: Ensure all vehicular activities during training are restricted to designated and previously identified areas that do not contain listed species.
- *Action*: Ensure all training activities are consistent with the fire management plan in Commander Naval Forces Marianas (COMNAVMAR) Instruction 3500.4A (Marianas Training Manual) (COMNAVMAR 2013).
- *Action*: Ensure no vegetation clearing, except for maintenance required to keep paved surfaces in the drop zone, landing zones, and bivouac areas in a safe and useable condition. Clearing of tree species greater than 4 inches in diameter used for foraging and roosting of Mariana fruit bats will be avoided. No new bivouac areas are proposed under MITT. Maneuver units will remain tactical and not establish support camps.
- *Action*: Ensure helicopter overflights as part of training activities are prohibited below 1,000 feet above ground level over NWF north of the South Runway to minimize visual disturbance and acoustic impacts on foraging and roosting Mariana fruit bats in the NWF area.
- *Action*: Ensure aircraft overflights as part of training activities along all Andersen AFB clifflines are prohibited below 1,000 feet above ground level.

- *Action*: Ensure flood lights at the Andersen AFB Combat Arms Training and Maintenance (CATM) range are maintained below the tree canopy level and directed inland and parallel to the coast. Lighting in this configuration will avoid impacts to nesting and hatching sea turtles and Mariana fruit bats.
- *Action*: Ensure weapons used at the CATM range do not produce percussive force to avoid disturbance to Mariana fruit bats.

TPS-8: COCONUT CRAB POPULATION ASSESSMENT

While the coconut crab is not a listed species, it is protected from harvest by Andersen AFB. This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; and Goal #2, Objective #1.

- *Strategy:* Develop an informed decision on whether coconut crab harvest should be allowed and if so, under what conditions or limitations.
- *Action:* Conduct coconut crab population and demographics surveys twice annually to monitor trends on Andersen AFB.

8.4.1.4 Migratory Bird Management

JRM installations manage and monitor the effects that both military readiness and non-readiness activities have on migratory bird species and populations. Relevant regulations and policies include the Military Readiness Rule (50 Code of Federal Regulations [CFR] 21.15); the 2014 Memorandum of Understanding (MOU) between the DoD and USFWS to Promote the Conservation of Migratory Birds; and EO 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*. Through the implementation of the INRMP, proper management of migratory bird species and habitats, including the timely implementation of appropriate conservation practices, will help installations avoid or minimize impacts to migratory birds.

To meet the goals and objectives of the INRMP, the following management project was identified for Migratory Bird Management (MIG) on Andersen AFB.

MIG-1: CONSERVATION MEASURES FOR MIGRATORY BIRDS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1-2 and 4; and Goal #6, Objective #1.

- *Strategy*: Develop and implement appropriate conservation measures for proposed actions that may have a significant adverse effect on a migratory bird population.
- *Action*: Include an inventory of all priority migratory bird species found on Andersen AFB. This installation-specific list of species of concern will include MBTA protected species, species listed under the ESA, Guam-listed species, USFWS Birds of Conservation Concern, candidate species (both federal and Guam), and DoD Mission-sensitive Priority Species.
- *Action*: For each species of management or monitoring, focus on the installation, provide a brief description of its life history, locations on the installation, and a statement of the interrelatedness between its conservation or priority status and installation mission activities.
- *Action*: Describe the installation's implementation of priority migratory bird conservation measures and explain how the installation uses these conservation measures to avoid or minimize impacts to military readiness.
- *Action*: Provide details on the installation's Bird/Animal Aircraft Strike Hazard program, if applicable, to include the types of birds using the airfield and areas surrounding the airfield throughout the year.

- *Action*: Conduct or support a Wildlife Hazard Assessment that identifies areas of the airfield that are attractive to birds and include recommendations for deterring birds from those areas.

8.4.1.5 Terrestrial Natural Resources Educational Outreach

Conservation awareness is instrumental in creating conditions needed to manage natural resources. The JRM approach to awareness stresses education. It provides military personnel and the public with insights into installation natural environments and conservation challenges. The more educated people are about the unique and valuable natural resources on JRM-administered lands, the more responsibly they will act when using them. Education also promotes awareness of critical environmental projects and the rationale behind them. As activities such as habitat management, wildlife management, and land rehabilitation are generally accepted and understood, minimal effort is required to communicate conservation priorities to installation personnel, recreationists, and the general public. However, issues such as protection of sensitive areas for plant and wildlife species, invasive species management (ungulate management), wildfire suppression and restrictions on some recreational activities in JRM-administered lands require effective conservation communication to garner positive support and, perhaps more importantly, to avoid adverse reactions from various users. A conservation awareness program must be directed to both installation and external interests if it is to be effective.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Natural Resources Educational Outreach (TEDU) on Andersen AFB. These management projects are in parallel and in concert with those identified and discussed in Section 8.4.2.4, *Marine Natural Resources Educational Outreach*.

TEDU-1: ESA-LISTED SPECIES AND TERRESTRIAL RESOURCES OUTREACH

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7; Objective #1-2. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017b).

- *Strategy*: Improve awareness among DoD personnel and the public of threats and stressors to terrestrial resources, including protected species, and the importance of conserving natural resources on Andersen AFB, in cooperative efforts with partners such as GovGuam and USFWS.
- *Action*: Install informational signs and interactive kiosks on Andersen AFB recreational beaches.
- *Action*: Develop, update, and distribute multimedia for public education to incoming military personnel, contractors, schools, and other outreach opportunities that address appropriate behavior around threatened and endangered species and the consequence of introduced non-native plant and animal species. Outreach materials will be reviewed every 2 to 5 years.
- *Action*: Review and update, as needed, current outreach videos/media used during the orientation briefs viewed by 100% of new personnel upon arrival to Guam.
- *Action*: Develop a contractor education program on ESA-listed and invasive species.

TEDU-2: JRM NATURAL RESOURCES STEWARDSHIP OUTREACH AND PUBLIC ENGAGEMENT PROGRAM

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7; Objective #1-3.

- *Strategy*: Implement a comprehensive natural resources outreach program regarding the federal, territorial, and base environmental regulations and policies, as well as information about the importance of protecting and conserving JRM's natural resources.
- *Action*: Update a comprehensive Natural Resources Stewardship Outreach online training system for military and civilian personnel.
- *Action*: Create a JRM Environmental Public Engagement Plan to outline the areas where JRM can significantly increase their outreach with military personnel and the public about appropriate behavior toward threatened and endangered species and the importance of conserving natural resources within lands and submerged lands administered by JRM.
- *Action*: Conduct marine debris clean-ups a minimum of twice yearly on sea turtle nesting beaches.
- *Action*: Utilize partnerships with the U.S. Coast Guard (USCG) and Naval Mobile Construction Battalions (SeaBees) during joint training exercises to minimize costs and raise awareness within military personnel of the importance of maintaining the beaches to protect threatened and endangered species and other marine and terrestrial natural resources.
- *Action*: Utilize annual high profile environmental days, such as Earth Day in April and the Ocean Conservancy's International Coastal Clean-up in September, to organize clean-ups and provide natural resource outreach materials to military personnel and other participants.
- *Action*: Develop, update, and implement a biosecurity education and outreach program for contractor personnel, military personnel, and dependents.

8.4.1.6 Terrestrial Natural Resources Law Enforcement

JRM has established the following objectives for enforcement: (1) enforce laws and regulations pertaining to the implementation of the natural resources program, (2) integrate natural resources enforcement into the overall natural resources program, and (3) use enforcement personnel to enhance the natural resources program at JRM.

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial Natural Resources Law Enforcement (TLAW) on Andersen AFB.

TLAW-1: CONSERVATION LAW ENFORCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-3; Goal #2, Objectives #1-2 and 4; Goal #3, Objectives #4; Goal # 6, Objectives #1-2; and Goal #7; Objectives #1-3.

- *Strategy*: Detect and deter unauthorized activity that negatively affects natural resources on Andersen AFB (e.g., poaching, off-roading) through conservation law enforcement.
- *Action*: Establish a Conservation Law Enforcement Program by hiring a Conservation Law Enforcement Officer and by partnering with other agencies, as applicable, to enforce natural resource laws, policies, and regulations on Andersen AFB. The Conservation Law Enforcement Officer will conduct outreach and enforce natural resource regulations.
- *Action*: Protect sea turtles from poaching on nesting beaches and submerged lands.

8.4.1.7 Terrestrial Geographic Information System and Data Management

Natural resources data are stored and maintained within a centralized JRM Geographic Information System (GIS) database. The GIS database also provides support for the entire environmental program and the training community. JRM uses GIS for complex analyses such as project siting, data interpolations, and risk assessments. GIS software enables installation staff to capture, store, update, manipulate, analyze, and

display all forms of geographically referenced data and tabular information about natural and physical resources found on JRM-administered lands. The training of JRM staff and the allocation of their time to data entry, mapmaking, data analysis, and interpretation of the results determines the success of the installation GIS. Once fully developed, the installation GIS databases can be used for projects such as the following:

- providing maps with locations of species, vegetation communities, surface waters, and other areas of potential concern
- selecting suitable areas for construction activities
- planning land rehabilitation projects
- providing special maps for Environmental Awareness materials
- ensuring avoidance of threatened and endangered species habitats and other areas of special concern during construction projects
- identifying site options for use during National Environmental Policy Act (NEPA) evaluation of alternative sites
- calculating drainages and water flows
- determining wildlife habitat preferences

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial GIS and Data Management (TGIS) on Andersen AFB.

TGIS-1: TERRESTRIAL NATURAL RESOURCES GIS AND DATA MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-5; and Goal #3, Objectives #1 and 4.

- *Strategies*:
  - Identify data gaps in terrestrial natural resources GIS to assist in the development of future data collection efforts, surveys, and management actions.
  - Ensure that GIS information is available to installation subject matter experts and military personnel, biologists, planners, contractors, and others in a timely manner to assist with planning and decision-making.
- *Action*: Update and continuously maintain existing centralized GIS database to effectively inform and guide future management of terrestrial natural resources on Andersen AFB and meet natural resources goals and objectives. Readily available GIS data will be used to develop natural resources constraints maps for use in current and future JRM management and planning decisions for Andersen AFB.

8.4.1.8 Summary – Terrestrial Ecosystem Management

Implementation of the JRM INRMP program and the focused strategies and actions of the management projects for terrestrial resources provides a conservation benefit to the natural ecosystems within Andersen AFB by maintaining and enhancing the natural community structure, function, species diversity, and resiliency. Enhancing and restoring native habitats supports viable populations of native species and increases biodiversity. Furthermore, proactive invasive species prevention, early detection, and control reduces the risk of intra- and inter-island species introductions. Data from regular monitoring of protected species informs management projects to enhance and restore habitat, reduce habitat fragmentation, buffer protected areas, implement new conservation strategies, and avoid and minimize impacts. Using this regional ecosystem-based approach for managing protected species and their associated ecosystems ensures

that JRM remains in compliance with federal and territorial laws while supporting the operational functionality of the Andersen AFB mission.

Twenty-two management projects addressing terrestrial natural resources management are proposed for implementation on Andersen AFB:

- Terrestrial Habitat Management – 2
  - THM-1: Forest Enhancement
  - THM-2: Urban Forestry Data Base, Maintenance, and Replacement of Trees
- Terrestrial Exotic and Invasive Species Management – 7
  - TIS-1: Brown Treesnake Interdiction
  - TIS-2: Brown Treesnake Suppression
  - TIS-3: Brown Treesnake Management for the Recovery of Protected Species
  - TIS-4: Invasive Species Management
  - TIS-5: Implementation of Regional Biosecurity Plan for Micronesia and Hawai‘i
  - TIS-6: Mariana Islands Training and Testing Implementation of the Biological Opinion
  - TIS-7: Control Feral Dogs and Cats
- Terrestrial Protected Species Management – 8
  - TPS-1: Sea Turtle Population Protection and Enhancement
  - TPS-2: Mariana Fruit Bat Population Protection and Enhancement
  - TPS-3: Moth Skink and Pacific Slender-toed Gecko Surveys
  - TPS-4: Protection of Listed Invertebrates
  - TPS-5: Conservation of Listed Plant Species
  - TPS-6: Support Recovery Planning Using Surrogate Native Species
  - TPS-7: Mariana Islands Training and Testing Implementation of the Biological Opinion
  - TPS-8: Coconut Crab Population Assessment
- Migratory Bird Management – 1
  - MIG-1: Conservation Measures for Migratory Birds
- Terrestrial Natural Resources Educational Outreach – 2
  - TEDU-1: ESA-listed Species and Terrestrial Resources Outreach
  - TEDU-2: JRM Natural Resources Stewardship Outreach and Public Engagement Program
- Terrestrial Natural Resources Law Enforcement – 1
  - TLAW-1: Conservation Law Enforcement
- Terrestrial Geographic Information System and Data Management – 1
  - TGIS-1: Terrestrial Natural Resources GIS and Data Management

8.4.2 Marine Ecosystem Management

The mission of Andersen AFB is to support USAF, U.S. Pacific Command, and other commands and warfighters based in Guam that are serviced and supplied by Andersen AFB. Submerged lands on Andersen AFB offer a realistic training environment and provide significant recreational opportunities for military personnel and their families. These lands are presently influenced by natural and anthropogenic forces that drive the short- and long-term integrity of the resources. Monitoring surveys that allow for trend analysis and provide information on reef resiliency help draw connections between various stressors and their impact on marine communities. Surveys can also help establish whether populations of native marine flora and fauna are healthier than previously known. This information allows JRM to design and implement adaptive management strategies and to make appropriate decisions about mission-essential training and operations

and recreational use to avoid and minimize impacts to marine resources, including federal ESA-listed marine species and their habitats.

Maintaining healthy marine communities supports the military mission by avoiding or alleviating potential training restrictions and/or restrictions on recreational access and use, allowing Andersen AFB to provide unimpeded support to DoD commands. The state of knowledge and the plans for managing marine resources on JRM-administered submerged lands differs from the management of terrestrial resources. The principal reason for the differences is that access to and direct knowledge of the marine resources by natural resource managers is extremely limited. Additionally, the cost and effort to obtain information about marine resources is typically much greater than that required for terrestrial resources. These restrictions could mean that evidence of the presence or the condition of resources may need to be inferred from indirect or infrequent measurements to a greater degree than is required on land. Therefore, the focus of this section of the INRMP takes a different approach to the management of marine resources compared to terrestrial resources.

The content and projects described in the INRMP serve three purposes that are consistent with Overarching Goal #1, *Ensure Military Mission Sustainability and Environmental Compliance* (see Section 3.3.1, *Goals and Objectives*) but may not be held entirely in common with terrestrial resources:

1) They serve the letter and spirit of the requirements of the Sikes Act for JRM to have a management plan for natural resources on its installation;
2) They serve as a starting point for the basic characterization of information regarding the marine environment on JRM installations that is commonly understood between the DoD and resource agencies and can be used for planning purposes for environmental compliance documents that will be prepared to support DoD actions; and
3) They may allow JRM and NMFS to come to agreement that the management projects that are planned in the INRMP are sufficient to preclude the need to designate critical habitat for ESA-listed species on JRM-administered submerged lands and implementing actions to support their recovery.

The second item emphasizes the use of INRMP content and the results of INRMP projects to inform a basic understanding of marine resources in JRM-administered submerged lands. This understanding helps with planning costs, schedules, and requirements of proposed DoD projects, such as the type of NEPA document to be prepared, the presence of federal ESA-listed species, the type of natural resources consultations to expect, and the estimated quantity of resources and/or habitat that could be impacted. It is understood that additional detailed, site-specific studies are likely to be necessary for NEPA analyses and associated consultations.

The purpose of this section is to identify projects with specific strategies for Andersen AFB and to obtain workable and useful solutions for marine natural resources management. In accordance with OPNAV M-5090.1 and the principles of adaptive ecosystem management, marine natural resources management goals, objectives, strategies, and actions were developed for Andersen AFB by an interdisciplinary team of ecologists, biologists, geologists, planners, and environmental scientists. Management of the JRM-administered submerged lands and associated marine resources in JRM: (1) protects and conserves threatened and endangered species through habitat conservation and enhancement, (2) promotes health and sustainability of coral reefs, (3) provides continued access to recreational areas, and (4) provides continued use and access to training areas, ensuring no net loss to the military mission.

The overall strategy follows a cycle of: (1) understanding the spatial distribution and types of marine habitat on JRM-administered submerged lands, (2) characterizing the species and communities that occur in the various habitats, (3) determining the condition of the resources in the habitat, (4) determining how species

that are present use or contribute to the habitat, and (5) managing the effects of stressors or threats on protected resources.

Adaptive management is intended to be an active part of all facets of the progression of resource management. Basic data collection to characterize a resource could be an endless process. Adaptive management will help to prioritize and focus effort to know when an emphasis needs to be on basic characterization, when responding to threats should be stressed, and what kind of balance between the two pursuits should be struck. Steps in the progression may be leaped past if conditions or information indicate a different step in the progression is needed. Adaptive management is not only depended on to determine what actions to take; it is also intended as a way to collaboratively review what is known about a resource so a collective agreement can be made on the next steps.

Similar to the terrestrial natural resources management program, the marine natural resources management program is divided into the following categories:

- Marine Habitat Management
- Marine Invasive Species Management
- Marine Protected Species Management
- Marine Natural Resources Educational Outreach
- Marine Natural Resources Law Enforcement
- Marine Natural Resources GIS and Data Management

As appropriate and applicable, all management projects will require evaluation or monitoring criteria, which are used to track the status of the management project and whether the management project: (a) addresses no net loss to the capability of Andersen AFB to support the military mission and (b) meets the identified goals and objectives. At a minimum, mid-year coordination meetings will be held with resource agencies to discuss ongoing and planned projects to include prioritization, scope, methodology, issues encountered, timelines, and evaluation or monitoring criteria; these factors will also be discussed at the annual INRMP Metrics meeting. These conversations are meant to facilitate information sharing and enable JRM and the agencies to take an adaptive management approach to managing INRMP projects. This approach will mean that projects are managed more dynamically and will be more responsive to arising needs than a static 5-year plan would be. A summary of the management project and the estimated timeframe for completion is presented in Table 13-11, *Planned Implementation Summary of Projects at Andersen AFB* found in Chapter 13, *Planning, Integration, and Implementation*.

Some of the management projects described in the following sections will be accomplished through interactive partnerships with federal and territorial natural resource agencies, universities, and local organizations. JRM natural resources management staff will establish partnerships based on the benefits to the regional ecosystem and the local environment.

8.4.2.1 Marine Habitat Management

Marine resources are inherently challenging to describe due to their inaccessibility and in many cases, low detectability. The initial approach to marine resource assessment is to describe the baseline, answering the question “what is there?” This is typically done by scuba divers who record species richness and abundance within a study site that is representative of a larger area. Habitat mapping is often done in advance of baseline assessments to provide spatial context for “where” marine resources are distributed. Additionally, developing habitat maps initially helps to determine how to subdivide the study area into representative sections (i.e., strata) and how to extrapolate those baseline assessments into a larger context. However, baseline assessments are often not designed specifically to be repeatable. Repetition is critical to obtain

sufficient statistical power that allows for the detection of change over time in various metrics. Monitoring designs typically increase statistical power by designing surveys that are repeatable with very high precision. Both baseline assessments and monitoring programs are essential for marine resource managers, who must first understand what resources are present and how they are distributed, and then how military operations and corresponding management actions affect those resources through time. When monitoring detects substantial changes in marine resource communities, the baseline must be adjusted.

Interagency efforts to develop consistent methods for evaluating impacts to nearshore marine resources and determining suitable mitigations that offset lost ecological functions and services are supported by the DON, NMFS, USFWS, USEPA, and U.S. Army Corps of Engineers (USACE). Standardized methods that agencies can agree on are expected to benefit processes associated with NEPA, interagency consultations (e.g., ESA), Clean Water Act Section 404 permitting, and natural resources management. Interim results from the interagency effort are expected in the near term for consideration, but repeatable processes that are agreed on by all agencies are expected to be established over the next 5 to 10 years.

Management projects in offshore areas are primarily focused on outreach and education and monitoring associated with testing and training given that the resources are mobile and wide-ranging and the logistical challenges of managing those resources. Divers cannot easily access marine resources below 98 to 131 feet (30 to 40 meters). Autonomous and remotely operated vehicles can be used to observe and assess resources at greater depths, but implementing management projects remotely is challenging enough with the current state of technology; therefore, autonomous/remotely operated vehicles are not a practical solution for most INRMP management projects.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Marine Habitat Management (MHM) on Andersen AFB.

MHM-1: CORAL HABITAT ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-5; Goal #3, Objectives #1-2 and 4; and Goal #5, Objectives #1-2.

- *Strategy*: Enhance coral habitat by monitoring health and acute impacts and through focused reef restoration efforts.
- *Action*: Establish long-term monitoring programs to track changes in the health of corals and water quality that is compatible with existing monitoring programs in Guam and the region.
- *Action*: Work with regulatory partners and local subject matter experts to identify priority resilience indicators. Using the same or similar methods to Maynard et al. (2015), synchronize data sets for at least one meaningful monitoring period to allow JRM sites to be compared to other sites within the Guam Coral Reef Resilience Assessment. Existing monitoring data from survey efforts that were initiated in 2012 will also inform this process (Schils et al. 2017). The measures for assessing resilience include: macroalgae percent cover (to be obtained as coarse level data in the benthic habitat mapping project), coral community (available for some sites from past studies), bleaching resistance, coral recruitment and connectivity, coral diversity (available for some sites from past studies), herbivore average functional group biomass, temperature variability, land-based sources of pollution, and accessibility due to wave exposure.
- *Action*: Using the results obtained above, further refine priority sites (e.g., those that have high resilience factor) for targeted management actions. Examples of targeted management actions, include but are not limited to actions that improve water quality (e.g., reduce land base sources of

pollution or runoff, wetland/mangrove enhancement), fisheries management and enforcement (see MLAW-1), no anchoring areas, outreach, and targeted reef restoration actions (e.g., macroalgae control, outplanting of coral recruits). JRM is already taking steps to address a number of these actions, which are described further below.

- *Action*: Determine presence/absence of individuals, movement patterns, habitat utilization, foraging locations, home range size, and site fidelity for indicator species and protected species.
- *Action*: JRM has programmed for annual monitoring to include pre, during, and post monitoring around bleaching events, coral disease, and active intervention during COTS outbreaks on Andersen AFB submerged lands. JRM is working with partners locally to align monitoring strategies and adapt as necessary. Monitoring methodology will be coordinated with the Guam Coral Reef Response Team, an interagency effort between NOAA, USFWS, National Park Service, Guam DAWR, Bureau of Statistics and Plans, Guam EPA, UOG Marine Laboratory, and DON. Utilize monitoring results to develop and prioritize response actions (e.g., implement control efforts in a timely manner using best available methods such as bile salts or sodium bisulphate if COTS outbreaks are detected; minimize harmful activities at sensitive sites during coral bleaching events to reduce local stress to corals).
- *Action*: Develop protocol for immediate assessment and response to reef damage caused by unanticipated events such as vessel groundings and anchor damage. The protocol will outline responsible parties, coordination process, and initial reef damage assessment requirements. This protocol will inform the long-term response plan.
- *Action*: Participate in bi-annual Guam Coral Reef Task Force and the reef restoration working group.
- *Action*: Conduct studies to monitor sediment and nutrient loads in time and space for managing stressors' inputs to the coastal and coral reef areas. Utilize a Soil and Water Assessment Tool (SWAT) model to simulate flow, soil erosion, sediment, nutrient transport, and for evaluating the effect of climate change, land use change, and BMP applications.
- *Action*: Develop protocol for immediate assessment and response to reef damage caused by natural disasters/events such as typhoons, tsunamis, heat waves, extreme flooding, and earthquakes.

MHM-2: MARINE RESOURCES DATA ANALYSIS AND COORDINATION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objectives #1 and 3-4; Goal #3, Objective #4; and Goal #7, Objective #3.

- *Strategy*: Establish long-term partnership with NMFS PIFSC to improve communication, collaboration, and information sharing to ensure the most up-to-date NOAA Pacific RAMP data are analyzed and available to inform JRM INRMP adaptive management strategies.
- *Action*: Develop an agreement with NMFS PIFSC to address critical data needs from tri-annual NOAA Pacific RAMP surveys for sites within JRM-administered submerged lands to evaluate trends over time and inform management actions. JRM will work with NMFS PIFSC to develop a scope, to determine an acceptable cycle for data analysis (e.g., within 12-18 months of survey completion), and to identify data categories and survey locations to prioritize for analysis. At a minimum, the analysis would include a summary of findings from coral, algal, benthic, and fish surveys within JRM-administered submerged lands and associated figures.

MHM-3: MARINE HABITAT MAPPING EFFORTS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objectives #1 and 3-5; Goal #3, Objectives #1 and 4; Goal #5, Objective #1; and Goal #7, Objective #3.

- *Strategy*: Classify and delineate benthic mapping and characterization in the nearshore waters of JRM-administered submerged lands on Andersen AFB, focusing on depths from 0–66 feet (0–20 meters) and 66–131 feet (20–40 meters) depending on water visibility.
- *Action*: Provide baseline data for monitoring changes in coral reef and marine benthic communities that are compatible with existing monitoring programs in Guam and the region.
- *Action*: Obtain high resolution habitat maps of submerged habitat to inform priorities as well as avoidance and minimization measures during military activities.
- *Action*: Work with NOAA National Centers for Coastal Ocean Science (NCCOS) to classify and delineate benthic habitats in the nearshore waters of JRM-administered submerged lands on Andersen AFB using side scan or multibeam sonar. Results from this project will be used to map threatened and endangered species (e.g., sea turtles, corals, scalloped hammerhead shark), EFH, and indicators of health.
- *Action*: Work with NOAA NCCOS to perform mapping projects of previously mapped locations/installations every 5 years to study/monitor temporal and spatial changes in habitat.

8.4.2.2 Marine Invasive Species Management

An invasive species is defined in EO 13112 as a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm, or harm to human, animal, or plant health. Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions. As with terrestrial ecosystems, marine invasive species can have a significant effect on the native marine species of island ecosystems.

Marine invasive species control and removal efforts are mandated by similar federal, DoD, and JRM regulations as terrestrial invasive species. The DON funded the development of the RBP for Micronesia and Hawai‘i. The RBP is a multi-disciplinary effort of federal and regional scientists and experts to address pathways and encourage a more holistic approach to evaluating and managing terrestrial, marine, and freshwater invasive species risks within Micronesia and Hawai‘i. The DON/JRM will implement necessary and appropriate DoD recommendations of the RBP (refer to Volume I, Attachment M, U.S. DoD Biosecurity Recommendations).

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Marine Invasive Species Management (MIS) on Andersen AFB.

MIS-1: IMPLEMENTATION OF REGIONAL BIOSECURITY PLAN FOR MICRONESIA AND HAWAI‘I

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #3; Goal #3, Objectives #1-2 and 4; Goal #4, Objectives #1-4; and Goal #7, Objective #1

- *Strategy*: Implement recommendations within the RBP that are applicable to JRM (Volume I, Attachment M, *U.S. DoD Biosecurity Recommendations*) (DON 2015e) that would avoid and

minimize: (1) new invasive species incursions into Guam's marine waters and (2) the transfer of invasive species from Guam to Hawai'i and other parts of Micronesia.

- *Action*: Develop and maintain a Marine Invasive Species Management Plan for Andersen AFB. This plan would include, but not be limited to, the following:
    1) Establish a watch list and effective monitoring program for high-risk non-native marine species that are known or thought to pose significant ecological, economic, social, or cultural impacts to Guam and CNMI, focusing on species that are not established or widely distributed in the region. The watch list will be coordinated and consistent with the Guam Marine Biosecurity Action Plan (2014) Appendix C on potential marine invasive species.
    2) Develop early detection and response protocols for new incursions by a few focal non-native marine species for Guam and CNMI.
    3) Develop standard language to be included in contract specifications that provides BMPs to lessen the risk of marine invasive species being transported to project sites.
- *Action*: JRM will work with appropriate U.S. Navy commands to determine if updates are warranted for Navy hull husbandry standards (NAVSEA S9086-CQ-STM-010) (U.S. Navy 2006) and ballast water requirements (*Note: The U.S. Navy adopts USCG standards*).
- *Action*: Implement JRM Marine Invasive Species Management Plan. Perform MIS baseline surveys for all installations. Implement necessary actions/protocols based on baseline results.
- *Action:* Create a marine invasive species database for JRM submerged lands.

MIS-2: FEDERAL AND TERRITORIAL COORDINATION AND COLLABORATION FOR MARINE INVASIVE SPECIES PREVENTION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #4; Goal #4, Objectives #4; and Goal #7, Objective #3.

- *Strategy*: Develop partnerships to improve coordination and collaboration with other federal and Guam agency staff, industry, and non-governmental organizations, and seek opportunities to synergize funding, resources, and efforts to accomplish common goals (i.e., those outlined in the 2014 Guam Marine Biosecurity Action Plan (Miller 2014).
- *Action*: Participate in the quarterly Guam Invasive Species Advisory Council meetings and coordinate regularly with the territorial marine invasive species coordinator, once hired.
- *Action*: Develop partnerships to improve coordination and collaboration with other Pacific Island governments as well, such as Palau, FDM, CNMI, New Zealand, and Australia.

8.4.2.3 Marine Protected Species Management

Management of marine threatened and endangered species on JRM-administered submerged lands includes implementing programs to protect species and coordinating efforts with the appropriate agencies. An INRMP is a primary tool for the DoD to fulfill its obligation to support section 7(a)(1) of the ESA, which states that all federal departments and agencies shall seek to conserve listed species and shall use their authorities to further the purpose of the ESA. In accordance with section 7(a)(2) of the ESA, a federal agency shall consult with NMFS to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species. In addition, the DON avoids impacts on habitat suitable for federal and Guam ESA-listed species, as the mission allows.

Federal ESA-listed species in JRM-submerged lands will continue to be managed by implementing specific management strategies that enhance habitat for these species and by initiating specific strategies that

address immediate conservation needs of listed species on the installation. To meet the goals and objectives of the INRMP, a suite of management projects was identified for Marine Protected Species Management (MPS) on Andersen AFB. Additional protection measures for marine protected species are presented in Section 8.4.2.5, *Marine Natural Resources Law Enforcement*.

MPS-1: SCALLOPED HAMMERHEAD SHARK STUDY

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2 and Goal #3, Objectives #1-2 and 4. This project supports conservation measures from the ESA section 7 Consultation BO and Conference Report for the U.S. Military MITT Activities (NMFS 2010, 2014b).

- *Strategy*: Conduct surveys to determine the temporal and spatial abundance, distribution, and habitat use of the threatened scalloped hammerhead shark.
- *Action*: Monitor shark population movements, habitat use, and behavior through capture and acoustic or satellite tagging efforts, or other appropriate methods.

MPS-2: SEA TURTLE POPULATION PROTECTION AND ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1-2 and 4; and Goal #7, Objective #3.

- *Strategy*: Monitor sea turtle activity and determine habitat use in the marine waters of JRM-administered submerged lands and adjacent Guam waters.
- *Action*: Examine distribution, movement, and habitat use of sea turtles on JRM-administered submerged lands around Guam. Up to 300 Passive Integrated Transponder tags will be attached to turtles captured by JRM. Of the turtles captured and fitted with Passive Integrated Transponder tags, 34 will be outfitted with GPS satellite telemetry or archival tags to monitor movement and collect data on habitat use (i.e., habitat type, depth, time at depth); drifters will be deployed to examine dispersal of hatchlings.
- *Action*: Continue to coordinate efforts with U.S. Pacific Fleet as long as their complementary sea turtle monitoring efforts continue.
- *Action*: Implement and coordinate water quality monitoring and ecosystem monitoring to evaluate runoff and implement actions to mitigate effects of erosion.
- *Action*: Continue in-water surveys and conduct additional surveys within JRM submerged lands to identify additional foraging/resting areas.

8.4.2.4 Marine Natural Resources Educational Outreach

Conservation awareness is instrumental in creating conditions needed to manage natural resources. The JRM approach to awareness stresses education. It provides military personnel and the public with insights into installation natural environments and conservation challenges. Education promotes awareness of threats and stressors to marine resources and threatened and endangered species. Activities such as habitat management, natural resources management, and submerged lands rehabilitation can be assisted by increasing the public's awareness of the importance of conserving the natural resources within JRM-administered submerged lands. However, issues such as protection of sensitive marine areas for fish and wildlife species, invasive species management, and restrictions on some recreational activities within JRM-administered submerged lands, require effective outreach with the public and military personnel in order to garner support and, perhaps more importantly, to avoid adverse reactions from various user

impacts. An outreach program focused on minimizing impacts to marine resources and protecting ESA-listed marine species must be directed to both installation and external stakeholders to be effective.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Marine Natural Resources Educational Outreach (MEDU) on Andersen AFB. These management projects are in parallel and in concert with those identified for discussed in Section 8.4.1.5, *Terrestrial Natural Resources Educational Outreach*.

MEDU-1: ESA-LISTED SPECIES AND MARINE RESOURCES OUTREACH

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7; Objective #1-2. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017b).

- *Strategy*: Implement a targeted outreach program to improve awareness among DoD personnel and the public of threats and stressors to marine resources, including protected species, and the importance of conserving natural resources on Andersen AFB through cooperative efforts with partners such as GovGuam and USFWS.
- *Action*: Update and maintain informational signs on Andersen AFB recreational beaches.
- *Action*: Develop, update, and distribute multimedia for public education to incoming military personnel, contractors, schools, and other outreach opportunities that address appropriate behavior around threatened and endangered species and the consequence of introduced non-native plant and animal species. Outreach materials will be reviewed every 2 to 5 years.
- *Action*: Review and update, as needed, current outreach videos/media utilized during the orientation briefs viewed by 100% of new personnel upon arrival to Guam.
- *Action*: Coordinate with the dive shops to help promote environmental education and awareness to reduce negative recreational impacts on JRM-administered submerged lands.

MEDU-2: JRM NATURAL RESOURCES STEWARDSHIP OUTREACH AND PUBLIC ENGAGEMENT PROGRAM

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7; Objective #1-3.

- *Strategy*: Implement a comprehensive natural resources outreach program regarding that all incoming military personnel receive comprehensive natural resources indoctrination training about the federal, territorial, and base environmental regulations and policies, as well as information about the importance of protecting ’nd conserving JRM's natural resources.
- *Action*: Update a comprehensive Natural Resources Stewardship Outreach online training system for military and civilian personnel.
- *Action*: Create a JRM Environmental Public Engagement Plan to outline the areas where JRM can significantly increase their outreach with military personnel and the public about appropriate behavior toward threatened and endangered species and the importance of conserving natural resources within JRM-administered lands and submerged lands.
- *Action*: Conduct marine debris clean-ups a minimum of twice yearly on sea turtle nesting beaches.
- *Action*: Utilize partnerships with the USCG and SeaBees during joint training exercises to minimize costs and to raise awareness within military personnel of the importance of maintaining the beaches to protect threatened and endangered species and other marine natural resources.

- *Action*: Use annual high profile environmental days, such as Earth Day in April and the Ocean Conservancy's International Coastal Clean-up in September, to organize clean-ups and provide natural resource outreach materials to military personnel and other participants.
- *Action*: Develop outreach materials for the public and military personnel about the importance of using reef-safe sunscreen to minimize impacts on the reefs and to educate military personnel and other participants about the importance of disposing trash properly and distribute this information at marine debris clean-up events.
- *Action*: Develop, update, and implement a biosecurity education and outreach program for contractor personnel, military personnel, and dependents.

8.4.2.5 Marine Natural Resources Law Enforcement

JRM has established the following objectives for enforcement: (1) enforce laws and regulations pertaining to the implementation of the natural resources program, (2) integrate natural resources enforcement into the overall natural resources program, and (3) use enforcement personnel to enhance the natural resources program at JRM.

To meet the goals and objectives of the INRMP, the following management project was identified for Marine Natural Resources Law Enforcement (MLAW) on Andersen AFB.

MLAW-1: CONSERVATION LAW ENFORCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-3; Goal #2, Objectives #1-2 and 4; Goal #3, Objectives #4; Goal # 6, Objectives #1-2; and Goal #7; Objectives #1-3.

- *Strategy*: Detect and deter unauthorized activity that negatively affects natural resources on Andersen AFB (e.g., poaching, littering, improper vessel anchoring, illegal fishing) through conservation law enforcement.
- *Action*: Establish a Conservation Law Enforcement Program by hiring a Conservation Law Enforcement Officer and by partnering with other agencies, as applicable, to enforce natural resource laws, policies, and regulations on Andersen AFB. The Conservation Law Enforcement Officer will conduct outreach and enforce natural resource regulations.
- *Action*: Protect sea turtles from poaching on nesting beaches and submerged lands.

8.4.2.6 Marine Geographic Information System and Data Management

Natural resources data are stored and maintained within a centralized JRM GIS database using GIS data collection standards. The GIS database also provides support for the entire environmental program and the training community. JRM uses GIS for complex analyses such as project siting, data interpolations, and risk assessments.

GIS software enables installation staff to capture, store, update, manipulate, analyze, and display all forms of geographically referenced data and tabular information about natural and physical resources found on JRM-administered submerged lands. The training of JRM staff and the allocation of their time to data entry, mapmaking, data analysis, and interpretation of the results determines the success of the installation GIS. Once fully developed, the installation GIS databases can be used for projects such as the following:

- providing maps with bathymetric contours and locations of species, marine habitat, EFH, and other areas of potential concern
- providing special maps for Environmental Awareness materials

- ensuring avoidance of threatened and endangered species habitats and other areas of special concern during construction projects
- identifying site options for use during NEPA evaluation of alternative sites
- calculating drainages and water flows
- determining species habitat preferences

To meet the goals and objectives of the INRMP, the following management project was identified for Marine GIS and Data Management (MGIS) on Andersen AFB.

MGIS-1: MARINE NATURAL RESOURCES GIS AND DATA MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-5; and Goal #3, Objectives #1 and 4.

- *Strategies*:
  - Identify data gaps in marine natural resources GIS to assist in the development of future data collection efforts, surveys, and management actions.
  - Ensure that GIS information is available to installation subject matter experts and military personnel, biologists, planners, contractors, and others in a timely manner to assist with planning and decision-making.
- *Action*: Update and continuously maintain existing centralized GIS database to effectively inform and guide future management of marine natural resources on Andersen AFB and to meet natural resources goals and objectives. Readily available GIS data can be used to develop natural resources constraints maps for use in current and future JRM management and planning decisions for Andersen AFB.
- *Action:* Create a marine invasive species database for JRM submerged lands.

8.4.2.7 Summary – Marine Ecosystem Management

Implementation of the JRM INRMP program and the focused strategies and actions of the management projects for marine resources provides a conservation benefit to the marine ecosystem on Andersen AFB by maintaining and enhancing marine community structure, function, species diversity, and resiliency. Inventorying and monitoring help maintain and improve the local scientific knowledge of coral reef ecosystems and their resilience to environmental stressors, guide adaptive management solutions, and aid in avoidance and minimization of potential impacts to sensitive resources. Furthermore, proactive invasive species prevention, early detection, and control reduces the risk of intra- and inter-island species introductions. Using this regional ecosystem-based approach for managing protected species and their associated ecosystems ensures that JRM remains in compliance with federal and territorial laws while supporting the operational functionality of the Andersen AFB mission.

Eleven management projects addressing marine natural resources management are proposed for implementation on Andersen AFB:

- Marine Habitat Management – 3
  - MHM-1: Coral Habitat Enhancement
  - MHM-2: Marine Resources Data Analysis and Coordination
  - MHM-3: Marine Habitat Mapping Efforts
- Marine Invasive Species Management – 2
  - MIS-1: Implementation of Regional Biosecurity Plan for Micronesia and Hawai‘i

  - MIS-2: Federal and Territorial Coordination and Collaboration for Marine Invasive Species Prevention
- Marine Protected Species Management – 2
  - MPS-1: Scalloped Hammerhead Shark Study
  - MPS-2: Sea Turtle Population Protection and Enhancement
- Marine Natural Resources Educational Outreach – 2
  - MEDU-1: ESA-listed Species and Marine Resources Outreach
  - MEDU-2: JRM Natural Resources Stewardship Outreach and Public Engagement Program
- Marine Natural Resources Law Enforcement – 1
  - MLAW-1: Conservation Law Enforcement
- Marine Geographic Information System and Data Management – 1
  - MGIS-1: Marine Natural Resources GIS and Data Management

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9 MARINE CORPS BASE CAMP BLAZ

9.1 MAIN CANTONMENT AND MCB CAMP BLAZ SOUTH

9.1.1 Current Operations and Land Use

The Department of Defense (DoD) in Guam supports Marine Corps activities to maintain operational readiness, which involves preserving the ability of units to respond to threats and to protect the interests of the United States (U.S.) and its allies in the region. Marine Corps Base (MCB) Camp Blaz Main Cantonment Area and MCB Camp Blaz South are located on the northwestern coast of the island.

9.1.1.1 Land Ownership and Management

MCB Camp Blaz Main Cantonment area (formerly Naval Base Guam [NBG] Telecommunications Site [TS]) encompasses 2,949 acres (1,193 hectares) of terrestrial lands and 11,241 acres (4,549 hectares) of submerged lands. The terrestrial lands acreage includes 2,604 acres (1,054 hectares) of Overlay Refuge lands, of which 252 acres (101 hectares) are the Haputo Ecological Reserve Area (ERA) (see Section 9.1.2, *Special Conservation Areas*). MCB Camp Blaz South (formerly South Finegayan) encompasses 290 acres (117 hectares) of terrestrial lands and 5,388 acres (2,180 hectares) of submerged lands. DON owns terrestrial lands within the boundaries of MCB Camp Blaz Main Cantonment area and submerged lands extending 3 miles (4.8 kilometers) from the shore.



Mowed grasslands surround satellite communication equipment on MCB Camp Blaz.
(*Photo*: L. Shaughnessy)

Land use on MCB Camp Blaz Main Cantonment area and MCB Camp Blaz South are similar and consist of six functional areas: Command Core, Unit Operations, Base Operations, Bachelor Enlisted and Bachelor Office Quarters, Community Support, and Training. As a result, MCB Camp Blaz Main Cantonment Area and MCB Camp Blaz South will be referred to together as MCB Camp Blaz for the remainder of this chapter (except where specified). Management activities include the conservation of coastal limestone forests and fringing reefs within the Haputo ERA (discussed in Section 9.1.2, *Special Conservation Areas*).

9.1.1.2 Training Areas

The lands and coastal waters of MCB Camp Blaz are used for military training. Training within MCB Camp Blaz occurs primarily at the Live-Fire Training Range Complex (Section 9.2) and Urban Training Complex (Section 9.3). However, limited training occurs within Camp Blaz, in areas such as the Small Arms Range north of Haputo Beach. A Surface Danger Zone (SDZ) associated with these small arms ranges extends out over the nearshore waters of Guam off Haputo Point (Figure 9-1). SDZ closures for the range on MCB Camp Blaz are communicated through the issuance of Notices to Airmen (NOTAMs) and Notices to Mariners (NOTMARs), as applicable, when the range is in use.

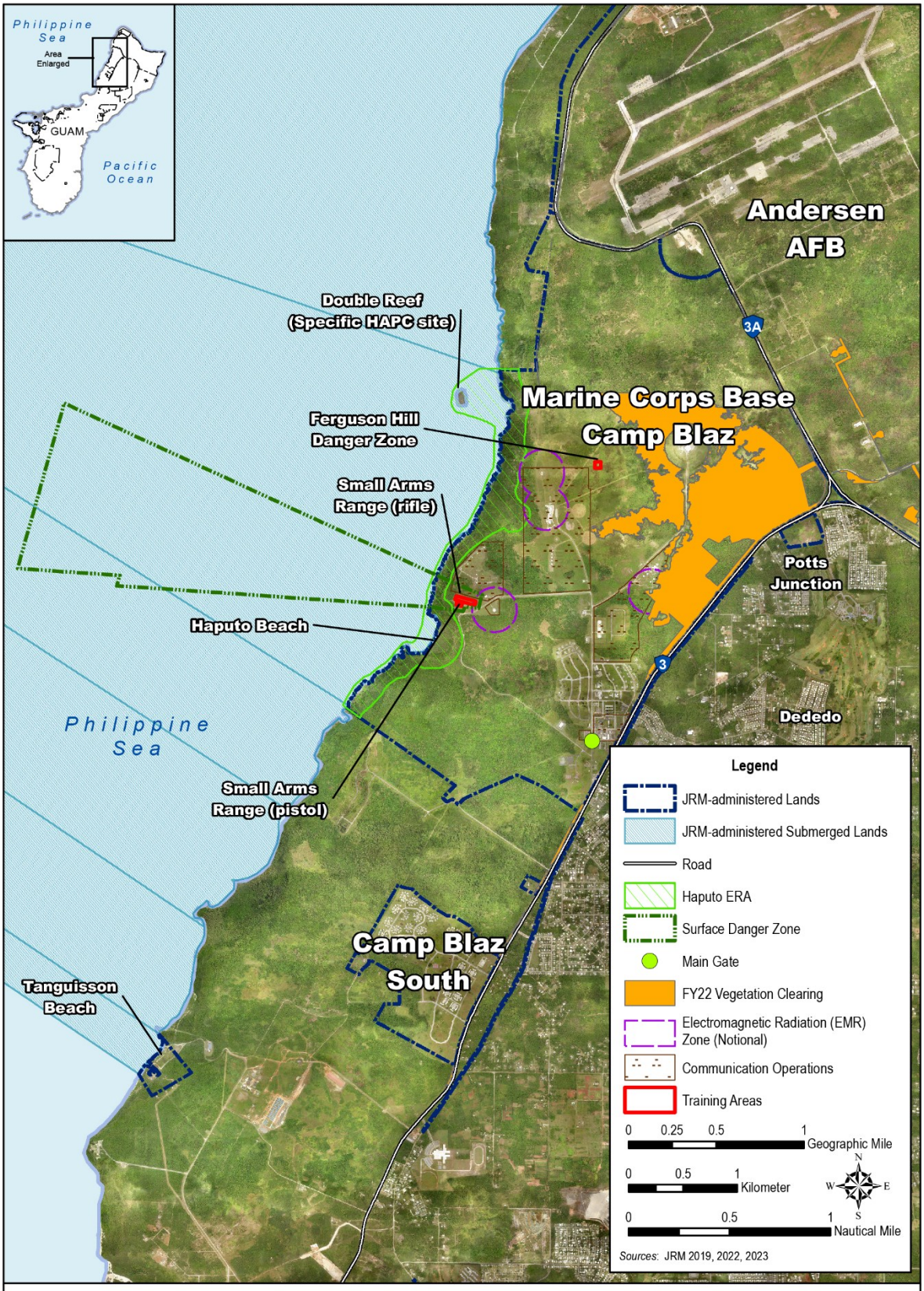


Figure 9-1
Overview of Marine Corps Base Camp Blaz

9.1.2 Special Conservation Areas

9.1.2.1 Haputo Ecological Reserve Area

An ERA is defined as an area dedicated primarily or exclusively to preserving examples of ecosystems and genetic diversity while providing opportunities for scientific research and education. Recognizing the need to maintain areas in natural and near-natural conditions, and to have available such areas for research and scientific treatments, natural areas on JRM-administered lands that warrant special conservation efforts may be identified as ERAs. These areas include characteristic or outstanding ecological, geological, and scenic features or processes (Naval Facilities Engineering Systems Command [NAVFAC] Marianas 2010a).

The DON established the 252-acre (102-hectare) Haputo ERA on the northwestern coastline of Guam in 1984 as a mitigation measure for the construction of Kilo Wharf in Outer Apra Harbor (NAVFAC Marianas 2010a) (Figure 9-2). The Haputo ERA was established to protect two biological units:

- *Terrestrial Unit*: Extends from the cliff boundary line to the mean lower low water line to encompass 283 acres (115 hectares). Although managed by the DON, the terrestrial unit lies within the Guam National Wildlife Refuge (NWR) Overlay, as described below in Section 9.1.4.2, *Overlay Refuge*.
- *Marine Unit*: Extends from the mean lower low water seaward including the Double Reef area to encompass approximately 72 acres (29 hectares). The Marine Unit of the Haputo ERA is a federal Marine Protected Area, which falls under the jurisdiction of Executive Order (EO) 13158, *Marine Protected Areas*.



The Haputo ERA protects terrestrial resources including limestone native forest and marine resources including the Double Reef area.
(*Photo*: L. Shaughnessy)

While the emphasis of the Haputo ERA is on conservation of natural resources, it also provides benefits to and protection of cultural resources. The Haputo ERA General Management Plan provides guidance on the preservation and management of the Haputo ERA and outlines measures to be taken to protect the natural and historical resources located within it (NAVFAC Marianas 2010a). Management actions and use regulations are intended to provide minimum interference by human or human-caused activities on the ecological processes occurring within the ERA. NBG Instruction 5090.2A states that no fishing is allowed in the Haputo ERA. However, there are currently no law enforcement personnel to enforce these regulations. JRM has ultimate management jurisdiction for the Haputo ERA, and NAVFAC Marianas provides management support (NAVFAC Marianas 2010a).

9.1.2.2 Overlay Refuge

The terrestrial unit of the Haputo ERA is located within the 2,097-acre (849-hectare) Overlay Refuge lands (see Figure 9-2). Cooperative Agreements were signed in 1994 to establish the Overlay Refuge and define the management and administrative roles and responsibilities (DON and USFWS 1994; U.S. Air Force [USAF] and USFWS 1994). Refer to Section 3.5.4, *Guam National Wildlife Refuge Comprehensive Conservation Plan*, for further details on the management and purposes of Overlay Refuge lands.

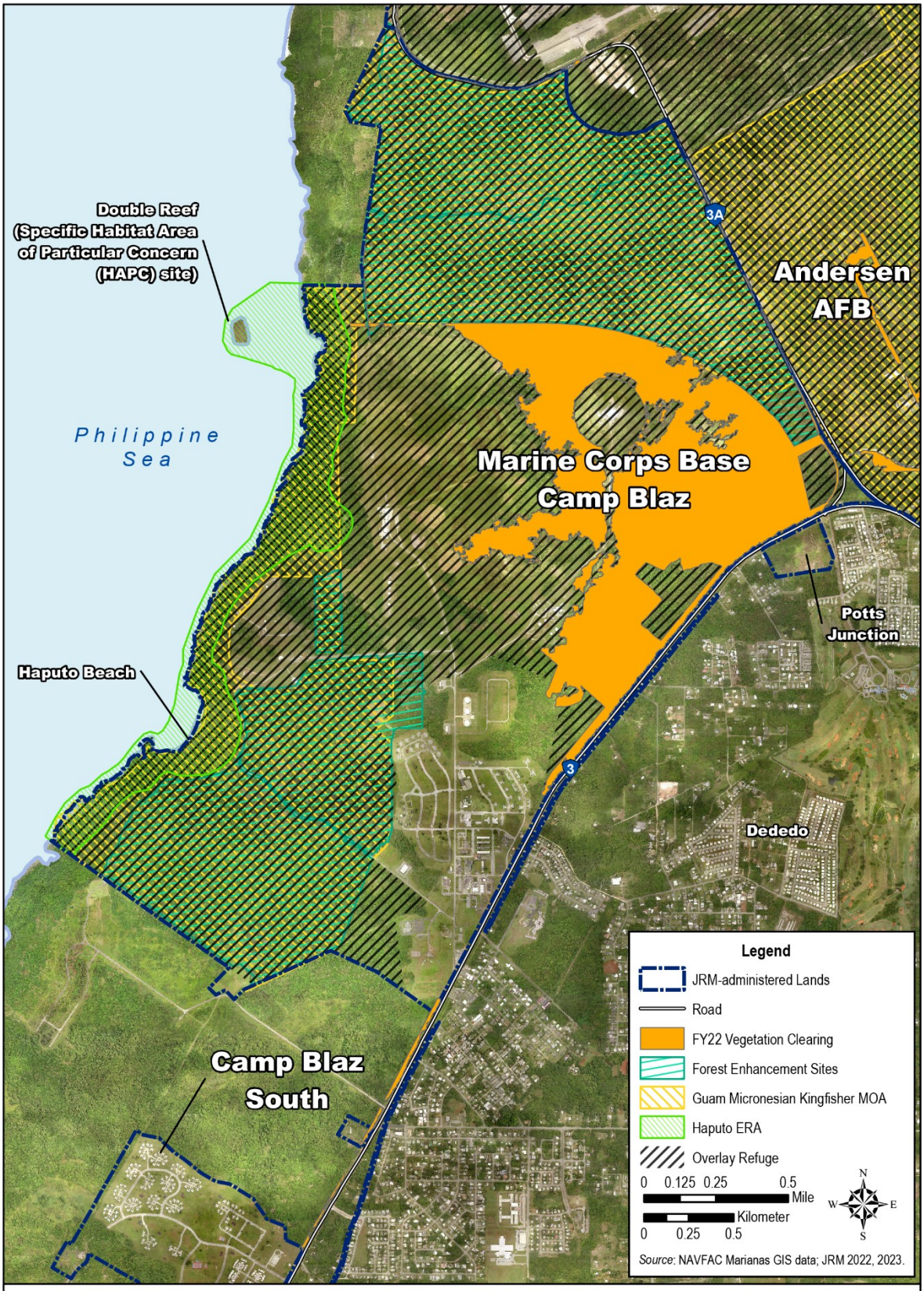


Figure 9-2
Special Conservation Areas - Marine Corps Base Camp Blaz

9.1.2.3 Caiguat Forest Enhancement Site

The 2015 Biological Opinion (BO) on the DON's Relocation of U.S. Marine Corps (USMC) from Okinawa to Guam and Associated Activities in Guam required the creation of approximately 1,000 acres of forest enhancement sites (FES). The northern site, referred to in the BO as the North Finegayan Forest Enhancement Site, is immediately north of the main cantonment and has been renamed Caiguat Forest Enhancement Site (FES) after the Chamorro place name for this area (see Figure 9-2). The site is divided into two management units, the 417-acre Phase 1 section and the 262-acre Phase 2 section.

Both phases will be enclosed by ungulate-proof fencing, with full eradication of all pigs and deer to follow. After the eradication, invasive plants and trees will be removed, and native plants will be established in the site.

9.1.2.4 Taguac Forest Enhancement Site

The second BO-required enhancement area is the Taguac FES, comprised of the 273-acre South Taguac FES and the 186-acre North Taguac FES (see Figure 9-2). An 11-acre corridor provides additional connectivity to the Haputo Ecological Reserve Area (ERA). This site will undergo the same treatment as Caiguat FES: ungulate barriers, ungulate eradication, invasive plant and tree removal, and native plant establishment.

North Taguac FES will additionally be enclosed by a multi-species barrier designed to prevent brown treesnakes (BTS), rodents, and cats from entering the site. After the barrier is constructed, snakes, rodents, and cats will be controlled.

9.1.2.5 Guam Micronesian Kingfisher Memorandum of Agreement Recovery Habitat

In 2015, 1,358 acres (549 hectares) of MCB Camp Blaz lands were designated as recovery habitat for the endangered Guam kingfisher (*Todiramphus cinnamominus*) under a Memorandum of Agreement (MOA) between the DON and the USFWS (DON and USFWS 2015a, 2015b). These lands encompass the Haputo ERA as well as Caiguat and Taguac FES (see Figure 9-2).

9.1.3 Terrestrial Environment

9.1.3.1 Geology, Topography, and Soils

Geology

Geologic Units

The coastal regions and the majority of MCB Camp Blaz are underlain by sedimentary Mariana limestone, and the central portion of the installation is underlain by Barrigada limestone (WERI 2017) (Figure 9-3). The substrate is composed of a heterogeneous mixture of limestone subtypes ranging from highly friable to well-cemented, depending on the depositional source (Commander Naval Forces Marianas [COMNAVMAR] 2001) (Figure 9-4). The coastline in this area includes Haputo Beach and two reef flats. One reef flat lies off Haputo Beach, while the second is situated inshore of Pugua Patch Reef (also known as Double Reef). A detailed characterization of these reefs appears in Section 9.3, *Marine Environment*.



Haputo Beach as observed from the water looking southeast.
(*Photo*: A.N.M. Reyes)

Seismology

An overview of seismology within the Mariana Islands is found in Section 4.2.1.3, *Seismology*. According to the Seismic Hazard Assessment for Guam and the Northern Mariana Islands (Mueller et al. 2012), seismicity in the region is primarily controlled by active convergence between two oceanic tectonic plates. The Pacific plate subducts northwestward beneath the Philippine Sea plate at the Mariana Trench. The largest earthquake recorded for this region occurred on August 8, 1993 at moment magnitude 7.8 causing over $200 million in damage in Guam, and generating a minor tsunami (Lander et al. 2002). In recorded history, Guam has experienced fewer than 15 tsunami events, all but three of which were considered insignificant. Haputo Beach and low-lying areas behind the beach are susceptible to flooding by a tsunami; however, the majority of MCB Camp Blaz has a low risk for tsunami inundation and liquefaction.

MCB Camp Blaz overlies a minor fault line and is susceptible to earthquake events; however, the overall likelihood for the occurrence of landslides is generally low due to the lack of steep areas that contain soils vulnerable to slipping in seismic events.

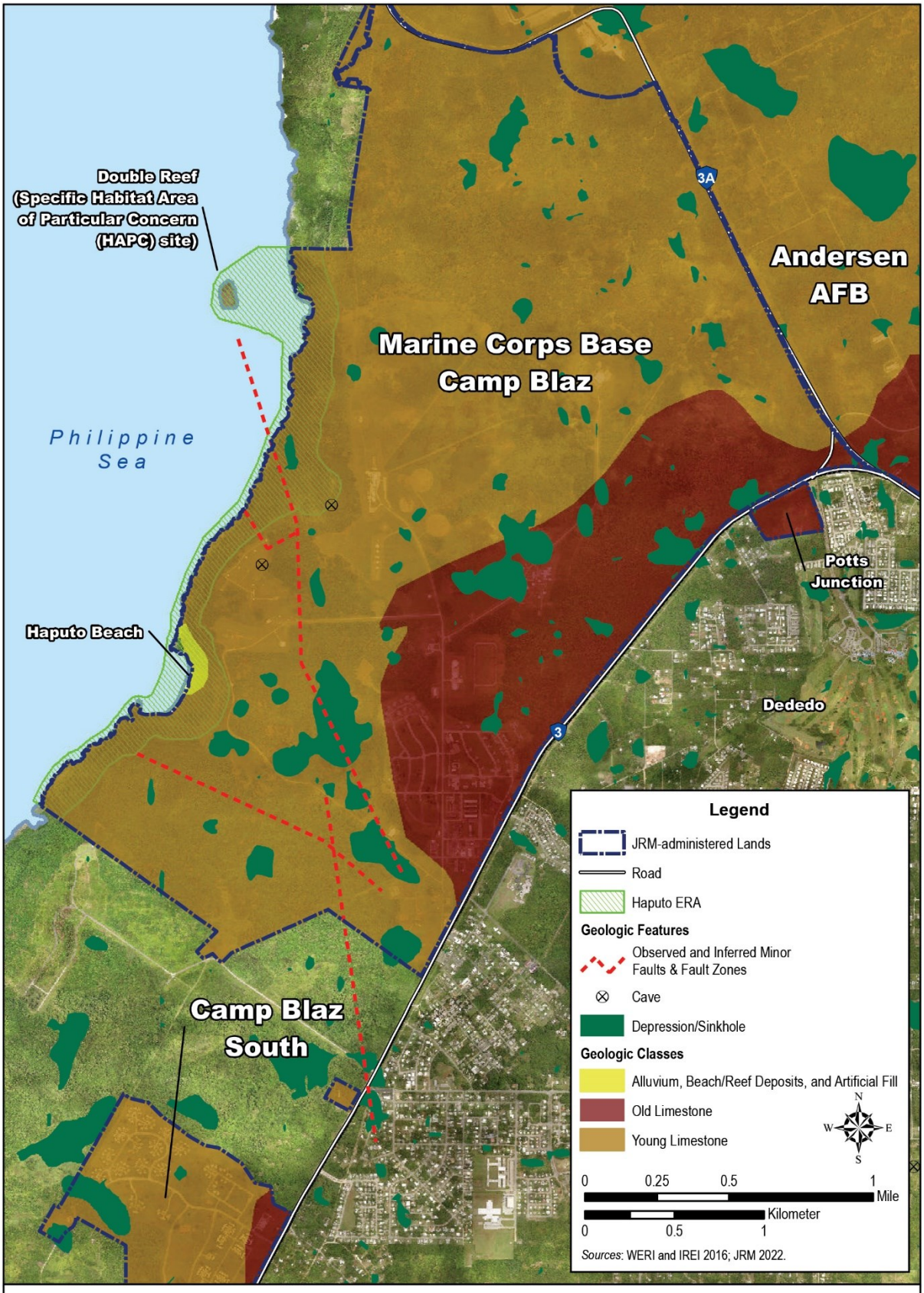


Figure 9-3
Geological Features - Marine Corps Base Camp Blaz

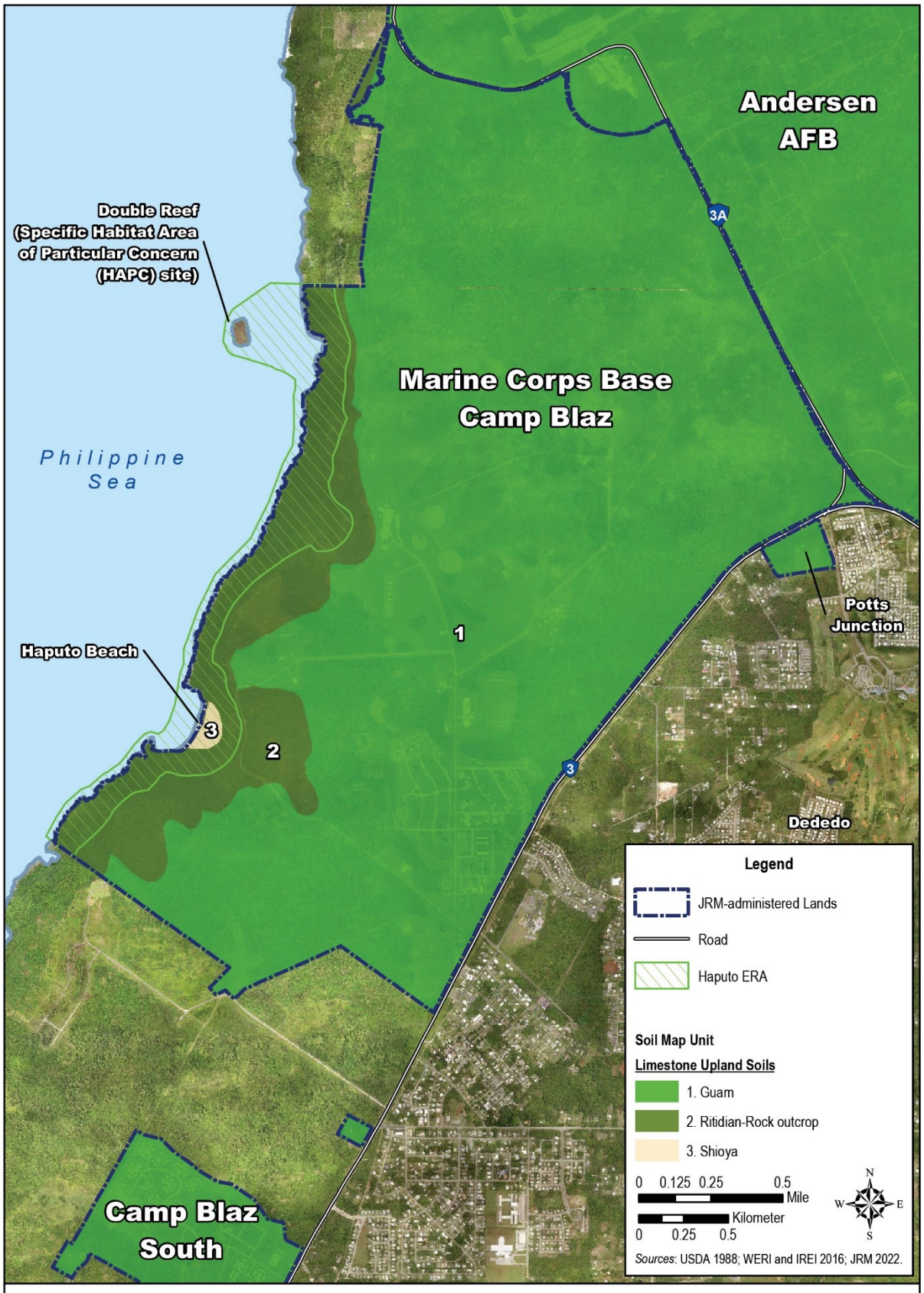


Figure 9-4
Soils - Marine Corps Base Camp Blaz

Topography

As discussed in Section 9.1.2, *Naval Base Guam Telecommunications Site Assets and Uses,* elevations at the top of the plateau range from 500-600 feet (152-183 meters) MSL. Along the western lip of the plateau, steep cliffs drop down to an intermittent narrow coastal lowland terrace. The coastal plateaus range from 200-900 feet (61-274 meters).



Native forests occur along steep cliffs in areas with little human disturbance (note heavy ungulate disturbance).
(*Photo*: L. Shaughnessy)

Soils

The majority of the soils on MCB Camp Blaz are shallow, well-drained soils on the limestone plateaus (see Figure 9-4); the descriptions of each soil type are summarized in Table 4-1. The cliffline areas are primarily rock outcrops that are very shallow with well-drained coralline limestone soils (COMNAVMAR 2001). Nearly all of the plateau area is Guam cobbly clay loam as described in Table 4-1. Erosion does not present a serious problem for most of MCB Camp Blaz, which is located on a broad limestone reef plateau underlain by volcanic rocks. However, steep slopes within Haputo ERA experience significant erosion, particularly in areas with high ungulate densities.

9.1.3.2 Hydrology

Surface Water

MCB Camp Blaz is located in the Agafa Gumas, Finegayan, and Yigo-Tumon drainage basins (refer to Figure 4-8a). No streams or other natural surface water features occur on the highly permeable limestone substrate underlying MCB Camp Blaz. However, Jocson et al. (2002) noted that temporary ponding, even on the highly conductive limestone plateau, can occur during prolonged heavy rains and typhoon events.

Groundwater

MCB Camp Blaz overlies the Finegayan sub-basin of the Northern Guam Lens Aquifer (refer to Figure 4-10) (Jocson et al. 2002). In northern Guam, thin basal freshwater-lens systems occur in highly permeable Mariana and Barrigada limestone rocks, and basal water levels within this system are generally at altitudes lower than 8 feet (2 meters) (Gingerich 2003). Barrigada limestone forms the bulk of the freshwater aquifer underlying northern Guam (Gingerich 2003).

Mean annual groundwater recharge within the MCB Camp Blaz ranges between 40 inches (102 centimeters) to 65 inches (165 centimeters) (Gingerich 2013); however, much of the lens is thin around the western periphery of MCB Camp Blaz due to the highly permeable aquifer that allows connection to the sea at the coast. Excessive withdrawal and droughts create problems with potability of groundwater in this region. The sustainable yield estimate for Finegayan sub-basin is estimated to be 21 million gallons per day (gpd) (79,494 cubic meters per day) (Johnson 2012).

9.1.3.3 Vegetation Communities

Vegetation communities identified on MCB Camp Blaz are shown in Table 9-1 and described below. Detailed descriptions of vegetation community types are found in Section 4.4.1, *Vegetation Communities*. Figure 9-5 depicts the terrestrial vegetation communities occurring on MCB Camp Blaz. The predominant landscapes on MCB Camp Blaz are the limestone plateau and coastal terrace (NAVFAC Marianas 2014a). The three largest vegetation communities by area are *Vitex* forest, limestone degraded forest, and other shrub/grasslands, comprising 33.7 percent (%), 25.7%, and 17%, respectively, of the total vegetated

undeveloped lands on the installation. Vegetation communities in the northern portion of MCB Camp Blaz consist of shrub/grasslands and highly disturbed *Vitex* forest. The southern portion of MCB Camp Blaz is dominated by degraded limestone forest with some *Vitex* forest (NAVFAC Marianas 2014a, 2016a). The cliffline along the western edge of the installation is dominated by limestone native forest and is associated with the Haputo ERA. These communities are described in detail in the following paragraphs. Barren and developed areas together constitute 18% of the total land area on the installation.

Table 9-1. Vegetation Communities on MCB Camp Blaz

Vegetation Community	*Area (acres)*	*% of Total Area*	*% of Vegetated, Undeveloped Area*
Casuarina Forest	1.8	0.1	0.1
Coconut Forest	16.5	0.6	0.7
Limestone Coastal Scrub	4.7	0.2	0.2
Limestone Degraded Forest	756.8	25.7	30.1
Limestone Native Forest	205.6	7.0	8.2
Scrub Forest	26.5	0.9	1.1
Grassland			
Other Shrub/Grassland	500.2	17.0	19.9
Non-native Forest			
Bambusa Forest	0.5	<0.1	<0.1
Spathodea Forest	12.2	0.4	0.5
Vitex Forest	990.3	33.7	39.4
Non-vegetated Categories			
Barren	9.4	0.3	NA
Developed	430.4	14.6	NA
Total	**2,944.7**		

Key: < = less than; % = percent; MCB = Marine Corps Base; NA = not applicable; NBG = Naval Base Guam.

Sources: USGS 2006; NAVFAC Marianas 2010b, 2016a.

During 2008 vegetation surveys on MCB Camp Blaz, many of the tree species encountered in limestone forests on the upper plateau in the northwestern corner of MCB Camp Blaz were determined to be native trees (NAVFAC Pacific 2010a) (Figure 9-5). Inversely, the northeast boundary of the base has the highest population of *Vitex*, and fewer native trees are found in this area (Figure 9-5).



***Vitex parviflora* is a medium- to large-sized tree and is the dominant plant in the *Vitex* forest community. This species produces purple flowers in the rainy season and sheds its leaves during the dry season, making this community visible in aerial imagery.**
(*Photo*: L. Gutierrez)

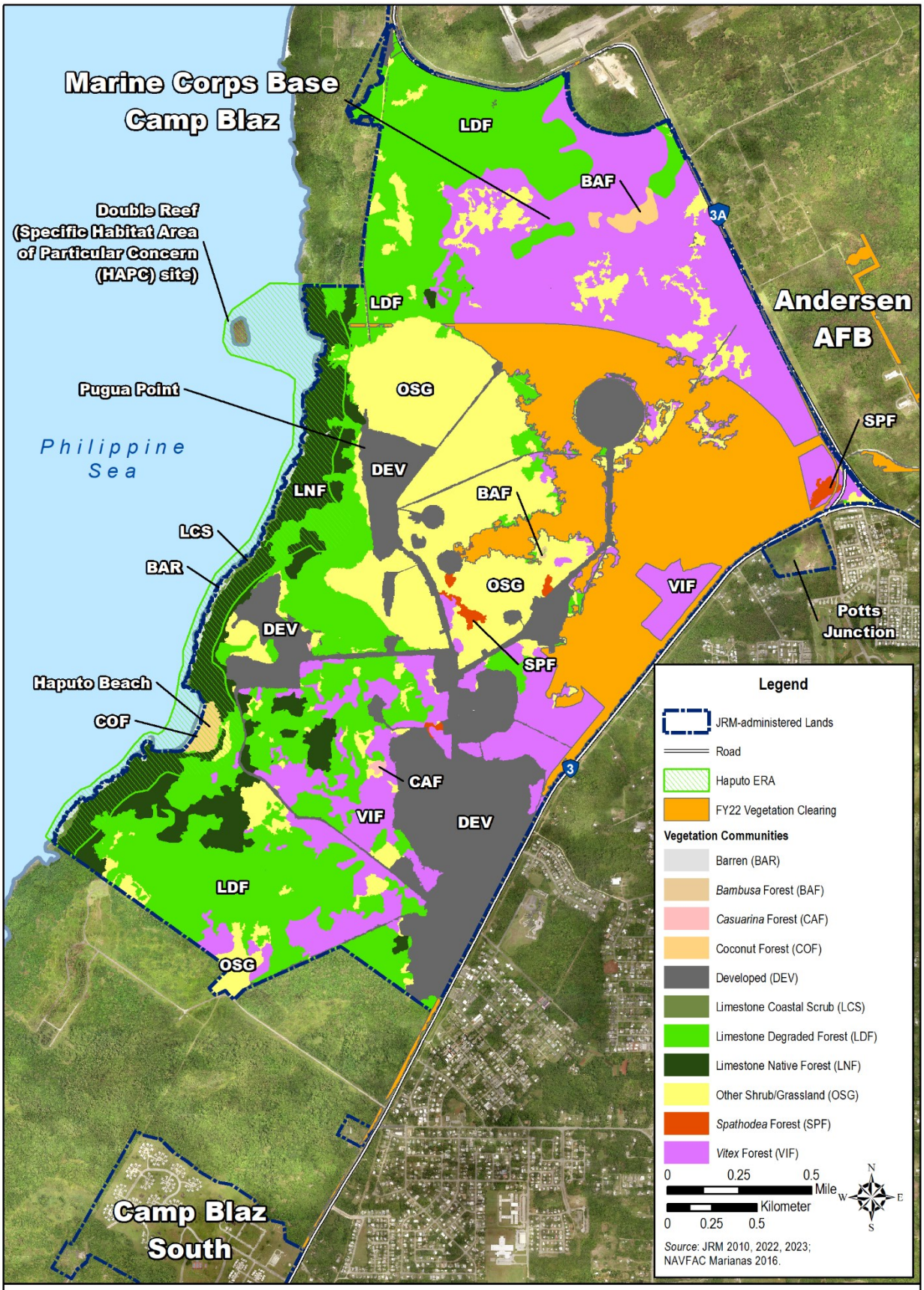


Figure 9-5
Vegetation Communities - Marine Corps Base Camp Blaz

Non-native *Vitex parviflora* is a dominant component of these forests. *Vitex* had the highest relative density followed by *Pandanus tectorius* and *Meiogyne cylindrocarpa* trees (NAVFAC Pacific 2010a). The limestone native forest below the cliffline on MCB Camp Blaz North is a distinctive community comprised of a stand of native *Merrilliodendron* trees that provide habitat for the Guam tree snail (*Partula radiolata*). The forest is situated close to sea level along the base of an escarpment and overlies karst limestone substrate.

From north to south, the site transitions from *Merrilliodendron*-dominated forest to a more mixed community (NAVFAC Pacific 2010b). In the forests of the southern section of MCB Camp Blaz, the three species with the highest relative densities were *M. cylindrocarpa*, *P. tectorius*, and *Ochrosia* (=*Neisosperma*) *oppositifolia*, all of which are native species that collectively accounted for 62% of the overall tree density. All native tree species within the southern portion of MCB Camp Blaz had a combined tree density of 87%. Two native tree species, *M. cylindrocarpa* and *Aglaia mariannensis*, are endemic to the Mariana Islands and had a combined tree density of 27% (Guam Division of Aquatics and Wildlife [DAWR] 2006; NAVFAC Pacific 2010b; JRM 2013; NAVFAC Marianas 2014a).

The west-central sector of MCB Camp Blaz, in the vicinity of Pugua Point, contains limestone forest with a native species density of 66%. The limestone native forest in the southern portion of MCB Camp Blaz is a distinctive community including a stand of *Merrilliodendron megacarpum* trees that provides habitat for the Guam tree snail. *M. megacarpum* is a native species found in only a few localities in Guam in limestone native forests (Guam DAWR 2006; NAVFAC Marianas 2014a).

The limestone degraded forested area on southern MCB Camp Blaz is dominated by non-native *Vitex*, tangantangan (*Leucaena leucocephala*), and papaya (*Carica papaya*), which comprise 67% of the trees. The remaining 33% of tree cover consisted of five native species, none of which is endemic to Guam or the other Northern Mariana Islands. The low native tree component might be the result of past clearing activities within the installation (NAVFAC Pacific 2010b; NAVFAC Marianas 2014a).

Regular clearing of mowed grasslands on MCB Camp Blaz has allowed for the establishment of non-native vegetation, primarily in the transition areas between the mowed grasslands and the forest areas. Non-native plant species have also moved into forested areas, especially along the roadsides where safety areas are maintained (JRM 2013). This disturbance and increase in non-native vegetation has contributed to a highly disturbed habitat and a severe decline in native forest species (DON 2009).



The non-native custard apple (*Annona reticulata*) is a dominant species found on the eastern edge of the Haputo ERA.
(*Photo*: L. Shaughnessy)

Although not known if the coconut palm (*Cocos nucifera*) is naturally occurring or human introduced (Raulerson and Rinehart 1991), humans established coconut plantations throughout the island (DON 2009; NAVFAC Marianas 2016a). A coconut grove that is a remnant from an abandoned coconut plantation occurs along the coast of the Haputo ERA embayment. A disturbed/weed plant community occurs at the forest edges and in patches within the forest. Near the shoreline, the native coastal shrub *Pemphis acidula* is abundant, often forming monotypic low-lying stands (NAVFAC Marianas 2010a). Landward of the *P. acidula* zone, other coastal species can be found including numerous native tree and shrub species such as nanaso (*Scaevola taccada*), the endemic shrub *Bikkia tetrandra*, and beach heliotrope (COMNAVMAR 2001). Coconut palms and *Hernandia sonora* dominate the tree community at the site. The eastern section of the Haputo ERA is dominated by non-native woody vegetation similar to that found in the plateau area, with abundant growth of custard apple (*Annona reticulata*) (NAVFAC Marianas 2010a).

Other common non-native species that occur on MCB Camp Blaz, include mile-a-minute vine (*Mikania micrantha*), Siam weed or jack-in-the-bush (*Chromolaena odorata*), and Indian snakeweed (*Stachytarpheta indica*) (NAVFAC Pacific 2010a). Other non-native plants found at Haputo ERA include jack-in-the-bush, sensitive plant (*Mimosa pudica*, burr marigold (*Bidens pilosa*), and African tulip tree (*Spathodea campanulata*) (NAVFAC Marianas 2011a).

Several sinkholes and drainage swales on MCB Camp Blaz were previously mapped in the 1980s as wetlands by the USFWS National Wetlands Inventory based upon remote sensing of aerial imagery. However, subsequent ground truth surveys conducted in May 2010 on MCB Camp Blaz found these designations to be incorrect (NAVFAC Pacific 2010b). The results of the surveys support the determination that no wetlands occur on MCB Camp Blaz (COMNAVMAR 2001). Geologic conditions needed to support wetland areas are rarely found in the highly permeable limestone plateau of northern Guam (U.S. Department of Agriculture [USDA] 1988; Wiles and Ritter 1993; COMNAVMAR 2001).

9.1.3.4 Terrestrial Wildlife

Mammals

Native Species

Populations of the endangered Mariana fruit bat (*Pteropus mariannus mariannus*), found in various parts of JRM-administered lands in Guam and Tinian, are believed to forage within the cliffline limestone forested habitats on MCB Camp Blaz (USFWS 2015b). This species is discussed in detail in Section 9.2.5, *Terrestrial Protected Species*.

Non-native Species

While no small mammal surveys have been recently conducted on MCB Camp Blaz, it is expected that common non-native small mammals found throughout Guam would also be found in MCB Camp Blaz. These include the Norway rat (*Rattus norvegicus*), black rat (*Rattus rattus*), Polynesian rat (*Rattus exulans*), house mouse (*Mus musculus*), and musk shrew (*Suncus murinus*) (USFWS 1986; Wiles 2005). Other non-native mammals likely occurring on the installation include feral cats (*Felis catus*) and dogs (*Canis lupus familiaris*).

Feral pigs (*Sus scrofa*), present within the MCB Camp Blaz and the Haputo ERA, are considered an invasive species. During a 14-day period in March 2019, 142 feral pigs were removed from unfenced areas of MCB Camp Blaz. During an eradication project in 2020 and 2021, 131 feral pigs were removed from 673 acres of fenced FES within MCB Camp Blaz. Based on these projects, feral pig densities on Camp Blaz range between 40 and 128 animals per square mile, with higher densities representing the forested areas.

The estimated number of feral pigs on MCB Camp Blaz in 2007 was 350-500 individuals. In 2010, abundant evidence of feral pig damage was observed on the upper plateau area of MCB Camp Blaz during vegetation surveys (NAVFAC Pacific 2010b). Feral pig tracks are routinely observed in the sand at Haputo Beach, where feral pig sign and damage are prevalent throughout, but more intense in areas farther away from human activity (NAVFAC Pacific 2010b).

Abundant signs of Philippine deer (*Rusa marianna*) were observed on the upper plateau area of MCB Camp Blaz during vegetation surveys (Brooke 2009). Evidence of deer browsing was most commonly encountered in the northern portion of MCB Camp Blaz adjacent to Andersen Air Force Base (AFB), resulting in a very open understory (Brooke 2009). During an eradication project in 2020 and 2021, 654 deer were removed from 673 acres of fenced FES within MCB Camp Blaz. Within forested areas, the deer density is about 621 deer per square mile. This figure is substantially higher than previous estimates of 43.5 deer per square mile (Brooke 2009).

Birds

Native Species

No Endangered Species Act (ESA) listed bird species have been recorded on MCB Camp Blaz in recent decades. However, the Guam kingfisher, Guam rail (*Gallirallus owstoni*), bridled white-eye (*Zosterops conspicillatus*), Mariana crow (*Corvus kubaryi*), and Guam flycatcher (*Myiagra freycineti*) were historically known from the Haputo ERA on MCB Camp Blaz (Jenkins 1983; Engbring and Ramsey 1984; NAVFAC Marianas 2010a). The Guam flycatcher is considered extinct, and the bridled white-eye and the Mariana crow are extirpated from Guam. Both the Guam kingfisher and Guam rail are no longer known in the wild. Of the avian species reported at DON installations in Guam in Section 4.4.2.2, *Birds,* one native species, the yellow bittern, was reported during the 2008-2010 roadside and forest bird surveys performed on MCB Camp Blaz South (formerly South Finegayan), a parcel of JRM-administered land approximately 1 mile (1.6 kilometers) south of MCB Camp Blaz.

The Pacific golden plover (*Pluvialis fulva*), a non-breeding visitor to Guam, was the most common species observed on MCB Camp Blaz (NAVFAC Pacific 2010a) and is protected by the Migratory Bird Treaty Act (MBTA). Although the native Micronesian starling (*Aplonis opaca*) is not listed under the MBTA or federal ESA, it is a Guam-listed endangered species and Guam-designated as a Species of Greatest Conservation Need (SOGCN) and is discussed further in Section 9.2.5, *Terrestrial Protected Species*, along with the Micronesian kingfisher, Guam rail, and Mariana crow.

Non-native Species

Of the avian species described from naval installations in Guam in Section 4.4.2.2, *Birds,* five non-native species were reported during the 2008-2010 roadside and forest bird surveys performed on MCB Camp Blaz South (formerly South Finegayan): island collared dove (*Streptopelia bitorquata*), black drongo (*Dicrurus macrocercus*), Eurasian tree sparrow (*Passer montanus*), black francolin (*Francolinus francolinus*) and rock dove (*Columba livia*). These species are common introduced residents in Guam (NAVFAC Marianas 2010a; NAVFAC Pacific 2010a). Table 9-2 lists the bird species found on MCB Camp Blaz.

Table 9-2. Bird Species Recorded on MCB Camp Blaz

Common Name/ Chamorro Name(1)	***Scientific Name***	***Residence Status***	***Listed under MBTA***
Micronesian starling/Sali	*Aplonis opaca*	Uncommon native breeding resident	N
Yellow bittern/Kakkak	*Ixobrychus sinensis*	Common native breeding resident	Y
Pacific golden plover/Dulili	*Pluvialis fulva*	Common non-breeding visitor	Y
Island collared dove/Palumat	*Streptopelia bitorquata*	Common introduced breeding resident	N
Black drongo/Salin Taiwan	*Dicrurus macrocercus*	Common introduced breeding resident	N
Rock dove/None	*Columba livia*	Common introduced breeding resident	N
Great frigatebird	*Fregata minor*	Native breeding resident	Y
White tern	*Gygis alba*	Native breeding resident	Y
Pacific reef heron	*Egretta sacra*	Native breeding resident	Y
Black winged stilt	*Himantopus himantopus*	Common introduced breeding resident	Y
Eurasian tree sparrow/Gagapale	*Passer montanus*	Common introduced breeding resident	N
Black francolin/None	*Francolinus francolinus*	Common introduced breeding resident	N

Note: (1) Common and scientific names based on Gill and Donsker (2017). Chamorro names from GovGuam (2009), Liske-Clark (2015), Topping et al. (1975), and USFWS (2015a).
Key: MBTA = Migratory Bird Treaty Act; N = no, does not occur; MCB = Marine Corps Base; Y = yes, known to occur.
Sources: NAVFAC Marianas 2013a; DON 2015a; A. Loerzel personal communications, 2023.

Reptiles and Amphibians

Native Species

Eight native herpetofauna species have been documented within MCB Camp Blaz (Table 9-3). Native species include the blue-tailed skink (*Emoia caeruleocauda*), moth skink (*Lipinia noctua*), mourning gecko (*Lepidodactylus lugubris*), mutilating gecko (*Gehyra mutilata*), Pacific slender-toed gecko (*Nactus pelagicus*), monitor lizard (*Varanus tsukamotoi*), green sea turtle (*Chelonia mydas*), and hawksbill turtle *(Eretmochelys imbricata*). The capture of two species which are Guam-listed ESA and Guam-designated as SOGCN (i.e., moth skink and Pacific slender-toed gecko) on MCB Camp Blaz in 2009 is noteworthy since the distribution and abundance of the moth skink in Guam is unknown and the Pacific slender-toed gecko is rarely seen in Guam (JRM 2013). Both species were captured in the northeastern forested portion of MCB Camp Blaz (NAVFAC Pacific 2010a). Green and hawksbill turtles are known to frequent beaches within MCB Camp Blaz (JRM 2013; NAVFAC Marianas 2013b).

Table 9-3. Reptile and Amphibian Species Recorded on MCB Camp Blaz

Common Name/ Chamorro Name[(1)]	*Scientific Name*	*Residence Status*
Reptiles		
Brown treesnake/Kolepbla	*Boiga irregularis*	Non-native
Brahminy blind snake/Ulo attilong	*Ramphotyphlops braminus*	Non-native
Curious skink/Gualiek halumtano	*Carlia ailanpalai*	Non-native
Pacific blue-tailed skink/Gualiek halumtano	*Emoia caeruleocauda*	Native
Moth skink/Gualiek halumtano	*Lipinia noctua*	Native
Green sea turtle/Haggan	*Chelonia mydas*	Native
Mutilating gecko/Achiak	*Gehyra mutilata*	Native
House gecko/Achiak	*Hemidactylus frenatus*	Non-native
Mourning gecko/Achiak	*Lepidodactylus lugubris*	Native
Pacific slender-toed gecko/Gualiek	*Nactus pelagicus*	Native
Monitor lizard/Hilitai	*Varanus tsukamotoi*	Native
Hawksbill turtle/Haggan karai	*Eretmochelys imbricata*	Native
Amphibians		
Greenhouse frog/Kairo	*Eleutherodactylus planirostris*	Non-native
Crab-eating frog	*Fejervarya cancrivora*	Non-native
Eastern dwarf frogs	*Litoria fallax*	Non-native
Hong Kong whipping frog	*Polypedates braueri*	Non-native
Gunther's Amoy frog	*Sylvirana guentheri*	Non-native
Marine toad or Cane toad/Kairo	*Rhinella* (=*Bufo*) *marina*	Non-native

Note: [(1)] Common and scientific names based on Gill and Donsker (2017). Chamorro names from GovGuam (2009), Topping et al. (1975), Liske-Clark (2015), and USFWS (2015a).
Key: MCB = Marine Corps Base.
Sources: NAVFAC Pacific 2010a; JRM 2013.

Non-native Species

Ten introduced herpetofauna species have been documented within MCB Camp Blaz: two snake species, one skink species, one gecko species, and six frog and toad species (see Table 9-3). Four introduced herpetofauna species were documented on MCB Camp Blaz during surveys conducted in 2008-2009: curious skink (*Carlia ailanpalai*), house gecko (*Hemidactylus frenatus*), Brahminy blind snake (*Ramphotyphlops braminus*), the marine toad (*Rhinella* [=*Bufo*] *marina*) (JRM 2013).

The monitor lizard (*Varanus tsukamotoi*) can be found on MCB Camp Blaz. Monitor lizards are native to the Mariana Islands (Weijola et al. 2020). Their remains have been found in pre-historic strata in Guam (Pregill and Steadman 2009), and are different from congeners in Palau (Crombie and Pregill 1999). Management projects are implemented to control monitor lizards in areas of highest conservation concern.

The introduced brown treesnake (BTS) (*Boiga irregularis*) has been found throughout Guam (Savidge 1987; Wiles et al. 2003) and is still present on MCB Camp Blaz (NAVFAC Marianas 2010a). The continued widespread presence of the BTS, curious skink, and other non-native reptile and amphibian species is of concern because of each species' potential deleterious impacts in Guam's native fauna. Of particular concern is the potential for introduced species to serve as additional food sources for the BTS (Christy et al. 2007; NAVFAC Marianas 2010c; NAVFAC Pacific 2010a; Lardner 2016).

Other introduced species documented within the Haputo ERA include the eastern dwarf frogs (*Litoria fallax*), greenhouse frogs (*Eleutherodactylus plarostris*), crab-eating frogs (*Fejervarya cancrivora*), Hong Kong whipping frogs (*Polypedates braueri*), and Gunther's Amoy frogs (*Sylvirana guentheri*) (Christy et al. 2007; NAVFAC Marianas 2010a; Lardner 2016).

Invertebrates

Native Species

Seven species of partulid tree snails, in two genera (*Partula* and *Samoana*), are known from the Mariana Islands. One of these species from Guam, *Partula salifana,* has not been seen in recent years and may be extinct (Kerr and Bauman 2013). The fragile tree snail (*Samoana fragilis*), Guam tree snail, and humped tree snail (*Partula gibba*) were historically distributed in Guam, and all three have been documented within the Haputo ERA (Hopper and Smith 1992; Smith and Hopper 1994; Smith et al. 2008). However, all three of these partulid species have experienced massive range reductions, and in 1994 they were listed as candidate endangered species (NAVFAC Marianas 2014b). The fragile tree snail, humped tree snail, and Guam tree snail are all listed as endangered under the ESA in Guam, and as Critically Endangered by the International Union for Conservation of Nature. All three species are present within Haputo ERA.

Land hermit crabs (*Coenobita brevimanus*) and coconut crabs (*Birgus latro*) occur at MCB Camp Blaz (NAVFAC Marianas 2011a).The abundance and distribution of coconut crabs was surveyed within MCB Camp Blaz by the USFWS (USFWS 2001). The estimated population of coconut crabs at Haputo ERA in 2001 was 964 crabs; however, only 11% of the population was of legal size (3 inches [76 millimeters] across the back) for harvest under Government of Guam (GovGuam), Department of Agriculture regulations. USFWS (2001) found that the population demographics were highly skewed toward younger, smaller crabs. They further speculated that pig predation upon smaller crabs may be limiting the populations of both hermit and coconut crabs in limestone plateau habitats on MCB Camp Blaz. Finally, they suggested that poaching may explain the dearth of larger coconut crabs on MCB Camp Blaz.

Non-native Species

Numerous insects have been introduced over the years into Guam including the Asian cycad scale (*Aulacaspis yasumatsui*), the Erythrina gall wasp (*Quadrastichus erythrinae*), the coconut rhinoceros beetle (CRB) (*Oryctes rhinoceros*), and the little fire ant (LFA) (*Wasmannia auropunctata*). CRB, a serious pest species known to damage coconut and oil palm trees, was first recorded from Guam in 2007 (Marshall et al. 2016). Defense Policy Research Institute (Olmsted 2016) found CRB damage to coconut trees throughout a significant portion of the installation. The cycad scale has negatively affected the health of remaining *Cycas micronesica* on MCB Camp Blaz (Quinata 2018). The cycad blue butterfly (*Luthrodes pandava*) recently invaded Guam (Moore et al. 2005), and has caused extensive damage to *C. micronesica* populations on the island (Marler et al. 2012).

The LFA was identified in the Primo Northern Wasteland off Route 15 in November 2011. The LFA is among the most noxious invasive pests worldwide and poses serious threats to human health and native species and habitats in areas where it has been introduced. By 2013, the ant had been found in 12 distinct areas of central and southern Guam and they are known to occur both in the Urban Training Complex and at Haputo ERA (Raymundo and Miller 2012). NAVFAC Marianas (NAVFAC Marianas 2011a) noted other invasive insects known or likely to be present in the Haputo ERA include at least 20 species of ants, including the African big-headed ant, yellow crazy ant, and 17 species of non-native mosquitos.

Introduced carnivorous snails (e.g., *Euglandina rosea*, *Gonaxis* sp.) and the New Guinea flatworm (*Platydemus manokwari*) from Papua New Guinea are known from MCB Camp Blaz (Hopper and Smith 1992). The African giant snail (*Achatina fulica*) was formerly abundant within MCB Camp Blaz, but its numbers have declined sharply and few live snails have been found in recent years. The cinnamon bun snail (*Satsuma succincta*), an introduced snail first documented from Guam in 1982, is one of the more common invasive snails and is found within MCB Camp Blaz and the Haputo ERA (NAVFAC Marianas 2014b).



The non-native cinnamon bun snail (*Satsuma succincta*) is one of the more common invasive snails found within MCB Camp Blazand the Haputo ERA.
(*Photo*: L. Shaughnessy)

9.1.3.5 Terrestrial Protected Species

Twelve federal ESA-listed species are known to occur on MCB Camp Blaz, with an additional two species potentially occurring (Table 9-4). Eleven Guam ESA-listed species are also known to occur or possibly occur. There are no native freshwater aquatic species listed as threatened or endangered in Guam. Following the table is a summary of known and potential occurrences of protected species on MCB Camp Blaz.

Table 9-4 and Figures 9-6 and 9-7 illustrate and summarize, respectively, the occurrence and location of federal and Guam ESA-listed species within MCB Camp Blaz.

Table 9-4. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded on MCB Camp Blaz

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat*	*Occurrence*
Mammals					
Mariana fruit bat/Fanihi	*Pteropus mariannus*	T	E	Limestone native and coconut forests	Y
Birds					
Micronesian starling/Sali	*Aplonis opaca*	--	E	All habitat types	Y
Reptiles					
Green sea turtle/Haggan	*Chelonia mydas*	E[3]	T	Open water and strand	Open water: Y; Strand: Y
Hawksbill turtle/Haggan karai	*Eretmochelys imbricata*	E	E	Open water and strand	Open water: Y; Strand: P
Moth skink/Gualiek halumtano	*Lipinia noctua*	--	E	Limestone native and degraded forests	Y
Azure-tailed skink/Gualiek halumtano	*Emoia cyanura*	--	E	Limestone forest, degraded forest	Y
Pacific slender-toed gecko/Gualiek	*Nactus pelagicus*	--	E	Limestone native forest	Y
Invertebrates					
Humped tree snail/Akaleha	*Partula gibba*	E	E	Limestone native forest	Y
Guam tree snail/Akaleha	*Partula radiolata*	E	E	Limestone native forest	Y
Fragile tree snail/Akaleha	*Samoana fragilis*	E	E	Limestone native forest	Y
Mariana eight-spot butterfly/Abaabang	*Hypolimnas octocula marianensis*	E	--	Limestone native forest	Y
Plants					
None/Siboyas halumtano	*Bulbophyllum guamense*	T	--	Limestone native and degraded forests	Y

Table 9-4. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded on MCB Camp Blaz

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat*	*Occurrence*
None/Fadang	*Cycas micronesica*	T	--	Limestone native and degraded forests	Y
None/None	*Dendrobium guamense*	T	--	Limestone native forest and limestone coastal scrub	Y
None/Aaban or aabang	*Eugenia bryanii*	E	--	Limestone coastal scrub	Y
None/Ufa halumtano	*Heritiera longipetiolata*	E	E	Limestone native forest	Y
None/None	*Tabernaemontana rotensis*	T	--	Limestone native and degraded forests	Y
None/None	*Tuberolabium guamense*	T	--	Limestone native forest and limestone coastal scrub	Y

Notes: [1] Chamorro names from GovGuam (2009), Topping et al. (1975), and USFWS (2015a).
[2] Historical occurrence.
[3] Central West Pacific Distinct Population Segment.

Key: -- = not listed; E = endangered; ESA = Endangered Species Act; N = no, does not occur; MCB = Marine Corps Base Camp Blaz; P = potential for occurrence; T = threatened; Y = yes, known to occur.

Sources: Schreiner and Nafus 1996; GovGuam 2009; USFWS 2011; NAVFAC Pacific 2013a; NAVFAC Marianas 2014b, 2014c, 2014d; USFWS 2015a; NAVFAC Marianas 2016a.

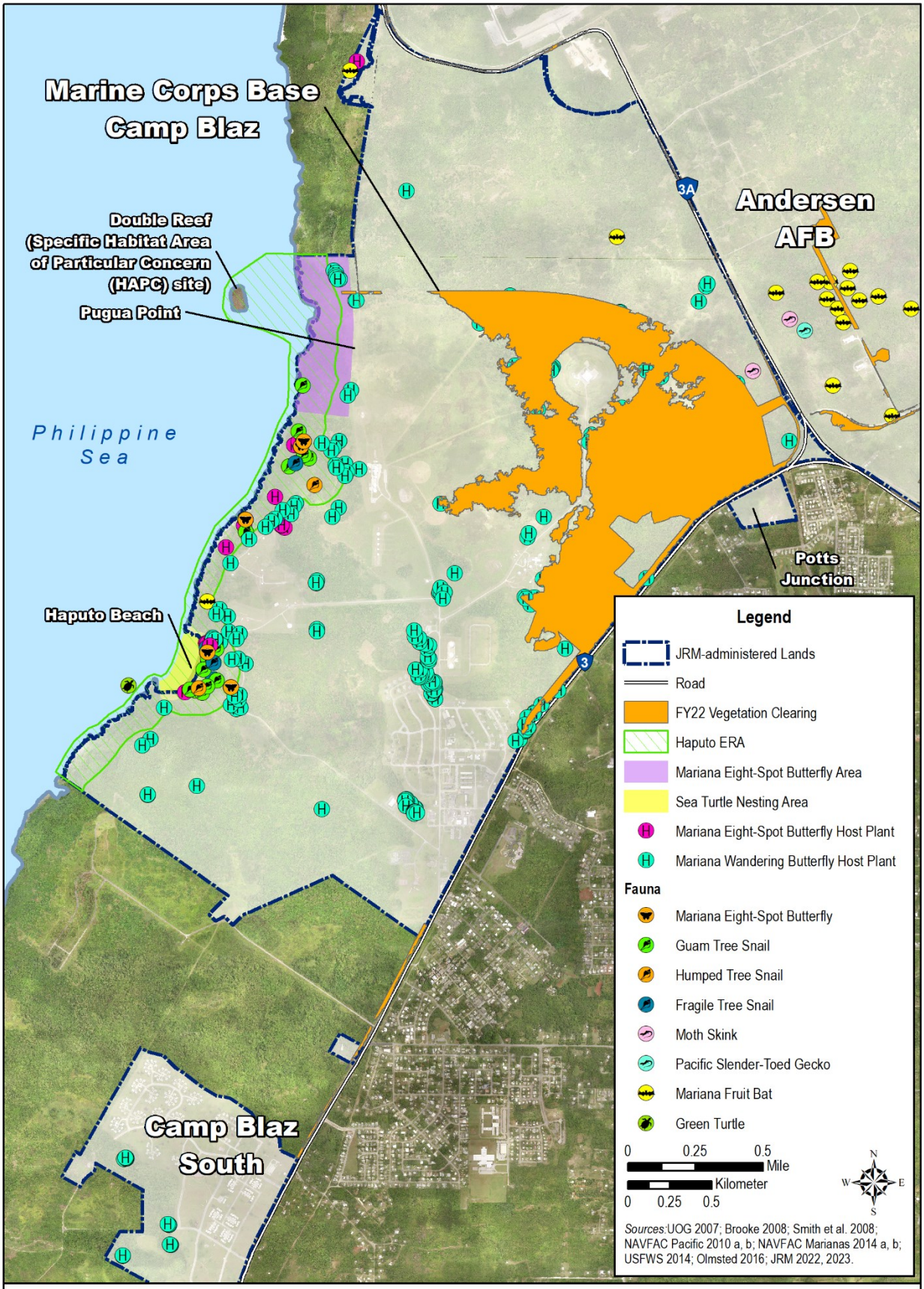


Figure 9-6
Protected Species Recorded on Marine Corps Base Camp Blaz

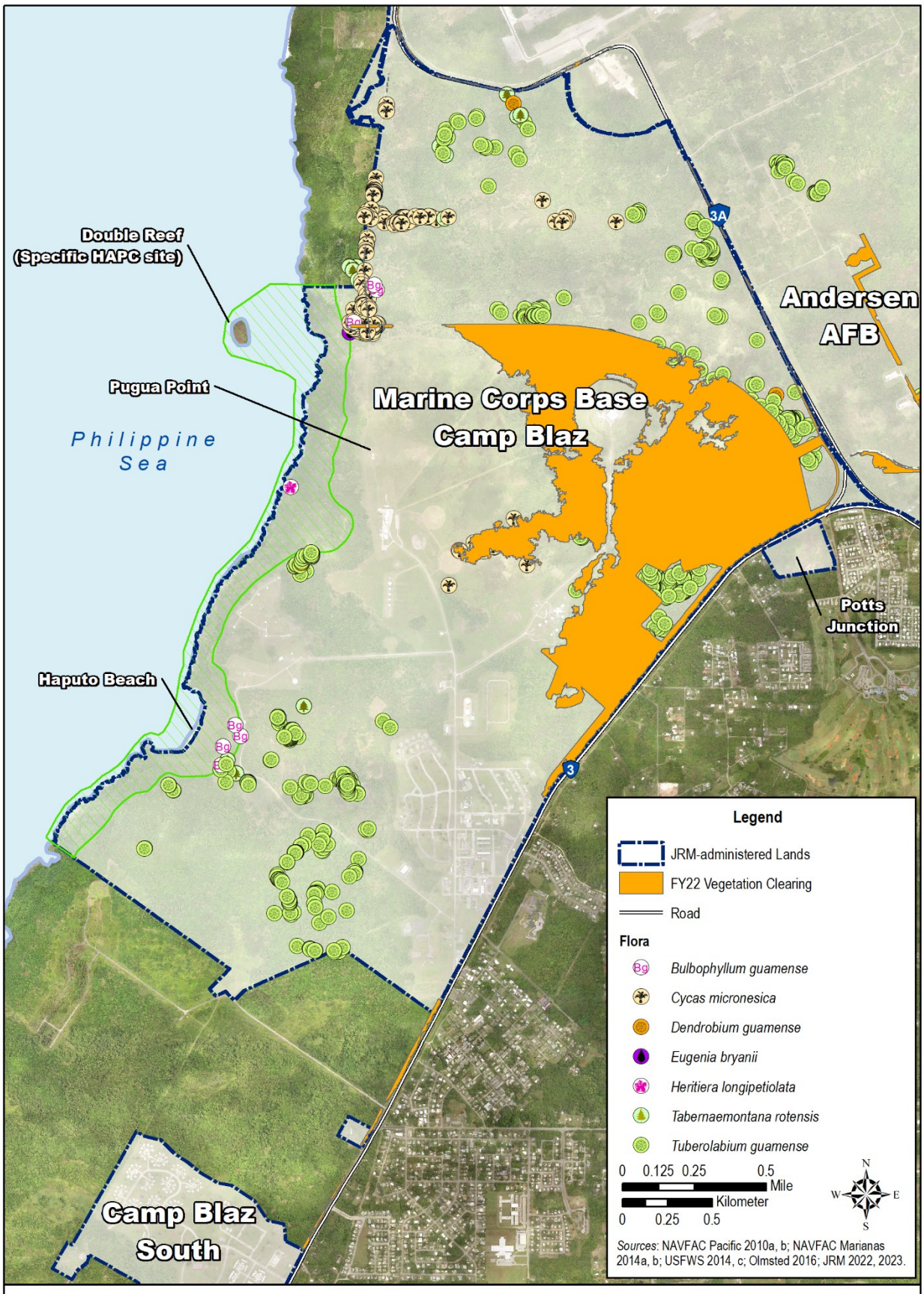


Figure 9-7
Protected Species - Marine Corps Base Camp Blaz

Mammals

Mariana Fruit Bat

The Mariana fruit bat is federal ESA-listed as threatened, Guam ESA-listed as endangered, and Guam-designated as SOGCN. The fruit bat is the only native mammal potentially present in MCB Camp Blaz. Surveys were conducted in MCB Camp Blaz between 1963 and 1968 as part of a regular effort by the Guam DAWR (Perez 1972). Fruit bat densities in the area at that time were found to have decreased from about 32 fruit bats per 100 acres (40 hectares) to about 18 fruit bats per 100 acres (40 hectares) over the survey period (Perez 1972). In the early 1980s, Wiles (1987) estimated that approximately 50-100 fruit bats occupied the cliffline forest of northern Guam as solitary individuals or small groups, outside of the large colonies on Andersen AFB. However, fruit bat surveys in forested cliffline habitat between Amantes Point and Achae Point in 1984 did not detect any bats (Wiles 1987; JRM 2013). Although MCB Camp Blaz and the Haputo ERA contain some of the best remaining fruit bat habitat on JRM-administered lands, there are no historical records of large fruit bat colony roosts in the cliffline forest areas of MCB Camp Blaz (JRM 2013), and no known roosting sites are present in the Haputo ERA (NAVFAC Marianas 2010a). Recovery habitat for the Mariana fruit bat is present in undeveloped portions of MCB Camp Blaz (USFWS 2009, 2010). During 10 observation days in 2008, one Mariana fruit bat was observed within the Haputo ERA and one in the northeastern portion of MCB Camp Blaz. Both bats were observed returning to their day-roost in the early morning (Brooke 2008). From 2010 to 2013, a single bat was observed flying across Route 3A on six occasions; four observations of a bat flying into the Habitat Management Unit (HMU) from MCB Camp Blaz, and two observations of a bat flying out of the HMU into MCB Camp Blaz in the late afternoon (USFWS 2015b). In 2023, five bat sightings within the Caiguat FES and one bat sighting within Taguac FES were incidentally reported by MCB Camp Blaz natural resource staff.

Birds

Mariana Crow

The Mariana crow is federal and Guam ESA-listed as endangered. It is considered extirpated from Guam since there have been no recent sightings of the species. Recovery habitat for the Mariana crow is present in undeveloped portions of MCB Camp Blaz (USFWS 2009, 2010).

Guam Kingfisher

The Guam kingfisher is federal and Guam ESA-listed as endangered. The Guam kingfisher is also Guam-designated as SOGCN. It is considered extirpated from Guam since there have been no recent sightings of the species. Recovery habitat for the Guam kingfisher is present in undeveloped portions of MCB Camp Blaz (USFWS 2009, 2010).

Guam Rail

The Guam rail is federal and Guam ESA-listed as endangered. The Guam rail is also Guam-designated as SOGCN. It is considered extirpated from Guam since there have been no recent sightings of the species in MCB Camp Blaz. Recovery habitat for the Guam rail is present in undeveloped portions of MCB Camp Blaz (USFWS 2009, 2010).

Micronesian Starling

The Micronesian starling is Guam ESA-listed as endangered and also Guam-designated as SOGCN. The native Micronesian starling is known to occur in areas where BTS populations might be reduced, including areas near the entrance to MCB Camp Blaz (Andersen AFB 2008a). However, BTS control has not occurred on MCB Camp Blaz for over 3 years.

Reptiles

Green Sea Turtles

The Central West Pacific Distinct Population Segment (DPS) of green sea turtles are federal ESA-listed as endangered, Guam ESA-listed as threatened, and Guam-designated as SOGCN. They are known to frequent the waters within the Haputo ERA (COMNAVMAR 2007). Green sea turtles can occur in the JRM-administered submerged lands and can nest on the beaches within MCB Camp Blaz. DON monitors for sea turtle nesting on selected beaches throughout the year. Regular monitoring for sea turtle nesting activity was initiated in 2007, and two suspected green sea turtle nest attempts and two false crawls were documented in 2008 (NAVFAC Marianas 2010c). Green sea turtles were observed in 2009 either underwater or on the surface at the Haputo ERA (NAVFAC Marianas 2010a, 2010c). During nesting surveys conducted by NBG from October 1, 2014 to October 23, 2015, surveyors observed nine nests at Haputo (NAVFAC Marianas 2016a). Nesting activity had not been observed in the surveys at Haputo 10 years prior to this survey period. During 2017 surveys, five nests were recorded at Haputo (Summers et al. 2018).

Hawksbill Turtles

Hawksbill turtles are federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. Haputo Beach provides suitable nesting habitat for sea turtles; however, it is unclear if hawksbill turtles use the beaches of the Haputo ERA (NAVFAC Marianas 2010c).

Moth Skinks

The moth skink is Guam-listed as endangered and Guam-designated as SOGCN; however, it is not protected under the federal ESA. Moth skinks were found within the northern portion of MCB Camp Blaz in 2008 (NAVFAC Pacific 2010b). One individual was captured in a glue-board trap, and seven others were observed during visual surveys.

Slender-toed Geckos

Two Pacific slender-toed geckos were recorded in the northeastern forested portion of MCB Camp Blaz during herpetofauna surveys in 2008 (NAVFAC Pacific 2010b).

Invertebrates

Mariana Eight-spot Butterfly

The Mariana eight-spot butterfly (*Hypolimnas octucula marianensis*) is federal ESA-listed as endangered. They are found in forested habitats within the MCB Camp Blaz, particularly within the Haputo ERA (NAVFAC Marianas 2010a; Rubinoff and Haines 2012; NAVFAC Marianas 2014c; Rubinoff 2016).



The ESA endangered Mariana eight-spot butterfly (*Hypolimnas octucula marianensis*) is found in forested habitats within MCB Camp Blaz, particularly within the Haputo ERA.
(*Photo*: B. Holland and D. Rubinoff)

Mariana Wandering Butterfly

The Mariana wandering butterfly (*Vagrans egistina*) is federal ESA-listed as endangered and Guam-designated as SOGCN, and is extirpated from Guam. NAVFAC Marianas (2014c) found no sign of the Mariana wandering butterfly within MCB Camp Blaz during their surveys in March through July 2013.

Tree Snails

The Guam tree snail, humped tree snail, and fragile tree snail are federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. Native partulid snail populations and predation upon them by non-native species were recently examined in the coastal backstrand and native limestone forest habitats within the Haputo ERA (NAVFAC Marianas 2014b, 2014c). The highest population density of Guam tree snail occurred in the limestone forest behind Haputo Beach, mainly in coconut trees and taro plants (*Alocasia macrorrhizos*), accounting for 1,099 individuals (NAVFAC Marianas 2014b).

A previously undocumented population of Guam tree snails was found along the footpath leading down the cliff face to Double Reef, accounting for 383 individuals. The same study also found an undocumented population of humped tree snails (88 individuals) south of Haputo Beach along a wide limestone bench at the base of a steep escarpment.

The fragile tree snail, *S. fragilis*, has been reported on both Guam and Rota. It was found at Pugua Point by Myounghee Noh & Associates in 2014, who at the time speculated that this may be the only known colony of the fragile tree snail in Guam (NAVFAC Marianas 2014b). However, five populations are currently known in Guam, including one in the northern portion of the Haputo ERA (NAVFAC Marianas 2019). NAVFAC Marianas (2014c) demonstrated that fragile tree snails within Haputo ERA show no genetic heterogeneity, "which is indicative of a small population that has recently undergone a population bottleneck and is isolated from other colonies." They further noted that "…the population at Pugua Point may be the best situation for conservation of this species in Guam and should be assessed thoroughly." All populations appear relatively small, ranging in estimates of 30-140 individuals (NAVFAC Marianas 2019). This species was listed as endangered along with other native tree snail species.

Plants

High Value Trees are plant species that have cultural and/or ecosystem value and require additional handling and processing procedures during pre-construction clearing activities on JRM-administered lands. Figure 9-8 identifies the locations of these High Value Trees on MCB Camp Blaz. For a more detailed discussion on High Value Trees, see Section 4.4.3.5, *Plants*. High Value Tree plant species on MCB Camp Blaz include host plants for the listed Mariana eight-spot and wandering butterflies: *Procris pedunculata*, *Elatostema calcareum*, and *Maytenus thompsonii*, respectively. Both *P. pedunculata* and *E. calcareum* are forest herbs in the family Urticaceae growing on karst limestone (Moore 2014, 2016). Notable plant species identified within the Haputo ERA by NAVFAC Marianas (2011b) include *Cycas micronesica*, *E. calcareum, Heritiera longipetiolata, Instia. Bijuga*, *M. thompsonii*, *Merilliodendron megacarpum, Pisonia grandis, and P. pedunculata*. *M. megacarpum* was found to be prevalent within the northern one-third of the Haputo ERA, and seedlings were commonly found beneath the crowns of most adult trees (NAVFAC Marianas 2011a). The same study found *Cycas micronesica* throughout the Haputo ERA with higher densities and wider distribution in the northern half of the reserve, the majority of which were in good condition. A few *C. micronesica* were found with trunk rot, and no seedlings or recruitment of *C. micronesica* were observed. The native *M. megacarpum* tree dominates the limestone community in one area of the Haputo ERA (NAVFAC Marianas 2010a), and provides habitat for three listed tree snail species (Smith et al. 2008; NAVFAC Marianas 2010a).

Olmsted (2016) conducted surveys of MCB Camp Blaz to locate High Value Trees for protection and conservation prior to proposed construction activities associated with the military buildup in Guam. The purpose of the pre-construction High Value Tree survey was to comply with cultural and natural resources conservation measures related to the buildup. These were identified in the 2010 Record of Decision (DON and Department of the Army 2010); the 2011 Programmatic Agreement Between the Advisory Council on Historic Preservation, the Guam Historic Preservation Officer (HPO), and the Commonwealth of the Northern Marianas Islands (CNMI) HPO Regarding the Military Relocation to the Islands of Guam and Tinian; and the 2015 Record of Decision (DON 2015b). During the pre-construction phase, Defense Policy Research Institute determined the location of High Value Tree species and: (1) coordinated with knowledgeable traditional practitioners for culturally important natural resources; and (2) recorded evidence of CRB infestations within the proposed limits of construction.

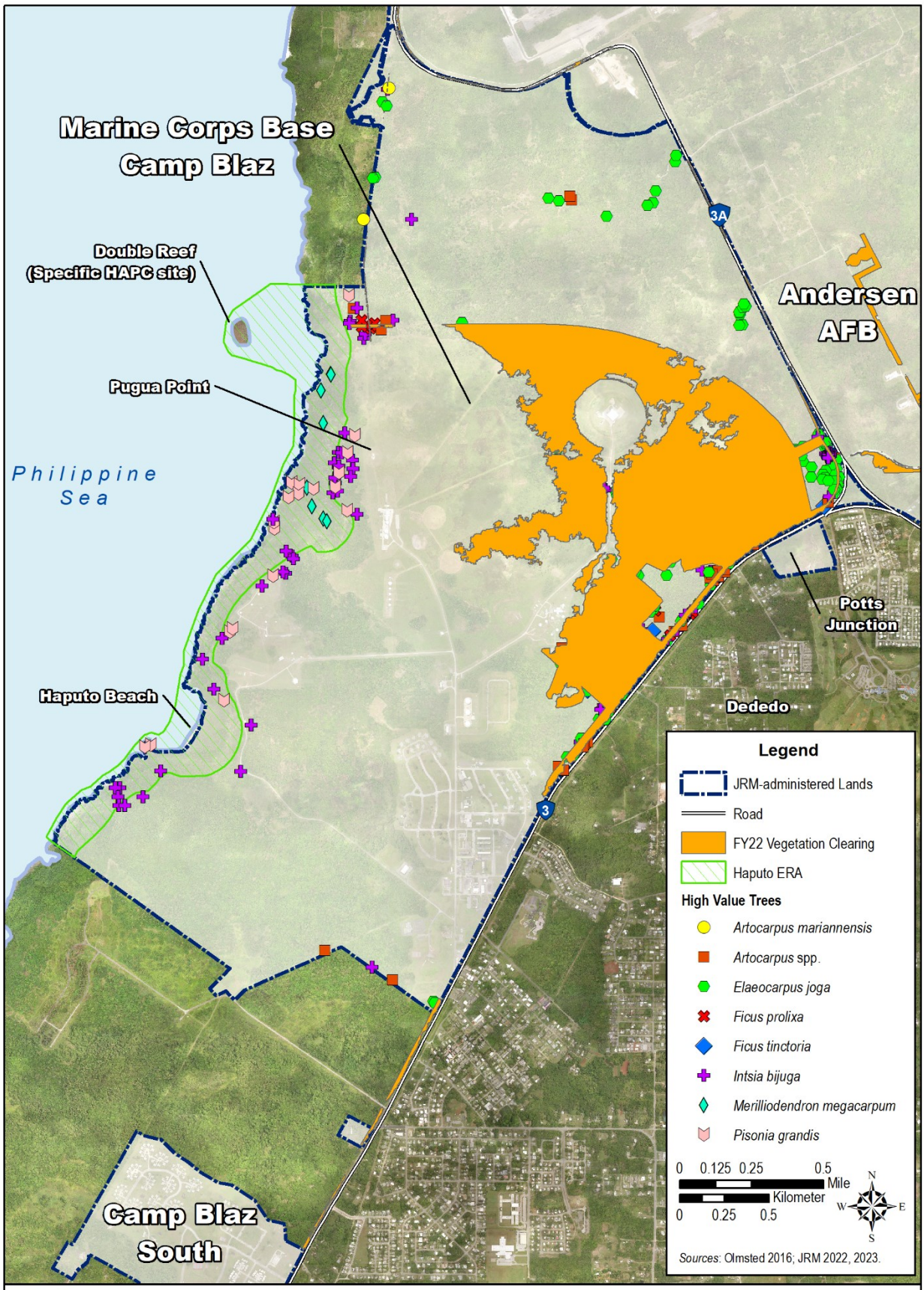


Figure 9-8
High Value Trees - Marine Corps Base Camp Blaz



Surveys conducted in MCB Camp Blaz found 4,278 endangered *Tuberolabium guamense* individuals.
(*Photo*: L. Shaughnessy)

The initial surveys conducted by Olmsted (2016) found that the study area was dominated by *Vitex*, pago (*Hibiscus tiliaceus*), *P. tectorius*, *M. cylindrocarpa*, noni (*Morinda citrifolia*), and *Triphasia trifolia*. The number of High Value Trees recorded on MCB Camp Blaz are summarized in Table 9-5. Numerous federal ESA-listed species were also found within the area proposed for clearing to accommodate a future construction project on MCB Camp Blaz. There were 110 *C. micronesica* found on MCB Camp Blaz (USFWS 2015b, 2017). High Value Trees found in those surveys included *C. micronesica*, ifit, joga (*Elaeocarpus joga*), nunu (*Ficus* spp.), luluhut (*M. thompsonii*), and both seeded and seedless breadfruit (*Artocarpus mariannensis* and *A. altilis*). Notably, there were 4,278 *Tuberolabium guamense* individuals found within the proposed action project boundary (Olmsted 2016); and more than 14,000 total *T. guamense* within MCB Camp Blaz (see Figure 9-7). Nine clumps of *Bulbophyllum guamense* have been found within MCB Camp Blaz. There were 17 clumps of *Dendrobium guamense* reported within MCB Camp Blaz (see Figure 9-7) (Olmsted 2016). There are many other native species present here, notably *A. mariannensis, O. oppositifolia,* and *Piper guahamense*. The remaining vegetation types within the project area consist of shrub/grassland, mowed lawns, communication corridors, and developed/disturbed areas (Olmsted 2016).

Table 9-5. High Value Trees Recorded on MCB Camp Blaz

Species	***Number Individuals***
Artocarpus sp.	35
Artocarpus mariannensis	--
Cycas micronesica	12
Elaeocarpus joga	180
Ficus sp.	31
Ficus prolixa	--
Ficus tinctoria	--
Heritiera longipetiolata	--
Intsia bijuga	48
Maytenus thompsonii	--
Merilliodendron megacarpum	--
Pisonia grandis	--

Key: -- = not listed; MCB = Marine Corps Base.
Source: Olmsted 2016.

Recovery habitat for the *Serianthes nelsonii* tree is found within undeveloped portions of MCB Camp Blaz (NAVFAC Marianas 2010a). Through an ongoing cooperative agreement, 121 *S. nelsonii* saplings were outplanted in the FES (A. Loerzel, personal communications, 18 January 2024).

9.1.4 Marine Environment

Refer to Section 9.1, *Current Operations and Land Use*, for an overview of MCB Camp Blaz and a discussion of the assets and uses of MCB Camp Blaz.

9.1.4.1 Joint Region Marianas-administered Submerged Lands

Submerged lands associated with MCB Camp Blaz comprise approximately 16,629 acres (6,729 hectares), or 20% of the total of JRM-administered submerged lands (85,364 acres [34,546 hectares]) in Guam, and approximately 9% of the total submerged lands surrounding Guam. The total shoreline length of Guam is approximately 150 miles (241 kilometers), with 3 miles (5 kilometers) of shoreline on MCB Camp Blaz, or roughly 2% of Guam's shoreline. Figure 9-9 shows JRM-administered submerged lands on MCB Camp Blaz as well as those off the west coast of Andersen AFB.

JRM-administered submerged lands on MCB Camp Blaz are also dually designated as Western Pacific Regional Fishery Management Council (WPRFMC) Essential Fish Habitat (EFH) and include the Haputo ERA, which is also a specific Habitat Area of Particular Concern (HAPC). HAPCs are those areas of EFH identified pursuant to Section 600.815(a)(9). Haputo ERA is a designated HAPC based on the following: rarity of habitat type, ecological function, and status as a protected area. HAPCs are identified by the WPRFMC (2009).

The Haputo ERA extends offshore of JRM-administrated land to a depth of 121 feet (37 meters) and includes Double Reef, a popular dive site that is also a coral area of significance due to its coral communities that contain unique features, including a highly heterogeneous habitat and a distinct backreef community (Waddell 2005). Access to the Haputo ERA is limited to hiking or boat only.

9.1.4.2 Physical Environment

The submerged lands offshore have not been subject to significant military construction activity, so the setting is very different than Apra Harbor. The coastline in the Haputo ERA is mainly steep limestone cliffs. Surface seawater temperatures off of the MCB Camp Blaz site typically range between 80.8 to 86.2 degrees Fahrenheit (°F) (27.1-30.1 degrees Celsius [°C]) (National Oceanic and Atmospheric Administration [NOAA] 2017a). However, during 2013, 2014, 2016, and 2017 water temperatures in Guam were elevated above normal due to El Nino conditions, which led to prolonged coral bleaching (Raymundo et al. 2016, 2017; Harvey 2016).

Bathymetry and Currents

The bathymetry off the MCB Camp Blaz is relatively steep close to shore, dropping off to approximately 1,000 feet (300 meters) water depth within about 0.5 miles (0.8 kilometers) from shore (Figure 9-10). Below this depth is the aphotic zone, where no sunlight penetrates. From there, the seafloor slopes more gently, reaching approximately 2,600-3,200 feet (800-1,000 meters) water depth around 5 miles (8 kilometers) out from shore. Mesophotic coral ecosystems are found in tropical regions at depths from about 100 feet (30 meters) to more than 500 feet (150 meters) (Kahng et al. 2010, 2014). Mesophotic coral ecosystems are possible offshore of the MCB Camp Blaz.

Nearshore currents off the MCB Camp Blaz generally flow northward along the coast, and southward farther out to sea, owing to eddy formation in the lee of the island from the northwesterly flow of the North Equatorial Current that bathes the island (Wolanski et al. 2003). During El Nino events, this current may slow or switch direction (Lagerloef et al. 1999), which would presumably change the direction and strength of nearshore currents off of MCB Camp Blaz.

The mean diurnal tidal range in Guam is 2.35 feet (0.72 meters), so tidal currents offshore MCB Camp Blaz are unlikely to be significant. MSL is reduced significantly during El Nino events, which can cause very shallow corals to become exposed during very low tides, leading to coral death (Widlanski et al. 2015; Raymundo et al. 2016).

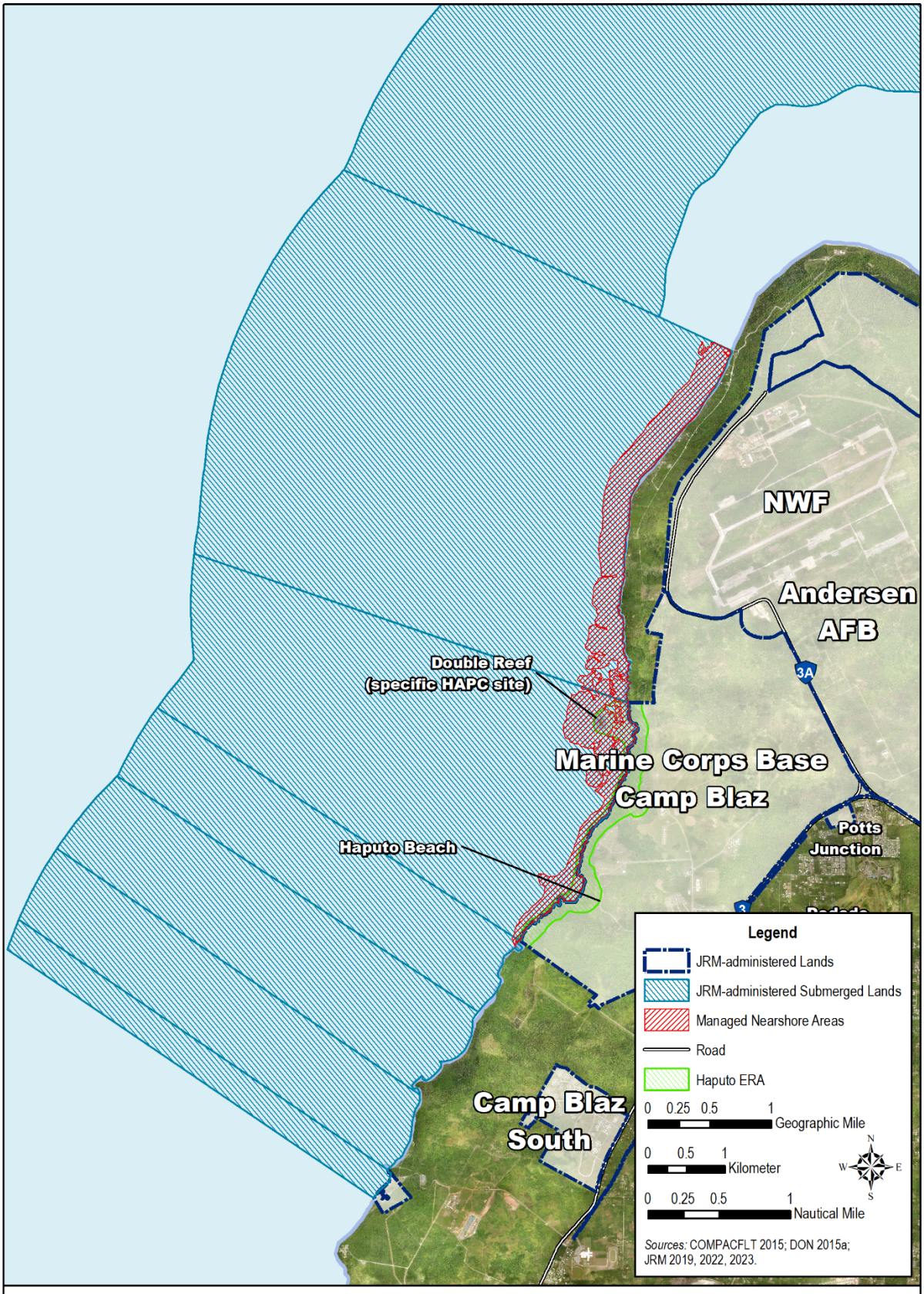


Figure 9-9
Submerged Lands Jurisdiction Offshore Marine Corps Base Camp Blaz

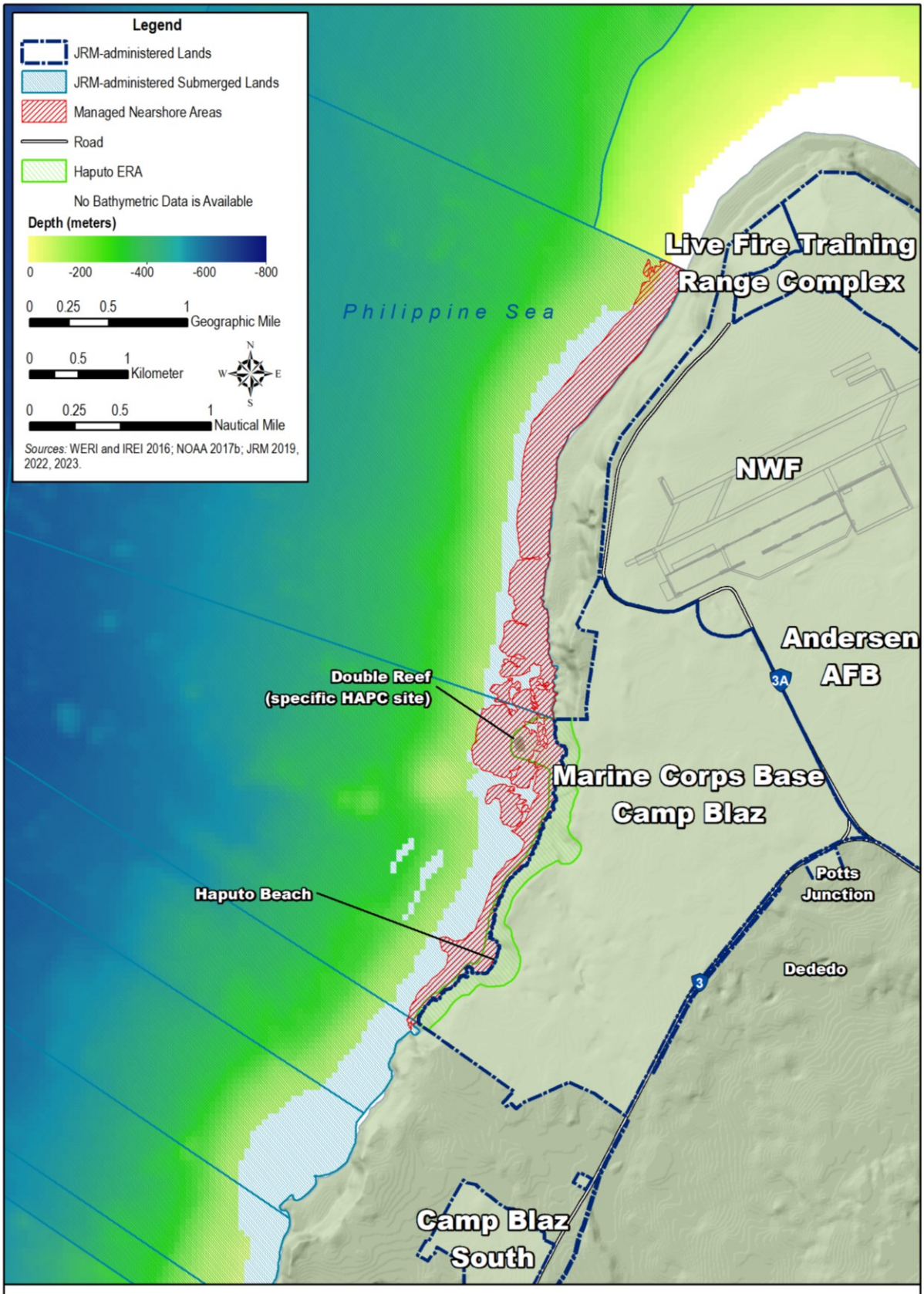


Figure 9-10
General Bathymetry of Submerged Lands - Marine Corps Base Camp Blaz

Turbidity and Water Quality

The submerged land offshore of the MCB Camp Blaz is not adjacent and/or down current from any streams, which are concentrated at the southern, volcanic portion of Guam. The northern region of Guam is dominated by limestone, and thus freshwater inputs typically occur as seeps instead of rivers, and do not deliver significant suspended sediment to coastal waters. This region is also generally protected from the majority of wave activity, being on the leeward side of the island.

Turbidity was very low in all measurements off of this region. In 2007, nitrate and phosphate were elevated offshore of the MCB Camp Blaz, compared with other locations around Guam, while nitrite and silicate were relatively depleted. Similarly, Redding et al. (2013) found elevated nitrogen isotopic signatures ($\delta^{15}N$) in soft corals and algae from the Haputo ERA, and interpreted this to be a signature from sewage outfalls in the south that are adverted north and/or seepage from leaking septic tanks through the porous limestone inland of this region.

A water quality sensor was deployed by Schils et al. (2017) off the MCB Camp Blaz shoreline for approximately 6 weeks in late 2015 to measure temperature, salinity/conductivity, chlorophyll, and turbidity. This data showed that during this time, waters at Urunao, just north of MCB Camp Blaz, were cooler and more saline, with lower turbidity and chlorophyll-a, than sites at Pati Point on Andersen AFB and around and within Apra Harbor. The limited timespan of this instrument deployment precludes robust interpretation, but suggests that during this time, land-based runoff affected Pati Point and/or Apra Harbor more strongly than MCB Camp Blaz. Expanded monitoring of water properties on MCB Camp Blaz, such as measuring the acidity/alkalinity and other properties over longer periods would allow the DON to understand physical oceanographic conditions at this site, which would help characterize changes here within the larger context of regional and global warming and acidification.

Marine resources offshore of the MCB Camp Blaz are likely subjected to some degree to the array of stressors in the marine environment that are described in Section 4.5.7, *Stressors on the Marine Environment of Guam*. However, with low levels of development onshore of this site, many local-scale stresses such as sedimentation, trampling, and sunscreen pollution are lower than at more heavily developed and frequented locations in Guam.

Waves and Storms

The most frequent and consistent wave energy impacting Guam is caused by the northeast trade winds; the MCB Camp Blaz is on the leeward side of the island and faces north/northwest, and thus is usually protected from strong waves (Brainard et al. 2012). Amesbury et al. (2001) describe it as relatively sheltered, with usually low to moderate wave impact and weak currents. However, typhoons and tropical storms usually pass close to Guam each typhoon season (typically May-October), and can cause significant wave energy and currents to impact the leeward side of the island (Brainard et al. 2012).

9.1.4.3 Marine Habitats



View from the Haputo ERA look-out point facing west towards Double Reef.
(*Photo*: SWCA)



View of the southern portion of the Haputo ERA from near the look-out point facing southwest.
(*Photo*: SWCA)

Bottom Habitat

The MCB Camp Blaz coastline has minimal area of broad reef flats connected to fringing reef between Haputo Beach and Double Reef. The coastline is bounded mostly by narrow, supratidal benches, or by rock faces lacking any reef protection. The northwest coast of Guam has limited marginal coral reef development as a whole, but some areas of localized high coral cover and high rugosity (Figure 9-11).

The Pacific Reef Assessment and Monitoring Program (Pacific RAMP) categorized habitat complexity on Haputo ERA as medium low to medium from surveys in 2003-2007 (Brainard et al. 2012). The Pacific Reef Assessment and Monitoring Program (Pacific RAMP) was previously named Marianas Archipelago Reef Assessment and Monitoring Program (MARAMP) through 2012. Relatively narrow reef flat and fringing reefs are found in the northwest coastline from the north of Double Reef toward Northwest Field. Amesbury et al. (2001) conducted a survey of physiographic features along with depth-related zonation in the Haputo ERA and established six macrohabitats:

1. Exposed Benches (supratidal to 3.3 feet [1 meter])
2. Protected Reef Flats (supratidal to 3.3 feet [1 meter])
3. Double Reef Top (supratidal to 3.3 feet [1 meter])
4. Back Reef (3.3-10 feet [1-9 meters])
5. Shallow Fore Reef (3.3-10 feet [1-9 meters])
6. Deep Fore Reef (10-60 feet [9-18 meters])

Double Reef lies on a shelf that remains relatively shallow, considerably further from the coast than adjacent areas of fore reef, making it an incipient barrier reef that breaks the surface at low tide. The area around Double Reef is highly heterogeneous. Elsewhere, the fore reef of northwest Guam shows relatively little variation in macrohabitat, although fine-scale variation in benthic communities is widespread. The following describes the six macrohabitats briefly. For a more detailed description, refer to Amesbury et al. (2001).

1. The northwest of Guam between Falcona Beach and Ague Point is dominated by exposed wave-cut platforms ("exposed benches") backed by undercut cliffs, interrupted by narrow pocket reef flats in Haputo Bay and inshore of Double Reef (also known as Pugua Patch Reef) and in places by vertical or over vertical cliffs that continue below the ocean's surface. Benches are generally less than 16 feet (5 meters) wide and sit 1.5-5.0 feet (0.5-1.5 meters) above sea level. The seaward edges of benches plunge steeply into the water, and their surfaces contain shallow splash pools that are wetted by sea spray but must survive significant periods of desiccation.
2. Two narrow, shallow protected reef flats lie within the Haputo ERA: one off Haputo Beach and the other shoreward of Double Reef. Both reef flats are largely intertidal and contain a typical low-diversity community that can cope with this physically stressful habitat.

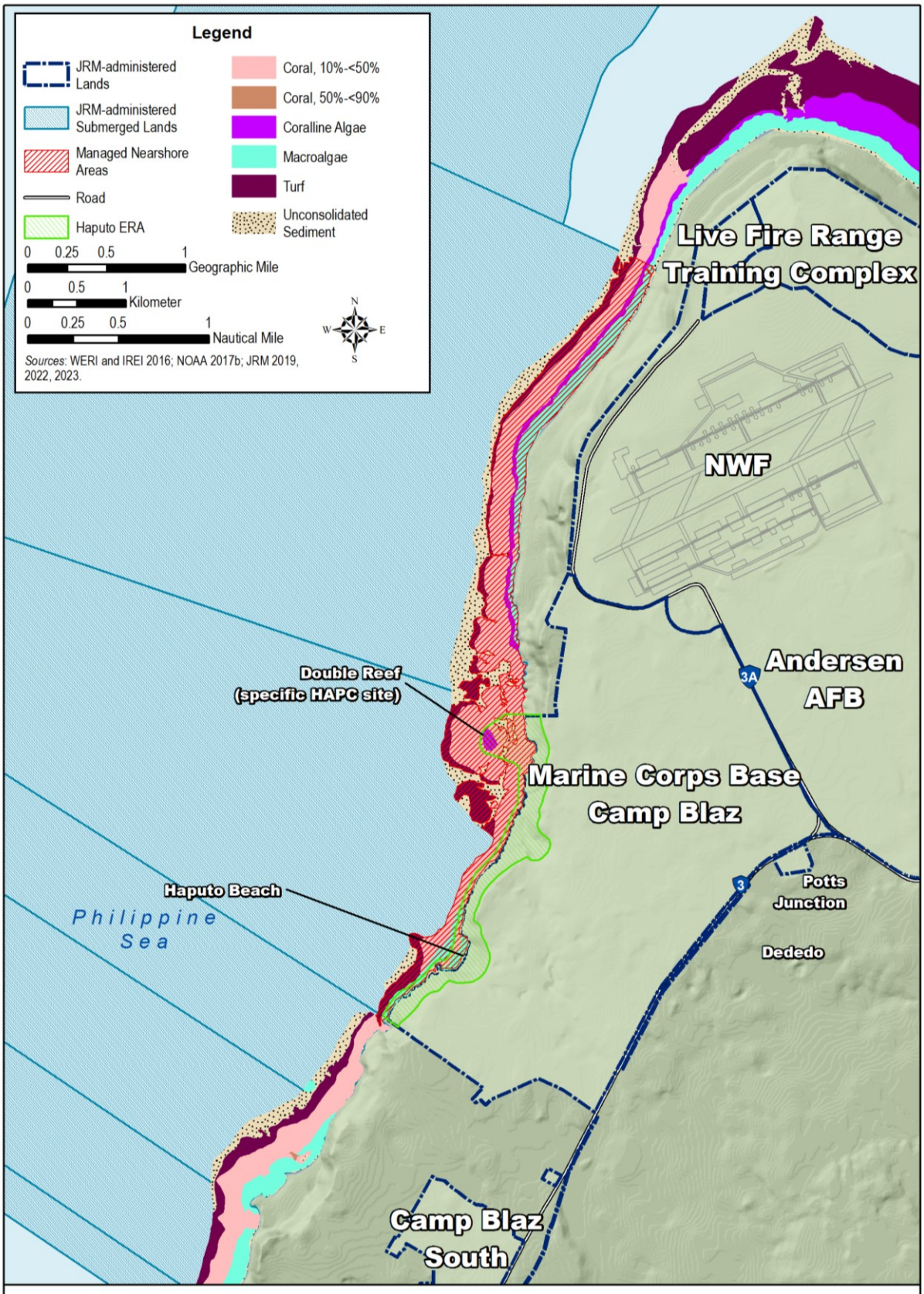


Figure 9-11
Benthic Habitats on JRM-administered Submerged Lands

3. Double Reef top lies in the shallowest depth zone and is a typical reef front/reef crest.
4. The back reef in the lee of the Double Reef top is highly complex, with numerous sand patches.
5. The fore reef south of Double Reef contains spur and groove morphology, as well as abundant underwater caves, cuts, and crevices. There is mild relief and high coral cover on the spurs and abundant rubble in the grooves. The fore reef in the lee of Double Reef is more complex in bathymetry and benthic communities. There is significant variability in communities within this depth zone due to alongshore and inshore-offshore differences in freshwater aquifer discharge, surge/scour, and light levels.
6. At the deeper end of the intermediate depth zone, the fore reef loses its structural complexity and becomes a gently sloping, moderately dissected reef slope, which transitions gradually into the deep fore reef macrohabitat. The deep fore reef generally has little or moderate (0-3 feet [0-1 meter]) vertical relief, with only occasional structures breaking the relatively even reef slope. There is typically an increase in reef slope at depths between 40-80 feet (12-25 meters).

The Amesbury et al. (2001) survey described Double Reef as the most striking offshore feature along the entire northwest coast of Guam. In 2001, Paulay et al. described Double Reef as one of Guam's few remaining examples of a healthy leeward fringing reef community (Paulay et al. 2001). Coral bleaching events, however, have significantly affected Double Reef and this system no longer provides the habitat and fishery values as described in the past (Raymundo et al. 2016).

Benthic habitat maps depicting general benthic cover habitat types were identified in the Guam Coastal Atlas by Burdick (2006) using satellite imagery provided by NOAA. Hard and soft bottom substrates were differentiated using acoustic imaging (NOAA 2017b). Figure 9-12 presents general benthic morphological structures, including spur and groove and sand. Section 4.5.2, *Marine Habitats*, describes some limitations of interpreting these maps. However, in general these maps and other studies indicate that habitats off the MCB Camp Blaz include uncolonized soft sediments primarily in deeper habitats, coral, a small amount of coralline algae-dominated habitat near Double Reef, and extensive turf and macroalgae dominated habitats.

Coastal Habitat

The coastline of MCB Camp Blaz is backed by steep limestone cliffs, some of which are fronted by narrow sandy beaches, particularly in the northern portion of MCB Camp Blaz. In the Haputo ERA area, only Haputo Beach has appreciable sand; this beach is approximately 1,000 feet (300 meters) long. The cliffs in this region are generally undercut by wave action at high tide and provide habitat for organisms that can survive extended periods exposed to the air, such as barnacles, limpets, and other intertidal species.

9.1.4.4 Marine Flora

Native Species

Marine flora serve a very important aspect of the coral reef ecosystem. Turf algae are small, filamentous assemblages of many algal species that serve as primary food sources for many reef grazers. Macroalgae are assemblages of large fleshy and/or calcified species with a wide range of growth forms. These algae can grow out of control without enough grazers or with excess nutrient enrichment. Crustose coralline algae (CCA) are often recognized as important "building blocks" of coral reefs. This type of algae serves as cement over and between fragments of dead coral and sand, providing a stronger foundation for the coral reef. CCA is also an important substrate onto which coral larvae preferentially settle (Heyward and Negri 1999). Cyanobacteria (sometimes called blue-green algae) often cause unsightly blooms in Guam (e.g., Thacker and Paul 2001 and references therein), and may indicate nutrient pollution (Albert et al. 2005).

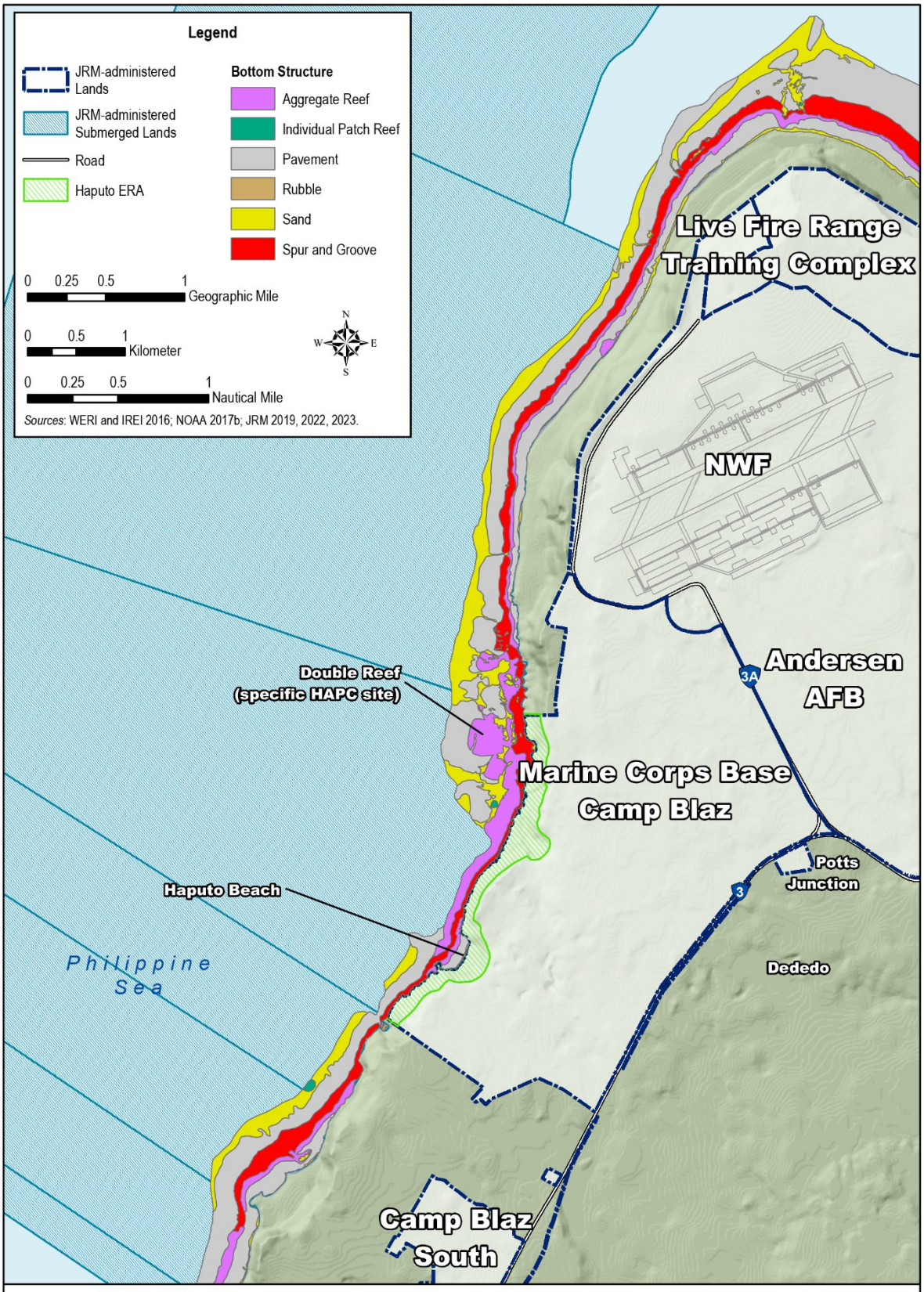


Figure 9-12
Hard and Soft Bottom Substrates - Marine Corps Base Camp Blaz

Turf algae, CCA, and cyanobacteria were all common around Guam in 2003 and 2005, while CCA was reduced at some sites around the island in 2007 (Brainard et al. 2012). In 2003, turf and macroalgae cover ranged between 10-60%, while CCA ranged between 10-30%. In 2005, there was an increase in turf and macroalgae cover to 30-75% and a decrease in CCA to 1-10% cover. In 2007, turf and macroalgae decreased again to 10-50% cover, while CCA was about the same at 0-8% cover. Surveys of CCA disease in 2007 found no incidences off the MCB Camp Blaz (Brainard et al. 2012).

All locations around Guam had relatively abundant calcified green *Halimeda* and *Neomeris* algae in 2003-2007 Pacific RAMP surveys; no unique floristic communities were observed at the MCB Camp Blaz compared to other locations around Guam during any of these surveys (Brainard et al. 2012). Surveys of the Haputo ERA in 2008 and 2009 identified algae belonging to 29 genera, and noted that cyanobacteria and *Halimeda* were common in this region (NAVFAC Marianas 2010c). There are no seagrass beds off the MCB Camp Blaz.

Healthy coral reefs require a certain balance of living coral and algae cover. Too much macroalgae can decrease appropriate substrate needed for coral larvae to settle, can exacerbate coral disease, and can reduce growth of established coral colonies. Overfishing of environmentally valuable herbivorous fish species may contribute to detrimental amounts of macroalgae. Further monitoring, which includes routine assessments of macroalgal cover during and outside of seasonal blooms, are required to determine normal percentages of algae and coral at a given site. Attention to nutrient-indicator species such as cyanobacteria and *Ulva* spp. may provide further insight into the influence of nutrient inputs or grazer control of algae off of MCB Camp Blaz.

Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.2, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine flora in Guam are presented in Section, 4.5.3 *Marine Flora*.

There are not yet reports of non-native or invasive marine flora offshore of MCB Camp Blaz. A nuisance marine species is native, but occasionally exhibits blooms or outbreaks or other undesirable characteristics, and to date there are no reports of nuisance marine flora on MCB Camp Blaz. The green angel hair algae (*Chaetomorpha* sp.) is a nuisance species that may occur on MCB Camp Blaz (Schils 2015), but the relatively strong waves and currents make blooms unlikely.

9.1.4.5 Marine Invertebrates

Native Species

Corals

Marine resource surveys of the Haputo ERA identified 154 species of corals in 2001 (Amesbury et al. 2001). In 2008 to 2009, repeat surveys performed by a different suite of researchers identified 163 species of corals in this region (NAVFAC Marianas 2010c).

Acropora corals, which are branching and also referred to as staghorn corals, provide important 3-dimensional structure to the ecosystem but are vulnerable to bleaching caused by warm water temperatures (Raymundo et al. 2017). Due to bleaching events in 2013 and 2014 (Reynolds et al. 2014), Guam as a whole lost on average over 50% of staghorn corals, a group of about six coral species with similar staghorn morphologies. Double Reef within the Haputo ERA lost approximately 30% of its staghorn *Acropora* (Raymundo et al. 2017). Global climate change is causing increasingly frequent and severe coral

bleaching events, which is now considered the primary threat to coral reef ecosystems in most parts of the world. The Guam Coral Reef Response Team developed ten "canary sites" around Guam where rapid reconnaissance surveys are conducted if NOAA issues a coral bleaching warning (Hoot and Burdick 2017). The Haputo ERA is closest to the canary sites at Gun Beach and Ritidian Point. Gun Beach is about 4 miles (6 kilometers) south of the Haputo ERA, located on the northern end of Tumon Bay. Ritidian Point is located about 6 miles (10 kilometers) north of the Haputo ERA. The status of coral bleaching within MCB Camp Blaz submerged lands is currently unknown, but a proposed Integrated Natural Resources Management Plan (INRMP) management action to monitor for coral bleaching would address this information gap.

The inner portion of the reef flat of Haputo Bay in 2001 had low diversity with *pavona divaricata* as the dominant species (Amesbury et al. 2001). The 2008 to 2009 surveys found that these shallow sites had higher diversity than at adjacent deeper sites, implying that the magnitude of disturbance was greater at shallow sites versus deeper sites (NAVFAC Marianas 2010c).

The federal ESA-listed coral, *Acropora globiceps,* was observed at the south end of Haputo ERA during 2013 bleaching surveys conducted by the Guam Coral Reef Response Team (Brown 2015). This coral occurs in relatively shallow reef areas. On the Haputo ERA, it was seen at depths of less than 23 feet (7 meters).

Double Reef has historically contained high coral cover. The reef top had extensive piles of heavily scoured rubble alternating with coral communities of >75% coral cover. The community was a typical, shallow reef front assemblage, dominated by *A. valida*, *A. digitifera,* and *Pocillopora* species. Coral diversity is higher here than in the other shallow macrohabitats (exposed benches and protected reef flats; see above), but is lower than the fore reef communities; none of the species were unique or unusual (Amesbury et al. 2001). This habitat also contained diverse corals during the 2008 to 2009 surveys (NAVFAC Marianas 2010c), but lost approximately 30% of branching *Acropora* corals to bleaching as observed in the 2013 to 2014 surveys (Raymundo et al. 2017).

Amesbury et al. (2001) notes that the reef front seaward of the Haputo reef flat, especially along its southern end, had the greatest population density of large (>1.5 foot [0.5 meter] diameter), massive corals other than *Porites* spp. in Guam. In this area, coral cover exceeded 80% and was comprised largely of large diameter colonies of a variety of faviid, mussid, and poritid species, including *Leptoria phrygia*, *Goniastrea* spp., *Platygyra* spp*., Favia stelligera*, *Lobophyllia hemprichii*, *Porites* spp., and others. This region still supported a similar assemblage of large corals in 2008 to 2009 (NAVFAC Marianas 2010c).

Faviids and mussids are slow-growing head corals that are more vulnerable to disturbance, including both crown-of-thorns seastar (COTS) predation and adverse physical conditions (such as warm waters) than species of *Porites*, the other main group of massive corals in Guam. Massive corals generally have slower growth rates than branching, encrusting, or plate corals, and thus take longer to reach large colony size than corals with other growth forms. The abundance of a diverse assemblage of large faviids in the Haputo reef front implies that this area had remained relatively undisturbed for a longer period than comparable habitats elsewhere in Guam. This may be the result of the physiography of the area, where lagoon-like depressions create coral gardens on the reef front that are sheltered by shallow reef-ridges from the open sea. This physical attribute protects against severe storms, and may also hamper COTS from accessing this population during rough seas, because COTS are vulnerable to damage and mortality from wave action and avoid shallow exposed reefs (Birkeland and Lucas 1990). The severe COTS outbreak that devastated the western coast of Guam in the late 1960s left Double Reef largely intact for this apparent reason (i.e., sea

conditions were presumably too rough at the time to have allowed COTS access to that reef). The Haputo reef front may have experienced similar protection. The Haputo reef front also had a small population of a rare *Acropora* sp. Coral unidentified to species in 2001 (Amesbury et al. 2001); this population was not identified in the 2008 to 2009 surveys, possibly because survey locations were not identically placed.

the fore reef south of Double Reef had the highest coral diversity in the MCB Camp Blaz region, including the ahermatypic coral *Dendrophyllia gracilis*, a rare coral species in Guam that was found in one of the small caverns (Amesbury et al. 2001). Coral communities on the shallow fore reef varied both with depth and along shore. Branching coral (*Acropora* spp. and *Pocillopora* spp.) dominated communities at 3-10 feet (1-3 meters) with few *Acropora* spp. but a diversity of other genera in deeper waters. Some areas were dominated almost exclusively by three to six species of encrusting *Montipora* spp., others were dominated by massive *Porites* spp., and yet others had a more heterogeneous coral community (Amesbury et al. 2001).

Amesbury et al. (2001) found that on the deep fore reef, coral communities were heterogeneous, *Porites* spp. dominated, and comparable in species richness to the shallow fore reef. The north-central section of the deep fore reef was dominated by *P. rus*, which is also resistant to COTS predation (Sonoda and Paul 1993). In addition to diverse hard corals, soft corals of several species were also found on the reef slope, with *Sinularia leptoclados, L. batarum*, and *Sarcophyton trocheliophorum* all common in the deeper parts of the shallow fore reef. The large *P. rus* colonies observed in 2001 were also observed during the 2008 to 2009 surveys in the Haputo ERA, south of Double Reef (NAVFAC Marianas 2010c). *P. rus* is considered a "weedy" coral that thrives In locations with high nutrient loads or turbidity (NAVFAC Marianas 2010c; Darling et al. 2012).

Amesbury et al. (2001) found that back reef tracts were dominated by the thick branching species *A. palifera* or *Pocillopora eydouxi*, the staghorn *Acropora acuminata*, the platy-to-columnar *P. rus*, large >6-foot (2-meter) diameter massive *Porites* heads, or by heterogeneous coral assemblages, all alternating on a scale of 160-320 feet (50-100 meters). The small soft coral *Asterospicularia randalli* was abundant and often dominant through much of the back reef. Several coral species that are patchily distributed around Guam are locally abundant on MCB Camp Blaz (e.g., *A. palifera* and *A. acuminata*).

Amesbury et al. (2001) noted that coral cover around most of Guam was <20% in 2001, but in the Haputo area it averaged 46% during their survey. The Pacific RAMP surveys found moderately low sand cover (<30%) and variable coral cover to 40-50% with the highest cover south of Haputo Point (Brainard et al. 2012). Coral cover and diversity remained high in the Haputo ERA during the 2008 to 2009 surveys (NAVFAC Marianas 2010c). The 2003 survey found that *Leptastrea* sp. dominated the northwest region of Guam. Maps from Williams et al. (2012) showed that the region offshore of the MCB Camp Blaz had in general good coral cover, low macroalgal cover, and a resulting relatively high coral to macroalgal index value. Aside from significant loss of *Acropora* spp. branching corals in 2013 to 2014 (Raymundo et al. 2016), no survey data for the submerged lands off of the MCB Camp Blaz have been published other than the reported accumulated heat stress (NOAA 2017a) and anecdotal reports of coral bleaching over multiple subsequent years around Guam (Harvey 2016). JRM is implementing a coral bleaching monitoring project that leverages information with the Pacific RAMP in order to understand which species of coral and coral colonies are more resilient to thermal stress (see Section 9.4.2.1, *Marine Habitat Management*).

The 2007 Pacific RAMP survey found relatively few corals with subacute tissue loss (from disease or predation), amounting to 0.3% (± 0.2) overall in Guam. Among the entire Guam survey, a site near Haputo Point had the greatest subacute tissue loss (2%). Tissue loss conditions occurred almost exclusively on the

genus *Porites*. In many instances, these lesions occurred in association with extensive, old partial mortality and turf algae overgrowth (Brainard et al. 2012).

The NAVFAC Marianas (2011b) Haputo ERA visitor use survey extrapolated from direct observations to estimate that the Haputo ERA receives approximately 381 anchor drops/year and approximately 5,000 swimmers, snorkelers, and divers. The survey cites literature that found that the vast majority of coral reef users make contact with the reef, which can cause severe damage to delicate corals. JRM is implementing a Conservation Law Enforcement Program to help protect federal ESA-listed marine species and to improve stewardship of JRM's natural resources (see Section 9.4.2.5, *Marine Natural Resources Law Enforcement*). JRM also is developing a comprehensive outreach program for incoming DoD personnel and their families, as well as the dive shops on NBG and Andersen AFB, to provide information about appropriate behavior toward federal ESA-listed marine species and to improve stewardship of JRM's marine resources (see Section 9.4.2.4, *Marine Natural Resources Educational Outreach*).

The Guam NWR, Ritidian Unit is not part of MCB Camp Blaz; however, the good condition of the coral reefs there as well as offshore of the MCB Camp Blaz and Andersen AFB may have a positive spill-over effect between these three regions. Ritidian Point is also an HAPC.

Other Invertebrates

In total, Amesbury et al. (2001) recorded 583 species of other invertebrates in the Haputo ERA. These included characteristic gastropod communities, hermit crabs, vermetid gastropods, the barnacle *Tesseropora pacifica*, the mussel *Modiolus auriculatus*, and the holothurian *Actinopyga varians* that all were found in the splash pools of the supratidal benches. The hermit crab *Calcinus seurati* and the shore crab *Grapsus longitarsis* are only found in this habitat in Guam. The barnacle *Balanus eburneus*, and two grapsid crabs: *Orcovita* sp. and *Grapsidae* sp. were found only in a freshwater seep area associated with the supratidal benches in the Haputo ERA, and nowhere else in Guam. Amesbury et al. (2001) speculated that the grapsid crab species were likely undescribed and endemic to Guam or the Marianas. These findings underscore the importance of the Haputo ERA from a natural resource protection standpoint.

At the two narrow, shallow reef flats that lie within the Haputo ERA, the hermit crabs *Clibanarius humilis, C. virescens,* and *C. eurysternus*, the crabs *Actaeodes tomentosus* and *Leptodius sanguineus*, the sea slug *Elysia rufescens* and the sea cucumbers *Synapta maculata* and *Holothuria leucospilota* were found (Amesbury et al. 2001).

The excavating echinoid *Echinometra* was abundant, particularly on the exposed reef pavement of Double Reef (Amesbury et al. 2001).

Amesbury et al. (2001) found the sponges *Neofibularia hartmani*, "yellow tough sponge," and "puff sponge," were all common in the shallow fore reef macrohabitat. They also found that the cryptofauna associated with the rubble fields was highly diverse and included several rare species: the xanthid crab *Atergatis granulatus*, the flatworm *Pseudoceros bimarginatus*, the hermit crab *Pylopaguropsis kiejii*, and the social ascidian *Clavelina* sp.

Amesbury et al. (2001) found the sea cucumber *Holothuria fuscopunctata* in relatively protected sand patches. The commensal crab *Caphyra* sp., living on *Asterospicularia* was found only in the Double Reef backreef zone. All eight species of photosymbiotic ascidians known in Guam – *Didemnum molle, Diplosoma similis, Lissoclinum patella, Lissoclinum timorense, Tridemnum clinides, Tridemnum*

cyclops, Tridemnum paracyclops, and *Diplosoma virens* – were also found in the Double Reef back reef; the last two species were known only from this area.

Giant clams were observed in relatively low densities off the MCB Camp Blaz (approximately one clam per 4,300 square feet [400 square meters]) (Brainard et al. 2012). There were moderate densities of sea cucumbers of the genera *Stichopus*, *Actinopyga*, *Bohadschia*, and *Holothuria* (approximately one sea cucumber per 1,000 square feet [100 square meters]), with *Stichopus* spp. most commonly encountered (Brainard et al. 2012).

The 2008 to 2009 marine resource surveys conducted in the Haputo ERA did not focus on cryptofauna or other small macroinvertebrates; that group of researchers only identified 254 non-coral invertebrate species, but this discrepancy compared to Amesbury et al. (2001) is likely due to lower or different effort between surveys (NAVFAC Marianas 2010c). In general, the 2008 to 2009 survey did not find any significant change in the numbers of common macroinvertebrates sighted compared to 2001; as in 2001, urchins, sea cucumbers of the genus *Stichopus,* and giant clams were the most common large non-coral invertebrates (NAVFAC Marianas 2010c). Invertebrates such as sea cucumbers, urchins, and giant clams are important components of healthy coral reef ecosystems; sea cucumbers process organic matter in sediments, urchins are important grazers, and giant clams filter organic matter and particulates from seawater. Protection of these resources, which are also valuable fishery targets, is an important component of natural resource protection off the MCB Camp Blaz. NBG Instruction 5090.2A states that no harvesting or collecting of mollusks, crustaceans, or echinoderms is allowed.

Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.2, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine invertebrates in Guam are presented in Section 4.5.4, *Marine Invertebrates*.

Paulay et al. (2002) conducted intensive surveys that included the Haputo area to identify invasive and cryptogenic (possibly invasive) species. Those authors found 20 invasive and cryptogenic species (not all of which were at the Haputo ERA): 1 gastropod, *Tectus niloticus*, 1 barnacle, *Balanus eburneus*, 1 brittlestar, *Ophiactis savignyi*, 10 ascidians, 5 hydroids, and 2 fish, *Gambusia affinis* and *Oreochromus mosambicus*.

The nuisance marine species *Terpios hoshinota,* a coral-killing sponge, has been observed at many sites in Guam, including offshore of the MCB Camp Blaz (Bryan 1973). At this time, however, outbreaks of this sponge do not appear to have had a lasting negative impact on the reef community. Plucer-Rosario (1987) found that *T. hoshinota* sponges grew fastest in the absence of living coral tissue, suggesting that it may be less effective at killing healthy coral than previously thought. Reimer et al. (2011) suggest that *T. hoshinota* may have serious outbreaks that kill and outcompete corals over short time periods, but do not necessarily cause a permanent loss of coral on reefs.

Outbreaks of the coral-eating COTS have occurred off the MCB Camp Blaz. The first recorded outbreak of this nuisance species occurred in 1967 to 1969, when large populations of COTS formed fronts that spread across reefs primarily on the leeward side of Guam, leaving behind almost completely dead reefs (Chesher 1969). Corals in very shallow water, large *Porites* coral heads in moderate swell conditions, and reefs with strong swell were generally the only survivors because the seastar were unable to maintain traction in these conditions (Chesher 1969). A major COTS removal campaign was initiated, and more than 20,000 seastars were removed or killed in-situ to control the outbreak. Despite this catastrophic event, by the early 1980s coral cover and species richness had recovered to higher levels than before the COTS

outbreak (Colgan 1987). Since that time, other COTS outbreaks have occurred at lower densities (refer to Figure 4-14). While the cause for COTS outbreaks is still under investigation, Timmers et al. (2012) found that outbreaks do not appear to be related to increased dispersal between islands, but instead are more likely caused by island-scale factors; this suggests that local management of COTS outbreaks is an important focus.

COTS have been an occasional problem in the Haputo ERA specifically, as well. During the outbreak of the late 1960s, the seastar spread to Double Reef. In November of 1968, 886 COTS were removed from 968,752 square feet (90,000 square meters) of the reef (Chesher 1969). During a 2001 survey of diversity in the Haputo ERA, the COTS was reported at 9 of the 31 survey sites (Amesbury et al. 2001). COTS were also detected during a 2008 survey of the Haputo ERA with a mean density of 19 individuals per acre (47 individuals per hectare) (NAVFAC Marianas 2011b). This number is alarming as it exceeds outbreak levels. COTS were also detected during 2011 manta tow transects and a snorkel survey of the Haputo ERA. Two adult COTS were observed during 14 manta tow transects; five COTS were observed during a 1-hour snorkel survey, two of which appeared to be juveniles (NAVFAC Marianas 2011b). The presence of juveniles on the reef indicates that COTS recruitment is occurring in the Haputo ERA Marine Unit. JRM is implementing a monitoring and control program for COTS (see Section 9.4.2.1, *Marine Habitat Management*).

9.1.4.6 Marine Fishes

Native Species

In total, Amesbury et al. (2001) recorded 204 fish species in the Haputo ERA. They note that in contrast to the great abundance and diversity of corals, the local fish fauna were taxonomically depauperate, of low population density, and had especially few fishes belonging to taxa targeted by fisheries. All of these factors indicate that overfishing is a serious problem in the area. However, Haputo ERA surveys in 2008 to 2009 found 339 species of fish, possibly due to differences in observer background or effort; most of the fish observed were small species: damselfish and clownfish (Pomacentridae), and gobies (Gobiidae) (NAVFAC Marianas 2010c). There was no significant difference in fish density between the 2001 and 2008 to 2009 surveys (NAVFAC Marianas 2010c).

The 2007 Pacific RAMP towed-diver surveys showed that near Ritidian Point in the northwest region, two reef sharks were observed: one grey reef shark (*Carcharhinus amblyrhynchos*) and one whitetip reef shark (*Triaenodon obesus*). Other notable observations during this survey included sightings of three humphead wrasse (*Cheilinus undulatus*) and three dogtooth tuna (*Gymnosarda unicolor*). This is relevant because these important species may migrate back and forth from Ritidian Point to MCB Camp Blaz. However, it is important to note that in the report produced after NOAA's 2012 Pacific RAMP surveys, none of these species were mentioned (Williams et al. 2012).

The 2014 Pacific Reef Monitoring and Assessment Program by NOAA Coral Reef Ecosystem Division found relatively low fish biomass offshore of the MCB Camp Blaz compared with other sites in the archipelago and other sites around Guam, with approximately 25-50 grams of fish/square meters (0.6-1 pound/square feet) (Pacific Islands Fisheries Science Center [PIFSC] 2014). In comparison, the highest fish biomass in Guam was found off of Pati Point, with approximately 300 grams of fish/square meters (7 pounds/square feet) (PIFSC 2014). Despite relatively low visitation of the Haputo ERA compared to other sites around Guam, and the ban on fishing in the ERA, overfishing is a problem that needs to be addressed. A proposed INRMP management action would establish a Conservation Law Enforcement Program on MCB Camp Blaz in order to deter and reduce activities that affect marine resources and federal ESA-listed marine species, such as illegal fishing, walking on coral, and anchoring without a mooring buoy.

Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.2, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine fishes in Guam are presented in Section 4.5.5, *Marine Fishes*.

To date, there are no reports of non-native or invasive marine fish or reports of nuisance marine fish in MCB Camp Blaz submerged lands. A nuisance marine species is native, but occasionally exhibits population booms or other undesirable characteristics.

9.1.4.7 Marine Protected Species

Federal ESA-listed marine species have been recorded on or near JRM-administered submerged lands of MCB Camp Blaz (Table 9-6; Figure 9-13). The following is a summary of known and potential occurrences of protected species in the JRM-administered submerged land areas. Because some records are not precise, their occurrences are approximated within the 3-mile (5-kilometer) JRM-administered submerged lands based on available records (see also Appendix E).

Invertebrates – Corals

Three coral species (*Acropora globiceps*, *A. retusa*, and *Seriatopora aculeata*) were listed by NMFS in 2014 as threatened under the ESA and are found in Guam waters (NMFS 2014a, 2014b; Brown 2015). There are few records of occurrences for these three species in Guam waters. Based on 2015 records, there are 23 known occurrences of *A. globiceps*, one occurrence of *A. retusa* at the southernmost point of Guam, and one occurrence of *S. aculeata* along the southwest coast (Brown 2015; refer to Figure 4-14). The federal ESA-listed coral *A. globiceps* has been observed at the southern end of Haputo ERA (Brown 2015). The other two federal ESA-listed coral species, *S. aculeata* and *A. retusa,* have not been recorded on MCB Camp Blaz.

The NMfS Final Listing Determination states that the listing of *Pavona diffluens* applies to species in the Indian Ocean and Red Sea (NMFS 2014a). The Final Listing Determination stated that corals fitting the description of *P. diffluens* in the Pacific are a different species. The specimens observed in Guam and Tinian were rare, and were conspicuously identifiable as the *Pavona* described in Randall and Meyers (1983). The species is shown as "present" in Guam but not considered to be subject to the ESA because there is insufficient morphological evidence to make a distinction between the "local" *P. diffluens* and the ESA-threatened *P. diffluens.*

Fishes

Scalloped Hammerhead Shark

The ESA lists six DPS for the scalloped hammerhead (*Sphyrna lewini*) (NMFS 2014b). Scalloped hammerhead sharks within the Indo-West Pacific DPS are federal ESA-listed as threatened and known to occur in the Mariana Archipelago. The International Union for Conservation of Nature Red List considers this shark endangered. Scalloped hammerheads are the second largest hammerhead shark species and reach a length of at least 13 feet (4 meters). Observations of scalloped hammerheads offshore of the MCB Camp Blaz have not been recorded. Scalloped hammerheads are found worldwide in tropical and temperate seas; therefore, these sharks could occur within MCB Camp Blaz JRM-administered submerged lands (Martin et al. 2016). However, there are limited shallow soft bottom habitats offshore of MCB Camp Blaz, which are their preferred locations when they move inshore.

Table 9-6. Federal and Guam ESA-listed Threatened and Endangered Marine Species on JRM-administered Submerged Lands on MCB Camp Blaz

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat[2]*	*Occurrence[3]*
Invertebrates (Corals)					
Coral/Acho Tasi	*Acropora globiceps*	T	--	Intertidal zone, upper reef slopes, and reef flats	Y
Coral/Acho Tasi	*Acropora retusa*	T	--	Shallow reef slope and back reef areas	P
Coral/Acho Tasi	*Seriatopora aculeata*	T	--	Shallow reef slopes	P
Fish					
Oceanic whitetip shark/Haluu	*Carcharhinus longimanus*	T	--	Open ocean, usually well offshore	PU
Giant manta ray/ Afula or Hafula or Fanihen Tasi	*Manta birostris*	T	--	Coastlines, oceanic island groups, and offshore pinnacles and seamounts	P
Scalloped hammerhead shark/ Haluun kiluus or Ulon matiyu na huluu	*Sphyrna lewini*	T[4]	--	Coastal seas from intertidal to depths of 1,640 feet (500 meters); nearshore nursery habitat includes bays and estuaries	Y
Reptiles					
Green sea turtle/Haggan	*Chelonia mydas*	E[5]	T	Offshore waters and nesting beaches	Y
Hawksbill turtle/Haggan karai	*Eretmochelys imbricata*	E	E	Offshore waters and nesting beaches	Y
Marine Mammals					
Fin whale/ Salungai or Bayena	*Balaenoptera physalus*	E	--	Generally near the 656-foot (200-meter) isobaths	P
Humpback whale/ Salungai or Bayena	*Megaptera novaeangliae*	E[6]	--	Coastline to 5,906-foot (1,800-meter) isobaths	P
Sei whale/ Salungai or Bayena	*Balaenoptera borealis*	E	--	Offshore, prefers deeper waters	P
Sperm whale/ Salungai or Bayena	*Physeter macrocephalus*	E	--	Deep waters generally >3,281 feet (>1,000 meters) depth	Y

Notes: [1] Chamorro names from GovGuam (2009), Kerr (1990, 2012), and Topping et al. (1975).
[2] Dominant adult habitat. Not necessarily inclusive of other life stages (e.g., egg/larvae/juvenile/breeding habitat).
[3] Occurrences approximated to JRM-administered submerged lands, but some fishery-based and acoustic-based records have imprecise locations.
[4] Indo-West Pacific Distinct Population Segment.
[5] Central West Pacific Distinct Population Segment.
[6] Western North Pacific Distinct Population Segment.

Key: > = greater than; -- = not listed; E = endangered; ESA = Endangered Species Act; JRM = Joint Region Marianas; MCB = Marine Corps Base; N = no, does not occur; P = potential for occurrence; PU = potential for occurrence, but unlikely; T = threatened; Y = yes, known to occur.

Sources: Guam DAWR 2006, 2015; GovGuam 2009; USFWS 2011; Hill et al. 2013, 2014, 2015, 2016; NMFS 2014a, 2014b, 2018a, 2018b; DON 2015c; Jones et al. 2015; Brown 2015; Lybolt 2015.

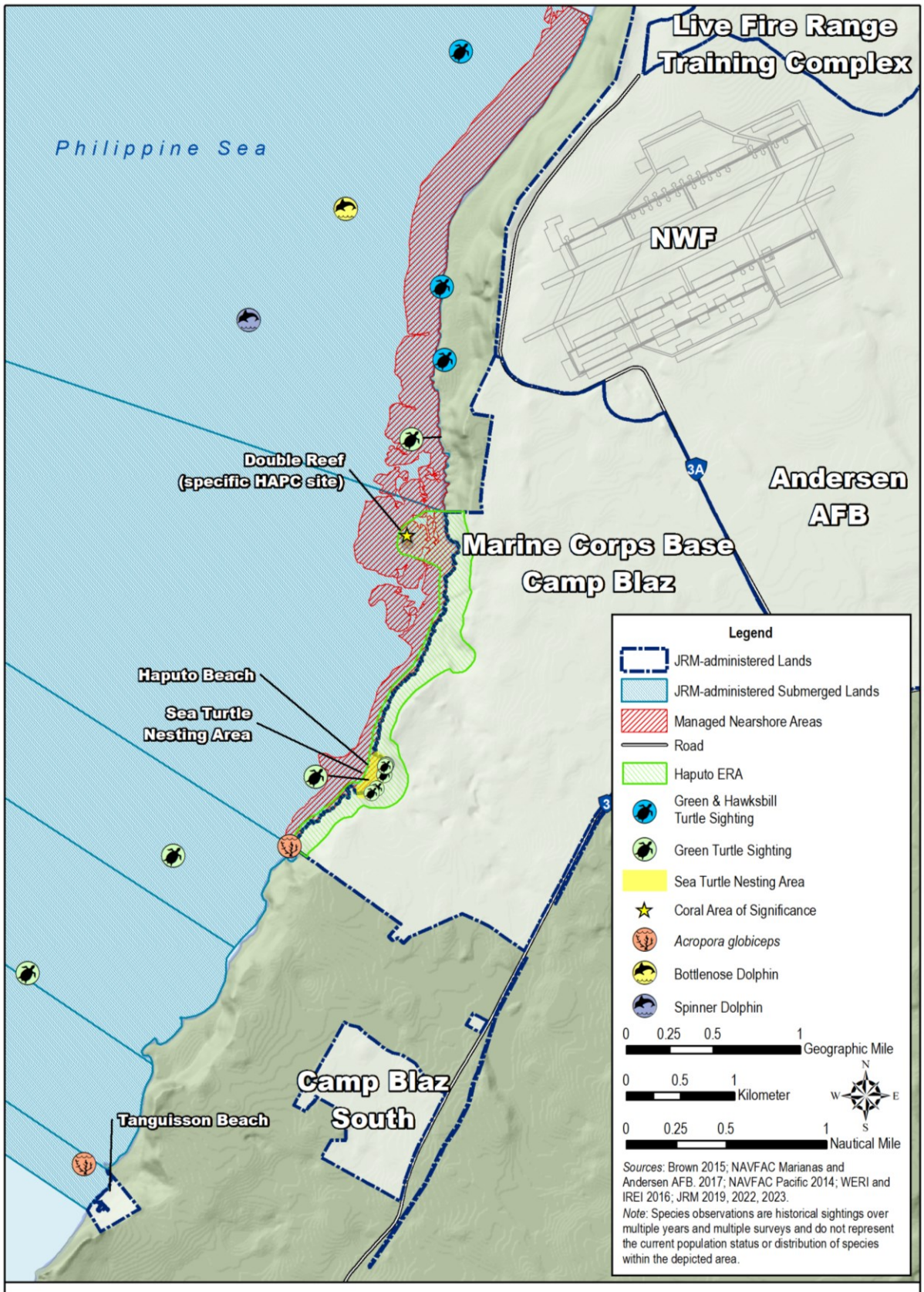


Figure 9-13
Selected Marine Protected Species Occurrences in Marine Corps Base Camp Blaz Submerged Lands

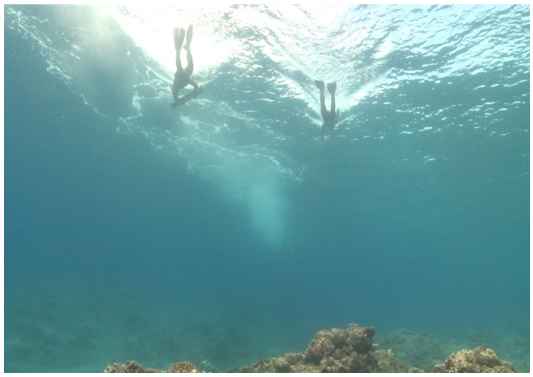
Humphead Wrasse and Bumphead Parrotfish

Two bony fishes occurring in the Mariana Archipelago are listed as federal species of concern and Guam-designated as SOGCN: the Napoleon or humphead wrasse (*Cheilinus undulatus*) and the bumphead parrotfish (*Bolbometopon muricatum*) (Guam DAWR 2006; NMFS 2015a, b). The NOAA (2012) status review of the humphead wrasse concluded that there was a low overall risk of extinction for this fish in the foreseeable future, with relatively low certainty regarding the available information. Despite its natural rarity and depressed abundance in certain areas, this no-to-low overall risk of extinction is based primarily on the species' sustained widespread distribution throughout most of its known range, and its recent effective protection from exploitation at a variety of localities under both U.S. and foreign jurisdiction (NOAA 2012). Graham et al. (2015) reported that between 2003 and 2011, an average of 0.055 humphead wrasse were observed per 10,000 square meters (12,000 square yards) of survey area in the MCB Camp Blaz region. The 2007 Pacific RAMP survey observed three humphead wrasse in this region (Brainard et al. 2012). Humphead wrasse were sighted at five sites during surveys in 2009, but most were juveniles or small females. In 2012, NOAA determined that the bumphead parrotfish (*Bolbometopon muricatum*) did not warrant ESA listing because the species still occupies its historical range, although at a lower and declining abundance, but with biological characteristics and management measures that support the population above the viability threshold. This parrotfish remains a federal species of concern (NOAA 2012). No bumphead parrotfish were sighted on MCB Camp Blaz in the 2007 Pacific RAMP surveys (Brainard et al. 2012). Fenner (2014) cites evidence that bumphead parrotfish were common in Guam in the 1960s, but by the 1970s they were targeted by fishers, and now they are rarely sighted.

Sea Turtles

Green Sea Turtle and Hawksbill Turtle

Two species of sea turtles have been sighted within JRM-administered submerged lands: the green sea turtle (*Chelonia mydas*) and the hawksbill turtle (*Eretmochelys imbricata*), including several observations of nesting activity (Figure 9-6). Martin et al. (2016) report data on sea turtle observations around Guam from semimonthly aerial surveys conducted through the year (24 surveys a year, weather permitting) by Guam DAWR. They found an eightfold increase in turtle observations island-wide since the 1960s, but this trend was driven by increases in turtles in the south of Guam. The area off MCB Camp Blaz typically had a lower number of turtle observations throughout this time period (Martin et al. 2016). Refer to Chapter 4, *Overview of Guam* for sea turtle information that is not specific to MCB Camp Blaz, but is applicable to all parcels in Guam.



Towed snorkeler surveys are a very efficient method to census sea turtles.
(*Photo*: R. Whitton)

Marine Mammals

All marine mammals are protected under the Marine Mammal Protection Act.

Spinner Dolphins

Spinner dolphins are frequently sighted around Guam during NMFS PIFSC's cetacean surveys (Hill et al. 2013, 2014, 2015, 2016; Martin et al. 2016). During NMFS PIFSC's 2015 cetacean survey, spinner dolphins were sighted in proximity to MCB Camp Blaz. Satellite tags showed that in 2015, individuals from this species frequented waters in the JRM-administered submerged lands off MCB Camp Blaz (Hill et al. 2016).

Common Bottlenose Dolphins

Deakos et al. (2016) sighted common bottlenose dolphins around Guam in 2015. Satellite tags deployed in 2015 and visual observations in 2014 and 2016 confirmed that common bottlenose dolphins use the waters off MCB Camp Blaz (Hill et al. 2015, 2016, 2017; Martin et al. 2016).

Pantropical Spotted Dolphins

During NMFS PIFSC's 2013, 2014, 2015, and 2016 cetacean surveys, pantropical spotted dolphins were sighted in proximity to MCB Camp Blaz (Hill et al. 2013, 2014, 2015, 2016, 2017). Deakos et al. (2016) also sighted one pantropical spotted dolphin off the northeast coast of Guam in 2015. Satellite tags showed that in 2015 and 2016, individuals from this species frequented waters in JRM-administered submerged lands off MCB Camp Blaz (Hill et al. 2016, 2017; Martin et al. 2016).

Short-finned Pilot Whales

During NMFS PIFSC's 2013, 2014, 2015, and 2016 cetacean surveys, short-finned pilot whales were sighted in proximity to MCB Camp Blaz. Satellite tags deployed in 2013, 2015, and 2016 also showed that individuals from this species frequented waters in JRM-administered submerged lands off MCB Camp Blaz (Hill et al. 2013, 2014, 2015, 2016, 2017; Martin et al. 2016).

Rough-toothed Dolphins

During the 2013 and 2014 NMFS PIFSC cetacean surveys, rough-toothed dolphins were sighted near Aguiguan and Saipan, with six of the individuals being confirmed in photo-identification catalogs (Hill et al. 2014, 2015; Martin et al. 2016). This species was not observed in JRM-administered submerged lands off MCB Camp Blaz, and occurrence is possible but unlikely.

False Killer Whales

During the 2015 NMFS PIFSC cetacean survey, a group of false killer whales were sighted off the north side of Guam near Ritidian Point (Hill et al. 2016). False killer whales were also sighted near Guam during the 2014 NMFS PIFSC cetacean survey (Hill et al. 2015; Martin et al. 2016).

Pygmy Killer Whales

A group of 11 pygmy killer whales off the southwest side of Guam were sighted during the 2015 NMFS PIFSC cetacean survey, with 9 individual whales being recognized from encounters in previous years (Hill et al. 2014, 2015, 2016; Martin et al. 2016). This species was not observed in JRM-administered submerged lands off MCB Camp Blaz, and occurrence is possible.

Blue Whales

Acoustic equipment has recorded the presence of blue whales in the Western Pacific waters around Guam; however, it is not known if they were in or near MCB Camp Blaz (Klinck et al. 2015, 2016; Oleson et al. 2015; Martin et al. 2016).

Fin Whales

Acoustic equipment has recorded the presence of fin whales in the Western Pacific waters around Guam; however, it is not known if they were in or near MCB Camp Blaz (Klinck et al. 2015, 2016; Oleson et al. 2015; Martin et al. 2016).

Humpback Whales

Acoustic equipment has recorded the presence of many humpback whales in the Western Pacific waters around Guam and CNMI, especially in the waters south of Guam and southeast of Tinian; however, it is not known if they were in or near MCB Camp Blaz (Klinck et al. 2015, 2016; Oleson et al. 2015).

Sei Whales

Acoustic equipment has recorded the presence of sei whales in the Western Pacific waters around Guam; however, it is not known if they were near MCB Camp Blaz (Klinck et al. 2015, 2016; Oleson et al. 2015; Martin et al. 2016).

Sperm Whales

During a small boat survey around Guam and Saipan in February and early March of 2010, there were two sperm whale sightings: (1) a group of nine animals off Orote Point, Guam, inshore from the 1,640 feet (500 meters) isobath; and (2) a group of six animals northwest of Saipan in waters greater than 3,281 feet (1,000 meters) deep (Ligon et al. 2011). A group of 10 sperm whales was also sighted during small boat surveys off western Guam in waters approximately 3,940 feet (1,200 meters) deep in March 2012 (NAVFAC Pacific 2012). The sperm whale was the most frequently sighted cetacean (21 sightings) during the 2007 survey with acoustic detections almost three times higher (61) than visual detections in the field (Fulling et al. 2011). Passive-acoustic glider surveys in 2014 and 2015 confirmed the presence of sperm whales around Guam (Klinck et al. 2015, 2016; Martin et al. 2016). This is an indication that they may occur in or around MCB Camp Blaz.

Blainville's Beaked Whales

Passive-acoustic glider surveys in 2014 and 2015 also confirmed the presence of Blainville's beaked whales around and to the south of Guam and between Rota and Tinian (Klinck et al. 2015, 2016; Martin et al. 2016). During the 2015 NMFS PIFSC cetacean survey, a single group of Blainville's beaked whales (one adult male with three or four females/juvenile males) were sighted off of Rota (Hill et al. 2016). Blainville's beaked whales were also seen near Rota during the NMFS PIFSC cetacean survey in 2014 (Hill et al. 2015). This is an indication that they may occur in or around MCB Camp Blaz.

Risso's Dolphins

Passive-acoustic glider surveys in 2014 and 2015 confirmed the presence of Risso's dolphin around and to the south of Guam and to the east of Saipan; however, it is not known if they were near MCB Camp Blaz (Klinck et al. 2015, 2016; Martin et al. 2016).

Common Minke Whales

Passive-acoustic glider surveys in 2015 confirmed the complex, amplitude-modulated calls of the common minke whale during a survey near the Mariana Trench southeast of Guam; however, it is not known if they were near MCB Camp Blaz (Klinck et al. 2016; Martin et al. 2016).

Killer Whales

Passive-acoustic glider surveys in 2014 confirmed the presence of killer whales around and to the south of Guam; however, it is not known if they were near MCB Camp Blaz (Klinck et al. 2015; Martin et al. 2016).

Bryde's Whales

Three Bryde's whales were sighted between Rota and Guam during the 2015 NMFS PIFSC cetacean survey with species identification confirmed by photos (Hill et al. 2016; Martin et al. 2016). This is an indication that they may occur in or around MCB Camp Blaz.

Melon-headed Whales

A group of melon-headed whales were sighted off the east coast of Guam during a Guam shore survey in 2015 (Deakos et al. 2016; Martin et al. 2016). This is an indication that they may occur in or around MCB Camp Blaz.

Cuvier's Beaked Whales

In the 2014 NMFS PIFSC cetacean survey, a confirmed sighting of a Cuvier's beaked whale occurred 12 miles (19 kilometers) off the west side of Saipan in 5,600-foot (1,700-meter) deep water (Hill et al. 2015; Martin et al. 2016). This is an indication that they may occur in or around MCB Camp Blaz.

9.1.4.8 Marine Resources Monitoring

While a number of survey efforts have been conducted to address specific questions and management needs, marine resources on MCB Camp Blaz have not been monitored regularly in the past. There is a need to understand long-term trends to assess temporal and spatial changes that will inform adaptive management strategies. Multiple agencies acting cooperatively with DoD and NOAA (principally GovGuam and University of Guam [UOG]) established a long-term monitoring program for benthic communities using belt transect methods (Burdick and Brown 2011). In some ways, this was a precursor to the current DoD-sponsored effort to monitor marine resources at 10 permanent sites in JRM-administered submerged lands on NBG but no sites within JRM-administered submerged lands on MCB Camp Blaz were included (Schils and Houk 2017; Schils et al. 2017). Both of these monitoring programs are specifically designed to detect change over time with high statistical confidence, and utilize multivariate statistical techniques to evaluate changes in select ecosystem indicators (McManus and McManus 2012). These monitoring designs are specifically built to integrate into and be directly comparable to existing broad scale island- and region-

wide monitoring programs (i.e., Pacific RAMP). Robust monitoring of this nature is critical for establishing context for MCB Camp Blaz marine resources and any associated management actions. These data are essential to evaluating the success of management actions and alerting managers to local or broad changes that could trigger the need to update baseline assessments. This data set can be spatially expanded as needed to include additional target strata (e.g., depths, habitats) or specific geographic locations where management actions are taking place. Similarly, monitoring frequency can be adjusted as needed to capture planned, expected, or stochastic events. Maintaining the core survey effort is essential for putting the expanded efforts into context.

The Guam Comprehensive Long-term Coral Reef Monitoring Program has had to utilize their resources on emergent needs such as coral bleaching monitoring; however, Burdick and Brown (2011) describe their initial findings consistent with the known baseline conditions, with the variability that is expected when single strata are placed in the context of a larger area. There is an ongoing Reef Resilience Assessment study currently in Guam. Field work commenced in July 2016, but no results are available. The surveys included 25 sites around Guam at two depths: 15 feet (5 meters) and 40 feet (12 meters). Sites include Pugua Patch Reef inside the JRM-administered submerged lands on MCB Camp Blaz.

Schils et al. (2017) have provided a report describing their findings for 10 permanent sites in JRM-administered submerged lands on NBG; however, these data only represent a single year of data collection, and again the Haputo ERA was not included in the monitoring sites. The real value of this effort will be realized when there are multiple years of data to compare and describe trends in benthic composition, coral community dynamics, fish assemblages, mobile invertebrates, and water quality. JRM will obtain feedback from the relevant territorial and federal agencies on which aspects should be continued for long-term marine resources monitoring within JRM-administered submerged lands and how frequently the survey should be conducted, as well as potential changes in type of data collection, location of sites, depth of sites, and new technologies that can be utilized to increase efficiency.

9.1.5 Management Goals, Objectives, Strategies, and Actions

JRM currently manages natural resources based on an ecosystem-focused approach that involves the implementation of several ongoing management projects. These projects, which are described in the following sections, provide examples of JRM's current efforts to manage and enhance natural resources in a manner consistent with the military mission. Appendix C lists management projects on MCB Camp Blaz for Fiscal Years (FY) 14-17. The following sections present management projects for MCB Camp Blaz that have been identified as necessary to achieve applicable goals and objectives identified in Chapter 3, *Environmental Management Strategy and Mission Sustainability*.

Management projects identified for MCB Camp Blaz provide direct support for the military mission and the goal of "no net loss" in a number of ways. For example, projects that improve the baseline status of species or their habitat, show that populations are stable, or that habitat is improving or expanding, may relieve restrictions on military training or operations, minimize costs and mitigation requirements, avoid workarounds, and/or streamline regulatory processes.

9.1.5.1 Terrestrial Ecosystem Management

MCB Camp Blaz's native terrestrial habitats have been impacted by historical activities, introduction and spread of invasive and non-native species, effects of climate change, and the resulting loss of functions necessary to support healthy native habitats. Ecosystem functions have been disrupted by the extirpation of native animal and plant species, which has resulted in both economic and cultural impacts on the ecosystem services provided by native habitats. The occurrence of healthy native habitats on MCB Camp Blaz is

necessary to support sustainability of native species including federal and Guam ESA-listed threatened and endangered species. JRM recognizes that restoration and enhancement of native habitats on lands that they manage is a long-term process, and that adaptive management is key to long-term success of the program.

Management projects are monitored and evaluated annually to ensure that they are meeting identified goals and objectives. JRM will establish mid-year coordination meetings with resource partners to discuss ongoing and planned projects, including prioritization, scope, methodology, issues or challenges, timelines, and performance evaluation criteria. These discussions are intended to facilitate improved coordination and information sharing to allow for course corrections, if necessary, to ensure an adaptive approach.

Terrestrial habitat management as described in the following sections is expected to: (1) improve the status of threatened and endangered species through habitat conservation and enhancement, and (2) promote health and sustainability of native forests. Healthy ecosystems will, in turn, relieve or reduce environmental constraints and allow for maximum operational flexibility for installations and continued/managed access to important recreational areas.

A summary of the management projects and the estimated timeframe for completion is presented in Table 13-10, *Planned Implementation Summary of Projects at MCB Camp Blaz*. Some of the projects described in this section are being accomplished through interactive partnerships with federal and territorial natural resource agencies (e.g., Guam DAWR), universities, and local organizations.

9.1.5.2 Terrestrial Habitat Management

JRM has ongoing and planned projects to restore and enhance native terrestrial habitats. These projects focus on improving the quality and availability of appropriate habitat for listed species, as well as increasing the quality and health of existing native habitats, such as native limestone forests. Numerous related activities are required for native habitat improvement, such as control of ungulates and other invasive species, propagating and outplanting native plant species to improve diversity, and addressing forest health issues, such as improvement of seed dispersal.

In order to achieve long-term goals, terrestrial habitat management requires successful daily and short-term management, coupled with long-term planning and investment. To ensure that JRM continues to meet the overriding goal of restoring and enhancing terrestrial habitats for native species (including listed species) over the long-term, JRM site land managers and resource agencies will continue coordinating on natural resource management.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Habitat Management (THM) on MCB Camp Blaz.

THM-1: WATERSHED MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #3 and 7-8.

- *Strategy*: Stabilize the eroding cliff in the Haputo ERA near Pugua Point to improve water quality by reducing sediment load into the nearshore environment, which can degrade and kill corals and reef communities.
- *Action*: Stabilize eroding cliff sites on the MCB Camp Blaz Overlay Refuge lands to benefit marine ecosystems, including Pugua Patch Reef.
- *Action*: Identify methods for controlling and stabilizing soils at eroding sites to promote plant growth through bioengineering, removal of invasive species, and planting.

- *Action*: Identify metrics that will be used to monitor success at each site and monitor at regular intervals, including after typhoons and heavy rains.

THM-2: PROTECTION OF ECOLOGICAL RESERVE AREA

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-4; Goal #3, Objectives #1 and 4; and Goal #4, Objectives #1-2. This project supports conservation measures from the Re-initiation of the 2015 Biological Opinion (BO) on the DON's Relocation of USMC from Okinawa to Guam and Associated Activities in Guam (USMC Relocation 2017 BO, which contains amendments to the 2015 BO) (USFWS 2017).

- *Strategy*: Long-term management planning for the Haputo ERA.
- *Action*: South Haputo ungulate fence was installed in 2021. North Haputo ungulate fence was 97% complete at the time Typhoon Mawar hit in May 2023. Ungulate eradication was proceeding in 2023 with expected completion in September 2023. Both fences were destroyed in Typhoon Mawar. Eradication focus shifted to large scale control and protection of priority sites, including *Partula gibba* locations, as there was not enough funding on the agreement to re-eradicate the site. The ungulate control team is anticipated to finish control operations by September 2024; fencing repairs have been contracted but not started, and MCB Camp Blaz will be seeking additional funding for eradication in upcoming years.
- *Action*: Control invasive plants and invertebrates, following the planned ungulate fence construction in the Haputo ERA for the Guam Micronesian kingfisher MOA.
- *Action*: Conduct pre-construction surveys for ESA-listed species avoidance in the Haputo ERA.
- *Action*: Integrate information into construction design for ungulate fence alignment to minimize impacts to listed species.

THM-3: FOREST ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-6; Goal #3, Objectives #1-4; and Goal #4, Objectives #1-2. This project supports the 2019 Guam Wildlife Action Plan (Guam DAWR 2019) and conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Protect and restore priority native habitats (i.e., limestone forest) for the benefit of native flora and fauna, including protected species, by focusing on step-wise forest enhancement activities and by protecting species from direct and indirect threats.
- *Action*: Develop a monitoring program for listed plants found throughout JRM-administered lands following the protocols for GPS data collection used at Northwest Field (NWF) and MCB Camp Blaz. Known locations will be monitored and new surveys will be conducted to identify additional locations.
- *Action*: Collect seeds of listed plants from the installations, propagate in a nursery, and outplant.
- *Action*: Conduct an annual health evaluation of plantings as a metric to track success of conservation actions.
- *Action*: Annually survey listed, native, and invasive plants in 460 plots on MCB Camp Blaz for 2 years. Surveys of sub-plots for seedlings will be done in both wet and dry seasons.
- *Action*: Enhance approximately 1,000 acres (405 hectares) of forest at MCB Camp Blaz and NWF. Work is triggered when a construction project begins clearing recovery habitat.

- *Action*: Improve the quality of existing habitat to defined areas on MCB Camp Blaz by erecting ungulate fencing and eradicating feral pigs and deer within fenced areas.
- *Action:* Inspect and maintain ungulate fencing around exclosure areas.
- *Action:* Monitor ungulate exclosure areas to detect and remove pigs and deer that have re-entered the site through fence breaches, open gates, or other means.
- *Action*: Remove invasive plant species and plant native forest species.
- *Action*: Determine if translocation of Micronesian starlings to MCB Camp Blaz is feasible. If determined to be feasible, install predator-proof nest boxes and translocate Micronesian starlings to MCB Camp Blaz using best management practices (BMPs) learned from Andersen AFB nest box studies.

9.1.5.3 Terrestrial Exotic and Invasive Species Management

An invasive species is defined in EO 13112, *Invasive Species*, as a species that is non-native (i.e., alien or exotic) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm, or harm to human health. Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions. Invasive species have had a catastrophic effect on the native flora and fauna of island ecosystems, particularly Guam. Attributes of island biota include small geographic ranges and population size, low reproductive rates, and lack of the ability to respond to invasive species and disturbed habitats. Islands typically have lower numbers of species than mainland areas, which results in fewer predators and competitors that could prohibit the establishment of invasive species. As a result of evolving in isolation, island plants and animals have few defenses when exposed to introduced competitors and predators. These limitations in Guam have caused exotic and invasive species to replace native island species (Wiles et al. 2003).

Many of the native species in Guam are threatened due to introduced predators, such as the BTS, and introduced ungulates, such as the Philippine deer, feral pig, and Asiatic water buffalo (carabao) which have significantly affected native vegetation communities. Feral populations of dogs and cats also pose threats to native wildlife populations. Secretary of the Navy Instructions (SECNAVINST) 6401.1B of September 29, 2006, prohibits dogs, cats, and other privately owned or stray animals from running at large on military installations. Several species of rats have colonized the island, preying on the eggs and young of native species and destroying native flora (i.e., seeds and seedlings). The continued widespread presence of the BTS, curious skink, and introduced amphibian species are of particular concern because of each species' potential negative impacts in Guam's native fauna. Examples of invasive species management approaches include the control of feral ungulates, the control of feral cats and dogs, and the removal of invasive plants to allow native species to flourish in degraded areas.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Exotic and Invasive Species Management (TIS) on MCB Camp Blaz.

TIS-1: BROWN TREESNAKE INTERDICTION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #3-4; Goal #3, Objectives #1 and 4; Goal #4, Objectives #1-3; and Goal #7, Objective #3.

- *Strategy*: Maintain, develop, and implement actions to prevent the spread of BTS via the transportation network.

- *Action*: Annually review, update as needed, and develop BTS interdiction projects reflecting BMPs, adaptive management, and cost benefits.
- *Action*: Annually assess continuity and compliance of BTS interdiction activities across BOs, DoD BTS interdiction operating instructions, and consistency with, and, to the benefit of other relevant JRM conservation actions.
- *Action*: Annually assess ongoing development of new/emergent management strategies and methodologies that reduce or eliminate the risk of BTS.
- *Action*: Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant long-term projects to benefit interdiction management objectives.

TIS-2: BROWN TREESNAKE SUPPRESSION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-4 and 6; Goal #3, Objectives #1 and 4; Goal #4, Objectives #1-3; and Goal #7, Objective #3. Actions listed are in accordance with the 2011 BTS MOA.

- *Strategy*: Suppress and control BTS numbers to support conservation goals for species and ecosystem recovery.
- *Action*: Develop an operational suppression implementation plan. The plan will identify and prioritize potential quality habitat site(s) for suppression actions. Site(s) must consider size, habitat, location, connectivity, synergistic effects, listed species benefits, ecological viability, and support regulatory and mission requirements. Suppression goals and activities will support USFWS recovery plan delisting requirements for threatened and endangered species.
- *Action*: Implement BTS suppression management actions in identified site(s) based on mission support impact and cost effectiveness. Data will be used to determine the minimum thresholds of BTS suppression activities needed to support conditions conducive to species persistence and recovery.
- *Action*: Through annual funding and partnerships, support development of tools and methods that improves monitoring, detection, and suppression in targeted habitat sites.
- *Action:* Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant projects to benefit long-term BTS suppression management actions.

TIS-3: BROWN TREESNAKE MANAGEMENT FOR THE RECOVERY OF PROTECTED SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-4 and 6; Goal #3, Objectives #1 and 4; Goal #4, Objectives #1-3; and Goal #7, Objective #3. Actions listed are in accordance with the 2011 BTS MOA.

- *Strategy*: Suppress and control BTS numbers to support listed vertebrate species recovery.
- *Action*: Develop an operational suppression implementation plan. The plan will identify and prioritize potential quality habitat site(s) for suppression actions. Site(s) must consider size, habitat, location, connectivity, synergistic effects, listed species benefits, ecological viability, and support regulatory and mission requirements. Suppression goals and activities will support USFWS recovery plan delisting requirements for threatened and endangered species.
- *Action*: Implement BTS suppression management actions in identified site(s) based on mission support impact and cost effectiveness. Data will be used to determine the minimum thresholds of

BTS suppression activities needed to support conditions conducive to species persistence and recovery.

- *Action*: Through annual funding and partnerships, support development of tools and methods that improves monitoring, detection, and suppression in targeted habitat sites.
- *Action:* Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant projects to benefit long-term BTS suppression management actions.

TIS-4: IMPLEMENTATION OF REGIONAL BIOSECURITY PLAN FOR MICRONESIA AND HAWAI'I

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #3; Goal #3, Objectives #1-2 and 4; Goal #4, Objectives #1-4; and Goal #7, Objective #1.

- *Strategy*: Implement appropriate recommendations within the Regional Biosecurity Plan (RBP) (DON 2015d) that will reduce the risk of introduction and spread of invasive species on MCB Camp Blaz.
- *Action*: Develop standard language for biosecurity BMPs, update as necessary, to be included in project specifications that support prevention, such as vegetation management, and cleanliness standards for materials and equipment operating on the installation.
- *Action*: Conduct early detection surveys (EDS) for high-risk invasive species in training areas; at facilities for staging, storage, and movement of cargo/equipment and vehicles, and at other locations as deemed necessary.
- *Action*: Review and update, as appropriate, DoD Attachment M of the RBP every 3 years.
- *Action*: Develop, implement, and update (as necessary) a JRM biosanitation instruction to ensure cleanliness standards are adhered for the movement of cargo and equipment.
- *Action:* Continue to develop high-risk invasive species protocols and implement control and/or eradication measurement when necessary.

TIS-5: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #2-4; Goal #3, Objectives #1 and 4; and Goal #4, Objectives #1-4. This project supports conservation measures from the 2015 BO for the Mariana Islands Training and Testing (MITT) Program (2015 MITT BO) (USFWS 2015b).

- *Strategy*: Implement biosecurity conservation measures listed in the 2015 MITT BO from USFWS.
- *Action*: During training events, ensure 100% BTS canine inspection of aircraft and cargo/equipment departing for an off-island destination.
- *Action*: Ensure BTS awareness briefings for all military and contractor personnel prior to all MITT training activities.
- *Action*: Maintain invasive species rapid response capabilities to control and/or eradicate introduced non-established, non-native invasive species sighted in vicinity of DoD training areas and facilities used for staging, storage, and movement of military personnel, cargo, and vehicles associated with training activities.
- *Action*: Ensure training personnel conduct self-inspections to avoid potential introductions of invasive species to Guam. Personnel will inspect all gear and clothing for soil accumulations, seeds, invertebrates, and vertebrates.

- *Action*: Ensure all training activities adhere to the Armed Forces Pest Management Board Technical Guide 31 on washdown procedures for all vehicles and equipment arriving from off-island locations and departing Guam for off-island destinations via inspections as deemed necessary.
- *Action*: Develop and implement control and eradication protocols for high-risk invasive species as species are identified.

TIS-6: INVASIVE SPECIES MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #3 and 6; Goal #3, Objectives #1 and 4; and Goal #4, Objectives #1-3. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Control and eventually eradicate invasive plant and invertebrate species on MCB Camp Blaz to protect and restore habitat.
- *Action*: Annually survey high-risk areas for LFA using established protocols. If LFA is detected on MCB Camp Blaz, implement proven control and eradication actions, followed by post-eradication monitoring.
- *Action*: Implement BMPs for CRB: (1) annually evaluate the need for comprehensive bio-sanitation of dead coconut trees and implement as necessary, (2) implement proper green waste management, (3) assist in release of landscape-level biocontrol agents for CRB, (4) implement awareness and reporting program in high-risk areas, and (5) implement long-term monitoring program and monitor coconut trees.
- *Action*: Develop and implement Hazard Analysis Critical Control Plan (HACCP) requirements for construction related to the USMC relocation.
- *Action*: As management tools become available (i.e., as informed by management at Andersen), implement adaptive management actions to remove or control invasive insects, including, but not limited to, feasible local controls of cycad scale (e.g., hand applications to individual trees).

TIS-7: CONTROL FERAL DOGS AND CATS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1 and 4; and Goal #4, Objective #2.

- *Strategy*: Reduce threats to native species by implementing control measures as needed to control feral dogs and cats on MCB Camp Blaz.
- *Action*: Conduct population surveys of areas of highest conservation concern, and/or human safety to determine locations and estimate numbers of feral dogs and cats, review accepted control measures, and coordinate with U.S. Army veterinarian and installation pest control personnel to control by authorized means if impacts to ESA-listed species or other native wildlife are identified.
- *Action*: Update MCB Camp Blaz instructions regarding feral cat and dog policy by 2020. This instruction will clearly articulate roles and responsibilities for feral cat and dog control in various locations of the base and will outline outreach and education for base personnel and residents on pet ownership requirements.
- *Action*: Include U.S. Navy installation feral dog and cat policy information in all installation outreach material presented to military and civilian personnel, housing residents, and contractors.

9.1.5.4 Terrestrial Protected Species Management

Management of terrestrial threatened and endangered species on JRM-administered lands includes implementing programs to protect species, and coordinating efforts with the appropriate agencies. Key threats to threatened and endangered species that can lead to extirpation include:

- predation by BTS of native forest birds, lizards, and bats;
- overgrazing, rooting, and trampling of plants and wildlife habitat by feral ungulates;
- predation by feral cats, dogs, and pigs, as well as predation by monitor lizards on birds, bats, and sea turtles;
- human disturbance and poaching of sea turtles and Mariana fruit bats;
- mortality or injury to native plants and wildlife due to natural events (e.g., typhoons);
- low reproductive success due to small population numbers; and
- habitat loss and fragmentation due to development.

To address these key threats to listed species, JRM has conducted and continues to conduct numerous management and research projects to reduce BTS numbers at the local and landscape scale, control BTS at swiftlet caves at Naval Munitions Site (NMS), and to prevent their spread to other Pacific Islands through rigorous inspections and interdiction of outgoing cargo at DoD ports (i.e., Apra Harbor, Andersen AFB). Captive breeding programs conducted by Guam DAWR and mainland zoological institutions are maintaining populations of Guam rail and Guam kingfisher and are adding to the information needed for successful recovery of these species. Additional ecological research and monitoring is also being conducted by various agencies in Guam, including DoD, USDA, and U.S. Geological Survey (USGS).

In accordance with section 7 of the ESA, a federal agency shall consult with the USFWS to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species. The DON will coordinate with the USFWS and Guam NWR for any federal action that is within Overlay Refuge lands and is identified as providing habitat for threatened or endangered species. In addition, the DON will avoid, as the mission allows, impacts on habitat suitable for threatened and endangered species, and Guam-listed species.

Sensitive species are being managed by implementing specific management projects that enhance habitat for these species and by initiating specific strategies that address immediate needs of listed species on the installation. In addition, adherence to the goals set for threatened and endangered species management ensure that the installation remains in compliance with ESA and associated consultation requirements.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Protected Species Management (TPS) on MCB Camp Blaz. Additional protection measures for terrestrial protected species are presented in Section 9.4.1.6, *Terrestrial Natural Resources Law Enforcement*.

TPS-1: ESA-LISTED SPECIES MONITORING

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-4; and Goal #3, Objectives #1-2 and 4.

- *Strategy*: Implement an ESA-listed species monitoring program to inform adaptive management actions and avoid sensitive areas during operations, and training.
- *Action*: Conduct surveys to document distribution and abundance of ESA-listed invertebrates and plants, focusing on newly listed species. JRM will prioritize areas that have not been recently surveyed for ESA-listed species. The monitoring program will update endangered species

population distribution maps and Geographic Information System (GIS) databases with data used to inform adaptive management of listed species.

- *Action*: Management actions described under THM-3 will benefit ESA-listed invertebrates and plants. Additional actions may be identified following baseline surveys for species.

TPS-2: CONSERVATION OF LISTED SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-6; Goal #3, Objectives 1-2 and 4; Goal #4, Objective #2. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Determine the occurrence of ESA-listed species to allow for management actions to avoid and minimize impacts to protected and host plant species in construction footprints.
- *Action*: Conduct pre-construction surveys for ESA-listed species within construction footprints.
- *Action*: Translocate ESA-listed species within construction footprints that cannot be avoided into protected habitat or Forest Enhancement sites.
- *Action*: Propagate and outplant ESA-listed species known to occur on JRM lands inside ungulate fenced areas.
- *Action*: Maintain and monitor translocated plants.

TPS-3: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal # 2, Objective #4; and Goal #3, Objectives #1-2 and 4. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Implement conservation measures listed in the 2015 MITT BO from USFWS.
- *Action*: Ensure "No Wildlife Disturbance" and "No Training" in locations where listed species are known to occur.
- *Action*: Ensure all vehicular activities during training are restricted to designated and previously identified areas that do not contain listed species.
- *Action*: Ensure all training activities are consistent with the fire management plan in COMNAVMAR Instruction 3500.4A (Marianas Training Manual) (COMNAVMAR 2013).
- *Action*: Vegetation removal shall be limited to the maintenance of existing bivouac areas that do not contain listed species or habitat. No new bivouac areas are proposed under MITT. Maneuver units will remain tactical and not establish support camps.

TPS-4: MARIANA FRUIT BAT POPULATION MONITORING

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-4; Goal #3, Objectives #1 and 4.

- *Strategy*: Identify and monitor Mariana fruit bat populations at MCB Camp Blaz to maintain and identify habitat relationships.
- *Action*: Conduct annual surveys for fruit bats at MCB Camp Blaz.
- *Action*: Search for aggregating locations. If aggregations or new colony locations are detected, roost counts will commence in accordance with established survey protocols. If changes in roost

locations, colony size, or movement are detected, investigate potential threats or stressors that may be causing disturbance.

TPS-5: SEA TURTLE POPULATION PROTECTION AND ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-5; Goal #3, Objectives #1-2 and 4; Goal #4, Objective #2; Goal #6, Objective #1-2; and Goal #7, Objectives #1-2.

- *Strategy*: Monitor and protect sea turtles at Haputo IRA to maintain habitat and improve nesting success.
- *Action*: Conduct surveys to monitor long-term trends of spatial and temporal distribution of sea turtle nesting activity at Haputo IRA.
- *Action*: Protect sea turtle nests from ungulates and monitor lizard predation through screening and monitoring.
- *Action*: Implement shoreline vegetation management to increase the likelihood of successful hatching of sea turtles and hatchling turtles successfully traversing the strand vegetation and beach to access the ocean. Removal of invasive vegetation will enhance natural regeneration of native strand vegetation.
- *Action*: Incorporate outreach and education program that includes two annual beach clean-ups at Haputo Beach, public presentations to schools and incoming families, and information to recreational beach visitors through signage and outreach materials.
- *Action*: Fund a JRM sea turtle recovery coordinator position to coordinate sea turtle monitoring and recovery efforts across Navy lands and submerged lands and coordinate with INRMP partners (DoD, Territory agencies, NOAA Fisheries, and USFWS) to align JRM sea turtle actions with other efforts in the Marianas and improve coordination of sea turtle projects.
- *Action*: Continue nesting surveys (twice a week minimum during peak nesting season) and conduct additional surveys to identify additional nesting beaches or assess status of known nesting areas on JRM lands.
- *Action*: Mitigate any light pollution or predation that might be affecting nesting habitats.

9.1.5.5 Migratory Bird Management

JRM installations manage and monitor the effects that both military readiness and non-readiness activities have on migratory bird species and populations. Relevant regulations and policies include the Military Readiness Rule (50 CFR 21.15); the 2014 Memorandum of Understanding (MOU) between the DoD and USFWS to Promote the Conservation of Migratory Birds; and EO 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*. Through the implementation of the INRMP, proper management of migratory bird species and habitats, including the timely implementation of appropriate conservation practices, will help installations avoid or minimize impacts to migratory birds.

To meet the goals and objectives of the INRMP, the following management project was identified for Migratory Bird Management (MIG) on MCB Camp Blaz.

MIG-1: MONITORING OF MBTA-LISTED BIRD SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objective #1-2 and 4; and Goal #6, Objectives #1 and 4.

- *Strategy*: Improve understanding of MBTA-listed bird habitat use and bird/mission interactions to avoid and minimize effects of takes on MBTA-listed birds.

- *Action*: Evaluate long-term data sets to identify migratory bird species of concern (referred to as "Mission Sensitive Species" in the DoD 2017 Guidance for Migratory Bird Management in Integrated Natural Resource Management Plans) and determine interrelatedness between these species and mission activities. These data will inform refinements to monitoring protocols and whether additional management actions for migratory birds are necessary.
- *Action*: Implement bird-safe building designs for new construction (e.g., facilities, utilities, alternative energy projects, etc.). For example, install bird-safe building glass to prevent collisions and ensure proper siting for wind energy. Review and update, if necessary, template design and construction specifications to include bird-safe building design guidelines (e.g., see Reducing Bird Collisions with Buildings and Building Glass Best Practices (USFWS 2016).
- *Action:* Continue annual monitoring of MBTA-listed birds on MCB Camp Blaz to improve understanding of MBTA-listed bird habitat use and bird/mission interactions.

9.1.5.6 Terrestrial Natural Resources Educational Outreach

Conservation awareness is instrumental in creating conditions needed to manage natural resources. The JRM approach to awareness stresses education. It provides military personnel and the public with insights into installation natural environments and conservation challenges. The more educated people are about the unique and valuable natural resources on JRM-administered lands, the more responsibly they will act when using them. Education also promotes awareness of critical environmental projects and the rationale behind them. As activities such as habitat management, wildlife management, and land rehabilitation are generally accepted and understood, minimal effort is required to communicate conservation priorities to installation personnel, recreationists, and the general public. However, issues such as protection of sensitive areas for plant and wildlife species, invasive species management (ungulate management), wildfire suppression, and restrictions on some recreational activities in JRM-administered lands require effective conservation communication to garner positive support and, perhaps more importantly, to avoid adverse reactions from various users. A conservation awareness program must be directed to both installation and external interests if it is to be effective.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Natural Resources Educational Outreach (TEDU) on MCB Camp Blaz. These management projects are in parallel and in concert with those identified and discussed in Section 9.4.2.4, *Marine Natural Resources Educational Outreach*.

TEDU-1: ESA-LISTED SPECIES AND TERRESTRIAL RESOURCES OUTREACH

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7; Objective #1-2. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Improve awareness among DoD personnel and the public of threats and stressors to terrestrial resources, including protected species, and the importance of conserving natural resources on MCB Camp Blaz, in cooperative efforts with partners such as GovGuam and USFWS.
- *Action*: Install informational signs and interactive kiosks on MCB Camp Blaz recreational beaches.
- *Action*: Develop, update, and distribute multimedia for public education to incoming military personnel, contractors, schools, and other outreach opportunities that address appropriate behavior around threatened and endangered species and the consequences of introduced non-native plant and animal species. Outreach materials will be reviewed every 2 to 5 years.

- *Action*: Review and update, as needed, current outreach videos/media used during the orientation briefs viewed by 100% of new personnel upon arrival to Guam.
- *Action*: Educate contractors on BMPs associated with federal and Guam ESA-listed and invasive species.

TEDU-2: JRM NATURAL RESOURCES STEWARDSHIP OUTREACH AND PUBLIC ENGAGEMENT PROGRAM

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7, Objectives 1-3.

- *Strategy*: Implement a comprehensive natural resources outreach program regarding the federal, territorial, and base environmental regulations and policies, as well as information about the importance of protecting and conserving JRM's natural resources.
- *Action*: Update a comprehensive Natural Resources Stewardship Outreach online training system for military and civilian personnel.
- *Action*: Create a JRM Environmental Public Engagement Plan to outline the areas where JRM can significantly increase their outreach with military personnel and the public about appropriate behavior toward threatened and endangered species and the importance of conserving natural resources within JRM-administered lands and submerged lands.
- *Action*: Conduct marine debris clean-ups a minimum of twice yearly on sea turtle nesting beaches.
- *Action*: Utilize partnerships with the U.S. Coast Guard (USCG) and Naval Mobile Construction Battalions (SeaBees) during joint training exercises to minimize costs and raise awareness within military personnel of the importance of maintaining the beaches to protect threatened and endangered species and other marine and terrestrial natural resources.
- *Action*: MCB Camp Blaz will utilize annual high profile environmental days, such as Earth Day in April and the Ocean Conservancy's International Coastal Clean-up in September, to organize clean-ups and provide natural resource outreach materials to military personnel and other participants.
- *Action*: Develop, update, and implement a biosecurity education and outreach program for contractor personnel, military personnel, and dependents.

9.1.5.7 Terrestrial Natural Resources Law Enforcement

JRM has established the following objectives for enforcement: (1) enforce laws and regulations pertaining to the implementation of the natural resources program, (2) integrate natural resources enforcement into the overall natural resources program, and (3) use enforcement personnel to enhance the natural resources program at JRM.

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial Natural Resources Law Enforcement (TLAW) on MCB Camp Blaz.

TLAW-1: CONSERVATION LAW ENFORCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-3; Goal #2, Objectives #1-2, and 4; Goal #3, Objective #4; Goal # 6, Objectives #1-2; and Goal #7; Objectives #1-3.

- *Strategy*: Detect and deter unauthorized activity that negatively affects natural resources on MCB Camp Blaz (e.g., poaching, off-roading) through conservation law enforcement.
- *Action*: Establish a Conservation Law Enforcement Program by hiring a Conservation Law Enforcement Officer, and by partnering with other agencies as applicable, to enforce natural

resource laws, policies, and regulations on MCB Camp Blaz. The Conservation Law Enforcement Officer will conduct outreach and enforce natural resource regulations.

- *Action*: Protect sea turtles from poaching on nesting beaches and submerged lands.

9.1.5.8 Terrestrial Geographic Information System and Data Management

Natural resources data are stored and maintained within a centralized JRM GIS database. The GIS database also provides support for the entire environmental program and the training community. JRM uses GIS for complex analyses such as project siting, data interpolations, and risk assessments. GIS software enables installation staff to capture, store, update, manipulate, analyze, and display all forms of geographically referenced data and tabular information about natural and physical resources found on JRM-administered lands. The training of JRM staff and the allocation of their time to data entry, mapmaking, data analysis, and interpretation of the results determines the success of the installation GIS. Once fully developed, the installation GIS databases can be used for projects such as the following:

- providing maps with locations of species, vegetation communities, surface waters, and other areas of potential concern
- selecting suitable areas for construction activities
- planning land rehabilitation projects
- providing special maps for Environmental Awareness materials
- ensuring avoidance of threatened and endangered species habitats and other areas of special concern during construction projects
- identifying site options for use during National Environmental Policy Act (NEPA) evaluation of alternative sites
- calculating drainages and water flows
- determining wildlife habitat preferences

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial GIS and Data Management (TGIS) on MCB Camp Blaz.

TGIS-1: TERRESTRIAL NATURAL RESOURCES GIS AND DATA MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-5; and Goal #3, Objectives #1 and 4.

- *Strategies*:
  - Identify data gaps in terrestrial natural resources GIS to assist in the development of future data collection efforts, surveys, and management actions.
  - Ensure that GIS information is available to installation subject matter experts and military personnel, biologists, planners, contractors, and others in a timely manner to assist with planning and decision-making.
- *Action*: Update and continuously maintain existing centralized GIS database to effectively inform and guide future management of terrestrial natural resources on MCB Camp Blaz and meet natural resources goals and objectives. Readily available GIS data will be used to develop natural resources constraints maps for use in current and future JRM management and planning decisions for MCB Camp Blaz.

9.1.5.9 Summary – Terrestrial Resources Ecosystem Management

Implementation of the JRM INRMP program and the focused strategies and actions of the management projects for terrestrial resources provides a conservation benefit to the natural ecosystems within MCB

Camp Blaz by maintaining and enhancing the natural community structure, function, species diversity, and resiliency. Enhancing and restoring native habitats supports viable populations of native species and increases biodiversity. Furthermore, proactive invasive species prevention, early detection, and control reduces the risk of intra- and inter-island species introductions. Data from regular monitoring of protected species can be used to implement better management projects to enhance and restore habitat, reduce habitat fragmentation, buffer protected areas, implement new conservation strategies, and avoid and minimize impacts. Using this regional ecosystem-based approach for managing protected species and their associated ecosystems ensures that JRM remains in compliance with federal and territorial laws while supporting the operational functionality of the MCB Camp Blaz mission.

Twenty management projects addressing terrestrial natural resources management are proposed for implementation on MCB Camp Blaz:

- Terrestrial Habitat Management – 3
  - THM-1: Watershed Management
  - THM-2: Protection of Ecological Reserve Area
  - THM-3: Forest Enhancement
- Terrestrial Exotic and Invasive Species Management – 7
  - TIS-1: Brown Treesnake Interdiction
  - TIS-2: Brown Treesnake Suppression
  - TIS-3: Brown Treesnake Management for the Recovery of Protected Species
  - TIS-4: Implementation of Regional Biosecurity Plan for Micronesia and Hawai‘i
  - TIS-5: Mariana Islands Training and Testing Implementation of the Biological Opinion
  - TIS-6: Invasive Species Management
  - TIS-7: Control Feral Dogs and Cats
- Terrestrial Protected Species Management – 4
  - TPS-1: ESA-listed Species Monitoring
  - TPS-2: Conservation of Listed Species
  - TPS-3: Mariana Islands Training and Testing Implementation of the Biological Opinion
  - TPS-4: Mariana Fruit Bat Population Monitoring
  - TPS-5: Sea Turtle Population Protection and Enhancement
- Migratory Bird Management – 1
  - MIG-1: Monitoring of MBTA-listed Bird Species
- Terrestrial Natural Resources Educational Outreach – 2
  - TEDU-1: ESA-listed Species and Terrestrial Resources Outreach
  - TEDU-2: JRM Natural Resources Stewardship Outreach and Public Engagement Program
- Terrestrial Natural Resources Law Enforcement – 1
  - TLAW-1: Conservation Law Enforcement
- Terrestrial Geographic Information System and Data Management – 1
  - TGIS-1: Terrestrial Natural Resources GIS and Data Management

9.1.5.10 Marine Ecosystem Management

The mission of MCB Camp Blaz is to support the forces of the U.S. Pacific Fleet, U.S. Pacific Air Forces, USMC Forces Pacific, and other commands and warfighters based in Guam. JRM-administered submerged lands on MCB Camp Blaz offer a realistic training environment and provide significant recreational opportunities for military personnel and their families. These lands are presently influenced by natural and anthropogenic forces that drive the short- and long-term integrity of the resources. Monitoring surveys that

allow for trend analysis and provide information on reef resiliency helps draw connections between various stressors and their impact on marine communities. Surveys can also help establish the status and condition of populations of native marine flora and fauna. This information allows JRM to design and implement adaptive management projects that avoid and minimize impacts to marine resources, including federal and Guam ESA-listed marine species and their habitats, while allowing mission-essential training, operations, and recreational use on JRM-administered lands.

Maintaining healthy marine communities supports the military mission by avoiding or alleviating potential training restrictions and/or restrictions on recreational access and use, allowing MCB Camp Blaz to provide unimpeded support to DoD commands. The state of knowledge and the plans for managing marine resources on JRM-administered submerged lands differs from the management of terrestrial resources. The principal reason for the differences is that access to and direct knowledge of the marine resources by natural resource managers is extremely limited. Additionally, the cost and effort to obtain information about marine resources is typically much greater than that required for terrestrial resources. These restrictions could mean that evidence of the presence or the condition of resources may need to be inferred from indirect or infrequent measurements to a greater degree than is required on land. Therefore, the focus of this section of the INRMP for marine resources takes a different approach to the management of marine resources compared to terrestrial resources.

The content and projects described in the INRMP serve three purposes that are consistent with Overarching Goal #1, *Ensure Military Mission Sustainability and Environmental Compliance* (see Section 3.3.1, *Goals and Objectives*) but may not be held entirely in common with terrestrial resources:

- They serve the letter and spirit of the requirements of the Sikes Act for JRM to have a management plan for natural resources on its installation;
- They serve as a starting point for the basic characterization of information regarding the marine environment on JRM installations that is commonly understood between the DoD and resource agencies, and can be used for planning purposes for environmental compliance documents that will be prepared to support DoD actions; and
- They may allow JRM and NMFS to come to agreement that the management projects that are planned in the INRMP are sufficient to preclude the need to designate critical habitat for federal ESA-listed species on JRM-administered submerged lands and implementing actions to support their recovery.

The second item emphasizes the use of INRMP content and the results of INRMP projects to inform a basic understanding of marine resources in JRM-administered submerged lands. This understanding helps with planning costs, schedules, and requirements of proposed DoD projects, such as the type of NEPA document to be prepared, the presence of federal ESA-listed species, the type of natural resources consultations to expect, and the estimated quantity of resources and/or habitat that could be impacted. It is understood that additional detailed, site-specific studies are likely to be necessary for NEPA analyses and associated consultations.

The purpose of this section is to identify projects with specific strategies for MCB Camp Blaz and to obtain workable and useful solutions for marine natural resources management. In accordance with OPNAV M-5090.1 and the principles of adaptive ecosystem management, marine natural resources management goals, objectives, strategies, and actions were developed for MCB Camp Blaz by an interdisciplinary team of ecologists, biologists, geologists, planners, and environmental scientists. Management of the submerged lands and associated marine resources administered by JRM: (1) protects and conserves threatened and endangered species through habitat conservation and enhancement, (2) promotes health and sustainability

of coral reefs, (3) provides continued access to recreational areas, and (4) provides continued use and access to training areas ensuring no net loss to the military mission.

The overall strategy follows a cycle of: (1) understanding the spatial distribution and types of marine habitat on JRM-administered submerged lands, (2) characterizing the species and communities that occur in the various habitats, (3) determining the condition of the resources in the habitat, (4) determining how species that are present use or contribute to the habitat, and (5) managing the effects of stressors or threats on protected resources.

Adaptive management is intended to be an active part of all facets of the progression of resource management. Basic data collection to characterize a resource could be an endless process. Adaptive management will help to prioritize and focus effort to know when an emphasis needs to be on basic characterization, when responding to threats should be stressed, and what kind of balance between the two pursuits should be struck. Steps in the progression may be leaped past if conditions or information indicate a different step in the progression is needed. Adaptive management is not only depended on to determine what actions to take; it is also intended as a way to collaboratively review what is known about a resource so a collective agreement can be made on the next steps.

Similar to the terrestrial natural resources management program, the marine natural resources management program is divided into the following categories:

- Marine Habitat Management
- Marine Invasive Species Management
- Marine Protected Species Management
- Marine Natural Resources Educational Outreach
- Marine Natural Resources Law Enforcement
- Marine Natural Resources GIS and Data Management

As appropriate and applicable, all management projects will require evaluation or monitoring criteria, which are used to track the status of the management project, and whether the management project: (a) addresses no net loss to the capability of MCB Camp Blaz to support the military mission and (b) meets the identified goals and objectives. At a minimum, mid-year coordination meetings will be held with resource agencies to discuss ongoing and planned projects to include prioritization, scope, methodology, issues encountered, timelines, and evaluation or monitoring criteria; these factors will also be discussed at the annual INRMP Metrics meeting. These conversations are meant to facilitate information sharing and enable JRM and the agencies to take an adaptive management approach to managing INRMP projects. This approach will mean that projects are managed more dynamically and will be more responsive to arising needs than a static 5-year plan would be. A summary of the management project and the estimated timeframe for completion is presented in Table 13-10, *Planned Implementation Summary of Projects at MCB Camp Blaz* found in Chapter 13, *Planning, Integration, and Implementation*.

Some of the management projects described in the following sections will be accomplished through interactive partnerships with federal and territorial natural resource agencies, universities, and local organizations. JRM natural resources management staff will establish partnerships with personnel at these organizations based on the benefits to the regional ecosystem and the local environment.

9.1.5.11 Marine Habitat Management

Marine resources are inherently challenging to describe due to their inaccessibility, and in many cases, low detectability. The initial approach to marine resource assessment is to describe the baseline, answering the

question "what is there?" This is typically done by scuba divers who record species richness and abundance within a study site that is representative of a larger area. Habitat mapping is often done in advance of baseline assessments to provide spatial context for "where" marine resources are distributed. Additionally, developing habitat maps initially helps to determine how to subdivide the study area into representative sections (i.e., strata) and how to extrapolate those baseline assessments into a larger context. However, baseline assessments are often not designed specifically to be repeatable. Repetition is critical to obtain sufficient statistical power that allows for the detection of change over time in various metrics. Monitoring designs typically increase statistical power by designing surveys that are repeatable with very high precision. Both baseline assessments and monitoring programs are essential for marine resource managers, who must first understand what resources are present and how they are distributed, and then how military operations and corresponding management actions affect those resources through time. When monitoring detects substantial changes in marine resource communities, the baseline must be adjusted.

Interagency efforts to develop consistent methods for evaluating impacts to nearshore marine resources and determining suitable mitigations that offset lost ecological functions and services are supported by the DON, NMFS, USFWS, U.S. Environmental Protection Agency, and U.S. Army Corps Engineers. Standardized methods that agencies can agree on are expected to benefit processes associated with NEPA, interagency consultations (e.g., ESA), Clean Water Act (CWA) Section 404 permitting, and natural resources management. Interim results from the interagency effort are expected in the near term for consideration, but repeatable processes that are agreed on by all agencies are expected to be established over the next 5 to 10 years.

Management projects in offshore areas are primarily focused on outreach and education and monitoring associated with testing and training given that the resources are mobile and wide-ranging and the logistical challenges of managing those resources. Divers cannot easily access marine resources below 98-131 feet (30-40 meters). Autonomous and remotely operated vehicles can be used to observe and assess resources at greater depths, but implementing management projects remotely is challenging enough with the current state of technology; therefore, autonomous/remotely operated vehicles are not a practical solution for most INRMP management projects.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Marine Habitat Management (MHM) on MCB Camp Blaz.

MHM-1: CORAL HABITAT ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-6; Goal #3, Objectives #1-2 and 4; and Goal #5, Objectives #1-2.

- *Strategy*: Enhance coral habitat by monitoring health and acute impacts and through focused reef restoration efforts.
- *Action*: Establish long-term monitoring programs to track changes in the health of corals and water quality that is compatible with existing monitoring programs in Guam and the region.
- *Action*: Work with regulatory partners and local subject matter experts to identify priority resilience indicators. Using the same or similar methods to Maynard et al. (2015), synchronize data sets for at least one meaningful monitoring period to allow JRM sites to be compared to other sites within the Guam Coral Reef Resilience Assessment. Existing monitoring data from survey efforts that were initiated in 2012 will also inform this process (Schils et al. 2017). The measures for assessing resilience include: macroalgae percent cover (to be obtained as coarse level data in the benthic

habitat mapping project), coral community (available for some sites from past studies), bleaching resistance, coral recruitment and connectivity, coral diversity (available for some sites from past studies), herbivore average functional group biomass, temperature variability, land-based sources of pollution, and accessibility due to wave exposure.

- *Action*: Using the results obtained above, further refine priority sites (e.g., those that have high resilience factor) for targeted management actions. Examples of targeted management actions, include but are not limited to actions that improve water quality (e.g., reduce land base sources of pollution or runoff, wetland/mangrove enhancement), fisheries management and enforcement (see MLAW-1), no anchoring areas, outreach, and targeted reef restoration actions (e.g., macroalgae control, outplanting of coral recruits). JRM is already taking steps to address a number of these actions which are described further below.
- *Action*: JRM has programmed for annual monitoring to include pre, during and post monitoring around bleaching events, coral disease, and active intervention during COTS outbreaks on MCB Camp Blaz submerged lands. JRM is working with partners locally to align monitoring strategies and will adapt as necessary. Monitoring methodology will be coordinated with the Guam Coral Reef Response Team, an interagency effort between NOAA, USFWS, National Park Service, Guam DAWR, Guam Bureau of Statistics and Plans, Guam Environmental Protection Agency, UOG Marine Laboratory, and DON. Utilize monitoring results to develop and prioritize response actions (e.g., implement control efforts in a timely manner using best available methods such as bile salts or sodium bisulphate) if COTS outbreaks are detected, minimize harmful activities at sensitive sites during coral bleaching events to reduce local stress to corals.
- *Action*: Develop protocol for immediate assessment and response to reef damage caused by unanticipated events such as vessel groundings and anchor damage. The protocol will outline responsible parties, coordination process, and initial reef damage assessment requirements. This protocol will inform the long-term response plan.
- *Action*: JRM will coordinate with local partners and subject matter experts to determine appropriate locations and methods for coral population enhancement and restoration efforts. JRM will align projects with the proposed Guam Restoration Strategy (in development). This may include projects that include sexual propagation that collect gametes, settle them on tiles, and eventually outplant new colonies, but can also include outplanting colonies, clones, or asexual propagation from fragments, or other restoration strategies such as algal removal.
- *Action*: Reduce adverse impacts from commercial and recreational boating to coral reef habitat and EFH due to improper vessel anchoring by installing and maintaining one or more mooring buoys at Double Reef.
- *Action:* Provide awareness on shallow mooring systems buoy locations to the local fishing community.
- *Action*: Participate in bi-annual Guam Coral Reef Task Force and the reef restoration working group.
- *Action*: Conduct studies to monitor sediment and nutrient loads in time and space fo' managing stressors' inputs to the coastal and coral reef areas. Utilize a Soil and Water Assessment Tool (SWAT) model to simulate flow, soil erosion, sediment, nutrient transport, and for evaluating the effect of climate change, land use change, and BMP applications.
- *Action*: Develop protocol for immediate assessment and response to reef damage caused by natural disasters/events such as typhoons, tsunamis, heat waves, extreme flooding, and earthquakes.

MHM-2: MARINE RESOURCES DATA ANALYSIS AND COORDINATION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1; Objective #1; Goal #2, Objectives #1 and 3-4; Goal #3, Objective #4; and Goal #7, Objective #3.

- *Strategy*: Establish long-term partnership with NMFS PIFSC to improve communication, collaboration, and information sharing to ensure the most up-to-date NOAA Pacific RAMP data are analyzed and available to inform JRM INRMP adaptive management strategies.
- *Action*: Develop an agreement with NMFS PIFSC to address critical data needs from tri-annual NOAA Pacific RAMP surveys for sites within JRM-administered submerged lands to evaluate trends over time and inform management actions. JRM will work with NMFS PIFSC to develop a scope, to determine an acceptable cycle for data analysis (e.g., within 12-18 months of survey completion), and to identify data categories and survey locations to prioritize for analysis. At a minimum, the analysis will include a summary of findings from coral, algal, benthic, and fish surveys within JRM-administered submerged lands on MCB Camp Blaz and associated figures.

MHM-3: MARINE HABITAT MAPPING EFFORTS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objectives #1 and 3-5; Goal #3, Objectives #1 and 4; Goal #5, Objective #1; and Goal #7, Objectives #3.

- *Strategy*: Classify and delineate benthic mapping and characterization in the nearshore waters of JRM-administered submerged lands on MCB Camp Blaz, focusing on depths from 0-66 feet (0-20 meters) and 66-131 feet (20-40 meters) depending on water visibility.
- *Action*: Provide baseline data for monitoring changes in coral reef and marine benthic communities that are compatible with existing monitoring programs in Guam and the region.
- *Action:* Obtain high resolution habitat maps of submerged habitat to inform priorities as well as avoidance and minimization measures during DON activities.
- *Action*: Work with NOAA National Centers for Coastal Ocean Science (NCCOS) to classify and delineate benthic habitats in the nearshore waters of JRM-administered submerged lands on MCB Camp Blaz using side scan or multibeam sonar. Results from this project will be used to map threatened and endangered species (e.g., sea turtles, corals, and scalloped hammerhead shark), EFH, and indicator of health.
- *Action*: Work with NOAA NCCOS to perform mapping projects of previously mapped locations/installations every 5 years to study/monitor temporal and spatial changes in habitat.

MHM-4: U.S. NAVY DIVER TRAINING FOR SUBMERGED NATURAL RESOURCES MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; and Goal #7, Objective #3.

- *Strategy*: Have NAVFAC Marianas marine resource specialists that are capable of participating in rapid assessment surveys of marine resources when necessary with other federal and territorial agencies.

- *Action*: NAVFAC Marianas marine resources specialists will complete Navy Diver Training (Navy prerequisite for conducting in-water work) to obtain the qualifications necessary to actively monitor and report on the health of marine resources on JRM-administered submerged lands.

9.1.5.12 Marine Invasive Species Management

An invasive species is defined in EO 13112 as a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm, or harm to human, animal, or plant health. Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions. As with terrestrial ecosystems, marine invasive species can have a significant effect on the native marine species of island ecosystems.

Marine invasive species control and removal efforts are mandated by similar federal, DoD, and JRM regulations as terrestrial invasive species. The DON funded the development of the RBP for MIcronesia and Hawai‘i (DON 2015d). The RBP is a multi-disciplinary effort of federal and regional scientists and experts to address pathways and encourage a more holistic approach to evaluating and managing terrestrial, marine, and freshwater invasive species risks within Micronesia and Hawai‘i. The DON/JRM will implement necessary and appropriate DoD recommendations of the RBP (refer to Volume I, Attachment M, U.S. DoD Biosecurity Recommendations).

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Marine Invasive Species Management (MIS) on MCB Camp Blaz.

MIS-1: IMPLEMENTATION OF REGIONAL BIOSECURITY PLAN FOR MICRONESIA AND HAWAI‘I

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #3; Goal #3, Objectives #1-2 and 4; Goal #4, Objectives #1-4; and Goal #7, Objective #1.

- *Strategy*: Implement recommendations within the RBP that are applicable to JRM (DON 2015d) that would avoid and minimize: (1) new invasive species incursions into Guam's marine waters and (2) the transfer of invasive specieI from Guam to Hawai‘i and other parts of Micronesia.
- *Action*: Develop and maintain a Marine Invasive Species Management Plan for MCB Camp Blaz. This plan would include, but not be limited to, the following:
    1) Establish a watch list and effective monitoring program for high-risk non-native marine species that are known or thought to pose significant ecological, economic, social, or cultural impacts to Guam and CNMI, focusing on species that are not established or widely distributed in the region. The watch list will be coordinated and consistent with the Guam Marine Biosecurity Action Plan (Miller 2014) Appendix C on potential marine invasive species.
    2) Develop early detection and response protocols for new incursions by a few focal non-native marine species for Guam and CNMI.
    3) Develop standard language to be included in contract specifications that provides BMPs to lessen the risk of marine invasive species being transported to project sites.
- *Action*: JRM will work with appropriate U.S. Navy commands to determine if updates are warranted for Navy hull husbandry standards (NAVSEA S9086-CQ-STM-010) (U.S. Navy 2006) and ballast water requirements (*Note: The U.S. Navy adopts USCG standards*).
- *Action*: Implement JRM Marine Invasive Species Management Plan. Perform MIS baseline surveys for all installations. Implement necessary actions/protocols based on baseline results.

- *Action:* Create a marine invasive species database for JRM submerged lands.

MIS-2: FEDERAL AND TERRITORIAL COORDINATION AND COLLABORATION FOR MARINE INVASIVE SPECIES PREVENTION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #4; Goal #4, Objective #4; and Goal #7, Objective #3.

- *Strategy*: Develop partnerships to improve coordination and collaboration with other federal and Guam agency staff, industry, and non-governmental organizations and seek opportunities to synergize funding, resources, and efforts to accomplish common goals (i.e., those outlined in the 2014 Guam Marine Biosecurity Action Plan (Miller 2014).
- *Action*: Participate in the quarterly Guam Invasive Species Advisory Council meetings and coordinate regularly with the territorial marine invasive species coordinator once hired.
- *Action*: Develop partnerships to improve coordination and collaboration with other Pacific Island governments as well, such as Palau, FDM, CNMI, New Zealand, and Australia.

9.1.5.13 Marine Protected Species Management

Management of marine threatened and endangered species on JRM-administered submerged lands includes implementing programs to protect species and coordinating efforts with the appropriate agencies. An INRMP is a primary tool for the DoD to fulfill its obligation to support section 7(a)(1) of the ESA, which states that all federal departments and agencies shall seek to conserve listed species and shall use their authorities to further the purpose of the ESA. In accordance with section 7(a)(2) of the ESA, a federal agency shall consult with NMFS to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species. In addition, the DON avoids impacts on habitat suitable for federal and Guam ESA-listed species, as the mission allows.

Federal ESA-listed species on JRM-administered submerged lands will continue to be managed by implementing specific management strategies that enhance habitat for these species and by initiating specific strategies that address immediate conservation needs of listed species on the installation. To meet the goals and objectives of the INRMP, a suite of management projects was identified for Marine Protected Species Management (MPS) on MCB Camp Blaz. Additional protection measures for marine protected species are presented in Section 9.4.2.5, *Marine Natural Resources Law Enforcement*.

MPS-1: SCALLOPED HAMMERHEAD SHARK SURVEY

This project supports the following goals and objectives identified in Section 3.3.1, *Overarching Goals and Objectives*: Goal #1, Objectives #1-2; and Goal #3, Objectives #1-2 and 4. This project supports conservation measures from the ESA section 7 Consultation BO and Conference Report for the U.S. Military MITT Activities (NMFS 2020).

- *Strategy*: Conduct surveys to determine the temporal and spatial abundance, distribution, and habitat use of the threatened scalloped hammerhead shark adjacent to the MCB Camp Blaz.
- *Action*: Monitor shark population movements, habitat use, and behavior through capture and acoustic or satellite tagging efforts.

MPS-2: SEA TURTLE POPULATION PROTECTION AND ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Overarching Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1-2 and 4; and Goal #7, Objective #3.

- *Strategy*: Monitor sea turtle activity and determine habitat use in the marine waters of JRM-administered submerged lands and adjacent Guam waters.
- *Action*: Examine distribution, movement, and habitat use of sea turtles on JRM-administered submerged lands around Guam. Up to 300 Passive Integrated Transponder tags will be attached to turtles captured by JRM. Of the turtles captured and fitted with Passive Integrated Transponder tags, 34 will be outfitted with GPS satellite telemetry or archival tags to monitor movement and collect data on habitat use (i.e., habitat type, depth, time at depth); drifters will be deployed to examine dispersal of hatchlings.
- *Action*: Continue to coordinate efforts with U.S. Pacific Fleet as long as their complementary sea turtle monitoring efforts continue.
- *Action*: Implement and coordinate water quality monitoring and ecosystem monitoring to evaluate runoff and implement actions to mitigate effects of erosion.
- *Action*: Continue in-water surveys and conduct additional surveys within JRM submerged lands to identify additional foraging/resting areas.

9.1.5.14 Marine Natural Resources Educational Outreach

Conservation awareness is instrumental in creating conditions needed to manage natural resources. The JRM approach to awareness stresses education. It provides military personnel and the public with insights into installation natural environments and conservation challenges. Education promotes awareness of threats and stressors to marine resources and threatened and endangered species. Activities such as habitat management, natural resources management, and submerged lands rehabilitation can be assisted by increasing the public's awareness of the importance of conserving the natural resources within JRM-administered submerged lands. However, issues such as protection of sensitive marine areas for fish and wildlife species, invasive species management, and restrictions on some recreational activities within JRM-administered submerged lands, require effective outreach with the public and military personnel in order to garner support and, perhaps more importantly, to avoid adverse reactions from various user impacts. An outreach program focused on minimizing impacts to marine resources and protecting federal ESA-listed marine species must be directed to both installation and external stakeholders to be effective.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Marine Natural Resources Educational Outreach (MEDU) on MCB Camp Blaz. These management projects are in parallel and in concert with those identified and discussed in Section 9.4.1.5, *Terrestrial Natural Resources Educational Outreach*.

MEDU-1: ESA-LISTED SPECIES AND MARINE RESOURCES OUTREACH

This project supports the following goals and objectives identified in Section 3.3.1, *Overarching Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7, Objectives #1-2. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Implement a targeted outreach program to improve awareness among DoD personnel and the public of threats and stressors to marine resources, including protected species, and the importance of conserving natural resources on MCB Camp Blaz through cooperative efforts with partners such as GovGuam and USFWS.
- *Action*: Install and maintain informational signs and interactive kiosks on MCB Camp Blaz recreational beaches.

- *Action*: Develop, update, and distribute multimedia for public education to incoming military personnel, contractors, schools, and other outreach opportunities that address appropriate behavior around threatened and endangered species and the consequence of introduced non-native plant and animal species. Outreach materials will be reviewed every 2 to 5 years.
- *Action*: Review and update, as needed, current outreach videos/media used during the orientation briefs viewed by 100% of new personnel upon arrival to Guam.
- *Action*: Coordinate with the dive shops to help promote environmental education and awareness to reduce negative recreational impacts on JRM-administered submerged lands.

MEDU-2: JRM NATURAL RESOURCES STEWARDSHIP OUTREACH AND PUBLIC ENGAGEMENT PROGRAM

This project supports the following goals and objectives identified in Section 3.3.1, *Overarching Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7, Objectives #1-3.

- *Strategy*: Implement a comprehensive natural resources outreach program regarding the federal, territorial, and base environmental regulations and policies, as well as information about the importance of protecting and conserving JRM's natural resources.
- *Action*: Update a comprehensive Natural Resources Stewardship Outreach online training system for military and civilian personnel.
- *Action*: Create a JRM Environmental Public Engagement Plan to outline the areas where JRM can significantly increase their outreach with military personnel and the public about appropriate behavior toward threatened and endangered species and the importance of conserving natural resources within JRM-administered lands and submerged lands.
- *Action*: Conduct marine debris clean-ups a minimum of twice yearly on sea turtle nesting beaches.
- *Action*: Utilize partnerships with the USCG and Naval Mobile Construction Battalions (SeaBees) during joint training exercises to minimize costs and to raise awareness within military personnel of the importance of maintaining the beaches to protect threatened and endangered species and other marine natural resources.
- *Action*: Use annual high profile environmental days, such as Earth Day in April and the Ocean Conservancy's International Coastal Clean-up in September, to organize clean-ups and provide natural resource outreach materials to military personnel and other participants.
- *Action*: Develop outreach materials for the public and military personnel about the importance of using reef-safe sunscreen to minimize impacts on the reefs and to educate military personnel and other participants about the importance of disposing trash properly and distribute this information at marine debris clean-up events.
- *Action*: Develop, update, and implement a biosecurity education and outreach program for contractor personnel, military personnel, and dependents.

9.1.5.15 Marine Natural Resources Law Enforcement

JRM has established the following objectives for enforcement: (1) enforce laws and regulations pertaining to the implementation of the natural resources program, (2) integrate natural resources enforcement into the overall natural resources program, and (3) use enforcement personnel to enhance the natural resources program at JRM.

To meet the goals and objectives of the INRMP, the following management project was identified for Marine Natural Resources Law Enforcement (MLAW) on MCB Camp Blaz.

MLAW-1: CONSERVATION LAW ENFORCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Overarching Goals and Objectives*: Goal #1, Objectives #1-3; Goal #2, Objectives #1-2 and 4; Goal #3, Objective #4; Goal # 6, Objectives #1-2; and Goal #7; Objectives #1-3.

- *Strategy*: Detect and deter unauthorized activity that negatively affects marine natural resources on MCB Camp Blaz (e.g., poaching, littering, improper vessel anchoring, illegal fishing) through conservation law enforcement.
- *Action*: Establish a Conservation Law Enforcement Program, by hiring a Conservation Law Enforcement Officer and by partnering with other agencies as applicable, to enforce natural resource laws, policies, and regulations on MCB Camp Blaz. The Conservation Law Enforcement Officer will conduct outreach and enforce natural resource regulations.
- *Action*: Protect sea turtles from poaching on nesting beaches and submerged lands.

9.1.5.16 Marine Geographic Information System and Data Management

Natural resources data are stored and maintained within a centralized JRM GIS database using GIS data collection standards. The GIS database provides support for the entire environmental program and the training community. JRM uses GIS for complex analyses such as project siting, data interpolations, and risk assessments.

GIS software enables installation staff to capture, store, update, manipulate, analyze, and display all forms of geographically referenced data and tabular information about natural and physical resources found on JRM-administered submerged lands. The training of JRM staff and the allocation of their time to data entry, mapmaking, data analysis, and interpretation of the results determines the success of the installation GIS. Once fully developed, the installation GIS databases can be used for projects such as the following:

- providing maps with bathymetric contours and locations of species, marine habitat, EFH, and other areas of potential concern
- providing special maps for Environmental Awareness materials
- ensuring avoidance of threatened and endangered species habitats and other areas of special concern during construction projects
- identifying site options for use during NEPA evaluation of alternative sites
- calculating drainages and water flows
- determining species habitat preferences

To meet the goals and objectives of the INRMP, the following management project was identified for Marine GIS and Data Management (MGIS) on MCB Camp Blaz.

MGIS-1: MARINE NATURAL RESOURCES GIS AND DATA MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Overarching Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-5; and Goal #3, Objectives #1 and 4.

- *Strategies*:
  - Identify data gaps in marine natural resources GIS to assist in the development of future data collection efforts, surveys, and management actions.
  - Ensure that GIS information is available to installation subject matter experts and military personnel, biologists, planners, contractors, and others in a timely manner to assist with planning and decision-making.

- *Action*: Update and continuously maintain existing centralized GIS database to effectively inform and guide future management of marine natural resources on MCB Camp Blaz and meet natural resources goals and objectives. Readily available GIS data can be used to develop natural resources constraints maps for use in current and future JRM management and planning decisions for MCB Camp Blaz.
- *Action:* Create a marine invasive species database for JRM submerged lands.

9.1.5.17 Summary – Marine Ecosystem Management

Implementation of the JRM INRMP program and the focused strategies and actions of the management projects for marine resources provides a conservation benefit to the marine ecosystem on MCB Camp Blaz by maintaining and enhancing marine community structure, function, species diversity, and resiliency. Inventorying and monitoring helps maintain and improve the local scientific knowledge of coral reef ecosystems and their resilience to environmental stressors, guide adaptive management solutions, and aid in avoidance and minimization of potential impacts to sensitive resources. Furthermore, proactive invasive species prevention, early detection, and control reduces the risk of intra- and inter-island species introductions. Using this regional ecosystem-based approach for managing protected species and their associated ecosystems ensures that JRM remains in compliance with federal and territorial laws while supporting the operational functionality of the MCB Camp Blaz mission.

Twelve management projects addressing marine natural resources management are proposed for implementation on MCB Camp Blaz:

- Marine Habitat Management – 4
  - MHM-1: Coral Habitat Enhancement
  - MHM-2: Marine Resources Data Analysis and Coordination
  - MHM-3: Marine Habitat Mapping Efforts
  - MHM-4: U.S. Navy Diver Training for Submerged Natural Resources Management
- Marine Invasive Species Management – 2
  - MIS-1: Implementation of Regional Biosecurity Plan for Micronesia and Hawai‘i
  - MIS-2: Federal and Territorial Coordination and Collaboration for Marine Invasive Species Prevention
- Marine Protected Species Management – 2
  - MPS-1: Scalloped Hammerhead Shark Survey
  - MPS-2: Sea Turtle Population Protection and Enhancement
- Marine Natural Resources Educational Outreach – 2
  - MEDU-1: ESA-listed Species and Marine Resources Outreach
  - MEDU-2: JRM Natural Resources Stewardship Outreach and Public Engagement Program
- Marine Natural Resources Law Enforcement – 1
  - MLAW-1: Conservation Law Enforcement
- Marine Geographic Information System and Data Management – 1
  - MGIS-1: Marine Natural Resources GIS and Data Management

9.2 LIVE-FIRE TRAINING RANGE COMPLEX

9.2.1 Current Operations and Land Use

9.2.1.1 Land Ownership and Management

The DoD in Guam supports Marine Corps activities to maintain operational readiness, which involves preserving the ability of units to respond to threats and to protect the interests of the U.S. and its allies in the region. The Live-Fire Training Range Complex is located on former Andersen AFB land at Ritidian Point.

9.2.1.2 Training Areas

The Live-Fire Training Range Complex includes the following ranges:

Known Distance Rifle Range: The Known Distance Rifle Range encompasses approximately 18.5 acres (7.5 hectares) and has 50 firing points for 5.56-millimeter weapons. It is 178 yards (163 meters) wide and 500 yards (457 meters) from the farthest firing line to the target line. The range also includes a 25-foot (8-meter) tall impact berm behind the target line.

Known Distance Pistol Range: The Known Distance Pistol Range encompasses approximately 0.4 acres (0.2 hectares) and provides 25 firing points for training with 9-millimeter and 0.45-caliber weapons. The range is 41 yards (37.5 meters) wide by 50 yards (46 meters) long with level ground from the firing line to the target line. The range also includes a 12-foot (4-meter) tall impact berm behind the target line and 12-foot (4-meter) lateral berms.

Non-standard Small Arms Range: The Non-standard Small Arms Range encompasses approximately 1.5 acres (0.6 hectares) and provides 25 firing points, and is used for training with 5.56-millimeter weapons. The range is 68 yards (62.5 meters) wide by 109.4 yards (100 meters) long with level ground from the 91-meter firing line to the target line. There is a 16-foot (5-meter) tall impact berm behind the target line, and 16-foot (5-meter) lateral berms.

Modified Record of Fire Range: The Modified Record of Fire Range encompasses approximately 7.9 acres (3.2 hectares) and has 16 firing points for use by 5.56-millimeter weapons. This live-fire range area is 175 yards (160 meters) wide by 219 yards (200 meters) in length with a 25-foot (8-meter) tall impact berm at the far end of the range.

Multi-Purpose Machine Gun Range: The Multi-Purpose Machine Gun Range encompasses approximately 59 acres (24 hectares) and has eight stationary firing lanes to support training with 5.56-millimeter, 7.62-millimeter, and 0.50-caliber weapons, and 40-millimeter inert training rounds (i.e., non-explosive). The range is 175 yards (160 meters) wide at the firing line, expanding to 350 yards (320 meters) wide at the far end of the range. The range is 1093.6 yards (1,000 meters) long and includes a 25-foot (8-meter) tall impact berm at the far end of the range.

The Live-Fire Training Range Complex includes a range operations tower, target storage and maintenance sheds, ammunition issue points, covered bleachers, portable toilets, perimeter fencing, safety signage and lighting, and parking.

9.2.2 Special Conservation Areas

Live-Fire Training Range Complex has several areas designated for conservation of natural resources. Figure 8-2 shows the locations of these areas.

9.2.2.1 Overlay Refuge Lands

Overlay Refuge lands were established in 1994 and provide a commitment by the DoD and USFWS for a coordinated program with Guam DAWR. The program is centered on the protection of threatened and endangered species and other native flora and fauna, the maintenance of native ecosystems, and the conservation of native biological diversity. The program does recognize that the primary purpose of Overlay Refuge lands is to support the national defense mission of the USAF (GovGuam et al. 1993; USAF and USFWS 1994).

Approximately 710.5 acres (387.53 hectares) of Overlay Refuge lands are designated on Live-Fire Training Range Complex (Figure 8-2). These lands are currently managed by JRM and were originally identified as providing important habitat for federal ESA-listed threatened and endangered species (e.g., Mariana crow [*Corvus kubaryi*], Guam kingfisher [*Todiramphus cinnamominus*], Guam rail [*Gallirallus owstoni*], and *Serianthes nelsonii*) as well as other Guam native species. The Overlay Refuge lands on Live-Fire Training Range Complex consist primarily of limestone degraded forest (269 acres [1,110 hectares]), and limestone native forest (310 acres [829 hectares]). Altogether, these two vegetation communities cover 81.5% of the Live-Fire Training Range Complex lands.

9.2.2.2 Ungulate Exclosures

Fenced ungulate exclosures are designed to enhance native habitat through the removal and exclusion of Philippine deer (*Rusa marianna*) and feral pigs (*Sus scrofa*). JRM is committed to erecting ungulate fencing in priority habitats on Live-Fire Training Range Complex. Ungulate enclosures encompass 642.13 acres [259.86 hectares]) of Live-Fire Training Range Complex lands.



USGS BTS Research Unit, Live-Fire Training Range, MCB Camp Blaz
(*Photo*: MCB Camp Blaz)

9.2.2.3 Guam Micronesian Kingfisher Memorandum of Agreement Recovery Habitat

As mentioned in Section 4.4.3.2, *Birds*, a MOA was signed between DON and USFWS to establish Recovery Habitat for the Guam kingfisher. A modification to the MOA was signed in December 2015, identifying 5,211 acres (2,108 hectares) (1,357.7 acres [549.4 hectares] within MCB Camp Blaz) of habitat that will be protected such that the land is suitable for the kingfisher. Live-Fire Training Range Complex includes 12.9 acres (5.22 hectares) of this suitable habitat. The MOA also requires habitat protection to offset any impacts to the habitat brought on as a result of the Guam Military Relocation (DON and USFWS 2015a, 2015b).

9.2.2.4 USGS BTS Closed Population Research Unit

The USGS maintains a 5-hectare BTS research unit on the Live Fire Training Complex. The area is used to study BTS behavior and to determine best methods for eradication and detection. All snakes within the unit are tagged and enclosed by a fence with wire mesh overlay to prevent movement in or out of the area.

9.2.3 Terrestrial Environment

As Live-Fire Training Range Complex was formerly part of Andersen AFB, the terrestrial environment is very similar to that described under Section 8.2. As such, the below text often refers to figures and tables in this section for more detail.

9.2.3.1 Geology, Topography, and Soils

Geology

Geologic Units

Live-Fire Training Range Complex is situated on a plateau that is composed of old (Barrigada) and young (Mariana) limestone bedrock (Figures 8-3 and 8-4). Cavities and sinkholes occur in the porous limestone karst. Rainwater easily percolates through the porous limestone (Gingerich 2003).

Seismology

Live-Fire Training Range Complex overlies a minor fault line and is susceptible to earthquake events. However, the overall likelihood for landslides to occur on northern Guam is generally low due to the lack of steep areas with soil vulnerable to slipping in seismic events. The Guam Hazard Mitigation Plan reports that the northern portion of Guam near Live-Fire Training Range Complex has a high-risk of liquefaction (Guam Homeland Security 2014).

Topography

Live-Fire Training Range Complex is situated in Guam's northern limestone plateau at an elevation of 500 feet (152 meters) above MSL with steep cliffs surrounding the plateau on the north, east, and west.

Soils

Live-Fire Training Range Complex is dominated by shallow, well-drained limestone upland soils (Figure 8-5); a description of each soil type is provided in Table 4-1 in Section 4.2.3, *Soils*.

9.2.3.2 Hydrology

Surface Water

Live-Fire Training Range Complex is located in the Agafa Gamas and Andersen drainage basins (refer to Figure 4-8a). No natural surface water resources such as lakes or streams occur on Live-Fire Training Range Complex because of the high permeability of the limestone bedrock; however, Jocson et al. (2002) note that temporary ponding, even on the high permeability limestone plateau, can occur during prolonged heavy rains and typhoon events. Rainfall typically percolates into limestone cavities or is channeled into dry wells located throughout Live-Fire Training Range Complex. Stormwater runoff from impervious surfaces is currently directed via concrete-lined culverts to underground injection control wells, which are permitted and regulated by Guam EPA (DON 2015c).

Groundwater

Live-Fire Training Range Complex overlies the northern portion of the Northern Guam Lens Aquifer (NGLA), an island karst aquifer located in uplifted young, highly conductive limestone that covers the northern half of Guam (Jocson et al. 2002). Live-Fire Training Range Complex is located atop the two northern sub-basins: the Finegayan Sub-basin and the Agafa Gumas Sub-basin (refer to Figure 4-10) (Gingerich 2003).

Groundwater is encountered around sea level, which averages around 450 feet (137 meters) below the ground surface under the limestone plateau upon which most of the base sits. Live-Fire Training Range Complex water supply comes from groundwater wells on Marine Corps Base Camp Blaz (MCBCB) Urban Training Complex.

9.2.3.3 Vegetation Communities

Live-Fire Training Range Complex is located on a limestone plateau. The classification system used to describe the vegetation on Live-Fire Training Range Complex is described in Section 4.4.1, *Vegetation Communities.* Live-Fire Training Range Complex is comprised primarily of limestone degraded forest and limestone native forest. Limestone native forests are typically dominated by one or more of the following: banyan (*Ficus* spp.), *Ochrosia* (=*Neisosperma*) *oppositifolia*, *Aglaia mariannensis, Meiogyne cylindrocarpa*, *Premna serratifolia*, *Eugenia reinwardtiana*, and *Pandanus tectorius*. Also dominant or prominent in some areas are *Macaranga thompsonii* and *Pisonia grandis*. Edges of limestone native forest often contain or are dominated by the tree/shrub *Ochrosia mariannensis*. Table 9-7 provides the vegetation communities found on Live-Fire Training Range Complex, the acreage of each type, and the percentage of undeveloped areas; Figure 8-7 identifies the locations of vegetation communities.

Table 9-7. Vegetation Communities on Live-Fire Training Range Complex

Vegetation Community	*Area (acres)*	*% of Total Area*	*% of Vegetated, Undeveloped Area*
Casuarina Forest [(1)]	1.0	0.1	0.1
Coconut Forest [(1)]	0	0	0
Limestone Coastal Scrub	12.5	1.8	1.8
Limestone Degraded Forest [(1)]	269.0	37.9	39.2
Limestone Native Forest	310.0	43.7	45.2
Non-native Forest			
Leucaena Forest [(1)]	11.7	1.6	1.7
Vitex Forest [(1)]	0	0	0
Other Shrub/Grassland	81.8	11.5	11.9
Strand	0	0	0
Non-vegetated categories			
Barren	0	0	NA
Developed	23.8	3.4	NA
Total	709.9		

Note: [(1)] Categorized as a type of degraded forest.
Key: % = percent; NA = not applicable.
Sources: USFS 2006; NAVFAC Marianas 2016b.

Approximately 40% of the vegetated, undeveloped areas of Live-Fire Training Range Complex are dominated primarily by degraded forest communities (NAVFAC Marianas 2016b). In some cliffline areas, and on the plateau away from the cliffline, the forest is substantially disturbed from prior clearing, ungulate damage, and/or invasive plant encroachment. These forested areas are mapped as degraded limestone forest. Other degraded areas have dominant species that might include the native pago (*Hibiscus tiliaceus*) or *P. tectorius*. While native, pago and *P. tectorius* can become invasive, forming dense stands and crowding out other natives.

Other invasive plants found in Live-Fire Training Range Complex include the small trees/shrubs custard apple (*Annona reticulata*), *Mikania micrantha,* and *Passiflora suberosa*, as well as the herbaceous ground covers *Chromolaena odorata* and *Bidens pilosa*.

Large stands of the endemic *Cycas micronesica* are present in areas of both native and degraded limestone forest. As with MCB Camp Blaz, most of these *C. micronesica* plants show signs of infestation by cycad scale (*Aulacaspis yasumatsui*) and are in very poor condition.

9.2.3.4 Terrestrial Environment

Mammals

Native Species

The only native mammal currently occurring in Guam is the Mariana fruit bat, which is discussed below in Section 9.2.5, *Terrestrial Protected Species*.

Non-native Species

Feral pigs and Philippine deer are known to negatively affect the native ecosystems on Live-Fire Training Range Complex (DON 2015e). They cause extensive habitat damage by rooting and digging, create browse lines and impair regeneration of native plants, promote proliferation of browse-resistant plant species, and have the potential to threaten sea turtle nests. Feral ungulate eradication is required by the Marine relocation BO for the Live-Fire Training Range Complex. Ungulate removal is discussed in more detail in Section 8.2.4.1 and summarized in Table 8-4.

While only a few small mammal surveys have been conducted on Live-Fire Training Range Complex, it is expected that the common non-native small mammals found throughout Guam would be present on Live-Fire Training Range Complex, including the Norway rat (*Rattus norvegicus*), black rat (*Rattus rattus*), Polynesian rat (*R. exulans*), house mouse (*Mus musculus*), and musk shrew (*Suncus murinus*) (Wiles 2005; Wiewel et al. 2009). Feral populations of domesticated animals such as dogs (*Canis lupus familiaris*) and cats (*Felis catus*) occur on Live-Fire Training Range Complex and pose threats to native wildlife populations (NAVFAC Marianas 2017a). Dogs are opportunistic feeders and have been known to prey on native waterbirds in Hawai‘i (Young et al. 2011), including Hawaiian coot (*Fulica americana alai*), Hawaiian moorhen (*Gallinula chloropus sandvicensis*), and Hawaiian stilt (*Himantopus mexicanus knudseni*) (Bergman et al. 2009). Cats hunt regardless of food availability (Loss et al. 2013). Cats on Live-Fire Training Range Complex have been known to prey on native skinks (Lardner et al. 2013). Feral cats destroyed an experimental population of Guam rail within the MSA (NAVFAC Marianas 2013b).

Birds

Native Species

Most avian species on the Live-Fire Training Range Complex are native to the region; however, many are seasonal visitors that use coastal, grassy, or other open habitats to forage during their annual migration. Migratory birds either spend the winter in Guam or migrate through during the spring and fall to breeding areas to the north and south.

Sea birds that have the potential to occur on Live-Fire Training Range Complex either during migration or as year-round residents include black noddy (*Anous minutus*), brown noddy (*Anous stolidus*), brown booby (*Sula leucogaster*), red-footed booby (*Sula sula*), white tern (*Gygis alba*), great frigatebird (*Fregata minor*), sooty tern (*Onychoprion fuscatus*), and the white-tailed tropicbird (*Phaethon lepturus*). Previous surveys (USAF 2009) reported that black noddies, brown noddies, white terns, and brown boobies were commonly observed on Andersen AFB and therefore have potential to occur on Live-Fire Training Range Complex. Shorebirds that have the potential to migrate through or occur in coastal areas include the whimbrel (*Numenius phaeopus*) and several species of sandpipers and plovers. Wading birds that have the potential to migrate through or reside on Live-Fire Training Range Complex include Eastern cattle egret (*Bubulcus coromandus*), intermediate egret (*Ardea intermedia*), Pacific reef heron (*Egretta sacra*), and yellow bittern

(*Ixobrychus sinesis*). These sea birds, shorebirds, and wading birds are protected by the MBTA. The white-tailed tropicbird, Pacific reef heron, brown booby, and all migratory shorebirds are also considered Guam SOGCN (Guam DAWR 2006).

Migratory bird surveys conducted on Live-Fire Training Range Complex in the fall of 2011 identified several shorebird and wading bird species present on the base. The Pacific golden plover (*Pluvialis fulva*) was the most commonly observed bird during those surveys, followed by the ruddy turnstone (*Arenaria interpres*). Other species observed included wood sandpiper (*Tringa glareola*), wandering tattler (*T. incana*), grey-tailed tattler (*T. brevipes*), sharp-tailed sandpiper (*Calidris acuminata*), Pacific reef heron, whimbrel, and ruff (*Calidris pugnax*). Table 8-5 summarizes the bird species present on Andersen AFB, which therefore have the potential to occur on Live-Fire Training Range Complex, and Appendix E provides a listing of the extirpated bird species.

Additional discussion may be found in Section 9.2.5, *Terrestrial Protected Species* and in Section 4.4.2.2, *Birds*.

Non-native Species

Four non-migratory introduced bird species occur on Andersen AFB and therefore have the potential to occur on Live-Fire Training Range Complex. These include black drongo (*Dicrurus macrocercus*), Eurasian tree sparrow (*Passer montanus*), black francolin (*Francolinus francolinus*), and island collared dove (*Streptopelia bitorquata*). Introduced birds pose a risk to native bird species because of their potential to displace or compete with native species or transmit diseases. The black francolin and island collared dove are game species per Guam regulation, but the current hunting instruction excludes them from being hunted on Live-Fire Training Range Complex. Black drongo are a conspicuous and aggressive avian species that can contribute to a decline in native bird species (USAF 2009). Roadside and forest bird surveys conducted from 2008 through 2010 at NWF, North Ramp, and a proposed utility corridor along Route 9, identified black francolin, island collared dove, black drongo, and Eurasian tree sparrow (NAVFAC Pacific 2010b). The black francolin was the most commonly observed species.

Feral chickens (*Gallus gallus*) are less of a threat to wildlife than dogs and cats, but as generalist feeders, they have the potential to prey on small native wildlife, including skinks and geckos. They also have the potential to spread avian diseases, which may affect both current native bird colonies and the recolonization efforts on Live-Fire Training Range Complex of extirpated native birds (Gottdenker et al. 2005).

Reptiles and Amphibians

Native Species

Herpetological surveys have been performed intermittently around Live-Fire Training Range Complex. While some species may not have been seen during particular surveys, nine species of reptiles and amphibians were documented during the 2008-2009 herpetofauna surveys performed in NWF, North Ramp, and proposed utility corridors on Live-Fire Training Range Complex (NAVFAC Pacific 2010b). Of these, the following three species are native: Pacific blue-tailed skink (*Emoia caeruleocauda*), moth skink (*Lipinia noctua*) (a Guam ESA-listed endangered species), and mutilating gecko (*Gehyra mutilata*).

Monitor lizards (*Varanus tsukamotoi*) are native to the Mariana Islands (Weijola et al. 2020). Their remains have been found in pre-historic strata in Guam (Pregill and Steadman 2009) and are different from congeners in Palau (Crombie and Pregill 1999). Biosecurity programs are in place to slow or prevent the

spread of this species. They are typically found in the more forested habitats or associated edges but have also been observed in more developed areas.

Non-native Species

During the 2008-2009 herpetofauna surveys discussed above, six introduced species were documented. These include curious skink (*Carlia ailanpalai*), house gecko (*Hemidactylus frenatus*), BTS, Brahminy blind snake (*Ramphotyphlops braminus*), marine toad (*Rhinella* [=*Bufo*] *marina*), and greenhouse frog (*Eleutherodactylus planirostris*) (NAVFAC Pacific 2010b).

The continued widespread presence of the curious skink, the BTS, and other non-native reptile and amphibian species is of concern because of each species' potentially deleterious impacts in Guam's native fauna. Of particular concern is the potential for introduced species to serve as additional food sources for the BTS (NAVFAC Pacific 2010b). Rodda et al. (1999) reported a change in the diet of BTS between 1989 and 1999 in response to the disappearance of prey species, notably Guam's native birds. Research conducted on arboreal BTS since 1989 has demonstrated that small lizards (geckos and skinks equally) and their eggs appear to be the most common prey consumed. Larger BTS that were captured while foraging on the ground were found to have mostly consumed the curious skink, which tend to spend their time on the ground. Marine toads can be heard calling, and their carcasses are often seen on roads. Table 8-6 summarizes the occurrence of reptiles and amphibians on Andersen AFB, which in turn have the potential to occur on Live-Fire Training Range Complex.

Invertebrates

Native Species

Four other native butterfly species were documented within forested areas on Andersen AFB during 2009-2010 butterfly surveys, and therefore have the potential to occur on Live-Fire Training Range Complex: lemon emigrant (*Catopsilia pomona*), monarch (*Danaus plexippus*), blue-banded king crow (*Euploea eunice*), and blue moon (*Hypolimnas bolina*) (NAVFAC Pacific 2010b). These species are fairly well distributed throughout Guam and portions of the Mariana Islands. Other native butterfly species documented on Live-Fire Training Range Complex include the three-spot grass yellow (*Eurema blanda*) and the tiny grass blue (*Zizula hylax*) (Schreiner and Nafus 1997; USAF 2009).

The native, federal ESA-listed Guam tree snail (*Partula radiolata*) is present on Live-Fire Training Range Complex and is discussed in further detail in Section 9.2.5, *Terrestrial Protected Species*.

Other terrestrial invertebrates that occur on Andersen AFB (and therefore have the potential to occur on Live-Fire Training Range Complex) include the nocturnal, native land hermit crab (*Coenobita brevimanus*) and the coconut crab (*Birgus latro*), both of which begin their life at sea and spend their adult life on land. Land hermit crabs rely on borrowed shells throughout their lives, often using the shell of the giant African snail (*Achatina fulica*). Further information on these species can be found in Section 8.2.4.4.

Non-native Species

Non-native butterflies documented on Live-Fire Training Range Complex include the common mormon (*Papilio polytes*) and the cycad blue or plains cupid (*Luthrodes pandava*).

Shells of the introduced giant African snail and the rosy wolf snail (*Euglandina rosea*), as well as both live snails and empty shells of the introduced cinnamon bun snail (*Satsuma mercatoria*), were observed during 2009 and 2016 tree snail surveys (NAVFAC Pacific 2010b, 2017). Additionally, the introduced New Guinea flatworms (*Platydemus manokwari*), a major predator of native invertebrates, were observed across the base. During the 2016 surveys, the tropical American lined tree snail (*Drymaeus multilineatus*) was observed in the MSA on Andersen AFB.



Tropical American lined tree snail (*Drymaeus multilineatus*)
(*Photo*: L. Shaughnessy)

The LFA (*Wasmannia auropunctata*), represents a serious threat to native invertebrate and vertebrate species; however, it is not yet known to occur on Live-Fire Training Range Complex. Accidentally introduced to northern Guam in 2011, it is slowly expanding its range in Guam despite extensive efforts to control it.

The greater banded hornet (*Vespa tropica*) was first identified in Guam in July 2016, based on collected specimens from Dededo (Rosario et al. 2016). This species is native to China, Japan, Malaysia, Hong Kong, Singapore, India, and the Philippines. Banded hornets usually nest underground, in tree hollows, or similar confined spaces and are known to attack the nests of the local boonie bees (*Ropalidia marginata*) in order to obtain the larvae to feed their own larvae (Rosario et al. 2016).

9.2.3.5 Terrestrial Protected Species

Four federal ESA-listed endangered species are known to occur on Live-Fire Training Range Complex. These include two plant species (*Heritiera longipetiolata* and *Eugenia bryanii*) and two animal species (Mariana eight-spot butterfly, and Guam tree snail). Six federal ESA-listed threatened plants and one threatened animal are known to occur on Live-Fire Training Range Complex: *Bulbophyllum guamense* (Johnson 2016a), *Cycas micronesica*, *Dendrobium guamense*, *Tabernaemontana rotensis*, *Tuberolabium guamense,* and the Mariana fruit bat. Of these, *H. longipetiolata*, *S. nelsonii*, Mariana fruit bat, and Guam tree snail are listed as endangered under the Guam ESA. The Micronesian starling is also listed as endangered under the Guam ESA. *C. micronesica* and *T. rotensis* are both designated as Guam SOGCN (Guam DAWR 2006).

Potential habitat is present on Live-Fire Training Range Complex or within the vicinity for nine other federal ESA-listed endangered, threatened, or candidate species, some of which might already be extinct. Table 9-8 summarizes the protected species in Guam and their occurrence on Live-Fire Training Range Complex.

Table 9-8. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded on Live-Fire Training Range Complex

Common Name/ Chamorro Name(1)	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat*	*Occurrence*
Mammals					
Mariana fruit bat/Fanihi	*Pteropus mariannus mariannus*	T	E	Limestone native and coconut forests	Y

Table 9-8. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded on Live-Fire Training Range Complex

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat*	*Occurrence*
Birds					
Mariana common moorhen/Pulattat	*Gallinula chloropus guami*	E	E	Wetland (herbaceous, mangrove, and shrub/herb)	N
Micronesian starling/Sali	*Aplonis opaca*	--	E	All habitat types	Y
Reptiles					
Tide-pool skink/ Gualiek halumtasi	*Emoia atrocostata*	--	E	Strand and wetland	PU[3]
Azure-tailed skink/ Gualiek halumtano	*Emoia cyanura*	--	E	Forest edge	PU[3]
Slevin's skink/ Gualiek halumtano	*Emoia slevini*	E	E	Limestone native forest	PU[3]
Moth skink/ Gualiek halumtano	*Lipinia noctua*	--	E	Limestone native and degraded forests.	Y
Pacific slender-toed gecko/ Gualiek or Achiak	*Nactus pelagicus*	--	E	Limestone native forest	Y
Micronesian gecko/ Gualiek	*Perochirus ateles*	--	E	Limestone native forest	PU[3]
Invertebrates					
Humped tree snail/Akaleha	*Partula gibba*	E	E	Limestone native forest	PU[3]
Guam tree snail/Akaleha	*Partula radiolata*	E	E	Limestone native forest and strand	P[3]
Plants					
None/Siboyas halumtano	*Bulbophyllum guamense*	T	--	Limestone native and degraded forests	Y
None/Fadang	*Cycas micronesica*	T	--	Limestone native and degraded forests	Y
None/None	*Dendrobium guamense*	T	--	Limestone native forest and limestone coastal scrub	Y
None/Aagan or aabang	*Eugenia bryanii*	E	--	Limestone coastal scrub	Y
None/Ufa halumtano	*Heritiera longipetiolata*	E	E	Limestone native forest	Y
None/None	*Maesa walkeri*	T	--	Limestone native and degraded forests	N
None/Seyaihagon or Maisa ulu	*Nervilia jacksoniae*	T	--	Limestone native and degraded forests	P
None/Aplokating-palaoan	*Psychotria malaspinae*	E	--	Limestone native forest and limestone coastal scrub	P
Fire tree/Hayun lago	*Serianthes nelsonii*	E	E	Limestone native and degraded forests	Y
None/Biringenas halumtano	*Solanum guamense*	E	--	Coastal limestone cliffs and terraces	PU
None/None	*Tabernaemontana rotensis*	T	--	Limestone native and degraded forests	Y
None/None	*Tinospora homosepala*	E	--	Limestone native forest and limestone coastal scrub	N

Table 9-8. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded on Live-Fire Training Range Complex

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat*	*Occurrence*
None/None	*Tuberolabium guamense*	T	--	Limestone native forest and limestone coastal scrub	Y

Notes: [1] Chamorro names from GovGuam (2009), Topping et al. (1975), Safford (2009), and USFWS (2015a).
[2] Central West Pacific Distinct Population Segment.
[3] Historical occurrence.
Key: -- = not listed; E = endangered; ESA = Endangered Species Act; P = potential for occurrence; PU = potential for occurrence, but unlikely; T = threatened; Y = yes, known to occur; N = does not occur.
Sources: Schreiner and Nafus 1997; Guam DAWR 2006; GovGuam 2009; Safford 2009; NAVFAC Pacific 2010b, 2013b; NAVFAC Marianas 2014c, 2016c; USFWS 2014, 2015b; NAVFAC Marianas and Andersen AFB 2015, 2017b.

9.2.3.6 Mammals

Mariana Fruit Bat

Mariana fruit bats are federal ESA-listed as threatened, Guam ESA-listed as endangered, and Guam-designated as SOGCN. Their population has been in a steady decline since the early part of the 20th century (NAVFAC Marianas 2017a). In 1972, the Mariana fruit bat population on Andersen AFB consisted of 500 to 600 individuals. By 1978, the number of fruit bats on all of Guam had been reduced to 50 individuals (Wheeler and Aguon 1978), and in 1984, they were federal ESA-listed as endangered (USFWS 1994, 2015b). Between 1980 and 1981, the fruit bat population in Guam grew to almost 1,000 bats divided into two main colonies on Pati Point, likely the result of immigration from Rota (Wiles 1987a, 1987b). Between 1981 and 1987, fruit bats roosted in at least 19 locations along the northern coast of Andersen AFB, within Live-Fire Training Range Complex, between Lafac Point and Ritidian Point (Wiles 1987c). Except for the increase in the early 1980s, the overall population trend of this species has continued its decline. In 2006, Janeke et al. (2006) estimated fewer than 100 fruit bats at Pati Point. A survey conducted on Andersen AFB from June 2007 until April 2008 indicated counts from 31 to 54 bats with an average count of 40 (Andersen AFB 2008b). A count in May 2010 recorded only 10 bats at the Pati Point colony (JRM 2013). Surveys in 2011 found two to three bats below Pati Point, but the colony is no longer present, and surveys have not found that the colony has relocated (JRM et al. 2012).

In 2014 and 2015, the estimated population of Andersen AFB fruit bats was 24 (NAVFAC Marianas 2015). There were only a few observations of fruit bats at northern Andersen AFB, within Live-Fire Training Range Complex, near Ritidian Point (see Figure 8-12). Two incidental sightings of bats in the Live-Fire Training Range Complex were collected by MCB Camp Blaz natural resource staff in 2023.

9.2.3.7 Birds

Micronesian Starling

The Micronesian starling is Guam ESA-listed as endangered and Guam-designated as SOGCN. They are found in the forests north of the flightline, within Live-Fire Training Range Complex (DON 2010). The starling has adapted to nesting in the housing area as well as on buildings and other man-made structures and is important for dispersal of native plant seeds (Caves et al. 2013). Starlings have persisted where BTS control has been ongoing for decades.

White-throated Ground Dove

The white-throated ground dove (*Alopecoenas xanthonurus*), a Guam ESA-listed endangered species, is considered to have been extirpated from the island by the BTS as of the late 1980s (Guam DAWR 2006).

However, since then, it has been seen in a few rare instances on Andersen AFB: in 2003, two male white-throated ground doves were sighted on the installation (Guam DAWR 2006) and an individual was heard during 2011 surveys (DON 2015c). These occurrences, along with a few others, are likely visitors from the nearby island of Rota.

Reptiles

There are no protected amphibian species at Live-Fire Training Range Complex.

Amphibians

There are no protected amphibian species at Live-Fire Training Range Complex.

9.2.3.8 Invertebrates

Guam tree snails use a wide variety of host plants, including coconut, *C. micronesica, Flagellaria indica*, *Hernandia sonora*, *Mammea odorata*, noni (*Morinda citrifolia*), *O. mariannensis*, and *O. oppositifolia*. While they are not limited by host plants, they are found in moist and shaded forest (NAVFAC Marianas 2013b), a characteristic that generally limits them to limestone native forests. Historical and current presence of tree snails on Live-Fire Training Range Complex are shown in Figure 8-12.

9.2.4 Management Goals, Objectives, Strategies, and Actions

JRM currently manages natural resources based on an ecosystem-focused approach that involves the implementation of several ongoing management projects. These projects, which are further described in the following sections, provide examples of JRM's current efforts to manage and enhance natural resources in a manner consistent with the military mission. Appendix C lists management projects on Andersen AFB for FY 14-17, many of which also still apply to Live-Fire Training Range Complex lands. The following sections present management projects for Live-Fire Training Range Complex that are identified as necessary to achieve applicable goals and objectives identified in Chapter 3, *Environmental Management Strategy and Mission Sustainability*.

Management projects identified for Live-Fire Training Range Complex provide direct support for the military mission and the goal of "no net loss" in a number of ways. For example, projects that improve the baseline status of species or their habitat show that populations are stable, or that habitat is improving or expanding, may relieve restrictions on military training or operations, minimize costs and mitigation requirements, avoid workarounds, and/or streamline regulatory processes.

9.2.4.1 Terrestrial Ecosystem Management

Live-Fire Training Range Complex's native terrestrial habitats have been impacted by historical activities, introduction and spread of invasive and non-native species, effects of climate change, and the resulting loss of functions necessary to support healthy native habitats. Ecosystem functions have been disrupted by the extirpation of native animal and plant species, which have resulted in both economic and cultural impacts on the ecosystem services provided by native habitats. The occurrence of healthy native habitats on Live-Fire Training Range Complex is necessary to support sustainability of native species, including federal and Guam ESA-listed species. JRM recognizes that restoration and enhancement of native habitats on lands that they manage is a long-term process, and that adaptive management is key to long-term success of the program.

Management projects are monitored and evaluated annually to ensure that they are meeting identified goals and objectives. JRM will establish mid-year coordination meetings with resource partners to discuss ongoing and planned projects, including prioritization, scope, methodology, issues or challenges, timelines,

and performance evaluation criteria. These discussions are intended to facilitate improved coordination and information sharing to allow for course corrections, if necessary, to ensure an adaptive approach.

Terrestrial ecosystem management as described in the following sections is expected to: (1) improve the status of threatened and endangered species through habitat conservation and enhancement, and (2) promote health and sustainability of native forests. Healthy ecosystems will, in turn, relieve or reduce environmental constraints and allow for maximum operational flexibility for the installations and continued/managed access to important recreational areas.

A summary of the management projects and the estimated timeframe for completion is presented in Table 13-10, *Planned Implementation Summary of Projects at MCB Camp Blaz* found in Chapter 13, *Planning, Integration, and Implementation*. Some of the projects described in this section are being accomplished through interactive partnerships with federal and territorial natural resource agencies (e.g., Guam DAWR), universities, and local organizations.

9.2.4.2 Terrestrial Habitat Management

JRM has ongoing and planned projects to restore and enhance native terrestrial habitats. These projects focus on improving the quality and availability of appropriate habitat for listed species, as well as increasing the quality and health of existing native habitats, such as limestone native forests. Numerous related activities are required for native habitat improvement, such as control of ungulates and other invasive species, propagating and outplanting native plant species to improve diversity, and addressing forest health issues, such as improvement of seed dispersal. The 2017 Restoration Plan for the HMU (NAVFAC Marianas and Andersen AFB 2017a) and the 2018 Conceptual Limestone Forest Restoration and Enhancement Plan serve as management tools to help guide site-specific restoration and enhancement efforts on Live-Fire Training Range Complex.

At the HMU, BTS suppression and eradication efforts are ongoing, with eradication efforts beginning in October 2018, using toxic baits. After evaluating 2 years of aerial baiting in the HMU, it was determined that aerial baiting is effective at targeting a critical (and most abundant) segment of the BTS population, medium-sized snakes, but less effective for smaller and larger snakes (Nafus et al. 2022; Goetz et al. 2020, 2021, and 2022; Yackel Adams et al. 2022). Indicating that the incorporation of other BTS removal tools are necessary to overcome size-based differences in susceptibility to achieve eradication. So in 2022, the USGS, USDA National Wildlife Research Center, and USDA Wildlife Services collaboratively developed a research project in support of the MOA between U.S. Navy and USFWS: Conservation of Guam Micronesian Kingfisher Recovery Habitat in Northern Guam. The intent of the project is to support the focal areas of the 2015 Guam Micronesian Kingfisher MOA; to ensure enough suitable survival and recovery habitat to support the reintroduction and recovery of the Guam kingfisher. The ongoing project will deploy standard (i.e., visual surveys, trapping, hand-delivered toxic baits on various lures) and modified (i.e., cage trap height and design, bird lures, and baits), ground-based BTS control tools complementary to aerial baiting to achieve BTS eradication in the HMU.

In order to achieve long-term goals, THM requires successful daily and short-term management, coupled with long-term planning and investment. To ensure that JRM continues to meet the overriding goal of restoring and enhancing terrestrial habitats for native species (including listed species) over the long-term, JRM site land managers and resource agencies will continue coordinating on natural resource management.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for THM on Live-Fire Training Range Complex.

THM-1: FOREST ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-6; Goal #3, Objectives #1 and 4; and Goal #4; Objective #2. This project supports conservation measures the reinitiation of the 2015 BO for the DON's Relocation of USMC from Okinawa to Guam and Associated Activities in Guam (USMC Relocation 2017 BO, which contains amendments to the 2015 BO) (USFWS 2017).

- *Strategy*: Protect and restore priority native habitats (i.e., limestone forest) for the benefit of native flora and fauna, including protected species, by focusing on step-wise forest enhancement activities and by protecting species from direct and indirect threats.
- *Action*: Propagate native forest species and plant nursery grown plants or seeding species in the wild. Young plants will be managed for approximately 3 years until they become established.
- *Action*: Develop a monitoring program for listed plants found throughout JRM-administered lands following the protocols for GPS data collection used at NWF and Finegayan. Known locations will be monitored and new surveys will be conducted to identify additional locations.
- *Action*: Conduct surveys to map locations and abundance of non-native invasive plants and rank occurrences by invasive plant species standards.
- *Action*: Implement control/eradication for top ranked invasive plant species and monitor to prevent recurrence.
- *Action:* Implement fire management plan actions to remove fire-prone grasses.
- *Action:* Convert stands of fire-prone grasses to native vegetation communities to reduce fire risk.
- *Action*: Monitor vegetation in fenced ungulate control areas prior to fencing and after removal to track invasive plants and monitor understory growth, increased groundcover, increased canopy cover, increased species diversity, and increased number of forest tree seedlings and saplings.
- *Action*: Construct ungulate fencing as a barrier to feral pigs and deer immigration in priority habitats.
- *Action*: Construct ungulate fencing surrounding the Live-Fire Training Range Complex.
- *Action*: Eradicate pigs and deer within fenced ungulate exclusion areas and control ungulates outside of fenced areas on Live-Fire Training Range Complex to protect threatened and endangered species and associated habitat.
- *Action:* Inspect and maintain ungulate fences to ensure ungulates cannot re-enter exclusion area.
- *Action:* Monitor ungulate exclusion areas to ensure no ungulates have re-entered the site and remove ungulates as they are detected.
- *Action*: Maintain the USGS BTS Closed Population. Fence maintenance will include: maintaining both sides of the fence to exclude vegetation within a minimum of 3 feet (1 meter) of the barrier; painting the barrier every 2 years with rust-proofing paint to increase the life of the barrier; power washing the base of the barrier annually to prevent debris from building up and developing breaches in the fence at ground level; conducting inspections on a weekly basis; and completing routine mechanical repair and maintenance of the barrier as needed on an annual basis.

THM-2: URBAN FORESTRY DATA BASE, MAINTENANCE, AND REPLACEMENT OF TREES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1 and Goal #2, Objectives #3 and 6.

- *Strategy*: Ensure that management of urban trees on Live-Fire Training Range Complex is compatible with JRM INRMP goals and objectives.

- *Action*: Continue to implement the integrated grounds maintenance program to minimize the amounts of chemicals and water needed to maintain grounds and landscaped areas in healthy and attractive conditions.
- *Action*: Collaborate with technical specialists from local agencies to develop an Urban Forestry Plan for JRM that includes specifications for soil types, planting requirements, watering and fertilizer regimens, pest control, disease treatments, and other maintenance practices.
- *Action*: Develop and maintain an urban forestry database to catalog existing trees and provide a schedule for their maintenance.
- *Action*: Continue to manage urban forest resources for disease, damage, and replacement.
- *Action*: Plant native trees along the cliff tops to provide native seed rain for passive native forest recovery.

9.2.4.3 Terrestrial Exotic and Invasive Species Management

An invasive species is defined in EO 13112, *Invasive Species*, as a species that is non-native (i.e., alien or exotic) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm, or harm to human health. Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions. Invasive species have had a catastrophic effect on the native flora and fauna of island ecosystems, particularly Guam. Attributes of island biota include small geographic ranges and population size, low reproductive rates, and lack of the ability to respond to invasive species and disturbed habitats. Islands typically have lower numbers of species than mainland areas, which results in fewer predators and competitors that could prevent the establishment of invasive species. As a result of evolving in isolation, island plants and animals have few defenses when exposed to introduced competitors and predators. These limitations in Guam have caused exotic and invasive species to replace native island species (Wiles et al. 2003).

Many of the native species in Guam are threatened due to introduced predators, such as the BTS, and introduced ungulates such as the Philippine deer, feral pig, and Asiatic water buffalo (carabao) (*Bubalus bubalis*), which have significantly affected native vegetation communities. Feral populations of dogs and cats also pose threats to native wildlife populations. SECNAVINST 6401.1B of September 29, 2006, prohibits dogs, cats, and other privately owned or stray animals from running at large on military installations. Several species of rats have colonized the island, preying on the eggs and young of native species and destroying native flora (i.e., seeds and seedlings). The continued widespread presence of the BTS, curious skink, and introduced amphibian species are of particular concern because of each species' potential negative impacts in Guam's native fauna. Examples of invasive species management approaches include the control of feral ungulates, the control of feral cats and dogs, and the removal of invasive plants to allow native species to flourish in degraded areas.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Exotic and Invasive Species Management (TIS) on Live-Fire Training Range Complex.

TIS-1: BROWN TREESNAKE INTERDICTION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1-2; Goal #2, Objectives #3-4; Goal #3, Objectives #1 and 4; and Goal #4, Objectives #1-3. This project supports conservation measures from the MOA for the Conservation of Guam Micronesian Kingfisher Recovery Habitat in Northern Guam (2015 Guam Micronesian Kingfisher MOA) (DON and USFWS 2015a)

- *Strategy*: Maintain, develop, and implement actions to prevent the spread of BTS via the transportation network.
- *Action*: Annually review, update as needed, and develop existing BTS interdiction projects reflecting BMPs, adaptive management, and cost benefits.
- *Action*: Annually assess continuity and compliance of BTS interdiction activities across BOs, DoD BTS interdiction operating instructions, and consistency with, and, to the benefit of other relevant JRM conservation actions.
- *Action*: Annually assess ongoing development of new/emergent management strategies and methodologies that reduce or eliminate the risk of BTS.
- *Action*: Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant long-term projects to benefit interdiction management objectives.
- *Action*: Consult with the USDA Animal and Plant Health Inspection Service (APHIS) Wildlife Services National Wildlife Research Center in Fort Collins to determine the most effective and least disruptive control strategies. Resulting research requirements will be finite projects that assist in the development of snake control techniques and in the management of Mariana fruit bat roosts through the adaptive management strategy.

TIS-2: BROWN TREESNAKE SUPPRESSION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-4 and 6; Goal #3, Objectives #1 and 4; Goal #4, Objectives #1-3; and Goal #7, Objective #3. Actions listed are in accordance with the 2011 BTS MOA.

- *Strategy*: Suppress and control BTS numbers to support conservation goals for species and ecosystem recovery.
- *Action*: Develop an operational suppression implementation plan. The plan will identify and prioritize potential quality habitat site(s) for suppression actions. Site(s) must consider size, habitat, location, connectivity, synergistic effects, listed species benefits, ecological viability, and support regulatory and mission requirements. Suppression goals and activities will support USFWS recovery plan delisting requirements for threatened and endangered species.
- *Action*: Implement BTS suppression management actions in identified site(s) based on mission support impact and cost effectiveness. Data will be used to determine the minimum thresholds of BTS suppression activities needed to support conditions conducive to species persistence and recovery. Potential BTS suppression actions will be consistent with the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017) for BTS control and suppression.
- *Action*: Through annual funding and partnerships, support development of tools and methods that improves monitoring, detection, and suppression in targeted habitat sites.
- *Action:* Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant projects to benefit long-term BTS suppression management actions.

TIS-3: BROWN TREESNAKE MANAGEMENT FOR THE RECOVERY OF PROTECTED SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-4 and 6; Goal #3, Objectives #1 and 4; Goal #4, Objectives #1-3; and Goal #7, Objective #3. Actions listed are in accordance with the 2011 BTS MOA.

- *Strategy*: Suppress and control BTS numbers to support listed vertebrate species recovery.

- *Action*: Complete trial eradication of BTS in the USGS Closed Population Facility and determine the level of search time or effort required to declare a low snake density and bounded-forested area eradicated.
- *Action*: Continue to conduct Guam kingfisher MOA-funded aerial and ground-based BTS control in fenced and unfenced landscapes to evaluate suppression and eradication feasibility. Annually measure, evaluate, and validate suppression and eradication activities to inform and guide application within other identified habitats of the JRM area of responsibility.
- *Action*: Through annual funding and partnerships, support development of tools and methods that improves monitoring, detection, and suppression in targeted habitat sites.
- *Action:* Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant projects to benefit long-term BTS suppression management actions.

TIS-4: INVASIVE SPECIES MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1-2; Goal #2, Objectives #2-4; Goal #3, Objective #1 and 4; and Goal #4, Objectives #1-3. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Remove and control invasive species that threaten the survival of listed species and other native plants or animals, negatively impact tourism and agriculture, and/or cause human life or safety issues.
- *Action*: Initiate eradication of feral cats and rats the year prior to rail releases and monitor while rails are present. Removal of mammalian predators will be ongoing as they are not excluded by the existing BTS fence. Predator control may include, but is not limited to, trapping, shooting, and baiting. The 2017 Restoration Plan for the HMU (NAVFAC Marianas and Andersen AFB 2017a) will be used to guide eradication and management actions.
- *Action*: Annually survey high-risk areas for LFA using established protocols. If LFA is detected on Live-Fire Training Range Complex, implement proven control and eradication actions, followed by post-eradication monitoring.
- *Action*: Implement BMPs for CRB: (1) annually evaluate the need for comprehensive bio-sanitation of dead coconut trees and implement as necessary, (2) implement proper green waste management; (3) assist in release of landscape-level biocontrol agents for CRB, (4) implement awareness and reporting program in high-risk areas annually, and (5) implement long-term monitoring program and monitor coconut trees.
- *Action*: Survey and map locations of invasive insect infestations and compromised plants.
- *Action*: Develop, test, and prioritize adaptive management actions to remove or control invasive insects, including, but not limited to, feasible local controls of cycad scale (e.g., hand applications to individual trees).
- *Action*: Develop a Hazard Analysis Critical Control Point (HACCP) Plan and implement requirements for construction related to the USMC relocation.
- *Action*: As management tools become available, implement adaptive management actions to remove or control invasive insects, including, but not limited to, feasible local controls of cycad scale (e.g., hand applications to individual trees).

TIS-5: IMPLEMENTATION OF REGIONAL BIOSECURITY PLAN FOR MICRONESIA AND HAWAI'I

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #3; Goal #3, Objectives #1-2 and 4; Goal #4, Objectives #1-4; and Goal #7, Objective #1.

- *Strategy*: Implement appropriate recommendations within the Regional Biosecurity Plan (RBP) (DON 2015d) that will reduce the risk of introduction and spread of invasive species on Live-Fire Training Range Complex.
- *Action*: Develop standard language for biosecurity BMPs, update as necessary, to be included in project specifications that support prevention, such as vegetation management, and cleanliness standards for materials and equipment operating on the installation.
- *Action*: Conduct early detection surveys (EDS) for high-risk invasive species in training areas; at facilities for staging, storage, and movement of cargo/equipment and vehicles, and at other locations as deemed necessary.
- *Action*: Review and update, as appropriate, DoD Attachment M of the RBP every 3 years.
- *Action*: Develop, implement, and update (as necessary) a JRM biosanitation instruction to ensure cleanliness standards are adhered for the movement of cargo and equipment.
- *Action:* Continue to develop high-risk invasive species protocols and implement control and/or eradication measurement when necessary.

TIS-6: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1; Objectives #1-2; Goal #2, Objectives #2-4; Goal #3, Objectives #1 and 4; and Goal #4, Objectives #1-4. This project supports conservation measures from the BO for the MITT Program (2015 MITT BO) (USFWS 2015b).

- *Strategy*: Implement biosecurity conservation measures listed in the 2015 MITT BO from USFWS.
- *Action*: During training events, ensure 100% BTS canine inspection of aircraft and cargo/equipment departing for an off-island destination.
- *Action*: During training activities, establish snake-free quarantine areas (barriers) as deemed necessary for cargo/equipment traveling from Guam to CNMI and locations outside of the MITT action area.
- *Action*: Ensure BTS awareness briefings for all military and contractor personnel prior to all MITT training activities.
- *Action*: Maintain invasive species rapid response capabilities to control and/or eradicate introduced non-established, non-native invasive species sighted in vicinity of DoD training areas and facilities used for staging, storage, and movement of military personnel, cargo, and vehicles associated with training activities.
- *Action*: Ensure training personnel conduct self-inspections to avoid potential introductions of invasive species to Guam. Personnel will inspect all gear and clothing for soil accumulations, seeds, invertebrates, and vertebrates.
- *Action*: Ensure all training activities adhere to the Armed Forces Pest Management Board Technical Guide 31 on washdown procedures for all vehicles and equipment arriving from off-island destinations and departing Guam for off-island destinations via inspections as deemed necessary.
- *Action*: Develop and implement control and eradication protocols for high-risk invasive species as species are identified.

TIS-7: CONTROL FERAL DOGS AND CATS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1 and 4; and Goal #4, Objective #2.

- *Strategy*: Reduce threats to native species by implementing a control program for feral dogs and cats on Live-Fire Training Range Complex.
- *Action*: Conduct population surveys of areas of highest conservation concern, and/or human safety to determine locations and estimate numbers of feral dogs and cats, review accepted control measures, and coordinate with U.S. Army veterinarian and installation pest control personnel to control by authorized means if impacts to ESA-listed species or other native wildlife are identified.
- *Action*: Update Live-Fire Training Range Complex instruction regarding feral dog and cat policy. This instruction will clearly articulate roles and responsibilities for feral dog and cat control in various locations of the base and will outline outreach and education for base personnel and residents on pet ownership requirements.
- *Action*: Include U.S. Navy installation feral dog and cat policy information in all installation outreach material presented to military and civilian personnel, housing residents, and contractors.

9.2.4.4 Terrestrial Protected Species Management

Management of terrestrial threatened and endangered species on JRM-administered lands includes implementing programs to protect species, and coordinating efforts with the appropriate agencies. Key threats to threatened and endangered species that can lead to extirpation include the following:

- predation by BTS of native forest birds, lizards, and bats
- overgrazing, rooting, and trampling of plants and wildlife habitat by feral ungulates
- predation by feral cats, dogs, and pigs, as well as predation by monitor lizards on birds, bats, and sea turtles
- human disturbance and poaching of sea turtles and Mariana fruit bats
- mortality or injury to native plants and wildlife due to natural stochastic events (e.g., typhoons)
- low reproductive success due to small population numbers
- habitat loss and fragmentation due to development

To address these key threats to listed species, JRM has conducted and continues to conduct numerous management and research projects to reduce BTS numbers at the local and landscape scale, control BTS at swiftlet caves at NMS, and to prevent their spread to other Pacific Islands through rigorous inspections and interdiction of outgoing cargo at DoD ports (i.e., Apra Harbor, Andersen AFB). Captive breeding programs conducted by Guam DAWR and mainland zoological institutions are maintaining populations of Guam rail and Guam kingfisher and are adding to the information needed for successful recovery of these species. Additional ecological research and monitoring is also being conducted by various agencies in Guam, including DoD, USDA, and USGS.

At the HMU, BTS suppression and eradication efforts are ongoing, with eradication efforts beginning in October 2018 using toxic baits. After evaluating 2 years of aerial baiting in the HMU, it was determined that aerial baiting is effective at targeting a critical (and most abundant) segment of the BTS population, medium sized snakes but less effective for smaller and larger snakes (Nafus et al. 2022; Goetz et al. 2020, 2021, and 2022; Yackel Adams et al. 2022). As such, the incorporation of other BTS removal tools was deemed necessary to overcome size-based differences in susceptibility to achieve eradication. In 2022, the USGS, USDA National Wildlife Research Center, and USDA Wildlife Services collaboratively developed a research project in support of the MOA between U.S. Navy and USFWS: Conservation of Guam

Micronesian Kingfisher Recovery Habitat in Northern Guam. The intent of the project is to support the focal areas of the 2015 Guam Micronesian Kingfisher MOA; to ensure enough suitable survival and recovery habitat to support the reintroduction and recovery of the Guam kingfisher. The ongoing project will deploy standard (i.e., visual surveys, trapping, hand-delivered toxic baits on various lures) and modified (i.e., cage trap height and design, bird lures and baits), ground-based BTS control tools complementary to aerial baiting to achieve BTS eradication in the HMU.

In accordance with section 7 of the ESA, a federal agency shall consult with the USFWS to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any threatened or endangered species. The DON will coordinate with the USFWS/Guam NWR for any federal action that is within Overlay Refuge lands and is identified as providing habitat for threatened or endangered species. In addition, the DON will avoid, as the mission allows, impacts on habitat suitable for threatened and endangered species, and locally rare, and Guam ESA-listed species.

Sensitive species are being managed by implementing specific management projects that enhance habitat for these species and by initiating specific strategies that address immediate needs of listed species on the installation. In addition, adherence to the goals set for threatened and endangered species management ensure that the installation remains in compliance with ESA and associated consultation requirements.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Protected Species Management (TPS) on Live-Fire Training Range Complex. Additional protection measures for terrestrial protected species are presented in Section 9.4.1.6, *Terrestrial Natural Resources Law Enforcement*.

TPS-1: MARIANA FRUIT BAT POPULATION PROTECTION AND ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1-2; Goal #2, Objectives #1 and #3-4; and Goal #3, Objectives #1 and #4. This project supports conservation measures the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Monitor Mariana fruit bat population status on Live-Fire Training Range Complex to maintain and identify habitat relationships.
- *Action*: Continue base-wide surveys annually in May/June to obtain abundance estimates using established base-wide survey protocols to allow for evaluation of trends over time, adjusting frequency if necessary.
- *Action*: Conduct quarterly surveys of the colony site at Pati Point for fruit bats.
- *Action*: Search for aggregating locations. If aggregations or new colony locations are detected, Live-Fire Training Range Complex will commence roost counts in accordance with established survey protocols. If changes in roost locations, colony size, or movement are detected, investigate potential threats or stressors that may be causing disturbance.
- *Action*: Collect ejecta and fecal samples for diet analysis and genetic testing according to established protocols and use data from dietary analysis to inform forest enhancement activities (e.g., outplanting and establishment of beneficial native flora).
- *Action*: Perform vegetation surveys in areas known to be used by fruit bats, specifically focused on distribution and density of important food trees, such as *F. prolixa*.
- *Action*: Provide new information from monitoring efforts to partners in fruit bat management during bi-annual project review meetings and INRMP annual review process.

- *Action*: Conduct spatial and temporal analysis to understand patterns in fruit bat activity (e.g., by vegetation type or season) and provide guidance for development planning and fruit bat management.
- *Action*: Conduct pre-construction surveys for fruit bats within construction footprints one week prior to vegetation clearing activities.

TPS-2: MOTH SKINK AND PACIFIC SLENDER-TOED GECKO SURVEYS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1-2; and Goal #3, Objectives #1 and 4.

- *Strategy*: Develop better understanding of occurrence and distribution of Guam ESA-listed moth skinks and Pacific slender-toed geckos on Live-Fire Training Range Complex B.
- *Action*: Survey the distribution and abundance of the moth skink and Pacific slender-toed gecko on Live-Fire Training Range Complex.
- *Action*: Consider potential reintroduction sites for protected reptile species in appropriate locations (e.g., Tarague Basin) when adequate fencing and predator control can be provided.

TPS-3: PROTECTION OF LISTED INVERTEBRATES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-6; and Goal #3, Objectives #1-2 and 4. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Monitor and conduct surveys for listed tree snails, butterfly, and plant species on Live-Fire Training Range Complex.
- *Action*: Conduct additional surveys of tree snail, butterfly, and listed plant species to identify new locations.
- *Action*: Conduct pre-construction surveys for ESA-listed species within construction footprints.
- *Action*: Locate and protect the host plants for Mariana eight-spot butterfly.
- *Action*: Propagate and plant host plants for Mariana eight-spot butterfly within FES and on the back side of berms of Live-Fire Training Range Complex.
- *Action*: Raise and disperse butterfly larvae to host plants.
- *Action*: Translocate listed butterflies from construction footprints at NWF and monitor host plants for one year.
- *Action*: Conduct studies that assess the impacts of parasitoids and develop methods for control of parasitoids.

TPS-4: CONSERVATION OF LISTED PLANT SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-6; Goal #3, Objectives 1-2 and 4; and Goal #4, Objective #2. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Conserve and monitor existing *C. micronesica* within *C. micronesica* ungulate exclusion plots.
- *Action*: Continue to monitor and implement conservation methods on existing populations of *C. micronesica* within pre-existing fenced plots.

- *Action*: Perform an annual health evaluation as a metric to track success of conservation actions.
- *Action*: Conduct non-native plant removal and chemical and mechanical protection from invasive insects as needed.
- *Action*: Install and maintain ungulate proof fencing.
- *Action*: Install mechanisms to protect plants during a typhoon.
- *Action*: Pollinate plants manually and perform propagation and outplanting of plants.
- *Action*: Conduct pre-construction surveys for ESA-listed species within construction footprints at NWF.
- *Action*: Translocate ESA-listed species within construction footprints that cannot be avoided into protected habitat or Forest Enhancement sites.
- *Action*: Maintain and monitor translocated plants for one year to ensure at least 50% survival.

TPS-5: SUPPORT RECOVERY PLANNING USING SURROGATE NATIVE SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #3; and Goal #3, Objectives #1-4. This project supports and is consistent with the Revised Recovery Plan for the Sihek or Guam Micronesian Kingfisher, *Recovery Action #2*.

- *Strategy*: As part of recovery planning efforts, determine the optimum level of BTS suppression and control measures needed to reduce mortality prior to reintroduction of the Guam Kingfisher using Micronesian starlings as a surrogate species. This project will also support expansion of Micronesian starlings across the landscape throughout Live-Fire Training Range Complex.
- *Action*: Expand the local range of Micronesian starlings on Live-Fire Training Range Complex by placing predator proof nesting boxes at increasing distances from existing nest sites in conjunction with BTS suppression efforts.
- *Action*: Monitor choice and use of nest boxes, success of fledging, survivorship, and foraging range.

TPS-6: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1-2 and 4; and Goal #4, Objective #2. This project supports conservation measures from the 2015 MITT BO (USFWS 2015b).

- *Strategy*: Implement conservation measures listed in the 2015 MITT BO from USFWS.
- *Action*: Ensure "No Wildlife Disturbance" and "No Training" in designated areas to include Tarague Beach and other locations where listed species are known to occur.
- *Action*: Ensure all vehicular activities during training are restricted to designated and previously identified areas that do not contain listed species.
- *Action*: Ensure all training activities are consistent with the fire management plan in Commander Naval Forces Marianas (COMNAVMAR) Instruction 3500.4A (Marianas Training Manual) (COMNAVMAR 2013).
- *Action*: Ensure no vegetation clearing, except for maintenance required to keep paved surfaces in the drop zone, landing zones, and bivouac areas in a safe and useable condition. Clearing of tree species greater than 4 inches in diameter used for foraging and roosting of Mariana fruit bats will be avoided. No new bivouac areas are proposed under MITT. Maneuver units will remain tactical and not establish support camps.
- *Action*: Ensure aircraft overflights as part of training activities along all Live-Fire Training Range Complex clifflines are prohibited below 1,000 feet above ground level.

- *Action*: Ensure flood lights at Live-Fire Training Range Complex range are maintained below the tree canopy level and directed inland and parallel to the coast. Lighting in this configuration will avoid impacts to nesting and hatching sea turtles and Mariana fruit bats.
- *Action*: Ensure weapons used at Live-Fire Training Range Complex do not produce percussive force to avoid disturbance to Mariana fruit bats.

9.2.4.5 Migratory Bird Management

JRM installations manage and monitor the effects that both military readiness and non-readiness activities have on migratory bird species and populations. Relevant regulations and policies include the Military Readiness Rule (50 CFR 21.15); the 2014 MOU between the DoD and USFWS to Promote the Conservation of Migratory Birds; and EO 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*. Through the implementation of the INRMP, proper management of migratory bird species and habitats, including the timely implementation of appropriate conservation practices, will help installations avoid or minimize impacts to migratory birds.

To meet the goals and objectives of the INRMP, the following management project was identified for Migratory Bird Management (MIG) on Live-Fire Training Range Complex.

MIG-1: CONSERVATION MEASURES FOR MIGRATORY BIRDS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1-2 and 4; and Goal #6, Objective #1.

- *Strategy*: Develop and implement appropriate conservation measures for proposed actions that may have a significant adverse effect on a migratory bird population.
- *Action*: Include an inventory of all priority migratory bird species found on Live-Fire Training Range Complex. This installation-specific list of species of concern will include MBTA protected species, species listed under the ESA, Guam-listed species, USFWS Birds of Conservation Concern, candidate species (both federal and Guam), and DoD Mission-sensitive Priority Species.
- *Action*: For each species of management or monitoring, focus on the installation, provide a brief description of its life history, locations on the installation, and a statement of the interrelatedness between its conservation or priority status and installation mission activities.
- *Action*: Describe the installation's implementation of priority migratory bird conservation measures and explain how the installation uses these conservation measures to avoid or minimize impacts to military readiness.
- *Action*: Provide details on the installation's Bird/Animal Aircraft Strike Hazard program, if applicable, to include the types of birds using the airfield and areas surrounding the airfield throughout the year.
- *Action*: Conduct or support a Wildlife Hazard Assessment that identifies areas of the airfield that are attractive to birds and include recommendations for deterring birds from those areas.

9.2.4.6 Terrestrial Natural Resources Educational Outreach

Conservation awareness is instrumental in creating conditions needed to manage natural resources. The JRM approach to awareness stresses education. It provides military personnel and the public with insights into installation natural environments and conservation challenges. The more educated people are about the unique and valuable natural resources on JRM-administered lands, the more responsibly they will act when using them. Education also promotes awareness of critical environmental projects and the rationale behind them. As activities such as habitat management, wildlife management, and land rehabilitation are generally

accepted and understood, minimal effort is required to communicate conservation priorities to installation personnel, recreationists, and to the general public. However, issues such as protection of sensitive areas for plant and wildlife species, invasive species management (ungulate management), wildfire suppression and restrictions on some recreational activities in JRM-administered lands require effective conservation communication to garner positive support and, perhaps more importantly, to avoid adverse reactions from various users. A conservation awareness program must be directed to both installation and external interests if it is to be effective.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Natural Resources Educational Outreach (TEDU) on Live-Fire Training Range Complex.

TEDU-1: ESA-LISTED SPECIES AND TERRESTRIAL RESOURCES OUTREACH

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7; Objective #1-2. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Improve awareness among DoD personnel and the public of threats and stressors to terrestrial resources, including protected species, and the importance of conserving natural resources on Live-Fire Training Range Complex, in cooperative efforts with partners such as GovGuam and USFWS.
- *Action*: Develop, update, and distribute multimedia for public education to incoming military personnel, contractors, schools, and other outreach opportunities that address appropriate behavior around threatened and endangered species and the consequence of introduced non-native plant and animal species. Outreach materials will be reviewed every 2 to 5 years.
- *Action*: Review and update, as needed, current outreach videos/media used during the orientation briefs viewed by 100% of new personnel upon arrival to Guam.
- *Action*: Develop a contractor education program on ESA-listed and invasive species.

TEDU-2: JRM NATURAL RESOURCES STEWARDSHIP OUTREACH AND PUBLIC ENGAGEMENT PROGRAM

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7; Objective #1-3.

- *Strategy*: Implement a comprehensive natural resources outreach regarding the federal, territorial, and base environmental regulations and policies, as well as information about the importance of protecting and conserving JRM's natural resources.
- *Action*: Update a comprehensive Natural Resources Stewardship Outreach online training system for military and civilian personnel.
- *Action*: Create a JRM Environmental Public Engagement Plan to outline the areas where JRM can significantly increase their outreach with military personnel and the public about appropriate behavior toward threatened and endangered species and the importance of conserving natural resources within lands and submerged lands administered by JRM.
- *Action*: Develop, update, and implement a biosecurity education and outreach program for contractor personnel, military personnel, and dependents.

9.2.4.7 Terrestrial Natural Resources Law Enforcement

JRM has established the following objectives for enforcement: (1) enforce laws and regulations pertaining to the implementation of the natural resources program, (2) integrate natural resources enforcement into the overall natural resources program, and (3) use enforcement personnel to enhance the natural resources program at JRM.

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial Natural Resources Law Enforcement (TLAW) on Live-Fire Training Range Complex.

TLAW-1: CONSERVATION LAW ENFORCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-3; Goal #2, Objectives #1-2 and 4; Goal #3, Objectives #4; Goal # 6, Objectives #1-2; and Goal #7; Objectives #1-3.

- *Strategy*: Detect and deter unauthorized activity that negatively affects natural resources on Live-Fire Training Range Complex (e.g., poaching, off-roading) through conservation law enforcement.
- *Action*: Establish a Conservation Law Enforcement Program by hiring a Conservation Law Enforcement Officer and by partnering with other agencies, as applicable, to enforce natural resource laws, policies, and regulations on Live-Fire Training Range Complex. The Conservation Law Enforcement Officer will conduct outreach and enforce natural resource regulations.
- *Action*: Protect sea turtles from poaching on nesting beaches and submerged lands.

9.2.4.8 Terrestrial Geographic Information System and Data Management

Natural resources data are stored and maintained within a centralized JRM GIS database. The GIS database also provides support for the entire environmental program and the training community. JRM uses GIS for complex analyses such as project siting, data interpolations, and risk assessments. GIS software enables installation staff to capture, store, update, manipulate, analyze, and display all forms of geographically referenced data and tabular information about natural and physical resources found on JRM-administered lands. The training of JRM staff and the allocation of their time to data entry, mapmaking, data analysis, and interpretation of the results determines the success of the installation GIS. Once fully developed, the installation GIS databases can be used for projects such as the following:

- providing maps with locations of species, vegetation communities, surface waters, and other areas of potential concern
- selecting suitable areas for construction activities
- planning land rehabilitation projects
- providing special maps for Environmental Awareness materials
- ensuring avoidance of threatened and endangered species habitats and other areas of special concern during construction projects
- identifying site options for use during NEPA evaluation of alternative sites
- calculating drainages and water flows
- determining wildlife habitat preferences

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial GIS and Data Management (TGIS) on Live-Fire Training Range Complex.

TGIS-1: TERRESTRIAL NATURAL RESOURCES GIS AND DATA MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-5; and Goal #3, Objectives #1 and 4.

- *Strategies*:
  - Identify data gaps in terrestrial natural resources GIS to assist in the development of future data collection efforts, surveys, and management actions.
  - Ensure that GIS information is available to installation subject matter experts and military personnel, biologists, planners, contractors, and others in a timely manner to assist with planning and decision-making.
- *Action*: Update and continuously maintain existing centralized GIS database to effectively inform and guide future management of terrestrial natural resources on Live-Fire Training Range Complex and meet natural resources goals and objectives. Readily available GIS data will be used to develop natural resources constraints maps for use in current and future JRM management and planning decisions for Live-Fire Training Range Complex.

9.2.4.9 Summary – Terrestrial Ecosystem Management

Implementation of the JRM INRMP program and the focused strategies and actions of the management projects for terrestrial resources provides a conservation benefit to the natural ecosystems within Live-Fire Training Range Complex by maintaining and enhancing the natural community structure, function, species diversity, and resiliency. Enhancing and restoring native habitats supports viable populations of native species and increases biodiversity. Furthermore, proactive invasive species prevention, early detection, and control reduces the risk of intra- and inter-island species introductions. Data from regular monitoring of protected species informs management projects to enhance and restore habitat, reduce habitat fragmentation, buffer protected areas, implement new conservation strategies, and avoid and minimize impacts. Using this regional ecosystem-based approach for managing protected species and their associated ecosystems ensures that JRM remains in compliance with federal and territorial laws while supporting the operational functionality of the Live-Fire Training Range Complex mission.

Twenty management projects addressing terrestrial natural resources management are proposed for implementation on Live-Fire Training Range Complex:

- Terrestrial Habitat Management – 2
  - THM-1: Forest Enhancement
  - THM-2: Urban Forestry Data Base, Maintenance, and Replacement of Trees
- Terrestrial Exotic and Invasive Species Management – 7
  - TIS-1: Brown Treesnake Interdiction
  - TIS-2: Brown Treesnake Suppression
  - TIS-3: Brown Treesnake Management for the Recovery of Protected Species
  - TIS-4: Invasive Species Management
  - TIS-5: Implementation of Regional Biosecurity Plan for Micronesia and Hawai‘i
  - TIS-6: Mariana Islands Training and Testing Implementation of the Biological Opinion
  - TIS-7: Control Feral Dogs and Cats
- Terrestrial Protected Species Management – 6
  - TPS-1: Mariana Fruit Bat Population Protection and Enhancement
  - TPS-2: Moth Skink and Pacific Slender-toed Gecko Surveys
  - TPS-3: Protection of Listed Invertebrates

  - TPS-4: Conservation of Listed Plant Species
  - TPS-5: Support Recovery Planning Using Surrogate Native Species
  - TPS-6: Mariana Islands Training and Testing Implementation of the Biological Opinion
- Migratory Bird Management – 1
  - MIG-1: Conservation Measures for Migratory Birds
- Terrestrial Natural Resources Educational Outreach – 2
  - TEDU-1: ESA-listed Species and Terrestrial Resources Outreach
  - TEDU-2: JRM Natural Resources Stewardship Outreach and Public Engagement Program
- Terrestrial Natural Resources Law Enforcement – 1
  - TLAW-1: Conservation Law Enforcement
- Terrestrial Geographic Information System and Data Management – 1
  - TGIS-1: Terrestrial Natural Resources GIS and Data Management

9.3 MCBCB URBAN TRAINING COMPLEX

9.3.1 Operations and Land Use

9.3.1.1 Current Operations and Land Use

Historically, MCBCB Urban Training Complex was used for family housing and barracks, and includes a wastewater pump station, water booster pump station, water tanks, and electrical substation. These facilities are not currently being used. There are installation restoration (clean-up) sites and water production wells with wellhead clearance buffers in the area. The vacant family housing and barracks area in the southern portion of the parcel and north of Route 15 (Figure 9-14) have been used for humanitarian operations, staging, bivouac, equipment inspection, and small unit tactics, including MOUT training.

MCBCB Urban Training Complex, formerly known as Andersen South, was used by the USAF for expeditionary training. The most intensive use at Andersen South occurred during exercises involving up to three U.S. Marine Corps (USMC) companies utilizing the MOUT area for up to 3 weeks, twice a year.

As part of the Record of Decision for the Guam and CNMI Military Relocation action (DON 2010b, 2015b), this area is now known as MCBCB Urban Training Complex. There is an 80-acre parcel land within the MCBCB Urban Training Complex that was deeded in 1992 to the Government of Guam for the construction of a public high school, but the land was returned to the DON in 2020 and the school was not developed.

9.3.1.2 Proposed Operations and Land Use

As part of the Record of Decision for the Guam and CNMI Military Relocation action (DON 2010b, 2015b), facilities and infrastructure to support military training operations at Andersen South have been constructed for the MCBCB Urban Training Complex. The following discussion and Figure 9-15 provide a summary of the new facilities constructed and military training operations that occur within the new MCBCB Urban Training Complex (NAVFAC Pacific 2010b, 2017; NAVFAC Marianas 2017).

Training Area 1 (TA1)

The wheeled vehicle driver and convoy course in TA1 includes a serpentine roadway course with built-in obstacles and various terrain features.

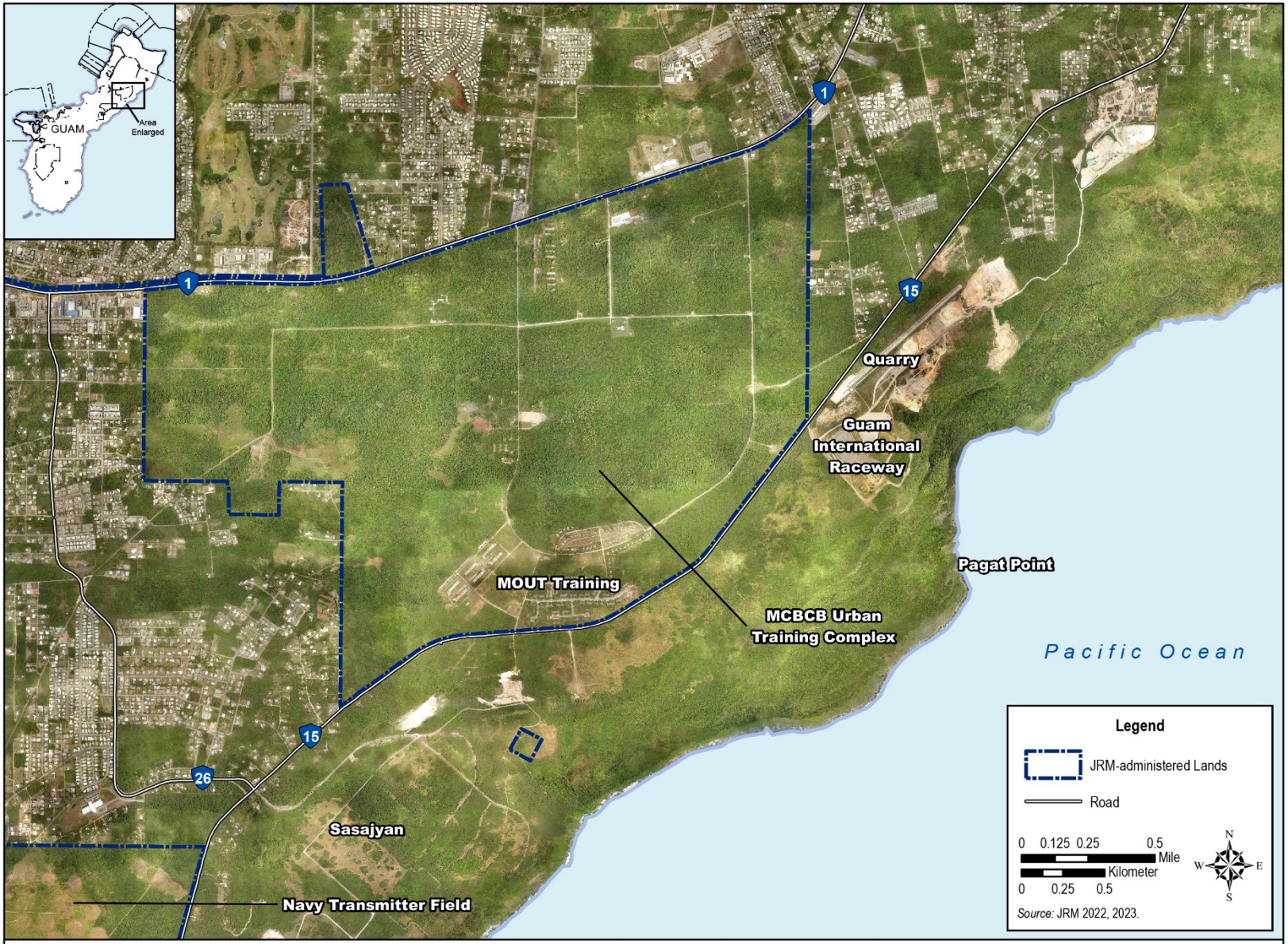


Figure 9-14
Overview of MCBCB Urban Training Complex

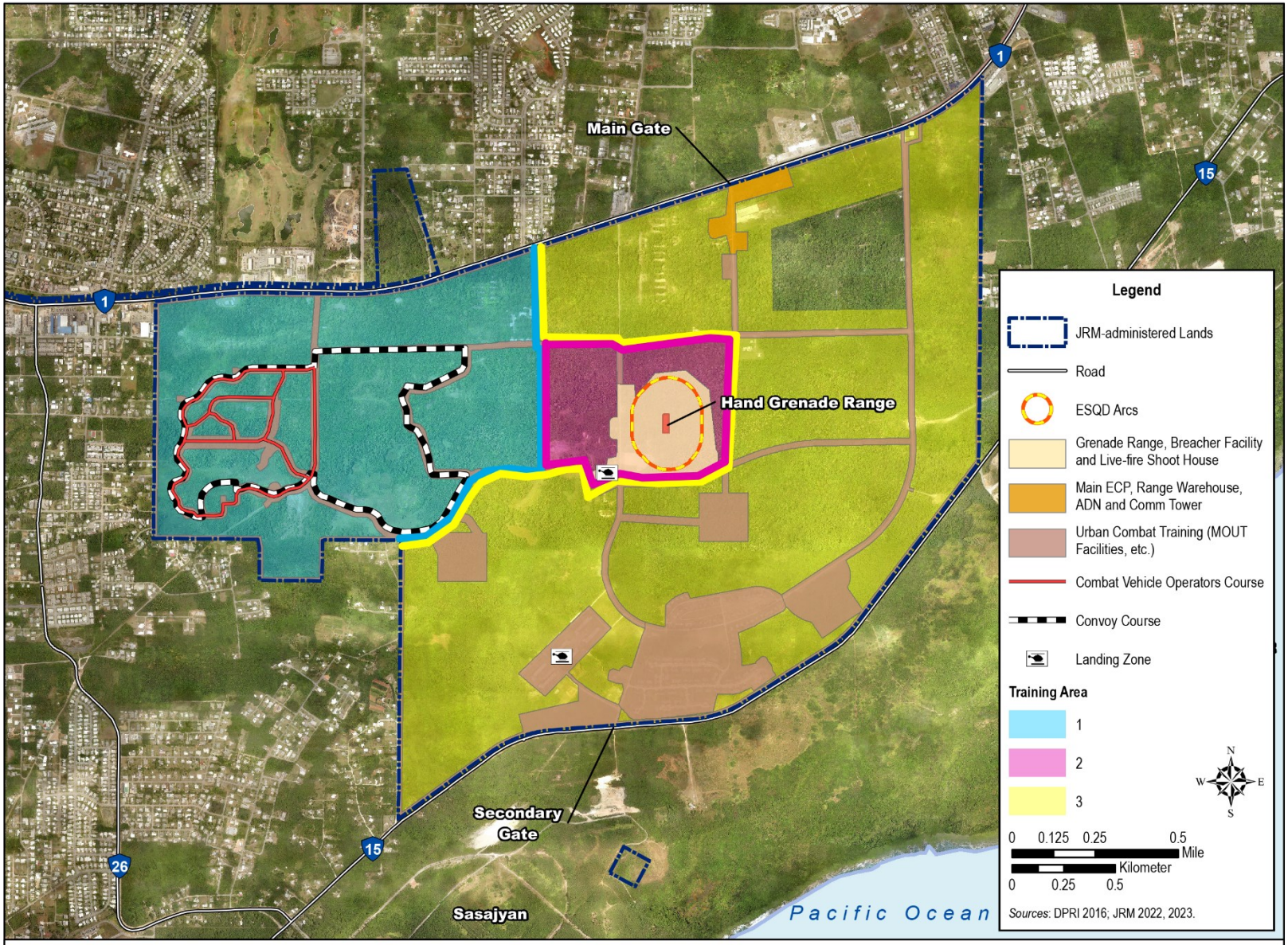


Figure 9-15
Proposed Training Areas on MCBCB Urban Training Complex

Training Area 2 (TA2)

TA2 provides infrastructure to meet training requirements for anti-terrorism/force protection (AT/FP), roads, and utilities (electrical, water, wastewater, and communications). TA2 consists of a Hand Grenade Range, a Live-Fire Shoot House/Close Quarter Combat Facility, and a Breacher Facility.

- Grenade Range: provides a collection of structures and site improvements supporting training requirements. Site improvements include earthen berms, concrete throwing pits, and preparation of the impact area. Grenade range components include:
  - *Hand Grenade Familiarization Course*
  - *Hand Grenade House*:
  - *Observation Tower*
  - *Munitions Issue Area*
  - *Waiting Relay Bunkers*
- Live-fire Close Quarters Combat Shoot House: provides units with a facility to train and evaluate individuals and squads on tactical maneuvers in a live-fire environment.
- Breacher House: a facility used to train personnel on the skills necessary to breach windows, walls, and doors using explosive techniques.
- Landing Zone: supports helicopter and tilt-rotor aircraft training operations.

Training Area 3 (TA3)

TA3 provides the associated requirements for AT/FP, roads, utilities (electrical, water, wastewater, and communications). TA3 consists of a Range Operations Center, a warehouse/range maintenance facility/range control facility, a MOUT area including a U.S. embassy, United Nations/UNICEF office, a business district, an industrial district, a market district, a municipal district, an apartment district, a suburban district, and a recreational district. The city complex has a minimum of five streets where trainees can conduct lane training.

Convoy operations, MOUT-related maneuver training, and general maneuver and air-ground operations vary from small unit to company-level exercises that occur 5 days a week, 45 weeks per year, day and night. This area of MCBCB Urban Training Complex was previously used by the USAF for expeditionary airfield training that has similarities to the proposed maneuver area training. The area continues to support this USAF training, while also accommodating USMC training requirements.

9.3.2 Geology, Topography, and Soils

9.3.2.1 Geology

MCBCB Urban Training Complex is located in limestone rock units. There are two sections of the Tamuning-Yigo Fault running east-west through the center of MCBCB Urban Training Complex (Figure 9-16).

9.3.2.2 Topography

MCBCB Urban Training Complex is located on relatively flat land on top of the limestone plateau of northern Guam. The elevation gently rises from approximately 300 feet (91 meters) MSL in the northwestern portion of the parcel to 500 feet (152 meters) above MSL at the southeastern corner.

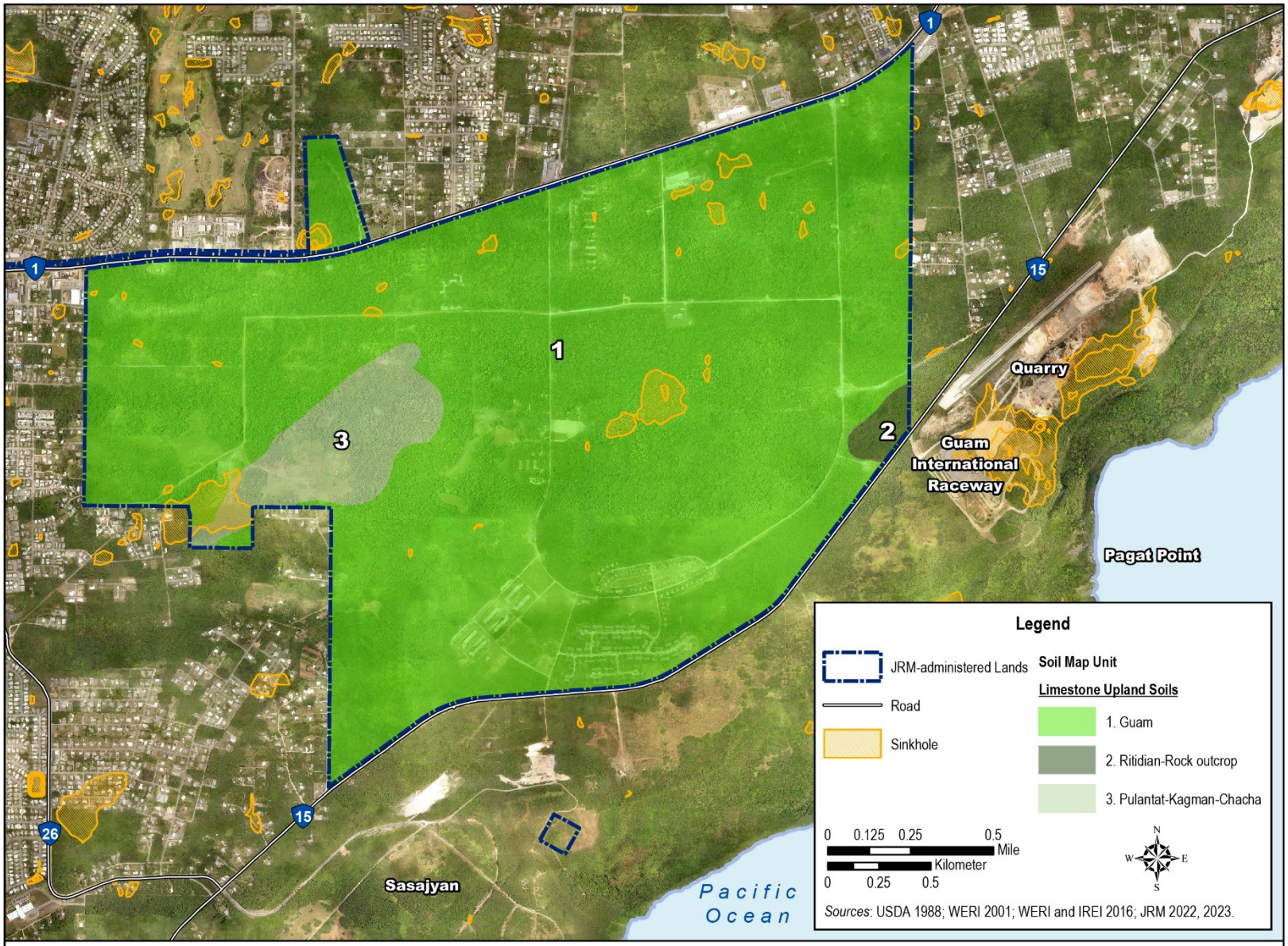


Figure 9-16
Soils on MCBCB Urban Training Complex

9.3.2.3 Soils

As is typical of areas in northern Guam, MCBCB Urban Training Complex is underlain with limestone upland soils (see Figure 9-16); the descriptions of each soil type are summarized in Table 4-1. The three types of soils found at MCBCB Urban Training Complex are all limestone upland soil and include Guam, Ritidian-rock outcrop, and Pulantat-Kagman-Chacha. They are all well drained, slowly permeable soils that are shallow over limestone, typically on plateaus (USDA 1988).

9.3.3 Hydrology

9.3.3.1 Surface Water

MCBCB Urban Training Complex is located in the Yigo-Tumon and Mangilao drainage basins (Figure 9-17). There are no surface water features on MCBCB Urban Training Complex.

9.3.3.2 Groundwater

MCBCB Urban Training Complex is underlain by very permeable limestone within the Yigo Sub-basin of the NGLA (refer to Figure 4-10). Refer to Section 4.3.2, *Groundwater,* for further discussion of the NGLA.



***Averrhoa bilimbi*, fagot (*Ochrosia* [=*Neisosperma*] *oppositifolia*), and bird's nest fern (*Asplenium nidum*) in Limestone degraded forest on MCBCB Urban Training Complex.**

9.3.4 Vegetation Communities

The majority (78%) of MCBCB Urban Training Complex is mapped as scrub forest, with the southern area that is associated with the previous housing area and current MOUT facility dominated by tangantangan (Table 9-9 and Figure 9-18). Vegetation surveys in 2010 found that the southwest and southeast corners of the site support more mature upper canopy vegetation layers, and in at least some locations these are dominated by native species (NAVFAC Pacific 2010b).

Table 9-9. Vegetation Communities on MCBCB Urban Training Complex

Vegetation Community	*Area (acres)*	*% of Total Area*	*% of Vegetated, Undeveloped Area*
Other Shrub/Grassland	77.9	3.9	3.8
Leucaena Forest	184.2	9.3	9.0
Cultivated Crops	1.7	0.1	0.1
Scrub Forest	1,551.0	78.3	75.4
Non-vegetated Categories			
Barren	2.0	0.1	NA
Developed	164.0	8.3	NA
Total	1,980.8		

Key: % = percent; NA = not applicable.
Source: USFS 2014.

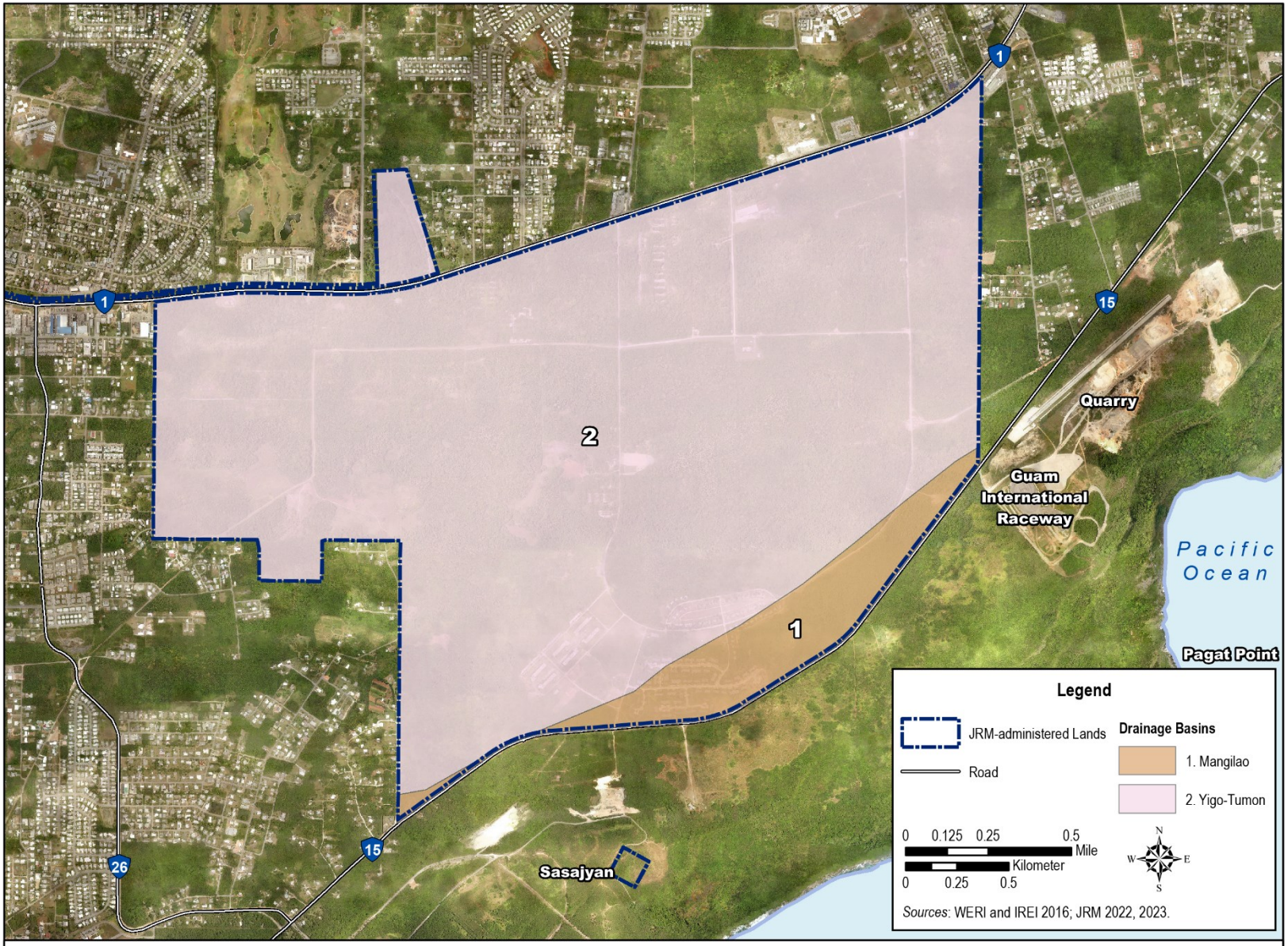


Figure 9-17
Drainage Basins on MCBCB Urban Training Complex

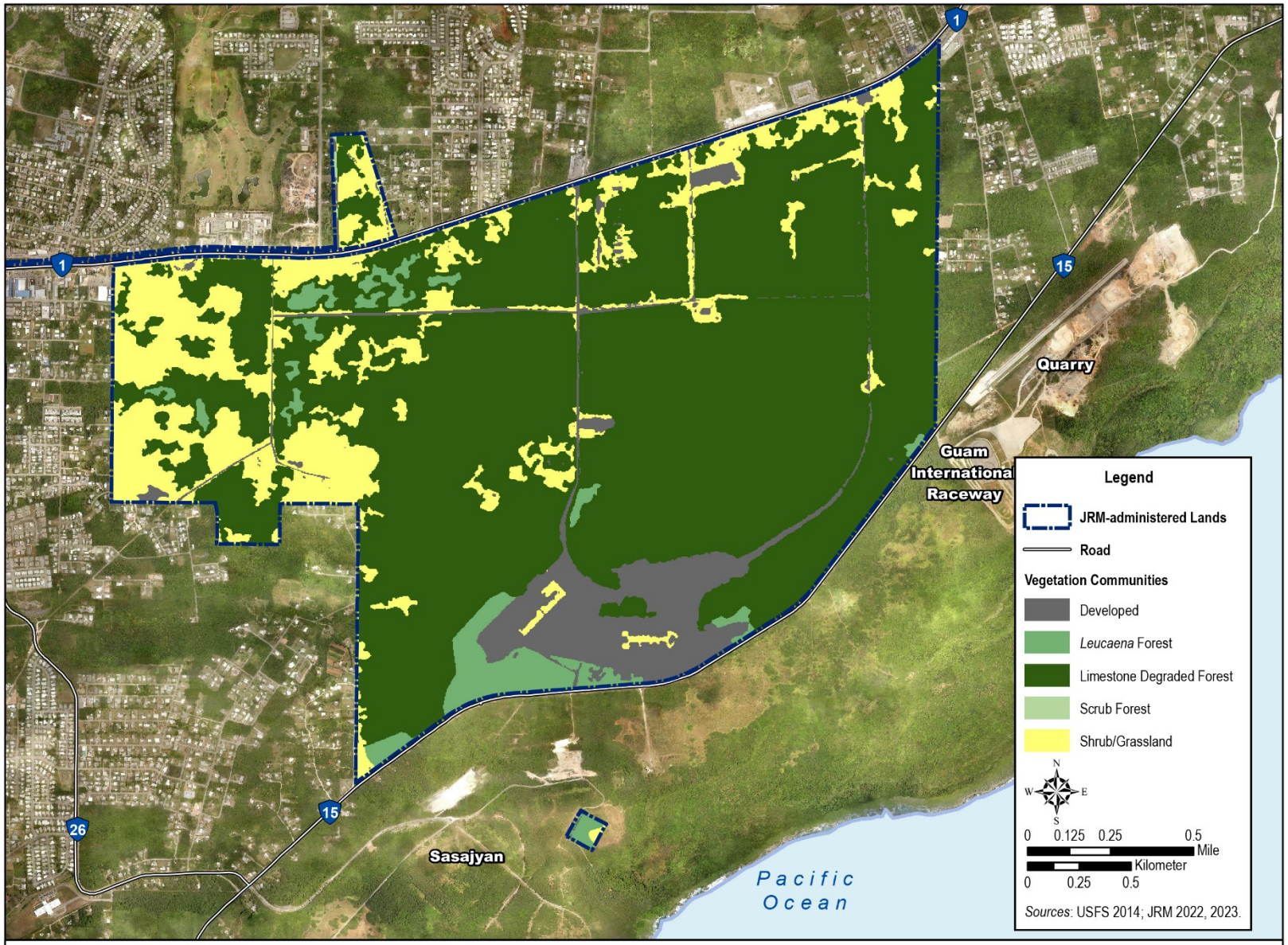


Figure 9-18
Vegetation Communities on MCBCB Urban Training Complex

9.3.5 Terrestrial Wildlife

9.3.5.1 Mammals

In December 2012 and May 2016, a single Mariana fruit bat was observed circling above the east area of MCBCB Urban Training Complex, a location where breadfruit trees occur (Guam DAWR 2017g).

Although no mammal surveys have been conducted within MCBCB Urban Training Complex, it is expected that the common non-native small mammals found throughout Guam would occur, including Norway rat, black rat, Polynesian rat, house mouse, and musk shrew (Wiles 2005; Wiewel et al. 2009). In addition, Philippine deer and feral pigs are very common on MCBCB Urban Training Complex and their occurrence is evident by the extensive signs of rooting, wallows, and vegetation damage (NAVFAC Pacific 2010b), as well as frequent visual observations by natural resources survey personnel (NAVFAC Pacific 2010b; Vogt and Farley 2013). Feral pigs cause extensive habitat damage by rooting and digging and pose threats to sea turtle nests, and deer cause loss of native plant and animal species, as well as degradation of native species' habitat.

In 2016, a cooperative agreement was entered into with White Buffalo, Inc. for field-based feral pig and deer control, eradication, and research operations on JRM-administered lands in Guam. Operations ran from October 2021 to November 2023. Extensive ungulate removal operations did not occur on MCBCB Urban Training Complex; however, White Buffalo monitored conservation fences within the area and installed "seam gates" within the Ungulate Conservation fences to facilitate movement of USDA and USGS snake teams for survey purposes (White Buffalo 2023).

9.3.5.2 Birds

Based on 21 roadside stations and point count stations along 7 forest transects surveyed during March and June 2008 and September 2009, six bird species have been observed at MCBCB Urban Training Complex, two of which are native and listed under the MBTA (Table 9-10) (NAVFAC Pacific 2010b). The same species were observed during Mariana fruit bat surveys in March 2013 (Vogt and Farley 2013). The only resident breeding species was the yellow bittern; all other breeding species are non-native species. One species (Pacific golden plover) is a common winter resident in Guam. The Pacific golden plover is Guam-designated as SOGCN.

Table 9-10. Bird Species Recorded on MCBCB Urban Training Complex

Common Name/ Chamorro Name[1]	*Scientific Name*	*Residence Status*	*Listed under MBTA*
Yellow bittern/Kakkak	*Ixobrychus sinensis*	Common native breeding resident	Y
Rock dove/None	*Columba livia*	Common introduced breeding resident	N
Black francolin/None	*Francolinus*	Common introduced breeding resident	N
Eurasian tree sparrow/Gagapale	*Passer montanus*	Common introduced breeding resident	N
Pacific golden plover/Dulili	*Pluvialis fulva*	Common non-breeding visitor	Y
Island collared dove/Palumat	*Streptopelia bitorquata*	Common introduced breeding resident	N
Micronesian starling/Sali	*Aplonis opaca*	Native	N

Note: [1] Common and scientific names based on Gill and Donsker (2017). Chamorro names from GovGuam (2009), Liske-Clark (2015), Topping et al. (1975), and USFWS (2015b).
Key: MBTA = Migratory Bird Treaty Act; N = no; Y = yes.
Sources: NAVFAC Pacific 2010b; Vogt and Farley 2013.

In May 2016, the native Micronesian starling was recorded during Guam DAWR's annual spring bird count (Guam DAWR 2017h). White-throated ground dove have been reported adjacent to MCBCB Urban

Training Complex since 2008 to the present (Guam DAWR 2017i). The white-throated ground dove and Micronesian starling are Guam-listed as endangered and Guam-designated as SOGCN.

9.3.5.3 Reptiles and Amphibians

Based on visual surveys and glue-board trapping conducted along seven transects in April and June 2008 and October 2009, seven reptile species (two native and five non-native) and two non-native amphibian species have been observed at MCBCB Urban Training Complex (Table 9-11) (NAVFAC Pacific 2010b).

Table 9-11. Reptile and Amphibian Species Recorded on MCBCB Urban Training Complex

Common Name/ Chamorro Name(1)	***Scientific Name***	***Residence Status***
Curious skink/Gualiek halumtano	*Carlia ailanpalai*	Non-native
Pacific blue-tailed skink/Gualiek halumtano	*Emoia caeruleocauda*	Native
Mutilating gecko/Achiak	*Gehyra mutilata*	Native
House gecko/Achiak	*Hemidactylus frenatus*	Non-native
Monitor lizard/Hilitai	*Varanus tsukamotoi*	Native
Brown treesnake/Kolepbla	*Boiga irregularis*	Non-native
Brahminy blind snake/Ulo attilong	*Ramphotyphlops braminus*	Non-native
Greenhouse frog/Kairo	*Eleutherodactylus planirostris*	Non-native
Marine toad or Cane toad/Kairo	*Rhinella* (=*Bufo*) *marina*	Non-native

Note: (1) Common and scientific names based on Gill and Donsker (2017). Chamorro names from GovGuam (2009), Liske-Clark (2015), and USFWS (2015b).
Source: NAVFAC Pacific 2010b.

9.3.5.4 Invertebrates



***Procris pedunculata*, a host plant for the ESA-listed Mariana eight-spot butterfly (*Hypolimnas octocula marianensis*), is present on Andersen South.**
(*Photo*: L. Shaughnessy)

In September 2009 and January 2010, butterfly surveys were conducted along a transect within scrub forest in the southeastern portion of MCBCB Urban Training Complex (NAVFAC Pacific 2010b). The purpose of the surveys was to determine the presence of the Mariana eight-spot butterfly (*Hypolimnas octocula marianensis*) and Mariana wandering butterfly, both candidate species for listing under the ESA at the time; both species were listed as endangered in October 2015 (USFWS 2015a, 2015b). In addition, the presence of host plants (i.e., *Procris pedunculata*, *Elatostema calcareum*, and *M. thompsonii*) for these species was also recorded. Three butterfly species were identified during the surveys: lemon emigrant (*Catopsilia pomona*), blue-banded king crow, and common Mormon. All of these species are common and widely distributed in the Mariana Islands. The host plants for the Mariana eight-spot butterfly were not observed. However, during the butterfly surveys and separate vegetation surveys on MCBCB Urban Training Complex, the Mariana wandering butterfly host plant, *M. thompsonii,* was observed (NAVFAC Pacific 2010b).

In October 2009, tree snail surveys were conducted along a transect within scrub forest in the southeastern portion of MCBCB Urban Training Complex. No living partulid tree snails or their shells were observed along the transect. Although no partulid tree snails were observed on MCBCB Urban Training Complex during the 2009 survey, the report concluded that since there were several known host plant species present throughout the survey area, the possibility that tree snails are present in habitat associated with the surveyed

transect cannot be dismissed. Shells of the introduced giant African snail and both live individuals and shells of the introduced snail (*Satsuma mercatoria*) were seen along the transect (NAVFAC Pacific 2010b).

The Little Fire Ant (LFA) (*Wasmannia auropunctata*) poses a risk to the survival and recovery of all proposed, threatened, and endangered species in Guam. In natural ecosystems, LFAs displace other ant species and predate on insects and vertebrates (Vanderwoude 2014). They can easily fall from their arboreal homes onto any other animals under them. When they become trapped in clothes or the fur of animals, they become alarmed, and the alarm pheromones emitted cause all nearby ants to sting in unison. Their sting can be quite painful and cause allergic reactions in certain individuals, posing a greater risk to chicks, hatchlings, pups, and other young that might fall prey. Often other animals sharing the same habitat simply relocate to uninfested areas to avoid the discomfort (Vanderwoude 2014). LFA were first noted in Guam in 2011 in dense colonies that reached from ground level to the canopy at densities of up to 500 workers/square meter) (Raymundo and Miller 2012). In the past 4 years, LFA have been spread by human activities to at least 28 sites throughout the island.

There are currently two colonies of LFA on MCBCB Urban Training Complex (Figure 9-19). The date of original infestation, current size, and status of these colonies is unknown. The origin of the colonies is thought to be from the dumping of infected garden waste on MCBCB Urban Training Complex. Delineation, eradication, and monitoring/control efforts are currently underway for LFA on MCBCB Urban Training Complex.

The CRB was first detected in Guam in the Tumon Bay area on September 12, 2007 and was considered to have spread island-wide by 2010. BMPs are implemented to help curb the spread of and damage from CRB.

9.3.6 Terrestrial Protected Species

Four federal ESA-listed species have been recorded on MCBCB Urban Training Complex: three plants and one tree snail (Table 9-12 and Figure 9-20). One of the species is also Guam-listed as ESA and two species are Guam-designated as SOGCN.

Table 9-12. Federal and Guam ESA-listed Threatened and Endangered Terrestrial Species Recorded on MCBCB Urban Training Complex

Common Name/ Chamorro Name(1)	*Scientific Name*	*Federal Status*	*Guam Status*	*Habitat*	*Occurrence*
Invertebrates					
Guam tree snail/ Akaleha	*Partula radiolata*	E	E	Limestone native and ravine forests.	Y
Plants					
None/Fadang	*Cycas micronesica*	T	--	Limestone native and degraded forests.	Y
None/None	*Dendrobium guamense*	T	--	Limestone native forest and limestone coastal scrub.	Y
None/None	*Tabernaemontana rotensis*	T	--	Limestone native and degraded forests.	Y

Notes: (1) Chamorro names from GovGuam (2009), Topping et al. (1975), Safford (2009), and USFWS (2015b).
Key: -- = not listed; E = endangered; ESA = Endangered Species Act; T = threatened; Y = yes.
Sources: GovGuam 2009; NAVFAC Pacific 2010b; USFWS 2015a, 2015b; NAVFAC Marianas 2016, 2017.

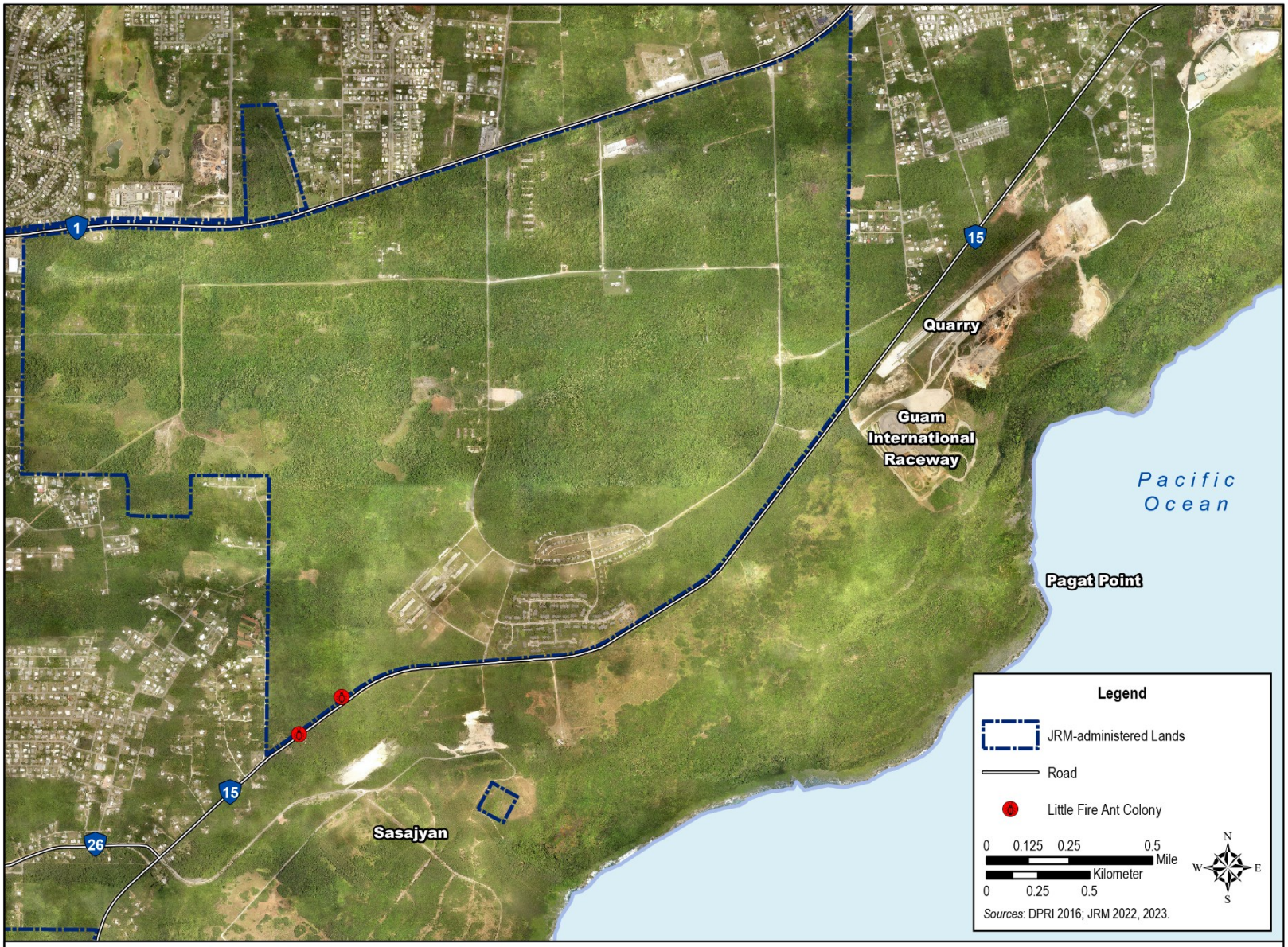


Figure 9-19
Little Fire Ant Colonies Recorded on MCBCB Urban Training Complex

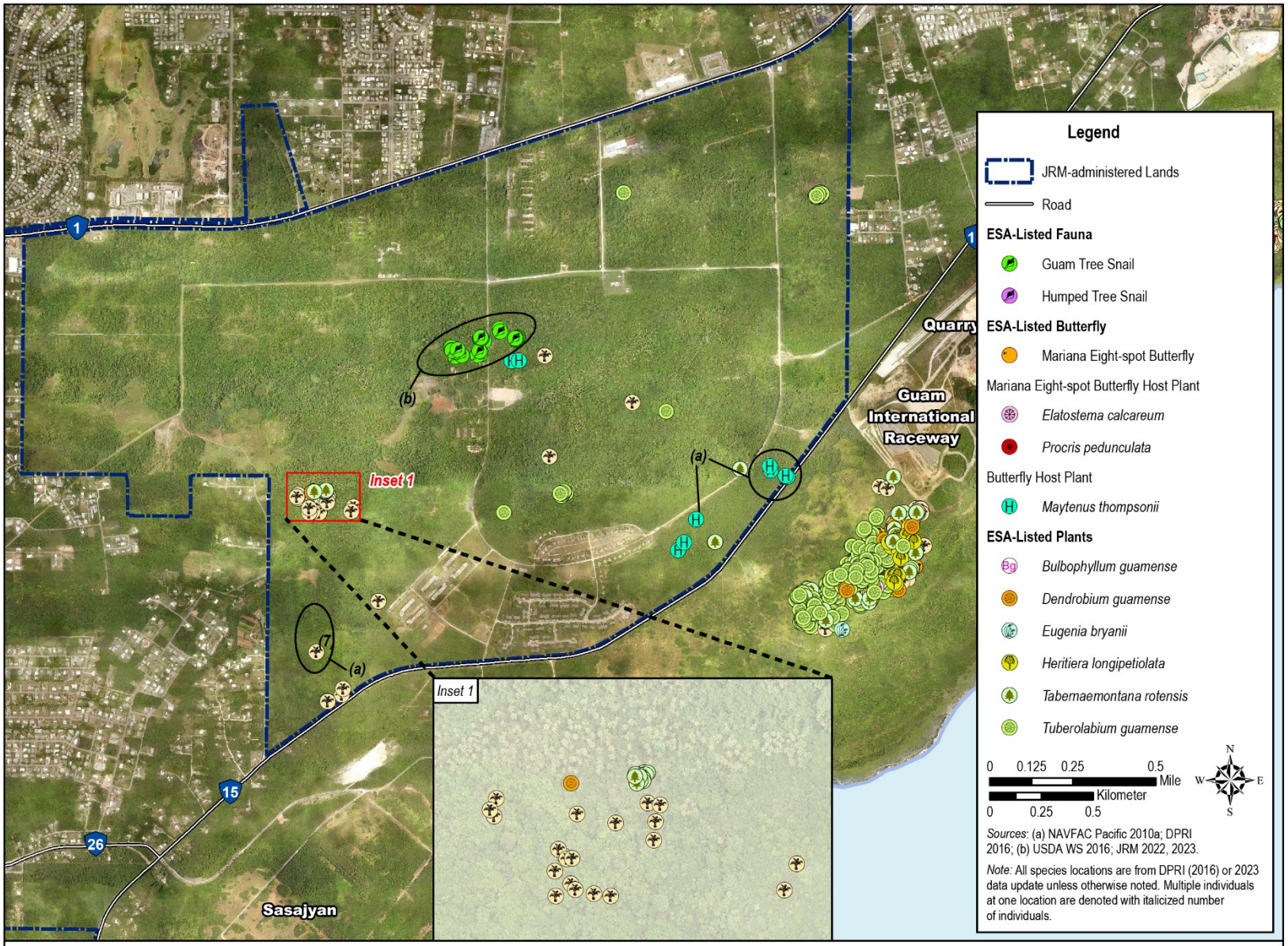


Figure 9-20
Protected Species and Butterfly Host Plants Recorded on MCBCB Urban Training Complex

In support of the construction of the MCBCB Urban Training Complex Training Complex, pre-construction surveys were conducted by JRM natural resources personnel in 2016 within proposed project footprints on MCBCB Urban Training Complex to determine the presence of ESA-listed species, host plants for federal ESA-listed butterflies, and plant species with high cultural and/or ecosystem value, called High Value Trees (Olmsted 2016). The list of High Value Trees was developed by DON natural resources personnel in coordination with the GovGuam, Department of Chamorro Affairs. Further discussion of High Value Trees is provided below.

Although none have been reported in recent years from MCBCB Urban Training Complex, Mariana fruit bat, Micronesian starling, and white-throated ground dove are considered to be potential visitors to the site by the Guam DAWR.

9.3.6.1 Invertebrates

Guam Tree Snail

The Guam tree snail is federal and Guam ESA-listed as endangered and Guam-designated as SOGCN. Surveys conducted in 2016 found 38 Guam tree snails within scrub forest in the central area of MCBCB Urban Training Complex (NAVFAC Marianas 2017) (see Figure 9-20).

9.3.6.2 Plants

Cycas micronesica

Surveys conducted in 2016 recorded 28 *C. micronesica* on MCBCB Urban Training Complex (see Figure 9-20) (NAVFAC Marianas 2016). The NAVFAC Pacific (2010b) surveys in 2009 recorded seven individuals along survey transects that were outside the NAVFAC Marianas (2016) survey area. It was noted in both survey efforts that the *C. micronesica* individuals were generally in poor health. The current status of the individuals observed in 2009 is unknown. *C. micronesica* is federal ESA-listed as threatened and Guam-designated as SOGCN.

Dendrobium guamense

Surveys conducted in 2016 recorded one occurrence of *Dendrobium guamense* on MCBCB Urban Training Complex (see Figure 9-20) (NAVFAC Marianas 2016). *D. guamense* can be found on a number of native and non-native host trees in the following genera: *Hernandia*, *Elaeocarpus*, *Premna*, *Heritiera*, *Pisonia*, *Persea*, *Vitex*, *Areca*, *Eugenia*, *Ficus*, *Dypsis*, and *Pandanus*, as well as in dead trees (USFWS 2017). *D. guamense* is federal ESA-listed as threatened.

Tabernaemontana rotensis

Tabernaemontana rotensis is federal ESA-listed as threatened. Once thought to be extremely rare in Guam, thousands of *Tabernaemontana rotensis* individuals have been discovered around forest margins and open patches (NAVFAC Marianas 2017). Surveys conducted in 2016 recorded 23 *Tabernaemontana rotensis* individuals on MCBCB Urban Training Complex (see Figure 9-20) (NAVFAC Marianas 2016).

Host Plants for Federal ESA-listed Butterflies

As stated in Section 7.4.5.4, *Invertebrates*, surveys were conducted in September 2009 and January 2010 to determine the presence of the Mariana eight-spot butterfly and Mariana wandering butterfly on MCBCB Urban Training Complex. In addition, the presence of host plants (i.e., *P. pedunculata*, *E. calcareum*, and *M. thompsonii*) for these species was also recorded. Neither of the two federal ESA-listed butterfly species were observed (NAVFAC Pacific 2010b). Relatively common in primary and disturbed limestone forests, *M. thompsonii* has been recorded from four locations within MCBCB Urban Training Complex (see Figure 9-20) (NAVFAC Pacific 2010b; NAVFAC Marianas 2014b, 2016). *P. pedunculata* and *E. calcareum* were not observed during surveys.

High Value Trees

High Value Trees are those tree species that have high cultural and/or ecosystem value and will require additional handling and processing procedures during pre-construction clearing activities on JRM-administered lands. For a more detailed discussion on High Value Trees, see Section 4.4.3.5, *Plants*. Based on the 2016 surveys, 563 individuals of 11 species were recorded and marked on MCBCB Urban Training Complex (Table 9-13 and Figures 7-22 and 7-23) (NAVFAC Marianas 2016). In addition, >14 individuals of 5 species were recorded along transects conducted during earlier natural resource surveys (NAVFAC Pacific 2010b).

Table 9-13. High Value Trees Recorded on MCBCB Urban Training Complex

Species	***Source and Number Individuals***	
	NAVFAC Marianas (2016)	***NAVFAC Pacific (2010a)***
Artocarpus altilis(1)	22	--
Artocarpus mariannensis(1)	4	*
Artocarpus spp.(1)	190	1
Cycas micronesica(2)	28	7
Elaeocarpus joga(1)	129	--
Ficus prolixa(1)	1	--
Ficus tinctoria(1)	4	2
Ficus spp.(1)	68	--
Intsia bijuga(1)	90	--
Maytenus thompsonii(2)	4	4
Tabernaemontana rotensis(2)	23	--
Total	**563**	**14**

Notes: *Observed but number of individuals not recorded.
(1) Refer to Figure 9-21.
(2) Refer to Figure 9-20.
Key: NAVFAC = Naval Facilities Engineering Systems Command.
Sources: NAVFAC Pacific 2010a; NAVFAC Marianas 2016.

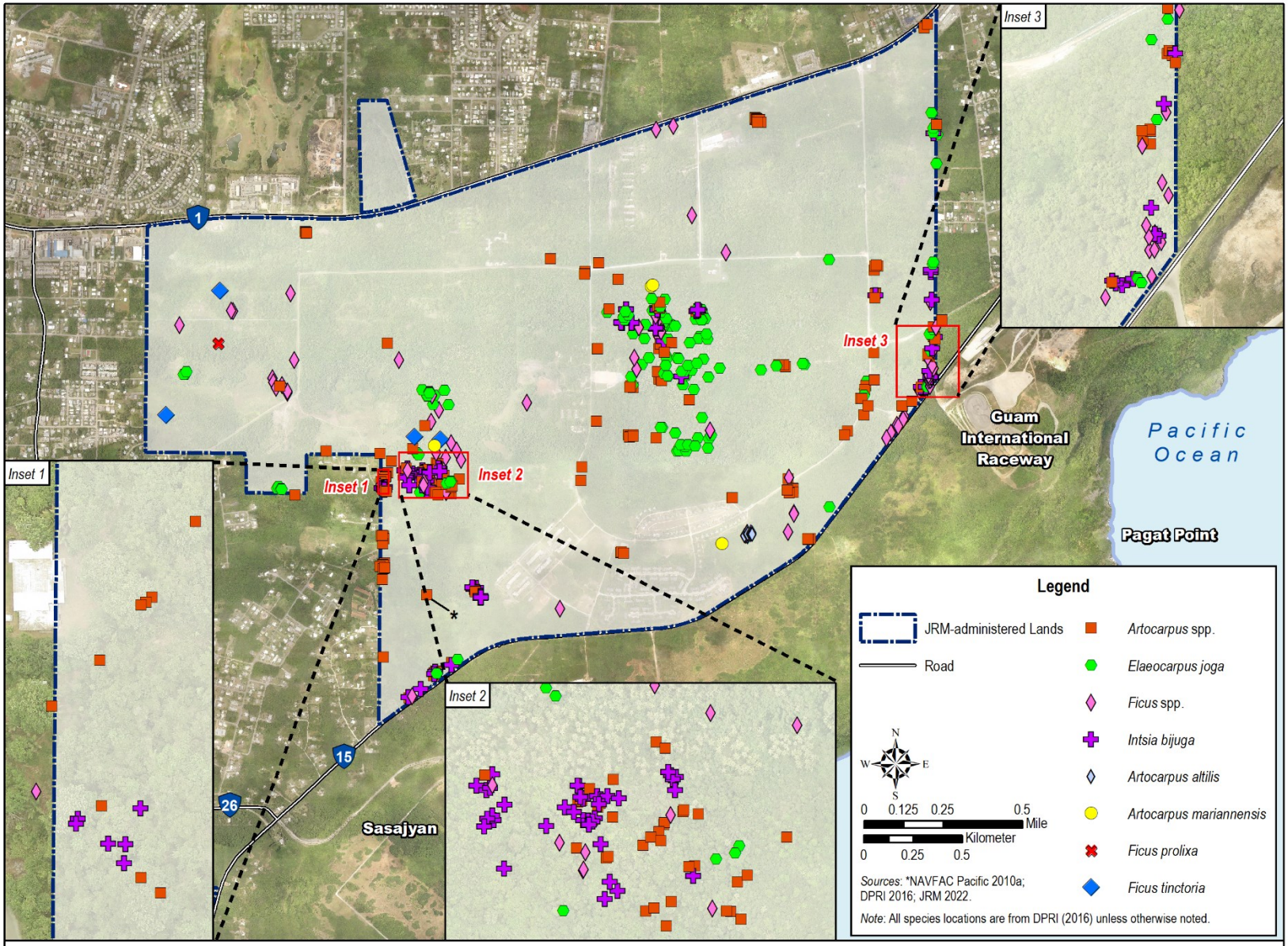


Figure 9-21
High Value Trees Recorded on MCBCB Urban Training Complex

9.3.7 Management Goals, Objectives, Strategies, and Actions

JRM currently manages natural resources based on an ecosystem-focused approach that involves the implementation of several ongoing management projects. These projects, which are further described in the following sections, provide examples of JRM's current efforts to manage and enhance natural resources in a manner consistent with the military mission. Appendix C lists management projects on Andersen AFB for FY 14-17, many of which also still apply to MCBCB Urban Training Complex lands. The following sections present management projects for MCBCB Urban Training Complex that are identified as necessary to achieve applicable goals and objectives identified in Chapter 3, *Environmental Management Strategy and Mission Sustainability*.

Management projects identified for the MCBCB Urban Training Complex provide direct support for the military mission and the goal of "no net loss" in a number of ways. For example, projects that improve the baseline status of species or their habitat show that populations are stable, or that habitat is improving or expanding, may relieve restrictions on military training or operations, minimize costs and mitigation requirements, avoid workarounds, and/or streamline regulatory processes.

9.3.7.1 Terrestrial Ecosystem Management

MCBCB Urban Training Complex's native terrestrial habitats have been impacted by historical activities, introduction and spread of invasive and non-native species, effects of climate change, and the resulting loss of functions necessary to support healthy native habitats. Ecosystem functions have been disrupted by the extirpation of native animal and plant species, which have resulted in both economic and cultural impacts on the ecosystem services provided by native habitats. The occurrence of healthy native habitats on the MCBCB Urban Training Complex is necessary to support sustainability of native species, including federal and Guam ESA-listed species. JRM recognizes that restoration and enhancement of native habitats on lands that they manage is a long-term process, and that adaptive management is key to long-term success of the program.

Management projects are monitored and evaluated annually to ensure that they are meeting identified goals and objectives. JRM will establish mid-year coordination meetings with resource partners to discuss ongoing and planned projects, including prioritization, scope, methodology, issues or challenges, timelines, and performance evaluation criteria. These discussions are intended to facilitate improved coordination and information sharing to allow for course corrections, if necessary, to ensure an adaptive approach.

Terrestrial ecosystem management as described in the following sections is expected to: (1) improve the status of threatened and endangered species through habitat conservation and enhancement, and (2) promote health and sustainability of native forests. Healthy ecosystems will, in turn, relieve or reduce environmental constraints and allow for maximum operational flexibility for the installations and continued/managed access to important recreational areas.

A summary of the management projects and the estimated timeframe for completion is presented in Table 13-10, *Planned Implementation Summary of Projects at MCB Camp Blaz* found in Chapter 13, *Planning, Integration, and Implementation*. Some of the projects described in this section are being accomplished through interactive partnerships with federal and territorial natural resource agencies (e.g., Guam DAWR), universities, and local organizations.

9.3.7.2 Terrestrial Habitat Management

JRM has ongoing and planned projects to restore and enhance native terrestrial habitats. These projects focus on improving the quality and availability of appropriate habitat for listed species, as well as increasing

the quality and health of existing native habitats, such as limestone native forests. Numerous related activities are required for native habitat improvement, such as control of ungulates and other invasive species, propagating and outplanting native plant species to improve diversity, and addressing forest health issues, such as improvement of seed dispersal. The 2017 Restoration Plan for the HMU (NAVFAC Marianas and Andersen AFB 2017a) and the 2018 Conceptual Limestone Forest Restoration and Enhancement Plan serve as management tools to help guide site-specific restoration and enhancement efforts on the MCBCB Urban Training Complex.

In order to achieve long-term goals, THM requires successful daily and short-term management, coupled with long-term planning and investment. To ensure that JRM continues to meet the overriding goal of restoring and enhancing terrestrial habitats for native species (including listed species) over the long-term, JRM site land managers and resource agencies will continue coordinating on natural resource management.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for THM on MCBCB Urban Training Complex.

THM-1: FOREST ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-6; Goal #3, Objectives #1 and 4; and Goal #4; Objective #2. This project supports conservation measures in the reinitiation of the 2015 BO for the DON's Relocation of USMC from Okinawa to Guam and Associated Activities in Guam (USMC Relocation 2017 BO, which contains amendments to the 2015 BO) (USFWS 2017).

- *Strategy*: Protect and restore priority native habitats (i.e., limestone forest) for the benefit of native flora and fauna, including protected species, by focusing on step-wise forest enhancement activities and by protecting species from direct and indirect threats.
- *Action*: Propagate native forest species and plant nursery grown plants or seeding species in the wild. Young plants will be managed for approximately 3 years until they become established.
- *Action*: Develop a monitoring program for listed plants found throughout JRM-administered lands following the protocols for GPS data collection used at NWF and Finegayan. Known locations will be monitored and new surveys will be conducted to identify additional locations.
- *Action*: Conduct surveys to map locations and abundance of non-native invasive plants and rank occurrences by invasive plant species standards.
- *Action*: Implement control/eradication for top ranked invasive plant species and monitor to prevent recurrence.
- *Action:* Implement fire management plan actions to remove fire-prone grasses.
- *Action:* Convert stands of fire-prone grasses to native vegetation communities to reduce fire risk.
- *Action*: Monitor vegetation in fenced ungulate control areas prior to fencing and after removal to track invasive plants and monitor understory growth, increased groundcover, increased canopy cover, increased species diversity, and increased number of forest tree seedlings and saplings.
- *Action*: Control pigs and deer throughout the MCBCB Urban Training Complex to protect threatened and endangered species and associated habitat. Control methods may include recreational hunting, targeted depredation actions, trapping, or other methods as appropriate to the site conditions.
- *Action*: Construct ungulate fencing as a barrier to feral pigs and deer immigration in priority habitats.
- *Action:* Inspect and maintain ungulate fences to ensure ungulates cannot re-enter exclusion area.

- *Action:* Monitor ungulate exclusion areas to ensure no ungulates have re-entered the site and remove ungulates as they are detected.

THM-2: URBAN FORESTRY DATA BASE, MAINTENANCE, AND REPLACEMENT OF TREES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1 and Goal #2, Objectives #3 and 6.

- *Strategy*: Ensure that management of urban trees on the MCBCB Urban Training Complex is compatible with JRM INRMP goals and objectives.
- *Action*: Continue to implement the integrated grounds maintenance program to minimize the amounts of chemicals and water needed to maintain grounds and landscaped areas in healthy and attractive conditions.
- *Action*: Collaborate with technical specialists from local agencies to develop an Urban Forestry Plan for JRM that includes specifications for soil types, planting requirements, watering and fertilizer regimens, pest control, disease treatments, and other maintenance practices.
- *Action*: Develop and maintain an urban forestry database to catalog existing trees and provide a schedule for their maintenance.
- *Action*: Continue to manage urban forest resources for disease, damage, and replacement.

9.3.7.3 Terrestrial Exotic and Invasive Species Management

An invasive species is defined in EO 13112, *Invasive Species*, as a species that is non-native (i.e., alien or exotic) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm, or harm to human health. Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions. Invasive species have had a catastrophic effect on the native flora and fauna of island ecosystems, particularly Guam. Attributes of island biota include small geographic ranges and population size, low reproductive rates, and lack of the ability to respond to invasive species and disturbed habitats. Islands typically have lower numbers of species than mainland areas, which results in fewer predators and competitors that could prevent the establishment of invasive species. As a result of evolving in isolation, island plants and animals have few defenses when exposed to introduced competitors and predators. These limitations in Guam have caused exotic and invasive species to replace native island species (Wiles et al. 2003).

Many of the native species in Guam are threatened due to introduced predators, such as the BTS, and introduced ungulates such as the Philippine deer, feral pig, and Asiatic water buffalo (carabao) (*Bubalus bubalis*), which have significantly affected native vegetation communities. Feral populations of dogs and cats also pose threats to native wildlife populations. SECNAVINST 6401.1B of September 29, 2006 prohibits dogs, cats, and other privately owned or stray animals from running at large on military installations. Several species of rats have colonized the island, preying on the eggs and young of native species and destroying native flora (i.e., seeds and seedlings). The continued widespread presence of the BTS, curious skink, and introduced amphibian species are of particular concern because of each species' potential negative impacts in Guam's native fauna. Examples of invasive species management approaches include the control of feral ungulates, the control of feral cats and dogs, and the removal of invasive plants to allow native species to flourish in degraded areas.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Exotic and Invasive Species Management (TIS) on the MCBCB Urban Training Complex.

TIS-1: BROWN TREESNAKE INTERDICTION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1-2; Goal #2, Objectives #3-4; Goal #3, Objectives #1 and 4; and Goal #4, Objectives #1-3. This project supports conservation measures from the MOA for the Conservation of Guam Micronesian Kingfisher Recovery Habitat in Northern Guam (2015 Guam Micronesian Kingfisher MOA) (DON and USFWS 2015a).

- *Strategy*: Maintain, develop, and implement actions to prevent the spread of BTS via the transportation network.
- *Action*: Annually review, update as needed, and develop existing BTS interdiction projects reflecting BMPs, adaptive management, and cost benefits.
- *Action*: Annually assess continuity and compliance of BTS interdiction activities across BOs, DoD BTS interdiction operating instructions, and consistency with, and, to the benefit of other relevant JRM conservation actions.
- *Action*: Annually assess ongoing development of new/emergent management strategies and methodologies that reduce or eliminate the risk of BTS.
- *Action*: Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant long-term projects to benefit interdiction management objectives.
- *Action*: Determine the most effective and least disruptive control strategies. Resulting research requirements will be finite projects that assist in the development of snake control techniques and in the management of Mariana fruit bat roosts through the adaptive management strategy.

TIS-2: BROWN TREESNAKE SUPPRESSION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-4 and 6; Goal #3, Objectives #1 and 4; Goal #4, Objectives #1-3; and Goal #7, Objective #3. Actions listed are in accordance with the 2011 BTS MOA.

- *Strategy*: Suppress and control BTS numbers to support conservation goals for species and ecosystem recovery.
- *Action*: Develop an operational suppression implementation plan. The plan will identify and prioritize potential quality habitat site(s) for suppression actions. Site(s) must consider size, habitat, location, connectivity, synergistic effects, listed species benefits, ecological viability, and support regulatory and mission requirements. Suppression goals and activities will support USFWS recovery plan delisting requirements for threatened and endangered species.
- *Action*: Implement BTS suppression management actions in identified site(s) based on mission support impact and cost effectiveness. Data will be used to determine the minimum thresholds of BTS suppression activities needed to support conditions conducive to species persistence and recovery.
- *Action*: Through annual funding and partnerships, support development of tools and methods that improves monitoring, detection, and suppression in targeted habitat sites.
- *Action*: Annually utilize coordination and collaboration with resource management partners and stakeholders to propose, evaluate, develop, and initiate relevant projects to benefit long-term BTS suppression management actions.

TIS-3: INVASIVE SPECIES MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1-2; Goal #2, Objectives #2-4; Goal #3, Objective #1 and 4; and Goal #4, Objectives #1-3. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017). Actions listed are in accordance with the 2011 BTS MOA.

- *Strategy*: Remove and control invasive species that threaten the survival of listed species and other native plants or animals, negatively impact tourism and agriculture, and/or cause human life or safety issues.
- *Action*: Initiate eradication of feral cats and rats the year prior to rail releases and monitor while rails are present. Removal of mammalian predators will be ongoing as they are not excluded by the existing BTS fence. Predator control may include, but is not limited to, trapping, shooting, and baiting.
- *Action*: Annually survey high-risk areas for LFA using established protocols. If LFA is detected, implement proven control and eradication actions, followed by post-eradication monitoring.
- *Action*: Implement BMPs for CRB: (1) annually evaluate the need for comprehensive bio-sanitation of dead coconut trees and implement as necessary, (2) implement proper green waste management; (3) assist in release of landscape-level biocontrol agents for CRB, (4) implement awareness and reporting program in high-risk areas annually, and (5) implement long-term monitoring program and monitor coconut trees.
- *Action*: Survey and map locations of invasive insect infestations and compromised plants.
- *Action*: Develop, test, and prioritize adaptive management actions to remove or control invasive insects, including, but not limited to, feasible local controls of cycad scale (e.g., hand applications to individual trees).
- *Action*: Develop a Hazard Analysis Critical Control Point (HACCP) Plan and implement requirements for construction related to the USMC relocation.
- *Action*: As management tools become available, implement adaptive management actions to remove or control invasive insects, including, but not limited to, feasible local controls of cycad scale (e.g., hand applications to individual trees).

TIS-4: IMPLEMENTATION OF REGIONAL BIOSECURITY PLAN FOR MICRONESIA AND HAWAI'I

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #3; Goal #3, Objectives #1-2 and 4; Goal #4, Objectives #1-4; and Goal #7, Objective #1.

- *Strategy*: Implement appropriate recommendations within the Regional Biosecurity Plan (RBP) (DON 2015d) that will reduce the risk of introduction and spread of invasive species on MCBCB Urban Training Complex.
- *Action*: Develop standard language for biosecurity BMPs, update as necessary, to be included in project specifications that support prevention, such as vegetation management, and cleanliness standards for materials and equipment operating on the installation.
- *Action*: Conduct early detection surveys (EDS) for high-risk invasive species in training areas; at facilities for staging, storage, and movement of cargo/equipment and vehicles, and at other locations as deemed necessary.
- *Action*: Review and update, as appropriate, DoD Attachment M of the RBP every 3 years.

- *Action*: Develop, implement, and update (as necessary) a JRM biosanitation instruction to ensure cleanliness standards are adhered for the movement of cargo and equipment.
- *Action:* Continue to develop high-risk invasive species protocols and implement control and/or eradication measurement when necessary.

TIS-5: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1; Objectives #1-2; Goal #2, Objectives #2-4; Goal #3, Objectives #1 and 4; and Goal #4, Objectives #1-4. This project supports conservation measures from the BO for the MITT Program (2015 MITT BO) (USFWS 2015b).

- *Strategy*: Implement biosecurity conservation measures listed in the 2015 MITT BO from USFWS.
- *Action*: During training events, ensure 100% BTS canine inspection of aircraft and cargo/equipment departing for an off-island destination.
- *Action*: During training activities, establish snake-free quarantine areas (barriers) as deemed necessary for cargo/equipment traveling from Guam to CNMI and locations outside of the MITT action area.
- *Action*: Ensure BTS awareness briefings for all military and contractor personnel prior to all MITT training activities.
- *Action*: Maintain invasive species rapid response capabilities to control and/or eradicate introduced non-established, non-native invasive species sighted in vicinity of DoD training areas and facilities used for staging, storage, and movement of military personnel, cargo, and vehicles associated with training activities.
- *Action*: Ensure training personnel conduct self-inspections to avoid potential introductions of invasive species to Guam. Personnel will inspect all gear and clothing for soil accumulations, seeds, invertebrates, and vertebrates.
- *Action*: Ensure all training activities adhere to the Armed Forces Pest Management Board Technical Guide 31 on washdown procedures for all vehicles and equipment arriving from off-island destinations and departing Guam for off-island destinations via inspections as deemed necessary.
- *Action*: Develop and implement control and eradication protocols for high-risk invasive species as species are identified.

TIS-6: CONTROL FERAL DOGS AND CATS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1 and 4; and Goal #4, Objective #2.

- *Strategy*: Reduce threats to native species by implementing a control program for feral dogs and cats on MCBCB Urban Training Complex.
- *Action*: Conduct population surveys of areas of highest conservation concern, and/or human safety to determine locations and estimate numbers of feral dogs and cats, review accepted control measures, and coordinate with U.S. Army veterinarian and installation pest control personnel to control by authorized means if impacts to ESA-listed species or other native wildlife are identified.
- *Action*: Update MCBCB Urban Training Complex instruction regarding feral dog and cat policy. This instruction will clearly articulate roles and responsibilities for feral dog and cat control in

various locations of the base and will outline outreach and education for base personnel and residents on pet ownership requirements.

- *Action*: Include U.S. Navy installation feral dog and cat policy information in all installation outreach material presented to military and civilian personnel, housing residents, and contractors.

9.3.7.4 Terrestrial Protected Species Management

Management of terrestrial threatened and endangered species on JRM-administered lands includes implementing programs to protect species, and coordinating efforts with the appropriate agencies. Key threats to threatened and endangered species that can lead to extirpation include the following:

- predation by BTS of native forest birds, lizards, and bats
- overgrazing, rooting, and trampling of plants and wildlife habitat by feral ungulates
- predation by feral cats, dogs, and pigs, as well as predation by monitor lizards on birds, bats, and sea turtles
- human disturbance and poaching of sea turtles and Mariana fruit bats
- mortality or injury to native plants and wildlife due to natural stochastic events (e.g., typhoons)
- low reproductive success due to small population numbers
- habitat loss and fragmentation due to development

To address these key threats to listed species, JRM has conducted and continues to conduct numerous management and research projects to reduce BTS numbers at the local and landscape scale, control BTS at swiftlet caves at NMS, and to prevent their spread to other Pacific Islands through rigorous inspections and interdiction of outgoing cargo at DoD ports (i.e., Apra Harbor, Andersen AFB). Captive breeding programs conducted by Guam DAWR and mainland zoological institutions are maintaining populations of Guam rail and Guam kingfisher and are adding to the information needed for successful recovery of these species. Additional ecological research and monitoring is also being conducted by various agencies in Guam, including DoD, USDA, and USGS.

In accordance with section 7 of the ESA, a federal agency shall consult with the USFWS to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any threatened or endangered species. The DON will coordinate with the USFWS/Guam NWR for any federal action that is within Overlay Refuge lands and is identified as providing habitat for threatened or endangered species. In addition, the DON will avoid, as the mission allows, impacts on habitat suitable for threatened and endangered species, and locally rare, and Guam ESA-listed species.

Sensitive species are being managed by implementing specific management projects that enhance habitat for these species and by initiating specific strategies that address immediate needs of listed species on the installation. In addition, adherence to the goals set for threatened and endangered species management ensure that the installation remains in compliance with ESA and associated consultation requirements.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Protected Species Management (TPS) on MCBCB Urban Training Complex. Additional protection measures for terrestrial protected species are presented in Section 9.4.1.6, *Terrestrial Natural Resources Law Enforcement*.

TPS-1: MARIANA FRUIT BAT POPULATION PROTECTION AND ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1-2; Goal #2, Objectives #1 and #3-4; and Goal #3, Objectives #1 and #4. This project

supports conservation measures the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Monitor Mariana fruit bat population status on MCBCB Urban Training Complex to maintain and identify habitat relationships.
- *Action*: Continue base-wide surveys annually in May/June to obtain abundance estimates using established base-wide survey protocols to allow for evaluation of trends over time, adjusting frequency if necessary.
- *Action*: Search for aggregating locations. If aggregations or new colony locations are detected, the MCBCB Urban Training Complex will commence roost counts in accordance with established survey protocols. If changes in roost locations, colony size, or movement are detected, investigate potential threats or stressors that may be causing disturbance.
- *Action*: Collect ejecta and fecal samples for diet analysis and genetic testing according to established protocols and use data from dietary analysis to inform forest enhancement activities (e.g., outplanting and establishment of beneficial native flora).
- *Action*: Perform vegetation surveys in areas known to be used by fruit bats, specifically focused on distribution and density of important food trees, such as *F. prolixa*.
- *Action*: Provide new information from monitoring efforts to partners in fruit bat management during bi-annual project review meetings and INRMP annual review process.
- *Action*: Conduct spatial and temporal analysis to understand patterns in fruit bat activity (e.g., by vegetation type or season) and provide guidance for development planning and fruit bat management.
- *Action*: Conduct pre-construction surveys for fruit bats within construction footprints one week prior to vegetation clearing activities.

TPS-2: MOTH SKINK AND PACIFIC SLENDER-TOED GECKO SURVEYS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1-2; and Goal #3, Objectives #1 and 4.

- *Strategy*: Develop better understanding of occurrence and distribution of Guam ESA-listed moth skinks and Pacific slender-toed geckos on MCBCB Urban Training Complex B.
- *Action*: Survey the distribution and abundance of the moth skink and Pacific slender-toed gecko on MBCB Urban Training Complex.
- *Action*: Consider potential reintroduction sites for protected reptile species in appropriate locations when adequate fencing and predator control can be provided.

TPS-3: PROTECTION OF LISTED INVERTEBRATES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-6; and Goal #3, Objectives #1-2 and 4. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Monitor and conduct surveys for listed tree snails, butterfly, and plant species on MCBCB Urban Training Complex.
- *Action*: Conduct additional surveys of tree snail, butterfly, and listed plant species to identify new locations.
- *Action*: Conduct pre-construction surveys for ESA-listed species within construction footprints.

- *Action*: Locate and protect the host plants for Mariana eight-spot butterfly.
- *Action*: Raise and disperse butterfly larvae to host plants.
- *Action*: Conduct studies that assess the impacts of parasitoids and develop methods for control of parasitoids.

TPS-4: CONSERVATION OF LISTED PLANT SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-6; Goal #3, Objectives 1-2 and 4; and Goal #4, Objective #2. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Conserve and monitor existing *C. micronesica.*
- *Action*: Continue to monitor and implement conservation methods on existing populations of *C. micronesica* within pre-existing fenced plots.
- *Action*: Perform an annual health evaluation as a metric to track success of conservation actions.
- *Action*: Conduct non-native plant removal and chemical and mechanical protection from invasive insects as needed.
- *Action*: Install and maintain ungulate proof fencing for priority habitats.
- *Action*: Install mechanisms to protect plants during a typhoon.
- *Action*: Pollinate plants manually and perform propagation and outplanting of plants.
- *Action*: Conduct pre-construction surveys for ESA-listed species within construction footprints at MCBCB Urban Training Complex.
- *Action*: Translocate ESA-listed species within construction footprints that cannot be avoided into protected habitat or Forest Enhancement sites.
- *Action*: Maintain and monitor translocated plants for 1 year to ensure at least 50% survival.

TPS-5: SUPPORT RECOVERY PLANNING USING SURROGATE NATIVE SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #3; and Goal #3, Objectives #1-4. This project supports and is consistent with the Revised Recovery Plan for the Sihek or Guam Micronesian Kingfisher, *Recovery Action #2*.

- *Strategy*: As part of recovery planning efforts, determine the optimum level of BTS suppression and control measures needed to reduce mortality prior to reintroduction of the Guam Kingfisher using Micronesian starlings as a surrogate species. This project will also support expansion of Micronesian starlings across the landscape throughout MCBCB Urban Training Complex.
- *Action*: If feasible, expand the local range of Micronesian starlings on MCBCB Urban Training Complex by placing predator proof nesting boxes at increasing distances from existing nest sites in conjunction with BTS suppression efforts.
- *Action*: Monitor choice and use of nest boxes, success of fledging, survivorship, and foraging range.

TPS-6: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1-2 and 4; and Goal #4, Objective #2. This project supports conservation measures from the 2015 MITT BO (USFWS 2015b).

- *Strategy*: Implement conservation measures listed in the 2015 MITT BO from USFWS.

- *Action*: Ensure "No Wildlife Disturbance" and "No Training" in designated areas to include Tarague Beach and other locations where listed species are known to occur.
- *Action*: Ensure all vehicular activities during training are restricted to designated and previously identified areas that do not contain listed species.
- *Action*: Ensure all training activities are consistent with the fire management plan in Commander Naval Forces Marianas (COMNAVMAR) Instruction 3500.4A (Marianas Training Manual) (COMNAVMAR 2013).
- *Action*: Ensure no vegetation clearing, except for maintenance required to keep paved surfaces in the drop zone, landing zones, and bivouac areas in a safe and useable condition. Clearing of tree species greater than 4 inches in diameter used for foraging and roosting of Mariana fruit bats will be avoided. No new bivouac areas are proposed under MITT. Maneuver units will remain tactical and not establish support camps.

9.3.7.5 Migratory Bird Management

JRM installations manage and monitor the effects that both military readiness and non-readiness activities have on migratory bird species and populations. Relevant regulations and policies include the Military Readiness Rule (50 CFR 21.15); the 2014 MOU between the DoD and USFWS to Promote the Conservation of Migratory Birds; and EO 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*. Through the implementation of the INRMP, proper management of migratory bird species and habitats, including the timely implementation of appropriate conservation practices, will help installations avoid or minimize impacts to migratory birds.

To meet the goals and objectives of the INRMP, the following management project was identified for Migratory Bird Management (MIG) on MCBCB Urban Training Complex.

MIG-1: CONSERVATION MEASURES FOR MIGRATORY BIRDS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1-2 and 4; and Goal #6, Objective #1.

- *Strategy*: Develop and implement appropriate conservation measures for proposed actions that may have a significant adverse effect on a migratory bird population.
- *Action*: Include an inventory of all priority migratory bird species found on MCBCB Urban Training Complex. This installation-specific list of species of concern will include MBTA protected species, species listed under the ESA, Guam-listed species, USFWS Birds of Conservation Concern, candidate species (both federal and Guam), and DoD Mission-sensitive Priority Species.
- *Action*: For each species of management or monitoring, focus on the installation, provide a brief description of its life history, locations on the installation, and a statement of the interrelatedness between its conservation or priority status and installation mission activities.
- *Action*: Describe the installation's implementation of priority migratory bird conservation measures and explain how the installation uses these conservation measures to avoid or minimize impacts to military readiness.
- *Action*: Provide details on the installation's Bird/Animal Aircraft Strike Hazard program, if applicable, to include the types of birds using the airfield and areas surrounding the airfield throughout the year.
- *Action*: Conduct or support a Wildlife Hazard Assessment that identifies areas of the airfield that are attractive to birds and include recommendations for deterring birds from those areas.

9.3.7.6 Terrestrial Natural Resources Educational Outreach

Conservation awareness is instrumental in creating conditions needed to manage natural resources. The JRM approach to awareness stresses education. It provides military personnel and the public with insights into installation natural environments and conservation challenges. The more educated people are about the unique and valuable natural resources on JRM-administered lands, the more responsibly they will act when using them. Education also promotes awareness of critical environmental projects and the rationale behind them. As activities such as habitat management, wildlife management, and land rehabilitation are generally accepted and understood, minimal effort is required to communicate conservation priorities to installation personnel, recreationists, and the general public. However, issues such as protection of sensitive areas for plant and wildlife species, invasive species management (ungulate management), wildfire suppression and restrictions on some recreational activities in JRM-administered lands require effective conservation communication to garner positive support and, perhaps more importantly, to avoid adverse reactions from various users. A conservation awareness program must be directed to both installation and external interests if it is to be effective.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Natural Resources Educational Outreach (TEDU) on MCBCB Urban Training Complex.

TEDU-1: ESA-LISTED SPECIES AND TERRESTRIAL RESOURCES OUTREACH

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7; Objective #1-2. This project supports conservation measures from the USMC Relocation 2017 BO, which contains amendments to the 2015 BO (USFWS 2017).

- *Strategy*: Improve awareness among DoD personnel and the public of threats and stressors to terrestrial resources, including protected species, and the importance of conserving natural resources on MCBCB Urban Training Complex, in cooperative efforts with partners such as GovGuam and USFWS.
- *Action*: Develop, update, and distribute multimedia for public education to incoming military personnel, contractors, schools, and other outreach opportunities that address appropriate behavior around threatened and endangered species and the consequence of introduced non-native plant and animal species. Outreach materials will be reviewed every 2 to 5 years.
- *Action*: Review and update, as needed, current outreach videos/media used during the orientation briefs viewed by 100% of new personnel upon arrival to Guam.
- *Action*: Develop a contractor education program on ESA-listed and invasive species.

TEDU-2: JRM NATURAL RESOURCES STEWARDSHIP OUTREACH AND PUBLIC ENGAGEMENT PROGRAM

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7; Objective #1-3.

- *Strategy*: Implement a comprehensive natural resources outreach regarding the federal, territorial, and base environmental regulations and policies, as well as information about the importance of protecting and conserving JRM's natural resources.
- *Action*: Update a comprehensive Natural Resources Stewardship Outreach online training system for military and civilian personnel.

- *Action*: Create a JRM Environmental Public Engagement Plan to outline the areas where JRM can significantly increase their outreach with military personnel and the public about appropriate behavior toward threatened and endangered species and the importance of conserving natural resources within lands and submerged lands administered by JRM.
- *Action*: Develop, update, and implement a biosecurity education and outreach program for contractor personnel, military personnel, and dependents.

9.3.7.7 Terrestrial Natural Resources Law Enforcement

JRM has established the following objectives for enforcement: (1) enforce laws and regulations pertaining to the implementation of the natural resources program, (2) integrate natural resources enforcement into the overall natural resources program, and (3) use enforcement personnel to enhance the natural resources program at JRM.

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial Natural Resources Law Enforcement (TLAW) on MCBCB Urban Training Complex.

TLAW-1: CONSERVATION LAW ENFORCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-3; Goal #2, Objectives #1-2 and 4; Goal #3, Objectives #4; Goal # 6, Objectives #1-2; and Goal #7; Objectives #1-3.

- *Strategy*: Detect and deter unauthorized activity that negatively affects natural resources on MCBCB Urban Training Complex (e.g., poaching, off-roading) through conservation law enforcement.
- *Action*: Establish a Conservation Law Enforcement Program by hiring a Conservation Law Enforcement Officer and by partnering with other agencies, as applicable, to enforce natural resource laws, policies, and regulations on MCBCB Urban Training Complex. The Conservation Law Enforcement Officer will conduct outreach and enforce natural resource regulations.

9.3.7.8 Terrestrial Geographic Information System and Data Management

Natural resources data are stored and maintained within a centralized JRM GIS database. The GIS database also provides support for the entire environmental program and the training community. JRM uses GIS for complex analyses such as project siting, data interpolations, and risk assessments. GIS software enables installation staff to capture, store, update, manipulate, analyze, and display all forms of geographically referenced data and tabular information about natural and physical resources found on JRM-administered lands. The training of JRM staff and the allocation of their time to data entry, mapmaking, data analysis, and interpretation of the results determines the success of the installation GIS. Once fully developed, the installation GIS databases can be used for projects such as the following:

- providing maps with locations of species, vegetation communities, surface waters, and other areas of potential concern
- selecting suitable areas for construction activities
- planning land rehabilitation projects
- providing special maps for Environmental Awareness materials
- ensuring avoidance of threatened and endangered species habitats and other areas of special concern during construction projects
- identifying site options for use during NEPA evaluation of alternative sites
- calculating drainages and water flows

- determining wildlife habitat preferences

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial GIS and Data Management (TGIS) on MCBCB Urban Training Complex.

TGIS-1: TERRESTRIAL NATURAL RESOURCES GIS AND DATA MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-5; and Goal #3, Objectives #1 and 4.

- *Strategies*:
  - Identify data gaps in terrestrial natural resources GIS to assist in the development of future data collection efforts, surveys, and management actions.
  - Ensure that GIS information is available to installation subject matter experts and military personnel, biologists, planners, contractors, and others in a timely manner to assist with planning and decision-making.
- *Action*: Update and continuously maintain existing centralized GIS database to effectively inform and guide future management of terrestrial natural resources on MCBCB Urban Training Complex and meet natural resources goals and objectives. Readily available GIS data will be used to develop natural resources constraints maps for use in current and future JRM management and planning decisions for MCBCB Urban Training Complex.

9.3.7.9 Summary – Terrestrial Ecosystem Management

Implementation of the JRM INRMP program and the focused strategies and actions of the management projects for terrestrial resources provides a conservation benefit to the natural ecosystems within Urban Training Complex by maintaining and enhancing the natural community structure, function, species diversity, and resiliency. Enhancing and restoring native habitats supports viable populations of native species and increases biodiversity. Furthermore, proactive invasive species prevention, early detection, and control reduces the risk of intra- and inter-island species introductions. Data from regular monitoring of protected species informs management projects to enhance and restore habitat, reduce habitat fragmentation, buffer protected areas, implement new conservation strategies, and avoid and minimize impacts. Using this regional ecosystem-based approach for managing protected species and their associated ecosystems ensures that JRM remains in compliance with federal and territorial laws while supporting the operational functionality of the MCBCB Urban Training Complex mission.

Twenty management projects addressing terrestrial natural resources management are proposed for implementation on Urban Training Complex:

- Terrestrial Habitat Management – 2
  - THM-1: Forest Enhancement
  - THM-2: Urban Forestry Data Base, Maintenance, and Replacement of Trees
- Terrestrial Exotic and Invasive Species Management – 7
  - TIS-1: Brown Treesnake Interdiction
  - TIS-2: Brown Treesnake Suppression
  - TIS-3: Brown Treesnake Management for the Recovery of Protected Species
  - TIS-4: Invasive Species Management
  - TIS-5: Implementation of Regional Biosecurity Plan for Micronesia and Hawai‘i
  - TIS-6: Mariana Islands Training and Testing Implementation of the Biological Opinion
  - TIS-7: Control Feral Dogs and Cats

- Terrestrial Protected Species Management – 6
  - TPS-1: Mariana Fruit Bat Population Protection and Enhancement
  - TPS-2: Moth Skink and Pacific Slender-toed Gecko Surveys
  - TPS-3: Protection of Listed Invertebrates
  - TPS-4: Conservation of Listed Plant Species
  - TPS-5: Support Recovery Planning Using Surrogate Native Species
  - TPS-6: Mariana Islands Training and Testing Implementation of the Biological Opinion
- Migratory Bird Management – 1
  - MIG-1: Conservation Measures for Migratory Birds
- Terrestrial Natural Resources Educational Outreach – 2
  - TEDU-1: ESA-listed Species and Terrestrial Resources Outreach
  - TEDU-2: JRM Natural Resources Stewardship Outreach and Public Engagement Program
- Terrestrial Natural Resources Law Enforcement – 1
  - TLAW-1: Conservation Law Enforcement
- Terrestrial Geographic Information System and Data Management – 1
  - TGIS-1: Terrestrial Natural Resources GIS and Data Management

10 OVERVIEW OF THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS

The Mariana Archipelago is a crescent-shaped chain of 15 islands that extends along the Izu-Bonin-Mariana arc system from Honshu, Japan southward beyond the island of Guam. The Archipelago contains two distinct political entities: the Territory of Guam and the Commonwealth of the Northern Mariana Islands (CNMI) (Figure 10-1). The CNMI consists of 14 main islands and various smaller islets trending south to north. The southern islands of Rota, Tinian, and Saipan have permanent year-round residents; other northern islands (e.g., Alamagan and Pagan) have over 100 voting residents and are visited on occasion. The following sections present an overview of the physical and biological environments of the CNMI. This overview provides a general context for the site-specific discussions of Joint Region Marianas (JRM) leased lands located within the CNMI, namely, Tinian (Chapter 11, *Tinian Military Lease Area*) and Farallon de Medinilla (FDM, locally referred to as Noos) (Chapter 12, *Farallon de Medinilla*).

10.1 CLIMATE

The CNMI is located in western Micronesia between latitudes 21 degrees (°) and 14° North and longitudes 145° and 146° East. The climate of the CNMI is hot and humid year-round with an average temperature of 84 degrees Fahrenheit (°F) (29 degrees Celsius [°C]) and an average humidity of 79 percent (%). Generally, the wet season runs from July to November and the dry season runs from December to June, but there are transitional periods between wet and dry seasons, as discussed below. During a typical dry season, the islands undergo the effects of drought, including an increase in wildfires, reduction of stream flows, defoliation and drying of grasslands and certain tree species, and reduction of well water levels (Pacific Islands Climate Education Partnership 2016).

The CNMI is located approximately 600 miles (966 kilometers) east of an area in the Western Pacific that produces a larger than average amount of tropical storms, some of which develop into typhoons. A tropical storm is categorized as a typhoon when maximum sustained winds reach 74 miles per hour (mph) (121 kilometers per hour [kph]) or higher. These storms typically affect the CNMI between July and November and bring heavy rainfall and violent winds that on occasion cause storm surges onto low-lying coastal areas. In 2018, the typhoon season brought Super Typhoon Yutu (25 October) to the CNMI, and the eye of the storm passed directly over Tinian causing catastrophic damage to the islands of Tinian and Saipan (Pacific Daily News 2018). At the time of impact, Super Typhoon Yutu had sustained winds of over 178 mph (286 kph). It was the strongest storm on record to ever hit U.S. soil and tied for the most powerful storm on earth in 2018. As of 2023, no tropical storms or typhoons have been recorded within 50 miles of Tinian, Saipan, or FDM since 2019 (Figure 10-2).

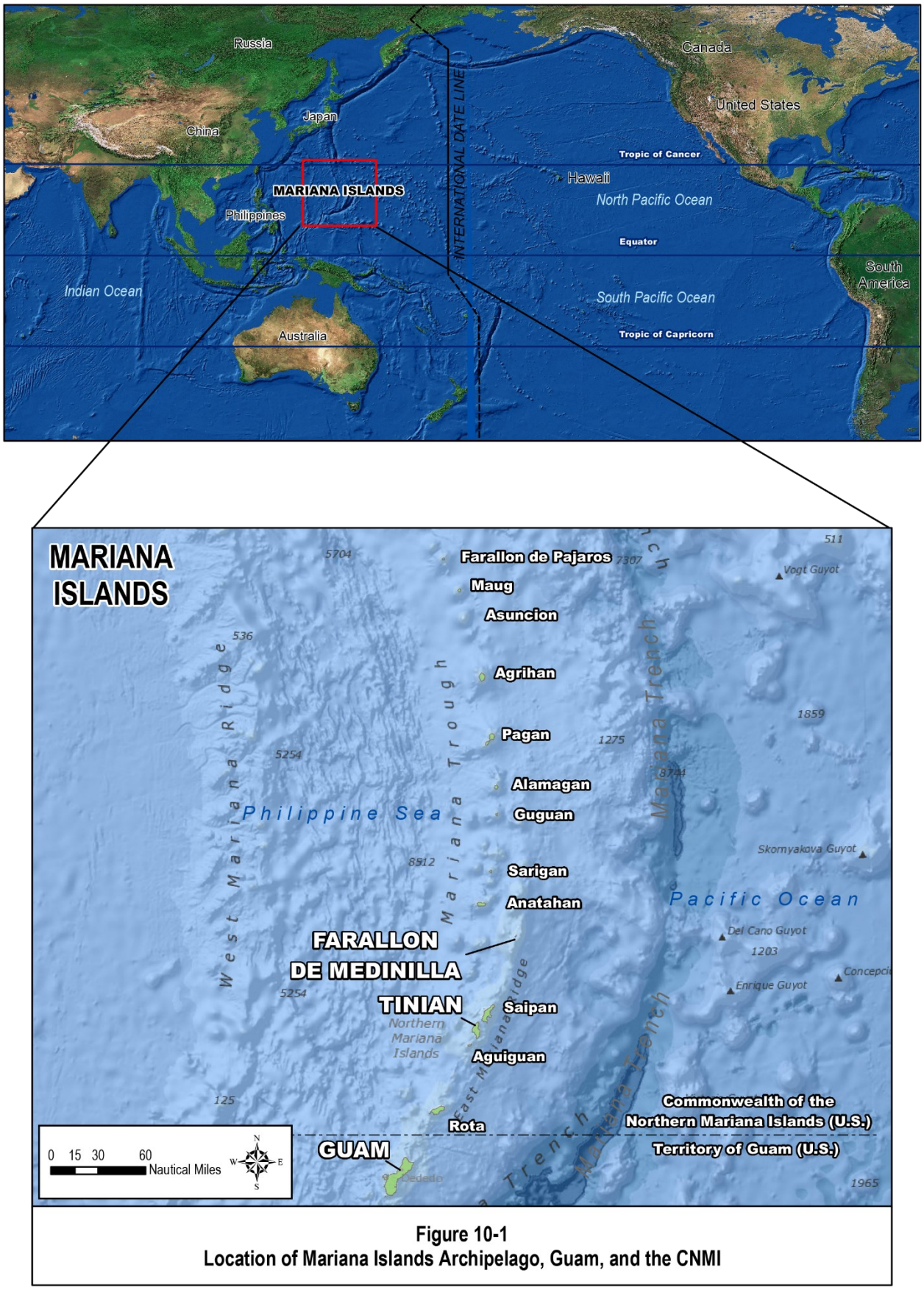


Figure 10-1
Location of Mariana Islands Archipelago, Guam, and the CNMI

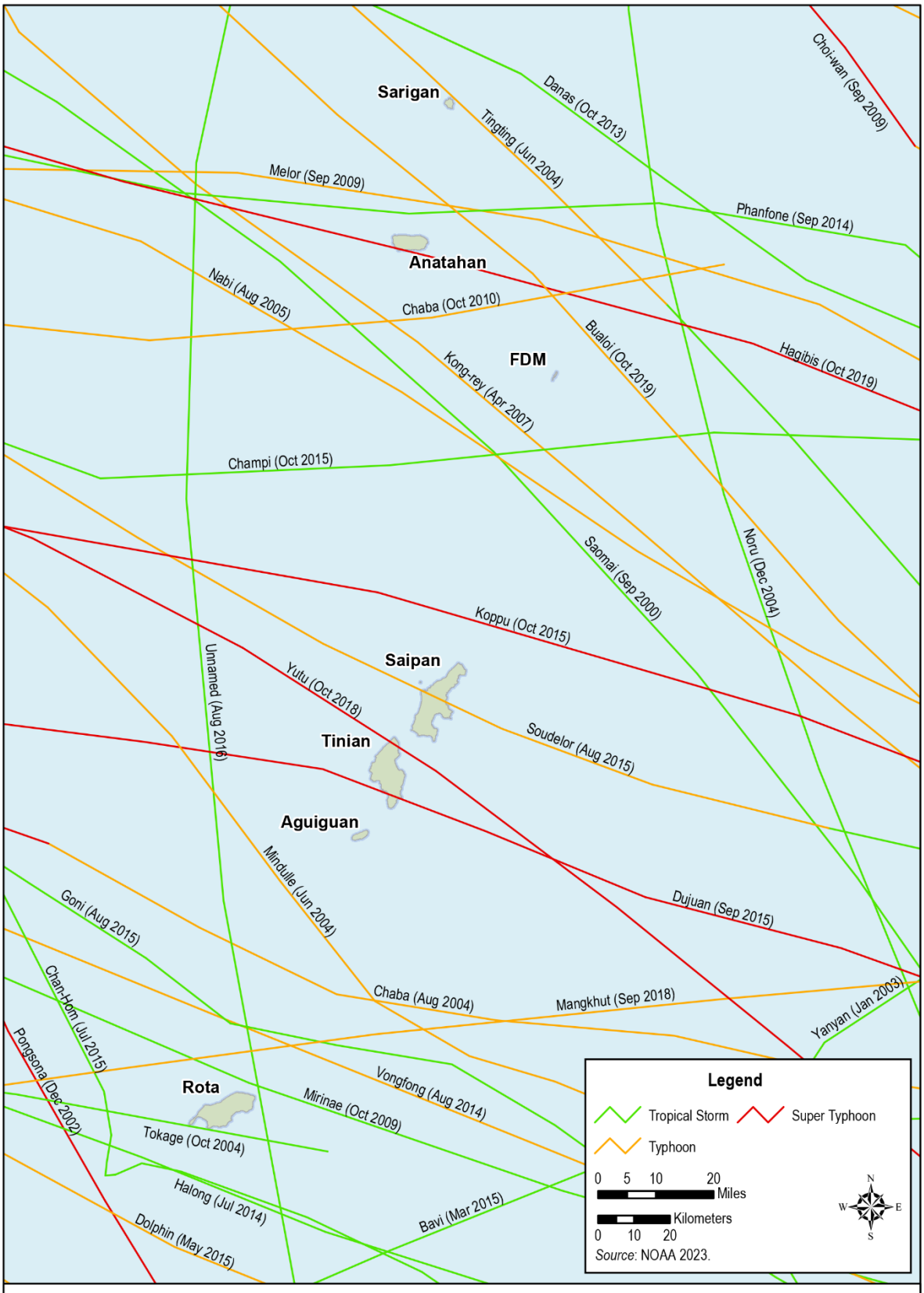


Figure 10-2
Tropical Storms and Typhoons within 50 Miles of Tinian, Saipan and FDM (2000-2023)



Farallon de Pajaros, the northern-most island in the CNMI, during the dry season in May.
(*Photo*: NMFS PIFSC)

Seasonal variation in precipitation is strongly influenced by the position of the Inter-tropical Convergence Zone and the subtropical high-pressure zones. These zones shift latitudinally in a seasonal cycle, resulting in the wet and dry climatic seasons. Tinian averages 84 inches (213 centimeters) of rainfall per year (Liske-Clark 2015). Typically, the driest month of the year is March (United States [U.S.] Fish and Wildlife Service [USFWS] 1996), and the months of November, December, January, and June are transitional months, when rainfall can be highly variable from year to year. Total annual rainfall is significantly influenced by tropical storms and typhoons; therefore, drought-like conditions are often attributed to a lack of storms (Gingerich 2002). Most of the precipitation evaporates, transpires, or percolates into openings in the limestone and volcanic rock beneath the thin soil surface (Gingerich 2002). There is increasing evidence suggesting that rainfall variability throughout the Western Pacific is associated with the periodic oscillation in the atmosphere-ocean system known as the El Nino–Southern Oscillation. During periods of El Nino–Southern Oscillation, rainfall levels can decline significantly, resulting in extended periods of drought (Kellman and Tackaberry 1997). Storm waves and surge associated with tropical storms and typhoons have a significant impact on littoral ecosystems within the Mariana Archipelago.

10.2 GEOLOGY, TOPOGRAPHY, AND SOILS

10.2.1 Geology



Reef organisms created all limestone in the Marianas; the remains of corals, coralline algae, and a giant clam are plainly visible in this limestone deposit at Unai Masalok on Tinian.
(*Photo*: E. Lovell)

Geologically, the Mariana Islands can be divided into two groups: the older southern islands of Guam, Rota, Aguiguan, Tinian, Saipan (and Marpi Bank), and FDM, which were formed 15–30 million years ago, and the younger northern islands of Anatahan, Sarigan, Guguan, Alamagan, Pagan, Agrihan, Asuncion, Maug, and Farallon de Pajaros, which were formed over the last 5 million years. The southern islands are part of the frontal arc of the Mariana Trench system. They are volcanic in origin and nearly covered with uplifted limestone from ancient coral reefs. The northern islands are part of the active Mariana arc and are comprised of lava flows and pyroclastic material, which is the result of the Pacific plate being subducted under the Philippine Sea plate. The northern islands of Anatahan, Guguan, Alamagan, Asuncion, Pagan, and Farallon de Pajaros are still volcanically active.



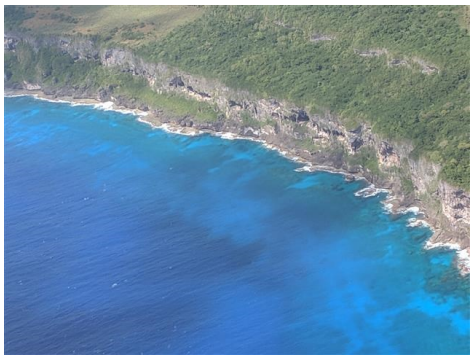
Many of the northern islands in the CNMI are still volcanically active. Left: The northern volcano on the island of Pagan has been erupting since 1981 and can be seen fuming in 2009. Right: Bubbles seen rising from underwater water sulfur vents near the volcanic island of Maug.
(*Photo*: NMFS PIFSC)

Approximately 80–130 miles (130–210 kilometers) east of and parallel to the archipelago lies the Mariana Trench, the deepest region of the ocean at 36,070 feet (10,994 meters) and stretching 1,584 miles (2,550 kilometers) along the seafloor at the subduction zone of the Pacific and Philippine Sea plates.

The process of the subduction of the Pacific plate beneath the Philippine Sea plate "controls seismic activity in the region" (Mueller et al. 2012). As the Pacific plate subducts west-northwestward beneath Guam at a rate of 2.5 inches per year (6.3 centimeters per year), the east-convex Mariana Trench-arc system opens at a rate of 1.9 inches per year (4.7 centimeters per year). It is suggested by Lander et al. (2002) that because of the nature of the subduction boundary along the Mariana Trench, earthquakes with a magnitude range of 6 to 7 on the Richter scale may occur on average once every 10 years and earthquakes greater than 7 magnitude may occur about once every 100 years (Lander et al. 2002). However, four earthquakes with a magnitude greater than 6.5 have occurred within 400 miles (644 kilometers) of the Mariana Islands within the past 25 years, including a 7.8-magnitude earthquake in 1993, a 7.1-magnitude earthquake in 2002, a 7.4-magnitude earthquake in 2007, and a 6.9-magnitude earthquake in 2010 (Department of the Navy [DON] 2010a, 2010b). Earthquakes ranging from 5 to 6 magnitude occur approximately 5 to 8 times a year within 250 miles (402 kilometers) of Tinian (DON 2010a). These earthquakes tend to originate from the shallower, southern region of the Mariana Trench. There have been 13 destructive earthquakes (greater than 6.5 magnitude) in the Mariana Islands during the past two centuries (Mueller et al. 2012) with the majority of the recorded impacts (i.e., property damage, injuries) in Guam (approximately 130 miles [225 kilometers] to the south of Saipan).

The largest tsunami in recent history within the Mariana Archipelago occurred on March 11, 2011, following the Great Tohoku earthquake in Japan. A maximum water height of 4 feet (1.2 meters) was recorded in Guam, some 1,714 miles (2,758 kilometers) from the source of the earthquake. On April 5, 1990, a surface wave, from a 7.5-magnitude earthquake, struck Guam and Saipan generating a tsunami that was observed at the dock at Tinian Port but did not result in any damage (Lander et al. 2002).

10.2.2 Topography and Soils



Limestone sea cliffs on the eastern coast of Rota.
(*Photo*: L. Shaughnessy)

The U.S. Department of Agriculture (USDA) (1989) remains the most comprehensive source of soils data for the islands of Rota, Aguiguan, Tinian, and Saipan. Carbonate rocks overlay the southern islands of Rota, Aguiguan, Tinian, Saipan, and FDM; however, the 11 islands north of FDM are exclusively volcanic (Cloud et al. 1956). The three southern islands, Rota, Tinian, and Saipan, are uplifted marine terraces that tilt westward, creating jagged limestone sea cliffs on the eastern coast that gently slope westward. Complex karst formations, including faults, caves, and fissures, are common on each of the islands (Stafford et al. 2005). Beaches on exposed shores are generally composed of limestone cobble and gravel with little fine sand accumulation. Leeward beaches, such as those within Saipan Lagoon, consist of finer sand particles. Surface soils are shallow in many places. Erosion, due to wind and rain, and steep slopes can be problematic for soil conservation, and sediment-laden runoff can be harmful to marine life. Metallic debris and unexploded ordnance (UXO) are common in World War II (WWII)-era dumpsites and battlefields on Saipan and Tinian, both on land and in nearshore waters (Denton et al. 2016).

10.3 HYDROLOGY

10.3.1 Surface Water

The raised limestone bedrock of the southern Mariana Islands is extremely permeable and, as a result, most rainfall that does not directly run off into the ocean percolates into the ground. Streams occur in limited areas where less permeable materials occur, and wetlands occur primarily in areas of low elevation where water tables intersect with land surface. Four principal inland surface water features/wetlands exist in the CNMI, including Lake Hagoi on Tinian, Lake Susupe on Saipan, and Laguna Sanhalom and Laguna Sanhiyon on Pagan (Sako et al. 1995). Together, wetlands and perennial streams comprise less than 5% of land surface in the CNMI (Bureau of Environmental and Coastal Quality 2016). No surface waters within the CNMI are used as a potable water supply source.

10.3.2 Groundwater

Carbonate karst formations are common within the CNMI. Karst is formed when water dissolves rock, creating large voids, such as sinkholes, caves, and epikarst (i.e., smaller features that act as a conduit for surface water to percolate to underlying aquifers). The fast flow of water through epikarst features does not allow for absorption, uptake, or microbial processes that would normally remove pollutants from surface waters before reaching groundwater. Groundwater generally flows seaward radially on the islands (Gingerich 2002).

Public water on Saipan and Tinian is supplied by production wells from the underlying aquifer. Public water supply on Rota is obtained from springs. There is no public water supply infrastructure on Aguiguan, FDM, or the islands north of Saipan.

10.4 TERRESTRIAL BIOLOGICAL ENVIRONMENT

As a continuation of the Mariana Archipelago, the biological environment in the CNMI is very similar to that of Guam. The islands are comprised of a range of native species that evolved in isolation for millions of years, are currently competing with several non-native species, and are exposed to abiotic stressors such as typhoons and fires (see Section 4.4, *Terrestrial Biological Environment,* for more information).

To identify solutions and encourage a more holistic approach to evaluating and managing terrestrial, marine, and freshwater invasive species risks, the DON funded and assisted in a multi-disciplinary effort of federal and regional scientists and experts to develop the Regional Biosecurity Plan (RBP) for Micronesia and Hawai‘i (DON 2015a). The purpose of the RBP was to evaluate terrestrial, marine, and freshwater invasive alien species risks to Micronesia (i.e., Guam, CNMI, Republic of the Marshall Islands, Republic of Palau, Federated States of Micronesia) and Hawai‘i. The RBP is a regionally vetted biosecurity plan that is intended to provide for the improvement and harmonization of biosecurity across Micronesia and Hawai‘i. The RBP provides stakeholders with a framework for implementation and a platform for coordination and integration of interagency invasive species management efforts such as control, interdiction, eradication, and adaptive management.

The following sections provide a brief overview of the major terrestrial species, native and non-native, that occur within the CNMI. Further details regarding Tinian and FDM are discussed as appropriate in Chapter 11, *Tinian Military Lease Area*, and Chapter 12, *Farallon de Medinilla*. See Appendix E for a complete list of plants and animals recorded on JRM leased lands mentioned in this Integrated Natural Resources Management Plan (INRMP).

10.4.1 Vegetation Communities

During the WWII invasions of Tinian and Saipan by the U. S. in 1944, coastal strand, wetlands, and forests were denuded and soils were disturbed by intense and prolonged bombardments from sea, air, and land. Most of the vegetation within the northeastern portion of Tinian was cleared for B-29 bomber airfields and supporting infrastructure between August 1944 and May 1945. Between 1944 and 1950, the U.S. Army Air Force conducted aerial seeding of Guam and also on Tinian and Saipan with tangantangan (*Leucaena leucocephala*) to stabilize soils and check erosion (Fosberg 1960).

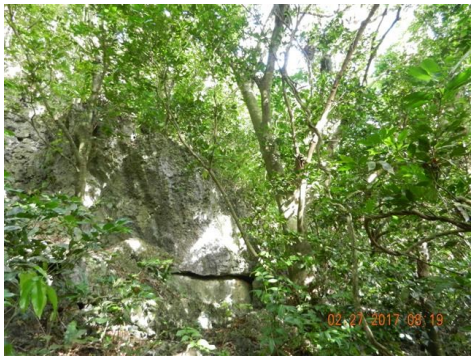
Post WWII vegetation communities within the CNMI have been described in Pratt (2011), Mueller-Dombois and Fosberg (1998), Whistler (1996), Raulerson and Rinehart (1991), Falanruw et al. (1989), and Fosberg (1960). Descriptions of pre- and immediate post-war vegetation and land use on Saipan, including descriptions of the expansive wetland habitats adjacent to Lake Susupe, appear in the Draft Detailed Project Report and Environmental Statement Susupe-Chalan Kanoa Flood Control Study conducted by the U.S. Army Corps of Engineers (USACE) (1979). Whistler (1996) conducted a limited vegetation survey for FDM.

The distribution of vegetation is influenced by the physical and chemical nature of the substratum, natural disturbances (i.e., windthrow from typhoons and interactions with invasive species), and anthropogenic disturbances (i.e., urbanization, fire, agriculture, and destructive land uses that disturb soils and vegetation). The northern islands are predominantly primary grasslands (colonized relatively recently after volcanic activity) with areas of secondary forest. Conversely, the southern islands are predominantly primary and secondary forests with secondary grasslands, a situation that likely arose from grassland expansion through agricultural burning and clearing (Mueller-Dombois and Fosberg 1998).

Both the intentional and inadvertent introduction of alien plant and animal species has contributed to a reduction in the range of native vegetation throughout the Mariana Islands. Currently, most of the existing

native vegetation on the islands persists on rugged karst or steep limestone slopes and other regions where unsuitable topography precludes urbanization and agricultural development, or where inaccessibility limits encroachment by non-native plants and grazing by feral ungulates (Berger et al. 2005).

Native limestone forests, mixed introduced forests, tangantangan, and other shrub, strand, and ironwood (*Casuarina equisetifolia*) forest are the most common vegetation communities within the CNMI (DON 2015b; Naval Facilities Engineering Systems Command [NAVFAC] Pacific 2018). Other vegetation communities present to a lesser degree on Tinian include coconut forest, freshwater wetlands, and savanna. Agricultural lands, developed areas, and barren soil, sand, and/or rock are also very common land cover types. Perennial emergent wetlands are uncommon. Principal inland waters and wetlands in the CNMI include Lake Hagoi on Tinian, Lake Susupe on Saipan, and Laguna Sanhalom and Laguna Sanhiyon on Pagan (Sako et al. 1995) and are also located in small isolated depressions throughout the archipelago. Forest, savanna, stream, and cave ecosystems are of primary importance to some of the CNMI's rarest species.



Native limestone forest on Tinian with native plants such as *Procris pedunculata* and *Meiogyne cylindrocarpa* in the understory and gulos (*Cynometra ramiflora*) dominating the overstory.
(*Photo*: L. Shaughnessy)

Mixed introduced forests on Tinian contain a mixture of trees, shrubs, and dense herbaceous plants. Dominant trees common in this vegetation community include tangantangan, ironwood, siris tree (*Albizia lebbeck*), Formosan koa (*Acacia confusa*), flame tree (*Delonix regia*), and Madras thorn (*Pithecellobium dulce*) (NAVFAC Pacific 2018).

There are six federal Endangered Species Act (ESA)-listed endangered plants within the CNMI, including *Serianthes nelsonii* and *Heritiera longipetiolata* and seven threatened plant species, including *Cycas micronesica* (USFWS 2015). See Section 10.4.3, *Terrestrial Protected Species*, for additional information regarding threatened and endangered plants.

10.4.2 Terrestrial Wildlife

10.4.2.1 Mammals

Native Species

Historically, three species of bats (Mariana fruit bat [*Pteropus mariannus mariannus*], little Mariana fruit bat [*Pteropus tokudae*], and Pacific sheath-tailed bat [*Emballonura semicaudata rotensis*]) were the only native mammals to occur within the CNMI (Wiles 2005). The little Mariana fruit bat is considered extinct. The Pacific sheath-tailed bat is federal ESA-listed as endangered, and the Mariana fruit bat is federal ESA-listed as threatened. See Section 10.4.3, *Terrestrial Protected Species*, for additional information regarding threatened and endangered mammals.

Non-native Species

Twelve non-native mammal species have been introduced and established within the CNMI. Spanish introductions included Philippine deer (*Rusa marianna*), dogs (*Canis lupus familiaris*), cats (*Felis catus*), pigs (*Sus scrofa*), goats (*Capra hircus*), and cattle (*Bos taurus*). Other introduced species include the Asian house shrew (*Suncus murinus*), house mouse (*Mus musculus*), black rat (*Rattus rattus*), Asian house rat (*R. tanezumi*), Norway rat (*R. norvegicus*), and Pacific rat (*R. exulans*) (Wiles 2005). The house mouse, house shrew, and rats are detrimental to birds, lizards, insects, and snails and may also disrupt seed dispersal of native plants (Wiewel et al. 2009). In addition, there is direct evidence that feral cats prey on native species (Lardner et al. 2013; Nogales et al. 2013). Feral ungulates are accelerating erosion and causing damage to native vegetation, particularly on Aguiguan (Kessler 2009, 2011).



A dead, non-native Asian house shrew (*Suncus murinus*) found on Tinian.
(*Photo*: L. Shaughnessy)

10.4.2.2 Birds

Native Species

Of the approximate 164 species of birds that have been reported from the CNMI (Avibase 2017), 13 species are endemic, 38 are considered rare/occasional visitors, and 4 are considered extinct. Conspicuous breeding resident species include yellow bittern (*Ixobrychus sinensis*), Micronesian megapode (*Megapodius laperouse*), Tinian monarch (*Monarcha takatsukasae*), Pacific reef heron (*Egretta sacra*), Mariana common moorhen (*Gallinula chloropus guami*), black noddy (*Anous minutus*), brown noddy (*Anous stolidus*), masked booby (*Sula dactylatra*), red-footed booby (*Sula sula*), brown booby (*Sula leucogaster*), white tern (*Gygis alba*), Mariana swiftlet (*Aerodramus bartschi*), Mariana kingfisher (*Todiramphus albicilla*), and Micronesian starling (*Aplonis opaca*).



Mariana kingfisher (*Todiramphus albicilla*)
(*Photo*: L. Shaughnessy)



Adult Micronesian starling (*Aplonis opaca*) resting in a seeded breadfruit tree (*Artocarpus marianensis*).
(*Photo*: L. Shaughnessy)

The Tinian monarch is no longer on the federal ESA-list of threatened and endangered species (USFWS 2004a); however, the species is once again undergoing review for possible federal ESA-listing as threatened and endangered based upon a 2013 petition from the Center for Biological Diversity. Appendix E provides

a list of all bird species known to currently occur within the CNMI, including those listed under the Migratory Bird Treaty Act (MBTA).

Common seabird species seen within the CNMI include brown noddy, white tern, black noddy, and brown booby, and white-tailed tropicbird (*Phaethon lepturus*). The coastal islets, reef flats, grassy fields, and other open areas within the islands provide seasonal foraging habitat to many migratory avian species. Most common among the annual visitors to the islands are the Pacific golden-plover (*Pluvialis fulva*), lesser sand plover (*Charadrius mongolus*), grey-tailed tattler (*Tringa brevipes*), whimbrel (*Numenius phaeopus*), ruddy turnstone (*Arenaria interpre*s), and western cattle egret (*Bubulcus ibis*) (Juan C. Tenorio and Associates 1979; Wiles 2003).



Adult white-tailed tropicbird (*Phaethon lepturus*) in flight near Chenchon Bird Sanctuary on Rota.
(*Photo*: L. Shaughnessy)

Non-native Species

Non-native bird species that are resident breeders in the CNMI include the island collared dove (*Streptopelia bitorquata*), red junglefowl (*Gallus gallus*), rock dove (*Columba livia*), Eurasian tree sparrow (*Passer montanus*), and black drongo (*Dicrurus macrocercus*). The Eurasian tree sparrow and rock dove are commonly observed in small flocks, usually in urbanized areas. The black drongo was introduced to the Mariana Islands from Formosa by the Japanese in the 1930s and within the CNMI, still only occurs on Rota, mostly in developed areas (National Research Council 1997).

10.4.2.3 Reptiles and Amphibians

Native Species

Nine native or potentially native terrestrial reptile species have been reported from the CNMI, including tide pool skink (*Emoia atrocostata*), oceanic snake-eyed skink (*Cryptoblepharus poecilopleurus*), Pacific blue-tailed skink (*Emoia caeruleocauda*), mourning gecko (*Lepidodactylus lugubris*), monitor lizard (*Varanus tsukamotoi*), Micronesian gecko (*Perochirus ateles*), Slevin's skink (*Emoia slevini*), Indo-Pacific house gecko (*Hemidactylus frenatus*), and Pacific slender-toed gecko (*Nactus pelagicus*) (Rodda et al. 1991; 2009). Two species of sea turtles also nest in the CNMI and are considered to be terrestrial reptiles. These include the green sea turtle (*Chelonia mydas*) and hawksbill turtle (*Eretmochelys imbricata*). See Section 10.4.3, *Terrestrial Protected Species*, for more details on protected reptiles.



Monitor lizard (*Varanus indicus*) climbing a *Heritiera longipetiolata* on Tinian.
(*Photo*: C. Camacho)

Non-native Species

Non-native reptile species that are residents of the CNMI include snakes, skinks, geckos, and toads. The marine toad (*Rhinella* [=*Bufo*] *marina*) is the most common amphibian species within the CNMI (Kerr 2013).

10.4.2.4 Freshwater Fishes

Native Species

Lakes, rivers, streams, wetlands, and other open sources of surface water make up 5% of land surface in the CNMI (Bureau of Environmental and Coastal Quality 2016), and studies on freshwater fishes have been limited. Lake Susupe and Lake Hagoi have been degraded by human activity since at least the early 1910s (Stinson 1990), and no studies of native freshwater fishes are known to exist prior to this degradation.

Non-native Species

The non-native mosquito fish (*Gambusia affinis*) was introduced into Lake Susupe, likely by the U.S. military for mosquito control during World War II (CNMI DFW 2008). Red tilapia (*Oreochromis mossambica*) was introduced to lakes on Tinian, Saipan, Anatahan, and Pagan for aquaculture (Ogo 2009; Starmer et al. 2005; Stinson 1990). In 1985, the Coastal Resources Management Office of the Governor CNMI reported that in addition to red tilapia and mosquito fish, freshwater eels (Anguillidae) and *Palaemon debilis*, a species of freshwater shrimp, also occurred in Lake Susupe (Coastal Resources Management Office of the Governor CNMI 1985). A study of invasive species in freshwater systems on Saipan conducted in 2008 reported that rock flagtails (*Kuhlia rupestris*) and milkfish (*Chanos chanos*) inhabit Lake Susupe on Saipan (CNMI DFW 2008). In addition to Lake Susupe, CNMI DFW also conducted surveys in streams, marshes, and man-made ponds on Saipan, and reported that tilapia, eels, rock flagtails, gobies (*Stiphodon elegans*), and two species of shrimp (*Macrobrachium lar* and *Caridina typus*) are present.

10.4.2.5 Invertebrates

Native Species

Although numerous native terrestrial invertebrate species are in the CNMI, there have been few focused surveys, and the occurrence of native invertebrate species on Tinian is not well documented. Surveys to date have observed numerous species of ants, termites, dragonflies, damselflies, as well as other aquatic insects (Hawaiian Agronomics International, Inc. 1985; Bourquin 2002; Richardson et al. 2009). In addition, three native crab species of cultural importance occur in the Mariana Islands. The coconut crab (*Birgus latro*) and two species of land crab (*Discoplax hirtipes* [previously *Cardisoma hirtipes*] and *Cardisoma carnifex*) are regulated as game species by the CNMI DFW. A license is required for harvesting these crabs during regulated hunting seasons. The hunting season for coconut crab is September 15 to November 15 with a bag limit of five individuals, and the seasons for land crabs are April 1 to June 30 and October 1 to December 31, with no bag limit.



CNMI DFW regulates the harvesting of coconut crabs (*Birgus latro*) by enforcing a hunting season and bag limit per person.
(*Photo*: L. Shaughnessy)

The humped tree snail (*Partula gibba*), Langford's tree snail (*Partula langfordi*), fragile tree snail (*Samoana fragilis*), Rota blue damselfly (*Ischnura luta*), Mariana wandering butterfly (*Vagrans egistina*) and Mariana eight-spot butterfly (*Hypolimnas octocula marianensis*) are federal ESA-listed and discussed in Section 10.4.3, *Terrestrial Protected Species*.

Non-native Species

Several non-native invertebrate species have been introduced to the CNMI, including the New Guinea flatworm (*Platydemus manokwari*), a paper wasp (*Ropalidia marginata*), and the coconut rhinoceros beetle (CRB) (*Oryctes rhinoceros*). The CRB was reported on Rota in 2017, and an active control program was put in progress in 2018 (CNMI DFW 2018). However, many of the non-native invertebrate species that have been introduced to Guam (such as the greater banded hornet [*Vespa tropica*] and little fire ant [LFA] [*Wasmannia auropunctata*]) have not been reported in the CNMI.



The non-native paper wasp (*Ropalidia marginata*) forms small to medium hives on tree leaves and branches.
(*Photo*: L. Shaughnessy)

10.4.3 Terrestrial Protected Species

Terrestrial species that occur within the CNMI and listed as threatened or endangered by the USFWS and CNMI DFW are listed in Table 10-1. There are 29 federal ESA-listed threatened and endangered terrestrial species listed by the USFWS known to or potentially occur within the CNMI, including 2 mammal species, 6 bird species, 3 reptile species, 6 invertebrate species, and 12 plant species. The CNMI government lists 13 species including 2 mammals, 6 birds, 3 reptiles, and 2 plants, as threatened and endangered (Commonwealth Law Revision Commission 2016).

Table 10-1. Federal and CNMI ESA-listed Threatened and Endangered Terrestrial Species Recorded within the CNMI

Common Name/ Chamorro Name[(1)]	*Scientific Name*	*Federal Status*	*CNMI Status*	*Habitat*	*Occurrence*
Mammals					
Mariana fruit bat/ Fanihi	*Pteropus mariannus mariannus*	T	T-E	Limestone native and coconut forests	Y
Pacific sheath-tailed bat/Fanihi	*Emballonura semicaudata rotensis*	E	T-E	Limestone native and mixed introduced forests, and caves	Y
Birds					
Mariana swiftlet/ Chachaguak or Yayaguak	*Aerodramus bartschi*	E	T-E	Nesting/roosting: Limestone native forest and caves Foraging: forest, grassland, and savanna	Y
Micronesian megapode/Sasangat	*Megapodius laperouse*	E	T-E	Native forest and coconut forests	Y
Mariana common moorhen/Pulattat	*Gallinula chloropus guami*	E	T-E	Wetlands[(2)]	Y
Nightingale reed-warbler/Gaga karisu	*Acrocephalus luscinia*	E	T-E	Wetlands[(2)], tangantangan, and mixed introduced forests	Y
Mariana crow/Aga	*Corvus kubaryi*	E, CH	T-E	All forests – preference for limestone native forest	Y
Rota white-eye/Nosa luta	*Zosterops rotensis*	E, CH	T-E	All forests – preference for limestone native forest	Y
Reptiles					
Green sea turtle/Haggan	*Chelonia mydas*	E[(3)]	T-E	Offshore waters, strand, and barren (sand)	Y

Table 10-1. Federal and CNMI ESA-listed Threatened and Endangered Terrestrial Species Recorded within the CNMI

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*CNMI Status*	*Habitat*	*Occurrence*
Hawksbill turtle/ Haggan karai	*Eretmochelys imbricata*	E	T-E	Offshore waters, strand, and barren (sand)	Offshore waters: Y Strand and barren: PU
Micronesian gecko/ Gualiek	*Perochirus ateles*	--	T-E	Limestone native forest	Y
Slevin's skink/ Gualiek halumtano	*Emoia slevini*	E	--	Limestone native forest	Y
Invertebrates					
Humped tree snail/ Akaleha	*Partula gibba*	E	--	Limestone native, mixed introduced forests, and strand	Y
Langford's tree snail/ Akaleha	*Partula langfordi*	E	--	Limestone native forest	P
Fragile tree snail/ Akaleha	*Samoana fragilis*	E	--	Limestone native forest	P
Mariana wandering butterfly/Abaabang	*Vagrans egistina*	E	--	Limestone native forest	P
Mariana eight-spot butterfly/Abaabang	*Hypolimnas octocula marianensis*	E	--	Limestone native forest	PU
Rota blue damselfly/Dualas Luta	*Ischnura luta*	E	--	Freshwater streams	Y
Plants					
None/Siboyas halumtano	*Bulbophyllum guamense*	T	--	Limestone native and mixed introduced forests	Y
None/Fadang	*Cycas micronesica*	T	--	Limestone native forest	Y
None/None	*Dendrobium guamense*	T	--	Limestone native and secondary forest	Y
None/Ufa halumtano	*Heritiera longipetiolata*	E	--	Limestone native forest	Y
Cat's tail/Disciplina	*Lycopodium phlegmaria* var. *longifolium*	--	T-E	Limestone native forest	Y
None/None	*Maesa walkeri*	T	--	Limestone native and mixed introduced forests and other shrub/grassland	Y
None/Seyaihagon or Maisa ulu	*Nervilia jacksoniae*	T	--	Limestone native and mixed introduced forest	Y
None/None	*Nesogenes rotensis*	E	--	Barren (coastal rock)	Y
None/None	*Osmoxylon mariannense*	E	--	Limestone native forest	Y
Fire tree/Hayun lago	*Serianthes nelsonii*	E	T-E	Limestone native forest	Y
None/None	*Solanum guamense*	E	--	Limestone native forest	Y

Table 10-1. Federal and CNMI ESA-listed Threatened and Endangered Terrestrial Species Recorded within the CNMI

Common Name/ Chamorro Name[(1)]	*Scientific Name*	*Federal Status*	*CNMI Status*	*Habitat*	*Occurrence*
None/None	*Tabernaemontana rotensis*	T	--	Limestone native and secondary forests	Y
None/None	*Tuberolabium guamense*	T	--	Limestone native and secondary forests	Y

Notes: [(1)] Chamorro names from GovGuam (2009), Liske-Clark (2015), USFWS (2004b, 2015), Topping et al. (1975), Safford (2009), and Kerr and Bauman (2013).
[(2)] Wetlands are not a vegetation category identified in Amidon (2009), but wetlands do occur in the CNMI.
[(3)] Central West Pacific Distinct Population Segment.

Key: -- = not listed; CH = critical habitat designated; CNMI = Commonwealth of the Northern Mariana Islands; DON = Department of the Navy; E = endangered; ESA = Endangered Species Act; GovGuam = Government of Guam; PU = potential for occurrence; T = threatened; T-E = listed as threatened/endangered by CNMI government; USFS = United States Forest Service; USFWS = United States Fish and Wildlife Service; Y = Yes.

Sources: USFWS 2004a, 2004c, 2006, 2015; USFS 2006; DON 2014a; Wiles et al. 1989; Wiles and Glass 1990; Esselstyn et al. 2004; Liske-Clark 2015.

10.4.3.1 Mammals

Pacific Sheath-tailed Bat

The Pacific sheath-tailed bat ranges from the CNMI in the northwest to Fiji and Samoa to the southeast (Helgen and Flannery 2002); however, populations have declined or disappeared throughout its island range (Bonaccorso and Allison 2008). The Pacific sheath-tailed bat is extirpated on all but Aguiguan within the CNMI (Oyler-McCance et al. 2013). This last known surviving population of Pacific sheath-tailed bat consists of a few hundred individuals that roost in caves and forage nocturnally in native limestone forests (Esselstyn et al. 2004). While the Pacific sheath-tailed bat only currently occurs on Aguiguan within the Mariana Islands (Oyler-McCance et al. 2013), its former range included Guam, Rota, Saipan, Anatahan, Maug (Helgen and Flannery 2002), and Tinian (Esselstyn et al. 2004; USFWS 2015), where it has been extirpated. It is federal ESA-listed and CNMI DFW-listed endangered species.

Mariana Fruit Bat



Colony of Mariana fruit bats (*Pteropus mariannus mariannus*) roosting in the CNMI.
(*Photo*: T. Mildenstein)

The range of the Mariana fruit bat includes all of the islands except Farallon de Pajaros. The more isolated northern islands support the majority of the Mariana fruit bats in the archipelago (USFWS 2010), but because of their remote location, these islands have not been surveyed as frequently as the southern islands. Rota supports the largest population of Mariana fruit bats in the southern islands, with approximately 4,000 individuals (NAVFAC Marianas and U.S. Marine Corps [USMC] 2013). The Mariana fruit bat was listed as endangered in Guam in 1984 (USFWS 1984). In 2005, the Mariana fruit bat subspecies was down-listed to threatened in Guam and listed as threatened throughout the CNMI (USFWS

2005). Most recently, in 2023, large-scale simultaneous surveys across Tinian military lands and surrounding habitat were conducted. Five bats were observed from four observation stations across the island, yielding a minimum density estimate of 21 bats on the island (U.S. Navy 2023). Notably, bat signs (ejecta and feces) were found within three areas of the MLA, and consequently a habitat-use monitoring program using transect surveys within MLA-forested areas has been planned (U.S. Navy 2023).

10.4.3.2 Birds

Six federal ESA-listed endangered bird species occur in the CNMI: Micronesian megapode, Mariana common moorhen, Mariana swiftlet, nightingale reed-warbler (*Acrocephalus luscinia*), Rota white-eye (*Zosterops rotensis*), and the Mariana crow (*Corvus kubaryi*). All six bird species are also recognized by the CNMI government as threatened and endangered and CNMI-designated as Species of Greatest Conservation Need (SOGCN). Critical habitat is designated on Rota for the Rota white-eye (USFWS 2006) and the Mariana crow (USFWS 2004c). The Rota white-eye, nightingale reed-warbler, and Mariana crow are not found on JRM leased lands and are not discussed further in the INRMP. The Mariana swiftlet has been extirpated from Tinian and, thus, is not found within JRM leased lands within the CNMI; however, because it occurs in Guam, it is discussed in appropriate chapters of the INRMP.

In addition to these federal ESA-listed bird species, the following 10 species or subspecies are designated SOGCN by the CNMI: Mariana kingfisher, Mariana fruit dove (*Ptilinopus roseicapilla*), white-throated ground dove (*Alopecoenas xanthonurus*), great frigatebird (*Fregata minor*), Micronesian honeyeater (*Myzomela rubratra saffordi*), wedge-tailed shearwater (*Ardenna pacifica*), rufous fantail (*Rhipidura rufifrons uraniae*), golden white-eye (*Cleptornis marchei*), masked booby (*Sula dactylatra*), and bridled white-eye (*Zosterops conspicillatus saypani*).



Micronesian honeyeater (*Myzomela rubratra saffordi*).
(*Photo*: L. Shaughnessy)

The remainder of this section provides information regarding the two federal ESA-listed bird species, which are present on JRM leased lands within the CNMI.

Micronesian Megapode

The Micronesian megapode is a medium-sized, stocky, brownish-black, ground-dwelling bird. Small remnant populations were known to occur on Aguiguan, Tinian, and Saipan as of 1997, while larger populations persist on Anatahan, Guguan, Sarigan, Alamagan, Pagan, Asuncion, and Maug (USFWS 1997). Chapters 11 and 12 contain detailed descriptions of populations on Tinian and FDM, respectively. The megapode is CNMI-designated as SOGCN.



The island of Sarigan is a volcanically active island in the CNMI known to support Micronesian megapodes (*Megapodius laperouse*). The population of megapodes is thought to have increased as a result of ungulate eradication efforts conducted in 1998 (Kessler 2010).
(*Photo*: NMFS PIFSC)

Mariana Common Moorhen

Within the CNMI, Mariana common moorhen are found primarily in both seasonal and permanent freshwater man-made and natural wetlands. Their preferred habitat includes freshwater lakes, marshes, and

swamps. The Mariana common moorhen was historically found on Tinian, Saipan, Rota, and Pagan but was extirpated from Pagan due to the 1981 eruption of Mount Pagan and habitat degradation by feral ungulates (USFWS 2012). Recent population genetic studies of Mariana common moorhen (Miller et al. 2015) detected long distance movement between islands, which has been interpreted as having positive repercussions for the management of the species.

10.4.3.3 Reptiles

Sea Turtles

The USFWS has jurisdiction over sea turtles in the terrestrial environment (i.e., nesting), including sea turtle eggs, nesting females, and hatchlings on the beach. The Central West Pacific Distinct Population Segment (DPS) of the green sea turtle is federal ESA-listed endangered and is known to nest on beaches within the CNMI (National Marine Fisheries Service [NMFS] and USFWS 2016). Historical records indicate the federal ESA-listed endangered hawksbill turtle has nested on CNMI beaches in the past (Liske-Clark 2015).

During project planning, JRM environmental planners take into consideration potential in-water construction, obstructions, barriers, or activity (e.g., dredging, training, etc.) impacts that would disrupt resting/foraging areas (e.g., destroy, damage, or adversely modify seagrass, macroalgae, invertebrates, or coral reefs) as well as those which would disrupt reproductive areas (e.g., disrupt sea turtle mating, prevent females from accessing nesting beaches and using inter-nesting habitats in nearshore waters, or prevent the egress of hatchlings) while also taking into consideration current mission requirements, long-term mission planning, and future mission flexibility. Resting/foraging areas are the marine areas, from the MHW line to 20 meters depth, where sea turtles forage on macroalgae, seagrass, and invertebrates and rest in refugia, such as coral reefs. Reproductive areas are the marine areas adjacent to nesting beaches, from the MHW line to 20 meters depth, where sea turtles mate, inter-nest, and transit onto and off nesting beaches. Planners minimize potential impacts while ensuring mission requirements are met.

Skinks and Geckos

Slevin's skink is federal ESA-listed as endangered. Slevin's skink has not been observed on the large southern islands in the last 50 years, though it still occurs in the far northern islands of Alamagan, Asuncion, Guguan, Pagan, and Sarigan (Rodda et al. 1991; McCoid et al. 1995; Liske-Clark 2015).

The Micronesian gecko is CNMI-listed as threatened and endangered. It is known to occur throughout western Micronesia, and in the CNMI, it is historically known from Rota, Tinian, and Saipan (Liske-Clark 2015). Only one individual was reported during intense surveys done on the Tinian Military Lease Area (MLA) in 2008. The species status on Rota and Saipan is unknown.

10.4.3.4 Invertebrates

Butterflies and Damselfly

The Mariana eight-spot butterfly, Mariana wandering butterfly, and Rota blue damselfly are federal ESA-listed endangered. The Mariana wandering butterfly is CNMI-designated as SOGCN. Within the CNMI, the Mariana wandering butterfly is known from Rota, while the Mariana eight-spot butterfly is known on Saipan. Both may be extirpated from their known ranges (USFWS 2015). The Rota blue damselfly was first described in 2000 based on specimens collected 4 years earlier from a perennial freshwater stream. It appears to be endemic to Rota, but absent from all other Mariana Islands (USFWS 2015).

Tree Snails

The humped tree snail, Langford's tree snail, and fragile tree snail are known to occur in the CNMI and were federal ESA-listed as endangered in 2015. The humped tree snail occurs on Rota, Aguiguan, Alamagan, Pagan, Sarigan, Saipan, and Tinian, with historical records placing it on Anatahan in the past (USFWS 2015). The fragile tree snail is the only tree snail in the genus *Samoana* to occur in the Mariana Islands and is only known from Rota within the CNMI (USFWS 2015). This species has not been seen on Rota since 1996, but surveys are infrequent. Langford's tree snail is endemic to Aguiguan but has not been seen in the wild since 1992. Surveys for tree snails on Aguiguan, as on Rota, have been minimal. More frequent and thorough surveys may lead to discovery of Langford's tree snail populations (USFWS 2015).



Five adult and one juvenile humped tree snail (*Partula gibba*) congregate on the underside of a *Hernandia sonora* leaf during the mid-afternoon heat (left). Adult humped tree snail foraging (top right) and resting (bottom right).
(*Photo*: L. Shaughnessy)

10.4.3.5 Plants

Seven plant species are federal ESA-listed as threatened, including four orchid species (*Bulbophyllum guamense*, *Dendrobium guamense*, *Tuberolabium guamense,* and *Nervilia jacksoniae*), two tree species (*Cycas micronesica* and *Tabernaemontana rotensis*), and one shrub (*Maesa walkeri*) (USFWS 2014a, 2015). Four plants (*Heritiera longipetiolata, Nesogenes rotensis, Osmoxylon mariannense,* and *S. nelsonii*) are federal ESA-listed as endangered. The CNMI government recognizes *Lycopodium phlegmaria var. longifolium* and *S. nelsonii* as threatened and endangered.

Bulbophyllum guamense, Dendrobium guamense, and *Tuberolabium guamense*



Large clump of the epiphytic orchid, *Dendrobium guamense*, located on Rota.
(*Photo*: L. Shaughnessy)

These three epiphytic orchids are typically found on branches of a variety of native and non-native host trees (e.g., *Vitex parviflora, Meiogyne cylindrocarpa*, *Ochrosia mariannensis*, *Aglaia* sp.) within native limestone forests and are federal ESA-listed as threatened. *D. guamense* is known to occur in Guam, Rota, Tinian, and Aguiguan (Zarones et al. 2015a). It was historically known to occur from Saipan and Agrihan but has not been found there in recent years (USFWS 2014a, 2015). *B. guamense* is known to occur on Rota, Saipan, and Guam, and was historically known to occur on Pagan but has not been found in more recent studies (Whistler 1996; USFWS 2014a, 2015). *T. guamense* is known to occur on Rota and Guam, and historically known to occur on Tinian and Aguiguan; however, it has not been found on Tinian and Aguiguan in recent surveys (USFWS 2014a, 2015).

Nervilia jacksoniae

A small herb in the orchid family, this species is found in lowland/limestone forests and is known only from Rota (USFWS 2014a, 2015). At the time of listing in October 2015, *N. jacksoniae* was known from 13 scattered occurrences totaling at least 320 individuals in the forest ecosystem (USFWS 2014a, 2015). Zarones et al. (2015b) conducted a survey on Rota, reporting 167 individuals of *N. jacksoniae* along four transects in just 1.5 hours, and estimated there may be as many as 100,000 individuals distributed across the Pandanus forest on the Rota Sabana (assuming uniform distribution).

Cycas micronesica

C. micronesica is federal ESA-listed as threatened. *C. micronesica* is a tree currently known to occur in the forest and savanna ecosystems of Guam and Rota (Raulerson 2006; USFWS 2014a, 2015) and on Pagan (Pratt 2011); it was not known historically to occur on Tinian. *C. micronesica* is severely impacted by Asian cycad scale (*Aulacaspis yasumatsui*), the non-native cycad blue butterfly (*Luthrodes pandava*), and non-native ungulates (Marler and Lawrence 2012). As a result, JRM is collaborating with the CNMI DLNR and others on a conservation project for *C. micronesica* on Tinian. In 2005, JRM collected 3,000 *C. micronesica* seeds from Guam, cleaned the seeds of scale insects, and germinated and raised seedlings in a nursery on Tinian. In 2008, 1,000 of the *C. micronesica* seedlings were planted in limestone native forest on Tinian. Although a *C. micronesica* population now occurs on Tinian, it was not included within the species' range in the final rule to list *C. micronesica* as a threatened species under the ESA (USFWS 2014a, 2015). More detail can be found in Chapter 11, *Tinian Military Lease Area*.

Nesogenes rotensis

Nesogenes rotensis is a herbaceous ground covering plant endemic to Rota (USFWS 2007a). It grows on exposed coastal limestone outcrop in association with *Scaevola taccada, Pemphis acidula, Pogonatherum paniceum*, and *Bikkia tetrandra*. One population of 20 individuals is thought to exist at Pona Point Fishing Cliff. In 2005, a population of 15-20 individuals was discovered at Puntan Fina Atkos (USFWS 2007a).



Flowering *Nesogenes rotensis* growing in association with *Pemphis acidula* (left) on coastal limestone outcrop on the island of Rota (right).
(*Photo*: L. Shaughnessy)

Osmoxylon rotensis

Osmoxylon rotensis is a tall, soft-wooded tree with yellow flowers and purple fleshy fruits (Raulerson and Rinehart 1991). Branches are grey with obvious leaf scars; mature leaves are large and palmately lobed with toothed margins. Leaves only grow at the tips of branches. It is endemic to Rota, and only eight living individuals were known in 2006. The primary threat is degradation or disturbance of its native forest habitat from a variety of factors, including competition from invasive non-native species and feral ungulate activity (USFWS 2007a).



Mature *Osmoxylon rotensis* (left) with purple fleshy fruits (right) located on Rota.
(*Photo*: L. Shaughnessy)

Solanum guamense

This species is a shrub in the nightshade family that occurs in native limestone forest on inland and coastal limestone cliffs (Stone 1970; Costion and Lorence 2012). *Solanum guamense* can grow to 6 feet (2 meters) tall. Plants have papery leaves and small white flowers, with red fruits resembling small tomatoes. The flowering and fruiting phenology of this species is unknown.

Tabernaemontana rotensis

Tabernaemontana rotensis is a federal ESA-listed threatened small- to medium-sized tree in the dogbane family known only from Rota and Guam in forested and limestone plateau habitats. In 2004, *T. rotensis* was known from eight individuals on Rota (USFWS 2014a, 2015; NAVFAC Marianas 2016). The USFWS recognizes the Guam and Rota *T. rotensis* populations to be a local form of *T. pandacaqui.* In 2007, more than 21,000 individuals were found throughout Andersen Air Force Base (AFB), with a population structure representing seedlings, juveniles, and reproductive, mature individuals (University of Guam [UOG] 2007). In 2014, a survey was completed of all known locations where *T. rotensis* naturally occurs on Rota and found nine living trees scattered across the western, southern, and eastern portion of the island (CNMI DLNR 2015).

Maesa walkeri

Maesa walkeri is a federal ESA-listed endangered species historically known from Rota and Guam (USFWS 2014a). A shrub or small tree in the primrose family typically found in limestone forests, *M. walkeri* was known from nine occurrences on Rota (USFWS 2015). Assuming a uniform distribution,

thousands of individual *M. walkeri* on Rota have been recorded across the Sabana region in small canopy gaps amidst the *Pandanus* forest and along the forest edge (Liske-Clark et al. 2015). The only healthy extant population of *M. walkeri* remains on the Rota Sabana within a very specialized niche habitat (USFWS 2015).

Heritiera longipetiolata

Heritiera longipetiolata is native to Guam, Saipan, and Tinian (Raulerson 2006). This tree species is federal ESA-listed as an endangered species. It grows primarily in moist native limestone forests along coastal cliffs. On Tinian, it is known from Puntan Masalok, along the Lamanibot Bay escarpment, the south-facing coastal forests (Hawaiian Agronomics International, Inc. 1985), Puntan Kastiyu, and Suicide Cliff (NAVFAC Pacific 2014; USFWS 2015).

Serianthes nelsonii

S. nelsonii is endemic to Guam and Rota. It is federal ESA-listed as an endangered species and is a CNMI ESA-listed species. Rota has more than 30 mature trees in the wild (NAVFAC Marianas 2016). CNMI DLNR propagates *S. nelsonii* seedlings in the Rota Forestry Nursery with programmatic assistance from the USFWS.



Large, mature *Serianthes nelsonii* located on Rota (left). The leaves are twice pinnate, and the flowers are brush-like with long pink filaments (right).
(*Photo*: L. Shaughnessy)

Lycopodium plegmaria var. *longifolium*

Within the CNMI, this epiphytic fern is known from the shaded native forests of Rota (Raulerson and Rinehart 1992). This species has shiny, flattened, and triangular leaves, and branches drape down from its growth substrate. Spores are produced on thin, long structures that hang from the tip of the stem. It is CNMI-listed as threatened and endangered.

10.4.4 Stressors on the Terrestrial Environment of the Commonwealth of the Northern Mariana Islands

Major threats to the terrestrial environment and native species in the CNMI include natural disasters, invasive species, climate change, pollution, poaching, wildfire, development and military expansion, and tourism and recreation (Liske-Clark 2015).

Natural disasters such as typhoons and volcanic activity can cause direct and indirect impacts to protected species. Species populations can be impacted immediately through the death of individuals who do not survive the disaster (Liske-Clark 2015). For example, volcanic eruptions can wipe out entire populations of organisms lying in the path of the lava flow. Indirect impacts include declines in populations of organisms after the natural disaster has passed. For example, a Mariana fruit bat population may suffer higher mortality from starvation of individuals after a typhoon if too many fruits are stripped from trees (Liske-Clark 2015).

A serious anthropogenic threat is the introduction and uncontrolled spread of invasive species. These introductions pose direct and indirect impacts on native species and habitats (Liske-Clark 2015) Invasive plants and animals can alter habitat structure, making the environment unsuitable for native organisms. For example, rooting by feral pigs can damage native trees and alter the forest structure. Introduced predators can prey on native species and decrease their population numbers.



At least five invasive species (*Chromolaena odorata*, bitter vine [*Mikania micrantha*], burr marigold [*Bidens pilosa*], *Lantana camara*, and ivy gourd [*Coccinia grandis*]) can be seen growing and smothering out any potential native plant seedlings in an area west of Broadway Street on Tinian.
(*Photo*: L. Shaughnessy)

Climate change poses a significant threat to terrestrial species as it has the potential to alter the environment in a number of catastrophic ways. For example, major shifts in temperatures and rainfall will affect the growth of plants and alter food webs, ultimately resulting in changes to the ecosystems found in the CNMI.

In addition to the impacts of invasive species and climate change, other anthropogenic stressors such as habitat loss and poaching have major impacts to the terrestrial environment. Urban development and military expansion lead to habitat loss and fragmentation. Increased urbanization stems from population growth and increased tourism. The current human population size in the CNMI is five times what it was 50 years ago (Worldometers 2018). Additionally, development and military expansion usually lead to increased pollution. For example, increased use of electrical lights on Saipan, Tinian, and Rota is occurring at a rapid rate in some areas, and the light pollution is resulting in loss or degradation of green sea turtle nesting habitat (NMFS and USFWS 2016). Military training can lead to soil pollution.

Poaching of sea turtle eggs as well as harvest of nesting females is a known ongoing problem in the CNMI (NMFS and USFWS 2016). In the CNMI, illegal hunting is a driving factor in the reduction of Mariana fruit bat populations (Mildenstein 2008; USFWS 2007b, 2009, 2014b; Wiles and Brooke 2009).

Natural wildfires are very rare in the Mariana Islands, and native species are not evolved to survive through them. Wildfires are occasionally set intentionally and unintentionally by humans in the CNMI, either destroying native habitat or preventing disturbed habitat from developing into native forest.

This INRMP strives to set forth the efforts needed to reduce the impacts of the terrestrial stressors by DON on JRM leased lands within the CNMI through active habitat management and restoration as well as implementation of best management practices (BMPs) during construction and training activities (DON 2015b).

10.5 MARINE BIOLOGICAL ENVIRONMENT

This INRMP addresses nearshore areas adjacent to JRM terrestrial holdings on Tinian and FDM. The geographic extent of JRM submerged lands is from the mean high tide line out 3 miles (4.8 kilometers), including nearshore and deep water environments (>5,400 feet [1,650 meters] depth). See Appendix E for a complete list of plants and animals mentioned in this INRMP.

10.5.1 Physical Environment

10.5.1.1 Currents

The Northern Equatorial Current (NEC) strongly influences surface currents around the Mariana Archipelago. It is an important factor influencing the dispersal and distribution of marine species throughout the CNMI. The easterly trade winds are the primary drivers of the NEC, which flows westward. This current is strongest during winter—particularly in February, when the trade winds are also the strongest. The NEC flows between 8° North and 15° North, with an average velocity less than 0.3 meter per second (1.0 foot per second) (Tomczak and Godfrey 2003; Wolanski et al. 2003). Net sea surface transport is to the west/northwest at an average speed of 0.3 to 0.7 feet per second (0.1 to 0.2 meter per second) (Uda 1970; Wolanski et al. 2003). The NEC forks at the Hawaiian Islands—one branch travels north and the other continues west. The westward-flowing branch of the NEC flows through the Mariana Islands, approaches Japan, and splits again, forming the southward-flowing Mindanao Current and the northward-flowing Kuroshio Current. On a broad scale, these are the major areas upstream and downstream of the Mariana Islands.

The west-flowing NEC generally extends as far north as 16° North latitude, almost exactly the latitude of FDM. The oceana current regime for the Mariana Islands north of FDM is highly variable, and in some long-term datasets, it appears to be statistically random (Kendall and Poti 2015; Maynard et al. 2015).

The large mass of the Mariana Archipelago can produce small eddies. These eddies are capable of returning reef organisms' larvae and eggs to the fringing reefs surrounding most of the islands. Eddies resulting from the relatively strong NEC results in net eastward coastal flows of about one quarter foot per second (several centimeters per second) on the lee side of the southern islands, resulting in significant larval retention (Maynard et al. 2015). The division of ocean current regimes between the northern and southern islands aligning with their geomorphological division is not coincidental. The role of the NEC eddies in larval retention for reef organisms contributes to the southern islands' reef development and limestone caps. The lack of consistent larval retention affects the development and composition of reef communities in the northern islands (Kendall and Poti 2015).

10.5.2 Marine Habitats

10.5.2.1 Coastal Habitat

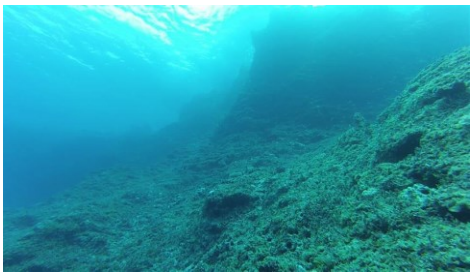
Common CNMI coastal habitats include intertidal shores (rocky, sandy, mudflat), coral reefs, artificial habitats, submarine canyons, and chemosynthetic communities. Because the land masses are small and overall topography of the Mariana Islands is relatively steeply sloped, the spatial extent of coastal habitats is constricted. Estuaries, mangroves, salt marshes, seagrass beds, and habitats associated with flats are also present but extremely limited. Seagrass beds and habitats associated with flats are mostly confined to Saipan, which has better-developed reef flats and lagoons (National Oceanic and Atmospheric Administration [NOAA] National Centers for Coastal Ocean Science [NCCOS] 2004).



The image of this well-developed reef flat is taken from the southern end of Lamanibot Bay on Tinian, looking north. Well-developed reef flat and shallow fore reef habitat is uncommon in CNMI. Drone camera, elevation 20 feet. Pictured: diving vessel Mighty Max.
(*Photo*: M. Mendoza)



Most reef habitat in CNMI is shore-attached fringing reef with a relatively steep slope. This photo shows a relatively narrow shore-attached fringing reef on southwest Saipan.
(*Photo*: M. Lybolt)



Except for the areas covered by coral reef, all shorelines in the Mariana Islands are erosional, and this type of hard shore/hard bottom is the most common in the southern islands. There is a veneer of macroalgae and sparse reef organisms. Coral cover is low, and most colonies do not live long enough to grow larger than 4-8 inches.
(*Photo:* B. Greene)

Coral reefs are the most prominent coastal habitat type in the CNMI. Positive geomorphological features for reefs include islands large enough to provide a variety of habitats, yet small enough that reef-inhibiting effects of rivers and runoff are generally trivial (Riegl et al. 2008; Brainard et al. 2012), except where radical land cover changes have caused erosion, sedimentation, and turbidity in Guam and Saipan (DON 2010a; Maynard et al. 2015). The islands of the CNMI are principally surrounded by fringing spur-and-groove reefs; barrier, lagoon, patch, and bank reefs are infrequent (Riegl et al. 2008). Four distinct geomorphological reef types encompass most reefs of the CNMI (Minton et al. 2009; Houk and Starmer 2010; Houk and van Woesik 2010), as follows:

- Holocene spur-and-groove—high coral densities, species richness, and large colony size
- Holocene high-relief slope—low coral species richness and high intra-site variation
- Holocene low-relief—low coral species richness, few large corals, and many small corals
- Pleistocene basement—few corals and little three-dimensional relief.

Constructional spur-and-groove reefs support larger coral colony size and higher coral species in comparison to other habitat types in the CNMI (Minton et al. 2009; Houk and van Woesik 2010). The most developed and oldest coral reefs of CNMI are on the southern archipelago islands. The younger volcanic islands in the northern part of the CNMI are somewhat less developed because of their differing antecedent geomorphology.

10.5.2.2 Essential Fish Habitat

As stated in Section 3.4.1.3, *Magnuson-Stevens Fishery Conservation and Management Act*, the Mariana Islands are within the jurisdiction of the Western Pacific Regional Fishery Management Council (WPRFMC), which has designated the marine waters around Tinian and FDM as Essential Fish Habitat (EFH). The descriptions of EFH around Tinian and FDM are basically identical to the descriptions for Guam (see Section 4.5.2.3, *Essential Fish Habitat*). Noteworthy exceptions are that Tinian and FDM have much less seagrass, mangrove, and estuarine habitat. The two Fishery Ecosystem Plans (FEPs), Mariana Archipelago FEP and Pacific Pelagic FEP, apply equally to Tinian and FDM (WPRFMC 2009a, 2009b, 2016a).

10.5.3 Marine Flora

10.5.3.1 Native Species

There are about 230 benthic macroalgae species known in the Mariana Islands (Lobban and Tsuda 2003). Of the major species groups of algae found in the Mariana Islands, there are about 26 species of blue-green algae, 109 species of red algae, 31 species of brown algae, and 71 species of green algae (Lobban and Tsuda 2003). Coralline algae, a group of red algae, is important in the formation of coral reefs. Turf algae is a broad category consisting of many different forms of primarily green algae that rapidly colonize bare substrate on the reef. They are primary producers in the reef community and also hold sediment. An abundance of crustose coralline algae is associated with reef health for its complementary role in coral recruitment. Macroalgae compete with corals for space on the reef, and abundance is controlled by herbivory pressures and nutrient availability. Coral reefs can undergo phase shifts from highly productive, coral dominated habitats to less productive, algal dominated habitats.

Seagrass is a type of flowering plant. The Mariana Islands have three species of seagrass, including tape seagrass (*Enhalus acoroides*), narrowleaf seagrass (*Halodule uninervis*), and hartog seagrass (*Halophila minor*). Of these, the tape seagrass is dominant; narrowleaf seagrass and hartog seagrass are physically smaller and somewhat seasonal (NAVFAC Marianas 2011). Seagrass is much more abundant in the upper 6 feet (2 meters) of the water column (NOAA NCCOS 2004) but *Halophila*, the small paddle-shaped grass, can be found to approximately 131 feet (40 meters) deep. The genus *Halophila* is under revision. *Halophila minor* may have a name change, and an additional species may be recognized in the CNMI (Fonseca and Olsen 2016).



Narrowleaf seagrass (*Halodule uninervis*) (foreground) and tape seagrass (*Enhalus acoroides*) (background) are two of the three seagrass species known to occur in the CNMI. Standard size clipboard (12 x 9 inches) for scale.
(*Photo*: M. Lybolt)



One of the three seagrass species in CNMI, hartog seagrass (*Halophila minor*). Each leaf is nearly 1 inch long. Halophila are prolific seed producers and seeds, about the size of a celery seed, can remain dormant for years.
(*Photo:* M. Lybolt)

Mangroves are a type of estuarine swamp environment dominated by mangroves and other saltwater-tolerant trees. Black mangrove (*Bruguiera gymnorrhiza*) is the most common species in Micronesia. Mangroves are present in the CNMI but are much less common than in Guam because CNMI coastlines are less suitable. Most of the mangrove communities in CNMI are located in the lagoons/harbors of Rota, Tinian, and Saipan (Starmer et al. 2005; 2008). Mangroves are important species that can moderate coastal dynamics, provide important nearshore habitat for diverse fish species, and bring indirect benefits to coral reefs (Furukawa et al. 1997; Nagelkerken et al. 2008). Their influence in CNMI is limited by the restricted range and habitat.

10.5.3.2 Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*.

To date, there are no reports of non-native or invasive marine flora from coastal marine habitats in the CNMI (Liske-Clark 2015). Nuisance marine flora species include golden noodle algae (a group of filament-forming diatoms in the Class Chrysophyceae) and angel hair algae (*Chaetomorpha* spp.) (DON 2017a; Liske-Clark 2015; Lobban and Tsuda 2003). These nuisance marine species are native, but occasionally exhibit blooms or outbreaks. In the CNMI, they have not yet been reported as a nuisance on the larger scales seen in Guam (Schils 2015).

10.5.4 Marine Invertebrates

10.5.4.1 Native Species

Major invertebrate species groups include those with greater than 1,000 species (Appeltans et al. 2010). All major marine invertebrate species groups are represented in the Mariana Islands. A limited selection is carried forward in this discussion with emphasis on reef-associated invertebrates.



Spider conch (*Lambis chiragra*) are relatively uncommon in CNMI and are CNMI-designated as SOGCN. The animal was placed back on the seafloor after the photo was taken.
(*Photo*: E. Lovell)

Randall (1995) reported that all of the 159 reef-building coral species in 43 genera collected in the northern islands were also collected in the southern islands, except for *Millepora foveolata*. However, there were 95 species in 14 genera collected in the southern islands that were not collected in the northern islands (Randall 1995). Additionally, results from rapid ecological assessment benthic surveys, conducted in the fore reef habitats of the Mariana Archipelago, recorded 50 genera of Anthozoa (Brainard et al. 2012). Based on a review of the limited data, the conclusion is that between 254 and 377 species of corals could occur in the Mariana Islands (Randall 1995, 2003; Richmond et al. 2008; Riegl et al. 2008).

The diversity of Mariana Islands reef-building corals is somewhat lower than other Western Pacific regions (Randall 1995), but it is more diverse than other U.S. Pacific islands (Richmond et al. 2008; Riegl and Dodge 2008). The most comprehensive work found 254 coral species in 56 genera (Randall 1995) and 377 coral species in 99 genera (Randall 2003), and the major differences between 1995 and 2003 are

attributable to improved taxonomy and improved discrimination among species. Most studies report increasing coral species richness from north to south (Randall 1995; Brainard et al. 2012).

Over 100 species of marine siliceous sponges (Class Demospongiae) and 4 species of the calcareous sponges (Class Calcarea) have been identified within the Mariana Islands (Kelly et al. 2003). In contrast to coral reef ecosystems in other regions of the world, sponges are trivial contributors to biogenic habitat of coral reefs in the Mariana Islands (Minton et al. 2009; Houk and van Woesik 2010; Brainard et al. 2012).

Coral cover throughout the Mariana Archipelago in 2001, estimated from satellite imagery, was about 28% of the coral reef area (NOAA NCCOS 2004). More recent island-specific and regional surveys show variable trends, with a general trend of reduced coral cover throughout the archipelago (Brainard et al. 2012; DON 2014b, 2017a; Maynard et al. 2015).

There are at least 1,722 known mollusk species in the Mariana Archipelago (Abraham et al. 2004). Creel surveys (estimates of local fisheries catch data) in Guam have shown that the main species collected for boat-based and shore-based fishing are octopuses (*Octopus cyanea, Callistoctopus ornatus*) and topsnails (*Tectus niloticus*), as well as giant spider conches (*Lambis truncata*) and bigfin reef squids (*Sepioteuthis lessoniana*) (Burdick et al. 2008).

Marine arthropods are found throughout the Mariana Archipelago in all bathymetric zones. There are at least 840 known arthropod species in the Mariana Archipelago (Abraham et al. 2004). Important human-harvested species of crustaceans, as indicated by creel surveys of the shore-based fishery in Guam, are spiny lobsters (*Panulirus penicillatus* and *P. versicolor*), slipper lobsters (*Parribacus antarcticus*), and crabs (*Scylla serrata*).

10.5.4.2 Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*.

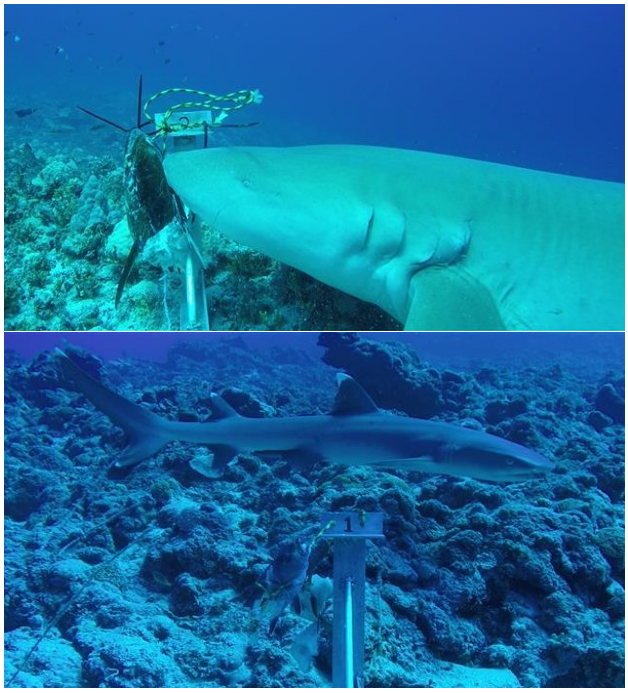
The presence of invasive marine invertebrate species has not been reported from coastal marine habitats in the CNMI (Liske-Clark 2015). The non-native topsnail is relatively abundant in CNMI and is known from all JRM submerged lands in CNMI (Liske-Clark 2015; Smith and Marx Jr. 2016; DON 2017a).

Nuisance marine invertebrate species in CNMI include crown-of-thorns seastar (COTS) (*Acanthaster planci*) and the gray sponge (*Terpios hoshinota*). These nuisance marine species are native but occasionally exhibit population booms or outbreaks. Both species have been reported from many locations in the CNMI (Quinn and Kolis 2003; DON 2014c, 2017a).

10.5.5 Marine Fishes

10.5.5.1 Native Species

Approximately 1,100 marine fish species are known from the Mariana Archipelago, most of which are known from the coastal zone (Myers and Donaldson 2003). Fish species composition in the Mariana Islands includes widespread Indo-Pacific species (58%), circumtropical species (3.6%), Indo-west Pacific and west Pacific species (17.6%), west-central Pacific and Pacific Plate species (18.3%), and species confined to specific geographic areas (such as Micronesia, the Philippine Sea plate, and those endemic to the Mariana Islands) (2.5%) (Myers and Donaldson 2003). Approximately 10 species are endemic to the Mariana Islands, though these records are under scrutiny (Myers and Donaldson 2003).



Reef-associated fish larger than 6 inches are uncommon in the southern islands of CNMI. One tawny nurse shark (*Nebrius ferrugineus*) (top) and two whitetip reef sharks (*Triaenodon obesus*) (bottom) were observed in 20 hours of baited remote video surveys on the west coast of Tinian. (*Photo*: NMFS PIFSC)

Extensive studies have focused on the biogeography of inshore and epipelagic fauna found in the Mariana Islands from 0 to 328 feet (0 to 100 meters) depth. Occurrence and distribution of benthic and mesopelagic species from 328 feet (100 meters) to greater than 656 feet (200 meters) have been incompletely studied and are poorly understood (Myers and Donaldson 2003). There is evidence of systematic overfishing of CNMI resources since early industrialized harvesting (Cuetos-Bueno and Houk 2015; WPRFMC 2016b, 2016c; Cuetos-Bueno et al. 2018) and in the last two decades since the implementation of national fisheries management programs (Trianni 2002; Starmer et al. 2005; Williams et al. 2011; Brainard et al. 2012; Heenan et al. 2015). Large-bodied coral reef fishes (i.e., those larger than 6 inches) are less abundant in Guam than in the CNMI (Richards et al. 2012). Large-bodied reef fishes are less abundant in the southern islands than in the northern islands (Houk et al. 2010; Houk and Starmer 2010; NOAA 2014; Smith and Marx Jr. 2016).

Fish within the southern islands exhibit year-round uniformity and stability in their abundances rather than seasonal transience (Amesbury and Myers 2001). Exceptions include several reef fish species that show strong seasonal fluctuation in abundance, usually related to juvenile recruitment (e.g., juvenile rabbitfish [Family Siganidae], juvenile jacks and bigeye scad [Family Carangidae], and juvenile goatfish [Family Mullidae]).

10.5.5.2 Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*.

The non-native striped eel catfish (*Plotosus lineatus*) is a venomous fish widely distributed throughout the Indo-Pacific. This species has been found to be an invasive threat around the world and their dangerous spines have proven fatal in rare cases among humans (NOAA 2019). The striped eel catfish was first recorded in Saipan in the CNMI DFW 2005 Sportfish Restoration Research Program Annual Report. Since

then, they have become a common occurrence in Saipan Lagoon (NOAA 2019). The non-native red tilapia (*Oreochromis mossambicus*) is likely to be accidentally released from onshore pools into Saipan Lagoon but has not yet been introduced to marine waters (Liske-Clark 2015). A nuisance marine species is native but occasionally exhibits population booms or other undesirable characteristics. To date, there are no reports of nuisance marine fishes in the CNMI.

10.5.6 Marine Protected Species

Federal and CNMI ESA-listed and MMPA-protected marine species are known to occur within the marine waters of the CNMI. Table 10-2 provides a summary of known and potential occurrences of protected species in the JRM submerged land areas. Because some records are not precise, their occurrences are approximated within the 3 miles (4.8-kilometers) JRM submerged lands based on available records.



Spinner dolphins (*Stenella longirostris*) are common in the Mariana Islands but rarely approach divers closely enough for a photograph. Near Lamanibot Bay on Tinian.
(*Photo*: V. Bonito)

Table 10-2. Federal and CNMI ESA-listed Threatened and Endangered and MMPA-protected Marine Species Recorded within JRM Submerged Lands of the CNMI

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*CNMI Status*	*Habitat*[2]	*Occurrence*[3]
Invertebrates (Corals)					
Coral/Acho tasi	*Acropora globiceps*	T	--	Coral reefs	Y
Coral/Acho tasi	*Acropora retusa*	T	--	Coral reefs	Y
Coral/Acho tasi	*Seriatopora aculeata*	T	--	Coral reefs	P
Fish					
Oceanic whitetip shark/Haluu	*Carcharhinus longimanus*	T	--	Marine water column	PU
Giant manta ray/Afulu or Hafula or Fanihen Tasi	*Manta birostris*	T	--	Marine water column	P
Scalloped hammerhead shark/Haluun kiluus or Ulon matiyu na huluu	*Sphyrna lewini*	T[4]	--	Marine water column	P
Reptiles					
Green sea turtle/Haggan	*Chelonia mydas*	E[5]	T-E	Nearshore, Marine water column, Seagrass, Coral reefs, Hardbottom	Y
Hawksbill turtle/Haggan karai	*Eretmochelys imbricata*	E	T-E	Nearshore, Marine water column, Coral reefs, Hardbottom	Y
Marine Mammals					
Spinner dolphin/Tuninos	*Stenella longirostris*	MMPA	--	Coastline to 3,281 feet (1,000 meters)	Y
Bottlenose dolphin//Tuninos	*Tursiops truncatus*	MMPA	--	Coastline to 6,562 feet (2,000 meters)	Y
Pantropical spotted dolphin/Tuninos	*Stenella attenuata*	MMPA	--	Coastline to 3,281 feet (1,000 meters)	Y

Table 10-2. Federal and CNMI ESA-listed Threatened and Endangered and MMPA-protected Marine Species Recorded within JRM Submerged Lands of the CNMI

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*CNMI Status*	*Habitat[2]*	*Occurrence[3]*
Short-finned pilot whale/Salungai or Bayena	*Globicephala macrorhynchus*	MMPA	--	Coastline to 6,562 feet (2,000 meters), prefers deeper waters	Y
Rough-toothed dolphin/Tuninos	*Steno bredanensis*	MMPA	--	Offshore, prefers deeper waters	Y
Dwarf sperm whale/ Salungai or Bayena	*Kogia sima*	MMPA	--	Generally near the 656-foot (200-meter) isobath	P
False killer whale/Salungai or Bayena	*Pseudorca crassidens*	MMPA	--	Offshore, prefers waters deeper than 3,281 feet (1,000 meters)	Y
Pygmy killer whale/ Salungai or Bayena	*Feresa attenuata*	MMPA	--	Offshore, prefers deeper waters	P
Blue whale/Salungai or Bayena	*Balaenoptera musculus*	E	--	Coastline to 984-foot (300-meter) isobath	P
Fin whale/Salungai or Bayena	*Balaenoptera physalus*	E	--	Generally near the 656-foot (200-meter) isobath	P
Humpback whale/Salungai or Bayena	*Megaptera novaeangliae*	E[6]	--	Coastline to 5,906-feet (1,800-meters) isobath	Y
Sei whale/Salungai or Bayena	*Balaenoptera borealis*	E	--	Offshore, prefers deeper waters	P
Sperm whale/Salungai or Bayena	*Physeter macrocephalus*	E	--	Deep waters generally >3,281 feet (>1,000 meters) depth	P
Blainville's beaked whale/Salungai or Bayena	*Mesoplodon densirostris*	MMPA	--	Prefer deep water generally around 3,281 feet (1,000 meters) depth	Y
Risso's dolphin/Tuninos	*Grampus griseus*	MMPA	--	Deep waters generally >3,281 feet (>1,000 meters) depth	P
Common minke whale Salungai or Bayena	*Balaenoptera acutorostrata*	MMPA	--	Prefer both inshore and offshore waters	P
Killer whale/Salungai or Bayena	*Orcinus orca*	MMPA	--	Prefers higher productivity waters	P
Bryde's whale/Salungai or Bayena	*Balaenoptera edeni*	MMPA	--	Offshore, prefers higher productivity waters	Y
Cuvier's beaked whale/Salungai or Bayena	*Ziphius cavirostris*	MMPA	--	Prefer deep waters generally >3,281 feet (>1,000 meters) depth	Y

Notes: [1] Chamorro names from GovGuam (2009), Kerr (1990), Kerr (2012), and Topping et al. (1975).
[2] Dominant adult habitat. Not necessarily inclusive of other life stages (e.g., egg/larvae/juvenile/breeding habitat).
[3] Occurrences approximated to JRM submerged lands, but some fishery-based and acoustic-based records have imprecise locations.
[4] Indo-West Pacific Distinct Population Segment.
[5] Central West Pacific Distinct Population Segment.
[6] Western North Pacific Distinct Population Segment.

Key: > = greater than; -- = not listed; CNMI = Commonwealth of the Northern Mariana Islands; E = endangered; ESA = Endangered Species Act; JRM = Joint Region Marianas; MMPA = Marine Mammal Protection Act; P = potential for occurrence; PU = potential for occurrence, but unlikely; T = threatened; Y = yes, known to occur.

Sources: Berger et al. 2005; DON 2014b, 2017a; Jones et al. 2015; Kobayashi et al. 2011; Liske-Clark 2015; Martin and Jones 2016; NMFS 2014a, 2014b, 2015a, 2018a, 2018b; Trianni and Tenorio 2012; Hill et al. 2017.

10.5.7 Stressors on the Marine Environment of Commonwealth of the Northern Mariana Islands

10.5.7.1 Climate Change



The inner reef crest at Unai Masalok on Tinian was a field of branching *Acropora digitifera* coral colonies in July 2013 (top). In April 2015, the same reef crest was void of living *A. digitifera* coral colonies as a result of bleaching and typhoon impacts (bottom). Dead coral skeletons, weakened by bioerosion, are readily broken off by storms.
(*Photo*: M. Lybolt)

The main consequences of global climate change have been measurable for several decades (U.S. Environmental Protection Agency [USEPA] 2016; DON 2017b), including sea level rise, stress on groundwater and disruptions to food supplies, plant and animal range shifts, and destruction of shallow coral reefs (Hughes et al. 2017). Many cyclic events are becoming more frequent and intense, including storms, droughts, floods, heat waves, and disease outbreaks (Hughes et al. 2003; Hoegh-Guldberg and Bruno 2010). Consequences of climate change in the marine environment are primarily driven by increased heat content of the oceans, and how that increased heat content affects physical, chemical, and biological processes. Thermal expansion is a major contributor to sea level rise and also accelerates melting of glaciers, a positive feedback that further accelerates sea level rise (Hoegh-Guldberg and Bruno 2010; USEPA 2016; DON 2017b). Increased heat content alters current patterns, with major consequences to the distribution and abundance of marine species. Because ocean currents strongly influence weather and climate on the continents, there is disruptive positive feedback between marine and terrestrial consequences of climate change (Department of Defense [DoD] 2014; Hoegh-Guldberg and Bruno 2010). Increased heat content lowers the total quantity of oxygen that seawater can carry and enhances the stratification of oxygen in seawater, which causes a positive feedback that further lowers oxygen content (NMFS 2023; Polovina et al. 2016). Increased heat content alters many chemical processes, with major physiological consequences to organisms including reduced reproduction, reduced survival of juveniles, skeletal deformations, and reduced awareness of predators (Hughes et al. 2017; NMFS 2023). Similar heat-related chemical processes increase the toxicity of many pollutants and decrease an organism's capacity to detoxify pollutants, which causes a positive feedback that degrades an organism's ability to heal, grow, or reproduce (Andersson et al. 2015). Increased physiological stress makes plants and animals more susceptible to disease, and the disruptions to ecosystems, heat content, and

oxygenation causes a positive feedback that makes diseases more transmissible and more severe (Hoegh-Guldberg and Bruno 2010; Hughes et al. 2017).

The DoD is implementing several global and regional strategies to address climate change that are discussed in Section 3.1.1, *Climate Change*. The following text highlights select differential consequences of climate change among JRM-administered and leased lands and submerged lands in Guam, Tinian, and FDM. Consequences of sea level rise will be much less intense on FDM because it has much less shallow marine habitat than Tinian or Guam, and very little of the shoreline is susceptible to coastal erosion. Similarly, processes linked to local human population density will be much less intense on FDM because it has no human population (e.g., consequences of stress on groundwater, disruptions to food supplies). Consequences of changes to ocean currents will affect larval supply, connectivity, and reef resilience (Hoegh-Guldberg and Bruno 2010; Maynard et al. 2015; Polovina et al. 2016). However, it is difficult to predict the nature and intensity of local-scale impacts.

10.5.7.2 Ocean Acidification

Ocean acidification is one of the major impacts on the marine environment. It is a separate process from climate change and is driven directly by carbon dioxide (CO_2) rather than being a consequence of rising temperatures. The effects of ocean acidification on marine communities and ecosystems vary among geographic regions due to local climate, hydrography, seawater chemistry, nutritional status, proximity to land, human influences, biodiversity, and the resilience of ecosystems (Andersson et al. 2015). If CO_2 emissions continue to increase at the present rate, model projections suggest that surface seawater acidity will increase by an additional 100–150% by the end of this century (Joos et al. 2011; Orr et al. 2005; Andersson et al. 2015). The effects on marine organisms and marine ecosystems are varied and depend on the ability of species to adapt. Calcifying organisms (e.g., mollusks, crustaceans, coral, etc.) are negatively impacted by higher CO_2 levels due to negative effects on growth, calcification rate, and survival. However, elevated seawater CO_2 stimulates the productivity of some marine algae and seagrasses. Temperature increases, de-oxygenation, and changes in food webs are particularly important co-stressors because they are pervasive, and both their causes and effects are often linked to acidification. Multiple stressors also need to be considered for management, mitigation, and adaptation to acidification and to increase public and policy recognition of the importance of addressing acidification in the context of the other stressors with which it potentially interacts (Breitburg et al. 2015).

JRM can incorporate ocean acidification monitoring into their marine ecosystem monitoring projects. By incorporating climate change indicators into current monitoring of JRM submerged lands and natural resources, JRM can better determine how to protect EFH and ESA-listed marine species. EFH is defined in Section 4.5.2.3, *Essential Fish Habitat*, and applies to CNMI without alteration.

10.5.7.3 Coral Stressors

Because corals are key habitat-forming invertebrates, threats to them and to coral reefs are well studied. Factors that can stress or damage coral reefs include coastal development (Downs et al. 2009; Risk 2009), impacts from inland pollution and erosion (Cortes and Risk 1985), coastal runoff (Downs et al. 2009), overexploitation and destructive fishing practices (Jackson et al. 2001; Pandolfi et al. 2003), global climate change and ocean acidification (Hughes et al. 2003), disease (Porter et al. 2001; Lesser et al. 2007), predation (Hayes 1990), harvest for the aquarium trade (Caribbean Fishery Management Council 1994), anchor damage (Burke and Maidens 2004), invasive species (Bryant et al. 1998; Wilkinson 2002; Galloway et al. 2009; NMFS 2010), vessel groundings (NMFS 2020), oil spills (NOAA 2010), bioprospecting (Hunt and Vincent 2006), sunscreen and toxicological threats, and, possibly, human-made noise, which may mask the natural reef sounds that serve as cues the planulae use to orient them toward suitable settlement sites

(Vermeij et al. 2010). Coral growth rates are reduced because of ocean acidification (Cohen et al. 2009) and increasing ocean temperatures are causing thermal stress events that lead to coral bleaching events (Keener 2018). From 2013 to 2017, coral reefs of the CNMI experienced unprecedented coral bleaching events and mortality (Keener 2018). The projected onset of annual severe bleaching events for the coral reefs surrounding CNMI range from 2020 to 2042 depending on the location of the reef (Keener et al. 2018).

Land-based pollutants include nutrients, sediment, toxins, and salinity stressors (Brainard et al. 2012). These stressors can act synergistically and are influenced by biological and hydrological factors (Brainard et al. 2011). Land-based sources of pollution may pose significant threats at local scales and reduce the resilience of corals to bleaching (Carilli et al. 2009; Wooldridge 2009); this is particularly important for species with limited range (Brainard et al. 2011). The impacts of watershed pollution on vulnerable corals species in CNMI are most apparent in less harsh environments, including enclosed bays and sheltered shorelines (Houk and van Woesik 2010).

Natural processes can also have harmful effects on marine ecosystems. Biological surveys after the 2003 eruption of the volcano on Anahatan show that ash from volcanic eruptions can cover the benthos and, consequently, coral reef communities. Post-eruption, corals showed signs of stress in the form of bleaching (Vroom and Zgliczynski 2011). In general, coral species may show differing levels of stress from pyroclastic events based on differences in ability of polyps to cope with sedimentation.

10.5.7.4 Marine Fish Stressors

In addition to the multiple stressors of climate change and ocean acidification, major stressors to marine fish include overfishing, habitat loss, pollution, and a variety of lesser stressors, such as noise.

Overfishing is the most serious threat, having led to listing of ESA-protected marine species (Kappel 2005; Crain et al. 2009) and with habitat loss also contributing to extinction risk (Musick et al. 2000; Dulvy and Polunin 2004; Cheung et al. 2007). Overfishing occurs when the rate of removal from a stock is too high, and a stock is considered overfished when the population falls below a prescribed threshold (NMFS 2011). Overfishing affects both targeted species and non-targeted species (or "bycatch" species) that are often important in marine food webs. Bycatch may also include seabirds, turtles, and marine mammals. In recent decades, marine fisheries have targeted species lower on the food web as abundance of higher-level predators has decreased; some entire marine food webs have collapsed as a result (Pauly and Palomares 2005; Crain et al. 2009). Reduction in grazing species through fishing can have an effect on the algae in reef communities, which, in turn, changes the communities on coral reefs (Miller and Hay 1996; Burkepile and Hay 2006; Kopp et al. 2010). CNMI fisheries show clear signs of overexploitation, particularly in the southern islands (Spalding et al. 2001; Starmer et al. 2005; 2008). There are multiple lines of evidence consistent with systematic overfishing of CNMI resources since early industrialized harvesting (Cuetos-Bueno and Houk 2015; WPRFMC 2016b, 2016c; Cuetos-Bueno et al. 2018) and in the recent two decades since the implementation of national fisheries management programs (Trianni 2002; Starmer et al. 2005; Williams et al. 2011; Brainard et al. 2012; Heenan et al. 2015).

Pollution primarily affects coastal fishes near the pollution source. However, global oceanic circulation patterns scatter a considerable amount of marine pollutants and debris throughout the open ocean (Crain et al. 2009). Pollutants in the marine environment that may impact marine fishes include organic contaminants (e.g., pesticides, herbicides, polycyclic aromatic hydrocarbons, flame retardants, oil, etc.); inorganic chemicals (e.g., heavy metals); and debris (e.g., plastics and wastes) (Pew Oceans Commission 2003). High chemical pollutant levels in marine fishes may induce behavioral changes, physiological changes, or genetic damage in some species (Pew Oceans Commission 2003; van der Oost et al. 2003; Moore 2008).

Bioaccumulation of metals and organic pollutants is also a concern in shallow harbors and coastal portions of CNMI (Denton et al. 2006, 2009). This is also a concern to human health, because people consume top predators with possibly high pollutant loads. Bioaccumulation is the net buildup of substances (e.g., chemicals or metals) in an organism from taking in contaminated water or sediment through the gills or skin, from ingesting food containing the substances (Brown and Depledge 1998), or from ingesting those substances directly (Moore 2008). The physical presence of marine debris such as abandoned nets and lines also poses a threat to marine fishes. Entanglement in abandoned commercial and recreational fishing gear has caused declines of some marine fishes (Musick et al. 2000).

Underwater noise, including sonar, is a threat to marine fishes. However, physiological and behavioral responses of marine fishes to underwater noise have been investigated for only a limited number of species (approximately 100; many of which are freshwater species) (Popper and Hastings 2009). In addition to vessels, other sources of underwater noise include pile-driving activity and seismic activity (Feist et al. 1996; California Department of Transportation 2001; Nedwell et al. 2003; Popper et al. 2006; Carlson et al. 2007; Popper and Hastings 2009; Mueller-Blenkle et al. 2010).

10.5.7.5 Other Anthropogenic Stressors

Some anthropogenic stress also affects nearshore resources around CNMI, such as overuse or misuse of popular scuba and snorkeling sites, personal watercraft, and anchoring damage (Liske-Clark 2015). CNMI created several marine preserves designed to benefit birds, fish, and habitat. Some anthropogenic stressors are affected by JRM management projects, or may be managed under future project implementation on JRM leased lands in the CNMI. Prioritization of these stressors is a challenge, and coordinated approaches such as the Micronesian Challenge, the Local Action Strategy, and Coral Reef Management Priorities under the U.S. Coral Reef Task Force are useful organizing frameworks for DoD actions.

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11 TINIAN MILITARY LEASE AREA

11.1 CURRENT OPERATIONS AND LAND USE

The northern two-thirds of Tinian is leased to the United States (U.S.) Department of Defense (DoD) from the Commonwealth of the Northern Mariana Islands (CNMI) pursuant to the Covenant to Establish a Commonwealth of the Northern Mariana Islands in Political Union with the United States of America, Public Law (PL) 94–241, Part 1, March 24, 1976, 90 Statute 263. This area is known as the Military Lease Area (MLA). The Tinian MLA is divided into the Exclusive Military Use Area (EMUA) and the Lease Back Area (LBA).



A Japanese air raid shelter built in World War II still stands in the MLA.
(*Photo*: L. Shaughnessy)

The Tinian MLA is controlled and managed by the U.S. Department of the Navy (DON) and is composed of approximately 15,355 contiguous acres (6,213 hectares) north of the Tinian International Airport (West Field) (Figure 11-1). The EMUA is approximately 7,574 acres (3,065 hectares) comprising the northernmost section of the MLA, and the LBA includes approximately 7,779 acres (3,148 hectares) comprising the southern portion of the MLA. Agricultural activities, including cattle grazing, and resident human occupation are not permitted in the EMUA, but agricultural activities are permitted in the LBA. There are no permanent military facilities in the MLA other than World War II (WWII)-era structures. The MLA is open to public access and recreational use (e.g., fishing, swimming, camping) except when military training activities may require closures of some or all of the MLA. As part of the 1999 Partial Release of Leasehold Interest, the U.S. executed an agreement with the CNMI for the release of leasehold interest of 10 acres (4 hectares) at Unai Masalok for the CNMI to establish a "Youth Site."



The International Broadcasting Bureau's (IBB) Philippines Transmitting Station located in the MLA.
(*Photo*: L. Shaughnessy)

The International Broadcasting Bureau's (IBB) Philippines Transmitting Station uses 777 acres (314 hectares) of the MLA under an agreement with the Office of the Assistant Secretary of Defense International Security Affairs and the Naval Facilities Engineering Systems Command (NAVFAC). The IBB is an independent government agency that supports day-to-day operations of Voice of America and provides transmission and technical support to non-military U.S. broadcasting services.

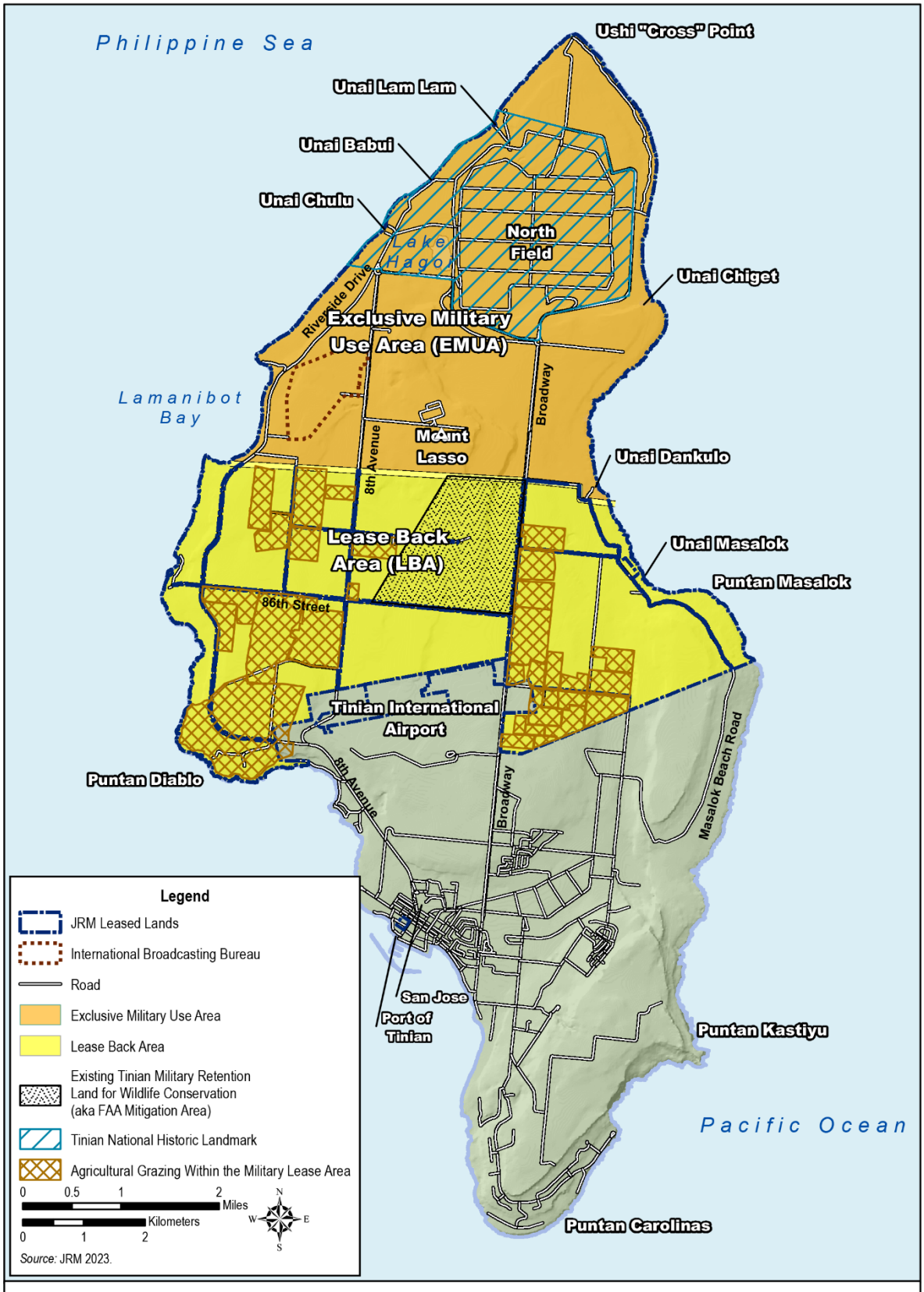


Figure 11-1
Overview of Tinian

11.1.1 Tinian Assets and Uses



Much of the Port of Tinian is in substantial disrepair. Foreground: dive launch Downrider I.
(*Photo*: D. Fenner)

Current military training on Tinian includes activities evaluated in the Mariana Islands Training and Testing (MITT) Environmental Impact Statement (EIS)/Overseas EIS (OEIS), with a Record of Decision (DON 2015a). Medium and small-scale training activities occur annually while large-scale training activities occur infrequently. These exercises include combat search and rescue, amphibious assault, amphibious raid, personnel insertion and extraction, airfield seizure, and humanitarian assistance/disaster relief operations (refer to Table 11-1). Humanitarian assistance/disaster relief operations consist of personnel airlift and drop/recovery using fixed-wing aircraft on the historic Baker runway. DoD is permitted to use areas outside of the MLA in coordination with the CNMI Port Authority, the Tinian Mayor's Office, and Commonwealth Ports Authority (CPA) (e.g., Port of Tinian, also known as the Tinian Harbor and Tinian International Airport). Amphibious assault training occurs at designated beach landing sites and MLA landing zones; however, mechanized amphibious vehicles (e.g., Amphibious Assault Vehicles and Landing Craft Air Cushion vessels) are not permitted on MLA beaches. Urban warfare training; Intelligence/Surveillance/Reconnaissance (ISR); and combat close quarters training are conducted in association with historic structures within the MLA (DON 2015a).

Terrestrial training exercises are grouped within six major training activities: Strike Warfare, Amphibious Warfare, Expeditionary Warfare, Special Warfare, Special Expeditionary Warfare, and Force Protection/Antiterrorism. Training conducted in these mission areas occurs to ensure the readiness of the DON, U.S. Marine Corps (USMC), U.S. Air Force (USAF), U.S. Army, U.S. Coast Guard (USCG), and foreign military readiness partners to the U.S.

There are no live-fire ranges in the MLA, with the exception of small arms fire into bullet traps associated with WWII structures located at North Field, the location of historic runways built in 1945. This area is used for bivouac training, fixed-wing and helicopter activities, and parachute drops (DON 2015a). The runways are also used for amphibious raids, airfield seizure, and expeditionary training. The LBA can be used for on-the-ground instruction associated with Military Operations on Urban Terrain (MOUT), bivouac, vehicle and land navigation, and other non-live-fire field activities.

North Field served as a WWII U.S. bomber base following the capture of Tinian by American Forces, and subsequently served as a key platform for daily attacks on the Japanese mainland. The atomic bomb attacks on Hiroshima and Nagasaki originated at North Field on August 6 and 9, 1945, respectively. North Field is currently designated as a National Historic Landmark that contains taxiways, four runways, two service aprons, and invasion beaches.



The loading pits that housed atomic bombs dropped on the Japanese cities of Hiroshima and Nagasaki during World War II form part of the National Historic Landmark on North Field in the MLA.
(*Photo*: L. Shaughnessy)

With respect to cultural resources, ongoing training activities permitted under the MITT EIS/OEIS are covered by the 2010 Mariana Islands Range Complex (MIRC) Programmatic Agreement between the CNMI Historic Preservation Office (HPO), Guam State HPO, Advisory Council on Historic Preservation, and the DON. Military training activities that are not specifically covered by the MIRC Programmatic Agreement require case-by-case consultation with the CNMI HPO under Section 106 of the National Historic Preservation Act (NHPA). For further information related to cultural resources, please refer to the 2015 Integrated Cultural Resource Management Plan.

Table 11-1 lists current training activities approved under the MITT EIS/OEIS.

Table 11-1. DoD Training Activities in the EMUA and LBA of Tinian

Location	*Training*	*Exercise*	
Tinian North Field	Strike Warfare	• Combat Search and Rescue	
Tinian MLA (Unai Chulu, Unai Dankulo, Unai Babui, Port of Tinian, and North Field)	Amphibious Warfare	• Amphibious Assault MAGTF • Amphibious Raid Special Purpose MAGTF	• Urban Warfare Training • NEO
Tinian MLA (Unai Chulu, Unai Dankulo, Unai Babui, Port of Tinian, and North Field)	Naval Special Warfare	• Personnel Insertion/Extraction • Parachute Insertion • Embassy Reinforcement • Direct Action (Combat Close Quarters)	• Direct Action (Breaching) • ISR • NEO • HADR
Tinian MLA (Unai Chulu, Unai Dankulo, Unai Babui, Port of Tinian, and North Field)	Other Training	• Force Protection • Maneuver (Convoy; Land Navigation) • Water Purification • FTX • Force Protection • Anti-Terrorism	• Seize Airfield and Airfield Expeditionary • Land Demolitions (IED Discovery Disposal) • Land Demolitions (UXO Discovery Disposal)
Tinian EMUA		• Geiger Fury • Forager Fury I/Forager Fury II/ Forager Fury III	• Valiant Shield

Key: DoD = Department of Defense; EMUA = Exclusive Military Use Area; FTX = Field Training Exercise; HADR = Humanitarian Assistance/Disaster Relief Operation; IED = Improvised Explosive Device; ISR = Intelligence/Surveillance/Reconnaissance; LBA = Lease Back Area; MAGTF = Marine Air Ground Task Force; MLA = Military Lease Area; NEO = Non-combatant Evaluation Operation; UXO = Unexploded Ordnance.
Source: DON 2015a.

11.1.2 Special Conservation Areas

In 1999, the DON dedicated the Existing Tinian Military Retention Land for Wildlife Conservation – also known as Federal Aviation Administration (FAA) Mitigation Area – as a conservation area for the Tinian monarch (*Monarcha takatsukasae*) to mitigate for past expansions of the Tinian International Airport (West Field) (Government of CNMI and United States of America 1999). This was done in cooperation with U.S. Fish and Wildlife Service (USFWS), CNMI Division of Fish and Wildlife (DFW), and FAA. The cooperative agreement allows the military to use the FAA Mitigation Area for low-impact training that will not adversely modify habitat.

11.2 TERRESTRIAL ENVIRONMENT

11.2.1 Geology, Topography, and Soils

11.2.1.1 Geology

Tinian is the fourth island from the south in the Mariana Islands chain (refer to Figure 2-1). It is approximately 12 miles (19 kilometers) long and 6 miles (10 kilometers) wide and covers approximately 25,000 acres (10,100 hectares). The island is formed from a 38 million-year-old extinct volcanic core covered by younger limestone formations (5 to 23 million years old) and recent beach and reef deposits. The island is composed mainly of coralline and algal limestone overlying volcanic rock. The volcanic rock, known as Tinian Pyroclastic Rock, is only observable at ground surface within the MLA in two localized areas in the vicinity of Mount Lasso (Gingerich 2002) (Figure 11-2). The raised limestone plateaus that characterize the island are evidence of uplifting caused by movement along high-angle normal faults. The limestone is highly porous, so water easily flows through it (Gingerich 2002). Figure 11-2 shows the four major geologic units that comprise Tinian, which are explained below.

Volcanic Units

Tinian Pyroclastic (volcanic) Rock is the oldest of the geological units on Tinian. It is fine-grained to coarse-grained consolidated ash and angular fragments that represent volcanic explosive materials ejected from an ancient (extinct) volcano that forms the core of the island. These materials are generally highly weathered and are altered to clay where exposed on the North-Central Highland and Southeastern Ridge (refer to Section 11.2.1.2, *Topography*, for descriptions of these physiographic area); they cover about 2 percent (%) of the surface of the island. Because of its texture and density, this rock unit has low permeability (i.e., water does not flow easily through it).

Limestone Units

Takpochau Limestone is exposed rock that is younger than the volcanic rock. Found on approximately 15% of the island's surface, generally in the North-Central Highland and the southern part of the Southeastern Ridge. This formation reaches thicknesses of up to 600 feet (180 meters). It is composed of fine to coarse-grained, partially-recrystallized broken limestone fragments and approximately 5% reworked volcanic fragments and clays. This formation is very porous and well drained.

Mariana Limestone is younger than Takpochau Limestone and covers approximately 80% of the island's surface, forming nearly all of the North Lowlands, the Central Plateau, and the Marpo Valley. This formation reaches thicknesses up to 450 feet (140 meters). It is composed of fine to coarse-grained fragmented limestone with some fossil and algal remains and small amounts of clay particles. Small voids and caverns are common in surface exposures. The Mariana Limestone has a higher coral content than the Takpochau Limestone but is similarly porous, allowing water to readily flow through it.

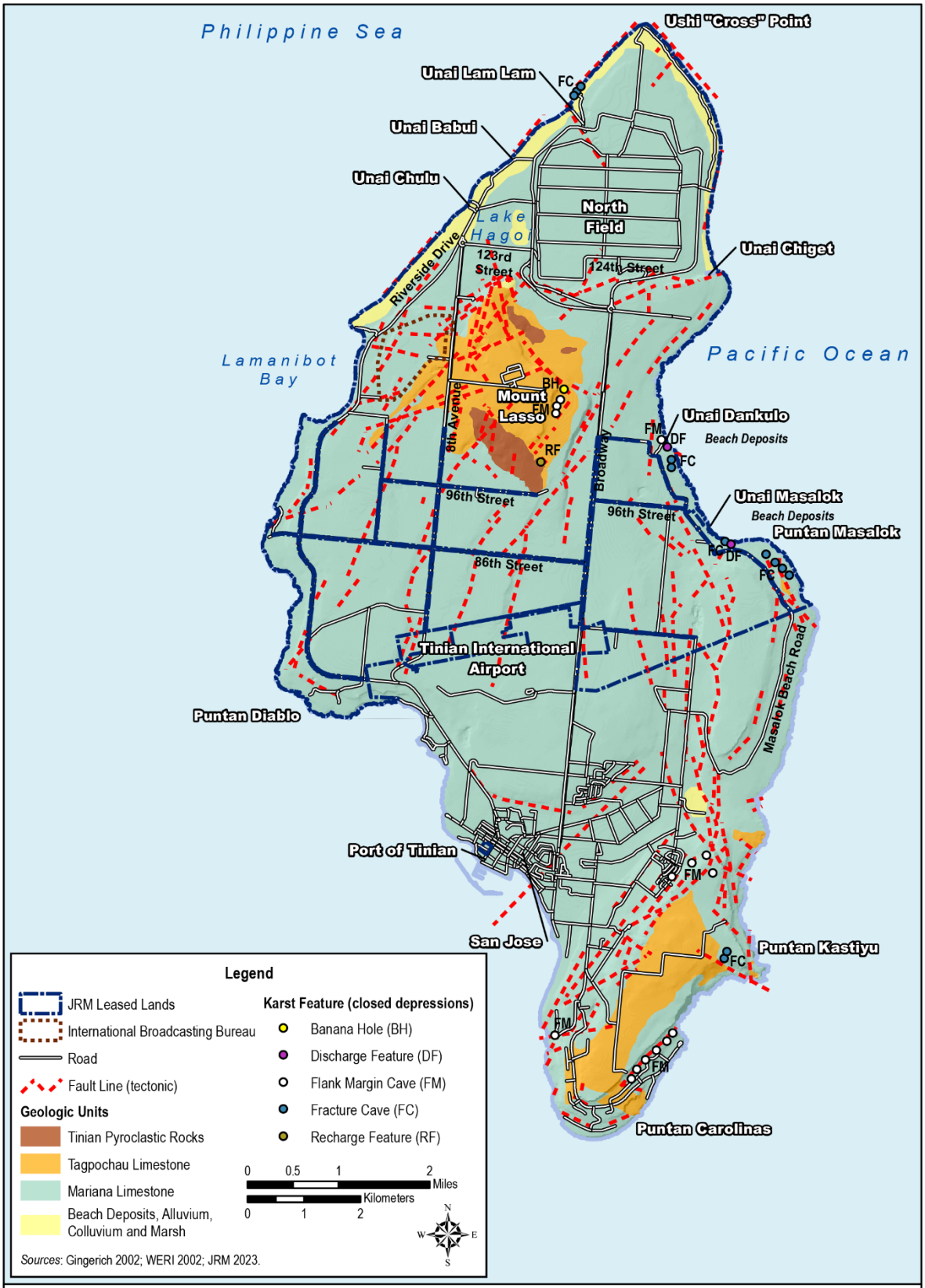


Figure 11-2
Geological Features - Tinian

Beach Deposits, Alluvium, Colluvium, and Marsh make up the youngest of all four geologic units. Deposits found mostly along the coast and cover less than 1% of the island's surface and reach a thickness of up to 15 feet (5 meters). The deposits are made up of poorly consolidated sediments, mostly sand and gravel deposited by waves. However, the deposits do contain clays and silt deposited inland at Lake Hagoi and Makpo (Marpo) Marsh, as well as loose soil and rock material found at the base of slopes.

11.2.1.2 Topography

Tinian is composed of a series of limestone plateaus separated by steep slopes and cliffs (U.S. Department of Agriculture [USDA] 1989). The surface landforms are categorized below into five major physiographic areas described, and shown on Figure 11-3 (Doan et al. 1960; Gingerich 2002).

- **Southeastern Ridge**: This land feature is the southernmost topographic feature and includes Mount Kastiyu, the highest part of the island at 614 feet (187 meters). It has steep slopes and cliffs as high as 500 feet (150 meters).
- **Median (Marpo) Valley**: A low, broad depression located north of the Southeastern Ridge, this area has a maximum elevation of 150 feet (46 meters). This area includes San Jose Village.
- **Central Plateau**: This land area extends northward from Marpo Valley and includes all of central Tinian and portions of northern Tinian. The plateau is broad and gently sloping with the majority of the vertical relief at its southern and northern boundaries. This area includes the Tinian International Airport and portions of the MLA.
- **North-Central Highland**: This land area is located within the northern part of the Central Plateau and midway between the east and west coasts of the island. The maximum elevation is 545 feet (166 meters) at Mount Lasso.
- **North Lowland**: This land area is located at the very northern part of Tinian. It is generally level with an average elevation of about 100 feet (30 meters), except for Lake Hagoi, where the elevation is approximately at sea level.

11.2.1.3 Soils

General soil classes on Tinian were identified by the USDA Soil Conservation Service in 1985 (USDA 1989). Table 11-2 describes the soil characteristics on Tinian, and Figure 11-4 shows the distribution of these soil classes.

11.2.2 Hydrology

Tinian averages 83 inches (211 centimeters) of rainfall per year based on the 50-year rainfall database (Lander and Guard 2003). Tinian's wet season typically occurs from July through October, while the dry season spans from January through April (JRM 2013), with transition periods in between.

Soil class and characteristics, as defined in Table 11-2, influence how surface water behaves in the environment. Soils developed on volcanic rock tend to be poorly-drained clays, whereas soils developed on limestone, such as the lowland and limestone upland soils, tend to be shallow and highly porous.

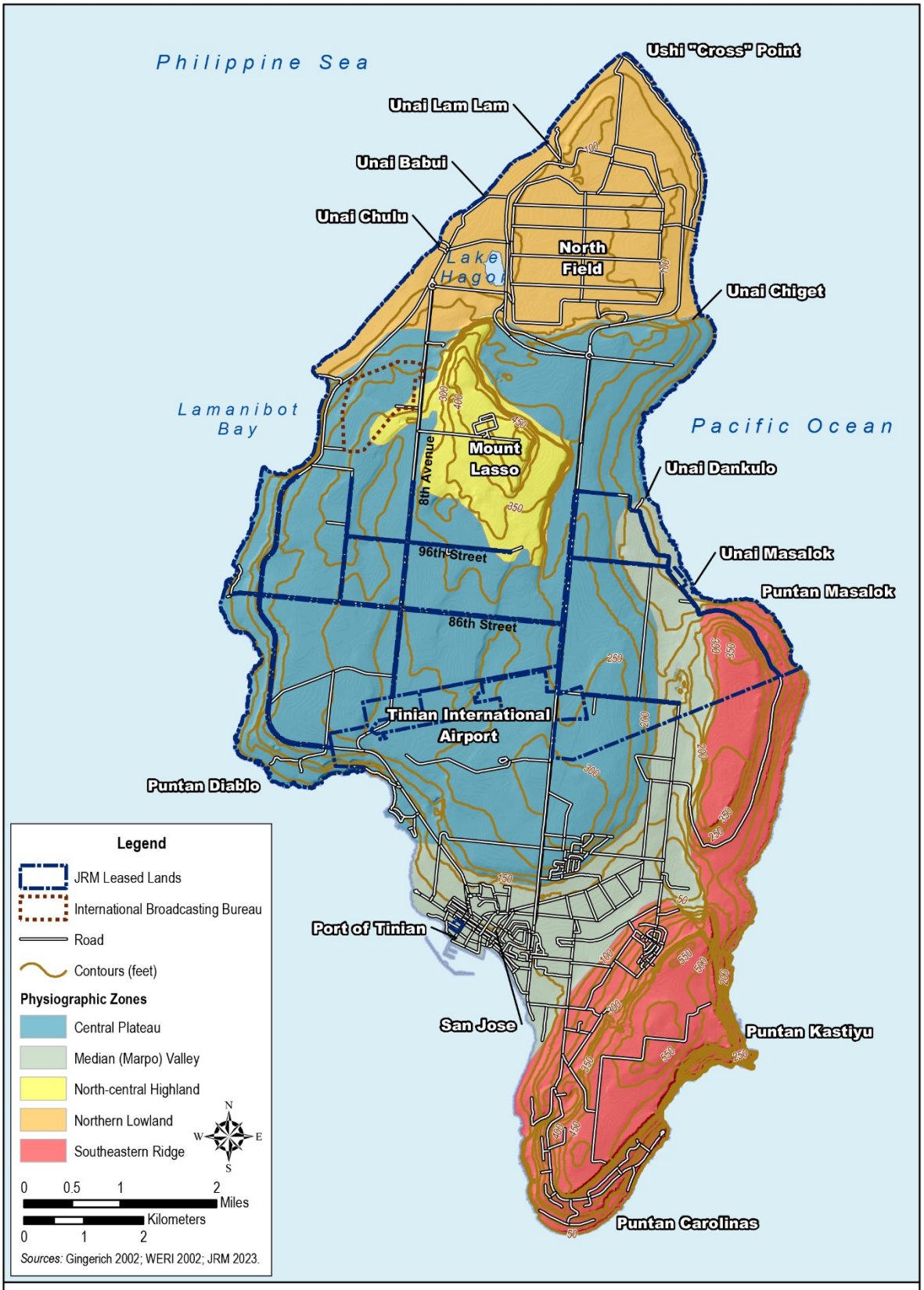


Figure 11-3
Physiographic and Topographic Features - Tinian

Table 11-2. General Soil Classes – Tinian

General Soil Class	*Description*	*Location*
Banaderu-Rock Outcrop	Shallow, well-drained, nearly level to moderately steep soils and rock outcrop	Limestone plateaus
Chacha	Shallow and deep, poorly-drained; on steep slopes, plateaus, and hills	Limestone uplands
Chinen-Takpochao	Very shallow and shallow, well-drained, nearly level to strongly sloping soils; on plateaus and side slopes	Limestone plateaus
Chinen-Urban Land	Shallow, well-drained, nearly level soils; in urban areas	Limestone plateaus
Dandan-Chinen	Shallow and moderately deep, well-drained, nearly level to strongly sloping soils	Limestone plateaus
Inarajan	Very deep, poorly-drained soils	Valley bottoms and coastal plains
Kagman-Saipan	Deep and very deep, well-drained, nearly level to strongly sloping soils	Limestone plateaus
Laolao-Akina	Moderately deep, well-drained, strongly sloping to steep soils; on volcanic uplands	Uplands
Luta	Very shallow, well-drained, nearly level to strongly sloping soils	Limestone plateaus
Mesei Variant	Moderately deep, very poorly-drained, level soils	Depressional areas
Rock Outcrop-Takpochao-Luta	Shallow and very shallow, well-drained, strongly sloping to extremely steep soils and rock outcrop; on limestone escarpments	Uplands
Saipan-Dandan	Moderately deep and very deep, well-drained, nearly level to gently sloping soils	Limestone plateaus
Shioya	Very deep, excessively-drained, level to nearly level soils; on coastal strands	Coastal limestone sands
Takpochao-Chinen-Rock Outcrop	Shallow, well-drained, strongly sloping to extremely steep soils and rock outcrop; on limestone escarpments and plateaus	Uplands
Takpochao Variant-Shioya	Very shallow to very deep, excessively-drained, level to gently sloping soils; on coastal stands and plateaus	Lowlands

Source: USDA 1989.

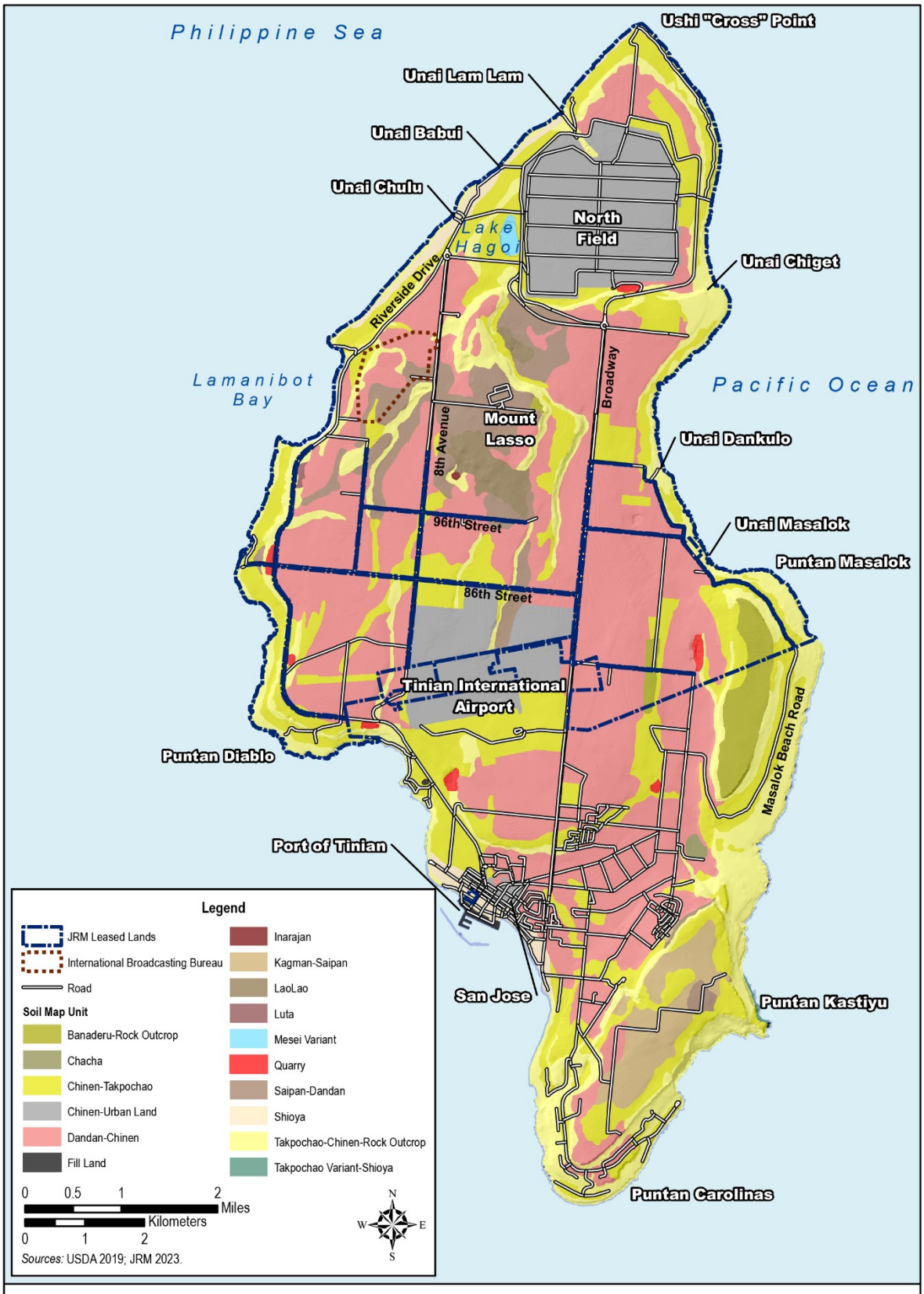


Figure 11-4
Soils - Tinian

11.2.2.1 Surface Water

There are three known inland water features within JRM leased lands in the Tinian MLA: Lake Hagoi, the Mahalang Complex, and Bateha (Figure 11-5). While these areas are not considered jurisdictional waters under the Clean Water Act (CWA) Sections 401 and 404, military training activities that occur on Tinian avoid the water features and treat them as if they were jurisdictional waters. Details of their hydrologic features are described in Table 11-3, and their role and significance as habitat is described in Section 11.2.3.11, *Wetlands*. Because Tinian is formed almost entirely of permeable limestone containing fractures, faults, and karst features, there are few springs and no perennial (permanently flowing) streams. Drainage throughout most of Tinian is underground, where rainwater generally percolates downward into porous rock (Doan et al. 1960) with the exception of stormwater runoff that enters the surface and nearshore waters via short-lived ephemeral streams during occasional heavy rain events.

Table 11-3. Surface Water Features on the Tinian MLA

Name	*Description*	*Area*
Lake Hagoi	Located on the northwest side of the MLA, Lake Hagoi is an area comprising open water and wetland vegetation. It is situated on a limestone terrace over either an impervious layer or a perched water table. Lake Hagoi is dependent entirely on rainfall as a water source; in periods of drought the water level drops and the coverage of open water decreases dramatically. Since 2010, a rapid reduction of open surface water has been observed. Due to sediment inflow, the open water area of Lake Hagoi is slowly transforming into a marsh, completely covering emergent vegetation.	38 acres (15 hectares)
Mahalang Complex	Located within the north-central portion of the MLA, the Mahalang Complex consists of craters and depressions, a subset of which ponds water during the wet season. The complex is located on a plateau in an area of grasslands, tangantangan, and mixed introduced forest. Some of the features are characterized as likely bomb craters from WWII activities (DON 2013a). Dominant vegetation within the craters consists of upland plant species, including introduced grass mixed with various weedy vines and herbaceous plants.	Approximately 24 individual sites (for which a total acreage is unavailable); the two largest features are estimated to be approximately 1.2 acres (0.5 hectare) each
Bateha sites	Located within the central portion of the MLA south of Mount Lasso, these features consist of two shallow depressional areas that contain water during wet periods. They are broad depressions or "moats" that have evolved as eroded clay and silt filled depressions in limestone bedrock. Vegetation within and surrounding these features is dominated by introduced species.	Approximately 1.0 acre (0.4 hectare) each

Key: DON = Department of the Navy; MLA = Military Lease Area; NAVFAC = Naval Facilities Engineering Systems Command; WWII = World War II

Source: NAVFAC Pacific 2015.

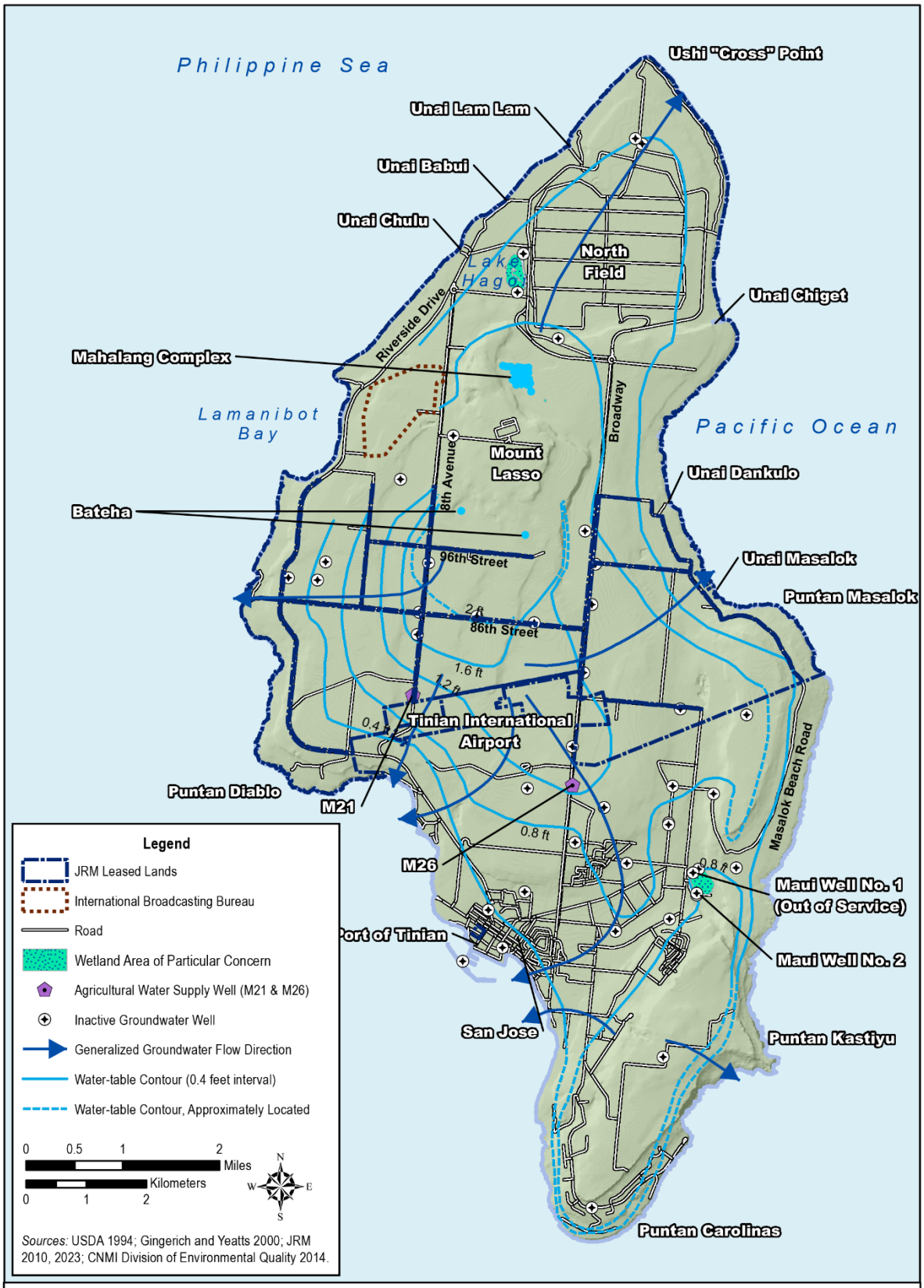


Figure 11-5
Groundwater and Surface Water - Tinian

11.2.2.2 Groundwater

Due to the porous nature of the carbonate rock on Tinian, rainwater percolates down to form a freshwater lens-shaped layer that "floats" over the saltwater groundwater table, known as a Ghyben-Herzberg lens. This lens is the primary source of fresh groundwater on Tinian (Doan et al. 1960). The portion of the lens that is usable for potable water is thickest in the North-Central Highland and Central Plateau and becomes increasingly thinner approaching the coastlines. The freshwater lens on Tinian extends from a maximum recorded elevation of 3.42 feet (1.04 meters) above mean sea level (MSL) to its deepest point at approximately 140 feet (42 meters) below MSL (DON 2010). The average annual rate of recharge for the groundwater lens is estimated to be approximately 30 inches (76 centimeters) per year. Most of Tinian's groundwater supply is located within the Takpochao Limestone. The flow direction of groundwater and location of groundwater wells are shown in Figure 11-5.

The freshwater lens on Tinian is designated by the CNMI government as an underground source of drinking water. The Commonwealth Utilities Corporation public system extracts potable water from the lens via a well system. Water for agricultural use is extracted from two wells labeled M21 and M26 (see Figure 11-5). Historically, groundwater resources supported over 150,000 military personnel during WWII. Peak usage during WWII is estimated at 2.3 million gallons per day (gpd) (8.7 million liters per day [lpd]). To fulfill these water requirements, approximately 40 wells were drilled at an average depth of 300 feet (70 meters). Most wells were abandoned after the war when military troops left Tinian. Water usage in 1992 was estimated at 650 gpd/person (2,460 lpd/person) compared to the U.S. average of 150 gpd/person (568 lpd/person). This difference in water consumption is attributed to leaking infrastructure and poor conservation practices on Tinian. The majority of households utilize municipal water, although approximately 10% depend on rainwater catchment (USDA 1994).

11.2.3 Vegetation Communities

Early reports dating from the 1700s describe Tinian as having predominately limestone forest supporting trees such as *Pisonia grandis*, *Cerbera dilatata*, gulos (*Cynometra ramiflora*), and *Meiogyne cylindrocarpa*. Tinian's native vegetation composition was impacted by agricultural and military use of the island, which began in the early 1800s and continued through WWII. In the 1920s, large sections of land were cleared by the Japanese to support sugarcane (*Saccharum* spp.) production. Sugarcane fields were abandoned in the early 1940s during WWII (Mueller-Dombois and Fosberg 1998). Aerial photographs reveal that WWII bombing, fires, and military reconstruction during and after the war significantly reduced the amount of limestone native forest on Tinian, and once-forested areas not under cultivation became susceptible to encroachment of the introduced non-native tangantangan (*Leucaena leucocephala*). Limestone native forests that once dominated the island were reduced to approximately 5% of the total vegetation cover (Camp et al. 2012; DON 2013a).

Island-wide vegetation mapping was conducted in 2006 by the U.S. Forest Service (USFS) (2006) and was updated in 2009 by the USFWS (Amidon 2009) (Figure 11-6). The 2009 vegetation assessment of Tinian noted that, since the 1980s, areas of open fields decreased 11.6% while mixed introduced forest increased 10.3%, likely a result of succession as open areas became reforested over the previous two decades. Smaller changes included a decrease in tangantangan and an increase in urban land cover (Amidon 2009).

The vegetation community descriptions used by Amidon 2009 and described below are summarized from Falanruw et al. (1989). Vegetation communities and the acreages found on JRM leased lands of Tinian are provided in Table 11-4.

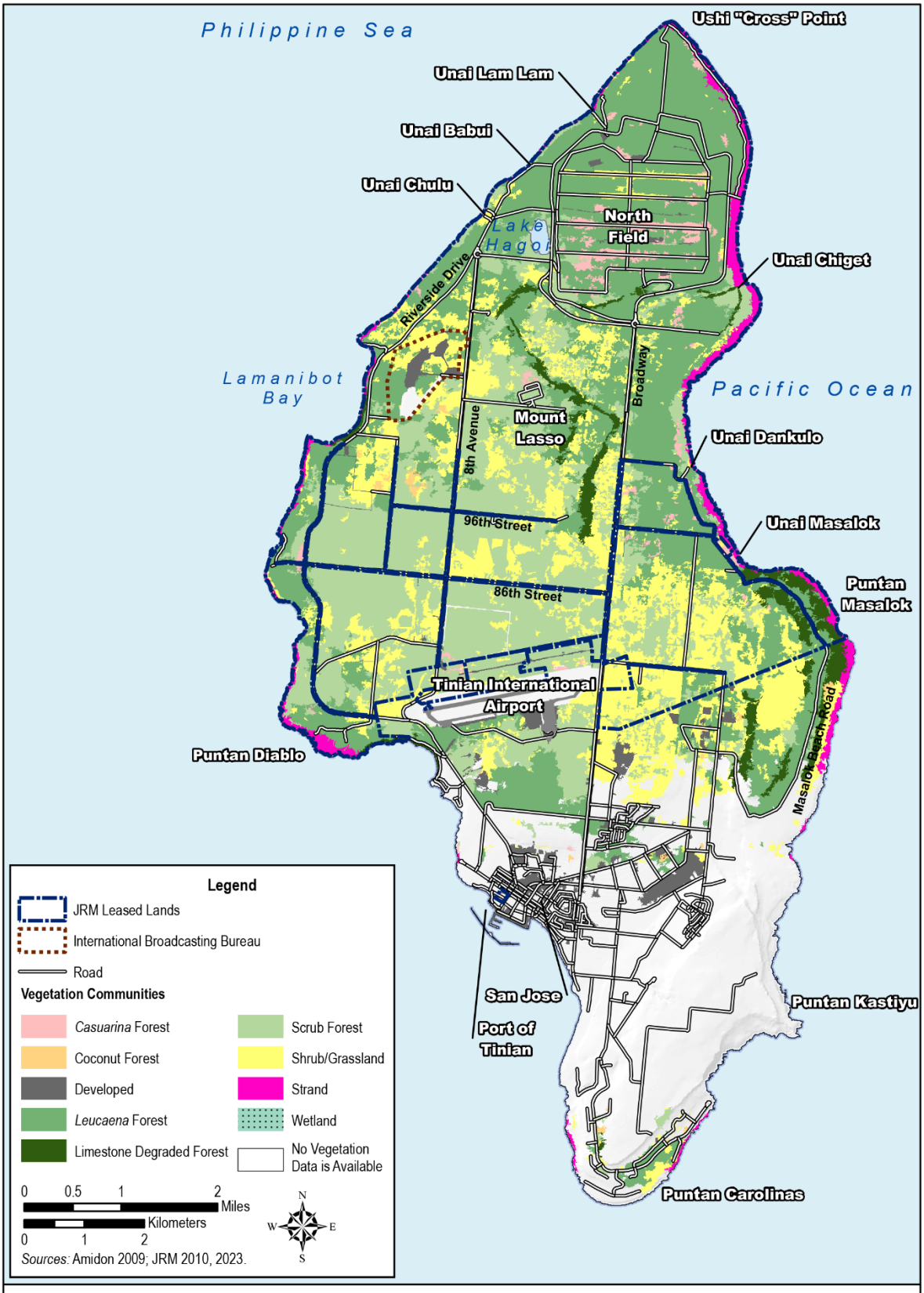


Figure 11-6
Vegetation - Tinian

Table 11-4. Vegetation Communities on Tinian

Vegetation Community	*MLA (acres)*	*Non-MLA (acres)*	*Total (acres)*
Limestone Native Forest	391.3	964.4	**1,355.7**
Mixed Introduced Forest	4,647.5	2,176.4	**6,823.9**
Tangantangan Forest	5,988.1	2,446.1	**8,434.2**
Other Shrub/Grassland	2,921.8	1,885.1	**4,806.9**
Casuarina Forest	296.4	54.7	**351.1**
Coconut Forest	32.1	65.8	**97.9**
Strand	394.7	156.3	**551.0**
Wetland*	33.7	31.2	**64.9**
Agriculture	2.5	329.2	**331.7**
Barren (soil, sand, or rock)	65.1	134.8	**199.9**
Developed Land	536.1	1,433.1	**1,969.2**
Total	**15,309.3**	**9,677.1**	**24,986.4**

Note: *The term wetlands refers to the habitat type and is not meant to infer a jurisdictional determination of wetlands as defined under the CWA.
Key: MLA = Military Lease Area.
Source: Amidon 2009.

11.2.3.1 Limestone Native Forest

The limestone native forest vegetation community harbors native trees such as gulos, *Ochrosia* (*=Neisosperma*) *oppositifolia, C. dilatata, Psychotria* spp., *Eugenia* spp., *M. cylindrocarpa,* pandanus (*Pandanus* spp.), coral tree (*Erythrina variegata* var. *orientalis*), nunu (*Ficus* spp.), *Mammea odorata*, *P. grandis*, and tropical almond (*Terminalia catappa*). Along coastal strips of limestone native forest, it is typical to see large *Barringtonia asiatica*, gulo, *Premna serratifolia*, and *P. grandis* mixed with ironwood (*Casuarina equisetifolia*) in the canopy layer with an understory of pandanus, nunu, *Eugenia reinwardtiana*, *Psychotria mariana*, and *Pemphis acidula*. Limestone native forest has been significantly reduced on Tinian due to past activities, including widespread cultivation of non-native species (e.g., sugarcane), activities during WWII, intentional and accidental introduction of non-native plants and animals, and grazing by non-native ungulates (e.g., Philippine deer [*Rusa marianna*] and feral goats *[Capra hircus*]). Limestone forests on Tinian are important because they retain the functional ecological components of limestone native forest. Limestone native forest provides habitat for the majority of Tinian's native species, including federal and CNMI Endangered Species Act (ESA)-listed species, those designated as Species of Greatest Conservation Need (SOGCN) by the CNMI government, as well as bird species protected under the Migratory Bird Treaty Act (MBTA). These forests also help maintain water quality and reduce fire risk. Non-native plant species (e.g., tangantangan) significantly alter the native forest structure, composition and resilience of the forest to other disturbances and also provide less suitable habitat conditions for native flora and fauna species than a native forest (Morton et al. 2000; Tang et al. 2011; DON 2013a).



A stand of the native *Mammea odorata* within limestone native forest on Tinian.
(*Photo*: L. Shaughnessy)

The few areas of limestone native forest remaining on Tinian within JRM leased lands occur along cliff lines near Mount Lasso, around the northern escarpment of Maga, along cliff lines to the west and south of Unai Chiget, along the coast of Lamanibot Bay, and above and to the south-southeast of Unai Masalok, and east of Puntan Diablo (see Figure 11-6).



Limestone native forest dominated by *Barringtonia asiatica* located on Tinian. Adult trees create a thick canopy cover under which numerous seedlings are found.
(*Photo*: L. Shaughnessy)

11.2.3.2 Mixed Introduced Forest

Mixed introduced forest contains a mixture of native and introduced trees, shrubs, and dense herbaceous plants, and is also referred to as secondary forest by Donnegan et al. (2004). Dominant trees common in this vegetation community include tangantangan, ironwood, siris tree (*Albizia lebbeck*), Formosan koa (*Acacia confusa*), flame tree (*Delonix regia*), and Madras thorn (*Pithecellobium dulce*). While not considered a native vegetation community on Tinian, the mixed introduced forest community provides habitat for some protected species.

11.2.3.3 Other Scrub/Grassland

The other scrub/grassland vegetation community occurs primarily within open fields and is dominated by grassy and low herbaceous vegetation with small thickets of native and introduced shrubs. Introduced species, including some considered invasive, such as lantana (*Lantana camara*), St. Thomas lidpod (*Operculina turpethum* var. *ventricosa*), Bitter vine (*Mikania scandens*), mission grass (*Pennisetum polystachion*), and giant sensitive plant (*Mimosa diplotricha*), are common, as are small groves of trees including African tulip tree (*Spathodea campanulata*).



Open fields of other scrub/grassland located south of Puntan Masalok are dominated by mission grass (*Pennisetum polystachion*).
(*Photo*: L. Shaughnessy)

11.2.3.4 Casuarina Forest

The *Casuarina* forest vegetation community consists of pure stands or stands dominated by ironwood. Ironwood tolerates dry and salty conditions. It often grows in shrub and grass habitat, and, in some locations, forms sparse woodland with little understory. Ironwood also occurs in exposed areas and in narrow bands along the coast. This species is generally accepted as native to the Mariana Islands and seems to be an early successional species that deters the growth of other species by producing a dense layer of fallen needle-like branches that have compounds inhibiting the growth, survival, and reproduction of other plant species within the immediate vicinity (Pratt 2011).

11.2.3.5 Tangantangan Forest

This plant community is dominated by the small, non-native tree tangantangan. It is the most abundant vegetation community within the MLA and on Tinian (see Table 11-4) where it forms large and often pure stands. In some places, where it is adjacent to native forest, it is invading and mixed with native woody species. This vegetation community is readily visible in high-quality aerial imagery (NAVFAC Marianas 2016a).



A dirt road cuts through a tangantangan (*Leucaena leucocephala*) forest on the eastern end of the MLA.
(*Photo*: L. Shaughnessy)

11.2.3.6 Coconut Forest

Coconut forest describes a vegetation community dominated by coconut palms (*Cocos nucifera*). These stands are remnants of coconut plantations. Approximately one-third of the island's coconut forests are located in five stands within the JRM leased lands. These stands are found adjacent to and south of the IBB (see Figure 11-6).

11.2.3.7 Strand

Strand vegetation communities are limited to narrow strips in coastal areas and have adapted to life on excessively-drained soils in areas subject to salt spray from the adjacent coastal waters. Many beach areas that support strand are occasionally inundated with saltwater during storm events. Strand vegetation supports both native and non-native vegetation, which includes beach heliotrope (*Tournefortia argentea*), bur-marigold (*Bidens pilosa*), portia tree (*Thespesia populnea*), false verbena (*Stachytarpheta* spp.), morning glory (*Ipomoea triloba*), lantana, nanaso (*Scaevola taccada*), and *P. acidula* in rocky areas.

11.2.3.8 Agriculture

For the purposes of the terrestrial biological resources discussion, the agricultural community is defined as those areas used for the cultivation of crops and raising livestock. Only 2.5 acres (1.0 hectare) of agricultural lands were identified within JRM leased lands by the USFWS (Amidon 2009) (see Table 11-4). These occur near the southwest corner of the IBB site (see Figure 11-6). In addition, portions of the other scrub/grassland vegetation community support cattle grazing on Tinian.

11.2.3.9 Barren (Soil, Sand, or Rock)

Barren areas of soil, sand, or rock occur primarily along Tinian's coastline. Approximately one-third of the island's barren areas are located within JRM leased lands and can be found around Puntan Diablo and southeast of Unai Masalok (see Table 11-4 and Figure 11-6).



Barren rock (limestone karst) along Tinian's eastern coast north of Unai Chiget.
(*Photo*: L. Shaughnessy)

11.2.3.10 Developed Land

Developed land includes human-occupied or otherwise highly disturbed areas that

include lawns, mowed grass fields, and other landscaped areas and impervious surfaces such as buildings, roads, airports, parking lots, and historic features. This category includes areas mapped by the USFS (2006) as "Urban and Built-up" and "Urban Vegetation."

11.2.3.11 Wetlands

Although not designated in vegetation community classification used by Amidon (2009), a description of this community is included as it is an important habitat for some species found on Tinian. Wetland vegetation communities are areas of grasses, sedges, herbs, or woody species that are typically found in standing water or soils that are saturated for most of the year. Wetlands are habitats that are subject to permanent or periodic inundation sufficient to support vegetation that is typically adapted for life in saturated soil conditions and include marshes, swamps, bogs, and similar areas.

Wetlands on Tinian are important because of their limited occurrence and the habitat they provide for migratory birds and the federal and CNMI ESA-listed endangered Mariana common moorhen (*Gallinula chloropus guami*) (Section 11.2.5.2, *Birds*) (DON 2013a). As such, military training activities that occur on Tinian avoid the water features and treat them as if they were jurisdictional waters under the CWA. Lake Hagoi is a 38-acre (15-hectare) area comprising open water and wetland vegetation that is the only permanent wetland habitat. A 1995 vegetation map of the area (USFWS 1996) showed a band of tall reed (*Phragmites karka*) and large patches of bulrush (*Schoenoplectus litoralis,* formerly *Scirpus litoralis*) around the perimeter. Patches of giant swampfern (*Acrostichum aureum*) and the grass *Paspalum distichum* were also present. All of the aforementioned species are native to Tinian (Raulerson 2006). The wetland submergent plant-like algae, *Chara* spp., is abundant in some of the open water areas within sedge vegetation. Green algae (Chlorophyta) are also present and increase in area during the dry season. During the dry season, more than 50% of the open water areas were found to be covered with algae (USFWS 1996). The DON (2013a) noted that as of 2012, Lake Hagoi vegetation appears to have changed relative to that mapped in 1995, with the occurrence of additional species such as the indigenous pago (*Hibiscus tiliaceus*), a type of tree. In addition, the range of existing plant species had expanded into previously open water areas of the wetland. The DON (2013b) report further noted that the lake's vegetation has been changing continually over the past 50 years with the expansion of bulrush into the wetland, resulting in a reduction of open water. In 2016, CNMI experienced a drought (Villanueva-Dizon 2016), causing the water at North Pond in Lake Hagoi to completely dry up (Johnson 2016). Particularly rapid changes in the range of bulrush were documented at Lake Hagoi between 2001 and 2013.

Two additional areas within JRM leased lands contain water during the wet season: Mahalang and Bateha. The Mahalang Complex consists of a number of ephemeral ponds located on a plateau within the northern portion of the MLA, south of Lake Hagoi (DON 2013a). At least 24 individual sites form the complex and are located within a matrix of grasslands (herbaceous-scrub), tangantangan, and mixed introduced forest. A subset of these individual sites contains water during the wet season, and all sites are dry during the dry season. Although no specific sizes for these sites are provided in previous reports, AECOS and Wil Chee-Planning (2009) estimated the two largest features as approximately 1.2 acres (0.5 hectare) each. The majority of the sites are bomb craters from WWII battles. The introduced and invasive mission grass and various species of non-native weedy vines dominate the interiors of the craters. Other sites in the complex consist of shallow depressions with various weedy vines and herbs. Results of wetland surveys conducted at a sample of the Mahalang sites in December 2014 indicate that only a single Mahalang site supports wetland vegetation (e.g., *Ipomoea aquatica*) and exhibits the characteristics of an isolated wetland (DON 2013a). Other surveyed Mahalang sites do not contain wetland soils, suitable hydrology, or wetland vegetation.

The Bateha sites located within the MLA (see Figure 11-6) consist of two shallow depressions that contain water during the wet season. These areas are approximately 1 acre (0.4 hectare) each. Numerous other small areas, previously identified as potential wetlands, did not have the characteristics of seasonal wetlands during observations made in December 2012. The larger western site at Bateha is dominated by the introduced, sprawling scrub-shrub giant sensitive plant, and contains the introduced shrub candle bush (*Senna alata*), along with other weedy species. Mission grass occurs along the perimeter. The eastern site is a deeper depression surrounded by ridges dominated by an overstory of the introduced Formosan koa and mission grass. Candle bush is dispersed throughout the northern and southern portions of the site (DON 2013a). Wetland surveys conducted at these two Bateha sites in December 2014 indicate that both sites exhibit characteristics of isolated wetlands, including the presence of wetland soils and wetland vegetation.

11.2.4 Terrestrial Wildlife

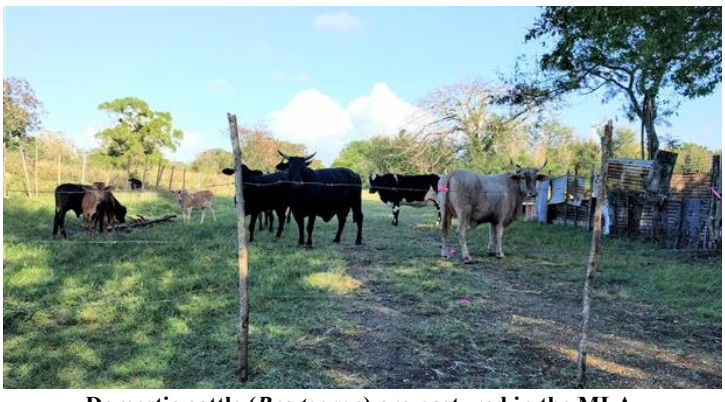
11.2.4.1 Mammals

Native Species

The only native terrestrial mammal species on Tinian is the Mariana fruit bat (*Pteropus mariannus mariannus*). This fruit bat is federal ESA-listed as threatened and CNMI ESA-listed as threatened and endangered. The Mariana fruit bat is discussed in detail in Section 11.2.5, *Terrestrial Protected Species*.

Non-native Species

Introduced mammals include the black rat (*Rattus rattus*), Polynesian rat (*Rattus exulans*), Norway rat (*Rattus norvegicus*), house mouse (*Mus musculus*), musk shrew (*Suncus murinus*), feral cat (*Felis catus*), feral dog (*Canis lupus familiaris*), feral goat (*Capra hircus*), and domestic cattle (*Bos taurus*). High densities of black rats are found in all habitats of JRM leased lands on Tinian. Polynesian rats and Norway rats also occur on Tinian, but in lower densities than black rats. Rat densities on Tinian are higher than on many other Pacific islands (Wiewel et al. 2009) and are likely detrimental to flora and fauna, including Tinian's native bird species. Musk shrew densities are high in native and tangantangan forest. Rodents and shrews are predators of native birds, lizards, insects, and snails. In addition, they consume seeds and seedlings, which contributes to long-term forest ecosystem impacts. High-density introduced small mammal populations on Tinian might also impact bird species through dietary competition (Wiewel et al. 2009). Feral cats are extremely common on Tinian and have been observed hunting in native forest at night (Vogt 2008a). While feral dogs do occur on Tinian, they generally occur south of the MLA. DON regulations require prevention and control of feral cat and dog populations and ensure their humane removal from JRM leased lands (Chief of Naval Operations Instruction [OPNAVINST] 2021).



Domestic cattle (*Bos taurus*) are pastured in the MLA.
(*Photo*: L. Shaughnessy)

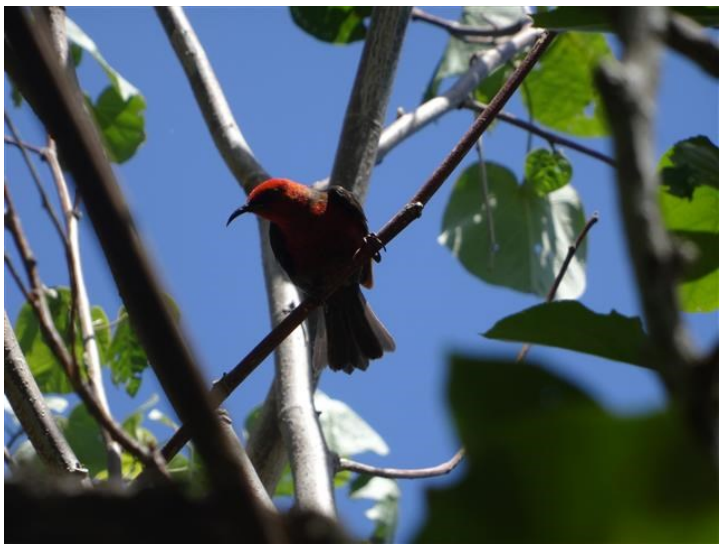
Goats have been transported from Aguiguan to Tinian, and a coastal survey in October 2008 confirmed at least 20 goats at Puntan Kastiyu, south of the MLA. There is some evidence that feral goats are creating trails, accelerating erosion, and impacting the native vegetation on Tinian. Currently, goats do not occur within the MLA (Kessler 2009). Domestic cattle are pastured in the LBA. Philippine

deer and their tracks have been observed outside the MLA (Mosher 2018). Philippine deer have been detected on the MLA, although rarely.

11.2.4.2 Birds

Native Species

There are 55 native bird species reported on Tinian, 49 of which are protected under the MBTA (DON 2017a). The Mariana common moorhen is a native bird species protected by the MBTA and the federal and CNMI ESA. In addition, another native bird species, the Micronesian megapode (*Megapodius laperouse*), is protected only under the federal and CNMI ESA. Section 11.2.5, *Terrestrial Protected Species*, further addresses bird species protected under the MBTA and the ESA. Five native bird species do not have a protected status: (1) Micronesian myzomela (*Myzomela rubratra*), (2) rufous fantail (*Rhipidura rufifrons*), (3) Tinian monarch, (4) bridled white-eye (*Zosterops conspicillatus*), and (5) Micronesian starling (*Aplonis opaca*) (Camp et al. 2012; JRM 2013; USFWS 2013; NAVFAC Pacific 2014a).



Micronesian myzomela (*Myzomela rubratra*).
(*Photo*: L. Shaughnessy)



The adult rufus fantail (*Rhipidura rufifrons*) (right) builds distinctive nests that resemble a little tornado (left).
(*Photo*: L. Shaughnessy)

Of the 55 species, 31 are migrants and 3 are vagrants. Migratory bird surveys were conducted on Tinian near Puntan Diablo in June 2017, during which 12 native bird species were detected. Five of the 12 detected are protected under the MBTA (DON 2017a). Migratory birds on Tinian include wintering shorebirds (e.g., sandpipers, plovers), waterbirds (e.g., ducks), and resident seabirds are protected under the MBTA and are discussed in Section 11.2.5, *Terrestrial Protected Species*.

Twenty-five of 55 native species on Tinian were regularly detected in monthly DON monitoring surveys conducted between 1982 and 2016; from periodic monitoring by the CNMI DFW, and from the Annual Audubon Society Christmas Bird Count (Camp et al. 2012; DON 2013b, 2014a, 2017a; Hawaiian Agronomics International, Inc. 1985; JRM 2013; Liske-Clark 2015; Pratt 2017; Reichel and Glass 1991; Stinson et al. 1997).

Since 1999, the CNMI DFW has conducted quarterly bird surveys at 50 fixed stations using a modified North American Breeding Bird Survey protocol. In 2022, bridled White-eye, Micronesian starling, Orange-

cheeked waxbill, and Mariana kingfisher were the most abundant species (CNMI Department of Lands and Natural Resources [DLNR] DFW 2022). Long-term trends suggest the bridled white-eye, Mariana kingfisher, Tinian monarch, and other forest bird populations are declining (Figure 11-7; CNMI DNLR DFW 2022). Orange-cheeked waxbills (*Estrilda melpoda*) appear to be increasing (CNMI DLNR DFW 2022).

"Island-wide" surveys for native birds were conducted in 1982, 1996, 2008, and 2013 along a set of transects established in 1982 by the USFWS (Spaulding et al 2022). The overall trends in abundance between 1982 and 2013 showed an increase in the Mariana Kingfisher, Micronesian Starling, Rufous Fantail, White-throated Ground Dove, and Philippine Collared Dove, while populations were stable for the Bridled White-eye and Tinian Monarch. Declines were seen for the Mariana Fruit Dove and Micronesian Myzomela. Surveys were repeated in 2021 on those transects located within the MLA (NAVFAC Marianas 2022a). In the 2021 survey, the most abundant native bird species on the Tinian MLA were bridled white-eye, rufous fantail, and Tinian monarch (NAVFAC Marianas 2022a).

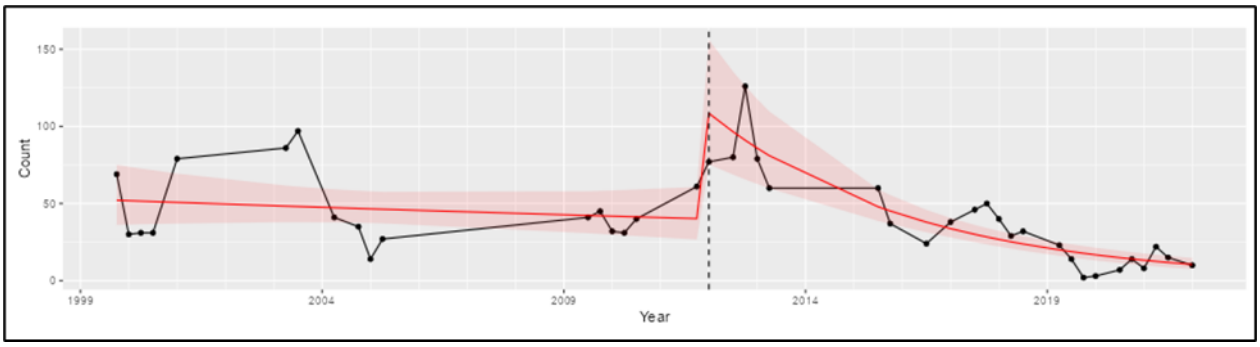
The Tinian monarch is endemic to Tinian and prefers to nest in native trees (*Note*: Tinian monarchs were introduced onto Guguan in 2015 and 2016 [Liske-Clark 2015; CNMI DFW 2016]). Nests have been found in limestone native, mixed introduced, and tangantangan forest communities (USFWS 1996). In the most comprehensive study of Tinian monarch breeding biology to date, University of Washington researchers found that the reproductive success of Tinian monarchs across all habitat types was higher than previously estimated, and that tangantangan forest provided the marginally highest refuge for monarch nests compared to the previously assumed preferred habitat, limestone native forest (Swift et al. 2023). Invasive predators including rats (*Rattus* sp.) and domestic cats (*Felis catus*) were the largest source of nest failure. The study also found that *Ficus tinctoria*, *Aglaia mariannensis*, and *Bauhinia monandra* were the three most common nesting trees within all the habitat types.

The Tinian monarch was federally listed as endangered under the Endangered Species Conservation Act of 1969 (superseded by the ESA of 1973) in June 1970 because its population was thought to be critically low due to the destruction of native forests by pre-WWII agricultural practices and by military activities during and after WWII. Based on forest bird surveys conducted by USFWS in 1982, which resulted in a population estimate of 39,338 individuals, the Tinian monarch was downlisted to threatened status in April 1987. Further studies in 1994 and 1995 resulted in a population estimate of approximately 52,904 birds. In 1996, surveys conducted along the same routes and using the same USFWS methods used in 1982 yielded a population estimate of 55,721 birds (Lusk et al. 2000). The 1996 survey also found a significant increase in forest vegetation density relative to 1982, indicating an improvement in monarch habitat. The USFWS proposed delisting the Tinian monarch in February 1999, and the species was ultimately delisted in 2004 (USFWS 2004). The Tinian monarch was also delisted by the CNMI government in 2009 (Commonwealth 1 Law Revision Commission 2009).

Roughly 66% of the Tinian monarch habitat is found within JRM leased lands on the island. This area supports approximately 52% of the total monarch population (NAVFAC Pacific 2014a). After the USFWS delisting of the Tinian monarch in 2004, the species was monitored for 5 years under the Post-delisting Monitoring Plan for the Tinian Monarch (USFWS 2005). In 2008, monitoring resulted in a population estimate of approximately 33,310 individuals, a decline of approximately 40% since 1996. In addition, monarch densities in high-quality habitats calculated from the 2008 surveys declined significantly from densities reported by USFWS (2005). Camp et al. (2012) hypothesized that the overall population decline between 1982 and 2008 was associated with reduced bird density in quality habitats, particularly limestone native forest. Based on these results, the USFWS received a petition in December 2013 to relist the Tinian

monarch as a threatened or endangered species under the ESA (Center for Biological Diversity 2013). USFWS finalized a Special Status Assessment for the Tinian monarch and on December 19, 2018 issued a finding declining to re-list the species (Federal Register vol 83 no 243 pp 65127–65134). Regardless, the Tinian monarch, as a single-island endemic with a declining population trend, continues to be a species of particular concern.

Figure 11-7 shows a changepoint model depicting the Tinian monarch population trend from CNMI DLNR DFW Breeding Bird Survey 1999–2022 data (reprinted with permission). The dotted lines represent where significant changes in the direction of the population trend occur.



Source: CNMI DLNR DFW 2022.

Figure 11-7. Estimated Tinian Monarch Population on Tinian (1999–2012)

Non-native Species

Naturalized non-native birds observed on Tinian include red junglefowl (*Gallus gallus*), rock dove (*Columba livia*), island collared dove (*Streptopelia bitorquata*), Eurasian tree sparrow (*Passer montanus*), and orange-cheeked waxbill (*Estrilda melpoda*) (DON 2013a, 2013b; NAVFAC Pacific 2014a). Red junglefowl are found throughout the island. Rock doves are found in JRM leased lands and in San Jose. The island collared dove is considered common. The most abundant non-native bird on Tinian is the Eurasian tree sparrow, which is conspicuous in San Jose. Flocks of orange-cheeked waxbills are present in grasslands and roadsides (Camp et al. 2012; DON 2013a, 2013b).

11.2.4.3 Reptiles and Amphibians

Native Species

There are two native marine reptile species reported to nest on Tinian: the green sea turtle (*Chelonia mydas*) and hawksbill turtle (*Eretmochelys imbricata*). Both are protected under the ESA and CNMI Administrative Code 85-30.1-101. These marine reptiles are addressed further in Section 11.3.7, *Marine Protected Species*, and their beach nesting areas are discussed in Section 11.2.5, *Terrestrial Protected Species*.

There are seven native terrestrial reptile species reported on Tinian, several of which were found during 2008 surveys on Tinian (USFWS 2009): mourning gecko (*Lepidodactylus lugubris*), Pacific slender-toed gecko (*Nactus pelagicus*), Micronesian gecko (*Perochirus ateles*), snake-eyed skink (*Cryptoblepharus poecilopleurus*), tide-pool skink (*Emoia atrocostata*), monitor lizard, and the Pacific blue-tailed skink (*Emoia caeruleocauda*). Of these, the Micronesian gecko is a special-status species and is described separately in Section 11.2.5, *Terrestrial Protected Species*. The mourning gecko was the most abundant lizard species in both mixed introduced and limestone native forest habitats, while the Indo-Pacific house gecko (*Hemidactylus frenatus*) was the most abundant in tangantangan forests (USFWS 2009). As in Guam, Tinian's monitor lizards have adapted to disturbed habitats and eat a variety of invertebrates and vertebrates

(Dryden 1965). The oceanic and tide-pool skinks were found predominantly within the vicinity of coastal areas. The blue-tailed skink was observed only in limestone native forest at Mount Lasso.

Non-native Species

Introduced reptiles include the oceanic gecko (*Gehyra oceanica*), mutilating gecko (*Gehyra mutilata*), curious skink (*Carlia ailanpalai*), emerald skink (*Lamprolepis smaragdina*), green anole (*Anolis carolinensis*), and Brahminy blind snake (*Ramphotyphlops braminus*). Oceanic geckos were reported during the 2008 USFWS surveys and constituted about half of the lizard biomass in limestone forest areas (USFWS 2009).



Non-native reptiles on Tinian include the oceanic gecko (*Gehyra oceanica*) (left) and emerald skink (*Lamprolepis smaragdina*) (right).
(*Photo*: L. Shaughnessy)

The brown treesnake (BTS) (*Boiga irregularis*), while no incipient populations exist on Tinian, has the potential to impact the economy, human safety, and island ecology in the CNMI. The BTS's native range is coastal Australia, Papua New Guinea, and a large number of islands in northwestern Melanesia. This species was inadvertently introduced to Guam after WWII (Rodda and Savidge 2007). As a result of this introduction, BTS caused the extinction or extirpation of 13 of the 21 native breeding birds and of the 13 native reptile species originally found in Guam, only 6 are known to currently occur (Rodda et al. 1992; Rodda and Savidge 2007; NAVFAC Pacific 2010, 2011, 2013a, 2013b). Strict BTS inspection protocols are a significant and important part of military activities. Nine unconfirmed BTS sightings have been reported on Tinian (Brown Treesnake Technical Working Group 2013). Individual BTS originating from Guam have been found in Kwajalein, Pohnpei, O'ahu, Diego Garcia, Spain, Alaska, Texas, Oklahoma, California, and neighboring CNMI islands (Rota, Tinian, and Saipan) (Brown Treesnake Technical Working Group 2013; Clark 2014; Kerrigan 2014). The DoD has collaborated with other partners and participated in the development of BTS-specific trapping techniques, using canine detection teams, exclusion fence design, development of toxicants, and toxicant delivery methods in an effort to prevent the snake from leaving



Canine detection teams are developed through the training of dogs to sniff out BTS (*Boiga irregularis*) in controlled settings. Training begins with exposing the dog to the smell of BTS and teaching the dog to ignore other smells. The behavior is reinforced through continual training, which consists of hiding a live, caged BTS (left) in cargo shipments, allowing the detection dog to sniff the cargo shipments (right), then rewarding the dog when he/she has successfully located the hidden snake.
(*Photo*: L. Shaughnessy)

Guam via transportation pathways. As part of the MITT training activities, a comprehensive biosecurity program was developed that includes multiple BTS inspections in Guam and for all small vessel, aircraft, and cargo equipment upon arrival on Tinian.

The marine toad (*Rhinella* [=*Bufo*] *marina*) is the only known amphibian on Tinian and was introduced from Guam between 1937 and 1944 (Townes 1946). In 1944, approximately 4,000 individuals were observed in lily ponds and cisterns (Stohler and Cooling 1945). Wiles, et al. (1989) found marine toads to be common throughout JRM leased lands. The toad was also reported to be common throughout Tinian in mixed introduced and limestone native forest habitats (JRM 2013). Marine toads currently occur in high densities at Lake Hagoi. The species possess large parotid glands that excrete poison and kill potential predators. Marine toads are prolific breeders and can lay up to 70,000 eggs per year and are a possible a threat to native reptiles on Tinian (JRM 2013).

11.2.4.4 Invertebrates

Native Species

USFWS (2009) summarized prior surveys of terrestrial invertebrates conducted on Tinian, and included recent observations of both native and non-native species from the island. However, USFWS (2009) did not summarize findings in tabular format nor make many identifications at the genus and species levels. Surveys were also conducted on Tinian from June to October 2008 to determine the presence or absence of two butterfly species, the Marianas wandering butterfly (*Vagrans egistina*) and the forest flicker (*Hypolimnas octocula marianensis*) (Family Nymphalidae); however, the surveys found none (USFWS 2009).

The humped tree snail (*Partula gibba*) occurs on Tinian. This endemic land snail was recently listed as endangered under the federal ESA and is CNMI-designated as SOGCN. This species is the only terrestrial invertebrate special-status species known to occur on Tinian and is discussed in Section 11.2.5, *Terrestrial Protected Species*.

The coconut crab (*Birgus latro*) and two species of land crab (*Discoplax hirtipes* [previously *Cardisoma hirtipes*] and *Cardisoma carnifex*) are regulated as game species by the CNMI DFW. The coconut crab is the largest land invertebrate in the world and can reach over 3 feet (1 meter) in width from leg to leg. In addition to being a highly valued game species in the CNMI, it serves important ecological functions including dispersing seeds and scavenging. Although coconut crabs occur in all forested habitats, females regularly migrate to the ocean to spawn. Coconut crab densities on Tinian have been estimated at 2 crabs/acre (5 crabs/hectare) in limestone native forest and 0.7 crab/acre (1.8 crabs/hectare) in tangantangan forest (Vogt 2009a). The hunting season for coconut crab is from September 15 to November 15, and the license carries a bag limit of 5 crabs and a season limit of 10 crabs.



The coconut crab (*Birgus latro*) serves important ecological functions including dispersing seeds and scavenging.
(*Photo*: L. Shaughnessy)

Land crabs are a common terrestrial burrowing crab found throughout the Indo-Pacific and are generally associated with wetland or coastal habitats, although juveniles can be found further inland. Their shells can measure 4–5 inches (10–13 centimeters) across. The two land crab species on Tinian are primarily herbivorous, eating leaves and other vegetation (Carpenter and Niem 1998). A license is required for harvesting land crabs during regulated hunting seasons. The hunting season for land crabs is from April 1 to June 30 and October 1 to December 31, and the license carries no bag or season limits.

Non-native Species

The predatory New Guinea flatworm (*Platydemus manokwari*) was discovered on Tinian between 1977 and 1984 (Eldredge 1988; Hopper and Smith 1992). The flatworm poses a serious threat to native land snails, including the humped tree snail that was recently listed as endangered under the ESA (discussed in Section 11.2.5, *Terrestrial Protected Species*) (Hopper and Smith 1992; NAVFAC Pacific 2014a; USFWS 2015a).

11.2.5 Terrestrial Protected Species

Tinian has nine federal ESA-listed endangered or threatened species: six animal species and three plant species. The federal ESA-listed bird, mammal, and reptile species are also protected under CNMI law, along with one additional reptile not protected under the federal ESA. The Mariana swiftlet, also federally endangered, has been documented on Tinian but has not been recorded since 1976 and is presumed extirpated from the island (Reichel and Glass 1991). Micronesian megapodes and Mariana fruit bats move between islands in the CNMI, and megapodes are rarely detected on Tinian. Table 11-5 provides a summary of the occurrence of federal and CNMI ESA-listed terrestrial species on Tinian.

Table 11-5. Federal and CNMI ESA-listed Threatened and Endangered Species Recorded on Tinian

Common Name/ Chamorro Name[1]	*Scientific Name[1]*	*Federal Status*	*CNMI Status*	*Habitat*	*Occurrence*
Mammals					
Mariana fruit bat/ Fanihi	*Pteropus mariannus mariannus*	T	T-E	Limestone native and coconut forests	Y
Birds					
Mariana common moorhen/Pulattat	*Gallinula chloropus guami*	E	T-E	Wetlands	Y
Micronesian megapode/Sasangat	*Megapodius laperouse*	E	T-E	Limestone native and coconut forests, and edges	P
Reptiles					
Green sea turtle/Haggan	*Chelonia mydas*[2]	E	T-E	Offshore waters, strand, and barren (sand)	Y
Hawksbill turtle/ Haggan karai	*Eretmochelys imbricata*	E	T-E	Offshore waters, strand, and barren (sand)	Offshore waters: Y; Strand and barren: PU
Micronesian gecko/ Gualiek	*Perochirus ateles*	--	T-E	Limestone native forest	Y
Invertebrates					
Humped tree snail/ Akaleha	*Partula gibba*	E	--	Limestone native and mixed introduced forests and strand	Y
Plants					
None/Fadang	*Cycas micronesica*[3]	T	--	Limestone native and mixed introduced forests	Y
None/Ufa halumtano	*Heritiera longipetiolata*	E	--	Limestone native forest	Y
None/None	*Dendrobium guamense*	T	--	Limestone native forest	Y

Notes: [1] Common and scientific names based on Gill and Donsker (2017). Chamorro names from GovGuam (2009), Liske-Clark (2015), Topping et al. (1975), Safford (2009), and USFWS (2015a)
[2] Central West Pacific Distinct Population Segment.
[3] Individuals established on Tinian by DON via translocations and residents via seeds from Rota are not included in the species' range in USFWS (2015a).

Key: -- = not listed; CNMI = Commonwealth of the Northern Mariana Islands; E = endangered; ESA = Endangered Species Act; P = potential for occurrence; PU = potential for occurrence, but unlikely; T = threatened; T-E = the CNMI Administrative Code does not specify whether a species is threatened or endangered: all species are considered threatened and endangered; Y = yes, known to occur.

Sources: Berger et al. 2005; Brooke 2009; DON 2010, 2011, 2012, 2014a; Holland and Sischo 2013; JRM 2013; Kessler and Amidon 2009; A.P. Marshall et al. 2009; Takano and Haig 2004a; Vogt 2008a, 2008b; USFWS 2012b, 2015b, U.S. Navy (2023).

11.2.5.1 Mammals

<u>Mariana Fruit Bat</u>

Mariana fruit bats have suffered declining populations on Tinian primarily due to native habitat fragmentation and loss. Native habitat fragmentation and loss within the populated southern islands of Saipan and Tinian began with prehistoric cultivation, through the 17th century introduction of livestock and mechanized agriculture, and likely peaked during the mid-20th century with landscape-scale habitat conversion by commercial agriculture, military infrastructure, and warfare (Bowers 1950; Fosberg 1960; Stone 1970). This long continuous and intense human disturbance is reflected by the near absence of Mariana fruit bats from Saipan and Tinian in



Mariana fruit bat (*Pteropus mariannus mariannus*) as seen flying overhead on Rota. (*Photo*: L. Shaughnessy)

2005 (USFWS 2005). However, bats may fly between islands in the southern islands of the CNMI, including Tinian (DON 2013b; NAVFAC Marianas and USMC 2013). Within the MLA, fruit bats are associated with the limestone native forest in the Maga region north of Mount Lasso and at other locations in western Tinian (Figure 11-8). In 2008, fruit bat surveys were conducted at eight separate count stations at seven locations on Tinian but no bats were observed (Brooke 2009; DON 2013a). In 2023, large-scale simultaneous surveys were conducted across Tinian military lands. Five bats were observed from four observation stations across the island, yielding a minimum density estimate of 21 bats on the island (U.S. Navy 2023). Notably, bat signs (ejecta and feces) were found within three areas of the MLA, and consequently a habitat-use monitoring program using transect surveys within MLA-forested areas has been planned (U.S. Navy 2023).

11.2.5.2 Birds

Thirty-nine bird species on Tinian are protected under the MBTA (Table 11-6). Numerous grey-tailed and wandering tattlers, Pacific reef herons, black noddies (*Anous minutus*), brown noddies (*Anous stolidus*), and white terns (including one large colony of more than 30 birds)—all protected under the MBTA—were recorded during 2008 shoreline surveys of the MLA. More shorebirds and seabirds were observed along the western coastline, which consists of flat coralline shelves along the water with large boulders in the bays and protection from the prevailing winds (Kessler 2009).



Brown noddy (*Anous stolidus*) hunting in association with jacks, likely bluefin trevally (*Caranx melampygus*). Photo taken near Unai Dankulo on Tinian.
(*Photo*: R. Whitton)

Table 11-6. Bird Species Recorded on Tinian and Protected under the MBTA

Barn swallow (*Hirundo rustica*)	Mariana kingfisher (*Todiramphus albicillia*)
Black kite (*Milvus migrans*)	Marsh sandpiper (*Tringa stagnatilis*)
Black noddy (*Anous minutus*)	Northern pintail (*Anas acuta*)
Black-crowned night heron (*Nycticorax nycticorax*)	Northern shoveler (*Anas clypeata*)
Black-winged stilt (*Himantopus himantopus*)	Pacific golden plover (*Pluvialis fulva*)
Brown booby (*Sula leucogaster*)	Pacific reef heron (*Egretta sacra*)
Brown noddy (*Anous stolidus*)	Ruddy turnstone (*Arenaria interpres*)
Common sandpiper (*Actitis hypoleucos*)	Sooty tern (*Onychoprion fuscatus*)
Common tern (*Sterna hirundo*)	Spectacled tern (*Onychoprion lunatus*)
Eastern cattle egret (*Bubulcus coromandus*)	Swinhoe's snipe (*Gallinago megala*)
Eurasian coot (*Fulica atra*)	Tufted duck (*Aythya fuligula*)
Eurasian wigeon (*Anas penelope*)	Wandering tattler (*Tringa incana*)
Gadwall (*Anas strepera*)	Whimbrel (*Numenius phaeopus*)
Garganey (*Anas querquedula*)	White-tailed tropicbird (*Phaethon lepturus*)
Grey-tailed tattler (*Tringa brevipes*)	White tern (*Gygis alba*)
Green-winged teal (*Anas carolinensis*)	White-throated ground dove (*Alopecoenas xanthonurus*)
Intermediate egret (*Egretta intermedia*)	White-winged tern (*Chlidonias leucopterus*)
Lesser sand plover (*Charadrius mongolus*)	Wood sandpiper (*Tringa glareola*)
Mariana common moorhen (*Gallinula chloropus guami*)	Yellow bittern (*Ixobrychus sinensis*)
Mariana fruit dove (*Ptilinopus roseicapilla*)	

Key MBTA = Migratory Bird Treaty Act.

Sources: Reichel and Glass 1991; Vogt and Williams 2004; Kessler 2009; Camp et al. 2012; JRM 2013; USFWS 2013; DON 2017a; Gill and Donsker 2017.

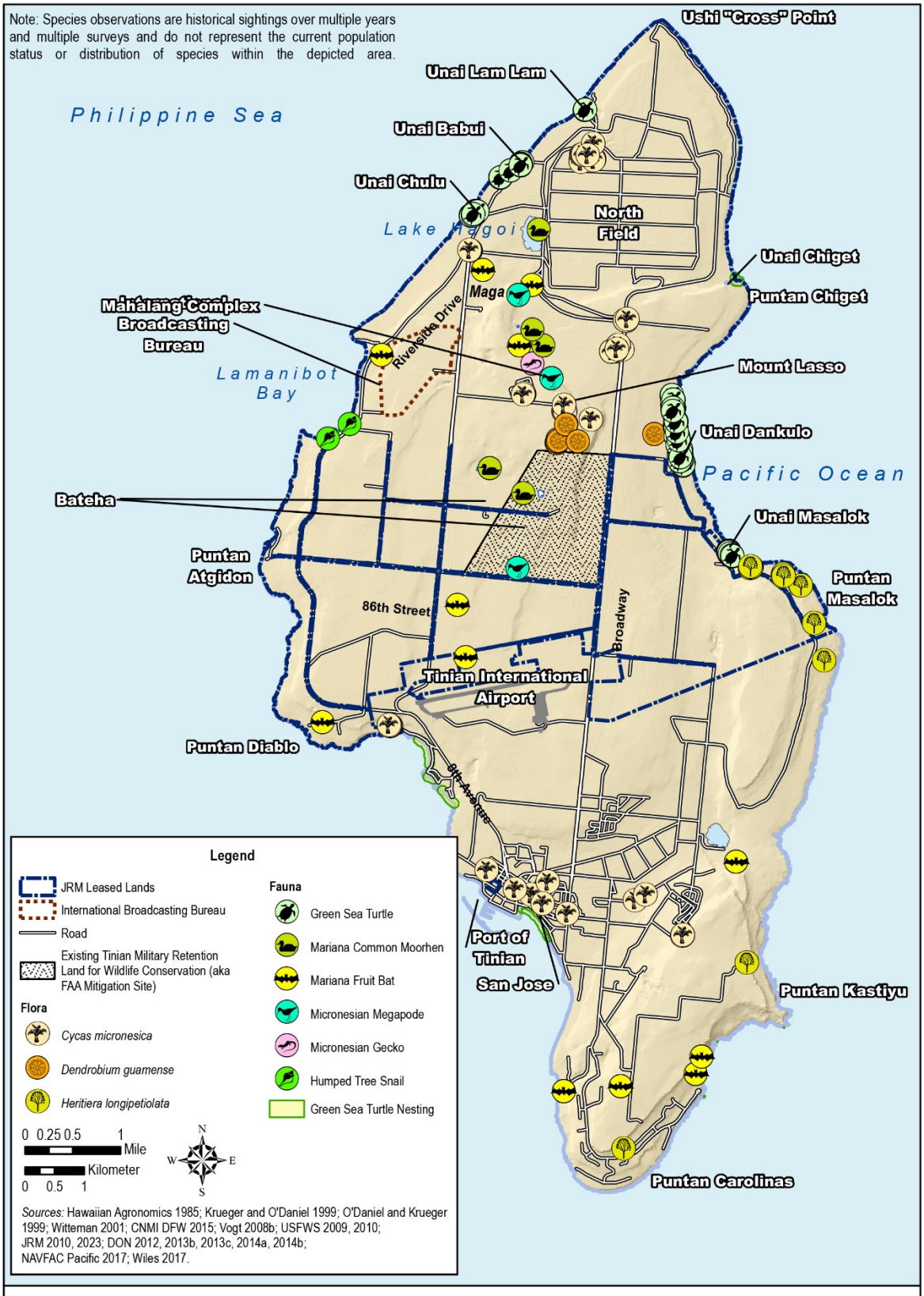


Figure 11-8
Historical Observations of ESA- and CNMI-listed Terrestrial Species - Tinian

The Mariana common moorhen and Micronesian megapode are federal and CNMI ESA-listed and are described in detail below. Also described below are the Mariana kingfisher, white-throated ground dove, and Mariana fruit dove, resident birds protected under the MBTA.

Mariana Common Moorhen



Mariana common moorhen (*Gallinula chloropus guami*).
(*Photo*: L. Shaughnessy)

Mariana common moorhen are federal ESA-listed as endangered, CNMI ESA-listed as threatened and endangered and CNMI-designated as SOGCN. Populations on Tinian have declined due to a reduction in wetland habitats caused by encroachment of tall reeds and dewaterment in wetland habitats, and predation on eggs and chicks by monitor lizards, feral cats and dogs, and rats (Stinson et al. 1991; Takano and Haig 2004a, 2004b; DON 2013a). Forest ponds reported on the Carolinas plateau near the southern tip of the island disappeared after deforestation in the 1930s (Nakajima 1944). The moorhen population size at Hagoi in 1945 was estimated to be 70 birds (JRM 2013). Makpo (Marpo) Swamp has been choked with vegetation and had its water source significantly reduced through groundwater and agricultural development (Stinson et al. 1991), though moorhen are still observed there on occasion. In 2012 and 2013, an average of five moorhens was recorded per survey in the area of the Bateha ephemeral wetlands (Figure 11-9), when ponded water was present (n = 11 surveys) (DON 2014a).

As of the early 1990s, CNMI DFW estimated 25–100 moorhens on Tinian, and Stinson et al. (1991) estimated 75 moorhens. USFWS (1996) estimated the Tinian moorhen population at 50 birds. Based upon surveys conducted in 2001, Takano and Haig (2004a) estimated a total moorhen population of 41 between Lake Hagoi, Mahalang and Bateha ephemeral wetlands (Figure 11-8). The population may have thus declined on Tinian by approximately 35 birds between the early 1990s and 2001. Takano and Haig (2004b), however, stated that moorhens on Saipan and Tinian likely comprise a single population, such that the apparent decrease on Tinian from 1991 to 2001 would have been more than compensated for by an increase of approximately 54 birds on Saipan during that period. Radio telemetry work by Takano and Haig (2004b) indicated that moorhens moved between Saipan and Tinian during the wet seasons of 2000 and 2001 (JRM 2013). Historical occurrences of Mariana moorhen on the Tinian MLA appears in Figure 11-10.

Lake Hagoi remains the most important wetland habitat for moorhen on Tinian. Past population estimates of moorhen at Lake Hagoi have ranged between 70 birds (Gleize 1945) to 125 (Engbring et al. 1986). Currently, moorhen are present throughout the year at Lake Hagoi and at the seasonal Bateha and Mahalang ephemeral wetlands when water is present. Moorhen numbers appear to be slightly increasing over the last 5 years overall (CNMI DFW 2023). No birds were recorded in May and June of 2010 when Lake Hagoi was completely dry. Notable drops in moorhen numbers in 2016 and 2019 may be due to Typhoon Soudelor in 2015 and Super Typhoon Yutu in 2018. Moorhen numbers are dependent on water being present. Because heavy vegetation at Lake Hagoi restricts visibility when conducting bird counts, recent surveys utilize novel approaches to quantifying waterbirds in spatially complex habitats (JRM 2013). Recent moorhen population estimates at Lake Hagoi average less than 20 birds (CNMI DFW 2023). During 2022 surveys, nine total nests were found in various conditions with a total of five nests that were in active or fair/good condition (CNMI DFW 2023). Population trends between 1999 and 2022 are summarized in Figure 11-10. Surveys did not occur in 2020, and the March 2022 survey was incomplete and, therefore, not included in Figure 11-10 data (CNMI DFW 2023).

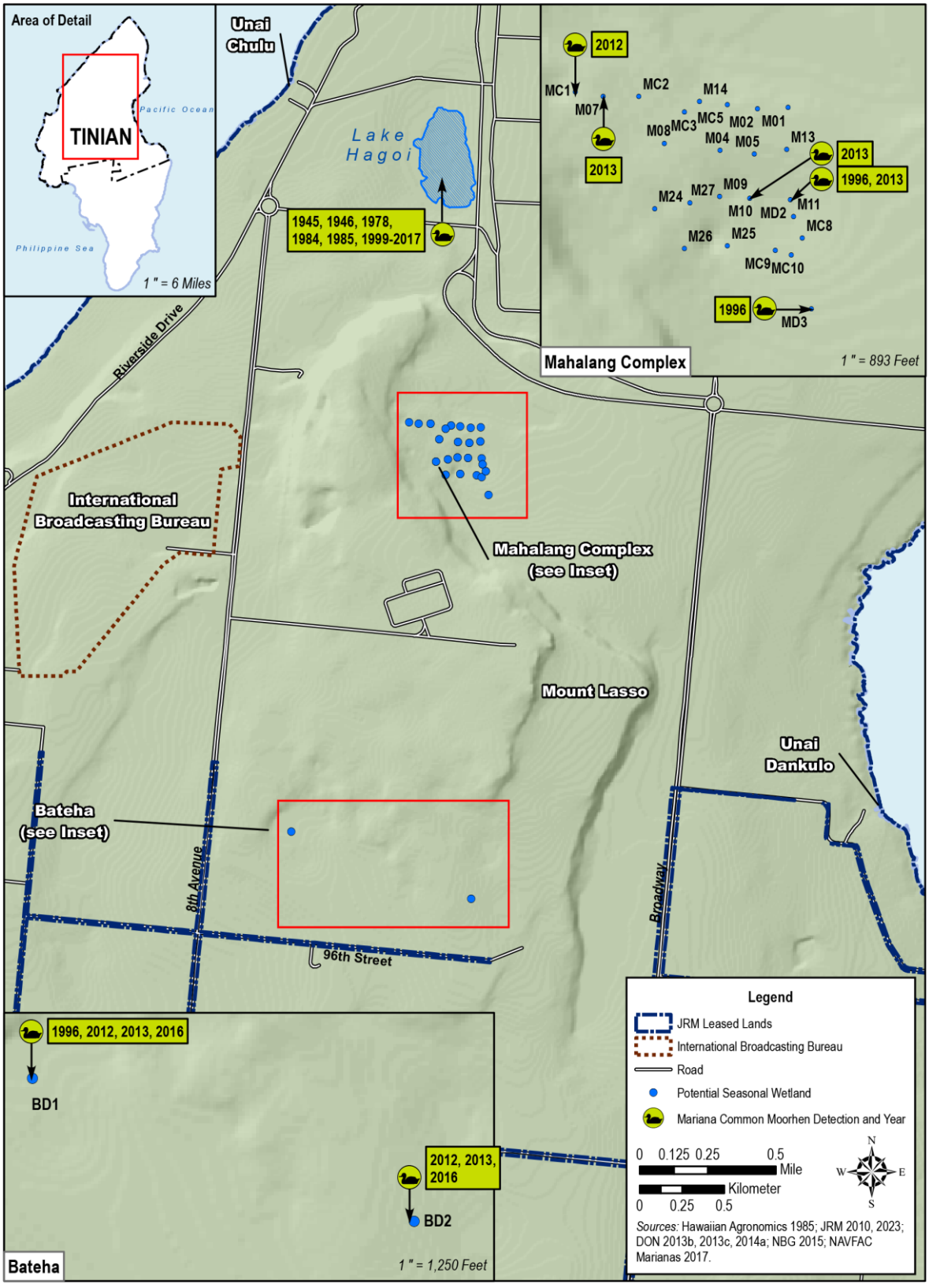


Figure 11-9
Occurrences of Mariana Common Moorhen within the Tinian MLA

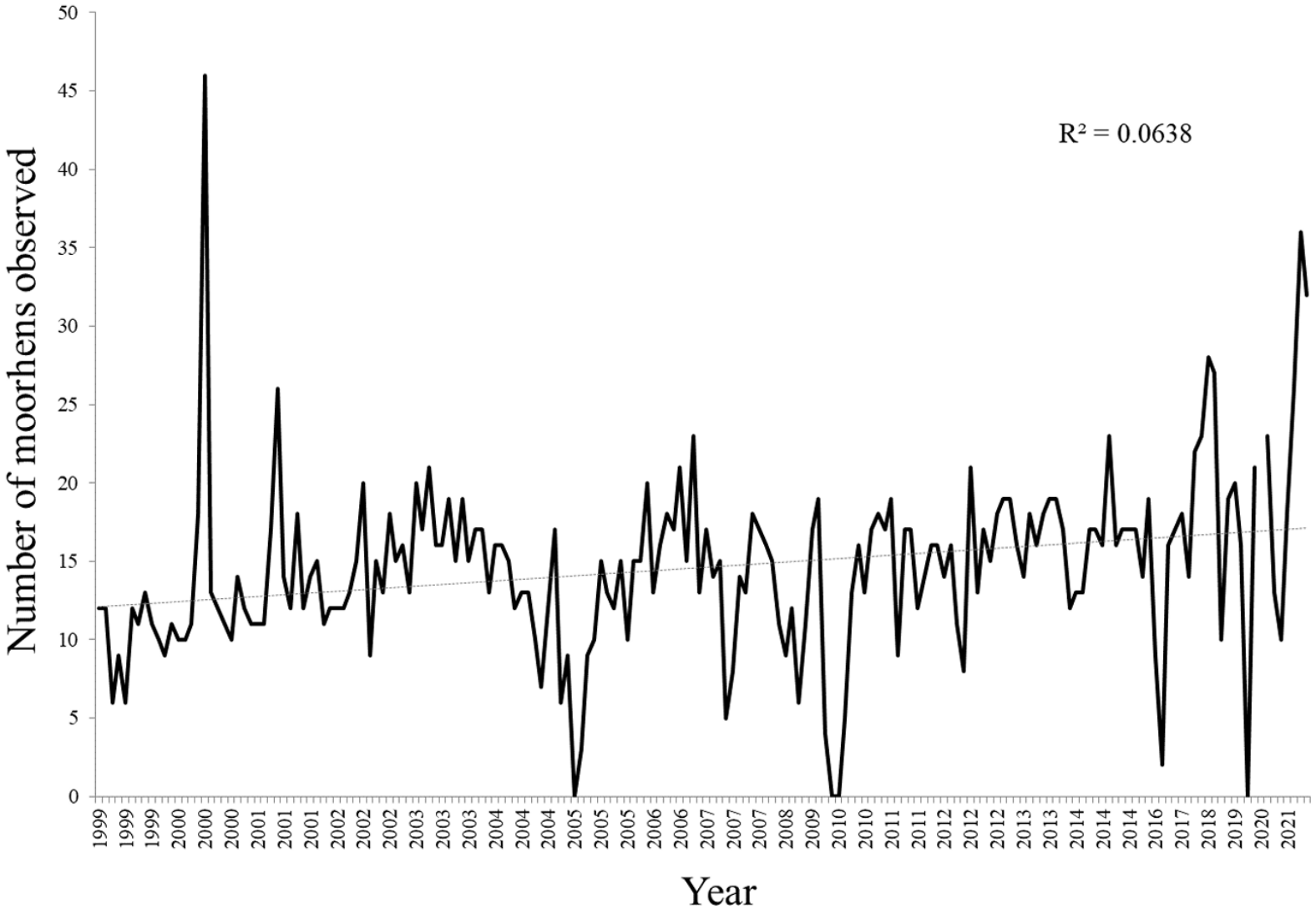


Figure 11-10. Mariana Common Moorhen Recorded at Lake Hagoi on Tinian (1999-2022)
Source: CNMI Division of Fish and Wildlife 2023.

Micronesian Megapode



A Micronesian megapode (*Megapodius laperouse*) foraging on Managaha Island off Saipan.
(*Photo*: L. Shaughnessy)

Micronesian megapodes are federal ESA-listed as endangered, CNMI ESA-listed as threatened and endangered, and CNMI-designated as SOGCN. Threats to the species on Tinian include habitat loss and degradation, overgrazing by feral ungulates, predation (by rats, feral dogs and cats, and monitor lizards), human disturbance (possibly including poaching), stochastic events (tropical storms/typhoons and drought), and climate change (USFWS 1998, 2010). Megapodes have been recorded in upland cliff line forest in areas that are least disturbed by storms and anthropogenic forces; however, sightings are not common on Tinian. The species was first collected on Tinian in 1820 (Baker 1951). During WWII and throughout the 1970s and early 1980s, most ornithological surveys and inventories failed to locate megapodes on the island (Gleize 1945; Downs 1946; Marshall 1949; Pratt et al. 1979; Engbring et al. 1986).

Infrequent surveys on Tinian from 1970 to 2000 detected a total of seven Micronesian megapodes. The Maga region was a common area for megapode detections in 2001, 2004, and 2005 (DON 2001; Vogt 2008a). Seven detections in 2001 were believed to represent two individual birds (DON 2001). Megapodes were not detected during surveys on Tinian in 2006, 2007, and 2008 (Vogt 2008a; Camp et al. 2012); however, one megapode was heard by an employee of Tinian's Department of Lands and Natural Resources (DLNR) near the Seabees Monument in 2009 (JRM 2013).

From 1999 to 2011, one or two transects were surveyed for megapodes and other terrestrial forest birds on a monthly basis (approximately), such that in any calendar or fiscal year (FY), each transect would be surveyed approximately twice (NAVFAC Pacific 2014a). In 2012, the megapode survey protocol was changed in an attempt to establish a more systematic, intensive approach. Rather than surveying one or two transects each month, one complete annual survey was conducted in each year from 2012–2014. During these annual surveys (conducted by two to four biologists), all seven transects at once were surveyed twice within a 5–10 day period (NAVFAC Pacific 2014a). During February 2004 surveys, a biologist observed one megapode while transiting between stations on the Maga transect. In June 2005, a biologist observed two megapodes while transiting between stations on the Maga transect. One megapode was detected on the Maga transect in 2013, and no megapodes were detected during 2012 and 2014 annual surveys. The new systematic intensive annual survey was conducted in 2014, representing the third consecutive year (NAVFAC Pacific 2014a). Critical habitat has not been designated for this species. Figure 11-8 shows the locations where megapodes have been detected.

In addition to transect surveys, playback surveys aimed at detecting the presence of megapodes have also been conducted on Tinian sporadically over the past 30 years. Detections of single megapodes were reported on Tinian in 1985, 1995, 2000, 2001, and 2009 (Wiles et al. 1989; O'Daniel and Kreuger 1999; Cruz et al. 2000; DON 2001; Vogt 2008b; NAVFAC Pacific 2014a). These detections have occurred most frequently within the Maga area around the Maga transects (Wiles et al. 1989; O'Daniel and Kreuger 1999; DON 2001; Vogt 2008a), as well as north of Cross Island Road (O'Daniel and Kreuger 1999) and along the southeastern cliff line forests south of the MLA (Cruz et al. 2000). Playback surveys were repeated in 2021 and 2023 within the MLA; no megapodes were detected either visually or aurally (NAVFAC Marianas 2023a).

Mariana Kingfisher

The Mariana kingfisher is federally protected under the MBTA and CNMI-designated as SOGCN. Stressors include nest predation by rats, typhoons and tropical storms, and habitat loss and disturbance due to urbanization and military activities (Liske-Clark 2015).



An adult Mariana kingfisher (*Todiramphus albicillia*) on a beachfront limestone outcrop at Unai Dankulo on Tinian.
(*Photos*: R. Whitton)

Abundance estimates for Mariana kingfishers across the four survey efforts, which were part of island-wide surveys of permanent transects (1982, 1996, 2008, and 2013), varied greatly, with an estimated 842 birds in 1982, 2,746 birds in 1996, 7,304 birds in 2008, and 2,201 birds in 2013. While the 2013 estimate showed a decrease in kingfisher abundance and density compared to 2008, the 2013 estimate was similar to the 1996 estimate. In terms of abundance and density by habitat type, there were decreases in density from 2008 to 2013 in limestone native forest, mixed introduced forest, and tangantangan habitats. Although there was a decrease in abundance and density from 2008 to 2013, the overall trend for Mariana kingfisher abundance and density since 1982 is increasing (NAVFAC Pacific 2014a). Surveys for Mariana kingfishers along 50 established roadside stations on Tinian conducted by CNMI DFW since 1999 also indicate that despite variability in some years, the abundance is increasing (CNMI DFW 2017).

Mariana Fruit Dove

The Mariana fruit dove is federally protected under the MBTA and CNMI-designated as SOGCN. Stressors include urbanization, grazing of habitat by feral ungulates, commercial development, and invasive vines (Liske-Clark 2015). Abundance estimates for the Mariana fruit dove also varied across the four survey efforts, with an estimated 6,600 birds in 1982, 2,445 birds in 1996, 5,112 birds in 2008, and 3,879 birds in 2013. In terms of abundance and density by habitat type, there were decreases in density from 2008 to 2013 in other scrub/grassland and tangantangan habitats. NAVFAC Pacific (2014a) reported an increasing trend in Mariana fruit dove abundance and density since 1982. Data from CNMI DFW (2017) also indicated variability in some years with an overall increase in abundance of Mariana fruit dove since 1999; however, Camp et al. (2012) show a gradual decrease in density between 1982 and 2008.



Mariana fruit dove (*Ptilinopus roseicapilla*).
(*Photo*: L. Shaughnessy)

White-throated Ground Dove



A male white-throated ground dove resting in the canopy of tangantangan (*Leucaena leucocephala*).
(*Photo*: L. Shaughnessy)

The white-throated ground dove is federally protected under the MBTA and CNMI-designated as SOGCN. The species stressors include urbanization, grazing of habitat by feral ungulates, commercial development, and invasive vines (Liske-Clark 2015). Abundance estimates for white-throated ground doves across the four survey efforts varied greatly and showed an increase across all years, with a low of 535 birds in 1982 and a high of approximately 4,500 birds in 2013. In terms of abundance and density by habitat type, there were no significant changes in density from 2008 to 2013. Overall, the trend for white-throated ground dove abundance and density since 1982 is increasing (Camp et al. 2012; NAVFAC Pacific 2014a). CNMI DWF roadside surveys for the white-throated ground dove showed an increase in abundance from 1999 to 2003 and 2005 to 2017, with a decrease between 2003 and 2005. Overall, however, the trend for white-throated ground dove abundance as estimated from the roadside surveys since 1999 is increasing (CNMI DFW 2017).

11.2.5.3 Reptiles

Sea Turtles

The Central West Pacific Distinct Population Segment (DPS) of green sea turtles and hawksbill turtles are federal ESA-listed as threatened, CNMI ESA-listed as threatened and endangered, and CNMI-designated as SOGCN. The occurrence of sea turtle nesting activities on land is covered in this section, and occurrence in the nearshore waters is discussed in Section 11.3, *Marine Environment*.



A green sea turtle (*Chelonia mydas*) on Unai Babui, Tinian.
(*Photo*: T.M. Summers)

On Tinian, the green sea turtle is threatened by increased human presence, coastal construction, algae/seagrass/reef degradation, and illegal harvesting (National Marine Fisheries Service [NMFS] and USFWS 1998). Hawksbill turtles nest on beaches with both high- and low-wave energy in tropical regions worldwide. Hawksbills will nest on small pocket beaches and, because of their small body size and great agility, can traverse fringing reefs that limit access to other sea turtle species (NMFS and USFWS 1998). Hawksbill turtles are rare on Tinian beaches, and no hawksbill turtles were recorded during a 13-month survey in 1994-1995 (DON 2010). No hawksbill turtle nests were recorded from 2014 to 2023 during ongoing systematic turtle surveys on Tinian beaches (NAVFAC Marianas 2022b).

The majority of nesting beaches for green sea turtles on Tinian are within JRM leased lands, where regular public use of nesting beaches represents a threat to sea turtle nesting habitat. The MITT Biological Opinion (BO) identifies the primary, human-related threats to green sea turtles in the CNMI as direct harvesting of sea turtles and eggs as well as habitat loss due to rapidly expanding tourism, including increased coastal

development on nesting beaches (NMFS and USFWS 1998). On Tinian, the hawksbill turtle is primarily threatened by direct take by humans. Historically, hawksbill turtles have been taken for trade (e.g., tortoiseshell crafts) and, to a lesser extent, for food. Although hawksbill turtle eggs are readily consumed, adults are not valued as highly as green sea turtles for food. This may be due to their poor taste and sporadic fatal poisonings from their occasional toxicity (NMFS and USFWS 1998).

Both green and hawksbill turtles are known to nest on Tinian (DON 2010, 2011, 2012, 2013b; Summers et al. 2017, 2018) (see Figure 11-8), though only a single hawksbill turtle nest was observed on the MLA at Unai Dankulo in May 2010 (NBG 2018; NAVFAC Marianas unpublished data). Beaches within JRM leased lands are surveyed twice monthly for sea turtle activity (i.e., crawls, nests, potential nests, and body pits). Peak nesting starts between February and March and lasts through July and August (NBG 2017; Summers et al. 2018).

For successful nesting, green sea turtles require deep sand beaches with open ocean exposure and minimal disturbance (DON 2010, 2012). Of the 13 distinct beaches or beach complexes on Tinian that could support nesting, 10 are within JRM leased lands, six of which have been surveyed monthly since 1998 and have been documented as nesting beaches: Unai Chulu, Unai Lam Lam, Unai Chiget, Unai Dankulo, Unai Masalok, and Unai Babui. Unai Dankulo consists of 13 pocket beaches separated by rocky outcrops and fronted by a coral reef system (DON 2014b). In 9 years of study on Tinian, Summers et al. (2018) recorded 28 nesters on Tinian of which at least three of the nesters were poached, with a mean abundance of 3.1 nesters/year. These estimates are thought to be low due to reduced level of survey effort (Summers et al. 2018).

Over 17 years (1998-2015) of monthly nesting beach surveys, data indicate that Unai Dankulo is the beach most frequently used by sea turtles. Approximately 55% of all green sea turtle activity on the six regularly surveyed beaches was observed on the Unai Dankulo pocket beaches (JRM 2017a). Surveys performed between January 2022 and December 2022 found a total of 36 green sea turtle nests: 33 on Unai Dankulo and three on Unai Masalok (NAVFAC Marianas 2022b). Green sea turtles nest regularly on Unai Chulu, Unai Babui, Unai Dankulo, and Unai Masalok, and Unai Lam Lam.

Based on the 1998-2016 surveys, it was believed that green sea turtle nesting activity on most of Tinian's sandy beaches would occur as early as late January and end in mid-July (JRM 2017a). However, surveys since October 2008 have indicated that nesting activity occurs during all months of the year. These more recent surveys also indicated a substantial increase in overall sea turtle nesting activity (JRM 2017a).

Micronesian Gecko

The Micronesian gecko is native to Micronesia and is the only CNMI ESA-listed terrestrial gecko. Threats to the species are not widely understood, but are believed to include predation by feral cats (DON 2015b) and predation or competition with the non-native oceanic gecko (*Gehyra oceanica*) (Rodda et al. 2009). It was believed to no longer exist on the island after 1946 but was collected in southern Tinian in August 2003, sighted in 2007 near Mount Lasso, and collected in limestone forest on Mount Lasso and Carolinas Plateau (located near the southern tip of the island) in 2008 (see Figure 11-8 for the location of the observation within the MLA) (Rodda et al. 2009).

11.2.5.4 Invertebrates

Humped Tree Snail



Several aged shells of a variety of species found in limestone native forest on Tinian: top left: non-native *Gonaxis kibweziensis*; bottom left: non-native giant African snail (*Achatina fulica*); right: native humped tree snails (*Partula gibba*); center: variety of unknown land snail species.
(*Photo*: L. Shaughnessy)

The humped tree snail was recently listed as endangered under the ESA (USFWS 2015b). It was historically present on Tinian but was thought to be extirpated on the island because of the presence of the predatory New Guinea flatworm, the rosy wolf snail (*Euglandina rosea*), *Gonaxis kibweziensis*, two predatory snails introduced to Tinian as biocontrol for the giant African snail (*Achatina fulica*), the loss of limestone native forest habitat, and because it had not been observed on Tinian since 1970 (Berger et al. 2005; DON 2014a; USFWS 2012a).

Holland and Sischo (2013) conducted a comprehensive survey of limestone native forest within JRM leased lands on Tinian in June of 2013. Surveys documented two discrete populations of the humped tree snail within limestone native forest along Lamanibot Bay, which is known as Dump Coke (see Figure 11-8). Ninety-two individuals were counted between the two sites, including adults, subadults, and juveniles. Aged humped tree snail shells were observed on the ground in limestone native forests in the vicinity of Unai Chiget, south of Lake Hagoi in the Maga area, the Mount Lasso area, and Unai Masalok (DON 2010, 2014a). At least 35 snails were found during surveys conducted in November 2022 at North Dump Coke site in two different areas; no snails were found at the South Dump Coke site (NAVFAC Marianas 2023b).

11.2.5.5 Plants

C. micronesica



***Cycas micronesica* individuals planted in limestone native forest in 2008 that had survived as on February 2017.**
(*Photo*: L. Shaughnessy)

C. micronesica is federally ESA-listed as threatened and CNMI ESA-listed as threatened and endangered. This tree is currently known to occur in the forest and savanna ecosystems of Guam, Rota, Palau, Yap (Raulerson 2006; USFWS 2015a) and potentially on Pagan (Pratt 2011). It is known from Tinian only from historic pollen records (Dixon et al 2011). In Guam and Rota, *C. micronesica* is severely impacted by the non-native Asian cycad scale (*Aulacaspis yasumatsui)*, the non-native cycad blue butterfly (*Luthrodes pandava*), and non-native ungulates (Marler and Lawrence 2012). To establish an assurance population on a scale-free island, in 2008 DON and conservation partners established ~1,000 *C.*

micronesica seedlings in plots below Mt Lasso on the Tinian MLA (see Figure 11-8). In addition, approximately 50 *C. micronesica* were planted by the Tinian Department of Lands and Natural Resources as ornamentals to beautify numerous tourist sites (e.g., North Field) on the MLA from "extra" plants grown through the same effort. Thus, although a *C. micronesica* population now occurs on Tinian, it was not included within the species' range in the final rule to list *C. micronesica* as a threatened species under the ESA (USFWS 2015a).

In response to the rapid rate of mortality, JRM contracted surveys and collected viable seed for propagation from habitats throughout Guam in 2005. More than 3,000 *C. micronesica* seeds were collected, cleaned of scale insects, and the source of each seed documented by individual mother-tree habitat type. Seeds were then stored over a period of 12 months, and then transported to a nursery on Tinian until they reached maturity. In 2008, 1,000 of these individuals were planted in a mapped experimental design on Tinian. During August 2019 maintenance activities, scale insect was discovered within the MLA plots. Despite control efforts, the scale insect spread throughout all plots and caused significant mortality. As of June 2023, less than 200 live cycads within the plots and 33 ornamentals at six tourist sites remain, with cycad scale occurring in the plots and at two of the six tourist sites (UOG 2023). Although Tinian is no longer a scale-free island, *C. micronesica* within the plots and at the tourist sites continues to be managed as a small assurance population and to mitigate the biosecurity risk of transfer of cycad scale to other scale-free islands, such as Saipan.

<u>*Heritiera longipetiolata*</u>

Heritiera longipetiolata is a tree species reported from Guam, Saipan, and Tinian (Raulerson 2006) and is known outside the Mariana Islands only from Pohnpei (Costion and Lorence 2012). It grows primarily in moist limestone native forests along coastal cliffs. The species was recently listed as endangered under the ESA (USFWS 2015a). Historically, clearing of forests for agriculture, WWII warfare, and subsequent land clearing for U.S. military airfields and support facilities resulted in significant loss of Tinian's native vegetation communities. USFWS (2015b) estimated that only 5% of limestone native forest remains on Tinian.



***Heritiera longipetiolata* grows primarily in moist limestone native forests along coastal cliffs and is sometimes found in groves.** (*Photo*: L. Shaughnessy)

On Tinian, this species is known historically from three sites within JRM leased lands (near Puntan Masalok, along the Lamanibot Bay escarpment, and the south-facing coastal forest east of Puntan Diablo and southwest of the airport) (Hawaiian Agronomics International, Inc. 1985) and two sites south of the MLA (coastal areas of Puntan Kastiyu and Suicide Cliff southwest of Puntan Kastiyu) (NAVFAC Pacific 2014a; USFWS 2015a). In surveys conducted in May 2016 and February/March 2017, approximately 360 individual *H. longipetiolata* (230 adults and 132 saplings or seedlings) were observed within limestone native forests at Puntan Masalok (NAVFAC Pacific 2018a) (see Figure 11-8). In June 2017, approximately 455 individual *H. longipetiolata* (230 adults and 225 saplings or seedlings) were observed within two survey areas at Puntan Masalok (NAVFAC Pacific 2018a). Groves of *H. longipetiolata* were also confirmed in the coastal areas of Puntan Kastiyu and Suicide Cliff southwest of Puntan Kastiyu. No individuals were observed along the Lamanibot Bay escarpment during the 2017 surveys.

Dendrobium guamense

Dendrobium guamense is an orchid species that grows on tree trunks and branches in forest habitats and was recently listed as threatened under the ESA. *D. guamense* is known historically from Guam, Rota, Saipan, and Tinian (USFWS 2015a). Comprehensive surveys for this species on the MLA have not been undertaken, thus occurrence data is limited. Approximately nine occurrences of *D. guamense* were observed within a single survey area at Mount Lasso ridge. All observed occurrences of *D. guamense* were on large gulos trees within the area of limestone native forest south of Mount Lasso (NAVFAC Pacific 2018a).



Approximately nine occurrences of *Dendrobium guamense* were found growing on large gulos trees (*Cynometra ramiflora*) within limestone native forest south of Mount Lasso.
(*Photo*: L. Shaughnessy)

11.3 MARINE ENVIRONMENT

11.3.1 Joint Region Marianas Submerged Lands

Submerged lands under the jurisdiction of the DoD extend 3.0 miles (4.8 kilometers) offshore from the Tinian MLA (Figure 11-11). Therefore, JRM submerged lands associated with Tinian MLA comprise approximately 47,418 acres (19,190 hectares). Under Presidential Proclamation 9077, issued January 15, 2014, the President withheld the transfer of submerged lands around Tinian, Farallon de Medinilla (FDM), Maug, Farallon de Pajaros, and Asuncion, until coordinated management plans can be developed between the U.S. and CNMI to protect these marine resources.

Under the Territorial Submerged Lands Act (PL 93-435), the President has the authority to withhold the transfer of all or some of these submerged lands for reasons of national interest, including defense preparedness and environmental protection. The total shoreline length of the Tinian MLA is approximately 21 miles (33 kilometers), and the entire Tinian coastline is approximately 38 miles (61 kilometers), so the JRM leased land comprises 55% of the Tinian shoreline (Table 11-7).

Table 11-7. Estimates of Select Total Physical Characteristics on Tinian

Physical Characteristics	*Tinian*
Coastline	38 miles (61 kilometers)
Seafloor area from 0-100 feet (0-30 meters) depth	6.25 square miles (16 square kilometers)
Total reef habitat	8.9 square miles (23 square kilometers)
Reef flat	0.10-0.15 square mile (0.28-0.39 square kilometer)

Source: NAVFAC Pacific 2014a.

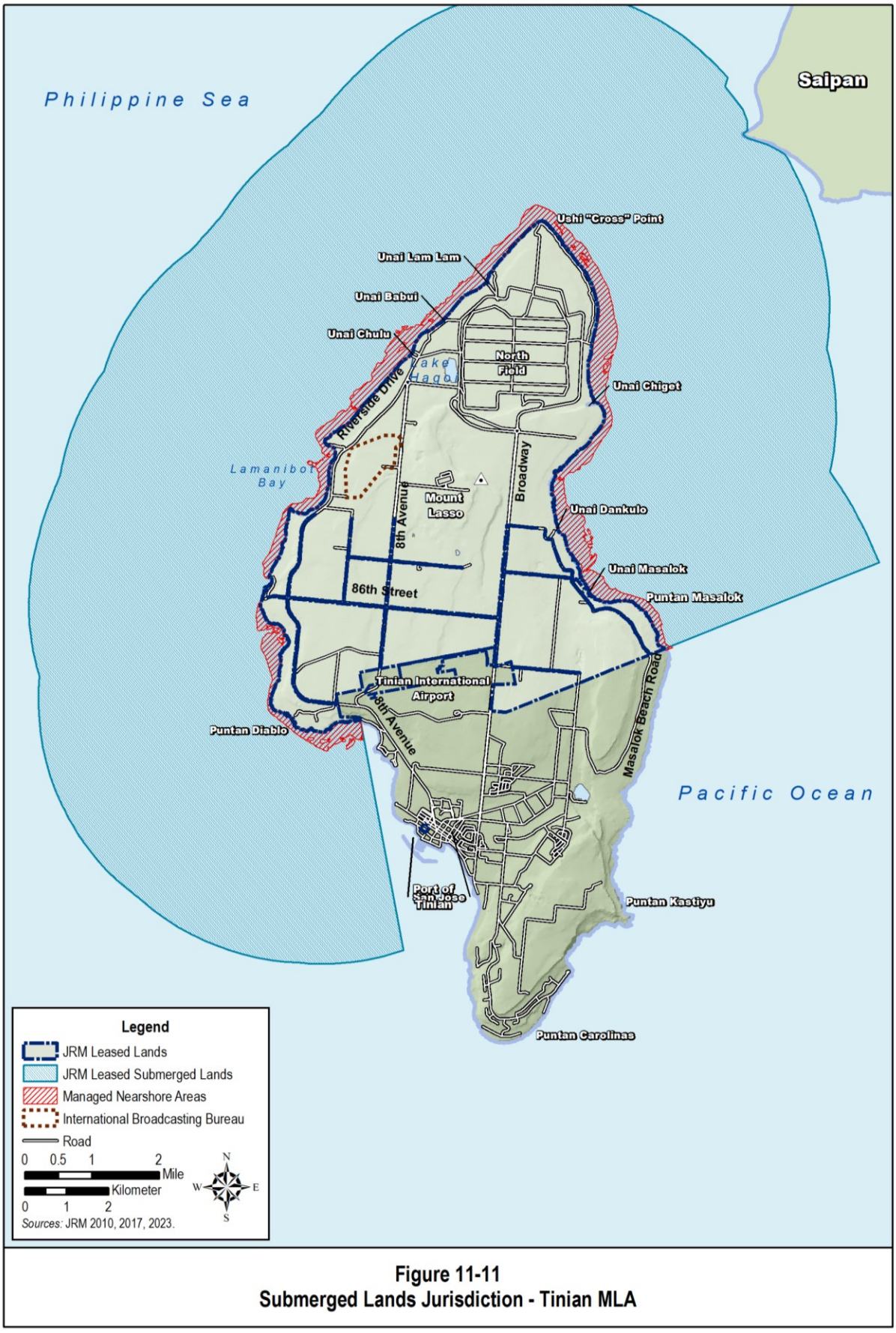


Figure 11-11
Submerged Lands Jurisdiction - Tinian MLA

11.3.2 Physical Environment

The Tinian MLA has no significant coastal infrastructure, no streams entering the coastal zone, and the only physical impacts of note are related to WWII (e.g., amphibious landings, unexploded ordnance [UXO], dumping). Apart from overfishing, the Tinian coastal zone is much less impacted than the other populated islands in the Mariana Archipelago. During the WWII invasion of Tinian, there was intense bombardment of the island. UXO, including armed 16-inch diameter projectiles fired from battleships, smaller artillery items, and rockets are present off Unai Babui and Unai Chulu (Smith 2012) and other parts of the island. Many of these ordnance items are heavily encrusted with coral and/or other benthic organisms, making them difficult to identify. The remains of sunken Amphibious Assault Vehicles from WWII are also present (Smith 2012). There are several reports of divers collecting white phosphorous, particularly at the Lamanibot dump site, but formal documentation of this UXO has not been obtained. During 1944 and 1945, the Twentieth Air Force flew hundreds of missions from North Field with Boeing B-29 Superfortress bomber aircraft. At least six of these crashed after take-off and are located off the northeast coast of Tinian at depths of slightly over 100 feet (30 meters) (Smith 2017).

The coastline is comprised of low limestone cliffs with small beaches. The hard shores primarily consist of rocky intertidal areas with steep cliffs and headlands, reinforced by large boulders at the base. Erosion and waves carve out these cliffs and create sea level benches. From the base of these cliffs, the depth of nearshore waters increases rapidly to approximately 23 feet (7 meters) into spur and groove formations (hard bottom habitat) that support high biological diversity. In order of relative areal extent, fore reef is the most abundant coral reef habitat type in the Mariana Islands by a large margin, followed by reef crest, and very small extents of reef flats (Riegl and Dodge 2008; Brainard et al. 2012).

Tinian's shoreline has 13 beaches (10 on the west coast [leeward side] and three on the east coast [windward side]) and is mostly undeveloped, except for the Port of Tinian. These beaches are primarily comprised of medium to coarse sands, gravel, and coral rubble. Reef flat habitat is of limited extent on Tinian, which has seven well-developed and two poorly-developed reef flats. Well-developed reef flats occur at Unai Chulu, Unai Babui, Unai Dankulo, Unai Masalok, Unai Barcinas, Unai Leprosarium, and Unai Taga south of the Tinian Dynasty Hotel. Poorly-developed reef flats occur at two locations on the leeward side, one at the south end of the IBB property and one approximately 1 mile (1.6 kilometers) south of Puntan Atgidon. On the east side of Tinian MLA, Unai Dankulo and Unai Masalok to the south form longer beaches, though there are some rock protrusions creating numerous small beaches at high tide. These two beaches have the largest reef flats within JRM submerged lands on Tinian.

Surface seawater temperatures off Tinian typically range between 80.6-86.4 degrees Fahrenheit (°F) (27-30.2 degrees Celsius [°C]) (National Oceanic and Atmospheric Administration [NOAA] 2017a). However, during 2013, 2014, and 2016, water temperatures around Tinian were elevated above normal due to prolonged El Nino conditions, which resulted in coral bleaching (Reynolds et al. 2014; NOAA 2017a). Preliminary results from comparing observations made during the summer of 2013 and the spring of 2017 at Unai Babui and Unai Chulu on the northwest side of Tinian suggest that there have been significant losses in the coral community during that time period. The shallow portions of the reef (reef flat, reef crest, and upper reef slope) have seen a reduction in coral cover and size distributions, but increases in colony density and species richness, reflecting the recruitment of young corals following extensive mortality of large colonies (DON 2014b, 2017b).

11.3.2.1 Bathymetry and Currents

The bathymetry around Tinian is relatively steep close to shore on the west side of the island, dropping off into the mesophotic and aphotic zone to approximately 1,000 feet (300 meters) water depth within less than

1 mile (1.6 kilometers) from shore. The bottom drops off less sharply on the west side of the island, with a wider shelf that remains above approximately 500 feet (150 meters) depth out to about 1 mile (1.6 kilometers) from shore. At that point, the depth increases again abruptly to approximately 1,000 feet (300 meters) before it continues to slope into deeper waters (Figure 11-12).

In one area of Unai Dankulo on the east coast of Tinian, there is a channel that appears to have been dredged or blasted into the reef crest some time ago. This feature may be natural, but it stands out in aerial photographs of this location as being possibly anthropogenic.

Tinian sits in the west-northwesterly flowing North Equatorial Current. Site-specific studies of nearshore currents off the Tinian MLA have been performed by DON in 2017 for Puntan Diablo and Barcinas Bay (located southeast of Puntan Diablo) (NAVFAC Pacific 2018b). The typical wave climate in the Tinian region is dominated by easterly trade wind waves (DON 2015c). The overall current flow is west, being deflected northwest or southwest along the Tinian windward coast. Tidal currents and the direction of the deflected net flow affects current direction and flow along Tinian's northwest and southwest coasts, with reversals and eddies as regular occurrences (Lagerloef et al. 1999; Wolanski et al. 2003; Kendall and Poti 2015). Studies of coastal processes around Unai Chulu and Unai Babui show that waves impacting the northwest coast predominantly have a significant wave height less than 2 feet (0.6 meter) (DON 2015c). Modelling indicates that the extreme wave events can be large with the 1-year wave event reaching 15.2 feet (4.6 meters) and the 50-year wave event reaching 26.4 feet (8 meters) near shore (NAVFAC Pacific 2014b). While these large events can strip beaches of sand, modelling demonstrated that coastal processes and the shape of the coastline serve to replenish and retain sand at the few small beaches on the Tinian coast.

The mean diurnal tidal range in Saipan, the nearest island to Tinian with a tide meter, is 2.19 feet (0.67 meter). Tidal currents are relatively weak on Tinian compared to wind- and wave-driven currents, though currents across flats and other restricted areas can be stronger. The MSL is reduced significantly during El Nino events, which may cause any very shallow corals to become exposed during very low tides, leading to coral death (Widlanski et al. 2015).

11.3.2.2 Turbidity and Water Quality

Turbidity increases with suspended sediment delivered to the coast in freshwater runoff, or by sediment resuspension from wave activity. The JRM submerged lands offshore of Tinian are not adjacent or down current from any streams; the surface of Tinian is dominated by limestone, and thus freshwater inputs at the coast typically occur as seeps instead of rivers, and do not deliver significant suspended sediment to coastal waters. In addition, the limestone acts as a natural filtration system through which stormwater percolates before reaching the underlying aquifer and exiting through seeps. Wave activity and sediment resuspension is generally stronger on the windward side of the island.

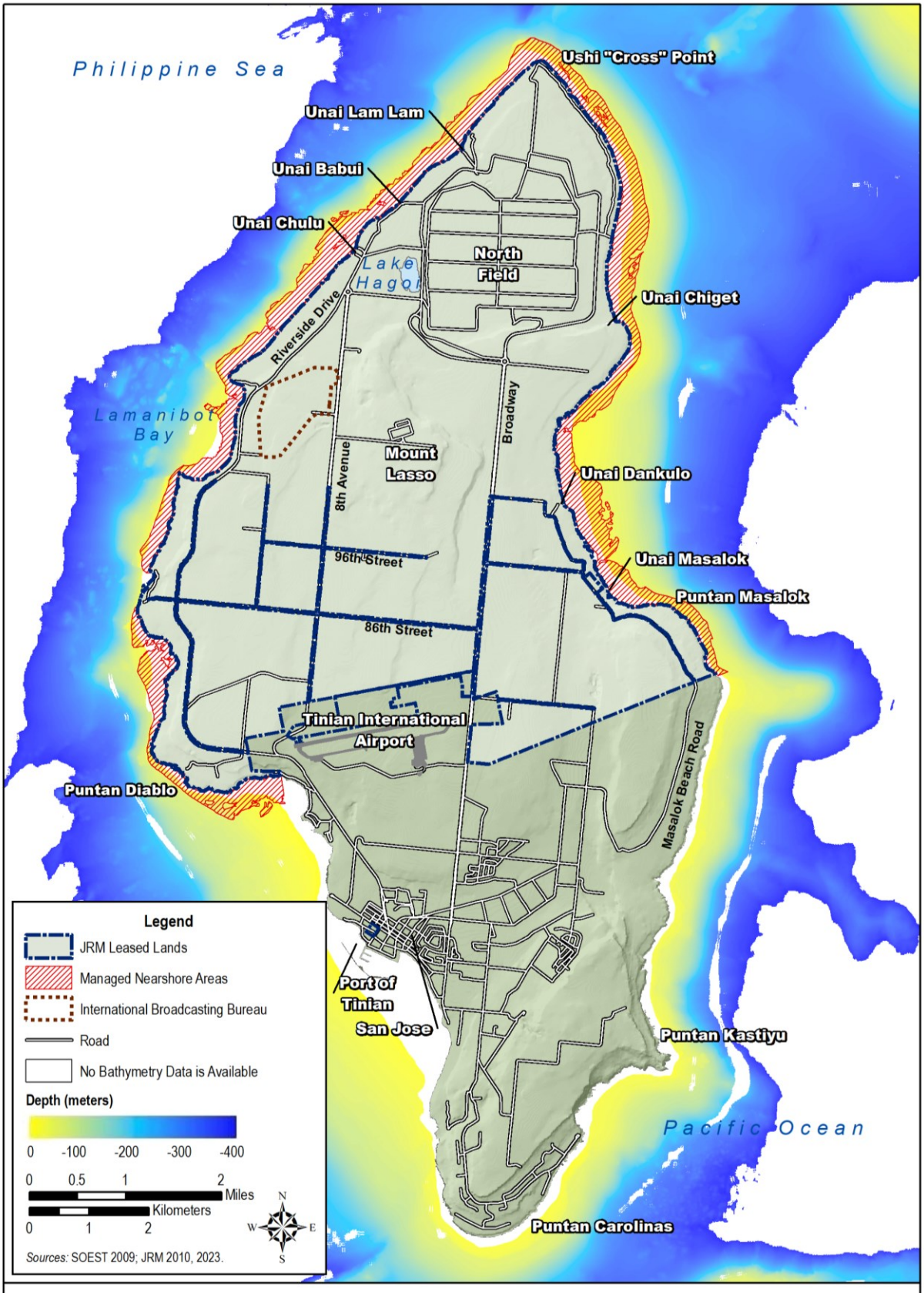


Figure 11-12
General Bathymetry of Submerged Lands Offshore Tinian

Whittall et al. (2016) assessed contaminants (heavy metals, polychlorinated biphenyls, and other organic contaminants) and nutrients on the southwest coast of Tinian. They found that, in general, nutrients and contaminants were low, outside of possible minor contamination mainly associated with the Port of Tinian. Because there are no permanent residents or other significant development within JRM leased lands on Tinian, sources of land-based pollution are expected to be minor. The DoD has leased land to parties that have used the area for grazing (i.e., the LBA). Some sources of nutrients associated with cattle, such as concentrations of animal waste, and locations where pesticides have been used may exist in JRM leased lands. Marine surveys in 2017 recorded areas on the reef slope covered by mats of golden algae (DON 2017b). These areas may be at the locations where groundwater enriched with nutrients is seeping into the marine environment or may be caused by other dynamics. Sources were not determined, and these mats are seen on other islands from time to time where human activity is virtually nonexistent (McKagan 2017). The island was essentially denuded of forests during WWII, and several dirt roads exist within JRM leased lands, but the island is also relatively flat with no streams or rivers that discharge into the ocean. While some soil erosion into the nearshore environment may occur, it is limited.

Conductivity-Temperature-Depth casts were carried out during the 2003-2007 NOAA Pacific Reef Assessment and Monitoring Program (Pacific RAMP) surveys, which are discussed in more detail in 11.3.8, *Marine Resources Monitoring*. They found slightly warmer and fresher waters off the leeward side of Tinian, compared with the windward side (Brainard et al. 2012).

Marine resources offshore of Tinian are likely subjected, to some degree, to the array of stressors in the marine environment that are described in Section 4.5.7, *Stressors on the Marine Environment of Guam*, but with essentially no development onshore; many local-scale impacts to water quality such as sewage and sunscreen pollution will be lower than more heavily populated and visited locations in the Mariana Islands. However, a number of popular dive sites on the west side of the island, such as Lamanibot and Fleming Point, could subject those locations to recreational stressors. The overall good water quality conditions should provide for improved coral resilience to climate impacts (Carilli et al. 2009) and acute events like typhoon strikes and crown-of-thorns seastar (COTS) (*Acanthaster planci*) outbreaks (Houk et al. 2014).

11.3.2.3 Waves and Storms

The most frequent and consistent wave energy impacting Tinian is caused by the northeast trade winds; the east (windward) side of the island is more exposed to these trade wind-driven waves than the west (leeward) side (Brainard et al. 2012). However, typhoons and tropical storms usually pass close to Tinian each typhoon season (typically May-October), and can cause significant wave energy to impact the leeward side of the island as well (Brainard et al. 2012). Tinian is also somewhat protected from wave activity by the island of Saipan, which is separated from Tinian by the Saipan channel, approximately 3 miles (4.8 kilometers) in width.

During the 2015 typhoon season, several powerful storms passed close to Tinian. In early July 2015, tropical storm Chan-Hom passed south of the island, followed by Typhoon Soudelor, which hit Saipan in August 2015 as it strengthened to a category 4 typhoon. This was the strongest storm in about 30 years to hit Saipan and a major disaster was declared on both islands in its wake. In mid-August, tropical storm Goni followed a similar track to Chan-Hom south of Tinian, and in mid-October, tropical storm Champi passed north of Tinian and Saipan, causing extensive flooding. Waves from these types of storms typically result in significant damage to coral reefs on Tinian.

The 2018 typhoon season brought Tropical Storm Maria (4 and 5 July), Typhoon Mangkhut (10 and 11 September), Super Typhoon Yutu (25 October), and Typhoon Man-Yi (22 November) to the CNMI. The eye of Super Typhoon Yutu passed directly over Tinian and caused catastrophic damage to the islands of

Tinian and Saipan (Pacific Daily News 2018). At the time of impact, Super Typhoon Yutu had sustained winds of over 178 mph (286 kph). It destroyed homes, buildings, and critical infrastructure; displaced hundreds of residents; and caused island-wide power and water outages (Gilbert 2018).

The years 1995 and 1996 also had exceptionally active storm seasons in the Pacific; there were 37 and 53 tropical storms, typhoons, or super typhoons in the region, respectively. In 1997, Super Typhoon Paka impacted Tinian with 145 miles per hour (230 kilometers per hour) sustained winds. Because of the historical frequency of typhoons impacting Tinian, the coral community may be dominated by species that can either withstand or recover relatively quickly from storm impacts. It is important to note that recovery of corals after acute disturbance is enhanced when other environmental conditions are good – for instance, when fish communities are robust and nutrients and other pollutants remain low (Connell 1997; Hughes et al. 2010).

11.3.3 Marine Habitats

11.3.3.1 Bottom Habitat



Sheltered reef habitat that is suitable for these types of staghorn coral are very uncommon in CNMI. These colonies of *Acropora pulchra* are in the interior of Port of Tinian.
(*Photo*: M. Lybolt)

The coast of JRM leased lands on Tinian is surrounded by fringing reefs in nearshore waters, with varying levels of coral, algae, and crustose coralline algae (CCA) dominating the hard substrate (Figure 11-13), and some areas of soft sediments, primarily sand in patches and channels between reef sections (Figure 11-14). Many regions of JRM submerged lands around Tinian have well-developed spur and groove coral reefs. Close to shore, very shallow reef flats host macroalgae, with extensive regions of turf algae and diverse coral communities. Reef crests that are shallower than the reef flats and often built from layers of CCA buffer the reef flats from wave action. Beyond the reef flats, the bottom slopes into deep water, but in most areas this fore reef region contains the highest coral cover. In locations with spur and groove formations, the fore reef and often the reef crest and part of the reef flat are incised with deep channels perpendicular to shore. Wave energy is funneled into these channels, causing scour on the bottom of the channels and serving to deepen them while preventing colonization by hard corals or CCA, but often the side of channels contain abundant hard coral and CCA growth.

In deeper and/or calmer waters, soft reef sediments are prime habitat for cryptofauna such as crabs. These are also the preferred habitats for some transient but important fish species such as the scalloped hammerhead shark (*Sphyrna lewini*).

Seagrass forms another benthic habitat. The Mariana Islands have three species of seagrass, described under Section 11.3.4, *Marine Flora*.

11.3.3.2 Coastal Habitat

The coastline of JRM leased lands on Tinian is primarily comprised of low limestone cliffs with generally small pocket beaches. A fault bisects the coastline north of Unai Dankulo and has resulted in an abrupt but small topography change across approximately half of the island.

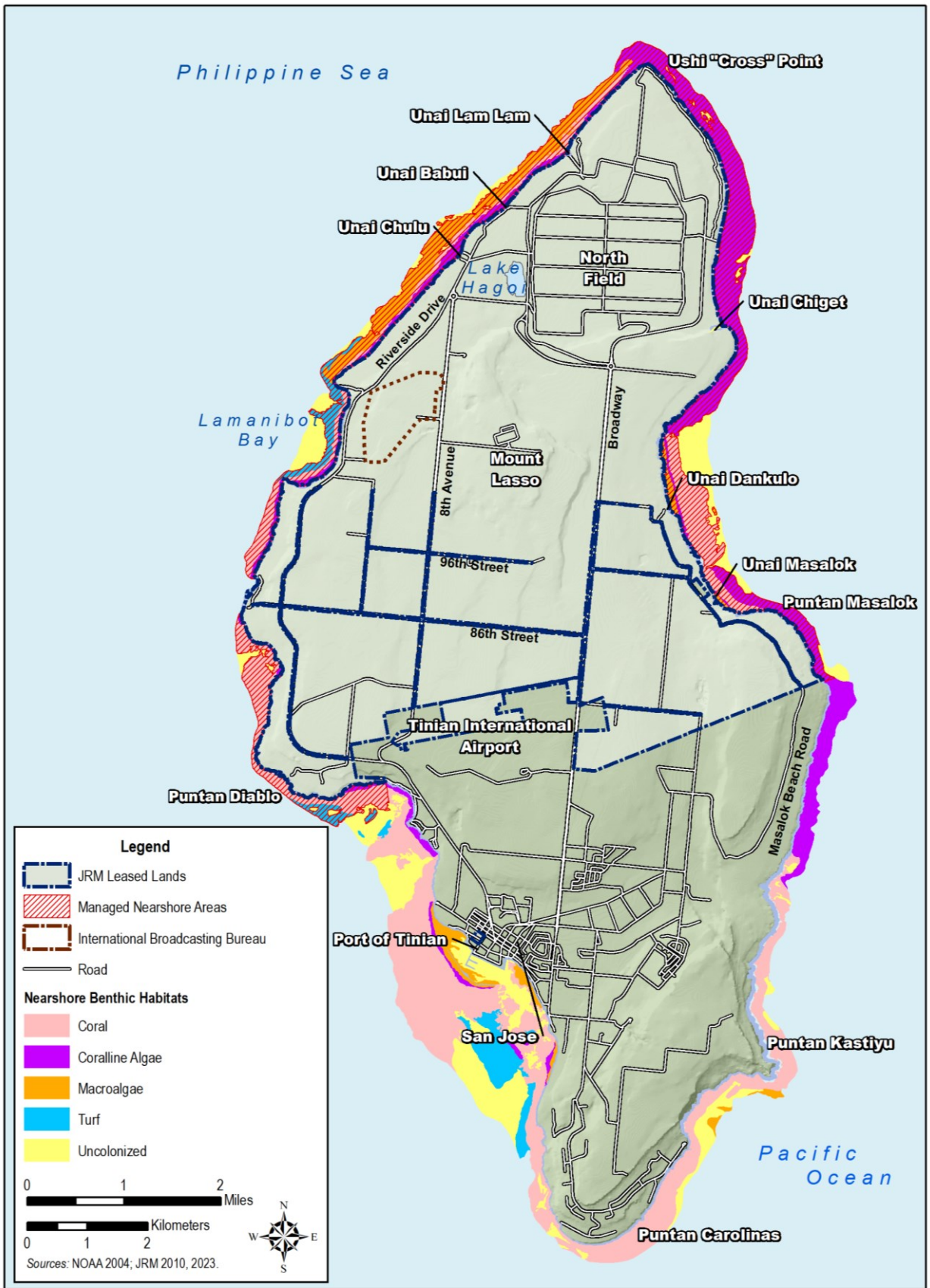


Figure 11-13
Benthic Habitats On Tinian



Figure 11-14
Hard/Soft Benthic Habitat Offshore Tinian

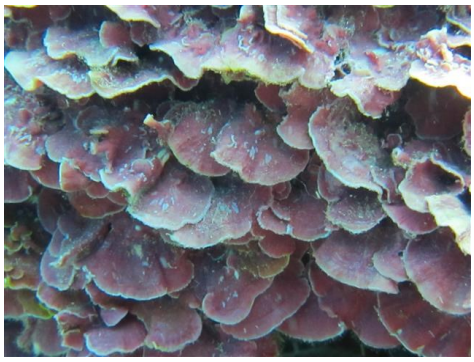
This fault has also created a shallow inlet, headed by Unai Chigit, approximately 70 feet (21 meters) wide along the length of the inlet, and 600 feet (183 meters) from the opening at the coast to the back of the inlet toward the center of the island. This feature presumably provides somewhat unique coastal habitat and may contain unique communities of organisms compared to more exposed areas elsewhere on Tinian. Along most of the JRM leased coastline, no soft sediment (sand) occurs at the coast; instead the coastal limestone provides hard substrate in both the intertidal and deeper waters.

The reef area on the northwest side of Tinian is physically complex with very deep, irregularly spaced grooves in the fore reef that transition rapidly to deep fore reef, with broken rock fragments in the grooves. The bases of the grooves have polished surfaces and polished cobble-sized fragments, indicating regular, active water motion and erosion. Many spurs are undercut by grooves that interconnect with other grooves, resulting in a network of tunnels, grottoes, fissures, and chimneys penetrating from the fore reef under the reef crest, and occasionally under the reef flat (DON 2014c).

11.3.4 Marine Flora

11.3.4.1 Native Species

Tinian supports a diverse algal flora, with representatives from all major taxa. CCA and turf algae dominate most habitats, but species from other functional groups, such as the calcareous green algae *Halimeda* spp. and the brown algae *Turbinaria ornata* are also significant. Tsuda (2004) surveyed the literature for the CNMI and found references to 76 marine algae species on Tinian: 4 Cyanophyta (cyanobacteria), 30 Chlorophyta (green algae), 12 Phaeophyta (brown algae), and 30 Rhodophyta (red algae).



Crustose coralline algae are very important reef-builders. These red algae are usually encrusting, but these foliose specimens of *Mastophora pacifica* were unusually common on the fore reef of Unai Dankulo and Unai Masalok in July 2013.
(*Photo*: D. Fenner)

NOAA's Pacific RAMP has conducted detailed assessments of marine flora on Tinian during each of their cruises. The first report covered the surveys conducted in 2003, 2005, and 2007. The NMFS recently completed their 2017 Pacific RAMP research in Guam and CNMI; however, the results are not yet available.

Minton et al. (2009) also completed marine floral assessments on Tinian in 2008. The primary characteristics of the marine flora off Tinian appear to have remained relatively stable during the survey periods mentioned above. However, as noted by Minton et al. (2009), some algae undergo seasonal changes; therefore the densities of species like *Padina* spp. fluctuate throughout each year.



Crustose coralline algae are very important reef-builders. These red algae are usually encrusting, but these foliose specimens of *Mastophora pacifica* were unusually common on the fore reef of Unai Dankulo and Unai Masalok in July 2013.
(*Photo*: D. Fenner)

CCA provides an essential role in coral reef formation, cementing together reef rubble and sediment, and providing important settlement substrate for juvenile corals. Vargas-Angel (2010) was one of the first investigators to assess crustose coralline algal disease, where he found that CCA diseases were common to abundant around the southern islands within CNMI. In 2007, the south coast of Tinian had higher overall CCA disease than Guam, and the second highest incidence in the CNMI. Approximately half of the cases were lethal orange disease, and half were white band syndrome. Tinian was the only location other than Saipan in CNMI where CCA were observed with this syndrome. However, the sites surveyed within JRM submerged lands had low or no CCA disease (Brainard et al. 2012). The projected increased frequency of elevated sea surface temperature events and ocean acidification in the Mariana Archipelago could have an adverse impact upon this important functional group (Kuffner et al. 2008).

The Mariana Islands have three species of seagrass: tape seagrass (*Enhalus acoroides*), narrowleaf seagrass (*Halodule uninervis*), and Hartog's seagrass (*Halophila minor*). Seagrasses, along with algae, are a food source for juvenile green sea turtles and many herbivorous fish, but are limited along much of the Tinian coastline. Seagrass reports on Tinian include Unai Chiget, Unai Masalok, Lamanibot Bay, and the Port of Tinian (Kolinski et al. 2004; NAVFAC Pacific 2004; DON 2014c).

11.3.4.2 Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine flora in the CNMI are presented in Section 10.5.3, *Marine Flora*.

There are not yet reports of non-native or invasive marine flora from coastal marine habitats in the CNMI (Liske-Clark 2015). Nuisance marine flora species include golden noodle algae (a group of filament-forming diatoms in the Class Chrysophyceae) and angel hair algae (*Chaetomorpha* spp.) (DON 2017b; Lobban and Tsuda 2003; Liske-Clark 2015). These nuisance marine species are native, but occasionally exhibit blooms or outbreaks. Outbreaks during the rainy season have been reported in the CNMI lagoons (Benavente 2018).



These filament-forming diatoms in the Class Chrysophyceae can become a nuisance marine flora. Photo from Barcinas Bay on Tinian.
(*Photo*: A. Reyes)

11.3.5 Marine Invertebrates

11.3.5.1 Native Species

Coral



Xanthid crab (*Zosimus aeneus*) and "star sands." The brown grains on and around the crab are living organisms called "star sands." They belong to the group of larger benthic foraminifera (family Calcarinidae) and are common on reef flats, sometimes in deposits several millimeters thick. Both are common in the Marianas and this photo is from Unai Babui on Tinian.
(*Photo*: M. Lybolt)

Corals dominate the hard bottom substrate in regions not dominated by CCA. Coral community structure changed after the COTS outbreak in the late 1960s, which primarily devastated branching species. Quinn and Kolis (2003) found that *Porites* corals, which are more resistant to COTS predation, dominated the benthos on Tinian in the late 1990s, and suggested COTS as a controlling force. Changes in coral community structure were documented on the northwest coast between July of 2013 and April of 2017, including reduced *Acropora* and increased *Porites* and *Goniastrea* (DON 2014c, 2017b). The controlling mechanism(s) are difficult to define because this interval included 3 years of coral bleaching, Typhoon Soudelor, and several large wave events from near-miss typhoons.

Minton et al. (2009) identified 79 species of corals in 24 genera and 72 species in 25 genera at two sites, respectively, on the northwest coast of the Tinian MLA. The shallow reef flats had lower species diversity than the reef slopes in deeper water, usually dominated by *Acropora* spp. and *Porites* spp. The shallow reef crests contain *Acropora verweyi* and *Leptastrea purpurea*. On the northwest coast, the reef slope was dominated by *Goniastrea, Favia*, and *Galaxea* in 2009. Most coral colonies were small. At Unai Dankulo, on the northeast side of Tinian, Minton et al. (2009) identified 87 species in 25 genera of corals. Surveys in 2011 (Smith 2012) also found that Unai Dankulo had the richest coral diversity not just of sites on Tinian, but of all sites those divers had surveyed in the Mariana Islands.

Detailed surveys of Unai Babui, Unai Chulu, Unai Lam Lam, Unai Masalok, and the reef slope of Unai Dankulo in 2013 recorded robust coral communities that have developed during a relatively long period of being undisturbed by significant storms (DON 2014c). The 2013 surveys found a larger number of species present at the beaches than other surveys, possibly due to the intensity and length of the surveys (Table 11-8). Unai Chulu and Unai Dankulo, the two of the largest beaches on the island, had the highest species counts; this could be a result of the fact that the larger area provides more habitat for even a single example of a species to occur. Clearly, not all species occur at all sites because the cumulative number of species is larger than the number of species seen at any single beach (Table 11-8). The most abundant species at most of the beaches was *Goniastrea retiformis*. Many colonies of the most abundant corals observed were small – less than 6.25 inches (15 centimeters) in diameter. However, some encrusting corals, such as *Acropora palmerae*, appeared to thrive in the energetic coastal environment and produced colonies that were up to 3 feet (1 meter) or more across.

Table 11-8. Coral Species Richness on Tinian Beaches Surveyed in 2013

	Unai Chulu	*Unai Babui*	*Unai Lam Lam*	*Unai Dankulo*[1]	*Unai Masalok*	*Cumulative Tinian (n=5 Sites)*
Total Species Richness	121	107	108	119	113	164

Note: (1) Species richness is not likely to be representative of the actual richness at Unai Dankulo because the fore reef was investigated, but the reef crest and reef flat were not. The other beaches were surveyed in these zones.
Key: n = number of sites.
Source: NAVFAC Pacific 2014a.

Out of the beaches surveyed in 2013, Unai Lam Lam was notable for having slightly different character than other beaches. There were more, and larger, branching corals; particularly *Acropora verweyi*. This species is a branching coral that provides significant 3-dimensional local structure to a reef. It occurred at a relatively high density of 0.1 colonies/square meter, suggesting that this species may be a significant contributor to the coral community and possibly to the reef structure at Unai Lam Lam.

Studies showed that Unai Dankulo, which boasted between 50-70% hard coral cover in 1994, had only 2% hard corals covering the benthos in 1999 (DoD 1999) in the wake of Super Typhoon Paka, the reduction was possibly also as a result of the global 1997/1998 bleaching event. The 2003 and 2005 Pacific RAMP cruises found that sites on the east and west of Tinian were dominated by small corals. A couple years later, substantial coral recovery had occurred: Pacific RAMP surveys in 2007 (Brainard et al. 2012) and surveys in 2008 reported in Minton et al. (2009) estimated that Unai Dankulo had the highest coral cover of any of the sites surveyed around Tinian. The 2007 Pacific RAMP surveys also found most corals in the second smallest size fraction that year, instead of the smallest. In 2011, approximately 14 years after the catastrophic loss of corals on Tinian, coral cover was estimated to be even greater than in 1994 at Unai Dankulo (Smith 2012). These temporal trends indicate that coral reefs on Tinian are relatively resilient to the acute impacts of typhoons, which is expected based on the historical frequency of typhoons throughout the Mariana Islands. However, this robust recovery of corals after devastation by Super Typhoon Paka also underscored that environmental conditions on Tinian were good enough to allow recovery; in some locations around the world, adverse water quality, overfishing, and other conditions have prevented recovery after acute stress (e.g., Hughes 1994).

Strong typhoons and regional coral bleaching events that have hit the CNMI in recent years have played an important role in changing the coral colonies that inhabit the waters (DON 2017b). Surveys conducted in 2017 by DON (2017b) showed negative changes at Unai Babui and Unai Chulu, particularly at the reef crest and shallow fore reef. These surveys showed a decrease in coral richness from 2013 to 2017, as well as a decrease in size of the colonies: in 2013, common coral colonies occurred in size classes greater than 20 inches (50 centimeters), while in 2017, common coral colonies occurred in size classes less than 20 inches (50 centimeters). Coral density increased from 2013 to 2017, indicating a higher level of mortality of large colonies, thus creating space for smaller juvenile colonies. Changes in coral density, richness, and colony size at Unai Chulu were present, but not as pronounced as at Unai Babui (DON 2017b).

Other Invertebrates

The Pacific RAMP surveys in 2003, 2005, and 2007 assessed giant clams, urchins, and sea cucumbers across the Mariana Islands. They found that sites on Tinian had, on average, twice the number giant clams as Guam, although the total population was still small; Tinian also had about five times as many urchins, and approximately equivalent numbers of sea cucumbers as in Guam (Brainard et al. 2012).



Giant clam (*Tridacna squamosa*) on the fore reef of Unai Dankulo on the windward side of Tinian.
(*Photo*: V. Bonito)



Two juvenile giant clams (*Tridacna maxima*) on the patch reef in Barcinas Bay on Tinian.
(*Photo*: V. Bonito)

Minton et al. (2009) found that tube worms and sea cucumbers dominated the reef flats at Unai Babui, while sea cucumbers and urchins dominated at Unai Chulu. At Unai Dankulo, urchins were most abundant on reef flats, followed by sea cucumbers. Deeper reef slope habitats differed; at Unai Babui, sea cucumbers and tube worms dominated the non-coral invertebrates, while sea urchins and tube worms dominated at Unai Chulu. At Unai Dankulo, urchins of different types dominated the non-coral invertebrates on the reef slope and tube worms were not abundant.

Urchins are important grazers of macroalgae on coral reefs; macroalgae competes with corals and can in some cases smother or kill corals indirectly by stimulating microbial overgrowth and disease. The abundance of urchins at Unai Chulu and Unai Dankulo may partly explain why coral cover is so high in these areas.

11.3.5.2 Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine invertebrates in the CNMI are presented in Section 10.5.4, *Marine Invertebrates*.

The presence of invasive marine invertebrate species has not been reported from coastal marine habitats in the CNMI (Liske-Clark 2015). The non-native topsnail (*Trochus niloticus*) is relatively abundant in CNMI and occurs in the Tinian MLA (DON 2017b).

Marine nuisance species on Tinian include COTS and the gray sponge *Terpios hoshinota* that overgrows corals. Occasional outbreaks of the coral-eating COTS have occurred in JRM submerged lands. The COTS is native to the Indo-Pacific and may be considered a nuisance species, warranting management measures,



Crown-of-thorns seastar (*Acanthaster planci*) on the deep fore reef of Unai Dankulo on the windward side of Tinian.
(*Photo*: V. Bonito)

but it plays an important role by feeding on the faster-growing corals and allowing slower growing species to establish. The first recorded outbreak began in 1964 or 1965 and lasted through 1969, when large populations of COTS formed fronts that killed essentially all of the coral on the leeward side of Tinian and most areas on the windward side with only about 5-10% of coral surviving or regenerating since the initial outbreak in those locations (Chesher 1969). Corals in very shallow water, and in waters down to approximately 33 feet (10 meters) on the windward side of the island, were spared, likely due to stronger wave conditions preventing COTS from maintaining a hold on those corals (Chesher 1969). During the 1969 survey, reefs down to about 33 feet (10 meters) depth at Unai Dankulo were in normal healthy conditions, but a front of COTS occurred at the outer edge of the healthy reef (Chesher 1969). Since that time, COTS outbreaks have apparently been rarer, and may in part have been kept in check by removal of the seastar by dive operators (Quinn and Kolis 2003). While the cause for COTS outbreaks is still under investigation, Timmers et al. (2012) found that outbreaks do not appear to be related to increased dispersal between islands, but instead are more likely caused by island-scale factors; this suggests that local management of COTS outbreaks is an important focus. The current status of COTS within JRM submerged lands is unknown, but a proposed Integrated Natural Resources Management Plan (INRMP) management action to monitor for COTS presence and bleaching would address this information gap. JRM will also coordinate with NOAA in order to obtain results from the 2017 NOAA Pacific RAMP cruise regarding COTS surveys.

11.3.6 Marine Fishes

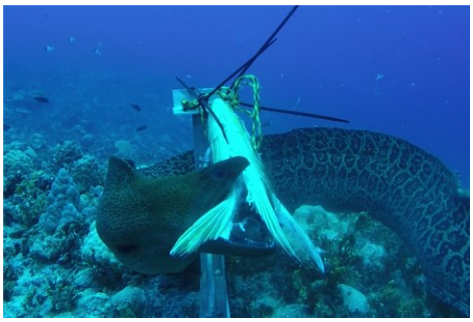
11.3.6.1 Native Species



Conducting a quantitative fish survey in Barcinas Bay, Tinian.
(*Photo*: B. Greene)

Myers and Donaldson (2003) list 1,106 species of native fishes known to occur within the Mariana Archipelago. Those authors state that 1,020 of those species are either inshore or epipelagic and that the majority inhabit coral reefs. Since that listing was made, additional species have been added, such as the new distribution record of the Honeycomb stingray (*Himantura uarnak*) (Smith and Marx Jr. 2016).

Pacific RAMP surveys have provided some of the most detailed information on the fish fauna on Tinian. The following highlights are taken from those investigations, discussed in Brainard et al. (2012). During the 2003, 2005, 2007 surveys, two primary techniques were utilized: Rapid Ecological Assessment and towed diver surveys (for fishes over 50 centimeters total length). Based upon the Rapid Ecological Assessments, fish species richness estimates have ranged from a low of 21 species/100 square meters to 38 species/100 square meters. The highest species richness value was obtained during the 2003 survey. Total fish biomass estimates ranged from 1 to 27 kilograms/100 square meters. The highest estimate was obtained in 2005. Surgeonfishes and parrotfishes dominated the biomass, with these two groups comprising between half and three-quarters of fish biomass during each survey. Towed diver surveys assessed large fish biomass; in 2003 sharks and snappers composed most of the large fish biomass; in 2005, snappers were dominant and in 2007, sharks and barracuda were the dominant families.



Giant moray eels (*Gymnothorax javanicus*) are somewhat uncommon on Tinian. Several individuals were observed in 20 hours of baited remote video surveys on the west coast of Tinian, and several dozen sightings were recorded during 620 staff hours of scuba observations. This photo is from a depth of 110 feet between Puntan Diablo and Barcinas Bay on Tinian.
(*Photo*: Baited Remote Video)

Data from Pacific RAMP surveys after 2007 were reported by Heenan et al. (2015). The techniques used during these later surveys were not identical to those used previously, most notably the stationary point count method described by Ault et al. (2006). Tinian was grouped with the southern Mariana Islands (Saipan, Tinian, Aguiguan, Rota, and Guam) in this study. The biomass of 'all fishes' on Tinian was nearly identical to the biomass estimates for Saipan and Guam. In all three cases, biomass was less than 20 grams/square meter (0.2 kilograms/100 square meters). Of the 40 Pacific islands surveyed, only O'ahu, Hawai'i had a lower estimated biomass. Heenan et al. (2015) also showed that the number of fishes over 50 centimeters total length was lower on Tinian than any of the other islands, except O'ahu. There are multiple lines of evidence consistent with systematic overfishing of CNMI resources since early industrialized harvesting (Cuetos-Bueno and Houk 2015; WPRFMC 2016), and in the recent two decades since the implementation of national fisheries management programs (Trianni 2002; Starmer et al. 2005; Williams et al. 2011; Brainard et al. 2012; Heenan et al. 2015). Chronic overfishing of these islands has been reported by numerous authors, and the fact that JRM leased lands are uninhabited does not protect this region from fishing impacts. A proposed INRMP management action would establish a Conservation Law Enforcement Program within JRM leased lands and submerged lands in order to deter and reduce activities that impact marine resources and ESA-listed marine species.

Tinian, like Guam and Saipan, has substantial areas of complex submerged high-relief habitat. Such habitat structure would normally support robust fish populations under 'natural' conditions. However, reef fish biomass in shallow nearshore waters of Tinian is dramatically less than that of similar remote islands lacking fishing pressure (Richards et al. 2012; Lindfield et al. 2014). Popular fishery target species are skittish around divers and generally flee when approached, a behavior that is characteristic of fish stocks routinely subjected to spear fishing (Freary et al. 2010; Tran et al. 2016).

11.3.6.2 Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine fishes in the CNMI are presented in Section 10.5.5, *Marine Fishes*.

There are not yet reports of non-native or invasive marine fish on Tinian. A nuisance marine species is native, but occasionally exhibits population booms or other undesirable characteristics, and there are not yet reports of nuisance marine fish on Tinian.

11.3.7 Marine Protected Species

Federal ESA-listed marine species are known to occur within JRM submerged lands on Tinian (Table 11-9). The following is a summary of known and potential occurrences of protected species in JRM submerged lands. Because some records are not precise, their occurrences are approximated within the 3-mile (5-kilometer) JRM submerged lands.

Table 11-9. Federal and CNMI ESA-listed Marine Species Recorded on JRM Submerged Lands of Tinian MLA

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*CNMI Status*	*Habitat[2]*	*Occurrence[3]*
Invertebrates (Corals)					
Coral/Acho tasi	*Acropora globiceps*	T	--	Intertidal zone, upper reef slopes, and reef flats	Y
Coral/Acho tasi	*Acropora retusa*	T	--	Upper reef slope	Y
Coral/Acho tasi	*Seriatopora aculeata*	T	--	Deep reef slopes	P
Fish					
Oceanic whitetip shark/Haluu	*Carcharhinus longimanus*	T	--	Open ocean, usually well offshore	PU
Giant manta ray/Afula or Hafula or Fanihen Tasi	*Manta birostris*	T	--	Coastlines, oceanic island groups, and offshore pinnacles and seamounts.	P
Scalloped hammerhead shark/Haluun kiluus or Ulon matiyu na huluu	*Sphyrna lewini*	T[4]	--	Coastal seas from intertidal to depths of 1,640 feet (500 meters); nearshore nursery habitat includes bays and estuaries.	P
Reptiles					
Green sea turtle/Haggan	*Chelonia mydas*	E[5]	T-E	Nearshore waters and nesting beaches	Y
Hawksbill turtle/ Haggan karai	*Eretmochelys imbricata*	E	T-E	Nearshore waters and nesting beaches	Y
Marine Mammals					
Blue whale/ Salungai or Bayena	*Balaenoptera musculus*	E	--	Coastline to 984 feet (300 meters) isobath	P
Fin whale/ Salungai or Bayena	*Balaenoptera physalus*	E	--	Generally near the 656 feet (200 meters) isobath	P
Humpback whale/ Salungai or Bayena	*Megaptera novaeangliae*	E[6]	--	Coastline to 5,906 feet (1,800 meters) isobath	Y
Sei whale/Salungai or Bayena	*Balaenoptera borealis*	E	--	Offshore, prefers deeper waters	P
Sperm whale/Salungai or Bayena	*Physeter macrocephalus*	E	--	Deep waters generally greater than 3,281 feet (1,000 meters) depth	Y

Notes: [1] Chamorro names from GovGuam (2009), Kerr (1990, 2012), Topping et al. (1975).
[2] Dominant adult habitat. Not necessarily inclusive of other life stages (e.g., egg/larvae/juvenile/breeding habitat).
[3] Occurrences approximated to JRM submerged lands, but some fishery-based and acoustic-based records have imprecise locations.
[4] Indo-West Pacific Distinct Population Segment.
[5] Central West Distinct Population Segment.
[6] Western North Pacific Distinct Population Segment.

Key: -- = not listed; CNMI = Commonwealth of the Northern Mariana Islands; E = endangered; ESA = Endangered Species Act; JRM = Joint Region Marianas; MLA = Military Lease Area; P = potential for occurrence; PU = potential for occurrence, but unlikely; T = threatened; T-E = the CNMI Administrative Code does not specify whether a species is threatened or endangered: all species are considered threatened and endangered;
Y = yes, known to occur.

Sources: Berger et al. 2005; DON 2014b, 2017b; Jones et al. 2015; Kobayashi et al. 2011; Liske-Clark 2015; Martin and Jones 2016; NMFS 2014a, 2014b, 2015a, 2018a, 2018b; Trianni and Tenorio 2012.

11.3.7.1 Invertebrates – Corals

Three coral species (*Acropora globiceps*, *Acropora retusa*, and *Seriatopora aculeata*) were recently listed by NMFS as threatened under the ESA and two have been found in Tinian's waters. *A. globiceps* is relatively common and has been observed at most survey locations on the northeast, northwest, and southwest coast of Tinian including Unai Masalok, Unai Dankulo, Unai Chulu, Unai Babui, Unai Lam Lam, Lamanibot, and Puntan Diablo. *A. retusa* is quite uncommon with only one sighting at Puntan Lamanibot Sanhilo (DON 2017b). *S. aculeata* is confirmed to be present in the Mariana Islands, but has not been observed on Tinian.

Pavona diffluens is present on Tinian (DON 2017b). The NMFS Final Listing Determination specifically states that the listing applies to the species called *P. diffluens* in the Indian Ocean and Red Sea (NMFS 2014a). The Final Listing Determination stated that corals fitting the description of *P. diffluens* in the Pacific are a different species. The specimens observed on Tinian were rare, and were conspicuously identifiable as the *Pavona* described in Randall and Meyers (1983). There is insufficient morphological evidence to make a distinction between the "local" *P. diffluens* and the federal ESA-listed threatened *P. diffluens*, consequently it is not considered to be subject to the ESA.



***Acropora globiceps* (background), federally ESA-listed threatened, is relatively common in the Mariana Islands. *Acropora* aff. *humilis* (foreground) is sometimes confused with *A. globiceps*, but when side-by-side their distinguishing characteristics are easier to discern. Photo from Atgidon on Tinian.** (*Photo*: V. Bonito)

11.3.7.2 Fishes

Scalloped Hammerhead Shark

The ESA lists six DPSs for the scalloped hammerhead. The Indo-West Pacific DPS is listed as threatened and includes the Mariana Archipelago (NMFS 2014b). The International Union for Conservation of Nature Red List considers this shark endangered. Scalloped hammerheads are the second largest hammerhead shark species and reach a length of at least 13 feet (4 meters). There are no records of scalloped hammerheads being sighted or caught off Tinian. Scalloped hammerheads are found worldwide in tropical and temperate seas; therefore, these sharks could occur on Tinian although the island lacks much shallow soft substrate, which is their preferred habitat when they move inshore.

Humphead Wrasse and Bumphead Parrotfish

Two bony fishes occurring in the Mariana Archipelago are listed as species of concern by NMFS: the Napoleon or humphead wrasse (*Cheilinus undulatus*) and the bumphead parrotfish (*Bolbometopon muricatum*) (NMFS 2015a, 2015b). The humphead wrasse is also CNMI-designated as SOGCN (Liske-Clark 2015). No recent reports of bumphead parrotfish were found in surveys or literature from Tinian, and they are exceptionally rare north of Rota. Neither of these species was observed during surveys at three locations around Tinian in 2009; however, juvenile and small adult humphead wrasse were observed off the west coast of Tinian (DON 2014c; NAVFAC Pacific 2018a). These fish are sought after by spearfishers; although spearfishing with scuba gear is banned in the CNMI. Anecdotal reports suggest that it continues to occur, which removes potential depth refuges for these large fish where taking is confined to only breath-hold diving (Lindfield et al. 2014).

11.3.7.3 Sea Turtles

Green Sea Turtle and Hawksbill Turtle



Green sea turtle (*Chelonia mydas*) feeding on macroalgae (mostly *Halimeda* spp., *Dictyota* spp., and red turf algae) at the base of a digitate coral (*Stylophora pistillata*). About 6 meters depth near Puntan Atgidon on Tinian.
(*Photo*: M. Lybolt)

Two species of sea turtles have been sighted on Tinian; the green sea turtle and the hawksbill turtle. Hawksbills are federal ESA-listed as endangered, worldwide. The Central West Pacific DPS of green sea turtles present within the Mariana Archipelago is also federal ESA-listed as endangered. Compared to green sea turtles, hawksbill turtles do not occur in large numbers anywhere within the Mariana Islands (NMFS and USFWS 2007; Martin and Jones 2016) except possibly around Rota. The waters of Rota have been recently shown to support hawksbill turtles in greater numbers than around Saipan (Summers et al. 2017).

Surveys that employed a variety of means for visually detecting sea turtles were conducted on Tinian during the summer of 2013 (DON 2014b). Scientists conducted towboard surveys behind a small boat, snorkel surveys, scuba surveys, and scan surveys from the cliffline. All parts of the island were covered to some degree by at least one survey method, but some survey methods, such as towboard surveys, could not be implemented safely off some parts of the island.

Observations made during cliffline surveys were primarily of green sea turtles (DON 2014b). Only 2% of the turtles sighted were hawksbill turtles and they were all juveniles seen off the southern tip of the island. Of the green sea turtles observed, the majority were juveniles (74.7%). Subadults comprised 19.9% of the observed green sea turtles and adults comprised only 4.8%. Out of seven adult sightings, only two of the adults were identifiably females. Notably, adult green sea turtles were observed only at the south end or the northeast side of the island.

Data from towboard surveys provided a similar pattern for green sea turtles (DON 2014b): most of the observations were of juvenile turtles (95%) seen all around the island (except the southeast quadrant which could not be surveyed with the towboard method). Subadults were the next most plentiful demographic group at 3.75% of the observations. A single adult male off Unai Dankulo comprised 1.25% of the observations. Compared to the cliffline surveys, a relatively large percentage of all turtle observations made by towboard were hawksbill turtles (13%). They were all observed on the west side of the island south of Puntan Lamanibot.

Using the survey methods above, two population estimates were able to be calculated for Tinian (DON 2014b). Overall, it was estimated that approximately 850 to 1,200 sea turtles occurred off Tinian in 2013. Table 11-10 has a summary of the methods and how the populations break down by sector of the island. Note that while satellite tracking records indicate inter-island travel by green and hawksbill turtles (Jones et al. 2015), these few records are insufficient to extrapolate archipelago populations from island-specific populations.

Table 11-10. Sea Turtle Population Estimates by Island Sector for Tinian Summer 2013

Island Sector	*Cliffline Survey Population*	*Towboard Survey Population*
Northwest	43	24
Northeast	119	43
East	77	63
Southeast	206	Not surveyed
Southwest	Not surveyed	467
West	266	42
Subtotal	**711**	**639**
Population estimates for sectors not surveyed	**467**	**206**
Total	**1,178**	**845**

Source: DON 2014b.

During sea turtle surveys and satellite tagging operations in July 2014, a total of five sub-adult green sea turtles and three sub-adult hawksbill turtles were captured along the western side of Tinian in Lamanibot Bay and the area just south known as Fleming Point (Jones et al. 2015). One green sea turtle and two hawksbill turtles were equipped with satellite tags to track their movements. The tagged hawksbill turtles made long range movements with one turtle leaving Tinian and now residing off southern Guam in the Cocos Lagoon region (migration covered a distance of 178 miles [286 kilometers] and lasted 7 days). The other hawksbill headed eastward along the northern edge of FDM. Dive patterns suggest that both hawksbill and green sea turtles remain in deeper waters during the day and move nearshore during the night. Hawksbill turtles spent more time in deeper waters than the green sea turtles, reaching depths of 330 feet (100 meters) or more. Green sea turtle average depth was less than 33 feet (10 meters) for day and night (Jones et al. 2015).

11.3.7.4 Marine Mammals

All marine mammals are protected under the Marine Mammal Protection Act (MMPA).

Spinner Dolphins

Spinner dolphins (*Stenella longirostris*) are frequently sighted around Tinian during NMFS Pacific Islands Fisheries Science Center's (PIFSC) cetacean surveys (Hill et al. 2014, 2015, 2016, 2017). During the 2013 and 2016 NMFS PIFSC cetacean surveys, spinner dolphins were sighted within JRM submerged lands (Hill et al. 2014, 2017). In 2008, spinner dolphins, spotted dolphins (*Stenella attenuata*) (identified tentatively), and pilot whales (*Globicephala macrorhynchus*) were observed from the surface during marine resource surveys around Tinian (Minton et al. 2009).



Spinner dolphins (*Stenella longirostris*) are frequently sighted around Tinian. Background: Saipan.
(*Photo*: P. Zuloaga)

Common Bottlenose Dolphins

During the 2013, 2014, and 2015 NMFS PIFSC cetacean survey, common bottlenose dolphins (*Tursiops truncatus*) were sighted within Tinian waters (Hill et al. 2014, 2015, 2016). Satellite tagged animals in 2013 used the waters within JRM submerged lands (Hill et al. 2014).

Pantropical Spotted Dolphins

During the 2013 NMFS PIFSC cetacean survey, pantropical spotted dolphins (*Stenella attenuata*) were sighted in waters offshore Saipan and Tinian (Hill et al. 2014).

Short-finned Pilot Whales

In 2008, short-finned pilot whales (*Globicephala macrorhynchus*) were observed from the surface during marine resource surveys around Tinian (Minton et al. 2009). During NMFS PIFSC's 2013 cetacean surveys, short-finned pilot whales were sighted within the waters offshore Saipan and Tinian, and satellite tagged animals used the waters within JRM submerged lands (Hill et al. 2014).

Rough-toothed Dolphins

In 2013, rough-toothed dolphins (*Steno bredanensis*) were sighted offshore Saipan and Tinian and one was tagged offshore of Aguiguan; over the next 2 weeks, the tagged dolphin swam through JRM submerged lands multiple times off the west coast of Tinian (Hill et al. 2013, 2014).

False Killer Whales

A false killer whale (*Pseudorca crassidens*) tagged in 2013 spent time in JRM submerged lands (Hill et al. 2014). The 2014 NMFS PIFSC cetacean survey also sighted false killer whales near Tinian (Hill et al. 2015).

Pygmy Killer Whales

In 2011 a group of pygmy killer whales (*Feresa attenuata*) were sighted off Marpi Reef off the northwest side of Saipan (Hill et al. 2016). This species was not observed in JRM submerged lands off Tinian, but occurrence is possible.

Blue Whales

Acoustic equipment has recorded the presence of blue whales (*Balaenoptera musculus*) in the waters around Tinian; however, it is not known if they were within JRM submerged lands (Klinck et al. 2015, 2016; Oleson et al. 2015).

Fin Whales

Acoustic equipment has recorded the presence of fin whales (*Balaenoptera physalus*) in the waters around Tinian; however, it is not known if they were within JRM submerged lands (Klinck et al. 2015, 2016; Oleson et al. 2015).

Humpback Whales

Acoustic equipment has recorded the presence of many humpback whales (*Megaptera novaeangliae*) in the waters around Guam and CNMI, especially in the waters south of Guam and southeast of Tinian (Klinck et al. 2015, 2016; Oleson et al. 2015). One humpback whale was sighted 9 miles (15 kilometers) off the northeast coast of Saipan in 2007 (Fulling et al. 2011) and more recently in 2015 four humpback whale mom/calf pairs and four other humpback whales were sighted off the west coasts of Saipan and Tinian (Hill et al. 2016).

Sei Whales

Sei whales (*Balaenoptera borealis*) were sighted during the 2007 Mariana Islands Sea Turtle and Cetacean Survey. All confirmed sightings of sei whales were south of Saipan (Fulling et al. 2011). Acoustic equipment has recorded the presence of sei whales in the waters around Tinian; however, it is not known if they were within JRM submerged lands (Klinck et al. 2015, 2016; Oleson et al. 2015).

Sperm Whales

During a small boat survey around Guam and Saipan in February and early March of 2010, there were two sperm whale (*Physeter macrocephalus*) sightings: (1) a group of nine animals off Orote Point, Guam, inshore from the 1,640 feet (500 meters) isobath; and (2) a group of six animals northwest of Saipan in waters greater than 3,281 feet (1,000 meters) deep (Ligon et al. 2011). A group of 10 sperm whales was also sighted during small boat surveys off western Guam in waters approximately 3,940 feet (1,200 meters) deep in March 2012 (NAVFAC Pacific 2012). The sperm whale was the most frequently sighted cetacean (21 sightings) during the 2007 survey with acoustic detections almost three times higher (61) than visual detections in the field (Fulling et al. 2011). Passive-acoustic glider surveys in 2015 confirmed the presence of sperm whales around Tinian (Klinck et al. 2015, 2016).

Blainville's Beaked Whales

During the 2015 NMFS PIFSC cetacean survey, a single group of Blainville's beaked whales (*Mesoplodon densirostris*) (one adult male with three or four females/juvenile males) were sighted off Rota (Hill et al. 2016). Blainville's beaked whales were also seen near Rota during the NMFS PIFSC cetacean survey in 2014. (Hill et al. 2015). Blainville's beaked whales have also been acoustically recorded near Tinian and are therefore assumed to use JRM submerged lands (Oleson et al. 2015).

Risso's Dolphins

Passive-acoustic glider surveys in 2014 and 2015 confirmed the presence of Risso's dolphins (*Grampus griseus*) to the east of Saipan (Klinck et al. 2015, 2016). This species was not observed in JRM submerged lands off Tinian, but occurrence is possible.

Common Minke Whales

Passive-acoustic glider surveys in 2015 confirmed the complex, amplitude-modulated calls of the common minke whale (*Balaenoptera acutorostrata*) during a survey near the Mariana Trench southeast of Guam (Klinck et al. 2016). This species was not observed in JRM submerged lands off Tinian, but occurrence is possible.

Killer Whales

Passive-acoustic glider surveys in 2014 confirmed the presence of killer whales (*Orcinus orca*) around and to the south of Guam (Klinck et al. 2015). This species was not observed in JRM submerged lands off Tinian, and occurrence is possible but unlikely.

Bryde's Whales

Three Bryde's whales (*Balaenoptera edeni*) were sighted between Rota and Guam during the 2015 NMFS PIFSC cetacean survey with species identification confirmed by photos (Hill et al. 2016). This species was not observed in JRM submerged lands off Tinian, but occurrence is possible.

Cuvier's Beaked Whales

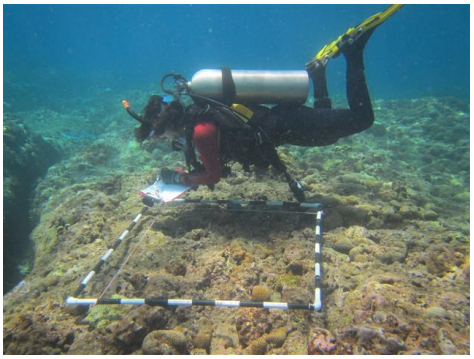
In the 2014 NMFS PIFSC cetacean survey, a confirmed sighting of a Cuvier's beaked whale (*Ziphius cavirostris*) occurred 12 miles (19 kilometers) off the west side of Saipan in 5,577 feet (1,700 meters) deep water (Hill et al. 2015). Cuvier's beaked whales have also been acoustically recorded near Tinian and are therefore assumed to use JRM submerged lands (Oleson et al. 2015).

Dwarf Sperm Whale and Pygmy Sperm Whale

A dwarf sperm whale (*Kogia sima*) stranded in the Saipan Lagoon in 1993, and a pygmy sperm whale (*Kogia breviceps*) stranded in the Saipan Lagoon in 1997 (Trianni and Tenorio 2012). These species are not listed in confirmation tables, but these events suggest presence in or near JRM submerged lands.

11.3.8 Marine Resources Monitoring

The NMFS Ecosystem Sciences Division (formerly Coral Reef Ecosystem Division) conducts extensive physical, chemical, and biological surveys around all 50 U.S. Flag Pacific Islands, including Tinian. Those surveys are generally referred to as the Pacific RAMP surveys. The Pacific RAMP program provides the most comprehensive survey for obtaining long-term data on marine resources on Tinian. The Pacific RAMP surveys are conducted every 3 years; with the most recent conducted in May 2017. Repeated, localized surveys (more limited in scope) would enable JRM to detect potential changes in a timely manner and allow JRM to implement adaptive management techniques as appropriate. Existing long-term monitoring programs implemented by CNMI DLNR and the CNMI NOAA offices provide added baseline information. Isolated surveys such as Minton et al. (2009) and DON (DON 2014c, 2017b) can complement baseline monitoring data. Lastly, establishing a rapid response capability to conduct limited surveys would enable JRM to respond and make appropriate management decisions when changes have the potential to occur or have been initially detected.



The outer reef crest at Unai Babui on Tinian in July 2013.
(*Photo*: V. Bonito)



The same section of outer reef crest at Unai Babui on Tinian in April 2017. After multiple years of severe bleaching, most corals are dead and the remnant community is dramatically different.
(*Photo*: M. Lybolt)

11.4 Management Goals, Objectives, Strategies, and Actions

JRM currently manages natural resources based on an ecosystem focused approach that involves the implementation of several ongoing management projects. These projects, which are described in the following sections, provide examples of JRM's current efforts to manage and enhance natural resources in a manner consistent with the military mission. Appendix C lists management projects on Tinian for FY14-17. The following sections present management projects for Tinian that have been identified as necessary to achieve applicable goals and objectives identified in Chapter 3, *Environmental Management Strategy and Mission Sustainability*.

Management projects identified for Tinian provide direct support for the military mission and the goal of "no net loss" in a number of ways. For example, projects that improve the baseline status of species or their habitat, show that populations are stable, or that habitat is improving or expanding may relieve restrictions on military training or operations, minimize costs and mitigation requirements, avoid workarounds, and/or streamline regulatory processes.

11.4.1 Terrestrial Ecosystem Management

Tinian's native terrestrial habitats have been impacted by historical activities, introduction and spread of invasive and non-native species, effects of climate change, and the resulting loss of functions necessary to

support healthy native habitats. Ecosystem functions have been disrupted by the extirpation of native animal and plant species which has resulted in both economic and cultural impacts on the ecosystem services provided by native habitats. The occurrence of healthy native habitats on Tinian is necessary to support sustainability of native species including federal and CNMI ESA-listed species. JRM recognizes that restoration and enhancement of native habitats on lands that they manage is a long-term process, and that adaptive management is key to long-term success of the program.

Management projects are monitored and evaluated annually to ensure that they are meeting identified goals and objectives. JRM will establish mid-year coordination meetings with resource partners to discuss ongoing and planned projects, including prioritization, scope, methodology, issues or challenges, timelines, and performance evaluation criteria. These discussions are intended to facilitate improved coordination and information sharing to allow for course corrections, if necessary, to ensure an adaptive approach.

Terrestrial ecosystem management, as described in the following sections, is expected to: (1) improve the status of threatened and endangered species through habitat conservation and enhancement, and (2) promote health and sustainability of native forests. Healthy ecosystems will, in turn, relieve or reduce environmental constraints and allow for maximum operational flexibility for supporting the readiness of U.S. and allied troops.

A summary of the management projects and the estimated timeframe for completion is presented in Table 13-12, *Planned Implementation Summary of Projects on Tinian*, found in Chapter 13, *Planning, Integration, and Implementation*. Some of the projects described in this section are being accomplished through interactive partnerships with federal and territorial natural resource agencies (e.g., CNMI DFW), universities, and local organizations.

11.4.1.1 Terrestrial Habitat Management

JRM has ongoing and planned projects to restore and enhance native terrestrial habitats. These projects focus on improving the quality and availability of appropriate habitat for listed species, as well as increasing the quality and health of existing native habitats, such as limestone native forests. Numerous related activities are required for native habitat improvement, such as control of ungulates and other invasive species, propagating and outplanting native plant species to improve diversity, and addressing forest health issues, such as improvement of seed dispersal.

In order to achieve long-term goals, terrestrial habitat management requires successful daily and short-term management coupled with long-term planning and investment. To ensure that JRM continues to meet the overriding goal of restoring and enhancing terrestrial habitats for native species (including listed species) over the long term, JRM site land managers and resource agencies will continue coordinating on natural resource management.

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial Habitat Management (THM) on Tinian.

THM-1: FOREST ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-6; and Goal #3, Objectives #1-2 and 4.

- *Strategy*: Enhance and restore native forest habitat on Tinian to benefit native flora and fauna including the Tinian monarch, protected species, and CNMI SOGCN.
- *Action*: Develop and implement site-specific, detailed plans to enhance existing native limestone forest, or to restore forest contiguous with existing native limestone forest. Enhancement/

restoration may include removal of non-native invasive plants and outplanting, establishment, and maintenance of native tree species.

- *Action*: Develop and test vegetation management methods to enhance the value of tangantangan forest habitat for Tinian monarch and protected species, such as interplanting with native trees or invasive plant control.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

11.4.1.2 Terrestrial Exotic and Invasive Species Management

An invasive species is defined in Executive Order (EO) 13112, *Invasive Species*, as a species that is non-native (i.e., alien or exotic) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm, or harm to human health. Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions. Invasive species have had a catastrophic effect on the native flora and fauna of island ecosystems within the Mariana Archipelago. Attributes of island biota include small geographic ranges and population size, low reproductive rates, and lack of the ability to respond to invasive species and disturbed habitats. Islands typically have lower numbers of species than mainland areas, which results in fewer predators and competitors that could prohibit the establishment of invasive species. As a result of evolving in isolation, island plants and animals have few defenses when exposed to introduced competitors and predators. These limitations on Tinian have caused exotic and invasive species to replace native island species (Wiles et al. 2003).

Many of the native species on Tinian are threatened due to introduced predators, such as feral cats and dogs, and introduced ungulates, such as goats and cattle, which have significantly affected native vegetation communities. Rats, mice, and Asian house shrews have colonized the island, preying on the eggs and young of native species and destroying native flora (i.e., seeds and seedlings). Although not present on Tinian, the BTS represents a serious threat should interdiction efforts fail and the species reaches the island.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Terrestrial Exotic and Invasive Species Management (TIS) on Tinian.

TIS-1: IMPLEMENTATION OF REGIONAL BIOSECURITY PLAN FOR MICRONESIA AND HAWAI'I

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #3; Goal #3, Objectives #1-2 and 4; Goal #4, Objectives #1-4; and Goal #7, Objective #1.

- *Strategy*: Implement appropriate recommendations within the Regional Biosecurity Plan (RBP) (DON 2015d) that will reduce the risk of introduction and spread of invasive species on Tinian.
- *Action*: Develop standard language for biosecurity BMPs, update as necessary, to be included in project specifications that support prevention, such as vegetation management, and cleanliness standards for materials and equipment operating on the installation.
- *Action*: Conduct early detection surveys (EDS) for high-risk invasive species in training areas; at facilities for staging, storage, and movement of cargo/equipment and vehicles, and at other locations as deemed necessary.
- *Action*: Review and update, as appropriate, DoD Attachment M of the RBP every 3 years.
- *Action*: Develop, implement, and update (as necessary) a JRM biosanitation instruction to ensure cleanliness standards are adhered for the movement of cargo and equipment.

- *Action:* Continue to develop high-risk invasive species protocols and implement control and/or eradication measurement when necessary.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

TIS-2: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #2-4; Goal #3, Objectives #1 and 4; and Goal #4, Objectives #1-4. This project supports conservation measures from the BO for the MITT Program (2015 MITT BO) (USFWS 2015b).

- *Strategy*: Implement biosecurity conservation measures listed in the 2015 MITT BO from USFWS.
- *Action*: Ensure 100% redundant inspection in Guam and Tinian for administrative and logistical training exercises using qualified BTS personnel, including canine inspection teams for all aircraft, cargo, and equipment.
- *Action*: Ensure for tactical training exercises, to the maximum extent practicable, inbound personnel and cargo are routed directly to the CNMI and Tinian. If Guam cannot be avoided for tactical approaches, JRM will work with USFWS to identify and implement appropriate interdiction methods such as multiple, redundant inspections and barrier use in Guam. In addition, JRM will ensure tactical approach exercises will involve only cargo/equipment that has not originated from areas containing a BTS population or will be 100% inspected by qualified BTS canine detection programs.
- *Action*: During training activities, establish snake-free quarantine areas (barriers) as deemed necessary for cargo/equipment arriving to Tinian from Guam.
- *Action*: Ensure BTS awareness briefings for all military and contractor personnel prior to all MITT training activities on Tinian.
- *Action*: Maintain invasive species rapid response capabilities to control and/or eradicate introduced non-established, non-native invasive species sighted in vicinity of DoD training areas and facilities used for staging, storage, and movement of military personnel, cargo, and vehicles associated with training activities.
- *Action*: Ensure training event personnel conduct biosecurity self-inspections of all personal gear and hand carried items to avoid potential introduction of invasive species to and from Tinian. Self-inspection will ensure the removal of soil accumulations, seeds, invertebrates, and vertebrates.
- *Action*: Ensure all training events adhere to the Armed Forces Pest Management Board Technical Guide No. 31 (AFPMB TG-31) cleanliness standards for all cargo/equipment, containers, and rolling stock arriving from off-island destinations and departing Tinian for off-island destinations via inspections as deemed necessary.
- *Action*: Implement high-risk invasive species protocols for the control and/or eradication for high-risk species as species are identified.
- *Action*: Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

11.4.1.3 Terrestrial Protected Species Management

Management of terrestrial threatened and endangered species on JRM leased lands includes implementing programs to protect species and coordinating efforts with the appropriate agencies. Key threats to threatened and endangered species that can lead to extirpation include:

- predation by feral cats, rats, and monitor lizards on birds, bats, and sea turtles;
- human disturbance and poaching of sea turtles and Mariana fruit bats;
- mortality or injury to native plants and wildlife due to natural events (e.g., typhoons) and wildfire;
- low reproductive success due to small population numbers;
- habitat loss and fragmentation; and
- risk of accidental introduction of BTS and other invasive species.

To address these key threats to listed species, JRM has conducted and continues to conduct monitoring and management. For example, JRM conducts quarterly surveys for moorhen at Lake Hagoi and Bateha wetlands, long-term forest bird monitoring, monthly surveys for sea turtle nesting at beaches within the MLA, and deployment of satellite transmitters on sea turtles to better understand migratory behavior. Additionally, JRM collects data on evidence of poaching, nest depredation, genetic sampling, hatching and emergence success of sea turtles, and collaborates with local partners to implement beach clean-ups to remove marine debris from known nesting beaches. To reduce the risks of further introductions of invasive species, JRM implements a comprehensive biosecurity control program in coordination with local and federal partners during military training and construction activities on Tinian. In accordance with section 7 of the ESA, a federal agency shall consult with the USFWS to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species. JRM will coordinate with the USFWS for any federal action that is within JRM leased lands and is identified as providing habitat for threatened or endangered species. In addition, the DON will avoid, as the mission allows, impacts on habitat suitable for threatened and endangered species, and locally rare, and CNMI-listed species.

Sensitive species are being managed by implementing specific management projects that enhance habitat for these species and by initiating specific strategies that address immediate needs of listed species on the island. In addition, adherence to the goals set for threatened and endangered species management ensure that JRM remains in compliance with ESA and associated consultation requirements.

To meet the goals and objectives of the INRMP, a suite of management strategies was identified for terrestrial protected species management on Tinian. Additional protection measures for Terrestrial Protected Species Management (TPS) are presented in Section 11.4.1.6, *Terrestrial Natural Resources Law Enforcement*.

TPS-1: CONSERVATION MANAGEMENT OF TINIAN *CYCAS MICRONESICA* PLANTINGS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objectives #1 and 3-6; Goal #3, Objectives #1-2 and 4; and Goal #4, Objective #2-3.

- *Strategy*: Maintain outplanted C. *micronesica* to conserve genetic diversity as a source for potential Guam reintroductions.
- *Action*: Monitor the health and survivorship of C. *micronesica* outplants.
- *Action*: Monitor and manage pests and other stressors that contribute to C. *micronesica* mortality or represent a biosecurity risk (e.g., *A. yasumatsui* scale).

- *Action*: Manage viability of *C. micronesica* through assisted pollination and dispersal.
- *Action:* Collaborate with other ex situ population managers to support conservation of overall species genetic diversity.
- *Action*: Manage competing plants as necessary using physical, mechanical, and chemical methods.
- *Action*: Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

TPS-2: SEA TURTLE POPULATION PROTECTION AND ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-6; Goal #3, Objectives #1-2 and 4; and Goal #6, Objective #1.

- *Strategy*: Monitor and protect sea turtles on Tinian to maintain habitat and improve nesting success.
- *Action*: Monitor sea turtle nesting at the 18 beaches on JRM leased lands, including Unai Chulu, Unai Lam Lam, Unai Babui, Unai Chiget and Unai Masalok, and the 13 separate pocket beaches within Unai Dankulo. Monitoring will be conducted twice monthly throughout the year. Collect data on sea turtle nesting activity, evidence of poaching, nest depredation, and hatching and emergence success. Genetic sampling will be conducted to determine population origins.
- *Action*: Protect nesting female turtles and nests through prevention of beach driving, coordination with conservation law enforcement on poaching and beach driving incidents, and development of parking and picnicking infrastructure at Unai Dankulo to direct activity to low-risk areas.
- *Action*: Enhance sea turtle nesting success by removing marine debris from all MLA beaches at least once annually.
- *Action*: Fund a JRM sea turtle recovery coordinator position to coordinate sea turtle monitoring and recovery efforts across Navy lands and submerged lands and coordinate with INRMP partners (DoD, Territory agencies, NOAA Fisheries, and USFWS) to align JRM sea turtle actions with other efforts in the Marianas and improve coordination of sea turtle projects.
- *Action:* Continue nesting surveys (twice a week minimum during peak nesting season) and conduct additional surveys to identify additional nesting beaches or assess status of known nesting areas on JRM lands.
- *Action:* Mitigate any light pollution or predation that might be affecting nesting habitats.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

TPS-3: CONSERVATION OF MARIANA COMMON MOORHEN

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-6; Goal #3, Objectives #1-2 and 4; Goal #4, Objective #2; and Goal #7, Objective #3.

- *Strategy*: Manage Mariana common moorhen populations and wetland habitat to maintain or increase populations.
- *Action*: Implement a comprehensive population and habitat monitoring program to track long-term trends, including 1) population monitoring at Lake Hagoi and priority wetlands, 2) nesting activity and productivity monitoring at Lake Hagoi, 3) vegetation community mapping and monitoring of

Lake Hagoi and priority wetlands, 4) invasive plant monitoring at Lake Hagoi, 5) hydrologic monitoring at Lake Hagoi and priority wetlands using data loggers or depth gauges.

- *Action*: At least once every 10 years, review and update the Lake Hagoi Wetland Management Plan. Implement the Plan at Hagoi and expand the geographic scope to include other MLA priority wetlands as appropriate.
- *Action*: Coordinate with conservation partners to share methods for consistency in approach range-wide.
- *Action*: Determine impacts of invasive predators (e.g. rats and feral cats) on the Lake Hagoi population. Design and implement predator control to enhance moorhen survivorship and nesting success.
- *Action:* Enhance and restore wetland habitat to benefit native flora and fauna including Mariana common moorhen, other protected species, and CNMI SOGCN.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

TPS-4: CONSERVATION OF FOREST BIRDS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; and Goal #3, Objectives #1-2 and 4.

- *Strategy*: Monitor the long-term population trend and manage threats to Tinian monarch, Micronesian megapode, and other native forest birds to enhance and conserve populations.
- *Action*: Conduct playback surveys twice annually, consistent with previous methods to detect Micronesian megapode presence. Develop and implement acoustic monitoring methods to replace or augment playback surveys.
- *Action*: Evaluate existing monitoring methods and implement systematic forest bird monitoring allowing comparability with historic data and optimized to detect changes in Tinian monarch population trends.
- *Action*: Develop and implement cost-effective forest management and invasive vertebrate control to enhance and conserve Tinian monarch and Micronesian megapode populations.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

TPS-5: CONSERVATION OF PROTECTED PLANTS, INVERTEBRATES, AND REPTILES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; and Goal #3, Objectives #1-2 and 4.

- *Strategy*: Improve knowledge of the distribution and status of *Dendrobium guamense*, *Heritiera longipetiolata*, humped tree snail, *Birgus latro*, and Micronesian gecko to enable conservation of extant populations.
- *Action*: Conduct surveys for protected plants, invertebrates, and reptiles on JRM leased lands to identify new populations.
- *Action*: Monitor and study known populations of plants, invertebrates, and reptiles to understand site-specific threats and habitat requirements. Manage site-specific threats as needed.
- *Action*: Determine the abundance and distribution of humped tree snail predators (i.e., rats and New Guinea flatworm) on JRM leased lands.

- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

TPS-6: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal # 2, Objective #4; and Goal #3, Objectives #1-2 and 4. This project supports conservation measures from the 2015 MITT BO (USFWS 2015b).

- *Strategy*: Implement conservation measures listed in the 2015 MITT BO from USFWS.
- *Action*: Ensure no disturbance of sea turtle nests and nesting turtles via (1) conducting pre-exercise surveys no more than 6 hours prior to training activities; (2) directing landing crafts to areas determined to be clear of sea turtles and sea turtle nests; (3) restoring beach topography using hand tools after exercises, as necessary; (4) use of an environmental monitor on site during night-time landing and training activities; (5) identifying any potential sea turtle nests and implementing a buffer zone based on criteria outlined in the BO.
- *Action*: Ensure all training activities are consistent with the fire management plan in Commander Naval Forces Marianas (COMNAVMAR) Instruction 3500.4A (Marianas Training Manual) (COMNAVMAR 2013).
- *Action*: Ensure Hagoi, Bateha and Mahalang "No Training Areas" are implemented to avoid impacts to Mariana common moorhen. Ensure no ground disturbance or vegetation removal in these designated "No Training Areas."
- *Action*: Ensure aircraft overflight restrictions are implemented over Tinian moorhen habitat areas (Hagoi, Bateha, Mahalang). During training exercises, aircraft must maintain a minimum of 1,000 feet (300 meters) above ground level to minimize visual and noise disturbance for Mariana common moorhens and to reduce the potential for aircraft strike.
- *Action*: Ensure aircraft overflights are restricted over limestone native forest areas of Tinian, which are found within the Tinian MLA along ridgelines in the Mount Lasso area. If aircraft must fly over limestone native forest during training exercises, the aircraft must fly at a minimum of 1,000 feet (300 meters) above ground level to minimize visual and noise disturbance of Micronesian megapodes and Mariana fruit bats and to reduce the potential for aircraft strike.
- *Action*: Ensure training does not occur in limestone native forests along the ridgelines associated with Mount Lasso to avoid impacts to the Micronesian megapode and other locations where listed species are known to occur.
- *Action*: Vegetation removal shall be limited to the maintenance of existing bivouac areas that do not contain listed species or habitat. No new bivouac areas are proposed under MITT. Maneuver units will remain tactical and not establish support camps in order to avoid and minimize impacts associated with ground maneuvers on listed species on Tinian.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

TPS-7: MARIANA FRUIT BAT CONSERVATION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-4; Goal #3, Objectives #1 and 4.

- *Strategy*: Monitor and manage Mariana fruit bat populations and habitat on the Tinian MLA.

- *Action:* Conduct an annual Tinian bat count in collaboration with conservation partners.
- *Action:* Monitor colonies at least once monthly in accordance with established survey protocols. If changes in roost locations, colony size, or movement are detected, investigate potential threats or stressors that may be causing disturbance.
- *Action:* Conduct bimonthly surveys of fruit bat sign (i.e. ejecta or scat) over at least 3 years to understand the temporal and spatial distribution of habitat use across the MLA
- *Action:* Investigate fruit bat diet, including food preferences, nutritional value, and seasonality to guide forest restoration and enhancement.
- *Action:* Assess the threat of poaching (e.g. acoustic monitoring of gunshots, social sciences study, etc.).
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

11.4.1.4 Migratory Bird Management

JRM manages and monitors the effects that both military readiness and non-readiness activities have on migratory bird species and populations. Relevant regulations and policies include the Military Readiness Rule (50 Code of Federal Regulations [CFR] 21.15); the 2014 Memorandum of Understanding (MOU) between the DoD and USFWS to Promote the Conservation of Migratory Birds; and EO 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*. Through the implementation of the INRMP, proper management of migratory bird species and habitats, including the timely implementation of appropriate conservation practices, will help JRM avoid or minimize impacts to migratory birds.

To meet the goals and objectives of the INRMP, the following management project was identified for Migratory Bird Management (MIG) on Tinian.

MIG-1 MANAGEMENT OF MBTA-LISTED BIRD SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1-2 and 4; and Goal #6, Objectives #1.

- *Strategy*: Improve understanding of MBTA-listed bird habitat use on JRM leased lands and bird/mission interactions to avoid and/or minimize effects of takes on MBTA-listed birds.
- *Action*: Monitor the status and location of nesting aggregations (colonies) of MBTA-protected species at least once every 5 years.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

11.4.1.5 Terrestrial Natural Resources Educational Outreach

Conservation awareness is instrumental in creating conditions needed to manage natural resources. The JRM approach to awareness stresses education. It provides military personnel and the public with insights into natural environments and conservation challenges. The more educated people are about the unique and valuable natural resources on JRM leased lands, the more responsibly they will act when using them. Education also promotes awareness of critical environmental projects and the rationale behind them. Activities such as habitat management, wildlife management, and land rehabilitation are generally accepted and understood, therefore minimal effort is required to communicate conservation priorities to installation personnel, recreationists, and the general public. However, issues such as protection of sensitive areas for

plant and wildlife species, invasive species management (ungulate management), wildfire suppression, and restrictions on some recreational activities in JRM leased lands require effective conservation communication to garner positive support and, perhaps more importantly, to avoid adverse reactions from various users. A conservation awareness program must be directed to both JRM and external interests if it is to be effective.

To meet the goals and objectives of the INRMP, the following project was identified for Terrestrial Natural Resources Educational Outreach (TEDU) on Tinian. This management project is in line with the management project identified and discussed in Section 11.4.2.4, *Marine Natural Resources Educational Outreach*.

TEDU-1: JRM NATURAL RESOURCES STEWARDSHIP OUTREACH AND ENGAGEMENT PROGRAM

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7; Objectives #1-3.

- *Strategy*: Ensure that all incoming military personnel receive comprehensive natural resources indoctrination training about the federal, territorial, and environmental regulations and policies applicable to the Tinian MLA, as well as information about the importance of protecting and conserving JRM's natural resources, in cooperative efforts with partners, such as USFWS.
- *Action*: Develop a comprehensive Natural Resources Stewardship Outreach online training system for military and civilian personnel.
- *Action*: Create a JRM Environmental Engagement Plan to outline the areas where JRM can significantly increase their outreach with military personnel about appropriate behavior toward threatened and endangered species and the importance of conserving natural resources within JRM leased lands and submerged lands.
- *Action*: Utilize partnerships with the USCG and Naval Mobile Construction Battalions (SeaBees) during joint training exercises to minimize costs and to raise awareness within military personnel of the importance of maintaining the beaches to protect threatened and endangered species and other marine and terrestrial natural resources.
- *Action*: Develop, update, and implement a biosecurity education and outreach program for contractor personnel, military personnel, and dependents.

11.4.1.6 Terrestrial Natural Resources Law Enforcement

JRM has established the following objectives for enforcement: (1) enforce laws and regulations pertaining to the implementation of the natural resources program, (2) integrate natural resources enforcement into the overall natural resources program, and (3) use enforcement personnel to enhance the natural resources program at JRM.

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial Natural Resources Law Enforcement (TLAW) on Tinian.

TLAW-1: CONSERVATION LAW ENFORCEMENT PROGRAM

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-3; Goal #2, Objectives #1-2 and 4; Goal #3, Objective #4; Goal # 6, Objectives #1-2; and Goal #7; Objectives #1-3.

- *Strategy*: Detect and deter unauthorized activity that negatively affects natural resources on Tinian (e.g., poaching, off-roading) through conservation law enforcement.
- *Action*: Establish a Conservation Law Enforcement Program by hiring a Conservation Law Enforcement Officer, and by collaborating with other agencies as applicable, to enforce natural resource laws, policies, and regulations on Tinian. The Conservation Law Enforcement Officer will conduct outreach and enforce natural resource regulations.
- *Action*: Protect sea turtles from poaching on nesting beaches and submerged lands.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

11.4.1.7 Terrestrial Geographic Information System and Data Management

Natural resources data are stored and maintained within a centralized JRM Geographic Information System (GIS) database. The GIS database provides support for the entire environmental program and the training community. JRM uses the GIS for complex analyses such as project siting, data interpolations, and risk assessments.

GIS software enables JRM staff to capture, store, update, manipulate, analyze, and display all forms of geographically referenced data and tabular information about natural and physical resources found on JRM leased lands. The training of JRM staff and the allocation of their time to data entry, mapmaking, data analysis, and interpretation of the results determine the success of JRM's GIS. Once fully developed, the GIS databases can be used for projects such as the following:

- providing maps with locations of species, vegetation communities, surface waters, and other areas of potential concern
- selecting suitable areas for construction activities
- planning land rehabilitation projects
- providing special maps for Environmental Awareness materials
- ensuring avoidance of threatened and endangered species habitats and other areas of special concern during construction projects
- identifying site options for use during National Environmental Policy Act (NEPA) evaluation of alternative sites
- calculating drainages and water flows
- determining wildlife habitat preferences

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial GIS and Data Management (TGIS) on Tinian.

TGIS-1: TERRESTRIAL NATURAL RESOURCES GIS AND DATA MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-5; and Goal #3, Objectives #1 and 4.

- *Strategies*:
  - Identify data gaps in terrestrial natural resources GIS to assist in the development of future data collection efforts, surveys, and management actions.
  - Ensure that GIS information is available to JRM subject matter experts and military personnel, biologists, planners, contractors, and others in a timely manner to assist with planning and decision-making.

- *Action*: Update the Tinian MLA land cover classification using methods consistent with Amidon (2017) at least once every 5 years.
- *Action:* Develop JRM project-specific modules in the Navy Data Model database as needed for more effective data management and analysis.

11.4.1.8 Summary – Terrestrial Ecosystem Management

Implementation of the JRM INRMP program and the focused strategies and actions of the management projects for terrestrial resources provides a conservation benefit to the natural ecosystems on Tinian by maintaining and enhancing the natural community structure, function, species diversity, and resiliency. Enhancing and restoring native habitats supports viable populations of native species and increases biodiversity. Furthermore, proactive invasive species prevention, early detection, and control reduces the risk of intra- and inter-island species introductions. Data from regular monitoring of protected species is used to implement better management projects to enhance and restore habitat, reduce habitat fragmentation, buffer protected areas, implement new conservation strategies, and avoid and minimize impacts. Using this regional ecosystem-based approach for managing protected species and their associated ecosystems ensures that JRM remains in compliance with federal and territorial laws while supporting the operational functionality of the military mission.

Fourteen management projects addressing terrestrial natural resources management are proposed for implementation on Tinian:

- Terrestrial Habitat Management – 1
  - THM-1: Forest Enhancement
- Terrestrial Exotic and Invasive Species Management – 2
  - TIS-1: Implementation of Regional Biosecurity Plan for Micronesia and Hawai‘i
  - TIS-2: Mariana Islands Training and Testing Implementation of the Biological Opinion
- Terrestrial Protected Species Management – 7
  - TPS-1: Conservation Management of Tinian *Cycas micronesica* Plantings
  - TPS-2: Sea Turtle Population Protection and Enhancement
  - TPS-3: Conservation of Mariana Common Moorhen
  - TPS-4: Conservation of Forest Birds
  - TPS-5: Protection of Listed Invertebrates
  - TPS-6: Mariana Islands Training and Testing Implementation of the Biological Opinion
  - TPS-7: Mariana Fruit Bat Population Monitoring
- Migratory Bird Management – 1
  - MIG-1: Management of MBTA-listed Bird Species
- Terrestrial Natural Resources Educational Outreach – 1
  - TEDU-1: JRM Natural Resources Stewardship Outreach and Public Engagement Program
- Terrestrial Natural Resources Law Enforcement – 1
  - TLAW-1: Conservation Law Enforcement
- Terrestrial Geographic Information System and Data Management – 1
  - TGIS-1: Terrestrial Natural Resources GIS and Data Management

11.4.2 Marine Ecosystem Management

The Tinian MLA is relatively undeveloped with little man-made change in the landscape or nearshore habitat since WWII. Submerged lands on Tinian offer a realistic training environment for amphibious operations and provide recreational opportunities for CNMI residents and tourists. Submerged lands around

Tinian are presently influenced by natural and, to a lesser degree than installations in Guam, anthropogenic forces that drive the short- and long-term integrity of the resources. Monitoring surveys that allow for trend analysis and provide information on reef resiliency helps draw connections between various stressors and their impact on marine communities. This information allows JRM to design and implement adaptive management strategies and make appropriate decisions about mission-essential training and operations to avoid and minimize impacts to marine resources, including ESA-listed marine species and their habitats.

Maintaining healthy marine communities supports the military mission by avoiding or alleviating potential training restrictions and/or restrictions on recreational access and use, allowing training ranges to provide unimpeded support to DoD commands. The state of knowledge and the plans for managing marine resources on JRM submerged lands differs from the management of terrestrial resources. The principal reason for the differences is access to and direct knowledge of marine resources by natural resource managers is extremely limited. Additionally, the cost and effort to obtain information about marine resources is typically much greater than that required for terrestrial resources. These restrictions could mean that evidence of the presence or the condition of resources may need to be inferred from indirect or infrequent measurements to a greater degree than is required on land. Therefore, the focus of this section of the INRMP for marine resources takes a different approach to the management of marine resources compared to terrestrial resources.

The content and projects described in the INRMP serve three purposes that are consistent with Overarching Goal #1, *Ensure Military Mission Sustainability and Environmental Compliance* (see Section 3.3.1, *Goals and Objectives*) but may not be held entirely in common with terrestrial resources:

- They serve the letter and spirit of the requirements of the Sikes Act for JRM to have a management plan for natural resources on its leased lands;
- They serve as a starting point for the basic characterization of information regarding the marine environment on JRM leased lands that is commonly understood between the DoD and resource agencies, and can be used for planning purposes for environmental compliance documents that will be prepared to support DoD actions; and
- They may allow JRM and NMFS to come to agreement that the management projects that are planned in the INRMP are sufficient to preclude the need to designate critical habitat for federal ESA-listed species on JRM submerged lands and implementing actions to support their recovery.

The second item emphasizes the use of INRMP content and the results of INRMP projects to inform a basic understanding of marine resources in JRM submerged lands. This understanding helps with planning costs, schedules, and requirements of proposed DoD projects, such as the type of NEPA document to be prepared, the presence of federal ESA-listed species, the type of natural resources consultations to expect, and the estimated quantity of resources and/or habitat that could be impacted. It is understood that additional detailed, site-specific studies are likely to be necessary for NEPA analyses and associated consultations.

The purpose of this section is to identify projects with specific strategies for Tinian and to obtain workable and useful solutions for marine natural resources management. In accordance with Office of the Chief of Naval Operations Manual (OPNAV M) 5090.1 , *Environmental Readiness Program* and the principles of adaptive ecosystem management, marine natural resources management goals, objectives, strategies, and actions were developed for Tinian by an interdisciplinary team of ecologists, biologists, geologists, planners, and environmental scientists. Management of the JRM leased lands and associated marine resources in JRM: (1) protects and conserves threatened and endangered species through habitat conservation and enhancement, (2) promotes health and sustainability of coral reefs, (3) provides continued

access to recreational areas, and (4) provides continued use and access to training areas ensuring no net loss to the military mission.

The overall strategy follows a cycle of: (1) understanding the spatial distribution and types of marine habitat on JRM submerged lands, (2) characterizing the species and communities that occur in the various habitats, (3) determining the condition of the resources in the habitat, (4) determining how species that are present use or contribute to the habitat, and (5) managing the effects of stressors or threats on protected resources.

Adaptive management is intended to be an active part of all facets of the progression of resource management. Basic data collection to characterize a resource could be an endless process. Adaptive management will help to prioritize and focus effort to know when an emphasis needs to be on basic characterization, when responding to threats should be stressed, and what kind of balance between the two pursuits should be struck. Steps in the progression may be leaped past if conditions or information indicate a different step in the progression is needed. Adaptive management is not only depended on to determine what actions to take; it is also intended as a way to collaboratively review what is known about a resource so a collective agreement can be made on the next steps.

Similar to the terrestrial natural resources management program, the marine natural resources management program is divided into the following categories:

- Marine Habitat Management
- Marine Invasive Species Management
- Marine Protected Species Management
- Marine Natural Resources Educational Outreach
- Marine Natural Resources Law Enforcement
- Marine Natural Resources GIS and Data Management

As appropriate and applicable, all management projects will require evaluation or monitoring criteria, which are used to track the status of the management project, and whether the management project: (1) addresses no net loss to the capability of Tinian to support the military mission, and (2) meets the identified goals and objectives. At a minimum, mid-year coordination meetings will be held with resource agencies to discuss ongoing and planned projects to include prioritization, scope, methodology, issues encountered, timelines, and evaluation or monitoring criteria; these factors will also be discussed at the annual INRMP Metrics meeting. These conversations are meant to facilitate information sharing and enable JRM and the Agencies to take an adaptive management approach to managing INRMP projects. This approach will mean that projects are managed more dynamically and will be more responsive to arising needs than a static 5-year plan would be. A summary of the management project and the estimated timeframe for completion is presented in Table 13-12, *Planned Implementation Summary of Projects on Tinian*, found in Chapter 13, *Planning, Integration, and Implementation*.

Some of the management projects described in the following sections will be accomplished through interactive partnerships with federal and territorial natural resource agencies, universities, and local organizations. JRM natural resources management staff will establish partnerships with personnel at these organizations based on the benefits to the regional ecosystem and the local environment.

11.4.2.1 Marine Habitat Management

Marine resources are inherently challenging to describe due to their inaccessibility and in many cases low detectability. The initial approach to marine resource assessment is to describe the baseline, answering the question “what is there?” This is typically done by scuba divers who record species richness and abundance

within a study site that is representative of a larger area. Habitat mapping is often done in advance of baseline assessments to provide spatial context for "where" marine resources are distributed. Additionally, developing habitat maps initially helps to determine how to subdivide the study area into representative sections (i.e., strata) and how to extrapolate those baseline assessments into a larger context. However, baseline assessments are often not designed specifically to be repeatable. Repetition is critical to obtain sufficient statistical power that allows for the detection of change over time in various metrics. Monitoring designs typically increase statistical power by designing surveys that are repeatable with very high precision. Both baseline assessments and monitoring programs are essential for marine resource managers, who must first understand what resources are present and how they are distributed, and then how military operations and corresponding management actions affect those resources through time. When monitoring detects substantial changes in marine resource communities, the management actions may be adjusted.

Interagency efforts to develop consistent methods for evaluating impacts to nearshore marine resources and determining suitable mitigations that offset lost ecological functions and services are supported by the DON, NMFS, USFWS, U.S. Environmental Protection Agency (USEPA), and U.S. Army Corps of Engineers (USACE). Standardized methods that agencies can agree on are expected to benefit processes associated with NEPA, interagency consultations (e.g., ESA), CWA Section 404(b)(1) Regulations (40 CFR 230) permitting, and natural resources management. Interim results from the interagency effort are expected in the near term for consideration, but repeatable processes that are agreed on by all agencies are expected to be established over the next 5 to 10 years.

Management projects in offshore areas are primarily focused on outreach and education and monitoring associated with testing and training given that the resources are mobile and wide-ranging and the logistical challenges of managing those resources. Divers cannot easily access marine resources below 98-131 feet (30-40 meters). Autonomous and remotely operated vehicles can be used to observe and assess resources at greater depths, but implementing management projects remotely is challenging enough with the current state of technology, therefore, autonomous/remotely operated vehicles are not a practical solution for most INRMP management projects.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Marine Habitat Management (MHM) on Tinian.

MHM-1: CORAL HABITAT ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-5; Goal #3, Objectives #1-2 and 4; Goal #5, Objective #1.

- *Strategy*: Enhance coral habitat by monitoring health and acute impacts.
- *Action*: Establish long-term monitoring programs to track changes in the health of corals and water quality that are compatible with existing monitoring programs in Guam and the CNMI.
- *Action*: Establish a monitoring program for the detection of coral bleaching and disease within JRM submerged lands. Monitoring methodology will be coordinated with resource partners.
- *Action*: Establish a COTS monitoring and control program based on best available methods that are effective in JRM submerged lands to reduce COTS predation on corals and fish in Essential Fish Habitat (EFH). When COTS control is enacted, it will include monitoring pre, during, and post-intervention.
- *Action*: Conduct studies to monitor sediment and nutrient loads in time and space for managing stressors' inputs to the coastal and coral reef areas. Utilize a Soil and Water Assessment Tool

(SWAT) model to simulate flow, soil erosion, sediment, nutrient transport, and for evaluating the effect of climate change, land use change, and BMP applications.

- *Action*: Reduce adverse impacts from commercial and recreational boating to coral reef habitat and EFH due to improper vessel anchoring by installing and maintaining mooring buoys at one or more locations in the Tinian MLA.
- *Action*: Provide awareness on shallow mooring systems buoy locations to the local fishing community.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

MHM-2: MARINE RESOURCES DATA ANALYSIS AND COORDINATION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objectives #1 and 3-4; Goal #3, Objective #4; and Goal #7, Objective #3.

- *Strategy*: Establish long-term partnership with NMFS PIFSC to improve communication, collaboration, and information sharing to ensure the most up-to-date Pacific RAMP data is analyzed and available to inform JRM INRMP adaptive management strategies.
- *Action*: Develop an agreement with NMFS PIFSC to address critical data needs from tri-annual NOAA Pacific RAMP surveys for sites within JRM submerged lands to evaluate trends over time and inform management actions. JRM will work with NMFS PIFSC to develop a scope, to determine an acceptable cycle for data analysis (e.g., within 12-18 months of survey completion), and to identify data categories and survey locations to prioritize for analysis. At a minimum, the analysis would include a summary of findings from coral, algal, benthic, and fish surveys within JRM submerged lands and associated figures.

MHM-3: MARINE FLORA MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objectives #1 and 3-5; Goal #3, Objective #1.

- *Strategy*: Survey and monitor sub-tidal areas for submerged aquatic vegetation, including seagrass and macroalgae.
- *Action*: Monitor and assess changes to health of seagrass beds at Unai Chiget. Survey information will include: species identification, abundance description, mapping of each species via GIS including existing aerial photograph verification, and assessment of ecosystem health. Follow-up surveys will be conducted at a regular interval to monitor health of existing seagrass beds.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

MHM-4: MARINE HABITAT MAPPING EFFORTS

This project supports the following goals and objectives identified in Section 3.3.1, Goals and Objectives: Goal #1, Objective #1; Goal #2, Objectives #1 and 3-5; Goal #3, Objectives #1 and 4; Goal #5, Objective #1; and Goal #7, Objective #3.

- *Strategy*: Classify and delineate benthic habitats in the nearshore waters of JRM-administered submerged lands at Tinian MLA, focusing on information gaps.

- *Action*: Monitor the status and trends in coral reef and marine benthic communities using methods that are compatible with existing monitoring programs in CNMI and the region.
- *Action*: Obtain high resolution habitat maps of submerged habitat to inform priorities as well as avoidance and minimization measures during DON activities.
- *Action*: Work with NOAA NCCOS to perform mapping projects of previously mapped locations/installations every 5 years to study/monitor temporal and spatial changes in habitat.
- *Action*: Work with partners to classify and delineate benthic habitats in the nearshore waters of submerged lands at Tinian MLA using side scan or multibeam sonar. Results from this project will be used to map threatened and endangered species (e.g., sea turtles, corals, and scalloped hammerhead shark), EFH, and indicator of health.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

MHM-5: U.S. NAVY DIVER TRAINING FOR SUBMERGED NATURAL RESOURCES MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, Goals and Objectives: Goal #1, Objectives #1 and 2; Goal #2, Objective #4; Goal #3, Objective #4; and Goal #7, Objective #3.

- *Strategy*: Ensure that NAVFAC Marianas natural resource specialists are capable of participating in rapid assessment surveys of marine resources with other federal and territorial agencies when necessary.
- *Action*: NAVFAC Marianas natural resource specialists will complete Navy Diver Training (Navy prerequisite for conducting in-water work) to obtain the qualifications necessary to actively monitor and report on the health of marine resources on JRM-administered lands.

11.4.2.2 Marine Invasive Species Management

An invasive species is defined in EO 13112 as a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm, or harm to human, animal, or plant health. Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions. As with terrestrial ecosystems, marine invasive species can have a significant effect on the native marine species of island ecosystems.

Marine invasive species control and removal efforts are mandated by similar federal, DoD, and JRM regulations as terrestrial invasive species. The DON funded the development of the RBP for Micronesia and Hawai‘i. The RBP is a multi-disciplinary effort of federal and regional scientists and experts to address pathways and encourage a more holistic approach to evaluating and managing terrestrial, marine, and freshwater invasive species risks within Micronesia and Hawai‘i. The DON/JRM will implement necessary and appropriate DoD recommendations of the RBP (refer to Volume I, Attachment M, U.S. DoD Biosecurity Recommendations).

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Marine Invasive Species Management (MIS) on Tinian.

MIS-1: IMPLEMENTATION OF REGIONAL BIOSECURITY PLAN FOR MICRONESIA AND HAWAI'I

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #3; Goal #3, Objectives #1-2 and 4; Goal #4, Objectives #1-4; and Goal #7, Objective #1.

- *Strategy*: Implement recommendations within the RBP that are applicable to JRM (DON 2015d) that would avoid and minimize: (1) new invasive species incursions into marine waters around the CNMI and (2) the transfer of invasive species from Guam to the CNMI and other parts of Micronesia.
- *Action*: Develop and maintain a Marine Invasive Species Management Plan for Tinian. This plan would include, but not be limited to, the following:
  - Establish a watchlist and effective monitoring program for high-risk non-native marine species that are known or thought to pose significant ecological, economic, social, or cultural impacts to Guam and CNMI, focusing on species that are not established or widely distributed in the region.
  - Develop early detection and response protocols for new incursions by a few focal non-native marine species for Guam and CNMI.
  - Develop standard language to be included in contract specifications that provides BMPs to lessen the risk of marine invasive species being transported to project sites.
- *Action*: JRM will work with appropriate U.S. Navy commands to determine if updates are warranted for Navy hull husbandry standards (Naval Sea Systems Command S9086-CQ-STM-010) (U.S. Navy 2006) and ballast water requirements (*Note: The U.S. Navy adopts USCG standards*).
- *Action*: Implement JRM Marine Invasive Species Management Plan, perform MIS baseline surveys for all installations. Implement necessary actions/protocols based on baseline results.
- *Action*: Create a marine invasive species database for JRM submerged lands.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

MIS-2: FEDERAL AND TERRITORIAL COORDINATION AND COLLABORATION FOR MARINE INVASIVE SPECIES PREVENTION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #4; Goal #4, Objective #4; and Goal #7, Objective #3.

- *Strategy*: Develop partnerships to improve coordination and collaboration with other federal and CNMI agency staff, industry, and non-governmental organizations and seek opportunities to synergize funding, resources, and efforts to accomplish common goals (e.g., similar to those outlined in the 2014 Guam Marine Biosecurity Action Plan) (Miller 2014).
- *Action*: Participate in the CNMI regional invasive species meetings and coordinate regularly with the CNMI marine invasive species point of contact.
- *Action*: Develop partnerships to improve coordination and collaboration with other Pacific Island governments as well, such as Palau, FDM, CNMI, New Zealand, and Australia.

11.4.2.3 Marine Protected Species Management

Management of marine threatened and endangered species on JRM submerged lands includes implementing programs to protect species and coordinating efforts with the appropriate agencies. An INRMP is a primary tool for the DoD to fulfill its obligation to support section 7(a)(1) of the ESA which states that all federal

departments and agencies shall seek to conserve listed species and shall use their authorities to further the purpose of the ESA.

In accordance with section 7(a)(2) of the ESA, a federal agency shall consult with NMFS to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species. In addition, the DON avoids impacts on habitat suitable for federal ESA-listed threatened and endangered species, and CNMI-listed species, as the mission allows.

Federal ESA-listed species on JRM submerged lands are being managed by implementing specific management strategies that enhance habitat for these species and by initiating specific strategies that address immediate conservation needs of listed species.

To meet the goals and objectives of the INRMP, the following management project was identified for Marine Protected Species Management (MPS) on Tinian. Additional protection measures for marine protected species are presented in Section 11.2.4.5, *Marine Natural Resources Law Enforcement*.

MPS-1: SEA TURTLE POPULATION PROTECTION AND ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1-2 and 4; and Goal #7, Objective #3.

- *Strategy*: Monitor sea turtle activity and determine habitat use in the marine waters of JRM submerged lands.
- *Action*: Continue to coordinate efforts with U.S. Pacific Fleet to examine distribution, movement, and habitat use of sea turtles on JRM submerged lands. Up to 300 Passive Integrated Transponder tags will be attached to turtles captured by JRM. Of the turtles captured and fitted with Passive Integrated Transponder tags, 34 will be outfitted with GPS satellite telemetry or archival tags to monitor movement and collect data on habitat use (i.e., habitat type, depth, time at depth); drifters will be deployed to examine dispersal of hatchlings.
- *Action*: Implement and coordinate water quality monitoring and ecosystem monitoring to evaluate runoff and mitigate effects of erosion.
- *Action*: Continue in-water surveys and conduct additional surveys within JRM submerged lands to identify additional foraging/resting areas.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

MPS-2: RECREATIONAL USE SURVEY

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1-2; Goal #2, Objective #4; Goal #3, Objective #4; and Goal #6, Objective #1.

- *Strategy*: Eliminate adverse impacts from commercial and recreational boating to coral reef habitat and EFH within JRM submerged lands.
- *Action*: Conduct a survey of recreational and commercial activities to better understand impacts to corals and other protected species within JRM submerged lands.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

MPS-3: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, Goals and Objectives: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 4; Goal #3, Objectives #1-2 and 4; and Goal #4, Objective #2. This project supports conservation measures from the ESA section 7 Consultation BO and Conference Report for the U.S. Military MITT Activities (NMFS 2020).

- *Strategy:* Implement conservation measures listed in the 2020 MITT BO from NMFS.
- *Action*: Ensure no impact to coral or hard substrates during MITT training activities occurring within or adjacent to reef habitats by implementing appropriate avoidance measures.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

11.4.2.4 Marine Natural Resources Educational Outreach

Conservation awareness is instrumental in creating conditions needed to manage natural resources. The JRM approach to awareness stresses education. It provides military personnel and the public with insights into natural environments and conservation challenges. Education promotes awareness of threats and stressors to marine resources and threatened and endangered species. Activities such as habitat management, natural resources management, and submerged lands rehabilitation can be assisted by increasing the public's awareness of the importance of conserving the natural resources within JRM submerged lands. However, issues such as protection of sensitive marine areas for fish and wildlife species, invasive species management, and restrictions on some recreational activities within JRM submerged lands, require effective outreach with the public and military personnel in order to garner support and, perhaps more importantly, to avoid adverse reactions from various user impacts. An outreach program focused on minimizing impacts to marine resources and protecting ESA-listed marine species must be directed to both JRM and external stakeholders to be effective.

To meet the goals and objectives of the INRMP, the following management project was identified for Marine Natural Resources Educational Outreach (MEDU) on Tinian. This management project is in parallel and in concert with the project identified and discussed in Section 11.4.1.5, *Terrestrial Natural Resources Educational Outreach*.

MEDU-1: JRM NATURAL RESOURCES STEWARDSHIP OUTREACH AND ENGAGEMENT PROGRAM

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7, Objectives #1-3.

- *Strategy*: Implement a comprehensive natural resources outreach program regarding the federal, territorial, and base environmental regulations and policies, as well as information about the importance of protecting and conserving JRM's natural resources through cooperative efforts with partners.
- *Action*: Update a comprehensive Natural Resources Stewardship Outreach online training system.
- *Action*: Create a JRM Environmental Engagement Plan to outline the areas where JRM can significantly increase their outreach with military personnel about appropriate behavior toward threatened and endangered species and the importance of conserving natural resources within JRM leased lands and submerged lands.

- *Action*: Utilize partnerships with the USCG and Naval Mobile Construction Battalions (SeaBees) during joint training exercises minimize costs and to raise awareness within military personnel of the importance of maintaining the beaches to protect threatened and endangered species and other marine natural resources.
- *Action*: Develop, update, and implement a biosecurity education and outreach program for contractor personnel, military personnel, and dependents.
- *Action*: Install informational signs at Tinian MLA beaches, including Unai Babui, Unai Chulu, Unai Dankulo, Unai Masalok, and Unai Lam Lam.

11.4.2.5 Marine Natural Resources Law Enforcement

JRM has established the following objectives for enforcement: (1) enforce laws and regulations pertaining to the implementation of the natural resources program, (2) integrate natural resources enforcement into the overall natural resources program, and (3) use enforcement personnel to enhance the natural resources program at JRM.

To meet the goals and objectives of the INRMP, the following management project was identified for Marine Natural Resources Law Enforcement (MLAW) on Tinian.

MLAW-1: CONSERVATION LAW ENFORCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-3; Goal #2, Objectives #1-2 and 4; Goal #3, Objectives #4; Goal # 6, Objectives #1-2; and Goal #7; Objectives #1-3.

- *Strategy*: Detect and deter unauthorized activity that negatively affects natural resources within JRM submerged lands (e.g., poaching, littering, improper vessel anchoring, illegal fishing) through conservation law enforcement.
- *Action*: Establish a Conservation Law Enforcement Program by hiring a Conservation Law Enforcement Officer, and by partnering with other agencies as applicable, to enforce natural resource laws, policies, and regulations within JRM submerged lands. The Conservation Law Enforcement Officer will conduct outreach and enforce natural resource regulations.
- *Action*: Protect sea turtles from poaching on nesting beaches and submerged lands.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

11.4.2.6 Marine Geographic Information System and Data Management

Natural resources data are stored and maintained within a centralized JRM GIS database using GIS data collection standards. The GIS database also provides support for the entire environmental program and the training community. JRM uses GIS for complex analyses such as project siting, data interpolations, and risk assessments.

GIS software enables JRM staff to capture, store, update, manipulate, analyze, and display all forms of geographically referenced data and tabular information about natural and physical resources found on JRM submerged lands. The training of JRM staff and the allocation of their time to data entry, mapmaking, data analysis, and interpretation of the results determines the success of JRM's GIS. Once fully developed, the GIS databases can be used for projects such as the following:

- providing maps with bathymetric contours and locations of species, marine habitat, EFH, and other areas of potential concern
- providing special maps for Environmental Awareness materials
- ensuring avoidance of threatened and endangered species habitats and other areas of special concern during construction projects
- identifying site options for use during NEPA evaluation of alternative sites
- calculating drainages and water flows
- determining species habitat preferences

To meet the goals and objectives of the INRMP, the following management project was identified for Marine GIS and Data Management (MGIS) on Tinian.

MGIS-1: MARINE NATURAL RESOURCES GIS AND DATA MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-5; and Goal #3, Objectives #1 and 4.

- *Strategies*:
  - Identify data gaps in marine natural resources GIS to assist in the development of future data collection efforts, surveys, and management actions.
  - Ensure that GIS information is available to JRM subject matter experts and military personnel, biologists, planners, contractors, and others in a timely manner to assist with planning and decision-making.
- *Action*: Update and continuously maintain existing centralized GIS database to effectively inform and guide future management of marine natural resources within JRM submerged lands and meet natural resources goals and objectives. Readily available GIS data are used to develop natural resources constraints maps for use in current and future JRM management and planning decisions.
- *Action*: Create a marine invasive species database for JRM submerged lands.

11.4.2.7 Summary – Marine Ecosystem Management

Implementation of the JRM INRMP program and the focused strategies and actions of the management projects for marine resources provide a conservation benefit to the marine ecosystem on Tinian by maintaining and enhancing marine community structure, function, species diversity, and resiliency. Inventorying and monitoring efforts help maintain and improve the local scientific knowledge of coral reef ecosystems and their resilience to environmental stressors, guide adaptive management solutions, and aid in avoidance and minimization of potential impacts to sensitive resources. Furthermore, proactive invasive species prevention, early detection, and control reduces the risk of intra- and inter-island species introductions. Using this regional ecosystem-based approach for managing protected species and their associated ecosystems ensures that JRM remains in compliance with federal and territorial laws while supporting the operational functionality of the military mission.

Eleven management projects addressing marine natural resource management are proposed for implementation on Tinian:

- Marine Habitat Management – 3
  - MHM-1: Coral Habitat Enhancement
  - MHM-2: Marine Resources Data Analysis and Coordination
  - MHM-3: Marine Flora Management
  - MHM-4: Marine Habitat Mapping Efforts

    - MHM-5: U.S. Navy Diver Training for Submerged Natural Resources Management
- Marine Invasive Species Management – 2
    - MIS-1: Implementation of Regional Biosecurity Plan for Micronesia and Hawai‘i
    - MIS-2: Federal and Territorial Coordination and Collaboration for Marine Invasive Species Prevention
- Marine Protected Species Management – 3
    - MPS-1: Sea Turtle Population Protection and Enhancement
    - MPS-2: Recreational Use Survey
    - MPS-3: Mariana Islands Training and Testing Implementation of the Biological Opinion
- Marine Natural Resources Educational Outreach – 1
    - MEDU-1: JRM Natural Resources Stewardship Outreach and Public Engagement Program
- Marine Natural Resources Law Enforcement – 1
    - MLAW-1: Conservation Law Enforcement
- Marine Geographic Information System and Data Management – 1
    - MGIS-1: Marine Natural Resources GIS and Data Management

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12 FARALLON DE MEDINILLA

12.1 CURRENT OPERATIONS AND LAND USE

Farallon de Medinilla (FDM) is the Pacific Fleets' only bombing range for live-fire training within the Mariana Islands Range Complex (MIRC). FDM has served as a bombing range since 1971, both for live- and inert-fire bombing. It supports activities such as surface-to-ground and air-to-ground gunnery exercise, bombing exercise, missile exercise, fire support, and precision weapons (United States [U.S.] Department of the Navy [DON] 2009).

The entire island of FDM is leased to the Department of Defense (DoD) from the Commonwealth of the Northern Mariana Islands (CNMI) pursuant to the Covenant to Establish a Commonwealth of the Northern Mariana Islands in Political Union with the United States of America, Public Law (PL) 94–241, Section 1, March 24, 1976, 90 Statute 263. The lease agreement contains renewable provisions that extend the lease period to 2075. Under the terms of the lease agreement, none of the leased lands may be privately owned, and no human habitation is allowed. DON must approve any non-military uses within the leased area. DON controls and manages access to and training on FDM and the surrounding nearshore waters.

The lease agreement with the CNMI for FDM does not include the deeper marine waters beyond 3 nautical miles (5.6 kilometers) from the shoreline (Naval Facilities Engineering Systems Command [NAVFAC] Pacific 2004). The DoD has a lease agreement with the CNMI to use FDM as a target range until 2083. When certain training and testing activities are scheduled, Notices to Mariners (NOTMARs) and Notices to Airmen (NOTAMs) are published for public safety and to help the public plan accordingly to avoid temporarily restricted areas. Between 2010 and 2012, the average annual rate for notices (NOTMARs/ NOTAMs, issued by the U.S. Coast Guard [USCG]) was 39 per year for FDM (DON 2015a). Over the 3-year period, access to waters around FDM was restricted for an average of 159 days per year (Note: access to nearshore waters [within 3 nautical miles {5.6 kilometers}] around FDM is restricted at all times). The DON coordinates with the USCG and Federal Aviation Administration (FAA) as appropriate to notify the public about at-sea training activities.

12.1.1 Farallon de Medinilla Assets and Uses

FDM serves as a live-fire bombing range and its coastal waters host military training exercises. The air and sea space surrounding FDM provide sufficient room for the many different attack profiles necessary for training needs in the CNMI. FDM presents a unique opportunity to maintain capability and proficiency in precision-guided weapons and specific target engagement. The range supports strike warfare exercises (air-to-ground bombing exercises, air-to-ground gunnery exercises, and missile and rocket exercises), amphibious warfare activities (fire support exercises from cruisers and destroyers), and U.S. Naval Special Warfare Command activities. Very limited ground-based training including tactical air controllers, naval shore bombardment observers, and ground-based small arms firing into impact areas on the island occurs on the island.

Two special use airspace "Restricted Areas" ranging from 0 to 60,000 feet (0 to 18,300 meters) surround FDM prohibiting non-participating aircraft from entering the airspace. Restricted Area (R-) 7201 restricts airspace and non-military aircraft within 0-3 nautical miles (0-5.6 kilometers) around the island, and R-7201A restricts airspace and non-military aircraft within 3-12 nautical miles (5.6-22.2 kilometers) around the island. It is unsafe to be within the area for surface-related activities when the airspace is active. There are no port facilities or airfields on FDM. Access to the island is by small boat from a larger vessel or by helicopter. There are no roads or buildings, only target structures located in the northern portion of the

island. A limited archaeological reconnaissance survey of the island was conducted in 1996 and no archaeological sites or isolated non-modern artifacts were discovered.

FDM is divided into five training areas, oriented north to south, for live-fire ship-to-shore naval gunfire and air-to-ground munitions delivery training and range maintenance activities (e.g., vegetation control) (Figure 12-1).

Zone 1 (Northern Special Use Area) is a special use area and is a No-Fire Area (NFA). Zone 2 (Impact Area 1) is an impact area that allows limited strafing (E-target only) and inert ordnances to be fired or dropped. Zone 3 (Impact Area 2) is an impact area that permits high explosive and inert ordnance to be fired or dropped. Zone 4 (Land Bridge Special Use Area) is another NFA where ordnance is prohibited from impacting the land bridge, an isthmus of FDM, to the greatest extent possible. Zone 5 (Impact Area 3) is an impact area that permits only inert ordnance to be fired or dropped.

The National Marine Fisheries Service (NMFS) (2015a) and U.S. Fish and Wildlife Service (USFWS) (2015a) approve training activities for limited take of federal Endangered Species Act (ESA)-listed endangered and threatened species through formal Biological Opinions (BOs) issued by the agencies. These BOs are included in Appendix F of this Integrated Natural Resources Management Plan (INRMP). Military training activities approved on FDM through these BOs include personnel insertion/extraction, parachute insertion, direct action (combat close quarters), direct action (breaching), and tactical (air control party) training activities. Also on FDM, shore bombardment of Naval Surface Fire Support target along approved cliff and central upland areas are also included under the Mariana Islands Training and Testing (MITT) (USFWS 2015a). Additional detail on duration and frequency of these activities is available in the 2015 MITT Environmental Impact Statement (EIS)/Overseas EIS (OEIS) and summarized below:

- **Strike warfare training and use of FDM.** The MITT Biological Assessment (BA) (DON 2014a) addressed an increased number of activities, amount of ordnance, and use of rockets on FDM relative to existing requirements. The increased activities include bombing exercise, gunnery exercise, missile exercise, and combat search and rescue training exercises. The increase in activities will result in a higher net explosive weight as measured cumulatively over the course of a year.
- **Amphibious warfare training on FDM.** The MITT BA (DON 2014a) noted that surface vessel crews will use large-caliber guns to fire on land-based targets in support of forces onshore.
- **Naval special warfare training on FDM.** The MITT BA (DON 2014a) reviewed an increase in direct action (tactical air control party/join tactical air control) operations for military personnel to obtain training in controlling combat support aircraft and designating targets for airspace de-confliction and terminal control for close air support. Teams will also train to use small arms and mortars.

Operational Range Clearance is conducted every 5 years and periodic vegetation management around targets is conducted one or two times per year. The FDM range is operated in accordance with the requirements specified in the MITT 2015 BO (USFWS 2015a) for the take of Micronesian megapodes (*Megapodius laperouse*) on FDM.

12.1.2 Special Conservation Areas

There are no designated Special Conservation Areas for terrestrial resources on FDM; however, the NFA at the northern tip of the island serves as a de-facto conservation area.

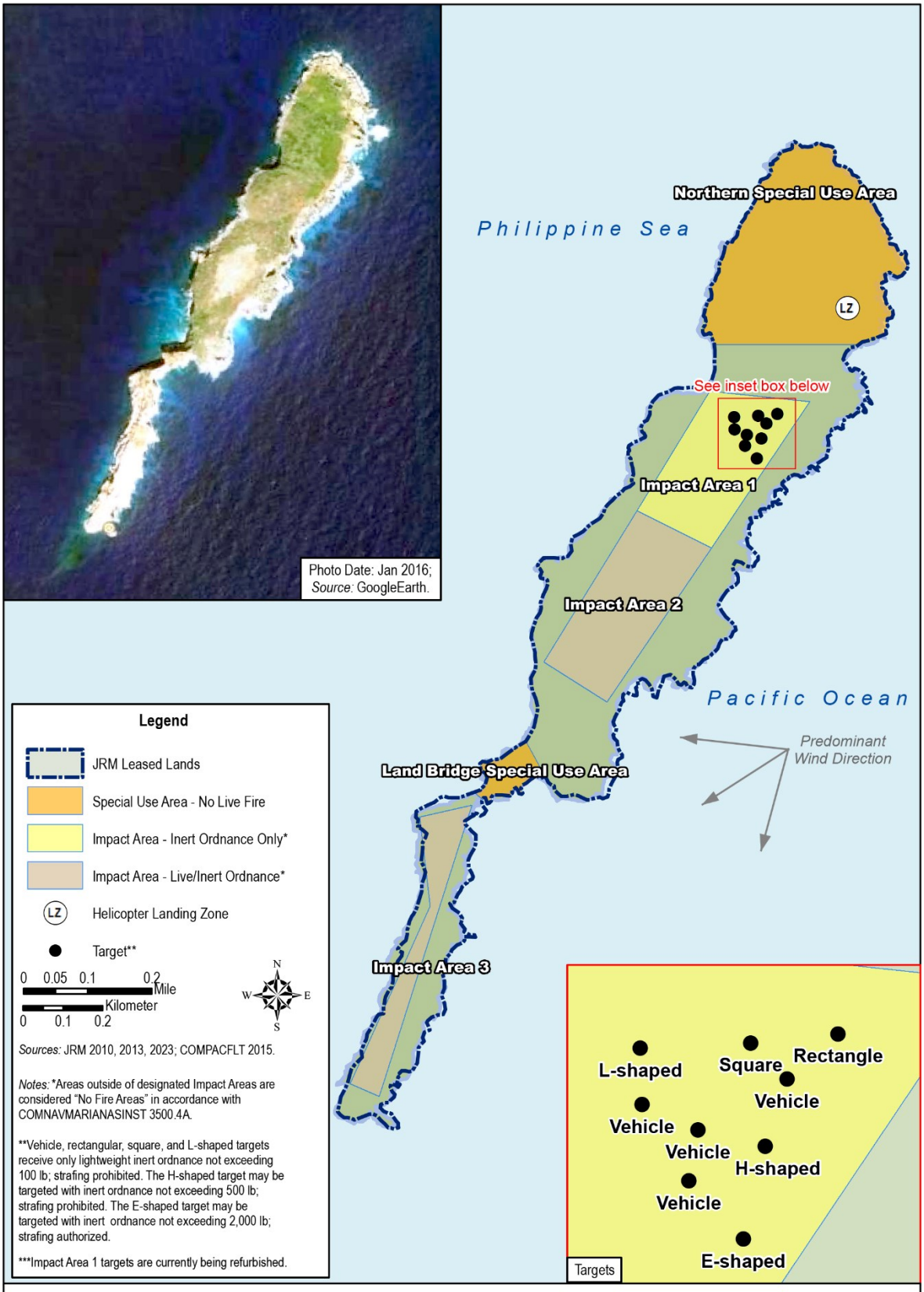


Figure 12-1
Overview of FDM

12.2 TERRESTRIAL ENVIRONMENT

12.2.1 Geology, Topography, and Soils

12.2.1.1 Geology

Submarine volcanic activity occurs in marine waters to the north, west, and south of FDM (NAVFAC Pacific 2004), but the island itself is not an active volcano. The Smithsonian Global Volcanism Program monitors nine active aerial volcanoes in the Northern Mariana Archipelago. The nearest island to FDM with recent volcanic activity (2005) is Anatahan, 32 miles (51 kilometers) northwest of FDM. Volcanic eruptions play a role in the distribution and dispersal of terrestrial and marine species within the Northern Mariana Islands (Vogt 2009; Smith and Marx Jr. 2016). There are no published reports describing geologic conditions on FDM (DON 2015b).

FDM is located on one of the most seismically active plate boundaries in the world. Thirty-five earthquakes above magnitude 5.0 were recorded in the archipelago between October 2011 and July 2012 (Earthquaketrack.com 2017). A single moderate-size earthquake is unlikely to produce significant impacts on FDM (Joint Region Marianas [JRM] 2013).

No official record of tsunami impact on FDM exists; however, the International Tsunami Information Center has recorded numerous events that could have produced tsunami effects on FDM (NAVFAC Pacific 2004). For example, between October 2008 and August 2009 there were at least 28 reported earthquake or tsunami events that could have produced un-recorded tsunami impacts on FDM (Earthquaketrack.com 2017). The largest event in modern history that may have affected FDM was on March 11, 2011, following the Great Tohoku earthquake in Japan. A maximum water height of 4 feet (1.2 meters) was recorded in Guam, some 1,714 miles (2,758 kilometers) from the source of the earthquake.

12.2.1.2 Topography

FDM is a narrow, flat-topped ridge of raised coral limestone, approximately 1.7 miles (2.7 kilometers) long and 0.3 mile (0.5 kilometer) wide (approximately 187 acres [75.7 hectares]), with a flat plateau-like interior reaching a height of 266 feet (81 meters). The island is surrounded by tall, jagged limestone cliffs (up to 320 feet [97.5 meters]) that drop to the ocean on all sides (Figure 12-2). The middle and northern sections of the island consist of gently rolling topography. Bomb craters are concentrated in the central portion of the island and can measure up to 6 feet (1.8 meters) deep and 20 feet (6.1 meters) in diameter. The southern portion of the island is steep with mostly exposed limestone and limited vegetation.

12.2.1.3 Soils

There are no published reports describing soils on FDM (DON 2015b). A thin layer of related porous soils sits atop the limestone and is interspersed with bare rock and limestone scrub. Two generic soil types have been observed: a red, highly plastic clay and a black humus probably from decaying vegetation and seabird guano (DON 2015b). Since 2005, only one small ephemeral beach has been observed; it is located on the west side of the island.

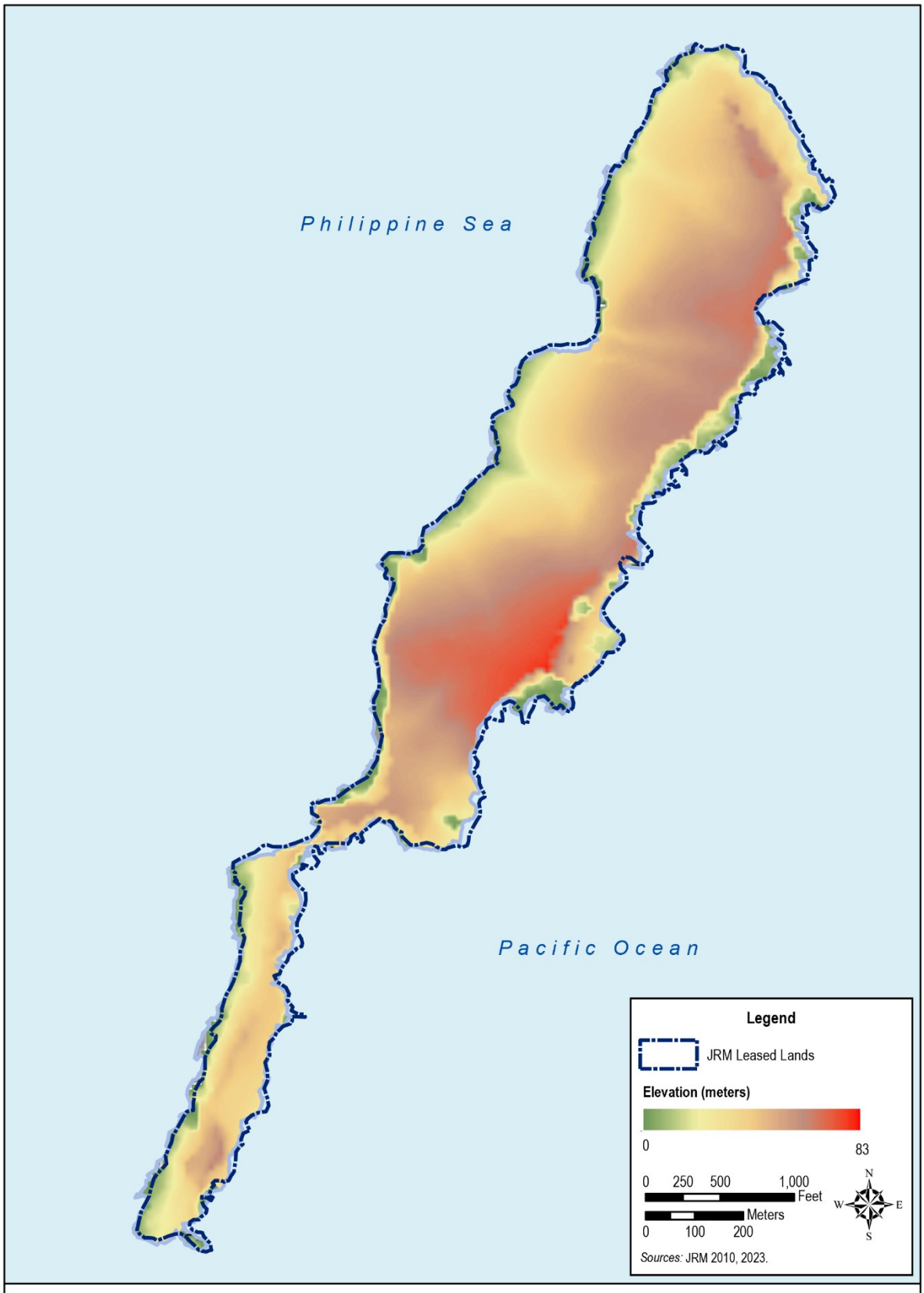


Figure 12-2
Topography - FDM

12.2.2 Hydrology

12.2.2.1 Surface Water

Surface water is not present on FDM (NAVFAC Pacific 2004).

12.2.2.2 Groundwater

There are no groundwater wells on FDM (NAVFAC Pacific 2004). Due to the island's small size, sloping topography, and limestone composition, it is unlikely that a significant groundwater resource is present on FDM.

12.2.3 Vegetation Communities

Few vegetation surveys have been conducted on FDM. Prior to its use as a bombing range, FDM was covered in littoral scrubland (Whistler 1996). Bombardment since that time has heavily impacted the current vegetation. A brief botanical survey of the northern portion of FDM carried out in 1996 showed that the island was covered with "herbaceous and shrubby vegetation dominated by littoral species" (Whistler 1996). Although there are no perennial wetlands on the island, numerous depressions that retain water after storms with sufficient moisture and relatively impermeable soil, foster the growth of facultative wetland sedges and grasses (Whistler 1996). Four principal vegetation communities are known on FDM: bare rock, bare soil/gravel, mixed grass/herbaceous, and scrub/shrub. (Amidon 2017).

A narrow band of vegetation located just above the high tide mark is dominated by indigenous littoral plant species. Limestone cliff communities on the eastern side of FDM are dominated by plants that can live rooted in cracks among limestone rocks. A mesic terrace community dominates the central uplands of the island. Whistler (1996) observed isolated patches of the native crinum lily (*Crinum asiaticum*) over much of this central region. Most of this upland community has been fragmented by cratering and habitat disturbance from bombardment by naval munitions and rockslides. The low-lying vegetation provides suitable habitat for some birds for nesting, foraging, and sheltering, particularly on the northern end of the island. Trees and shrubs are comparatively sparse on the southern end of the island, south of the land bridge.

Whistler (1996) identified 43 plant species, 32 of which were native. During Micronesian megapode surveys in August 2008 and April 2019, common plant species were also recorded (NAVFAC Pacific 2010; NAVFAC Marianas 2019b). Table 12-1 provides a list of plant species observed during the 1996, 2008, and 2019 trips to FDM.

Table 12-1. Plant Species Recorded on FDM

Family	*Common Name/ Chamorro Name*	*Scientific Name*
Acanthaceae	Blackweed/Yerbas babui	*Ruellia blechum*
Aizoaceae	Seaside purslane/Chara	*Sesuvium portulacastrum*
Amaranthaceae	None/None	*Achyranthes canescens*
Amaranthaceae	Slender amaranth/None	*Amaranthus viridis*
Amaryllidaceae	Crinum lily/Piga-palayi	*Crinum asiaticum*
Asteraceae	Beach sunflower/Masigsig	*Wedelia biflora*
Asteraceae	Beach daisy/None	*Wollastonia biflora*
Capparaceae	Spiny caper/Atkaparas	*Capparis cordifolia*
Caricaceae	Papaya/None	*Carica papaya*
Clusiaceae	Alexandrian laurel or Palomaria or Mastwood//Daog or Daok	*Calophyllum inophyllum*
Convolvulaceae	Beach morning glory/Alalag-tasi	*Ipomoea pes-caprae*
Convolvulaceae	St. Thomas lidpod/None	*Operculina turpethum* var. *ventricosa*

Table 12-1. Plant Species Recorded on FDM

Family	*Common Name/ Chamorro Name*	*Scientific Name*
Cyperaceae	Tropical fimbry/None	*Fimbristylis cymosa*
Cyperaceae	None/None	*Cyperus javanicus*
Euphorbiaceae	Garden spurge/Golandrina	*Euphorbia hirta*
Euphorbiaceae	Blinding tree/None	*Excoecaria agallocha*
Euphorbiaceae	Fly-Roost/Maigo-lalo	*Phyllanthus amarus*
Fabaceae	None/Gulo	*Millettia pinnata*
Fabaceae	Hedge Acacia/Tangantangan	*Leucaena leucocephala*
Lamiaceae	Malbau tree/Hayun Lagu	*Premna serratifolia*
Lamiaceae	Malayan lilac/ None	*Callicarpa candicans*
Malvaceae	Mallow/Matbas	*Abutilon indicum*
Malvaceae	Cotton/Algodon	*Gossypium hirsutum*
Malvaceae	Beach hibiscus/Pago	*Hibiscus tiliaceus*
Moraceae	None/Nunu	*Ficus* spp.
Myrtaceae	Beach Cherry/Aagan or aabang	*Eugenia reinwardtiana*
Nyctaginaceae	None/Dafao	*Boerhavia albiflora*
Nyctaginaceae	None/Dafao	*Boerhavia repens*
Nyctaginaceae	None/Umumu	*Pisonia grandis*
Poaceae	Creeping panic grass/None	*Urochloa reptans*
Poaceae	Bermuda grass/None	*Cynodon dactylon*
Poaceae	None/None	*Digitaria gaudichaudii*
Poaceae	None/None	*Digitaria radicosa*
Poaceae	Tangle-head/None	*Heteropogon contortus*
Poaceae	None/Lesaga	*Lepturus repens*
Portulacaceae	None/None	*Portulaca australis*
Portulacaceae	Sea purslane/None	*Portulaca lutea*
Portulacaceae	Purslane/Botdolagas	*Portulaca oleracea*
Rubiaceae	None/Gausali	*Bikkia tetrandra*
Rubiaceae	None/None	*Oldenlandia strigulosa*
Rubiaceae	Noni/Lada	*Morinda citrifolia*
Solanaceae	Wild cape gooseberry/Tomate chaca	*Physalis angulata*
Sterculiaceae	None/Sayafe	*Melochia villosissima*
Urticaceae	Native mulberry/Noni	*Pipturus argenteus*
Verbenaceae	None/Qualitay, kualitai	*Callicarpa candicans*
Verbenaceae	None/Ahgao	*Premna serratifolia*
Verbenaceae	False verbena/None	*Stachytarpheta jamaicensis*

Notes: Common, Chamorro, and scientific names from GovGuam (2009), Liske-Clark (2015), Topping et al. (1975), Safford (2009), and USFWS (2015b), CABI (2023)
Key: FDM = Farallon de Medinilla.
Sources: Whistler 1996; NAVFAC Pacific 2010; NAVFAC Marianas 2019b.

Two plant species, *Digitaria gaudichaudii* and *Gossypium hirsutum* var. *taitense*, considered rare in the Mariana Islands, occur on FDM (NAVFAC Pacific 2004).

12.2.3.1 Non-native Species

Virtually all the plants recorded on FDM are indigenous; however, Whistler (1996) reported finding 11 species that appeared to be weedy and non-native. These included *Ruellia blechum*, slender amaranth (*Amaranthus viridis*), cutleaf groundcherry (*Physalis angulata*), and False verbena (*Stachytarpheta jamaicensis*). Most of these species were restricted to areas of disturbed habitats and did not pose a threat to the native species. Tangantangan (*Leucaena leucocephala*) and St. Thomas lidpod (*Operculina turpethum* var. *ventricosa*) were two non-native species that appeared to demonstrate some encroachment

into native habitats. St. Thomas lipod is native to tropical America and is assumed to have arrived on FDM via passive dispersal from other islands (Whistler 1996).

12.2.4 Terrestrial Wildlife

12.2.4.1 Mammals

Native Species

The only native mammal known to occur on FDM is the Mariana fruit bat (*Pteropus mariannus mariannus*) (see Section 12.2.5, *Terrestrial Protected Species*, for an expanded discussion of the Mariana fruit bat on FDM).

Non-native Species

A rat thought to be the Polynesian rat (*Rattus exulans*) is the only known non-native mammal species on FDM (Whistler 1996). Rats have been implicated in up to 60 percent (%) of recorded bird and reptile extinctions worldwide (Wanless et al. 2007). They are predators of nesting birds, land invertebrates, and plants, as well as a reservoir of disease and disperser of invasive plant seeds (Amori and Clout 2003). Rats also contribute to the decline of native vegetation by consuming native seeds or seedlings (DeMattia et al. 2004).

12.2.4.2 Birds

Native Species

FDM serves as an important resting area for migratory bird species, including a number of shorebirds, waterbirds, and seabirds (Lusk et al. 2000; NAVFAC Marianas 2013; Camp et al. 2014) (Table 12-2). Seabirds nest on FDM, while waterbirds and shorebirds forage there. A ground survey of avifauna on FDM in November 1996 identified 17 species of seabirds, shorebirds, and resident landbirds (Lusk et al. 2000). From 1997 through 2016, DON conducted monthly helicopter surveys from 1997-2008 and quarterly surveys from 2008-2016 to quantify brown booby (*Sula leucogaster*), masked booby (*Sula dactylatra*), and red-footed booby (*Sula sula*) populations on FDM (Appendix H) (Camp et al. 2014; Vogt 2017; NAVFAC 2023). Camp et al. (2014) presents the most recent summary of these surveys. Incidental observations were conducted in 2019 and 2021. Surveys conducted in 2023 were the first ground-based counts of boobies and other MBTA-species from fixed vantage points on FDM. Though these types of surveys have constraints, ground-based counts will continue to be utilized due to limited accessibility of other forms of transportation and accessibility due to the clearance of range operations (NAVFAC 2023).

Breeding has been reported on FDM for seven seabird species: black noddies (*Anous minutus*), brown noddies (*Anous stolidus*), brown boobies, masked boobies, red-footed boobies, white terns (*Gygis alba*), and great frigatebirds (*Fregata minor*) (Reichel and Glass 1991; Lusk et al. 2000; JRM 2013). Booby species are the most readily identifiable due to their numbers and individual sizes. The other species breeding locations are either dispersed or breeding activity is sporadic. The great frigatebird may occasionally nest on FDM, which is one of only two small breeding colonies known to exist within the Mariana Islands (the other is located on Maug in the northern portion of the archipelago) (Figure 12-3). FDM does not appear to be a temporally or spatially stable rookery location (DON 2015c). Lusk et al. (2000) visited the island in November 1996 and confirmed breeding on FDM for the great frigatebird, while others have reported the great frigatebird as only roosting on FDM (Reichel and Glass 1991). Lusk et al. (2000) estimated 25 birds, including several juveniles roosting with the main group or flying near shore. Several nests were observed, one with a single egg. In November of 2012, an individual great frigatebird was observed, while 15 were observed in February of 2013 (Wenninger 2013). The area where great frigatebirds were last observed in 2016 was not accessible during the 2023 survey (NAVFAC 2023).

Table 12-2. Bird Species Recorded on FDM

*Common Name/ Chamorro Name**	*Scientific Name**	*Residence Status*	*Listed under MBTA*
Black noddy/Fahang dikiki	*Anous minutus*	Native breeding resident	Y
Bristle-thighed curlew/None	*Numenius tahitiensis*	Migrant	Y
Brown booby/Luao	*Sula leucogaster*	Native breeding resident	Y
Brown noddy/Fahang dankolo	*Anous stolidus*	Native breeding resident	Y
Christmas shearwater/None	*Puffinus nativitatus*	Reported, status unknown	Y
Eastern cattle egret/Chuchuko	*Bubulcus coromandus*	Migrant	Y
Eurasian tree sparrow/Gagapale	*Passer montanus*	Reported, status unknown	N
Fork-tailed swift/None	*Apus pacificus*	Migrant	Y
Great frigatebird/Payaya	*Fregata minor*	Reported, status unknown	Y
Island collared dove/Palumat	*Streptopelia bitorquata*	Reported, status unknown	N
Mariana fruit dove/Paluman totot	*Ptilinopus roseicapilla*	Reported, status unknown	Y
Masked booby/Luao talisai	*Sula dactylatra*	Native breeding resident	Y
Micronesian megapode/Sasangat	*Megapodius laperouse*	Native breeding resident	Y
Oriental pratincole	*Glareola maldivarum*	Reported, status unknown	N
Pacific golden plover/Dulili	*Pluvialis fulva*	Migrant	Y
Pacific reef heron/Chuchuko atilong	*Egretta sacra*	Reported, status unknown	Y
Red-footed booby/Luao talisai	*Sula*	Native breeding resident	Y
Red-tailed tropicbird/Fagpi	*Phaethon rubricauda*	Reported, status unknown	Y
Ruddy turnstone/Dulili	*Arenaria interpres*	Migrant	Y
Sooty tern/Giree girak	*Onychoprion fuscatus*	Migrant	Y
Wandering tattler/Dulili	*Tringa incana*	Migrant	Y
Wedge-tailed shearwater/Lifaru	*Ardenna pacifica*	Migrant	Y
Whimbrel/Kalalang	*Numenius phaeopus*	Migrant	Y
White tern/Chunge	*Gygis alba*	Native breeding resident	Y
White-tailed tropicbird/Fagpi apaka	*Phaethon lepturus*	Reported, status unknown	Y
White-throated ground dove/ Paluman apaka (male) and Paluman fache (female)	*Alopecoenas xanthonurus*	Reported, status unknown	Y

Note: *Common and scientific names based on Gill and Donsker (2018). Chamorro names from GovGuam (2009), Liske-Clark (2015), Topping et al. (1975), and USFWS (2015b).
Key: FDM = Farallon de Medinilla; MBTA = Migratory Bird Treaty Act; N = no; Y = yes.
Sources: Lusk et al. 2000; NAVFAC Pacific 2010; DON 2015b. NAVFAC Marianas 2019a; NAVFAC Pacific, unpublished data.

Red-footed boobies, which roost and nest in trees, appear more common than masked and brown boobies, which roost and nest on the ground (Figure 12-3). During surveys conducted from 1997 to 2016, the numbers detected during each survey ranged from 0 to 447 for brown booby, 6 to 404 for masked booby, and 42 to 1,195 for red-footed booby (Camp et al. 2014; DON 2015a; NAVFAC Marianas 2016). During aerial surveys conducted in 2016, biologists counted 233 brown boobies, 324 masked boobies, and 1,195 red-footed boobies on FDM (NAVFAC Marianas 2016). There is some evidence that masked and red-footed booby populations declined from 1996-2017 while brown booby populations increased. However, the general conclusion was that all three species exhibited population fluctuations over this time period. That, combined with the level of variability observed in the count data, precluded any definite conclusion about long-term significant population trends (Camp et al. 2014; DON 2015a; NAVFAC Marianas 2016). Although areas previously covered in aerial surveys were not surveyed in 2023, there were still 90 masked boobies, 123 brown boobies, and 147 red-footed boobies counted on FDM. These three booby species were also observed breeding on this survey.

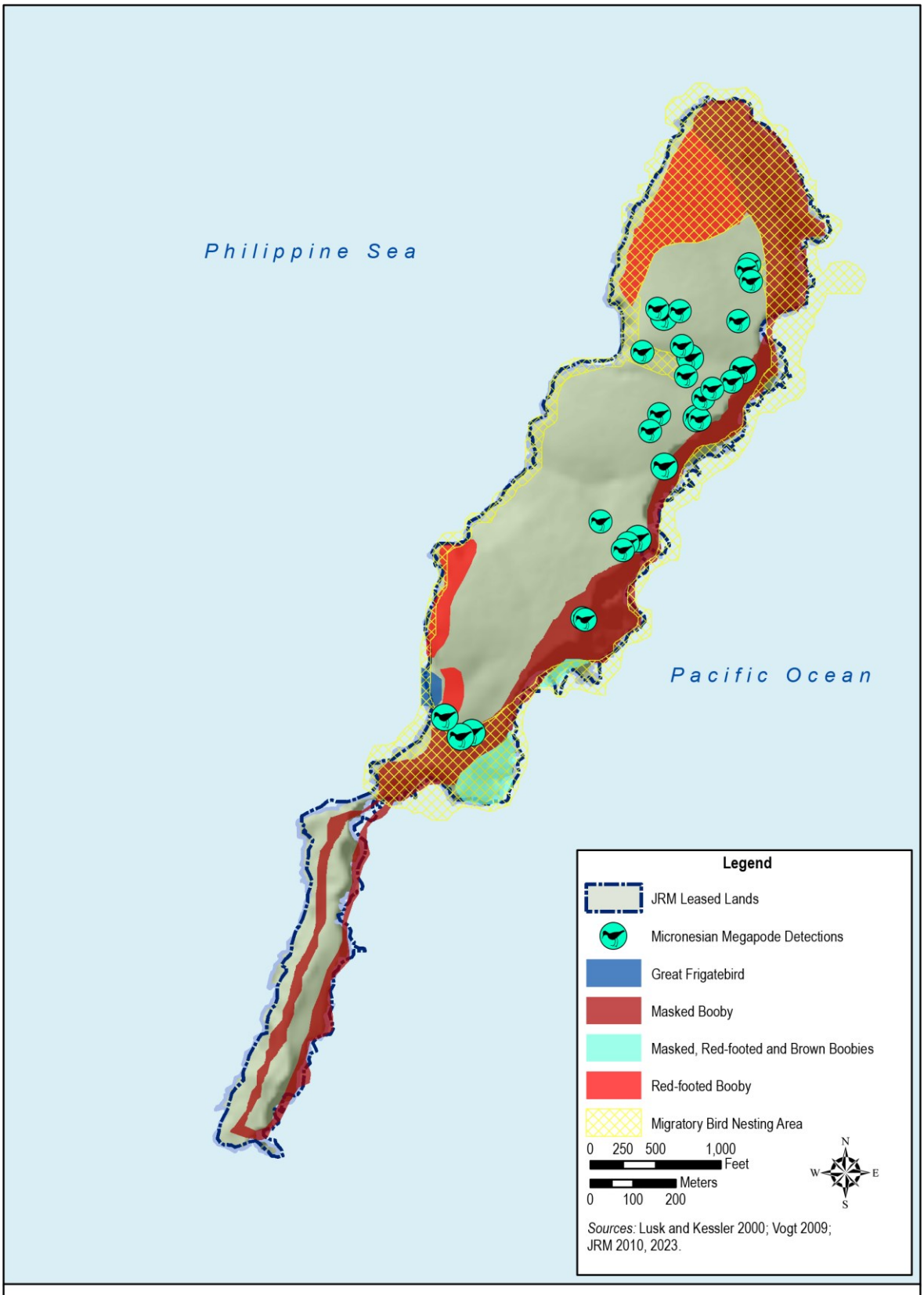


Figure 12-3
Occurrence of Seabirds and Micronesian Megapode - FDM

The majority of the bird species observed on FDM are protected under the Migratory Bird Treaty Act (MBTA). Provisions of the MBTA are described in detail in Chapter 3, *Environmental Management Strategy and Mission Sustainability*. In 2007, the USFWS published a final rule that granted authorization for incidental take of migratory birds during military readiness operations, provided that the DoD action proponent confers with USFWS to develop and implement appropriate conservation measures to minimize or mitigate negative effects if it is determined that an action will have a significant negative effect on the sustainability of a species' population (72 Federal Register 8931; 50 CFR Part 21.15) (USFWS 2007). Lusk et al. (2000) reported white-throated ground doves on FDM, which are protected under the MBTA and CNMI-designated as a Species of Greatest Conservation Need (SOGCN); however, no information was provided relating to population size or status on the island. Furthermore, no white-throated ground doves have been detected on FDM in recent years.

Non-native Species

Non-native bird species found on FDM in years past include the island collared dove (*Streptopelia bitorquata*) and the Eurasian tree sparrow (*Passer montanus*).

During a survey for Micronesian megapodes on FDM, two Christmas shearwaters *(Puffinus nativitatus*) were observed (NAVFAC Marianas 2019a). Notably, this was the first time Christmas shearwaters have been observed on FDM. No Christmas shearwaters were observed during the 2023 survey (NAVFAC 2023).

12.2.4.3 Reptiles and Amphibians

NAVFAC Pacific (2005) and Vogt (2009) reported the native snake-eyed skink (*Cryptoblepharus poecilopleurus*) and blue-tailed skink (*Emoia caeruleocauda*) on FDM.

12.2.4.4 Invertebrates

Coconut crabs (*Birgus latro*) occur on FDM. No information is available on other terrestrial invertebrates.

12.2.5 Terrestrial Protected Species

There are two federal ESA-listed terrestrial species that could occur on FDM including one mammal species, the Mariana fruit bat, and one bird species, the Micronesian megapode. Table 12-3 provides a summary of the occurrence of federal and CNMI ESA-listed terrestrial species on FDM. Principal threats to protected species identified in the MITT 2014 BA include percussive force and direct strike from aerial and naval bombardment, habitat fragmentation and loss, potential for introduction of invasive species, and wildfires (DON 2014a).

Table 12-3. Federal and CNMI ESA-listed Threatened and Endangered Species on FDM

*Common Name/ Chamorro Name**	*Scientific Name**	*Federal Status*	*CNMI Status*	*Habitat*	*Occurrence*
Mammals					
Mariana fruit bat/Fanihi	*Pteropus mariannus mariannus*	T	T-E	Mature forests (limited habitat exists on FDM)	P
Birds					
Micronesian megapode/Sasangat	*Megapodius laperouse*	E	T-E	Scrub-shrub vegetation	P

Notes: *Common, scientific, and Chamorro names based on Liske-Clark (2015).
Key: CNMI = Commonwealth of the Northern Mariana Islands; E = endangered; ESA = Endangered Species Act; FDM = Farallon de Medinilla; P = potential for occurrence; T = threatened; T-E = the CNMI Administrative Code does not specify whether a species is threatened or endangered: all species are considered threatened and endangered.
Sources: NAVFAC Marianas 2013; USFWS 2015a, 2015b.

12.2.5.1 Mammals

Mariana Fruit Bat

The Mariana fruit bat is CNMI-listed as threatened and endangered and CNMI-designated as SOGCN. This species was federal ESA-listed as endangered in Guam in 1984 (USFWS 1984), and was down-listed to threatened in 2005 when the Mariana fruit bat subspecies was listed as threatened throughout the Mariana Islands (USFWS 2005). No designated critical habitat for this species is located on FDM. Although the species is endemic to the archipelago, only a few incidental observations of fruit bats are known on FDM (USFWS 2015a, 2015b). Wiles et al. (1989) reported that fishermen had seen modest numbers of fruit bats on FDM prior to the advent of military bombing in 1971. Since then, during a 1996 survey, a single fruit bat has been observed by a NAVFAC Pacific biologist in the interior mesic terrace community. One fruit bat was observed in 2008 flying south in the northern region of the island, just north of the NFA (USFWS 2009). These observations suggest that FDM serves as a stopover location for a small number of fruit bats and as a sanctuary for fruit bats escaping volcanic eruptions on neighboring islands (USFWS 2010).

The limited availability of foraging and roosting habitat may restrict the number of fruit bats recorded on FDM (NAVFAC Marianas 2013). Military bombardment is a primary factor affecting fruit bat habitat and numbers on FDM. Although more intact forests, and hence fruit bat roosting areas, are located at the northern tip of FDM, recent observations of bomb craters in the same area prove that the best precautions are sometimes insufficient, and bombardments sometimes miss their targets (USFWS 2015a). Limited fruit bat food sources known to occur on FDM include the fruits of introduced *Ficus* spp. and papaya (*Carica papaya)* (Wiles 1987).

12.2.5.2 Birds

Micronesian Megapode

The Micronesian megapode was federal ESA-listed as endangered in 1970 (USFWS 1970), and is the only federal ESA-listed endangered species with a breeding population on FDM. The USFWS has not designated critical habitat for this species (USFWS 2015b). Population status and trends throughout the CNMI have been difficult to assess; however, recent surveys and population models suggest that the highest densities of megapodes occur on islands absent of ungulates and with low human populations (Amidon et al. 2011).

FDM is thought to harbor a small breeding population of Micronesian megapodes. Figure 12-3 illustrates the detection locations of megapodes on the island resulting from reports cited in this section. Lusk et al.

(2000) reported finding burrows similar to those used by megapodes for nesting in the CNMI during a 1996 survey and observed four megapodes. Two birds were observed during a DON site visit in December 1996 (Lusk et al. 2000). Vogt (2009) found evidence of reproduction when he observed one juvenile and one chick on FDM. He estimated a population of at least 11 megapodes based on 16 detections during his December 2007 survey. Twelve pairs and four individual megapodes were detected during surveys in 2008 resulting in a minimum estimate of 28 megapodes on FDM (Vogt 2009). Biologists have speculated that megapodes may have dispersed from Anatahan to other islands in the CNMI, including FDM, following volcanic eruptions in 2005. Since 2011, few wildlife surveys have been conducted on FDM due to safety concerns. The discovery of Vietnam-era sub-munitions on FDM led to a changed safety policy in 2011 that was consequential for continued megapode surveys. On the ground megapode surveys are conducted by JRM biologists only immediately after removal of unexploded ordnance (UXO) during operational range clearance, which is normally conducted every 2 years. Additional megapode surveys were conducted in 2019, 2021, and 2023. The surveys are restricted to a narrow set of limited trails, which has made it difficult to obtain an accurate population assessment on FDM. However, a limited survey on FDM in 2013 detected 11 megapodes in the northern part of the island (JRM 2013) indicating that megapodes have persisted on FDM despite intense bombardment of the island since the 1970s (USFWS 2015a).

Lusk et al. (2000) suggested that megapodes on FDM may serve as a critical genetic link for the rest of the population throughout the Mariana Archipelago. The island is also believed to be a stopover location for dispersing megapodes from other islands (Lusk et al. 2000). The MITT BO (USFWS 2015a) identified habitat used by the Micronesian megapode on FDM as predominantly dense herbaceous communities, scrubby brush, stunted trees, grasslands, and bare earth. Characteristic plants in this habitat on FDM include: *Melanthera biflora, Cyperus javanicus,* caper (*Capparis spinosa*)*,* beach morning glory (*Ipomoea pes-caprae*)*, Boerhavia* spp., *Portulaca lutea, O. turpethum* var. *ventricosa,* and stunted *Pisonia grandis* (Lusk et al. 2000; DON 2009). Megapodes can nest in forests, open fields, cinder and ash fields, and coastal strand. Primary foraging habitat for the megapode is native and secondary forest. Vogt (2009) found megapodes on FDM wherever tree or shrub cover was present. Megapode breeding has been observed on the islands within the CNMI during all months of the year except October, November, and December (USFWS 1998). USFWS (2015a) reports that the absence of breeding activity in the late fall and winter may be an artifact of sampling methods.

12.2.5.3 Reptiles and Amphibians

There are no known threatened or endangered reptile or amphibian species on FDM (JRM 2013; USFWS 2015a). However, sea turtles are present in JRM submerged lands surrounding FDM and are discussed in detail in Section 12.3.7, *Marine Protected Species*.

12.2.5.4 Invertebrates

No systematic terrestrial invertebrate surveys have been, nor can be, completed on FDM. Presence of protected invertebrate species is not presently known (JRM 2013; USFWS 2015a).

12.2.5.5 Plants

No systematic plant surveys have been, nor can be, completed on FDM. A limited survey conducted in 1996 did not record any protected plant species on FDM (Whistler 1996; JRM 2013; USFWS 2015a).

12.3 MARINE ENVIRONMENT

The lease agreement between CNMI and the U.S. measures the 3-mile (5-kilometer) FDM boundary in geographical miles. The units “nautical mile” and “geographical mile” originally shared the same definition.

The nautical mile remained defined as 6,076 feet (1,852 meters), but the geographical mile became more precisely defined with modern geodetic measurements and is now 6,080.4 feet (1,855.3 meters). The worldwide convention is to write "nautical mile" for the benefit of improved comprehension, even when a legal boundary is measured in geographical miles. Because these units differ by only 4.4 feet (3.3 meters), using the more familiar "nautical mile" is inconsequential for practical purposes.

FDM is currently surrounded by a 3-nautical mile (5.6-kilometer) radius restricted area associated with restricted airspace (R-7201) having altitude limits of zero (0) feet to flight level 600 (60,000 feet [18,288 meters]) (FAA 2017). Public access to FDM is prohibited in R-7201. The MIRC EIS/OEIS (2010) proposed to establish a 10-nautical mile (19-kilometer) radius danger zone (in accordance with 33 Code of Federal Regulations [CFR] 334 and Commander Naval Forces Marianas (COMNAVMAR) Instruction 3502.1, *Mariana Training Manual*) to restrict all private and commercial vessels from entering the area to minimize danger from hazardous activity in the area. The MIRC EIS/OEIS states that NOTMARs/NOTAMs may advise restrictions beyond 3 to 30 nautical miles (5.6 to 56 kilometers) from FDM or greater, if necessary for a training event (DON 2010).

The MITT Final EIS/OEIS (2015b) proposed to increase the initial 10-nautical mile (19-kilometer) radius to a 12-nautical mile (22-kilometer) radius danger zone (R-7201A) to maximize public awareness of hazardous military training activities and to optimize public safety. Currently, DON is in the process of developing a letter to the U.S. Army Corps of Engineers (USACE) to propose a potentially "variable" exclusion area, up to a 12-nautical mile (22-kilometer) danger zone, around FDM. The extent of the danger zone will be determined by Commander, JRM and will be based on the type of range event scheduled and associated hazards. Actions and consequences outside the jurisdiction of the JRM INRMP are discussed in the relevant EIS/OEIS.

The lease agreement between CNMI and the U.S. states in Article 12 of the lease: "c. Farallon de Medinilla: Public access to Farallon de Medinilla Island and the waters of the Commonwealth immediately adjacent, thereto shall be permanently restricted for safety reasons." At present, aside from R-7201 (14 CFR 73) and the NOTMARs/NOTAMs advisements when the range is actively in use for live-fire training, the 10- or 12-nautical mile (19- or 22-kilometer) radius danger zones have not yet been codified in 33 CFR 334. In accordance with the lease agreement with the CNMI, the lease of FDM does not include the deeper marine waters located seaward of the coastal ecosystem (NAVFAC Pacific 2004).

12.3.1 Joint Region Marianas Submerged Lands

JRM submerged lands extend 3.0 nautical miles (5.6 kilometers) offshore from the island of FDM (Figure 12-4) and comprise approximately 25,094 acres (10,155 hectares). The total shoreline length of FDM is approximately 5 miles (8 kilometers).

Under Presidential Proclamation 9077, issued January 15, 2014, the President withheld the transfer of submerged lands on Tinian, FDM, Maug, Farallon de Pajaros, and Asuncion, until coordinated management plans can be developed between the U.S. and CNMI to protect these marine resources. Under the Territorial Submerged Lands Act (PL 93-435), the President has the authority to withhold the transfer of all or some of these submerged lands for reasons of national interest, including defense preparedness and environmental protection.

12.3.2 Physical Environment

The JRM submerged lands on FDM are relatively natural and undisturbed. No military construction activity has occurred in these waters or at the coastline, which is primarily comprised of steep limestone cliffs. Rare occurrences of bombs missing or skipping off the island into the nearshore environment have been recorded

by underwater surveys that were conducted annually from 1999-2010, and in 1997 and 2012. Surface seawater temperatures around FDM typically range between 80.4-86.7 degrees Fahrenheit (°F) (26.9-30.4 degrees Celsius [°C]) (National Oceanic and Atmospheric Administration [NOAA] 2017a). During portions of 2013, 2014, and 2016, water temperatures around FDM were elevated above normal due to prolonged El Nino conditions.

Like all of the Mariana Islands, FDM is frequently subject to earthquakes, volcanism, tsunamis, and tropical storms and typhoons. At FDM in particular, seismic and volcanic activity including in the vicinity of nearby Anatahan has direct effects (Smith and Marx Jr. 2016). Anatahan is located only 37 miles (60 kilometers) from FDM and is an active volcano. In 2005, there was a magnitude 6.6 earthquake 12 miles (20 kilometers) northwest of FDM. Since 2006, there have been three magnitude 5.0 earthquakes within 31 miles (50 kilometers), and on July 30, 2016, a 7.7 magnitude earthquake occurred approximately 112 miles (180 kilometers) north-northwest of FDM. FDM is at risk from tsunamis produced by seismic events around the Pacific, as well as locally generated events. All of these external forces may affect the physical marine environment of FDM.

In addition to aerial volcanoes, the archipelago also has four active submarine volcanoes. Schils (2012) and Richmond et al. (2008) have shown that volcanic activity in the Mariana Archipelago impacts marine life; this occurs as a result of increased temperatures, sulfurous discharges/sulfur boils and changes in pH. Section 12.3.2.3, *Waves and Storms,* describes wave and storm energy impacting FDM.

12.3.2.1 Bathymetry and Currents

All sides of FDM are surrounded by nearly vertical cliff faces, which continue below the water's surface around most of the island; caves are common and dynamic erosional features are present around the island. Within the 3 nautical miles (5.6 kilometers) JRM submerged lands limit, water depth reaches approximately 180 feet (55 meters) (Figure 12-5). Some nearshore regions contain rockfalls, including areas where large cliff blocks have fallen into the water. On a wider scale, FDM is a small subaerial exposure of a larger submerged platform, which spans approximately 12 nautical miles (22.2 kilometers) east-west and 22 nautical miles (40.7 kilometers) north-south and averages between about 260-330 feet (80-100 meters) in depth; at the edge of this platform, the seafloor quickly drops off into aphotic depths.



Natural rockfalls are frequent in CNMI because most shorelines are erosional. Boulders shown are from Puntan Diablo on Tinian where coastal construction and training bombardments are absent. These have broken off of the coastal cliff, with larger boulders the size of a car are seen. (*Photo*: A.N.M. Reyes)

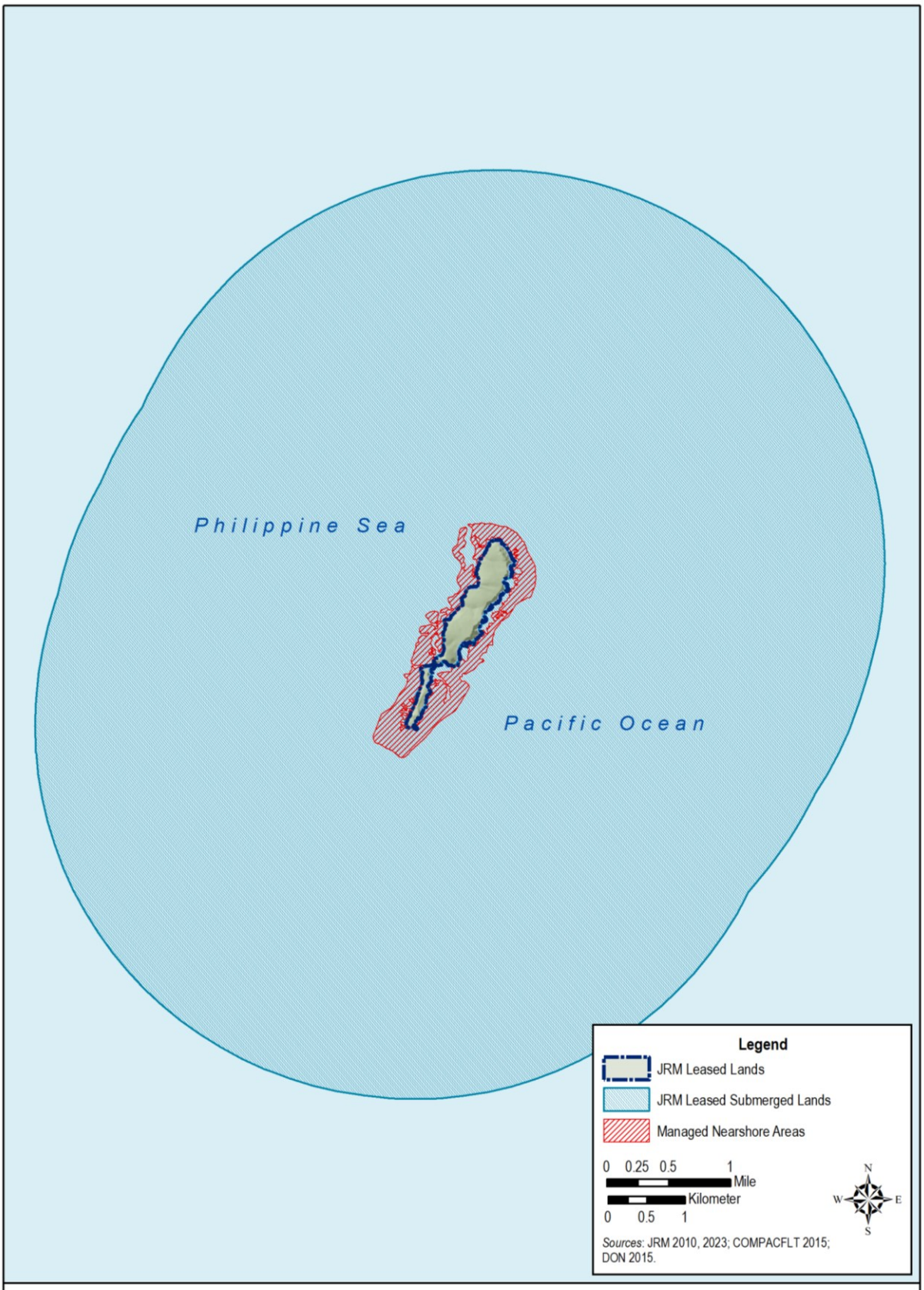


Figure 12-4
Submerged Lands Jurisdiction - FDM

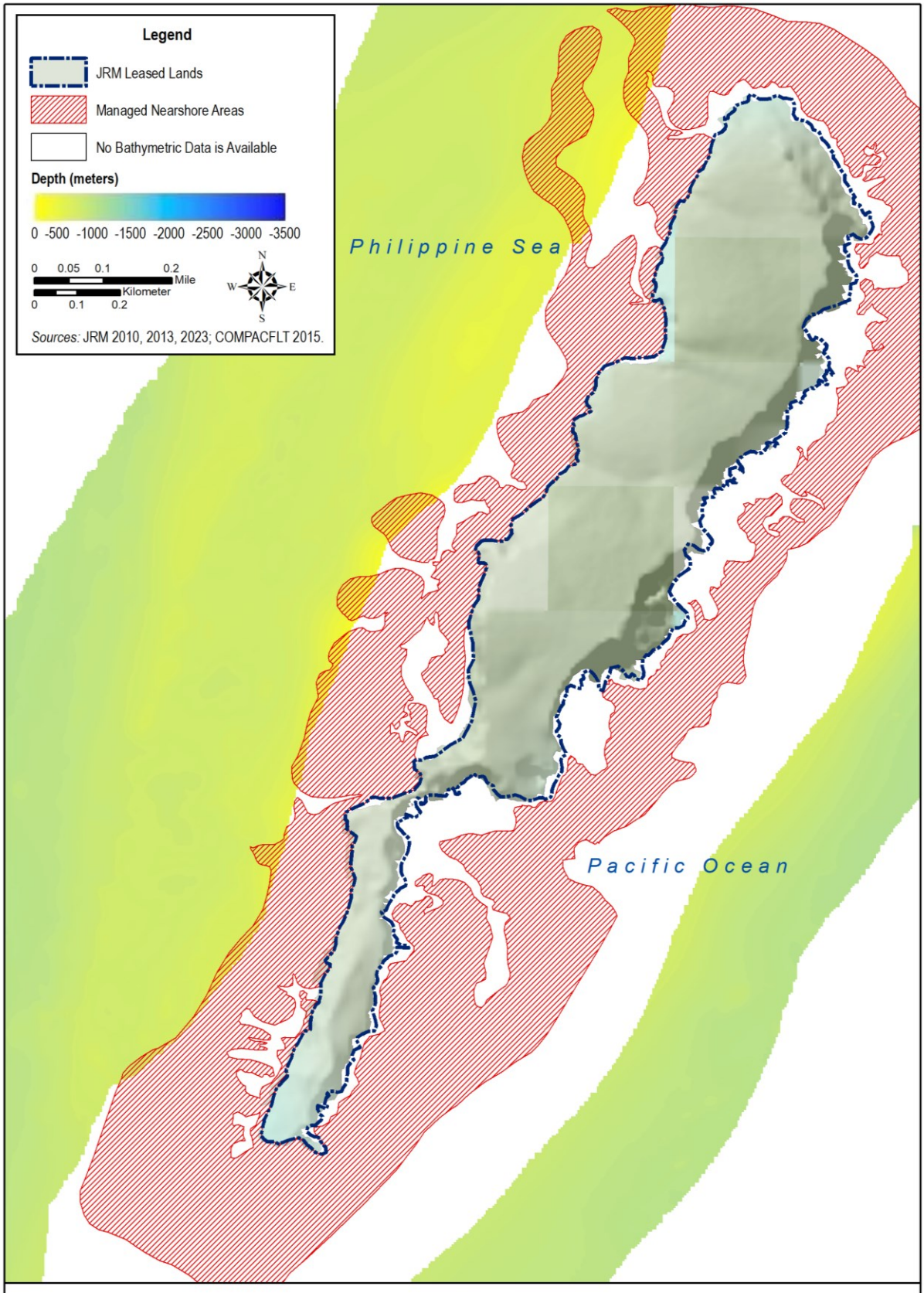


Figure 12-5
General Bathymetry of Submerged Lands Offshore FDM

FDM sits in the path of the North Equatorial Current, which flows from east to west driven primarily by the trade winds in this region. No nearshore physical oceanographic studies have been completed around FDM, but nearshore currents observed by DON scientists around the island are consistently strong (Smith et al. 2013), possibly due to shoaling of currents over the relatively shallow platform surrounding FDM. During El Nino events, the North Equatorial Current may slow or switch direction (Lagerloef et al. 2003), which would presumably change the direction and strength of nearshore currents around FDM. Regional-scale modeling of currents and biological connectivity shows complex dynamics in space and time (Kendall and Poti 2015).

The mean diurnal tidal range in Saipan, the nearest island to FDM with a tide meter, is 2.19 feet (0.67 meters), so tidal currents are relatively weak compared to wind- and wave-driven currents on FDM. Mean sea level (MSL) is reduced significantly in the Mariana Islands during El Nino events (Widlanski et al. 2015).

12.3.2.2 Turbidity and Water Quality

Turbidity increases with suspended sediment delivered to the coast in freshwater runoff, or by sediment resuspension from wave activity. There are no streams or other surface water bodies on FDM, and the existence of any freshwater aquifer and associated potential seeps is unknown. The land surface on FDM is comprised of uplifted limestone that forms steep cliffs around the island. Since 2005, only one small ephemeral beach has been observed; it is located on the west side of the island. Milky white turbidity plumes extend off this beach during high surf conditions. Underwater lateral visibility averaged 98 feet (30 meters) during marine resource surveys, but exceeded 230 feet (70 meters) on some occasions, and was as low as 23 feet (7 meters) adjacent to the island during heavy surge conditions (Smith and Marx Jr. 2016). Increased rates of erosion of limestone material from the island may occur at areas adjacent to the zones where live and inert ordnance are dropped. There is also no evidence that FDM has ever been inhabited (Whistler 1996). Because FDM is uninhabited, no additional anthropogenic nutrients are added to the waters surrounding the island.

Marine resources offshore FDM are likely subjected to a similar array of stressors in the marine environment that are described in Section 4.5.7, *Stressors on the Marine Environment of Guam*, with the exception of commercial development and overfishing impacts (Smith and Marx Jr. 2016). These overall good conditions should provide for improved coral resilience to climate impacts (Carilli et al. 2009), ocean acidification, and acute events like typhoon strikes.

12.3.2.3 Waves and Storms

The most frequent and consistent wave energy impacting FDM is caused by the northeast trade winds; thus the east (windward) side of the island is more frequently impacted by wave energy (Brainard et al. 2012). However, typhoons and tropical storms usually pass close to FDM during each typhoon season (typically May-October) and can cause significant wave energy to impact the leeward side of the island (Brainard et al. 2012). Tropical storm Phanfone passed approximately 25 miles (40 kilometers) north of FDM in 2014. In 2015, tropical storm Champi passed, essentially, directly over FDM, while Typhoon Soudelor increased in strength from a category 2 to 4 storm as it passed approximately 60 miles (95 kilometers) south of FDM.

12.3.3 Marine Habitats

12.3.3.1 Bottom Habitat

Richmond et al. (2008) note that the following stressors limit coral reef development in the Northern Mariana Islands: (1) unfavorable bathymetry, (2) lack of suitable substrate on which corals can recruit and grow, (3) frequent exposure to high wave energy, (4) resuspension of volcanic ash, and (5) volcanic eruptions.

Marine ecological surveys were conducted almost annually from 1997-2012. Over 315 person dives were completed between 2005 and 2012 and FDM was circumnavigated during every survey except one; dive coverage extended to a depth of 102 feet (31 meters). Currently, the U.S. Pacific Fleet funds marine surveys that monitor coral reefs around FDM every 5 years.



Much of the reef habitat on FDM is a veneer of corals on underlying rock. This is typical of high energy and erosional settings.
(*Photo*: S. Smith)



The central portion of FDM has well-developed reef on the western side.
(*Photo*: S. Smith)

The nearshore marine environment on FDM has been categorized into six main habitat types (Figure 12-6) that supplement the geomorphologic mapping data (Figure 12-7):

1. Type 1, unconsolidated and uncolonized coarse sediment and rubble.
2. Type 2, boulder and cliff block habitat over unconsolidated and/or consolidated bottom; boulders and cliff blocks occupy 10-20% of the sea floor around FDM. Coral cover on individual boulders and cliff blocks generally ranges from 0 to <10%.
3. Type 3, colonized hardbottom with generally <5% coral cover.

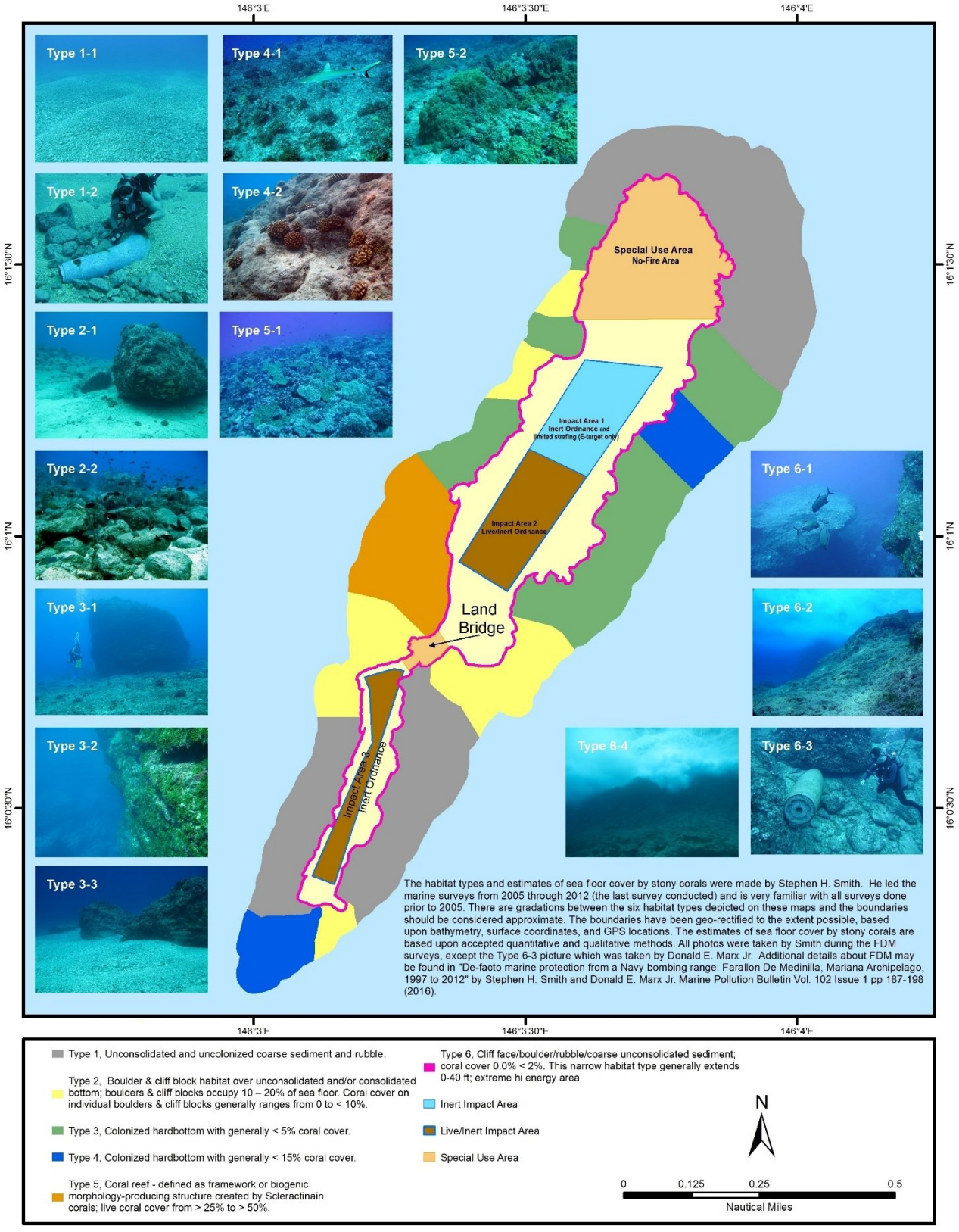


Figure 12-6. Visually Identified Nearshore Marine Habitat Types on FDM

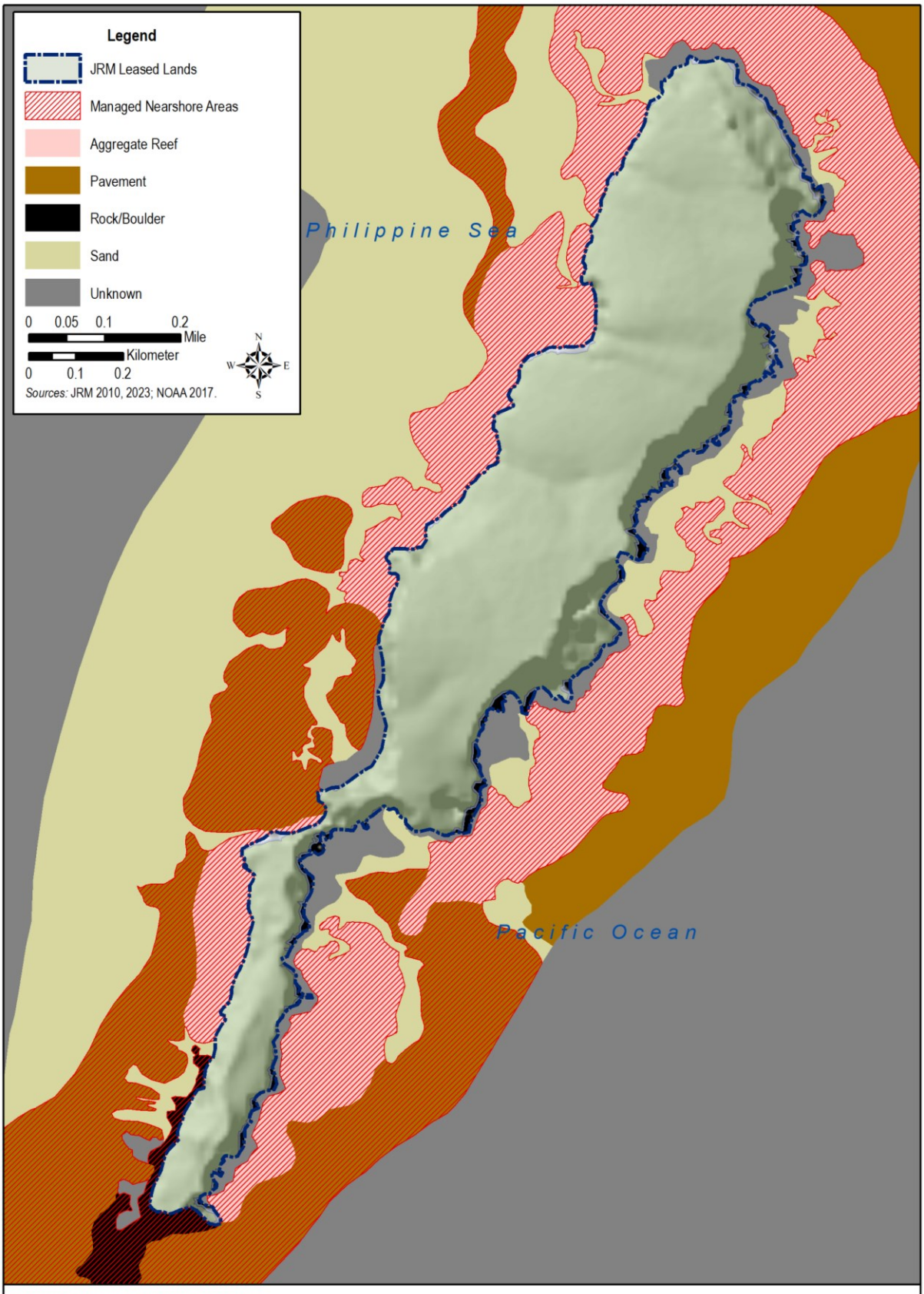


Figure 12-7
Nearshore Benthic Morphology - FDM

4. Type 4, colonized hardbottom with generally <15% coral cover.
5. Type 5, coral reef – defined as framework or biogenic morphology-producing structure created by Scleractinian corals; live coral cover from >25%, some places >50%.
6. Type 6, cliff face/boulder/rubble/coarse unconsolidated sediment; coral cover 0% to <2%. This narrow habitat type generally extends from 0-40 feet (0-12 meters) water depth; extreme high wave energy area.

True coral reef development around FDM is limited to a single area on the west side of the island. Corals are also present on submerged cliff blocks, cliff faces, and other stable hard bottom areas, but they do not form reefs in the traditional sense. Figure 12-6 provides coral cover estimates in the six major habitat types defined above, and includes the approximate boundaries of each of these visually-delineated habitat types, as well as photographs typifying each category. In addition to the six habitats above, the island contains many underwater caves, some of which have openings in excess of 33 feet (10 meters) high or wide.

12.3.3.2 Coastal Habitat

The coastline of FDM is comprised of steep limestone cliffs, which almost all plunge directly into the ocean. High wave energy impacts most of the intertidal zones where the cliffs intersect with the water. No coastal resource surveys have been undertaken on FDM.

12.3.4 Marine Flora

12.3.4.1 Native Species

No systematic/taxonomic surveys of marine flora on FDM have ever been conducted. Tsuda (2004) included only one record from FDM: green alga (*Ulva lactuca*). The following qualitative overview of marine flora is taken from Smith et al. (2013):

> "A robust and diverse community of algae has been observed at FDM during all the previous assessments. Cyanophyta/Cyanobacteria (blue-green algae), Chlorophyta (green algae), Phaeophyta (brown algae) and Rhodophyta (red algae) were all represented by many species. The prevalence or occurrence of algal species can vary substantially from year to year and seasonally."
>
> "Based upon total sea floor cover, crustose coralline algae (Rhodophyta) and turf algae (a multi-species assemblage), were clearly the dominant algal groups from the intertidal zone to about 100 feet (30 meters). This has been the case during every survey between 2005 and 2012 and for all zones. However, at depths below about 50 feet (15 meters) on the near vertical faces of large boulders, cliff blocks and sheer portions of the island's submerged walls, the calcareous green algae (*Halimeda* sp.) was very abundant and sometimes dominant in these 'micro-habitats.'…"

No seagrass habitats have been observed around FDM.

12.3.4.2 Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine flora in the CNMI are presented in Section 10.5.3, *Marine Flora*.

There are not yet reports of non-native or invasive marine flora from coastal marine habitats in the CNMI (Liske-Clark 2015). However, no systematic investigation of marine algae on FDM has ever been conducted. The fact that there is no harbor on FDM and no routine visits by commercial or military vessels reduces the likelihood that invasive algae would be introduced. Nuisance marine flora are native, but occasionally exhibit blooms or outbreaks, and there are not yet reports of nuisance marine flora species on FDM.

12.3.5 Marine Invertebrates



Spider conchs, such as the *Lambis truncata* pictured, were sighted in each year's survey at FDM.
(*Photo*: D. Marx)

12.3.5.1 Native Species

Coral

FDM supports coral-bearing substrate in five of the six habitat types described in Section 12.3.3.1, *Bottom Habitat*. However, only habitat type number 5 supports a classic coral reef (see Figure 12-6). Stony corals (Scleractinia) were the dominant coral group on FDM, based upon the percent cover, frequency of occurrence, species diversity, and other invertebrates and fishes supported by corals (Smith and Marx Jr. 2016). Between 1999 and 2012, over 60 species of stony corals were field-identified (Smith 2017). More than twice as many coral species were confirmed on Pagan, Saipan, and Tinian (about 152, 180, and 186 respectively) (Berger et al. 2005; DON 2014b, 2017). The low number at FDM could be due to different levels of sampling intensity, methods, and/or inconsistency in the level of taxonomic expertise involved. However, it almost certainly indicates a data gap that would be resolved by a targeted richness survey. Table 12-4 lists the most frequently sighted stony coral species (order Scleractinia) off FDM. *Pocillopora* was the dominant genus; with the two most abundant species being *Pocillopora meandrina* and *Pocillopora grandis.* Note that based upon new morphological and genetic evidence, *P. meandrina*, *Pocillopora verrucosa,* and *Pocillopora elegans* may prove to be a single species (Marti-Puig et al. 2014). Massive *Porites* was the second most common genus, based on percent cover. Four species of massive *Porites* (*Porites lobata*, *Porites lutea*, *Porites australiensis*, and *Porites murrayensis*) were recorded (Table 12-4), but many experts no longer make distinctions between these species (Fenner 2017).

Table 12-4. Most Frequently Observed Stony Coral Species on FDM

Pocillopora grandis	*Pocillopora meandrina*	*Pocillopora elegans*	*Leptastrea purpurea*
Favia sp.	*Goniastrea retiformis* (tentative; and/or *edwardsi*)	*Cyphastrea microphthalma*	*Astreopora myriophthalma*
*Astrea (*formerly *Montastraea*) *curta*	*Pavona varians*	*Porites lobata*	*Porites lutea*
Porites australiensis	*Porites murrayensis*		

Key: FDM = Farallon de Medinilla.
Source: Smith et al. 2013.

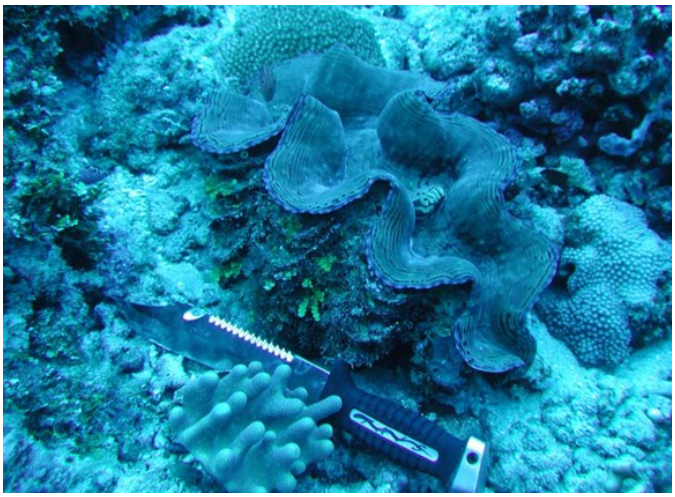
Mydlarz et al. (2006) reviewed how environmental stressors adversely impact the health of stony corals. Based upon the absence and/or scarcity of coral bleaching, coral disease, excess mucous secretions, growth anomalies, and algal overgrowth, Smith and Marx Jr. (2016) defend a qualitative assertion that the corals on FDM were relatively healthy. Additionally, coral recruits have been abundant during all surveys. The only exception to these indicators of good health was an infestation of *P. meandrina* by the coral barnacle *Cantellus* sp.

Six other taxonomic coral orders were present in addition to the stony Scleractinia. Based (subjectively) upon percent of sea floor cover, the other orders ranked, in decreasing importance: soft coral, horny coral, sea fans (Alcyonacea), lace corals (Stylasterina), fire coral (Milleporina), black coral (Antipatharia), and blue coral (Helioporacea). Soft corals were well represented, particularly at depths of 65-100 feet (20-30 meters), where specimens of *Sinularia* sp., *Sarcophyton* sp., and *Lobophyton* sp. Were most common. Those three genera of soft corals occupied more sea floor than all the other non-stony coral taxa combined. Horny corals and black corals were most abundant below 65 feet (20 meters). Lace corals were

primarily found in cave entrances; two genera appeared to be present: *Stylaster* sp. And *Disticopora* sp. Neither fire coral nor blue coral were common (Smith et al. 2013).

Other Invertebrates

Qualitative population estimates of giant clams (*Tridacna* sp.), spider conch (*Lambis* sp.), top shells (*Tectus niloticus*), and sea cucumbers indicated greater numbers of these species and larger sizes than have been observed by Smith and Marx Jr. in Guam or Tinian during the period from 2003 to 2016 (Smith and Marx Jr. 2016). This is probably due to the de-facto marine preserve effect of the island being uninhabited and rarely visited by fishermen. Two species of giant clams have been recorded, *Tridacna squamosa* and *Tridacna maxima* (Smith and Marx Jr. 2016).



Giant clams were sighted at an average rate of six per dive in all year's surveys at FDM. Pictured specimen is *Tridacna squamosa*. (*Photo*: S. Smith)

All classes of Echinoderms were represented on FDM. The following sea cucumber species (Class Holothuroidea) have been recorded: *Stichopus chloronotus*, *Thelonata anax*, *Thelonata ananas*, *Actinopyga varians*, *Bohadschia argus*, *Bohadschia marmorata*, *Holothuria atra*, *Holothuria* sp., and *Pearsonothuria graeffei* (formerly *Bohadschia graeffei*). The latter species is a new record for the Mariana Archipelago; identification was confirmed by Alexander Kerr (Smith et al. 2013). Feather stars, also known as sea lilies (Class Crinoidea) were very abundant at both the north and south ends of the island during all surveys, and common island-wide. The most commonly sighted species, according to Kerr, was *Oxycomanthus bennetti*, identified from photographs (Smith et al. 2013). Echinoidea (sea urchins) sighted included: *Diadema savignyi*, *Echinothrix diadema*, *Echinothrix calamaris*, and *Echinostrephus aciculatus*. Seastars (Asteroidea) and brittle stars (Opiuroidea) were also present, but were not identified to species, with the exception of the cushion star *Culcita novaeguineae*.

12.3.5.2 Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine invertebrates in the CNMI are presented in Section 10.5.4, *Marine Invertebrates*.

There are not yet reports of invasive marine invertebrates on FDM. The non-native *Trochus niloticus* is relatively abundant in the CNMI and occurs on FDM (Smith and Marx Jr. 2016).

Marine nuisance species on FDM include crown-of-thorns seastar (COTS) (*Acanthaster planci*). Occasional population booms (outbreaks) of COTS and their devastating effects on coral reefs are a relatively recent phenomenon, documented only since the 1960s. The causes of COTS outbreaks appear to involve multiple natural and man-made factors operating at varying scales to influence larval production, dispersal, survival, and recruitment (Miller et al. 2015; Babcock et al. 2016). Once a COTS population reaches outbreak status (present at high densities and consuming corals at a rate exceeding recovery), it should be treated as a nuisance species, subject to management measures to limit its effects. COTS have only been sighted on FDM once between 1999 and 2012 (<5 individuals were observed in 2003), in spite

of the fact that there have been COTS outbreaks during this time period around other Mariana Islands (Brainard et al. 2012; Smith and Marx Jr. 2016).

The gray sponge (*Terpios hoshinota*), which overgrows corals has not been observed on FDM but is probable given sightings elsewhere in the CNMI (Quinn and Kolis 2003; DON 2014b, 2017).

12.3.6 Marine Fishes

12.3.6.1 Native Species

The large total numbers, size, species diversity, and presence of abundant apex predators are key factors cited by Smith and Marx, Jr. (2016) as indicating that military use and restriction of access on FDM have created a de-facto marine preserve. High level predators routinely recorded include: blacktip reef sharks (*Carcharhinus melanopterus*), grey reef sharks (*Carcharhinus amblyrhynchos*), unidentified sharks (*Carcharhinus* sp.), whitetip reef sharks (*Triaenodon obesus*), tawny nurse sharks (*Nebrius ferrugineus*), giant trevally (*Caranx ignobilis*), dogtooth tuna (*Gymnosarda unicolor*), great barracuda (*Sphyraena barracuda*), and wahoo (*Acanthocybium solandri*). Representatives of 45 different fish families have been sighted (Table 12-5); members from at least 42 fish families have been recorded during every survey. The FDM fish species community closely matched the fish species composition from other islands in the archipelago, as recorded by the NMFS Pacific Islands Fisheries Service Center (PIFSC) (Brainard et al. 2012) and Schroeder et al. (2006). However, target fishery species were generally larger and more numerous on FDM than inhabited islands in the archipelago.



Exceptionally robust fish stocks have been present during every FDM survey since 1999. The black/sleek unicornfish (*Naso hexacanthus*) and yellowback fusiliers (*Caseo teres*) are among FDM's most abundant species.
(*Photo*: S. Smith)



Bigeye trevally (*Caranx sexfasciatus*) were the most common fishery target species.
(*Photo*: S. Smith)

Table 12-5. Fish Families Observed on FDM

Family Common Name	*Family Name*	*Family Common Name*	*Family Name*
Nurse sharks	Ginglymostomatidae	Butterflyfishes	Chaetodontidae
*Requiem sharks	Carcharhinidae	Angelfishes	Pomacanthidae
Stingrays	Dasyatidae	*Chubs and Rudderfish	Kyphosidae
Eagle rays	Myliobatidae	Damselfishes	Pomacentridae
Moray eels	Muraenidae	*Wrasses	Labridae
*Herrings, Sardines	Clupeidae	*Parrotfishes	Scaridae
Lizardfishes	Synodontidae	Sandperches	Pinguipedidae
*Soldier and Squirrel fishes	Holocentridae	Blennies	Blenniidae
Trumpetfishes	Aulostomidae	Gobies	Gobiidae
Scorpionfishes	Scorpaenidae	Dartfishes	Microdesmidae
Coral Crouchers	Caracanthidae	*Rabbitfishes	Siganidae
*Anthiases, Groupers, etc.	Serranidae	Moorish Idol	Zanclidae
Hawkfishes	Cirrhitidae	*Surgeon, Tangs, and unicornfishes	Acanthuridae
Cardinalfishes	Apogonidae	*Barracuda	Sphyraenidae
Sand tilefishes	Malacanthidae	*Tunas, Mackerels	Scombridae
*Jacks and Trevallies	Carangidae	*Lefteye Flounder	Bothidae
*Snappers	Lutjanidae	*Triggerfishes	Balistidae
Fusiliers	Caesionidae	Filefishes	Monocanthidae
*Sweetlips and Grunts	Haemulidae	Trunk fishes, Boxfishes, and Cowfishes	Ostraciidae
*Emperors	Lethrinidae	Pufferfish	Tetraodontidae
*Goatfishes	Mullidae	Knifejaws	Oplegnathidae
Sweepers	Pempheridae	Porcupinefishes	Diodontidae
Spadefishes and Batfishes	Ephippidae		

Note: *Families contain key fishery target species.
Key: FDM = Farallon de Medinilla.

In 2010 and 2012, there was evidence that highly sought-after fishes had been targeted by spear fishermen (Smith et al. 2013). Prior to the 2010 survey, large parrotfish, (e.g., Redlipped parrotfish [*Scarus rubroviolaceus*], and Slopehead parrotfish [*Chlorurus frontalis*]) were sighted in all habitats and would fearlessly approach divers. During the last survey, large parrotfish were markedly fewer and those that were present would quickly swim away from divers. Black jacks (*Caranx lugubris*) and twinspot snappers (*Lutjanus bohar*) likewise were less abundant and were skittish around divers. Smith and Marx Jr. (2016) noted that twinspot snapper counts exceeded 25 individuals in 20 minutes until 2012 and that aggregations of over 100 individuals were sighted; in 2012 the largest number sighted during any (entire dive) was 20. Until 2012, normalized counts of bluelined snapper (*Lutjanus kasmira*) and humpback snapper (*Lutjanus gibbus*) exceed 25 individuals in 20 minutes of observation island-wide; in 2012 not a single specimen of either species was sighted on 6 of 19 fish surveys (Smith and Marx Jr. 2016). Fishing pressure is the most likely cause of these changes, but it would be meaningful to examine the influence of other factors such as transient predators, recruitment, habitat loss, and other species level life history responses. Fishing pressure, transient predators, and recruitment are data-poor, but there is evidence that recruitment and connectivity are particularly complex in this part of the CNMI (Kendall and Poti 2015).

At the time of the last FDM survey (2012), fish stocks remained superior to those in Guam, Rota, Tinian, and Saipan. However, the island's small size makes its nearshore fishes especially vulnerable to overfishing, particularly by spear fishermen. Currently, the U.S. Pacific Fleet funds marine surveys that monitor coral reef and fish around FDM every 5 years, and the most recent survey was in September 2017. Recreational fishing activity is a significant safety hazard within the area of an active range.

12.3.6.2 Non-native and Nuisance Species

The distinctions between non-native, invasive, and nuisance marine species are presented in Section 3.5.3, *Regional Biosecurity Plan for Micronesia and Hawai'i*. General issues for non-native, invasive, and nuisance marine fishes in the CNMI are presented in Section 10.5.5, *Marine Fishes*.

There are not yet reports of non-native or invasive marine fish on FDM. A nuisance marine species is native, but occasionally exhibits population booms or other undesirable characteristics, and there are not yet reports of nuisance marine fish on FDM.

12.3.7 Marine Protected Species

Federal ESA-listed marine species are known to occur within the marine waters/submerged lands of FDM (Table 12-6). The following is a summary of known and potential occurrences of protected species in the JRM submerged land areas. Because some records are not precise, their occurrences are approximated within the 3-mile (5.6-kilometer) JRM submerged lands based on available records. Further details on each species are presented in Appendix E.

12.3.7.1 Invertebrates – Corals

Three coral species (*Acropora globiceps*, *Acropora retusa*, and *Seriatopora aculeata*), confirmed to occur within the Mariana Archipelago, were recently listed by NMFS as threatened under the ESA. One of these (*A. globiceps*) has been tentatively identified on FDM (Smith and Marx Jr. 2016). *A. globiceps* closely resembles several other *Acropora* species, in particular *Acropora humilis*, *Acropora gemmifera* and *A. retusa*. Of these four species, only *A. globiceps* has been field-identified from FDM. Regardless of taxonomic uncertainty, field-identified *A. globiceps* were uncommon (<5 specimens observed) during any individual annual marine survey. *Acropora retusa* and *S. aculeata* are the other two threatened stony corals confirmed to be present in the Northern Mariana Islands. Since FDM is down current from islands to the south where those species are confirmed, it is possible that these species could successfully recruit to FDM (Kendall and Poti 2015).

12.3.7.2 Fishes

Scalloped Hammerhead Shark

The ESA lists six Distinct Population Segments (DPSs) for the scalloped hammerhead (*Sphyrna lewini*). The Indo-West Pacific DPS, which includes the Mariana Archipelago, of scalloped hammerheads is listed as threatened. The International Union for Conservation of Nature Red List considers this shark endangered.

Scalloped hammerheads are the second largest hammerhead shark species and reach a length of at least 13 feet (4 meters). Although sharks are numerous on FDM, and five different species have been sighted, there are no records of scalloped hammerheads being sighted or caught on FDM.

Scalloped hammerheads are found worldwide in tropical and temperate seas; therefore, these sharks could occur on FDM although the island lacks any bays or shallow soft bottom habitats which are their preferred locations when they move inshore (NMFS 2014a).

Table 12-6. Federal and CNMI ESA-listed Marine Species on JRM Submerged Lands of FDM

Common Name/ Chamorro Name[1]	*Scientific Name*	*Federal Status*	*CNMI Status*	*Habitat[2]*	*Occurrence[3]*
Invertebrates (Corals)					
Coral/Acho tasi	*Acropora globiceps*	T	--	Coral reefs	Y
Coral/Acho tasi	*Acropora retusa*	T	--	Coral reefs	P
Coral/Acho tasi	*Seriatopora aculeata*	T	--	Coral reefs	P
Fish					
Oceanic whitetip shark/Haluu	*Carcharhinus longimanus*	T	--	Marine water column	PU
Scalloped hammerhead shark/Haluun kiluus or Ulon matiyu na huluu	*Sphyrna lewini*	T[4]	--	Marine water column	P
Giant manta ray/Afula or Hafula or Fanihen Tasi	*Manta birostris*	T	--	Marine water column	P
Reptiles					
Green sea turtle/Haggan	*Chelonia mydas*	E[5]	T-E	Nearshore, Marine water column, Seagrass, Coral reefs, hardbottom	Y
Hawksbill turtle/Haggan karai	*Eretmochelys imbricata*	E	T-E	Nearshore, Marine water column, Coral reefs, hardbottom	Y
Marine Mammals					
Blue whale/Salungai or Bayena	*Balaenoptera musculus*	E	--	Coastline to 984 foot (300 meter) isobath	P
Fin whale/Salungai or Bayena	*Balaenoptera physalus*	E	--	Generally near the 656 foot (200 meter) isobath	P
Humpback whale/Salungai or Bayena	*Megaptera novaeangliae*	E[6]	--	Coastline to 5,906 foot (1,800 meter) isobath	Y
Sei whale/Salungai or Bayena	*Balaenoptera borealis*	E	--	Offshore, prefers deeper waters	P
Sperm whale/Salungai or Bayena	*Physeter macrocephalus*	E	--	Deep waters generally >3,281 feet (>1,000 meters) depth	Y

Notes: [1] Chamorro names from GovGuam (2009); Kerr (1990, 2012), and Topping et al. (1975).
[2] Dominant adult habitat. Not necessarily inclusive of other life stages (e.g., egg/larvae/juvenile/breeding habitat).
[3] Occurrences approximated to JRM submerged lands, but some fishery-based and acoustic-based records have imprecise locations.
[4] Indo-West Pacific Distinct Population Segment.
[5] Central West Pacific Distinct Population Segment.
[6] Western North Pacific Distinct Population Segment.

Key: -- = not listed; CNMI = Commonwealth of the Northern Mariana Islands; E = endangered; ESA = Endangered Species Act; FDM = Farallon de Medinilla; JRM = Joint Region Marianas; P = potential for occurrence; PU = potential for occurrence, but unlikely; T = threatened; T-E = the CNMI Administrative Code does not specify whether a species is threatened or endangered: all species are considered threatened and endangered; Y = yes, known to occur.

Sources: Berger et al. 2005; Kobayashi et al. 2011; Trianni and Tenorio 2012; Smith et al. 2013; DON 2014b, 2017; Hill et al. 2014; NMFS 2014a, 2014b, 2015a, 2018a, 2018b; Uyeyama 2014; Jones et al. 2015; Klinck et al. 2015, 2016; Liske-Clark 2015; Oleson et al. 2015; Martin and Jones 2016; Smith and Marx Jr. 2016.

Humphead Wrasse and Bumphead Parrotfish

Two bony fishes occurring in the Mariana Archipelago are listed as species of concern by NMFS: the Napoleon or humphead wrasse (*Cheilinus undulatus*) and the bumphead parrotfish (*Bolbometopon muricatum*) (NMFS 2015a, 2015b), and the humphead wrasse is also CNMI-designated as SOGCN (Liske-Clark 2015; NMFS 2015a, 2015b). No bumphead parrotfish have ever been recorded from FDM, and they are exceptionally rare north of Rota. Napoleon/humphead wrasse have been sighted on FDM during every survey, including large mature males in excess of 6.5 feet (2 meters) total length (Smith and Marx Jr. 2016). All sightings of the Napoleon/humphead wrasse were made at depths over 65 feet (20 meters).

12.3.7.3 Sea Turtles

Two species of sea turtles have been sighted in the waters around FDM: green and hawksbill (*Chelonia mydas* and *Eretmochelys imbricata*) (Table 12-7). However, because sea turtles range over thousands of miles of open ocean, it is possible that any of the world's sea turtle species could pass within 3 miles (5 kilometers) of FDM occasionally. Hawksbills are federal ESA-listed as endangered, worldwide. The Central West Pacific DPS of the green sea turtle is federal ESA-listed as endangered. Table 12-7 summarizes the in-water sea turtle sightings between 2005 and 2012 (Smith et al. 2013). Out of 45 sightings of sea turtles in the waters off FDM between 2005 and 2012, 13% of the observed turtles have been identified as hawksbill turtles. This percentage is relatively high and is similar to the percentage of sightings of hawksbills observed on Tinian using a towboard survey methodology. None of the sea turtles sighted in the waters around FDM had any visible fibro-papilloma tumors, or any other visible lesions or abnormalities. In 2020, 23 unidentified sea turtles were recorded in nearshore waters via aerial surveys (Castro et al. 2020).

Table 12-7. Sea Turtles Recorded on FDM between 2005 and 2020

Species	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2012*	*2020*	*Total*
Unidentified	0	0	1	2	0	1	0	23	**27**
Hawksbill turtle (<30 centimeter carapace)	1	1	0	0	0	0	0	-	
Hawksbill turtle (>30 centimeter carapace)	1	1	0	0	0	1	1	-	**6**
Green sea turtle (<50 centimeter carapace)	2	1	2	4	0	1	2	-	
Green sea turtle (>50 and <100 centimeter carapace)	0	1	1	5	3	6	4	-	
Green sea turtle (≥100 centimeter carapace)	1	1	1	0	0	0	0	-	**35**
Total	**5**	**5**	**5**	**11**	**3**	**9**	**7**	**23**	**68**

Note: No surveys were conducted on FDM in 2011.
Key: > = greater than; ≥ = greater than or equal to; < = less than; FDM = Farallon de Medinilla.
Source: Smith et al. 2013; Castro et al. 2020

12.3.7.4 Marine Mammals

All marine mammals are protected under the Marine Mammal Protection Act (MMPA). Marine mammal observations around FDM are summarized below.

The waters within 3 nautical miles (5.6 kilometers) of FDM are not surveyed regularly for marine mammals. Therefore, systematic data that provides a comprehensive species list of marine mammals that might be found near FDM does not exist. There are a few incidental sightings of marine mammals from other survey activities on FDM. There may be patterns in the way marine mammals use the waters around FDM, but those patterns cannot be determined from current information because of the small number of sightings close to the island.



Sperm whale sighted September 20, 2011, during aerial transit between Saipan and Farallon de Medinilla.
(*Photo*: P. Wenninger)

Species that may be found near FDM could be expected to be the same species observed near Tinian, Saipan, and Guam. The species seen around those islands include spinner dolphin (*Stenella longirostris*), pantropical spotted dolphin (*Stenella attenuatat*), common bottlenose dolphin (*Tursiops truncatus*), rough-toothed dolphin (*Steno bredanensis*), pygmy killer whale (*Feresa attenuata*), melon-headed whale (*Peponocephala electra*), false killer whale (*Pseudorca crassidens*), short-finned pilot whale (*Globicephala macrorhynchus*), Cuvier's beaked whale (*Ziphius cavirostris*), sperm whale (*Physeter macrocephalus*), humpback whales (*Megaptera novaeangliae*), and dwarf sperm whale (*Kogia sima*) (Minton et al. 2009; Hill et al. 2014, 2015, 2016, 2017). The species seen most frequently near shore in those locations could be expected in the nearshore environment on FDM, to include spinner dolphin, common bottlenose dolphin, and pantropical spotted dolphin. Species that occur rarely near shore such as sperm whale and Cuvier's beaked whale would also be expected to rarely occur close to FDM.

Spinner Dolphins

The only dolphin species with confirmed sightings on FDM is the spinner dolphin. The DON contracted coral surveys on FDM in 1997, 1999, 2000, 2001, 2002, 2003, and 2004. Spinner dolphins were observed during those efforts in 1999 and 2001 (DON 2001, 2003; NAVFAC Pacific 2003, 2005). During the 1999 survey, a pod of approximately 10-12 spinner dolphins was observed on two separate days on the outer banks surrounding FDM, approximately 1 mile (1.6 kilometers) from land. In 2001, a pod of spinner dolphins was observed by divers during a towed diver survey. The dolphins were approximately 165 feet (50 meters) from land near the northwestern tip of the island. After 2004, the DON used in-house teams to survey on FDM. In 2006, DON scientists observed a small pod of about 15 spinner dolphins off the southern end of the island. Two similar pods were seen in the same area in 2007 (Smith and Marx Jr. 2009). In 2012, a pod of more than 25 mature and juvenile spinner dolphins were seen on east side of the south end of FDM. The pod was approximately 985 feet (300 meters) offshore (Smith et al. 2013).

Common Bottlenose Dolphins

During the 2013 NMFS PIFSC cetacean surveys, satellite-tagged common bottlenose dolphins were recorded on JRM submerged lands of FDM (Hill et al. 2014).

Pantropical Spotted Dolphins

During the 2013 NMFS PIFSC cetacean survey, pantropical spotted dolphins were sighted in waters offshore Saipan and Tinian (Hill et al. 2014).

Short-finned Pilot Whales

In 2008, short-finned pilot whales were observed from the surface during marine resource surveys around Tinian (Minton et al. 2009). During the 2013 NMFS PIFSC cetacean surveys, short-finned pilot whales were sighted within the waters offshore Saipan and Tinian, and satellite-tagged animals transited through the waters around FDM (Hill et al. 2014).

False Killer Whales

During the 2013 NMFS PIFSC cetacean surveys, satellite-tagged false killer whales were recorded on JRM submerged lands of FDM (Hill et al. 2014).

Pygmy Killer Whales

In 2011, a group of pygmy killer whales were sighted off Marpi Reef off the northwest side of Saipan (Hill et al. 2016).

Blue Whale

Acoustic equipment has recorded the presence of blue whales (*Balaenoptera musculus*) in the waters around FDM; however, it is not known if they were near JRM submerged lands around FDM (Klinck et al. 2015, 2016; Oleson et al. 2015).

Fin Whale

Acoustic equipment has recorded the presence of fin whales (*Balaenoptera physalus*) in the waters around FDM; however, it is not known if they were near JRM submerged lands (Klinck et al. 2015, 2016; Oleson et al. 2015).

Humpback Whale

Acoustic equipment has recorded the presence of humpback whales (*Megaptera novaeangliae*) in the waters around FDM (Klinck et al. 2015, 2016; Oleson et al. 2015). The most recent sighting of humpback whales in the nearshore waters surrounding FDM was in 2017 (NOAA 2017b). One humpback whale was sighted 9 nautical miles (16.6 kilometers) off the northeast coast of Saipan in 2007 (Fulling et al. 2011) and more recently in 2015 four humpback whale mom/calf pairs and four other humpback whales were sighted off the west coasts of Saipan and Tinian (Hill et al. 2016). During the 2016 NMFS PIFSC cetacean survey, a humpback whale was spotted at Marpi Reef, between Saipan and FDM (Hill et al. 2017).

Sei Whale

Sei whales (*Balaenoptera borealis*) were sighted during the 2007 Mariana Islands Sea Turtle and Cetacean Survey. All confirmed sightings of sei whales were south of Saipan (approximately 15° north) (Fulling et al. 2011). Acoustic equipment has recorded the presence of sei whales in the waters around FDM; however, it is not known if they were near JRM submerged lands (Klinck et al. 2015, 2016; Oleson et al. 2015).

Sperm Whale

A sperm whale was sighted incidentally on aerial transit between Saipan and FDM on September 20, 2011 (Uyeyama 2014). The sperm whale was the most frequently sighted cetacean (21 sightings) during the 2007 MITT survey with acoustic detections almost three times higher (61) than visual detections in the field (Fulling et al. 2011). Passive-acoustic glider surveys in 2015 confirmed the presence of sperm whales around FDM (Klinck et al. 2015, 2016).

Blainville's Beaked Whales

During the 2015 NMFS PIFSC cetacean survey, a single group of Blainville's beaked whales (*Mesoplodon densirostris*) (one adult male with three or four females/juvenile males) were sighted off Rota (Hill et al. 2016). Blainville's beaked whales were also seen near Rota during the NMFS PIFSC cetacean survey in 2014 (Hill et al. 2015). Blainville's beaked whales have also been acoustically recorded near Saipan, so their presence around FDM is possible (Oleson et al. 2015).

Risso's Dolphins

Passive-acoustic glider surveys in 2014 and 2015 confirmed the presence of Risso's dolphins (*Grampus griseus*) to the east of Saipan, so their presence around FDM is possible (Klinck et al. 2015, 2016).

Common Minke Whales

Passive-acoustic glider surveys in 2015 confirmed the complex, amplitude-modulated calls of the common minke whale (*Balaenoptera acutorostrata*) during a survey near the Mariana Trench southeast of Guam (Klinck et al. 2016). Their presence around FDM is possible, but unlikely.

Killer Whales

Passive-acoustic glider surveys in 2014 confirmed the presence of killer whales (*Orcinus orca*) around and to the south of Guam (Klinck et al. 2015). Their presence around FDM is possible, but unlikely.

Bryde's Whales

Three Bryde's whales (*Balaenoptera edeni*) were sighted between Rota and Guam during the 2015 NMFS PIFSC cetacean survey with species identification confirmed by photos (Hill et al. 2016). Their presence around FDM is possible, but unlikely.

Cuvier's Beaked Whales

In the 2014 NMFS PIFSC cetacean survey, a confirmed sighting of a Cuvier's beaked whale occurred 12 miles (19 kilometers) off the west side of Saipan in 5,600 feet (1,700 meters) deep water (Hill et al. 2015). Cuvier's beaked whales have also been acoustically recorded near Saipan (Oleson et al. 2015). Their presence around FDM is possible.

12.3.8 Marine Resources Monitoring

The 2017 NMFS BO for the MITT EIS/OEIS requires DON to conduct a marine survey on FDM every 5 years (NMFS 2017). The most recent survey occurred in late 2017. The BO's requirements emphasize assessing federal ESA-listed scleractinian corals.

12.4 Management Goals, Objectives, Strategies, and Actions

JRM currently manages natural resources based on an ecosystem focused approach that involves the implementation of several ongoing management projects. These projects, which are described in the following sections, provide examples of JRM's current efforts to manage and enhance natural resources in a manner consistent with the military mission. Appendix C lists management projects on FDM for Fiscal Years (FY) 2014-2017. The following sections present management projects for FDM that have been identified as necessary to achieve applicable goals and objectives identified in Chapter 3, *Environmental Management Strategy and Mission Sustainability*.

Management projects identified for FDM provide direct support for the military mission and the goal of "no net loss" in a number of ways. For example, projects that improve the baseline status of species or their

habitat, show that populations are stable, or that habitat is improving or expanding may relieve restrictions on military training or operations, minimize costs and mitigation requirements, avoid workarounds, and/or streamline regulatory processes.

12.4.1 Terrestrial Ecosystem Management

FDM's native terrestrial habitats have been impacted primarily by naval bombardment related to training activities over the past four decades. The occurrence of healthy native habitats on FDM is necessary to support sustainability of native species including federal and CNMI ESA-listed threatened and endangered species. JRM recognizes that restoration and enhancement of native habitats on lands that they manage is a long-term process, and that adaptive management is key to long-term success of the program.

Management projects are monitored and evaluated annually to ensure that they are meeting identified goals and objectives. JRM will establish mid-year coordination meetings with resource partners to discuss ongoing and planned projects, including prioritization, scope, methodology, issues or challenges, timelines, and performance evaluation criteria. These discussions are intended to facilitate improved coordination and information sharing to allow for course corrections, if necessary, to ensure an adaptive approach.

Terrestrial ecosystem management, as described in the following sections, is expected to: (1) improve the status of threatened and endangered species through habitat conservation and enhancement, and (2) promote health and sustainability of native forests on JRM leased lands. Healthy ecosystems will, in turn, relieve or reduce environmental constraints and allow for maximum operational flexibility for supporting the readiness of U.S. and allied troops.

A summary of the management projects and the estimated timeframe for completion is presented in Table 13-13, *Planned Implementation Summary of Projects on FDM*, found in Chapter 13, *Planning, Integration, and Implementation*. Some of the projects described in this section are being accomplished through interactive partnerships with federal and territorial natural resource agencies (e.g., CNMI Division of Fish and Wildlife [DFW]), universities, and local organizations.

12.4.1.1 Terrestrial Exotic and Invasive Species Management

An invasive species is defined in Executive Order (EO) 13112, *Invasive Species*, as a species that is non-native (i.e., alien or exotic) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm, or harm to human health. Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions. Invasive species have had a catastrophic effect on the native flora and fauna of island ecosystems within the Mariana Archipelago. Attributes of island biota include small geographic ranges and population size, low reproductive rates, and lack of the ability to respond to invasive species and disturbed habitats. Islands typically have lower numbers of species than mainland areas, which results in fewer predators and competitors that could prohibit the establishment of invasive species. As a result of evolving in isolation, island plants and animals have few defenses when exposed to introduced competitors and predators. These limitations on FDM have caused exotic and invasive species to replace native island species (Wiles et al. 2003).

Rats have colonized FDM, preying on the eggs and young of native species and destroying native flora (i.e., seeds and seedlings). Although not present on FDM, the brown treesnake (BTS) represents a serious threat should interdiction efforts fail and the species reaches the island.

To meet the goals and objectives of the INRMP, a suite of management projects have been identified for Terrestrial Exotic and Invasive Species Management (TIS) on FDM.

TIS-1: IMPLEMENTATION OF THE REGIONAL BIOSECURITY PLAN FOR MICRONESIA AND HAWAI'I

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objective #3; Goal #3, Objectives #1-2 and 4; Goal #4, Objectives #1-4; and Goal #7, Objective #1.

- *Strategy*: Implement appropriate recommendations within the Regional Biosecurity Plan (RBP) (DON 2015d) that will reduce the risk of introduction and spread of invasive species on FDM.
- *Action*: Develop standard language for biosecurity BMPs, update as necessary, to be included in project specifications that support prevention, such as vegetation management, and cleanliness standards for materials and equipment operating on the installation.
- *Action*: Conduct early detection surveys (EDS) for high-risk invasive species in training areas; at facilities for staging, storage, and movement of cargo/equipment and vehicles, and at other locations as deemed necessary.
- *Action*: Review and update, as appropriate, DoD Attachment M of the RBP every three years.
- *Action*: Develop, implement, and update (as necessary) a JRM biosanitation instruction to ensure cleanliness standards are adhered for the movement of cargo and equipment.
- *Action*: Continue to develop high-risk invasive species protocols and implement control and/or eradication measurement when necessary.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

TIS-2: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #2-4; Goal #3, Objectives #1 and 4; and Goal #4, Objectives #1-4. This project supports conservation measures from the MITT BO (2015 MITT BO) (USFWS 2015a).

- *Strategy*: Implement biosecurity conservation measures listed in the 2015 MITT BO from USFWS.
- *Action*: During training events, ensure 100% BTS canine inspection of aircraft, small vessels (<100ft length), and cargo/equipment departing for an off-island destination.
- *Action*: JRM considers all movements between Guam and FDM as tactical in nature and work with appropriate stakeholders to determine the appropriate interdiction methods required for aircraft, personnel, and equipment/gear movements. Ensure aircraft and equipment/gear will be 100% inspected prior to departing Guam. Additional interdiction measures in Guam may be required after discussions with appropriate stakeholders.
- *Action*: Ensure training operations that go from Guam to Saipan and then FDM via aircraft will obtain required canine inspection on Saipan or other BTS inspection as mutually agreed upon by JRM and USFWS.
- *Action*: Ensure BTS awareness briefings for all military and contractor personnel prior to all MITT training activities on FDM.
- *Action*: Maintain invasive species rapid response capabilities to control and/or eradicate introduced non-established, non-native invasive species where deemed realistic due to UXO.
- *Action*: Ensure training event personnel conduct biosecurity self-inspections of all personal gear and hand carried items to avoid potential introduction of invasive species to and from Guam. Self-inspection will ensure the removal of soil accumulations, seeds, invertebrates, and vertebrates.

- *Action*: Ensure all training events and operational range clearance events adhere to the Armed Forces Pest Management Board Technical Guide No. 31 (AFPMB TG-31) cleanliness standards for all cargo/equipment, rolling stock, and targets prior to arriving on FDM.
- *Action*: Implement high-risk invasive species protocols for the control and/or eradication of high-risk species in Guam installations and in the Tinian MLA to prevent any movements to FDM.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

12.4.1.2 Terrestrial Protected Species Management

Management of terrestrial threatened and endangered species on JRM lease lands includes implementing programs to protect species, and coordinating efforts with the appropriate agencies. Key threats to threatened and endangered species that can lead to extirpation include:

- direct mortality caused by live-fire exercises;
- habitat destruction caused by live-fire exercises;
- predation by rats;
- mortality or injury to native plants and wildlife due to natural events (e.g., typhoons);
- low reproductive success due to small population numbers;
- habitat loss and fragmentation due to bombardment; and
- risk of accidental introduction of BTS and other invasive species.

To reduce the risks of accidental introductions of invasive species, JRM implements a comprehensive biosecurity control program in coordination with local and federal partners during military training activities on FDM. JRM also conducts Micronesian megapode and vegetation monitoring in conjunction with range clearing activities.

In accordance with section 7 of the ESA, a federal agency shall consult with the USFWS to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species. JRM will coordinate with the USFWS for any federal action that is within JRM leased lands and is identified as providing habitat for threatened or endangered species. In addition, the DON will avoid, as the mission allows, impacts on habitat suitable for threatened and endangered species, and locally rare and CNMI-listed species.

Sensitive species are being managed by implementing specific management projects that enhance habitat for these species and by initiating specific strategies that address immediate needs of listed species on the island. In addition, adherence to the goals set for threatened and endangered species management ensure that JRM remains in compliance with ESA and associated consultation requirements.

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial Protected Species Management (TPS) on FDM.

TPS-1: MONITORING FOR MICRONESIAN MEGAPODES AND MARIANA FRUIT BATS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 3-4; and Goal #3, Objectives #1 and 4. This project supports conservation measures from the 2015 MITT BO (USFWS 2015a).

- *Strategy*: Implement the terms and conditions of the 2015 MITT BO.
- *Action*: Conduct Micronesian megapode surveys in known habitats on FDM in conjunction with Operational Range Clearance activities to monitor long-term population trends on FDM.

- *Action*: Any sightings of Mariana fruit bats during Micronesian megapode surveys shall be recorded.
- *Action*: Conduct habitat ground surveys to monitor Micronesian megapode and Mariana fruit bat habitat changes over time on FDM in conjunction with operational range maintenance activities.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

TPS-2: MARIANA ISLANDS TRAINING AND TESTING IMPLEMENTATION OF THE BIOLOGICAL OPINION

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective # 4; and Goal #3, Objectives #1-2 and 4. This project supports conservation measures from the 2015 MITT BO (USFWS 2015a).

- *Strategy*: Implement conservation measures listed in the 2015 MITT BO from USFWS.
- *Action*: To protect the Micronesian megapode and Mariana fruit bat, ensure implementation of targeting and access restrictions, such as (1) no targeting of the northern Special Use Area (north of the "No Fire Line") and no targeting of the narrow land bridge; (2) only targeting Impact Areas 1, 2, and 3 during air-to-ground bombing exercises and air-to-ground missile and gunnery exercises; Impact Area 1 (closest to the northern Special Use Area) is for inert ordnance only; and (3) personnel are not authorized on FDM without approval from JRM operations.
- *Action*: To protect the Micronesian megapode and Mariana fruit bats, ensure implementation of prohibition of live cluster weapons/scatterable munitions, fuel air explosives, incendiary munitions, depleted uranium rounds, or bombs greater than 2,000 pounds (907 kilograms).
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

12.4.1.3 Migratory Bird Management

JRM installations manage and monitor the effects that both military readiness and non-readiness activities have on migratory bird species and populations. Relevant regulations and policies include the Military Readiness Rule (50 CFR 21.15); the 2014 Memorandum of Understanding (MOU) between the DoD and USFWS to Promote the Conservation of Migratory Birds; and EO 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*. Through the implementation of the INRMP, proper management of migratory bird species and habitats, including the timely implementation of appropriate conservation practices, help installations avoid or minimize impacts to migratory birds.

To meet the goals and objectives of the INRMP, the following management project was identified for Migratory Bird Management (MIG) on FDM.

MIG-1: MONITORING OF MBTA-LISTED BIRD SPECIES

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1-2 and 4, and Goal #6, Objective #1.

- *Strategy*: Minimize interactions between training activities and MBTA-listed birds on FDM.
- *Action*: Monitor the distribution and abundance of MBTA-listed birds on FDM annually during peak nesting season, based on previous monitoring efforts, to guide the location of training activities.

- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

12.4.1.4 Terrestrial Natural Resources Educational Outreach

Conservation awareness is instrumental in creating conditions needed to manage natural resources. The JRM approach to awareness stresses education. It provides military personnel and the public with insights into installation natural environments and conservation challenges. The more educated people are about the unique and valuable natural resources on JRM leased lands, the more responsibly they will act when using them. Education also promotes awareness of critical environmental projects and the rationale behind them.

JRM personnel, recreationalists, and the general public understand and support conservation efforts such as habitat management, wildlife management, and land rehabilitation. As such, minimal effort is required to communicate these conservation priorities to such audiences. However, issues such as protection of sensitive areas for plant and wildlife species, invasive species management (ungulate management), wildfire suppression, and restrictions on some recreational activities in JRM leased lands require effective conservation communication to garner positive support and, perhaps more importantly, to avoid adverse reactions from various users. A conservation awareness program must be directed to both installation and external interests if it is to be effective.

To meet the goals and objectives of the INRMP, the following project was identified for Terrestrial Natural Resources Educational Outreach (TEDU) on FDM. This management project is in parallel and in concert with the management project identified and discussed in Section 12.4.2.3, *Marine Natural Resources Educational Outreach*.

TEDU-1: JRM NATURAL RESOURCES STEWARDSHIP OUTREACH AND ENGAGEMENT PROGRAM

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objective #4; Goal #3, Objective #4; Goal #4, Objectives #1 and 4; Goal #6, Objectives #1-2; and Goal #7, Objectives #1-3.

- *Strategy*: Ensure that all incoming military personnel receive comprehensive natural resources indoctrination training about the federal, territorial, and base environmental regulations and policies, as well as information about the importance of protecting and conserving JRM's natural resources, in cooperative efforts with partners, such as USFWS.
- *Action:* Develop a comprehensive Natural Resources Stewardship Outreach online training system for military and civilian personnel.
- *Action*: Create a JRM Environmental Engagement Plan to outline the areas where JRM can significantly increase their outreach with military personnel about appropriate behavior toward threatened and endangered species and the importance of conserving natural resources within JRM leased lands and submerged lands.
- *Action*: Develop, update, and implement a biosecurity education and outreach program for contractor personnel and military personnel.

12.4.1.5 Terrestrial Geographic Information System and Data Management

Natural resources data are stored and maintained within a centralized JRM Geographic Information System (GIS) database. The GIS database provides support for the entire environmental program and the training community. JRM uses the GIS for complex analyses such as project siting, data interpolations, and risk assessments.

GIS software enables installation staff to capture, store, update, manipulate, analyze, and display all forms of geographically referenced data and tabular information about natural and physical resources found on JRM leased lands. The training of JRM staff and the allocation of their time to data entry, mapmaking, data analysis, and interpretation of the results determines the success of JRM's GIS. Once fully developed, JRM's GIS databases can be used for projects such as the following:

- providing maps with locations of species, vegetation communities, surface waters, and other areas of potential concern
- selecting suitable areas for construction activities
- planning land rehabilitation projects
- providing special maps for Environmental Awareness materials;
- ensuring avoidance of threatened and endangered species habitats and other areas of special concern during construction projects
- identifying site options for use during National Environmental Policy Act (NEPA) evaluation of alternative sites
- calculating drainages and water flows
- determining wildlife habitat preferences

To meet the goals and objectives of the INRMP, the following management project was identified for Terrestrial GIS and Data Management (TGIS) on FDM.

TGIS-1: TERRESTRIAL NATURAL RESOURCES GIS AND DATA MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-5; and Goal #3, Objectives #1 and 4.

- *Strategies*:
  - Identify data gaps in terrestrial natural resources GIS to assist in the development of future data collection efforts, surveys, and management actions.
  - Ensure that GIS information is available to JRM subject matter experts and military personnel, biologists, planners, contractors, and others in a timely manner to assist with planning and decision-making.
- *Action*: Update and continuously maintain existing centralized GIS database to effectively inform and guide future management of terrestrial natural resources on FDM and meet natural resources goals and objectives. Readily available GIS data will be used to develop natural resources constraints maps for use in current and future JRM management and planning decisions for FDM.
- *Action*: Update the FDM land cover classification using methods consistent with Amidon (2017) at least once every 5 years.
- *Action*: Develop JRM project-specific modules in the Navy Data Model database as needed for more effective data management and analysis.

12.4.1.6 Summary – Terrestrial Ecosystem Management

Implementation of the JRM INRMP program and the focused strategies and actions of the management projects for terrestrial resources provides a conservation benefit to the natural ecosystems on FDM by maintaining and enhancing the natural community structure, function, species diversity, and resiliency. Enhancing and restoring native habitats supports viable populations of native species and increases biodiversity. Furthermore, proactive invasive species prevention, early detection, and control reduces the risk of intra- and inter-island species introductions. Data from regular monitoring of protected species is used to implement better management projects to enhance and restore habitat, reduce habitat fragmentation,

buffer protected areas, implement new conservation strategies, and avoid and minimize impacts. Using this regional ecosystem-based approach for managing protected species and their associated ecosystems ensures that JRM remains in compliance with federal and territorial laws while supporting the operational functionality of the FDM mission.

Seven management projects addressing terrestrial natural resources management are proposed for implementation on FDM:

- Terrestrial Exotic and Invasive Species Management – 2
  - TIS-1: Implementation of Regional Biosecurity Plan for Micronesia and Hawai‘i
  - TIS-2: Mariana Islands Training and Testing Implementation of the Biological Opinion
- Terrestrial Protected Species Management – 2
  - TPS-1: Monitoring for Micronesian Megapodes and Mariana Fruit Bats
  - TPS-2: Mariana Islands Training and Testing Implementation of the Biological Opinion
- Migratory Bird Management – 1
  - MIG-1: Monitoring of MBTA-listed Bird Species
- Terrestrial Natural Resources Educational Outreach – 1
  - TEDU-1: JRM Natural Resources Stewardship Outreach and Public Engagement Program
- Terrestrial Geographic Information System and Data Management – 1
  - TGIS-1: Terrestrial Natural Resources GIS and Data Management

12.4.2 Marine Ecosystem Management

JRM submerged lands around FDM are presently influenced by natural and anthropogenic forces that drive the short- and long-term integrity of the resources. Monitoring surveys that allow for trend analysis and provide information on reef resiliency helps draw connections between various stressors and their impact on marine communities. This information allows JRM to design and implement adaptive management strategies and make appropriate decisions about mission-essential training and operations to avoid and minimize impacts to marine resources, including ESA-listed marine species and their habitats.

Maintaining healthy marine communities supports the military mission by avoiding or alleviating potential training restrictions and/or restrictions on recreational access and use, allowing training ranges to provide unimpeded support to DoD commands. The state of knowledge and the plans for managing marine resources on JRM submerged lands differs from the management of terrestrial resources. The principal reason for the differences is that access to and direct knowledge of the marine resources by natural resource managers is extremely limited. Additionally, the cost and effort to obtain information about marine resources is typically much greater than that required for terrestrial resources. These restrictions could mean that evidence of the presence or the condition of resources may need to be inferred from indirect or infrequent measurements to a greater degree than is required on land. Therefore, the focus of this section of the INRMP for marine resources takes a different approach to the management of marine resources compared to terrestrial resources.

The content and projects described in the INRMP serve three purposes that are consistent with Overarching Goal #1, *Ensure Military Mission Sustainability and Environmental Compliance* (see Section 3.3.1, *Goals and Objectives*) but may not be held entirely in common with terrestrial resources:

- They serve the letter and spirit of the requirements of the Sikes Act for JRM to have a management plan for natural resources on its installation.
- They serve as a starting point for the basic characterization of information regarding the marine environment on JRM installations that is commonly understood between the DoD and resource

agencies, and can be used for planning purposes for environmental compliance documents that will be prepared to support DoD actions.

- They may allow JRM and NMFS to come to agreement that the management projects that are planned in the INRMP are sufficient to preclude the need to designate critical habitat for federal ESA-listed species on JRM submerged lands.

The second item emphasizes the use of INRMP content and the results of INRMP projects to inform a basic understanding of marine resources in JRM submerged lands. This understanding helps with planning costs, schedules, and requirements of proposed DoD projects, such as the type of NEPA document to be prepared, the presence of federal ESA-listed species, the type of natural resources consultations to expect, and the estimated quantity of resources and/or habitat that could be impacted. It is understood that additional detailed, site-specific studies are likely to be necessary for NEPA analyses and associated consultations.

The purpose of this section is to identify projects with specific strategies for FDM and to obtain workable and useful solutions for marine natural resources management. In accordance with Office of the Chief of Naval Operations Manual (OPNAV M)-5090.1 (2021) and the principles of adaptive ecosystem management, marine natural resources management goals, objectives, strategies, and actions were developed for FDM by an interdisciplinary team of ecologists, biologists, geologists, planners, and environmental scientists. Management of the JRM submerged lands and associated marine resources in JRM: (1) protects and conserves threatened and endangered species through habitat conservation and enhancement, (2) promotes health and sustainability of coral reefs, (3) provides continued access to recreational areas, and (4) provides continued use and access to training areas ensuring no net loss to the military mission.

The overall strategy follows a cycle of: (1) understanding the spatial distribution and types of marine habitat on JRM submerged lands, (2) characterizing the species and communities that occur in the various habitats, (3) determining the condition of the resources in the habitat, (4) determining how species that are present use or contribute to the habitat, and (5) managing the effects of stressors or threats on protected resources.

Adaptive management is intended to be an active part of all facets of the progression of resource management. Basic data collection to characterize a resource could be an endless process. Adaptive management will help to prioritize and focus effort to know when an emphasis needs to be on basic characterization, when responding to threats should be stressed, and what kind of balance between the two pursuits should be struck. Steps in the progression may be leaped past if conditions or information indicate a different step in the progression is needed. Adaptive management is not only depended on to determine what actions to take; it is also intended as a way to collaboratively review what is known about a resource so a collective agreement can be made on the next steps.

Similar to the terrestrial natural resources management program, the marine natural resources management program is divided into the following categories:

- Marine Habitat Management
- Marine Invasive Species Management
- Marine Protected Species Management
- Marine Natural Resources Educational Outreach
- Marine Natural Resources Law Enforcement
- Marine Natural Resources GIS and Data Management

As appropriate and applicable, all management projects will require evaluation or monitoring criteria, which are used to track the status of the management project, and whether the management project: (a) addresses

no net loss to the capability of FDM to support the military mission, and (b) meets the identified goals and objectives. At a minimum, mid-year coordination meetings will be held with resource agencies to discuss ongoing and planned projects to include prioritization, scope, methodology, issues encountered, timelines, and evaluation or monitoring criteria; these factors will also be discussed at the annual INRMP Metrics meeting. These conversations are meant to facilitate information sharing and enable JRM and the Agencies to take an adaptive management approach to managing INRMP projects. This approach will mean that projects are managed more dynamically and will be more responsive to arising needs than a static 5-year plan would be. A summary of the management project and the estimated timeframe for completion is presented in Table 13-13, *Planned Implementation Summary of Projects on FDM*, found in Chapter 13, *Planning, Integration, and Implementation*.

Some of the management projects described in the following sections will be accomplished through interactive partnerships with federal and territorial natural resource agencies, universities, and local organizations. JRM natural resources management staff will establish partnerships with personnel at these organizations based on the benefits to the regional ecosystem and the local environment.

12.4.2.1 Marine Habitat Management

Marine resources are inherently challenging to describe due to their inaccessibility and in many cases low detectability. The initial approach to marine resource assessment is to describe the baseline, answering the question "what is there?" This is typically done by scuba divers who record species richness and abundance within a study site that is representative of a larger area. Habitat mapping is often done in advance of baseline assessments to provide spatial context for "where" marine resources are distributed. Additionally, developing habitat maps initially helps to determine how to subdivide the study area into representative sections (i.e., strata) and how to extrapolate those baseline assessments into a larger context. However, baseline assessments are often not designed specifically to be repeatable. Repetition is critical to obtain sufficient statistical power that allows for the detection of change over time in various metrics. Monitoring designs typically increase statistical power by designing surveys that are repeatable with very high precision. Both baseline assessments and monitoring programs are essential for marine resource managers, who must first understand what resources are present and how they are distributed, and then how military operations and corresponding management actions affect those resources through time. When monitoring detects substantial changes in marine resource communities, the management actions may be adjusted.

Interagency efforts to develop consistent methods for evaluating impacts to nearshore marine resources and determining suitable mitigations that offset lost ecological functions and services are supported by the DON, NMFS, USFWS, U.S. Environmental Protection Agency (USEPA), and USACE. Standardized methods that agencies can agree on are expected to benefit processes associated with NEPA, interagency consultations (e.g., ESA), Clean Water Act (CWA) Section 404 permitting, and natural resources management. Interim results from the interagency effort are expected in the near term for consideration, but repeatable processes that are agreed on by all agencies are expected to be established over the next 5 to 10 years.

Management projects in offshore areas are primarily focused on outreach and education, and monitoring associated with testing and training given that the resources are mobile and wide-ranging and the logistical challenges of managing those resources. Divers cannot easily access marine resources below 98-131 feet (30-40 meters). Autonomous and remotely operated vehicles can be used to observe and assess resources at greater depths, but implementing management projects remotely is challenging enough with the current state of technology, therefore, autonomous/remotely operated vehicles are not a practical solution for most INRMP management projects.

To meet the goals and objectives of the INRMP, a suite of management projects was identified for Marine Habitat Management (MHM) on FDM.

MHM-1: FISH, CORAL, AND MARINE FLORA SURVEYS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1-2; Goal #3, Objectives #1 and 4; and Goal #7, Objectives #3.

- *Strategy*: Improve understanding of fish assemblages around the nearshore waters on FDM in order to comply with the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).
- *Action*: Examine fish diversity, abundance, and size of fish on JRM submerged lands around FDM.
- *Action*: Collect data of fish assemblages around the nearshore waters on FDM from 0–33 feet (0–10 meters), and from 33–66 feet (10–20 meters).
- *Action*: Document shallow (164–328 feet [50–100 meters]) and deep (820–1,148 feet [250–350 meters]) bottomfish resources on the bank surrounding FDM.
- *Action*: Analyze data in collaboration with fisheries experts.
- *Action*: Conduct a systematic survey to develop a coral species list.
- *Action*: Conduct a systematic survey to develop a marine macroalgae species list.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

MHM-2: MARINE HABITAT MAPPING EFFORTS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objective #1; Goal #2, Objectives #1 and 3-5; Goal #3, Objectives #1 and 4; Goal #5, Objective #1; and Goal #7, Objective #3.

- *Strategy*: Classify and delineate benthic mapping and characterization in the nearshore waters on FDM, focusing on depths from 0–66 feet (0–20 meters) and 66–131 feet (20–40 meters) depending on water clarity. Results from this project are being used to map habitat for threatened and endangered species (e.g., sea turtles, corals, scalloped hammerhead sharks) and Essential Fish Habitat (EFH).
- *Action*: Provide baseline data for monitoring changes in coral reef and marine benthic communities that is compatible with existing monitoring programs in Guam and the CNMI.
- *Action*: Work with NOAA NCCOS or NOAA RAMP partners to perform mapping projects of previously mapped locations/installations every 5 years (partner timeline dependent) to study and monitor temporal and spatial changes in habitat.

12.4.2.2 Marine Protected Species Management

Management of marine threatened and endangered species on JRM submerged lands includes implementing programs to protect species and coordinating efforts with the appropriate agencies. An INRMP is a primary tool for the DoD to fulfill its obligation to support section 7(a)(1) of the ESA which states that all federal departments and agencies shall seek to conserve listed species and shall use their authorities to further the purpose of the ESA.

In accordance with section 7(a)(2) of the ESA, a federal agency shall consult with NMFS to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species. In addition, the DON avoids impacts on habitat suitable for federal and CNMI ESA-listed species, as the mission allows.

Federal ESA-listed species on JRM submerged lands are being managed by implementing specific management strategies that enhance habitat for these species and by initiating specific strategies that address immediate conservation needs of listed species on the installation.

To meet the goals and objectives of the INRMP, the following management project was identified for Marine Protected Species Management (MPS) on FDM. Additional protection measures for marine protected species are presented in Section 12.4.2.4, *Marine Natural Resources Law Enforcement*.

MPS-1: SEA TURTLE POPULATION PROTECTION AND ENHANCEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #3, Objectives #1-2 and 4; and Goal #7, Objective #3.

- *Strategy*: Use existing data from monitoring events throughout CNMI and Guam to determine habitat use in the marine waters of JRM submerged lands and adjacent waters. In particular, for FDM, information on the timing that sea turtle numbers are greater or fewer could be used to alter training and testing schedules to reduce impact. Information on poaching can inform law enforcement strategies.
- *Action*: Examine distribution, movement, and habitat use of sea turtles on JRM submerged lands around FDM. When feasible, aerial surveys will be conducted in coordination with terrestrial wildlife surveys.
- *Action*: Continue to coordinate efforts with U.S. Pacific Fleet as long as their complementary sea turtle monitoring efforts continue.
- *Action*: Fund a JRM sea turtle recovery coordinator position to coordinate sea turtle monitoring and recovery efforts across Navy lands and submerged lands and coordinate with INRMP partners (DoD, Territory agencies, NOAA Fisheries, and USFWS) to align JRM sea turtle actions with other efforts in the Marianas and improve coordination of sea turtle projects.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

MPS-2: ASSESS ESA-LISTED SCLERACTINIAN CORALS

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1 and 4; and Goal #3, Objectives #1 and 4. This project supports conservation measures from the ESA section 7 Consultation BO and Conference Report for the U.S. Military MITT Activities (NMFS 2020).

- *Strategy*: Assess federal ESA-listed scleractinian corals in the marine waters around FDM.
- *Action*: Conduct surveys of federal ESA-listed scleractinian corals in the marine waters of FDM.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

12.4.2.3 Marine Natural Resources Educational Outreach

Conservation awareness is instrumental in creating conditions needed to manage natural resources. The JRM approach to awareness stresses education. It provides military personnel and the public with insights into installation natural environments and conservation challenges. Education promotes awareness of threats and stressors to marine resources and threatened and endangered species. Activities such as habitat management, natural resources management, and submerged lands rehabilitation can be assisted by

increasing the public's awareness of the importance of conserving the natural resources within JRM submerged lands. However, issues such as protection of sensitive marine areas for fish and wildlife species, invasive species management, and restrictions on some recreational activities within JRM submerged lands, require effective outreach with the public and military personnel in order to garner support and, perhaps more importantly, to avoid adverse reactions from various user impacts. An outreach program focused on minimizing impacts to marine resources and protecting ESA-listed marine species must be directed to both JRM and external stakeholders to be effective.

12.4.2.4 Marine Natural Resources Law Enforcement

JRM has established the following objectives for enforcement: (1) enforce laws and regulations pertaining to the implementation of the natural resources program, (2) integrate natural resources enforcement into the overall natural resources program, and (3) use enforcement personnel to enhance the natural resources program at JRM.

To meet the goals and objectives of the INRMP, the following management project was identified for Marine Natural Resources Law Enforcement (MLAW) on FDM.

MLAW-1: MONITORING, CONTROL, AND SURVEILLANCE PLAN

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-3; Goal #2, Objectives #1-2 and 4; Goal #3, Objectives #4; Goal # 6, Objectives #1-2; and Goal #7; Objectives #1-3.

- *Strategy*: Detect unauthorized activity that negatively affects natural resources within JRM submerged land (e.g., poaching, littering, improper vessel anchoring, illegal fishing).
- *Action*: Develop a JRM monitoring, control, and surveillance plan to determine if natural resources are being negatively impacted in nearshore waters around FDM.
- *Action*: Utilize existing expert groups, such as the U.S. Pacific Command-led Maritime Domain Awareness Working Group, to learn from already established BMPs.
- *Action:* Promote conservation by engaging the public in outreach and education on project-relevant CNMI listed species and SOGCN, important habitat, and JRM natural resource projects, as well as leading natural resource themed activities.

12.4.2.5 Marine Geographic Information System and Data Management

Natural resources data are stored and maintained within a centralized JRM GIS database using GIS data collection standards. The GIS database also provides support for the entire environmental program and the training community. JRM uses GIS for complex analyses such as project siting, data interpolations, and risk assessments.

GIS software enables installation staff to capture, store, update, manipulate, analyze, and display all forms of geographically referenced data and tabular information about natural and physical resources found on JRM submerged lands. The training of JRM staff and the allocation of their time to data entry, mapmaking, data analysis, and interpretation of the results determines the success of the installation GIS. Once fully developed, JRM's GIS databases can be used for projects such as the following:

- providing maps with bathymetric contours and locations of species, marine habitat, EFH, and other areas of potential concern
- providing special maps for Environmental Awareness materials
- ensuring avoidance of threatened and endangered species habitats and other areas of special concern during construction projects

- identifying site options for use during NEPA evaluation of alternative sites
- determining species habitat preferences

To meet the goals and objectives of the INRMP, the following management project was identified for Marine GIS and Data Management (MGIS) for FDM.

MGIS-1: MARINE NATURAL RESOURCES GIS AND DATA MANAGEMENT

This project supports the following goals and objectives identified in Section 3.3.1, *Goals and Objectives*: Goal #1, Objectives #1-2; Goal #2, Objectives #1-5; and Goal #3, Objectives #1 and 4.

- *Strategies*:
  - Identify data gaps in marine natural resources GIS to assist in the development of future data collection efforts, surveys, and management actions.
  - Ensure that GIS information is available to JRM subject matter experts and military personnel, biologists, planners, contractors, and others in a timely manner to assist with planning and decision-making.
- *Action*: Update and continuously maintain existing centralized GIS database to effectively inform and guide future management of marine natural resources on JRM submerged lands and meet natural resources goals and objectives. Readily available GIS data are used to develop natural resources constraints maps for use in current and future JRM management and planning decisions for FDM.
- *Action*: Create a marine invasive species database for JRM submerged lands.

12.4.2.6 Summary – Marine Ecosystem Management

Implementation of the JRM INRMP program and the focused strategies and actions of the management projects for marine resources provide a conservation benefit to the marine ecosystem on FDM by maintaining and enhancing marine community structure, function, species diversity, and resiliency. Inventorying and monitoring help mainta-1in and improve the local scientific knowledge of coral reef ecosystems and their resilience to environmental stressors, guide adaptive management solutions, and aid in avoidance and minimization of potential impacts to sensitive resources. Using this regional ecosystem-based approach for managing protected species and their associated ecosystems ensures that JRM remains in compliance with federal and territorial laws while supporting the operational functionality of the FDM mission.

Seven management projects addressing marine natural resources management are proposed for implementation on FDM:

- Marine Habitat Management – 2
  - MHM-1: Fish, Coral, and Marine Flora Surveys
  - MHM-2: Marine Habitat Mapping Efforts
- Marine Protected Species Management – 2
  - MPS-1: Sea Turtle Population Protection and Enhancement
  - MPS-2: Assess ESA-listed Scleractinian Corals
- Marine Natural Resources Law Enforcement – 1
  - MLAW-1: Monitoring, Control, and Surveillance Plan
- Marine Geographic Information System and Data Management – 1
  - MGIS-1: Marine Natural Resources GIS and Data Management

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13 PLANNING, INTEGRATION, AND IMPLEMENTATION

This chapter summarizes the planning, funding, staffing, coordination, and documentation associated with the Integrated Natural Resources Management Plan (INRMP) implementation for Joint Region Marianas (JRM) and those military installations that fall under the JRM area of responsibility. In Guam these installations include: Naval Base Guam (NBG) Main Base, NBG Telecommunications Site (TS), Naval Munitions Site (NMS), Apra Heights Housing, Sasa Valley and Tenjo Vista Tank Farms, Naval Computer and Telecommunications Station (NCTS) Barrigada, Barrigada Transmitter Site, Andersen Air Force Base (AFB), and Marine Corps Base Camp Blaz (MCBCB) Urban Training Complex. Also included within the JRM area of responsibility are the Tinian Military Lease Area (MLA) and Farallon de Medinilla (FDM) within the Commonwealth of the Northern Mariana Islands (CNMI).

The Sikes Act (16 United States [U.S.] Code [USC] 670[a]) is the overarching legislation mandating the preparation and implementation of INRMPs for Department of Defense (DoD) installations. DoD Instruction (DoDI) 4715.03 (2011) and DoD Manual 4715.03 (2013) require that current and planned installation activities (e.g., development plans, construction requests, site approval requests, host-tenant agreements, and out-leases) are effectively coordinated and consistent with activities described in this INRMP. It also requires DoD components to ensure that their INRMPs provide for no net loss in the capability of installation lands to support the military mission, pursuant to Section 670a(b)(1)(I) of the Sikes Act, to the extent appropriate, applicable and consistent with the installation's use. Relevant U.S. Department of the Navy (DON) guidance includes the October 2002 Secretary of the Navy (SECNAV) *Memorandum on Sikes Act Improvement Amendments*, Office of the Chief of Naval Operations (OPNAV) Manual (OPNAV M) 5090.1 (2021), and the April 2006 *Integrated Natural Resources Management Plan Guidance for Navy Installations*. Additional guidance includes Marine Corps Order P5090.2A, AFI 32-7064, Army Regulation 200-1, U.S. Fish and Wildlife Service (USFWS) INRMP guidance, the 2013 *Memorandum of Understanding Between the U.S. Department of Defense and the U.S. Fish And Wildlife Service and the Association of Fish and Wildlife Agencies for a Cooperative Integrated Natural Resource Management Program on Military Installations*, and the July 20, 2015, *Mutual Department of Defense & U.S. Fish and Wildlife Service Guidelines for Streamlined Review of Integrated Natural Resources Management Plan Updates*, a memorandum from the USFWS to DON, Army, and U.S. Air Force (USAF).

Per the Sikes Act (as amended), an INRMP is considered implemented if an installation:

- actively requests, receives, and funds "must fund" management projects and activities (see Section 13.7.1, *Programmatic Management*);
- ensures that sufficient numbers of professionally trained natural resources management staff are available to perform the tasks required by the INRMP;
- coordinates annually with all cooperating offices; and
- documents specific INRMP action accomplishments undertaken each year.

The DON's mission is to maintain, train, and equip combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. This chapter establishes the requirements for maintaining the health and long-term ecological integrity of the environment while ensuring the continued availability of the land, air, and sea space necessary for the readiness of the operating forces and the shore support of the DON (OPNAV M 2021). JRM depends on natural resources for the sustainability of many mission-related programs (e.g., operations, recreation for military personnel, drinking water, stormwater collection and conveyance, etc.). JRM will manage these natural resources to support INRMP goals and objectives, incorporate sustainable practices, and apply ecosystem management principles. Successful implementation of this INRMP will depend not only on guidelines and projects, but also on how well these

are translated into performance work statements (e.g., who will do what and with what money), project lists and scopes of work, and work plans.

13.1 RESPONSIBILITIES FOR IMPLEMENTATION

Multiple command levels share responsibility for preparation, revision, and implementation of INRMPs. SECNAV Instruction 6240.6E assigns responsibility for establishing, implementing, and maintaining the natural resources programs under the jurisdiction of SECNAV to the Chief of Naval Operations (CNO)/Commander, Naval Installations Command (CNIC). These entities ensure the programming of resources necessary to establish and support an integrated natural resources program throughout the DON that is consistent with legislative requirements, DoD policy, and stewardship requirements. JRM provides regional command and coordination. Naval Facilities Engineering Systems Command (NAVFAC) Marianas is responsible for providing technical assistance for compliance and stewardship obligations and for the evaluation of requests for funds for natural resource projects within JRM. JRM also maintains natural resources program information needed to satisfy reporting requirements and legislative information requests, and to support project requests of the installations within JRM responsibility. In accordance with Chief of Naval Operations Instruction (OPNAVINST) 5090.1C and pending further guidance, for joint bases where the DON provides facility services (e.g., to Andersen AFB), the DON will coordinate with tenant commands to ensure that environmental requirements are met.

NAVFAC Marianas, under the direction of JRM, coordinates natural resources requirements with other federal, territorial, or commonwealth agencies, including the acquisition of INRMP mutual agreements between the DON, USFWS, National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS), and territorial and commonwealth fish and wildlife agencies.

The JRM Regional Commander is responsible for and oversees INRMP implementation throughout Guam, Tinian, and FDM. However, stewardship of lands at each installation is the responsibility of the installation commanding officer. The installation commanding officer delegates the day-to-day management responsibility to the installation's professional environmental staff. It is imperative that the natural resources managers are familiar with the activities conducted on the installation by commands and tenants (including other military services and the U.S. Coast Guard [USCG]). Managers must also understand the overall conservation efforts taking place within their respective geographic region and be able to identify the support needed for those missions in the form of natural resources management.

13.2 INTEGRATED NATURAL RESOURCES MANAGEMENT AT JOINT REGION MARIANAS

Integrated management ensures that military operations and natural resources conservation are integrated and consistent with stewardship and legal requirements. Preparation of this INRMP was coordinated with other existing plans and management procedures. Prior to the Joint Base agreement, NBG and Andersen AFB prepared INRMPs unique to their organizations and managed natural resources on their installations separately. Command of DON and USAF installations in Guam was combined under JRM in 2009, and one consolidated INRMP for all JRM-administered lands was prepared in 2013. The 2013 JRM INRMP was not signed by cooperating agencies due to disagreements over management actions and projects; nevertheless, the entire plan was implemented.

Environmental readiness encompasses all aspects of environmental compliance, planning, conservation, cultural resources, and restoration (OPNAV M 2021). Thus, the INRMP also integrates facilities master plans, installation development plans, operational plans and procedures, Integrated Cultural Resources Management Plans, Integrated Pest Management Plans, Installation Restoration Program and Munition

Response Program Plans, submerged lands management plans, Guam Landscaping Guidelines, and other appropriate plans and procedures. Under the terms of its charter, the JRM Environmental Review Board oversees the National Environmental Policy Act (NEPA) process for activities potentially affecting their mission (JRM 2016). The Environmental Review Board also addresses significant section 7 Endangered Species Act (ESA) and Section 106 National Historic Preservation Act (NHPA) consultations, and environmental compliance issues. The Environmental Review Board is chaired by the J4 Regional Engineer (who is currently also the JRM Commander), and its quarterly meetings are facilitated by the J45 Regional Environmental Director. Other Environmental Review Board members include representatives from Andersen AFB, NBG, the U.S. Army, and Marine Corps Base Camp Blaz.

13.2.1 Planning and the National Environmental Policy Act

The Sikes Act does not supersede the authority of other environmental laws and regulations. As an overarching planning document, the INRMP facilitates compliance with federal environmental laws and regulations including NEPA. NEPA is the basic national charter for the protection of the environment and is a procedural planning tool that requires a clear evaluation of all federal decisions potentially affecting the human and natural environment. JRM must consider environmental consequences of its actions and projects before making a commitment to proceed with a project or proposed action. The approach to NEPA compliance taken by JRM focuses upon early planning and engagement with stakeholders to identify, avoid, and minimize impacts. An Environmental Assessment (EA) that addresses the impacts associated with implementing this INRMP is provided in Appendix H.

13.2.2 Environmental Compliance

The Environmental Management System (EMS) is the DON's primary system for maintaining environmental compliance at installations. In accordance with the NBG EMS Manual (NBG 2016), JRM policy is to integrate environmental considerations as early as possible into all business processes including planning, design, and procurements in order to reduce the impact to environmental resources and maximize mission capabilities. The Environmental Aspects and Requirements Review process is the EMS mechanism for monitoring changes to facilities and operations in order to identify environmental impacts and compliance requirements. It is linked to other review processes, most notably reviews performed by the Explosive Safety Office, Facilities Planning and Asset Management, the Security Officer, and the Public Affairs Officer. See Section 13.4, *Planning for Proposed Actions*, for further description of the planning and project review process.

13.2.3 Cultural Resources Program Coordination

In accordance with Section 106 NHPA Public Law (PL) 89-665; (54 USC 300101 et seq.), the installation Cultural Resource Managers will review activities in the INRMP that have the potential to affect cultural resources. The 2015 JRM Integrated Cultural Resources Management Plan addresses cultural resources management goals, resource inventory, and procedures for compliance with requirements set forth in Sections 106 and 110 of the NHPA, DoDI 4715.03 (2011), *Natural Resources Conservation Program*, and OPNAV M-5090.1 (2021) for all installations. Natural resources management activities that may require consultation under Section 106 of the NHPA include, but are not limited to, activities that are ground disturbing or may have an adverse effect on archaeological resources (i.e., all ground disturbing activities associated with land and facility management, habitat management, wetland enhancement, and maintenance).

13.2.4 Installation Restoration and Military Munition Response Programs

The Installation Restoration Program (IRP) and the Military Munitions Response Program (MMRP) identify, investigate, and direct the clean-up areas subject to past contamination. These two programs generally follow similar procedures, but the MMRP has unique characteristics that include Munitions and Explosives of Concern.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 and the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) (40 Code of Federal Regulations [CFR] 300) establish a decision-making process with respect to the clean-up of past contamination that involves informed decision-making and public participation. The U.S. Department of Justice determined that these provisions of CERCLA, enacted into law after NEPA, are the functional equivalent of the NEPA process. Accordingly, compliance with the requirements of CERCLA satisfies NEPA's similar objectives of informed decision-making and public participation. However, it does not obviate the need for other statutory compliance such as ESA consultation. JRM has an IRP that coordinates clean-up efforts with natural resource programs on all installations. Natural and cultural protection laws are considered at each step of the IRP/MMRP environmental restoration process, with DON working closely with regulatory agencies to ensure compliance with the substantive provisions of those laws.

13.3 Facilities Interface and Compliance with the Integrated Natural Resource Management Plan

Facilities planning activities include installation master plans, project and site development planning, construction requests, area development plans, installation appearance plans, site approval requests, host-tenant agreements, and real estate actions and projects. Facilities management and maintenance activities with specific relevance to natural resource management at JRM include recreation, utilities, potable water, fuel storage and transfer, flight line and port infrastructure, magazine maintenance, explosives safety, physical security, and on-going management of facilities infrastructure in support of the military mission.

13.3.1 Integrated Facilities Planning and Compatible Use

Facilities planning decisions need to consider alternative locations for competing uses and the relative impacts of each alternative. Executive Order (EO) 13693 directs federal agencies to design, use, or promote construction practices that are environmentally preferred and have a lesser or reduced effect on human health and the natural environment when compared with competing products or services that serve the same purpose where cost effective and to the extent practicable. Numerous regulatory requirements apply and are driven by the Clean Water Act (CWA), Clean Air Act, ESA, NEPA, Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), Fish and Wildlife Coordination Act (FWCA), and the Soil Conservation Act. Economic and military considerations are balanced with environmental impacts along with the understanding that environmental impacts from land use can eventually inhibit military mission.

Guidelines for integrated facilities planning and compatible use include the following:

- ensuring that facilities planning and management actions and projects are consistent with INRMP requirements, objectives, and targets
- aligning infrastructure to contribute to maximum performance and mission support and concentrate it in operations areas
- engaging the NEPA planning team at the earliest possible development and planning stages to identify potential constraints, as well as avoidance and minimization measures that will inform the decision-making process
- working with stakeholders and community partners to identify potential encroachment issues, including those related to environmental compliance and conservation
- maintaining a healthy ecological environment using principles of sustainability and ecosystem management to balance short-term projects with long-term goals
- working in conjunction with environmental personnel to establish protocols for emergency repair of infrastructure so that human life, health, and safety are given precedence, but sensitive resources are also protected

13.3.2 Site Approval Process

The Public Works Department, Facilities Management Division administers the site approval process that ensures all proposed site planning, project development, and facilities use requests meet DON facilities management requirements. Facilities management requirements include:

- OPNAVINST 11010.20H – *Facilities Project Instruction* (OPNAVINST 2021)
- Secretary of the Navy Instruction (SECNAVINST) 11011.47C – *Acquisition, Management, and Disposal of Real Property and Real Property Interests by the Department of the Navy; and NAVFAC* (DON 2013)
- P-73 – *NAVFAC Real Estate Procedural Manual* (NAVFAC Asset Management n.d.)
- *Environmental Condition of Property*

All natural resources management activities will be evaluated by the DON's Cultural Resources Managers to evaluate potential impacts and requirements. In addition to consideration of environmental constraints, the site approval process also considers explosive safety requirements. The site approval process also involves coordination and approval of proposed projects by Naval Ordnance Safety and Security Activity.

13.4 PLANNING FOR PROPOSED ACTIONS

The project development and planning process focuses on avoidance and minimization in areas that support sensitive resources to the greatest extent possible. This process enables planners to reduce costs (in terms of funding, labor, and time) to plan, obtain regulatory agency approvals, and implement proposed actions and projects.



A well-attended public coordination meeting.
(*Photo:* M. Lybolt)

The planning process carefully evaluates the siting of proposed actions and projects and their potential impacts. As part of the planning process, management areas having lower resource or habitat values are considered first as siting alternatives. Considering low value areas first assists planners in avoiding sensitive resources. As described in Section 13.2.1, *Planning and the National Environmental Policy Act*, proposed actions and projects with potential to affect the natural or human environment require review and approval through the NEPA process. Similarly, CERCLA projects are also evaluated and approved in a parallel review process through the IRP/MMRP.

Reviews occur following the proposal of actions and projects. Proposed actions and projects for operations and facilities changes are reviewed by facilities and environmental planners within each installation to identify potential impacts to natural resources, compliance with applicable laws, regulations and DoD policies, and conformance to the INRMP. In accordance with the November 2009 *Department of Defense Environmental Management Systems Compliance Management Plan*, a project review typically starts with a review of environmental aspects and requirements, and incorporates avoidance and minimization strategies as appropriate (DoD 2009). Projects may require regulatory consultations and/or permits, and in some instances, compensatory mitigation. Individual projects are evaluated on a case-by-case basis, considering the possible need for regulatory consultation and/or public participation. Project review can be as simple as participation in early planning discussions or as involved as conducting formal consultations, obtaining regulatory agency permits, and implementing compensatory mitigation.

Under NEPA, there are three levels of review, from lowest to highest:

- Categorical Exclusion (CATEX)
- Environmental Assessment (EA)
- Environmental Impact Statement (EIS)

NEPA requirements and timelines vary depending upon the project's size, scale, duration, environmental footprint, and potential for adverse effects. Necessary approvals can range from as little as 2 weeks for the issuance of a CATEX to 3 or more years for an EIS and associated agency consultations.

The majority of projects for JRM avoid and minimize potential adverse effects to sensitive resources, such that the NEPA review may be covered under a CATEX. Where necessary, natural resources personnel work directly with project proponents to find ways to avoid and minimize impacts to natural resources so that projects reach approval while minimizing delays or other costs. Common avoidance and minimization measures include the following:

- relocating a project to an area with no or minimal sensitive natural resources
- adjusting the size/shape of a project to avoid sensitive natural resources

- avoiding sensitive seasons of the year (e.g., breeding or nesting seasons)
- working only during daylight hours to avoid impacts from nighttime lighting
- installing soil conservation and stormwater best management practices (BMPs)
- delineating project perimeter, staging areas, and ingress/egress resources in the field to limit impact areas
- implementing biosecurity BMPs (e.g., equipment wash down and inspection procedures)
- reducing noise from construction, vibration, etc.
- implementing construction monitoring to ensure a project stays within approved limits
- implementing measures to reduce long-term effects of facility operation and maintenance (e.g., reduction or elimination of nighttime lighting, installation of berms or catchments for stormwater runoff, incorporating energy efficient designs)

JRM has a legal obligation to consider and protect Guam and CNMI ESA-listed species on federally owned, leased, and managed properties during the NEPA process. DON endeavors to protect species at risk and other sensitive species (e.g., Species of Greatest Conservation Need [SOGCN], Migratory Bird Treaty Act [MBTA]-protected species), in accordance with the Sikes Act and DoD implementing regulations (i.e., SECNAVINST 5090.8A (2006) and OPNAV M-5090.1 (2021). Proactive protection of species at risk and other sensitive species may avoid future listing of these species as threatened or endangered under the ESA, and may reduce time and other costs associated with ESA consultation.

During project reviews and approvals, DON takes into consideration current mission requirements, long-term mission planning, and future mission flexibility. Encroachment pressures on the mission present an increasing challenge for project planning as urbanization within the region continues, and available lands for development diminish.

13.5 COMPLYING WITH NATURAL RESOURCES LAWS AND REGULATIONS

Implementation of INRMP management actions and projects requires compliance with federal laws, Eos, policies, regulations, and guidelines. Maintaining compliance with the numerous laws, policies, and regulations that provide protection of environmental elements and guidance for management of natural resources may affect the military mission. Chapter 3 *Environmental Management Strategy and Mission Sustainability*, discusses the ESA, MBTA, MSFCMA, National Invasive Species Act (NISA), FWCA, CWA, Rivers and Harbors Act, and Coastal Zone Management Act (CZMA). Refer to Appendix B for a list of relevant environmental laws, regulations, policies, guidance, instructions, and Eos. Additional information specific to INRMP implementation that is targeted to avoid the incidental take of listed species, is provided below.

13.5.1 Endangered Species Act

As described in Section 3.4.1.1, *Endangered Species Act*, federal agencies are required by the ESA to seek to conserve federal ESA-listed threatened and endangered species and their habitat. At JRM sites, proposed projects, operations, or other actions are initially assessed for potential impacts on threatened and endangered species through a formal review process. In accordance with OPNAV M-5090.1 (2021), the DON consults with USFWS and/or NMFS when any action authorized, funded, or to be carried out by the DON may affect any federal ESA-threatened or endangered species or primary constituent elements of designated critical habitat. Some species (e.g., sea turtles) are jointly managed by both USFWS and NMFS so it is important to identify the life stage of the species potentially affected by a proposed action, as this will determine the agency with which to consult.

If a proposed action may affect federal ESA-listed species or designated critical habitat, the action proponent must request ESA section 7 consultations with USFWS and/or NMFS per reference (OPNAV M 2021). There is no statutory obligation to consult with USFWS or NMFS if a proposed action does not affect federal ESA-listed species or designated critical habitat. The Natural Resources Manager will use the INRMP as a tool to identify the potential impacts of planned DON actions on endangered or threatened species and provide a basis for altering the action to prevent or minimize those impacts. The natural resources managers must ensure INRMPs are prepared and implemented using the ecosystem management approach, and in a manner consistent with the military mission to preclude designations of critical habitat under ESA. Federal ESA-listed threatened and endangered species known to occur on the JRM-administered lands or submerged lands are listed in Appendix E, and addressed specifically in Chapters 4-12.

In accordance with DoD policy on ESA section 7 consultation, INRMPs should incorporate, by reference, the results of an installation's previous species-by-species ESA consultations, including any reasonable and prudent measures that might have been identified in an incidental take statement (DON 2006). In accordance with OPNAV M-5090.1 (2021), a Biological Assessment (BA) is required for evaluating the effects of a proposed major construction action (or other actions having similar physical impacts) on listed species. BAs evaluate the effects of proposed actions on federal ESA-listed species and species proposed for federal listing, designated critical habitat, and critical habitat proposed for designation. The BA, along with a letter requesting formal consultation, shall constitute the DON's formal consultation package.

Neither a separate BA nor a separate formal consultation should be necessary concerning most INRMPs or INRMP revisions. Nonetheless, because the INRMP might include management strategies or other actions designed to balance the potentially competing needs of multiple species, listed or not, it may be prudent to engage in informal consultation with USFWS and/or NMFS during the INRMP revision process to confirm that these proposed actions will not affect ESA-listed species or designated critical habitat. If the INRMP does include management strategies or other actions that could affect listed species or designated critical habitat, and these actions have not been the subject of previous consultations, then formal section 7 consultation on these actions will be necessary before the actions may be implemented.

13.5.2 Migratory Birds

DoDI 4715.03 requires that all DoD components shall, where appropriate, protect migratory bird species pursuant to the MBTA, EO 13186, and the 2014 *Memorandum of Understanding (MOU) between DoD and USFWS to Promote the Conservation of Migratory Birds*. The MBTA implements four bilateral treaties, or conventions, between the U.S. and Canada, Japan, Mexico, and the former Soviet Union (now Russia) for the protection of migratory birds. In accordance with Section 315 of the National Defense Authorization Act of 2003, the Migratory Bird Rule relates to military readiness activities. The 2007 final rule, *Migratory Bird Permits: Take of Migratory Birds by the Armed Forces* published in 72 Federal Register 8931 authorizes the "take" of migratory birds without a permit, but if the military determines that the activity will "significantly affect" a population of migratory birds, they must work with the USFWS to implement conservation measures to minimize/mitigate the effects. At this time, there is no specific regulation for incidental take permits under MBTA. Necessary information on what constitutes a military readiness activity and what is covered under the MBTA role, is found in the 2017 *Guidance on Addressing Migratory Bird Management in Integrated Natural Resources Management Plans*.

13.5.3 Magnuson-Stevens Fishery Conservation and Management Act

The MSFCMA governs marine fisheries management in U.S. federal waters to manage biological and economic sustainability (NOAA 2018). It sets mandates for NMFS, regional fishery management councils,

and federal action agencies to identify and protect important marine and anadromous fish habitat (JRM 2013). The councils, with assistance from NMFS, are required to delineate essential fish habitat (EFH) in fishery management plans or fishery management plan amendments for all managed species. Authority to implement the MSFCMA is given to the Secretary of Commerce through NMFS. The MSFCMA requires that the EFH be identified and described for each federally managed species. It also requires federal agencies to consult with NMFS on activities that could adversely affect EFH or when NMFS independently learns of a federal activity that could adversely affect EFH. An adverse effect is defined as "any impact which reduces quality and/or quantity of EFH [and] may include direct (e.g., contamination or physical disruption), indirect (e.g., loss of prey, reduction in species' fecundity), site-specific or habitat wide impacts, including individual, cumulative, or synergistic consequences of actions" (50 CFR 600.810). In 2011, the U.S. Navy released a policy on EFH assessments and consultations which supersedes 5090.1C; Chapter 24, Section 24-6(f) and clarifies the MSFCMA consultation requirements with NMFS (OPNAVINST 2021).

13.5.4 Marine Mammal Protection Act

Unlike the ESA, there is no consultation requirement under the Marine Mammal Protection Act (MMPA). If take (lethal and non-lethal) is reasonably foreseeable, DON must obtain a Letter of Authorization (LOA; for potential lethal take) or an Incidental Harassment Authorization (IHA; no potential for lethal take) from NMFS. Obtaining an LOA takes 12 to 18 months, while an IHA can take as little as 6 to 9 months. An IHA may be issued if (a) there is no potential for serious injury or mortality; or (b) the potential for serious injury or mortality can be negated through mitigation requirements. If a proposed action may affect a species protected under the MMPA, the action proponent must obtain an LOA or IHA (OPNAV M 2021).

13.5.5 Fish and Wildlife Coordination Act

The FWCA requires federal agencies involved with water resource development projects to first consult with the USFWS, NMFS, and the respective state or territory's fish and wildlife agencies regarding the potential impacts of the project on fish and wildlife resources. The results of the consultation are not binding, but the federal agency must strongly consider input received during consultation to prevent loss or damage to wildlife resources and provide for any measures taken to mitigate such impacts.

Whenever the waters or channel of a body of water are modified by a federal agency, or by any other entity where a federal permit is required, adequate consideration must be made for the conservation, maintenance, and management of wildlife resources and habitat. The Secretary of the Interior, through the USFWS and the U.S. Bureau of Mines, is further authorized to investigate and determine the effects of domestic sewage, mine, petroleum, and industrial wastes, erosion silt, and other polluting substances on wildlife, and to report recommendations to Congress.

As a collaborative effort, federal agencies, USFWS, NMFS, and state or territorial fish and wildlife agencies must develop measures to protect, develop, and improve wildlife and their habitat. Reports or decision-making documents subsequently prepared by the requesting federal agency must include the recommendations of the USFWS, NMFS, and the affected state(s) or territory for protecting fish and wildlife. Where possible, the agency must incorporate these recommendations in the project plans. The constructing, licensing, or permitting federal agency is to include in the project plans such justifiable means and measures as it finds should be adopted to obtain maximum overall project benefits.

In order to comply with the requirements laid out in the FWCA, federal agencies must first determine whether a proposed activity will result in the control or modification of a body of water. Typical actions that would fall under the jurisdiction of the FWCA include discharges of pollutants, including industrial,

mining, and municipal wastes or dredged and fill material into a body of water or wetlands; and projects involving construction of dams, levees, impoundments, stream relocation, and water-diversion structures.

13.5.6 Clean Water Act

Section 404 of the CWA prohibits the discharge of dredged or fill material into waters of the U.S. without a permit from the U.S. Army Corps of Engineers (USACE). If JRM determines that a given project (including management actions) will result in unavoidable impacts to wetlands or other waters of the U.S. (33 CFR Part 328), compensatory mitigation including wetland creation, or restoration or enhancement of previously degraded ones, may be required under Department of the Army Permit. Refer to Section 13.5.7, *Avoidance, Minimization, and Compensatory Mitigation*.

13.5.7 Avoidance, Minimization, and Compensatory Mitigation

Mitigation broadly refers to measures taken to avoid, minimize, or offset potential adverse effects to listed species and/or other sensitive resources from a proposed action. Ideally, mitigation in the form of avoidance and minimization provide sufficient environmental protection to preclude the need for compensatory mitigation. However, some projects may necessitate some form of compensatory mitigation for unavoidable impacts.

According to OPNAV M-5090.1 (2021), compensatory mitigation measures must have, at the very least, some reasonable expectation of success based on prior practice or best available commercial or scientific information. For more information about laws, regulations, and DON guidance regarding compensatory mitigation, see OPNAV M-5090.1 (2021). Pursuing programmatic approaches to landscape-scale compensatory mitigation outside of an installation should be given proper consideration in the development of natural resources management goals as contingency planning for when such measures become necessary. Generally, these mechanisms assist project proponents to offset unavoidable adverse impacts in ways that would be more ecologically effective and fiscally responsible than multiple small-scale singular actions and projects. However, off-installation options are limited to compensatory mitigation for which DON has fiscal authority. Advanced mitigation program considerations may include conservation banking, encroachment collaboration, and other such programs.

JRM natural resources personnel participated in a DON-funded Pacific Conservation Banking Workshop with partners in Honolulu in November 2017. The workshop provided participants with a foundational understanding of regulations, policies, and processes to facilitate the establishment of banks, in-lieu fees, and other advanced mitigation tools. The use of these tools has the potential to streamline regulatory processes and result in better conservation outcomes. JRM hopes to explore feasibility of advanced mitigation tools and potential collaborative approaches with partners going forward.

13.6 FUNDING INTEGRATED NATURAL RESOURCES MANAGEMENT PLAN IMPLEMENTATION

DON intends to implement INRMP actions and projects within the framework of regulatory compliance, mission obligations, anti-terrorism and force protection limitations, and funding constraints. However, obligations of funding for projects in this INRMP are subject to the availability of funds appropriated by Congress. None of the proposed management projects shall be interpreted to require obligation or payment of funds in violation of any applicable federal law, including the Anti-Deficiency Act, 31 USC Part 1341, et seq.

For the purposes of this INRMP, the terms stewardship and compliance have specific meanings as criteria for implementing management projects. Project rankings follow mandatory compliance with a legal requirement such as under the ESA, CWA, MSFCMA, or MBTA. However, other projects that may be

considered good land stewardship do not necessarily facilitate compliance with relevant laws and regulations. Projects considered necessary to comply with relevant laws are generally funded within budget constraints, whereas stewardship projects are ranked lower for funding consideration when projects are proposed by various installations then reviewed and prioritized.

Projects in support of the INRMP are described and prioritized in Tables 13-3 through 13-11 at the end of this chapter. INRMP implementation is based on programming and budgeting priorities for conservation programs described in OPNAV M-5090.1 (2021), and in Section 13.7.2, *Partnership and Project Support*. On behalf of CNIC, JRM identifies, plans for and programs the funding necessary to implement natural resources management.

13.6.1 Environmental Program Requirements

The Environmental Portal and Environmental Program Requirements (EPR-Web) is an online database located on DON's Environmental Portal that is used to define all programming for the DON environmental requirements. EPR-Web tracks project expenditures and provides immediate, web-based access to requirements entered by multiple DON environmental programs, including environmental compliance, pollution prevention, conservation, radiological controls, and range sustainment as related to environmental costs on military installations. In some cases, DON projects may be funded by other agency sources, such as the U.S. Marine Corps (USMC), in which case those projects are financially processed outside of the DON and not tracked in the EPR-Web. It is the DON's policy to fund compliance with all applicable federal, territorial, and commonwealth laws, Eos and associated implementation rules, regulations, and DoD instructions and directives. All natural resources requirements are entered into the EPR-Web and are available for review/approval by the chain of command by the dates specified in the Guidance Letter that is provided annually by CNO (N41). This database is the source for determining all programming and budgeting requirements of the Environmental Quality Program. EPR-Web is also the tool used to document the four Environmental Readiness Level (ERL) capabilities, which are used in determining programming and budgeting requirements for the review processes within the budget planning system.

13.6.2 Department of the Navy Assessment Levels for Budget Prioritization

DON's budget programming hierarchy for this INRMP is based on both DoD and DON funding level classifications. The four programming and budgeting priority levels detailed in DoDI 4715.03 *Natural Resources Conservation Program*, implement policy, assign responsibilities, and prescribe procedures for the integrated management of natural and cultural resources on property under DoD control. Budget priorities are also described in OPNAV M-5090.1 (2021). The four DON ERLs (Table 13-1) enable capability-based programming and budgeting of environmental funding to facilitate capability versus cost trade-off decisions. ERL 4 is the absolute minimum level of environmental readiness capability required to maintain compliance with applicable legal requirements. DON policy requires funding of all must fund projects, which DON INRMP guidance identifies as ERL 3 and ERL 4 projects. Budget priorities for threatened and endangered species management, especially compliance with a Biological Opinion (BO), receive the highest possible budgeting priority, and supports the need for JRM to comply with EO 13089 and avoid EFH Conservation Recommendations under MSFCMA and Critical Habitat designations under Section 4(b)(2) of the ESA, or Section 4(a)(3) of the ESA (exclusions from Critical Habitat designations for national security reasons).

Pursuant to the Sikes Act, the natural resources conservation program for each installation with an INRMP is to identify all requirements (management projects) based on the goals and objectives of the INRMP no matter the ERL level. Once requirements are identified through the funding process, they are reviewed by the chain of command for accuracy and appropriateness. Appropriate requirements are approved, but

unfortunately not all are able to be funded due to Navy-wide funding controls (or availability). All requirements are further prioritized based on funding levels authorized/appropriated by Congress, the degree to which they ensure "no net loss in the capability of installation lands to support the military mission of the installation," and Navy risk prioritization. The ERL ranking does not guarantee funding, however JRM is unique in that the program receives funding from multiple DoD sources. In addition, JRM works to implement the program through coordination with other partners (e.g. brown treesnake [BTS] program). Finally, through the Annual Metrics and JRM's enhanced coordination process outlined in Section 13.7.2.1, *Resource Partners*, JRM invites annual feedback on the effectiveness of its INRMP, documents specific INRMP management project accomplishments undertaken each year, evaluates the effectiveness of past and current management activities, and will adapt those activities as needed to implement future management projects. This annual feedback and coordination allow for partner feedback to assist with management project prioritization.

13.6.3 Department of Defense Funding Classifications

The guidance on DoD funding classifications has been updated and Enclosure 4 of DoDI 4715.03 defines the four classes of conservation programs, which are described in the paragraphs below. The projects recommended in this INRMP have also been prioritized based upon compliance and stewardship criteria provided in the hierarchy described below. The first three listed below are considered "must fund" under DON funding criteria as they are needed to maintain compliance with applicable laws and regulations.

13.6.3.1 Recurring Natural Resource Conservation Management Requirements

These activities are needed to cover the administrative, personnel, and other costs associated with managing the DoD natural resources conservation program projects that are necessary to meet applicable compliance requirements in federal, territorial, and commonwealth laws, regulations, Eos, and DoD policies, or in direct support of the military mission. DoD components shall give priority to recurring natural resources conservation management requirements associated with the operations of facilities, installations, and deployed weapons systems. These activities include day-to-day costs of sustaining an effective natural resources management program, as well as annual requirements, including manpower, training, supplies, permits, fees, testing and monitoring, sampling and analysis, reporting and record keeping, maintenance of natural resources conservation equipment, and compliance self-assessments.

13.6.3.2 Non-recurring Current Compliance

These projects and activities are needed to support an installation that is currently out of compliance, and to support signed compliance agreements or consent orders; and to ensure compliance with applicable federal or state laws, regulations standards, Eos, and/or policies. They also include projects and activities that support immediate and essential maintenance of operational integrity or military mission sustainment and projects or activities that will be out of compliance if not implemented in the current program year.

13.6.3.3 Non-recurring Maintenance Requirements

These projects and activities are needed to meet an established deadline beyond the current program year and to maintain compliance. Examples include compliance with future deadlines; conservation (such as recommendations in Bos issued pursuant to the ESA); Geographic Information System (GIS) mapping and data management to comply with federal, territorial, and commonwealth regulations; Eos; DoD policy; efforts undertaken in accordance with the non-deadline specific compliance requirements of leadership initiatives; and wetlands enhancements to minimize wetlands loss, and enhance existing degraded wetlands.

Table 13-1. DON Environmental Readiness Levels

Environmental Readiness Level	*Supported Capabilities*
"Must Fund" **ERL 4** is the absolute minimum requirement to achieve compliance and has the highest funding priority. ERL 4 is for legal requirements derived from existing laws, regulations, Eos, Final Governing Standards, or the Overseas Environmental Baseline Guidance Document, as applicable; and applies to DON activities, platforms, and operations. It supports all actions and projects specifically required by law, regulation, or EO.	• Supports all DoD Class 0 requirements as they relate to a specific statute, such as hazardous waste disposal, permits, fees, monitoring, sampling and analysis, reporting, and record keeping.
	• Supports recurring administrative, personnel, and other costs associated with managing environmental programs that are necessary to meet applicable compliance requirements.
	• Supports minimum feasible DON executive agent responsibilities, participation in OSD sponsored inter-department and interagency efforts, and OSD mandated regional coordination efforts.
ERL 3 is for requirements derived from DoD policy and DON policy, or proactive initiatives that could enable future compliance or result in a positive return on DON investments. They could also support critical readiness activities by decreasing encumbrances of statutory compliance requirements. These efforts are not mandated by law or other federal, state, or local requirements but would minimize current or future impacts (including costs) to the DON mission.	• Supports all capabilities provided by ERL 4.
	• Supports existing level of DON executive agent responsibilities, participation in OSD sponsored inter-department and interagency efforts, and OSD mandated regional coordination efforts.
	• Supports proactive involvement in the legislative and regulatory process to identity and mitigate requirements that will impose excessive costs or restrictions on operations and training.
	• Supports proactive initiatives critical to the protection of DON operational readiness.
ERL 2 is for requirements derived from pending federal, state, or local legal requirements, laws, regulations, or Eos that could enable future compliance but result in less certain returns on investments and uncertain benefits to the DON's mission. These project efforts are not mandated by existing law or other federal, state, or local requirements. Funding requirements should be based on best available scientific or commercial data; or on pending federal, state, or local regulations under development (where publication is scheduled) using model state regulations or permit standards, if available.	• Supports all capabilities provided under ERL 3.
	• Supports enhanced proactive initiatives critical to the protection of DON operational readiness.
	• Supports all DON and DoD policy requirements.
	• Supports investments in pollution reduction, compliance enhancement, energy conservation, and cost reduction.
ERL 1 is for investments in environmental leadership and general proactive environmental stewardship.	• Supports all capabilities provided under ERL 2.
	• Supports proactive actions and projects required to ensure compliance with pending/strong anticipated laws and regulations in a timely manner and/or to prevent adverse impact to DON mission.
	• Supports investments that demonstrate DON environmental leadership and proactive environmental stewardship.

Key: DoD = Department of Defense; DON = Department of the Navy; EO = Executive Order; ERL = Environmental Readiness Level; OSD = Office of the Secretary of Defense.

13.6.3.4 Non-recurring Enhancement Actions beyond Compliance

These projects and activities enhance conservation resources, enhance the integrity of the installation mission or are needed to address overall environmental goals and objectives, but are not specifically required by law, regulation, or EO, and are not of an immediate nature. Examples include community outreach activities; educational and public awareness projects; restoration or enhancement of natural

resources when no specific compliance requirement dictates a course of action; and management and execution of volunteer and partnership programs.

13.6.4 Natural Resources Personnel

The Sikes Act and DoD M-4715.03 require "sufficient numbers of professionally trained natural resources management and natural resources enforcement personnel to be available and assigned responsibility to prepare and implement the INRMP." NAVFAC Marianas supports JRM in this regard and is responsible for identifying personnel requirements to accomplish INRMP goals and objectives. The NAVFAC Marianas Environmental staff elevates budgeting and staffing recommendations to higher authority for allocation of funding. Personnel assigned to natural resources management are responsible to administer a consistent conservation program based upon strategies outlined in the INRMP to support the DON mission and achieve its goals and objectives.

NAVFAC Marianas staff includes a Conservation and Planning Supervisor, a Conservation Resources Program Manager, a BTS Program Manager, a Regional Marine Resources Program Manager, a Regional Biosecurity Plan (RBP) Program Manager, a Marine Resources Specialist, and three Natural Resources Specialists. Future staffing includes a Mariana Islands Training and Testing (MITT) BO Program Manager and a NEPA Subject Matter Expert.

NBG staff includes an Installation Environmental Program Director, three Natural Resource Specialists, and an Archaeological/Cultural Resource Program Manager.

Andersen AFB Environmental Flight Program staff currently includes a Supervisory Environmental Engineer, a Conservation Program Supervisor, a Cultural Resources Specialist, and three Natural Resources Specialists, as well as Compliance and Restoration staff.

The Defense Policy Review Initiative Program Management Office, Environmental Division staff includes an Environmental Director, two Natural Resource Specialists, a Compliance Specialist, Biomonitor, Biosecurity Program Manager, a Cultural Resource Specialist, a State Historic Preservation Officer Liaison, and three Student Conservation Associates.

Adequate training of natural resource personnel is important to the success of military sustainability and land management. Personnel must have sufficient subject matter expertise including range certification, endangered species biology and consultation processes, knowledge of local terrestrial and marine ecology, understanding of animal behavior and plant-animal interactions, island biology, invasive and noxious species ecology, and familiarity with resources and site-specific issues in Guam and in the CNMI. JRM and the installations in Guam provide their staff with necessary supplemental training to help ensure that management activities are planned and executed in a fully informed and efficient manner. The professional staff members also participate in annual professional conferences and workshops, as appropriate and as funding allows.

Training opportunities may be offered through structured courses and conferences, workshops, and symposia including the National Military Fish and Wildlife Association annual workshop and the North American Natural Resources Conference. The Wildlife Society, Society of Wetland Scientists, the American Fisheries Society, Society for Ecological Restoration, and Society for Conservation Biology are among a hundred or more professional societies that can meet the information requirements and training targets for DON natural resource managers.

13.6.5 Funding Sources

The principal source of funding for JRM's natural resource program is Operations and Maintenance (O&M) funding (annually appropriated) provided by CNIC. All requirements are submitted for O&M funding in EPR-Web. The DON EPR-Web system is the basis for maintaining the personnel and core programs required for natural resources programs (conservation funds). These appropriated funds are the primary source of resources to support must fund, such as DON ERL 3 and 4 projects.

Other sources of funding that support the conservation program include funding from facilities maintenance and housing to address pest management issues (e.g., BTS control and interdiction); military construction funding (MILCON); and Research, and Development, Testing, & Evaluation funding. DoD programs that provide limited competitive funding opportunities for conservation program initiatives include the Legacy Resource Management Program (Legacy), Living Marine Resources Program, Strategic Environmental Research and Development Program, Environmental Security Technology Certification Program, and the DON Environmental Sustainability Development to Integration Program. USMC and USAF also provide other sources of funding. The Readiness and Environmental Protection Integration Program is an alternative funding tool administered by the Office of the Secretary of Defense (OSD) that leverages public and private funds to alleviate encroachment that can limit or restrict military training, testing, and operations. In addition to DoD funding sources to implement natural resources projects on JRM-administered lands, federal partner agencies (such as the U.S. Department of Agriculture [USDA]-Animal and Plant Health Inspections Service [APHIS], the U.S. Geological Survey [USGS] Fort Collins Science Center, NMFS, etc.) implement projects on JRM-administered lands with agency allocated funds or grants that align with INRMP management objectives.

13.7 IMPLEMENTATION PROCESS

This INRMP is effective upon the acceptance and signatory release described in Section 13.1, *Responsibilities for Implementation*. As the plan serves as a formal structuring and integration of the existing natural resources management program, current projects, activities, and plans have been incorporated into the INRMP. Priorities are based, in part, on annual requirements, environmental considerations, and mission support needs. NAVFAC Marianas Environmental staff determines what projects and activities are appropriate to initiate, subject to priorities of the Installation Commanding Officer and given funding at any particular time. The INRMP is meant to be flexible, dynamic, and adaptable to the immediate concerns and needs of natural resources management and the DON mission. DON coordinates and collaborates on a regular basis with partners on planned projects and changes to planned projects. Future work identified herein will be implemented as funding becomes available.

13.7.1 Programmatic Management

Natural resources management and implementation of INRMP policies entail an on-going effort to integrate requirements and objectives into existing facilities and operational processes and procedures. The following on-going facilities management activities must conform to the INRMP policies and implementation objectives:

- landscape management and grounds maintenance based upon the Final Guam Landscaping Guidelines (NAVFAC Pacific 2011)
- vegetation clearing to support fire, explosives safety and security clear zones
- road and roadside maintenance for both paved and unpaved roads
- fire management actions and projects, including both pre-suppression and suppression

- facilities routine maintenance and repair
- utilities routine maintenance and repair
- normal and on-going mission operations

Planning and implementation of the following facilities management activities should consider and integrate natural resource management goals and objectives. The following mission business processes and operational controls should be reviewed to ensure that natural resources programmatic requirements are fully integrated:

- installation command policies and procedures in the form of written instructions
- facilities service contracts for grounds maintenance and pest management
- facilities repair and construction contract standard specifications
- design and construction specifications, with a focus on Temporary Environmental Controls section
- recurring maintenance work orders using enterprise geodatabases
- Standard Operating Procedures for ordnance and security operations

13.7.2 Partnerships and Project Support

The success of natural resources management and the implementation of this INRMP require a cooperative planning effort among the parties directly responsible for operating and maintaining the installations. The level of success can be enhanced by developing partnerships among other parties that have a vested interest in the responsible management of the natural resources within the installation. Cooperative planning groups often include representatives from federal, state, and local agencies, citizen groups, developers, and universities. The involvement of these agencies is based on their designation as cooperating agencies and on cooperative agreements, regulatory authority, and technical assistance, as required by federal legislation and regulation. Also, limitations to staff time at installations necessitate using contracted services or other federal agency services, cooperators, and contractors. Typically, contractors perform targeted surveys as this also enables obtaining needed expertise. Opportunities for external assistance with natural resource programs at JRM are summarized below.

Refer to Chapter 3, *Environmental Management Strategy and Mission Sustainability*, for a detailed discussion of teaming partners for project support.

13.7.2.1 Resource Partners

In accordance with the Sikes Act, the USFWS, NMFS, Guam Division of Aquatic and Wildlife Resources (Guam DAWR), and CNMI Division of Fish and Wildlife (DFW) are cooperating on INRMP implementation with other federal and local agencies. Cooperative efforts with USFWS and NMFS involve identifying potential federal ESA-listed threatened and endangered species on JRM-administered lands and submerged lands, and conducting informal and/or formal consultations prior to implementation of any action that may affect species, or species proposed for listing. The Installation Environmental Offices and NAVFAC Marianas Environmental Staff work with Guam DAWR and CNMI DFW to manage fish and wildlife on JRM-administered lands.

The NAVFAC Marianas Environmental staff will coordinate with USFWS, Guam DAWR, CNMI DFW and NMFS each year to discuss proposed projects and, solicit comments recommendations for each project. Installation Environmental Office and NAVFAC Marianas Environmental staff subject matter experts (SMEs) will continue to engage with appropriate USFWS, Guam DAWR, CNMI DFW and NMFS SMEs to finalize projects plans and monitor implementation. Table 13-2 outlines the schedule of coordination and collaboration on project development and implementation.

Table 13-2. NAVFAC Marianas Environmental Schedule of Coordination and Collaboration with Resource Partner Agencies

Coordination Topic	*Timeframe*
Meet with CNMI DFW, Guam DAWR, USFWS, and NMFS to present proposed projects for implementation. Discussion will include Partner input on project prioritization.	4th Quarter of FY prior to FY of execution (e.g., July-September of FY18 for FY19 projects)
JRM SME technical discussions on specific projects with appropriate CNMI DFW, Guam DAWR, USFWS, and NMFS staff.	1st Quarter of FY of execution (October-December)
Meet with CNMI DFW, Guam DAWR, USFWS, and NMFS to discuss projects. Discussion will include challenges and successes with coordination and collaboration on projects.	2nd Quarter of FY of execution (January-March)
JRM SME continue technical discussions on project implementation and completion.	As needed, throughout the FY

Key: CNMI = Commonwealth of the Northern Mariana Islands; DFW = Division of Fish and Wildlife; FY = Fiscal Year; Guam DAWR = Guam Division of Aquatic and Wildlife Resources; JRM = Joint Region Marianas; NAVFAC = Naval Facilities Engineering Systems Command; NMFS = National Marine Fisheries Service; SME = Subject Matter Expert; USFWS = United States Fish and Wildlife Service.

13.7.2.2 Contractors

Circular A-76 mandates the federal government to use commercial sources to supply the products and services the government needs. Contractors are able to provide a wide variety of specialties. Contractors may be hired to perform specialized management projects or provide technical knowledge about natural resources management to aid JRM with implementation of this INRMP. Contractors must adhere to the requirements and management strategies detailed in the INRMP. Following are examples of contractor support for implementation of natural resources management goals:

- threatened and endangered species surveys
- invasive species surveys
- soil surveys
- ungulate control
- management plans for threatened and endangered species
- vegetation surveys
- field and nursery studies relating to native plant ecology and propagation
- monitoring hydrology and soil erosion
- monitoring the terrestrial and marine resources of the Ecological Reserve Area (ERAs)
- wetlands and waters of the U.S. delineations

Contractor supported projects require preparation of a request for proposal and a Performance Work Statement to acquire services, which should be considered during project planning to ensure appropriate funding can be obtained in a timely manner.

13.7.2.3 Interagency Agreements

JRM recognizes the importance of cooperating with federal, territorial, and commonwealth agencies in addition to private organizations. In addition to working with the INRMP signatory partners (USFWS, NMFS, Guam DAWR, and CNMI DFW), JRM currently has multiple-year interagency agreements with USDA APHIS Wildlife Services (BTS and ungulates), USDA-National Wildlife Research Center (BTS and small vertebrates), USGS-Fort Collins Science Center (BTS and small vertebrates), and NMFS (sea turtle tagging) to implement natural resources projects.

13.7.2.4 Cooperative Agreements and Partnerships

Cooperative agreements are legal instruments that are used to enter into relationships in which substantial involvement among DON and the territorial and commonwealth governments, institutions of higher education, hospitals, non-profit organizations, and individuals, is expected. The principal purpose of these relationships is to transfer value to another recipient as authorized by a law instead of acquiring (by purchase, lease, or barter) property or services for the direct benefit or use of the U.S. Government.

Cooperative agreements may be entered into for inventories, monitoring, research, minor construction and maintenance, and public awareness, to provide for the maintenance and improvement of natural resources or conservation research on DoD installations (DoD 2011). To use a cooperative agreement, substantial involvement is expected between DON and the state, local government, or other recipient when carrying out the activity contemplated in the agreement. They provide a mutually beneficial means of acquiring, analyzing, and interpreting natural resources data, which can then be used to inform natural resources management decisions. Funded by DON, cooperative agreements produce information that can be used to help resource managers achieve project-specific compliance with environmental laws. Authorization for cooperative agreements is arranged through NAVFAC Marianas.

Universities are an excellent source of assistance for research, surveys, and development of monitoring programs to inform the natural resource management program. Additionally, they can provide resource specific expertise as well as assistance with implementation of restoration activities. Collaborative investigations performed in conjunction with JRM biologists provide an effective source of assistance with implementation of the INRMP. These include the University of Hawai‘i, Colorado State University, University of Georgia, and University of Guam (UOG). For example, UOG, in conjunction with JRM staff, has conducted baseline surveys of the nearshore marine environment at the Andersen AFB Marine Resources Preserve, field and nursery studies relating to native plant ecology and propagation, monitoring of hydrology and soil erosion on NBG, marine monitoring at Orote Peninsula ERA and Haputo ERA, surveys of endangered tree snails on JRM-administered lands, monitoring of the Haputo ERA, and assisted in the *Serianthes nelsonii* Tree Recovery Project.

The Cooperative Ecosystem Studies Units (CESU) program is a working collaboration among federal agencies, universities, local government and non-governmental organizations, and other nonfederal institutional partners. The CESU National Network provides multidisciplinary research, technical assistance, and education to resource and environmental managers. The DoD is a participant in the CESU program, which is overseen by U.S. Department of Interior. There are numerous CESU throughout the U.S. and JRM is not limited to using a specific CESU. Often specific localized expertise in natural resources of specific interest can be obtained through agreements with CESU organizations.

13.7.2.5 Volunteer Groups

OPNAV M-5090.1, *Environmental Readiness Program Manual* (2021), which implements the policy set forth in OPNAVINST 5090.1, states that commands shall interact with the surrounding community to develop positive and productive community involvement, participation, and educational opportunities, and use volunteers under the supervision of professionally trained natural resources personnel, when feasible. Through support from volunteers, JRM is able to educate the public on the natural resources programs conducted at JRM sites, demonstrate environmental stewardship of natural resources, and develop and maintain partnerships with the local community.

An example of volunteer work that supports JRM natural resources management includes activities conducted by Haggan Watch, which is an organization that collects data in Guam’s sea turtles. Members

of the organization walk along the coast of Guam to record data on endangered and threatened species of sea turtles. Other examples include Andersen AFB bat counts, recreational hunting program, Volunteer Conservation Officers, and Marine Patrol.

13.7.2.6 Non-governmental Organizations

The Nature Conservancy (TNC) and DoD signed a cooperative agreement in 1988. This agreement allows installation commanders to obtain technical assistance from TNC and to participate in programs and projects of mutual interest. It also permits TNC to study significant ecosystems under DoD's control. Natural resources staff at JRM sites can benefit from this agreement through use of TNC resources and staff to manage natural resources on the installation.

13.8 INTEGRATED NATURAL RESOURCES MANAGEMENT PLAN REVIEW, UPDATE, AND REVISION

13.8.1 Annual Metrics Review

Per DoD and DON policy, DON natural resources managers review the natural resources program and INRMPs annually and complete the Natural Resource Conservation Metrics (formerly known as INRMP Conservation Metrics, Annual Reviews or INRMP Metrics) using the DON Conservation Web. Metrics ensure that DON installations comply with the Sikes Act and that each region or installation is preparing, maintaining, and implementing its INRMP. Metrics support ESA expenditure reporting to Congress by the USFWS and other media-related data collection. Metrics also inform and contribute to information collected for the Defenses Environmental Program Annual Report to Congress and the OSD Environmental Management Review. Metrics inform briefings up the DoD and DON chains of command regarding the status of DON's natural resources programs. DoD policy requires that installations review their INRMP each year via an "adaptive management" approach. As detailed in Chapter 3, *Environmental Management Strategy and Mission Sustainability*, adaptive management is an iterative cycle of planning, monitoring, evaluation, adjustment, and implementation, which is best used to assess ecosystem function, health, and the effectiveness of management practices. Annual metrics reviews provide an opportunity for stakeholders to review the goals and objectives of the INRMP, and establish a realistic schedule for undertaking proposed management projects. Metrics provide the essential information required by Congress, EOs, existing laws, and DoD policies and instructions. INRMP Metrics consist of seven focus areas:

- *Ecosystem Integrity* – Defines the status and integrity of ecosystems, natural resources, and management effectiveness of the INRMP program of each installation.
- *Listed Species and Critical Habitat* – Evaluates the effectiveness of the INRMP in providing conservation benefits to federal, territorial, and commonwealth-listed species and their habitats.
- *Recreational Use and Access* – Evaluates the availability and adequacy of public recreational use opportunities, such as fishing and hunting, and access for handicapped and disabled persons, given security, safety, and wildlife protection requirements for each installation.
- *Sikes Act Cooperation* – Evaluates the efficacy of cooperation between JRM, the installations, and the USFWS, NMFS, Guam DAWR, and CNMI DFW in the management of natural resources addressed by the INRMP.
- *Team Adequacy* – Evaluates the effectiveness of the JRM natural resources professional staff, and each installations SMEs in accomplishing INRMP goals and objectives.
- *INRMP Implementation* – Evaluates the efficacy of the management projects and activities prescribed and executed to achieve INRMP goals and objectives.

- *INRMP Support of the Installation Mission* – Evaluates the ability of each installation to support natural resource objectives and sustain the military mission, ensuring "no net loss" of mission capability to be consistent with the rest of the document.

INRMPs are intended to be living, long-term planning documents, not static five-year plans. Accordingly, INRMPs are reviewed, updated, and revised as necessary to accommodate adaptive management. This process aims to achieve goals and objectives, incorporate relevant new information as it becomes available, and address changing environmental conditions and mission requirements on an installation.

Section 101(b)(2) of the Sikes Act requires the INRMP to undergo a review as to operation and effect on a regular basis, or not less often than every 5 years by all stakeholders – DoD, USFWS, NMFS, and state and territory fish and wildlife agencies – to determine compliance with the requirements of the Sikes Act. These reviews must be documented and signed by these parties. The review must: (1) determine whether the existing INRMP is meeting the Sikes Act requirements, and (2) contribute to the conservation and rehabilitation of natural resources on military installations and lands.

In addition, DoD and DON policy requires yearly evaluations by JRM to determine the effectiveness of management projects in achieving the goals and objectives of the INRMP. The annual review process also facilitates adaptive management decisions and project funding and schedule adjustments. This annual review is a cooperative effort between JRM, installation SMEs, USFWS, NMFS, Guam DAWR, and CNMI DFW. DoDI 4715.03 (2011) and OPNAV M-5090.1 (2021) provide guidance for the yearly INRMP review process. Additional guidance appears in the following:

- Deputy Under Secretary of Defense Installations and Environment (DUSD[I&E]) Policy Memorandum October 10, 2002
- DoDI 4715.17, Environmental Management Systems (April 15, 2009, incorporating Change 1, November 16, 2017)
- Supplemental DoD INRMP Guidance (September 2005)

The September 2005 Supplemental DoD INRMP Guidance requires that all INRMPs also address resource management of DoD lands occupied by tenants or lessees, or lands being used under permit, license, or right-of-way. Installations may require that tenants, lessees, permittees accept responsibility for natural resource management actions and projects, as appropriate, on these lands. The INRMP must refer to previous formal and informal listed species consultations with the USFWS and NMFS, including any incidental take statements affecting the management of these lands.

13.9 INTEGRATED NATURAL RESOURCES MANAGEMENT PLAN IMPLEMENTATION SUMMARY AND SCHEDULE

INRMP projects and schedules are to be reviewed annually and may be modified based on need, available funding, resources, seasonal requirements, new information that necessitates adaptive management, and the results of annual metrics evaluations.

Tables 13-3 and 13-4, below, provide codes for missions and ecosystems supported by planned management projects. Tables 13-5 and 13-6 provide a summary of management projects supported by DON personnel and implemented regionally by JRM. Tables 13-7 through 13-13 provide a detailed summary of individual management projects for each installation and planned implementation schedule.

Table 13-3. Codes for Missions Supported

Title	*Short Name*	*Description*
Aircraft Ops	Air Ops	Military mission activities that include operation and maintenance of all types of fixed wing and rotary aircraft.
Amphibious Ops	Amphib Ops	Military mission activities that involve special training and equipment for conducting landings from naval vessels to shore and the nearshore environment.
Communications (C4)	Comm	Those military activities that include telecommunications, radio transmissions, computer equipment, signal relays, satellite ground stations, and other forms of military communications.
Ground-Based Ops	Ground Ops	Military mission activities that involve training personnel and mobile equipment for conducting land-based operations in a wide variety of environments.
Helicopter Ops	Helo Ops	Activities associated with rotary wing aircraft. Such as: landing, taking off, hovering, dropping off cargo/personnel, picking up cargo/personnel, fast lining, or other helicopter operations. This includes hybrid wing aircraft such as V-22 Osprey.
Homeport/Shipyard Ops	Shore Ops	The permanent location of active duty units which may include ships, submarines, or other sea-going vessels. A land facility designated for reception of personnel or material moved by sea, and that serves as an authorized port of entrance into or departure from the country in which located.
Logistics	Log	Military activities that include the planning and carrying out of movement, storage, and maintenance of military forces and associated hardware and supplies.
Military Construction	MILCON	A base that supports the construction, alteration, development, demolition, conversion, or extension of any kind carried out with respect to a military installation.
Military Housing	Housing	Land areas and structures developed for the housing, health and welfare of military personnel and their families. This includes support centers and facilities for the morale, welfare, and recreation of military personnel.
Ordnance Ops	Ord Ops	Military mission activities that involve the storage or transfer of explosives, chemicals, pyrotechnics, and similar stores, e.g., bombs, guns and ammunition, flares, smoke, or other chemicals.
Research & Development	R & D	Installation activities that support research and studies directed towards increased knowledge of manmade and natural phenomena. This includes basic and applied research in the disciplines of science and engineering that may have military benefits.
Special Forces	Spec Ops	(a) Installation or site that supports the unconventional warfare capabilities of Special Forces. (b) A command, control, and support base established and operated by a Special Forces group or battalion from organic and attached resources.
Submarine Ops	Sub Ops	An installation or site established for the support of submarine operations, servicing and maintenance.

Table 13-4. Codes for Ecosystems Supported

Terrestrial Ecosystem	*Acronym*
Guam	
Casuarina Forest	CAF
Coconut Forest	COF
Limestone Coastal Scrub	LCS
Limestone Degraded Forest	LDF
Limestone Native Forest	LNF
Ravine Forest	RAF
Strand	STR
Savanna Complex	SAC
Wetlands	WTL
Other Shrub/Grassland	OSG
CNMI	
Casuarina Forest	CAF
Coconut Forest	COF
Mixed Introduced Forest	MIF
Limestone Native Forest	LNF
Strand	STR
Wetlands	WTL
Other Shrub/Grassland	OSG
Marine Ecosystem	***Acronym***
General Marine Environment	MAR
Mangroves	MAN

Note: A list of CNMI and Guam ESA-listed species, SOGCN, and MBTA-listed species can be found in Appendix E.

Table 13-5. Planned Implementation Summary of Projects Supported by DON Personnel

Goals and Objectives	*Project Description*	*Reference /Driver*	*ERL Priority*	*Funding Source*
Terrestrial Habitat Management (THM) and Marine Habitat Management (MHM)				
1:1-2; 6:1; 7:3	Coordination with regulatory agencies (e.g., CNMI Department of Lands and Natural Resources [DLNR] and USFWS) to support military training in the CNMI	2015 MITT BO	4	CNIC
1:1-2; 7:3	Coordination with local and federal agencies for marine resources management	ESA, EO 13112, Sikes Act	4	CNIC
Terrestrial Invasive Species Management (TIS) and Marine Invasive Species Management (MIS)				
1:1-2; 4:1-4; 7:3	• Coordination with local and federal agencies to identify and share information on the control of invasive alien species • Coordination with local and federal agencies to implement biosecurity measures to reduce and control the spread invasive alien species	RBP for Micronesia and Hawai‘i	4	CNIC
1:1-2; 4:1-3; 7:3	Coordination with USDA APHIS Wildlife Services and USFWS for BTS interdiction related to military training in Guam	2015 MITT BO	4	CNIC
1:1-2; 4:1-4; 7:3	Coordination with local and federal agencies for invasive species management	ESA, EO 13112, Sikes Act	4	CNIC
Terrestrial Protected Species Management (TPS) and Marine Protected Species Management (MPS)				
1:1-2; 2:1, 3-5; 3:1, 4	• Pre-construction surveys for listed species • Contractor natural resources awareness training • Biomonitor support for Hazard Analysis and Critical Control Point (HACCP)	USMC Relocation 2017 BO, which contains amendments to the 2015 BO	4	USMC
1:1-2; 3:1, 4	• Sea turtle surveys • Mariana fruit bat surveys • Mariana swiftlet surveys • Listed plant surveys	ESA, Sikes Act	4	CNIC
1:1-2; 2:1, 3-5; 3:1, 4; 7:3	Coordination with local and federal agencies for threatened and endangered species management	ESA, EO 13112, Sikes Act	4	CNIC
Migratory Bird Management (MIG)				
1:1-2; 3:1-2, 4; 6:1	MBTA-listed bird surveys	ESA, Sikes Act	4	CNIC
1:1-2; 3:1-2, 4; 6:1	MBTA-listed bird surveys at FDM	2015 MITT BO	4	CNIC
Terrestrial Natural Resources Educational Outreach (TEDU) and Marine Natural Resources Educational Outreach (MEDU)				
1:1-2; 2:4; 3:4; 4:1, 4; 6:1-2; 7:1-3	Coordination with local and federal agencies for natural resources outreach	ESA, EO 13112, Sikes Act	4	CNIC
Terrestrial Natural Resources Law Enforcement (TLAW) and Marine Natural Resources Law Enforcement (MLAW)				
1:1-3; 2:1-2, 4; 3:4; 6:1-2; 7:1-3	Coordinate the development of a Regional Conservation Law Enforcement program with local and federal agencies	ESA, Sikes Act	4	CNIC
Terrestrial GIS and Data Management (TGIS) and Marine GIS and Data Management (MGIS)				
1:1-2; 2:1-5; 3:1, 4	GIS database management	ESA, EO 13112, Sikes Act	4	CNIC

Table 13-6. Planned Implementation Summary of JRM Regional Projects

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystem Supported* | *Species Supported* | | |

Table 13-6. Planned Implementation Summary of JRM Regional Projects

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Table 13-7. Planned Implementation Summary of Projects at NBG Main Base

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystems Supported* | *Species Supported* | | |

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Goals and Objectives	*INRMP Project Code/Title (Abbreviated)*	*EPR#*	*EPR Project Title*	*Planned Implementation (Fiscal Year [FY])*	*Reference/ Driver*	*ERL Priority*	*Funding Source*	*Missions Supported*	*Ecosystems Supported*	*Species Supported*																																
										Mariana fruit bat	Mariana swiftlet	Mariana common moorhen	Mariana crow	Guam kingfisher	Guam rail	Micronesian megapodes	Nightingale reed-warbler	EFH	Green sea turtle	Hawksbill sea turtle	Scalloped hammerhead	ESA-listed Corals	*Serianthes nelsonii*	*Eugenia bryanii*	*Hedyotis megalantha*	*Heritiera longipetiolata*	*Phyllanthus saffordii*	*Psychotria malaspinae*	*Solanum guamense*	*Tinaspora homosepala*	*Bulbophyllum guamense*	*Cycas micronesica*	*Dendrobium guamense*	*Maesa walkeri*	*Nervilia jacksoniae*	*Tabernaemontana rotensis*	*Tuberolabium guamense*	*Sphaeropteris lunulata*	Mariana eight-spot butterfly	Guam tree snail	Humped tree snail	Fragile tree snail	CNMI ESA-listed species	Guam ESA-listed species	SOGCN	MBTA-listed Species
1:1-2; 2:3, 6; 3:1, 4; 4:1-3	TIS-5: Invasive Species Management	NA	Hazard Analysis Critical Control Point Program Implementation and Effectiveness Monitoring	Recurring annually	USMC Relocation 2017 BO, which contains amendments to the 2015 BO	4	USMC	NA	CAF, COF, LCS, LDF, LNF, RAF, STR, SAC, WTL, OSG, MIF	X	X	X	X	X	X	X	X		X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1:1-2; 2:2-4; 3:1, 4; 4:1-4	TIS-6: Mariana Islands Training and Testing Implementation of the Biological Opinion	61128NR218	Mariana Islands Training and Testing Implementation of the Biological Opinion	Recurring annually	2015 MITT BO	4	CNIC/ USMC/ PACFLT	Air Ops, Amphib Ops, Comm, Ground Ops, Helo Ops, Shore Ops, Log, Ord Ops, R&D, Spec Ops, Sub Ops	CAF, COF, LCS, LDF, LNF, RAF, STR, SAC, WTL, OSG, MIF	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1:1-2; 3:1, 4; 4:2	TIS-7: Control Feral Dogs and Cats	61755NR358	Control Feral Dogs and Cats	Recurring annually	ESA, Invasive Species EO 13751/13112, Sikes Act	4	CNIC	MILCON, R&D, Ground Ops	COF, LDF, LNF, STR, WTL, RAF	X	X	X	X	X	X	X	X																								X	X	X	X	X	X	X	X
Terrestrial Protected Species Management																																																
1:1-2; 2:4; 3:1-4	TPS-1: ESA-listed Species Monitoring	61755NR142	Endangered Species Monitoring	Recurring annually	ESA, Sikes Act	4	CNIC	Amphib Ops, MILCON, R&D, Ground Ops	NA		X	X						X	X																								X	X	X	X
1:1-2; 2:1-6; 3:1-2, 4; 4:2; 6:1-2	TPS-2: Sea Turtle Population Protection and Enhancement	61755NR142	Protection and Monitoring of Sea Turtle Nesting	Recurring annually	ESA, Sikes Act	4	CNIC	Amphib Ops, MILCON, R&D, Ground Ops	MAR									X	X																								X	X	X	
		61755NR808	Green and Hawksbill Sea Turtle Nesting Habitat – Invasive Plant and Predator Control	Recurring annually	ESA, Sikes Act	4	CNIC	Amphib Ops, MILCON, R&D, Ground Ops	MAR									X	X																								X	X	X	
1:1-2; 3:1-4; 4:2	TPS-3: Mariana Common Moorhen Habitat Enhancement	NA	Mariana Common Moorhen Habitat Enhancement	NA	ESA, Sikes Act	4	CNIC	MILCON, R&D, Ground Ops	WTL			X																								X						X	X	

Table 13-7. Planned Implementation Summary of Projects at NBG Main Base

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystems Supported* | *Species Supported* | | |

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Table 13-8. Planned Implementation Summary of Projects at NMS

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystem Supported* | *Species Supported* | | |

Table 13-8. Planned Implementation Summary of Projects at NMS

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystem Supported* | *Species Supported* | | |

Table 13-8. Planned Implementation Summary of Projects at NMS

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystem Supported* | *Species Supported* | | |

Table 13-8. Planned Implementation Summary of Projects at NMS

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystem Supported* | *Species Supported* | | |

Table 13-8. Planned Implementation Summary of Projects at NMS

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystem Supported* | *Species Supported* | | |

Table 13-8. Planned Implementation Summary of Projects at NMS

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystem Supported* | *Species Supported* | | |

Table 13-9. Planned Implementation Summary of Projects at Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, Barrigada Transmitter Site, and MCBCB Urban Training Complex

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystems Supported* | *Species Supported* | | |

Table 13-9. Planned Implementation Summary of Projects at Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, Barrigada Transmitter Site, and MCBCB Urban Training Complex

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystems Supported* | *Species Supported* | | |

Table 13-9. Planned Implementation Summary of Projects at Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, Barrigada Transmitter Site, and MCBCB Urban Training Complex

Goals and Objectives	*INRMP Project Code/Title (Abbreviated)*	*EPR#*	*EPR Project Title*	*Planned Implementation (Fiscal Year [FY])*	*Reference/ Driver*	*ERL Priority*	*Funding Source*	*Missions Supported*	*Ecosystems Supported*	*Species Supported*																																		
										Mariana fruit bat	Mariana swiftlet	Mariana common moorhen	Mariana crow	Guam kingfisher	Guam rail	Micronesian megapodes	Nightingale reed-warbler	EFH	Green sea turtle	Hawksbill sea turtle	Scalloped hammerhead	ESA-listed Corals	*Serianthes nelsonii*	*Eugenia bryanii*	*Hedyotis megalantha*	*Heritiera longipetiolata*	*Phyllanthus saffordii*	*Psychotria malaspinae*	*Solanum guamense*	*Tinaspora homosepala*	*Bulbophyllum guamense*	*Cycas micronesica*	*Dendrobium guamense*	*Maesa walkeri*	*Nervilia jacksoniae*	*Tabernaemontana rotensis*	*Tuberolabium guamense*	*Sphaeropteris lunulata*	Mariana eight-spot butterfly	Guam tree snail	Humped tree snail	Fragile tree snail	CNMI ESA-listed species	Guam ESA-listed species	SOGCN	MBTA-listed Species
1:1; 2:3; 3:1-2, 4; 4:1-4; 7:1	TIS-5: Implementation of Regional Biosecurity Plan Micronesia and Hawai‘i	61128NR860	Implementation of Regional Biosecurity Plan Micronesia and Hawai‘i	Recurring annually	EO 13112, Sikes Act	4	CNIC	Air Ops, Amphib Ops, Comm, Ground Ops, Helo Ops, Shore Ops, Log, Ord Ops, R&D, Spec Ops, Sub Ops	CAF, COF, LCS, LDF, LNF, RAF, STR, SAC, WTL, OSG, MIF, MAR, MAN	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1:1-2; 2:2-4; 3:1, 4; 4:1-4	TIS-6: Mariana Islands Training and Testing Implementation of the Biological Opinion	61128NR218	Mariana Islands Training and Testing Implementation of the Biological Opinion	Recurring annually	2015 MITT BO	4	CNIC/ USMC/ PACFLT	Air Ops, Amphib Ops, Comm, Ground Ops, Helo Ops, Shore Ops, Log, Ord Ops, R&D, Spec Ops, Sub Ops	CAF, COF, LCS, LDF, LNF, RAF, STR, SAC, WTL, OSG, MIF	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1:1-2; 3:1, 4; 4:2	TIS-7: Control Feral Dogs and Cats	61755NR358	Control Feral Dogs and Cats	Recurring annually	ESA, Invasive Species EO 13751/13112, Sikes Act	4	CNIC	MILCON, R&D, Ground Ops	COF, LDF, LNF, STR, WTL, RAF	X	X	X	X	X	X	X	X																						X	X	X	X	X	X	X	X
Terrestrial Protected Species Management																																																	
1:1-2; 2:1, 3-4; 3:1-2, 4	TPS-1: ESA-listed Species Monitoring	61755NR142	Endangered Species Monitoring	Recurring annually	ESA, Sikes Act	4	CNIC	MILCON, R&D, Ground Ops	COF, LDF, LNF, STR, WTL, RAF, MAR																																									
		M5240CN048	Monitoring and Surveys for Listed Tree Snails, Butterflies, and Plants	FY18-FY24	ESA, Sikes Act	4	CNIC	Air Ops, Ground Ops, MILCON, R&D, Spec Ops	CAF, COF, LNF, LDF																																									
		NA	Pre-construction Surveys for ESA-listed Species	Recurring annually	USMC Relocation 2017 BO, which contains amendments to the 2015 BO	4	USMC	NA	LDF, OSG	X															X		X		X			X	X	X			X	X	X	X	X	X	X	X	X	X	X	X

Table 13-9. Planned Implementation Summary of Projects at Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, Barrigada Transmitter Site, and MCBCB Urban Training Complex

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystems Supported* | *Species Supported* | | |

Table 13-9. Planned Implementation Summary of Projects at Apra Heights, Sasa Valley and Tenjo Vista Tank Farms, NCTS Barrigada, Barrigada Transmitter Site, and MCBCB Urban Training Complex

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystems Supported* | *Species Supported* | | |

Table 13-10. Planned Implementation Summary of Projects at MCB Camp Blaz

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystems Supported* | *Species Supported* | | |

Table 13-10. Planned Implementation Summary of Projects at MCB Camp Blaz

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystems Supported* | *Species Supported* | | |

Table 13-10. Planned Implementation Summary of Projects at MCB Camp Blaz

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystems Supported* | *Species Supported* | | |

Table 13-10. Planned Implementation Summary of Projects at MCB Camp Blaz

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystems Supported* | *Species Supported* | | |

Table 13-10. Planned Implementation Summary of Projects at MCB Camp Blaz

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystems Supported* | *Species Supported* | | |

Table 13-10. Planned Implementation Summary of Projects at MCB Camp Blaz

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystems Supported* | *Species Supported* | | |

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Table 13-11. Planned Implementation Summary of Projects at Andersen AFB

Goals and Objectives	*INRMP Project Code/Title (Abbreviated)*	*EPR#*	*EPR Project Title*	*Planned Implementation (Fiscal Year [FY])*	*Reference/ Driver*	*ERL Priority*	*Funding Source*	*Missions Supported*	*Ecosystems Supported*	*Species Supported*																																				
										Mariana fruit bat	Mariana swiftlet	Mariana common moorhen	Mariana crow	Guam kingfisher	Guam rail	Micronesian megapodes	Nightingale reed-warbler	EFH	Green sea turtle	Hawksbill sea turtle	Scalloped hammerhead	ESA-listed Corals	*Serianthes nelsonii*	*Eugenia bryanii*	*Hedyotis megalantha*	*Heritiera longipetiolata*	*Phyllanthus saffordii*	*Psychotria malaspinae*	*Solanum guamense*	*Tinaspora homosepala*	*Bulbophyllum guamense*	*Cycas micronesica*	*Dendrobium guamense*	*Maesa walkeri*	*Nervilia jacksoniae*	*Tabernaemontana rotensis*	*Tuberolabium guamense*	*Sphaeropteris lunulata*	Mariana eight-spot butterfly	Guam tree snail	Humped tree snail	Fragile tree snail	CNMI ESA-listed species	Guam ESA-listed species	SOGCN	MBTA-listed Species
Terrestrial Habitat Management																																														
1:1-2; 2:1-6; 3:1, 4; 4:2	THM-1: Forest Enhancement	M5240NR067	Native Forest Habitat Restoration	Recurring annually	2006 Intelligence/ Surveillance/ Reconnaissance (ISR) Strike BO	4	NA	Air Ops, Comm, Ground Ops, Helo Ops, Log, MILCON, Housing, Ord Ops, R&D, Spec Ops	CAF, COF, LCS, LDF, LNF, RAF, STR	X			X	X	X				X	X			X	X		X		X			X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X
		61128NR209	Listed Plant Surveys, Propagation, Planting and Establishment in the Wild	Recurring annually	Sikes Act	4	CNIC	Air Ops, Comm, Ground Ops, Helo Ops, Log, MILCON, Housing, Ord Ops, R&D, Spec Ops	CAF, COF, LCS, LDF, LNF, RAF, STR	X			X	X	X				X	X			X	X		X		X			X	X	X			X	X	X	X	X	X	X	X	X	X	X	
		61128NR210	Monitoring Native Ecosystem Health and Growth	Recurring annually	Sikes Act	4	CNIC	Air Ops, Comm, Ground Ops, Helo Ops, Log, MILCON, Housing, Ord Ops, R&D, Spec Ops	CAF, COF, LCS, LDF, LNF, RAF, STR	X			X	X	X				X	X			X	X		X		X			X	X	X			X	X	X	X	X	X	X	X	X	X	X	X
		M524010004	Native Plant Propagation and Outplanting for Habitat Improvement in the Habitat Management Unit	FY20-FY24	NA	4	NA	Air Ops, Comm, Ground Ops, Helo Ops, Log, MILCON, Housing, Ord Ops, R&D, Spec Ops	CAF, COF, LCS, LDF, LNF, RAF, STR	X			X	X	X				X	X			X	X		X		X			X	X	X			X	X	X	X	X	X	X	X	X	X	X	X
		M524010005	Non-native Plant Removal and Control in the Habitat Management Unit	FY20-FY24	NA	4	NA	Air Ops, Comm, Ground Ops, Helo Ops, Log, MILCON, Housing, Ord Ops, R&D, Spec Ops	CAF, COF, LCS, LDF, LNF, RAF, STR	X			X	X	X				X	X			X	X		X		X			X	X	X			X	X	X	X	X	X	X	X	X	X	X	X
		M524010013	Invasive Plant Species Monitoring and Control on Andersen AFB	FY20-FY24	NA	4	NA	Air Ops, Comm, Ground Ops, Helo Ops, Log, MILCON, Housing, Ord Ops, R&D, Spec Ops	CAF, COF, LCS, LDF, LNF, RAF, STR	X			X	X	X				X	X			X	X		X		X			X	X	X			X	X	X	X	X	X	X	X	X	X	X	X

Table 13-11. Planned Implementation Summary of Projects at Andersen AFB

| *Goals and Objectives* | *INRMP Project Code/Title (Abbreviated)* | *EPR#* | *EPR Project Title* | *Planned Implementation (Fiscal Year [FY])* | *Reference/ Driver* | *ERL Priority* | *Funding Source* | *Missions Supported* | *Ecosystems Supported* | *Species Supported* | | |

Table 13-11. Planned Implementation Summary of Projects at Andersen AFB

Goals and Objectives	*INRMP Project Code/Title (Abbreviated)*	*EPR#*	*EPR Project Title*	*Planned Implementation (Fiscal Year [FY])*	*Reference/ Driver*	*ERL Priority*	*Funding Source*	*Missions Supported*	*Ecosystems Supported*	*Species Supported*																																				
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1:1-2; 2:1-6; 3:1, 4; 4:2	THM-1: Forest Enhancement	NA	Maintenance of Ritidian Ungulate Exclosure	NA	USMC Relocation 2017 BO, which contains amendments to the 2015 BO	4	NA	Air Ops, Comm, Ground Ops, Helo Ops, Log, MILCON, Housing, Ord Ops, R&D, Spec Ops	CAF, COF, LCS, LDF, LNF, RAF	X			X	X	X								X	X		X		X			X	X	X			X	X	X	X	X	X	X	X	X	X	X
		M524010000	Barrier Maintenance for the Habitat Management Unit	Recurring annually	NA	4	NA	Air Ops, Comm, Ground Ops, Helo Ops, Log, MILCON, Housing, Ord Ops, R&D, Spec Ops	COF, LCS, LDF	X			X	X	X							X	X		X		X			X	X	X			X	X	X	X	X	X	X	X	X	X
1:1; 2:3, 6	THM-2: Urban Forestry Data Base, Maintenance, and Replacement of Trees	M5240NR066	Urban Forestry Data Base, Maintenance, and Replacement of Trees	FY20-FY24	NA	4	NA	Air Ops, Comm, Ground Ops, Helo Ops, Log, MILCON, Housing, Ord Ops, R&D, Spec Ops	CAF, COF, LCS, LDF, LNF, RAF	X			X	X	X							X	X		X		X			X	X	X			X	X	X	X	X	X	X	X	X	X	X
1:1-2; 2:3-4; 3:1, 4; 4:1-3; 7:3	TIS-1: Brown Treesnake Interdiction	61128NR202	Brown Treesnake Eradication, Control and Adaptive Management to Support Recovery of ESA-listed Species	Recurring annually	EO 13112, Sikes Act	4	CNIC	Air Ops, Comm, Ground Ops, Helo Ops, Log, Ord Ops, R&D, Spec Ops	CAF, COF, LCS, LDF, LNF, RAF, STR, SAC, OSG, MIF	X	X	X	X	X	X	X	X						X																	X	X	X	X
		M5240CN042	Survivorship of Mariana Fruit Bat to Support Guam Intelligence, Surveillance, and Reconnaissance Strike Requirements	Recurring annually	NA	4	CNIC	Air Ops, Comm, Ground Ops, Helo Ops, Log, MILCON, Housing, Ord Ops, R&D, Spec Ops	CAF, COF, LCS, LDF, LNF, RAF	X			X	X	X							X	X		X		X			X	X	X			X	X	X	X	X	X	X	X	X	X	X

Table 13-11. Planned Implementation Summary of Projects at Andersen AFB

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1:1; 2:3; 3:1-2, 4; 4:1-4; 7:1	TIS-5: Implementation of Regional Biosecurity Plan for Micronesia and Hawai‘i	61128NR860	Implementation of Regional Biosecurity Plan for Micronesia and Hawai‘i	Recurring annually	EO 13112, Sikes Act	4	CNIC	Air Ops, Amphib Ops, Comm, Ground Ops, Helo Ops, Shore Ops, Log, Ord Ops, R&D, Spec Ops, Sub Ops	CAF, COF, LCS, LDF, LNF, RAF, STR, SAC, WTL, OSG, MIF, MAR, MAN	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1:1-2; 2:2-4; 3:1, 4; 4:1-4	TIS-6: Mariana Islands Training and Testing Implementation of the Biological Opinion	61128NR218	Mariana Islands Training and Testing Implementation of the Biological Opinion	Recurring annually	2015 MITT BO	4	CNIC/ USMC/ PACFLT	Air Ops, Amphib Ops, Comm, Ground Ops, Helo Ops, Shore Ops, Log, Ord Ops, R&D, Spec Ops, Sub Ops	CAF, COF, LCS, LDF, LNF, RAF, STR, SAC, WTL, OSG, MIF	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1:1-2; 3:1, 4; 4:2	TIS-7: Control Feral Dogs and Cats	61755NR358	Control Feral Dogs and Cats	FY20-FY24	ESA, Invasive Species EO 13751/13112, Sikes Act	4	CNIC	MILCON, R&D, Ground Ops	COF, LDF, LNF, STR, WTL, RAF	X	X	X	X	X	X	X	X																								X	X	X	X	X	X	X	X
Terrestrial Protected Species Management																																																
1:1-2; 2:1-5; 3:1-2, 4; 4:2; 6:1-2; 7:1-2	TPS-1: Sea Turtle Population Protection and Enhancement	M5240CN037	Sea Turtle Monitoring, Protection and Educational Outreach	Recurring annually	NA	4	NA	Air Ops, Comm, Ground Ops, Helo Ops, Log, MILCON, Housing, Ord Ops, R&D, Spec Ops	LCS, STR									X	X																								X	X	X	
1:1-2; 2:1, 3-4; 3:1, 4	TPS-2: Mariana Fruit Bat Population Protection and Enhancement	M5240CN041	Mariana Fruit Bat Monitoring	Recurring annually	NA	4	CNIC	Air Ops, Comm, Ground Ops, Helo Ops, Log, MILCON, Housing, Ord Ops, R&D, Spec Ops	CAF, COF, LCS, LDF, LNF, RAF, STR	X																																	X	X	X	
1:1-2; 2:1, 3-4; 3:1, 4	TPS-2: Mariana Fruit Bat Population Protection and Enhancement	M5240NR155	Fruit Bat Demography and Population Estimation	FY20-FY24	USMC Relocation 2017 BO, which contains amendments to the 2015 BO	4	NA	Air Ops, Comm, Ground Ops, Helo Ops, Log, MILCON, Housing, Ord Ops, R&D, Spec Ops	CAF, COF, LCS, LDF, LNF, RAF, STR	X																																	X	X	X	

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15 REFERENCES

15.1 CHAPTER 1 – OVERVIEW INTEGRATED NATURAL RESOURCES MANAGEMENT PLAN

CNIC. 2018. Welcome to Joint Region Marianas. Commander, Navy Installations Command. Accessed 22 March 2018, from https://www.cnic.navy.mil/regions/jrm.html.

DoD. 2002. Implementation of Sikes Act Improvement Act: Updated Guidance. Office of the Under Secretary of Defense. 10 October.

DoD. 2004. Implementation of Sikes Act Improvement Amendments: Supplemental Guidance Concerning INRMP Reviews. Office of the Under Secretary of Defense, Washington, DC.

DoD. 2005. Supplemental Guidance for Implementation of the Sikes Act Improvement Act. Additional Guidance Concerning INRMP Preparation. Memorandum from the Office of the Under Secretary of Defense. 5 September.

DoD. 2011. Department of Defense Instruction (DoDI) 4715.03. 18 March.

DoD. 2013. Department of Defense Manual (DoDM) 4715. Integrated Natural Resources Management Plan (INRMP) Implementation Manual. 25 November 2013, incorporating Change 1, December 13, 2017.

DoD, USFWS, and Association of Fish and Wildlife Agencies. 2013. Memorandum of Understanding between the U.S. Department of Defense and the U.S. Fish and Wildlife Service and the Association of Fish and Wildlife Agencies for a Cooperative Integrated Natural Resource Management Program on Military Installations. 29 July.

DON. 2006. Integrated Natural Resources Management Program Guidance for Navy Installations: How to Prepare, Implement, and Revise Integrated Natural Resource Management Plans (INRMP). Chief of Naval Operations (OPNAV N41).

DON. 2010. Update of Integrated Natural Resources Management Plans for Navy Leased Lands on Tinian and Farallon de Medinilla, Plan Years 2010-2015. Prepared by SWCA Environmental Consultants, Hagatna, GU. 29 May.

DON and USFWS. 1994. Cooperative Agreement between the U.S. Navy and the U.S. Fish and Wildlife Service for the Establishment and Management of the Guam National Wildlife Refuge, Guam. March.

JRM. 2010. JRM-administered Lands GIS Data.

JRM. 2017. JRM Leased Submerged Lands GIS Data for Tinian.

JRM. 2019. JRM-administered Submerged Lands GIS Data.

JRM. 2020. Memorandum of Agreement.

NAVFAC. 2018. Naval Facilities Engineering Systems Command—About Us. Accessed 30 March 2018, from https://www.navfac.navy.mil/about_us.html.

NMFS. 2016. NOAA Fisheries: About Us – Our Mission. Accessed 5 November 2017, from https://www.fisheries.noaa.gov/about-us.

NOAA. 2016. National Oceanic and Atmospheric Administration: Our Mission and Vision – Science, Service and Stewardship. Accessed 5 November 2017, from http://www.noaa.gov/our-mission-and-vision.

OPNAV Notice. 2009. Chief of Naval Operations (OPNAV) Notice 5400, Establishment of U.S. Naval Support Activity Andersen Guam, Mariana Islands. 17 September.

OPNAV M. 2021. Chapter 12: Natural Resources Conservation in Environmental Readiness Program Manual. In OPNAV Manual 5090.1 (OPNAV M-5090.1), Washington, D.C. 25 June.

OPNAVINST. 2021. OPNAV Instruction (OPNAVINST) 5090.1. Environmental Readiness Program. Office of the Chief of Naval Operations, Washington, D.C. 25 June.

Rodda, G. H. and Savidge, J. A. 2007. Biology and impacts of Pacific Island invasive species. 2. *Boiga irregularis* the brown treesnake (Reptilia: Colubridae). Pacific Science, 61, 307–324.

SECNAV. 2006. SECNAV Instructions (SECNAVINST) 5090.8A. Policy for Environmental Protection, Natural Resources, and Cultural Resources Programs. 30 January.

USAF and USFWS. 1994. Cooperative Agreement between the U.S. Air Force and the U.S. Fish and Wildlife Service for the Establishment and Management of the Guam National Wildlife Refuge, Guam. March.

USFWS. 2004. Integrated Natural Resources Management Plans. May.

USFWS. 2015. U.S. Fish and Wildlife Service Guidelines for Coordination on Integrated Natural Resource Management Plans. June.

15.2 CHAPTER 2 – MILITARY MISSION AND OVERVIEW OF HISTORY AND LAND USE

Belt Collins Hawai'i. 1997. Historical Overview of Farallon de Medinilla: 1543 to 1997. Honolulu, HI.

Bowers, N. M. 1950. Problems of Resettlement on Saipan, Tinian, and Rota. CNMI Division of Historic Preservation.

CNIC. 2018. Welcome to Joint Region Marianas. Commander, Navy Installations Command. Accessed 22 March 2018, from https://www.cnic.navy.mil/regions/jrm.html.

COMNAVMAR. 2013. Instruction 3500.4A. Marianas Training Manual. Department of the Navy, Joint Region Marianas.

DON. 1983. Memorandum for the Assistant Secretary of the Navy. Assignment of Accountability for Leased Property in the Northern Mariana Islands. 1 November.

DON. 2010. Final Environmental Impact Statement. Guam and CNMI Military Relocation: Relocating Marines from Okinawa, Visiting Aircraft Carrier Berthing, and Army Air and Missile Defense Task Force. Volume 2: Marine Corps Relocation – Guam. Prepared by NAVFAC Pacific, Pearl Harbor, HI for Joint Guam Program Office, Washington, D.C. July.

DON. 2015a. Final Supplemental Environmental Impact Statement Guam and the Commonwealth of the Northern Mariana Islands Military Relocation (2012 Roadmap Adjustments). Prepared by NAVFAC Pacific, Pearl Harbor, HI for Joint Guam Program Office, Washington, D.C. July.

DON. 2015b. Record of Decision for the Final Supplemental Environmental Impact Statement for Guam and Commonwealth of the Northern Mariana Islands Military Relocation. 28 August.

DON. 2017. Cultural Resources Survey of Tinian Clifflines in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement. Prepared by Cardno-AECOM/JV for U.S. Navy, NAVFAC Pacific.

DON and Department of the Army. 2010. Record of Decision for Guam and CNMI Military Relocation including Relocating Marines from Okinawa, Transient Nuclear Aircraft Carrier Berth, Air and Missile Defense Task Force. 21 September.

Guam Visitors Bureau. 2014. 2014 Annual Report. Tumon, GU.

JRM. 2010. JRM-administered Lands GIS Data.

JRM. 2019. JRM-administered Submerged Lands GIS Data.

Rogers, R. F. 2011. Destiny's Landfall: A History of Guam. University of Hawai'i Press, Honolulu, HI.

Spennemann, D. H. R. 1999. Exploitation of bird plumages in the German Mariana Islands. Micronesica, 31, 309–318.

U.S. Census Bureau. 2014. CNMI Summary File. 2010 Census of Population and Housing (No. SFMP/10-3 (RV).

USAF. 2013. Fact Sheets: Andersen AFB, Guam. Accessed 20 July 2016, from http://www.andersen.af.mil/About-Us/Fact-Sheets/Display/Article/414482/andersen%C2%Adair%C2%Adforce%C2%Adbase%C2%Adguam/. Last updated July 2016.

15.3 CHAPTER 3 – ENVIRONMENTAL MANAGEMENT STRATEGY AND MISSION SUSTAINABILITY

Angermeier, P. L. and Karr, J. R. 1994. Biological Integrity Versus Biological Diversity as Policy Directives: Protecting Biotic Resources. Pages 264-275 *in* Ecosystem Management. Springer, New York, NY.

Benton, N. J., Ripley, D., and Powledge, F. (Eds.). 2008. Conserving Biodiversity on Military Lands: A Guide for Natural Resources Managers. 2008 Edition. NatureServe, Arlington, VA.

Berger, G. M., Gourley, J., and Shroer, G. 2005. Comprehensive Wildlife Conservation Strategy for the Commonwealth of the Northern Mariana Islands. Prepared by CNMI Department of Lands and Natural Resources, Division of Fish and Wildlife for National Advisory Acceptance Team, Migratory Birds and State Programs, USFWS, Portland, OR. September.

CNMI and NOAA CRCP. 2010. Commonwealth of the Northern Mariana Islands' Coral Reef Management Priorities. Silver Spring, MD.

DCRM. 2019. https://dcrm.gov.mp/about-dcrm/. Website copyrighted 2018. Accessed 15 April 2019.

DoD. 2011. Department of Defense Instruction (DoDI) 4715.03. 18 March.

DoD. 2013. Department of Defense Manual (DoDM) 4715. Integrated Natural Resources Management Plan (INRMP) Implementation Manual. 25 November 2013, incorporating Change 1, December 13, 2017.

DoD. 2016. DoD Directive 4715.21, Climate Change Adaptation and Resilience.

DON. 2006. Integrated Natural Resources Management Program Guidance for Navy Installations: How to Prepare, Implement, and Revise Integrated Natural Resource Management Plans (INRMP). Chief of Naval Operations (OPNAV N41).

DON. 2008. Environmental Strategy: Sustaining Our Environment, Protecting Our Freedom. Office of the Assistant Secretary of the Navy (Installations and Environment). 11 April.

DON. 2015c. Regional Biosecurity Plan for Micronesia and Hawai‘i: 4 Volumes.

DON and USFWS. 1994. Cooperative Agreement between the U.S. Navy and the U.S. Fish and Wildlife Service for the Establishment and Management of the Guam National Wildlife Refuge, Guam. March.

DON, USMC, and USCG. 2015. A Cooperative Strategy for 21st Century Seapower. March.

DON. 2019. Consultation Agreement Between The U.S. Department of Navy and U.S. Fish and Wildlife Service, Region 1 for Endangered Species Act Section 7 Consultations. March.

DON. 2022. Office of the Assistant Secretary of the Navy for Energy, Installations, and Environment. Department of the Navy Climate Action 2030. Washington, DC. May.

GovGuam and NOAA CRCP. 2010. Guam's Coral Reef Management Priorities. Silver Spring, MD.

GovGuam, U.S. Air Force, U.S. Navy, and U.S. Fish and Wildlife Service. 1993. Memorandum of Understanding among the Government of Guam and the U.S. Air Force and the U.S. Navy and the U.S. Fish and Wildlife Service for the Establishment and Management of the Guam National Wildlife Refuge, Guam. December.

Guam Coastal Management Program. 2018. Water Quality. Accessed 21 March 2018, from http://bsp.guam.gov/guam-coastal-management-program/.

Guam DAWR. 2006. Comprehensive Wildlife Conservation Strategy (GCWCS). Department of Agriculture, Government of Guam, Mangilao, GU. 7 November.

JRM. 2010. JRM-administered Lands GIS Data.

Liske-Clark, J. 2015. Wildlife Action Plan for the Commonwealth of the Northern Mariana Islands, 2015-2025. CNMI DLNR-Division of Fish and Wildlife, Saipan, MP. 16 December.

Miller, R. 2014. Guam Marine Biosecurity Action Plan. Prepared by the UOG Center for Island Sustainability for NOAA Coral Reef Conservation Program, as administered by the Office of Ocean and Coastal Resource Management and the Bureau of Statistics and Plans, Guam Coastal Management Program. September.

NAVFAC Marianas. 2013. Threatened and Endangered Species and Migratory Birds Monitoring Report, Naval Support Activity Andersen, Guam. Prepared by HDR Inc., San Diego, CA.

NMFS. 2023. Pacific Islands Regional Action Plan to Implement the NOAA Fisheries Climate Science Strategy Through 2024. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-142, 35 p.

NOAA Office for Coastal Management. 2019. https://coast.noaa.gov/czm/mystate/. Website last reviewed on 15 February 2019. Accessed 15 April 2019.

OPNAV M. 2021. Chapter 12: Natural Resources Conservation in Environmental Readiness Program Manual. In OPNAV Manual 5090.1 (OPNAV M-5090.1), Washington, D.C. 25 June.

OPNAVINST. 2021. OPNAV Instruction (OPNAVINST) 5090.1. Environmental Readiness Program. Office of the Chief of Naval Operations, Washington, D.C. 25 June.

OUSD I&E. 2005. Best Practices for Integrated Natural Resources Management (INRMP) Implementation. Prepared by Horne Engineering Services, Inc., Falls Church, VA.

Polovina, J. J., Dreflak, K., Baker, J., Bloom, S., Brooke, S., Chan, V., Ellgen, S., Golden, D., Hospital, J., Van Houtan, K., Kolinski, S., Lumsden, B., Maison, K., Mansker, M., Oliver, T., Spalding, S., and Woodworth-Jefcoats, P. 2016. Pacific Islands Regional Action Plan. NOAA Fisheries Climate Science Strategy. NMFS, Pacific Islands Fisheries Science Center, Honolulu, HI. December.

Rogers, H.S., Buhle, E.R., HilleRisLambers, J., Fricke, E.C., Miller, R.H., and Tewksbury, J.J. 2017. Effects of an invasive predator cascade to plants via mutualism disruption. *Nat. Commun.* 8, 14557.

SECNAV. 2004. SECNAV Instructions (SECNAVINST) 5090.6A. Environmental Planning for Department of the Navy Action. 26 April.

SECNAV. 2006. SECNAV Instructions (SECNAVINST) 5090.8A. Policy for Environmental Protection, Natural Resources, and Cultural Resources Programs. 30 January.

USAF and USFWS. 1994. Cooperative Agreement between the U.S. Air Force and the U.S. Fish and Wildlife Service for the Establishment and Management of the Guam National Wildlife Refuge, Guam.

USDA APHIS Wildlife Services. 2016a. State Report FY 2015 Guam. Accessed 21 March 2018, from https://www.aphis.usda.gov/wildlife_damage/informational_notebooks/2015/WS%20State%20Operations/Guam.pdf.

USDA APHIS Wildlife Services. 2016b. Program Data Report G – 2016 Animals Dispersed / Killed or Euthanized / Removed or Destroyed / Freed. Accessed 22 March 2018, from https://www.aphis.usda.gov/wildlife_damage/pdr/PDR-G_Report.php?fy=2016andfld=stateandfld_val=GU.

USDA APHIS Wildlife Services. 2016c. About APHIS. Accessed 3 August 2016, from https://www.aphis.usda.gov/aphis/banner/aboutaphis.

USDA NRCS. 2017. NRCS Conservation Programs.

USEPA. 2016. Climate Change: Basic Information. Accessed 19 December 2019, from https://www.epa.gov/climatechange/climatechangebasicinformation.

USEPA. 2017. Our Mission and What We Do. https://www.epa.gov/aboutepa/our-mission-and-what-we-do. Accessed 30 November 2017, from https://www.epa.gov/aboutepa/our-mission-and-what-we-do.

USFWS. 2004. Endangered And Threatened Wildlife And Plants; Designation of Critical Habitat for the Mariana Fruit Bat And Guam Micronesian Kingfisher on Guam and the Mariana Crow on Guam and in the Commonwealth of the Northern Mariana Islands; Final Rule. Federal Register, 69, 62944–62990.

USFWS. 2007. Migratory Bird Permits; Take of Migratory Birds by the Armed Forces; Final Rule. Federal Register, 72, 8931–8950.

USFWS. 2009. Guam National Wildlife Refuge Comprehensive Conservation Plan. Prepared by Guam NWR, Yigo, Guam and USFWS, Pacific Islands Field Office, Honolulu, HI. September.

USFWS. 2015. Interagency Cooperation—Endangered Species Act of 1973, as Amended; Incidental Take Statements. Final Rule. Federal Register, 80, 26832–26845. 11 May.

USFWS and NMFS. 1998. Endangered Species Consultation Handbook—Procedures for Conducting Consultation and Conference Activities under Section 7 of the Endangered Species Act. Final. March.

WPRFMC. 2009. Fishery Ecosystem Plan for the Mariana Archipelago. Honolulu, HI. September.

WPRFMC. 2016. Fishery Ecosystem Plan for the Mariana Archipelago. Working Draft. Honolulu, HI. 26 February.

15.4 CHAPTER 4 – OVERVIEW OF GUAM

Adams, J. 2018. Observations and photos of a scalloped hammerhead shark at Crevice dive site, Orote Peninsula, Guam. Personal communication via email from J. Adams, PADI Course Director, Micronesian Diver's Associates to M. Lybolt, Marine Ecologist/Project Manager, Cardno, Honolulu, HI. 7 March.

Allen, S. and Bartram, P. 2008. Guam as a Fishing Community. Pacific Islands Fisheries Science Center Administrative Report H-08-01. Honolulu, HI. February.

Andersen AFB. 2008. Basewide Vegetation Survey, Mapping, and Report of Andersen AFB, Guam. Contract report prepared by e2M. August.

Andersen AFB. 2013. *Cycas micronesica* Management Plan for Andersen AFB, Guam. Prepared by Isla Paraiso, Barrigada, Guam for 36 CES/CEVN Natural Resources Conservation Program, Andersen AFB. April.

Andersen AFB. 2014. *Serianthes* Monitoring, Final Report. Prepared by Isla Paraiso, Barrigada, Guam for Natural Resources Conservation Program, 36 CES/CEVN, Andersen AFB. April.

Andersen AFB. 2015. Conservation of *Cycas micronesica* on Guam. Prepared by UOG for Environmental Flight, 36 CES/CEVN, Andersen AFB. March.

Andersson, A. J., Kline, D. I., Edmunds, P. J., Archer, S. D., Bednaršek, N., Carpenter, R. C., Chadsey, M., Goldstein, P., Grottoli, A. G., Hurst, T. P., King, A. L., Kübler, J. E., Kuffner, I. B., Mackey, K. R. M., Menge, B. A., Paytan, A., Riebesell, U., Schnetzer, A., Warner, M. E., and Zimmerman, R. C. 2015. Understanding ocean acidification impacts on organismal to ecological scales. Oceanography, 28, 16–27.

Bahr, K. D., Jokiel, P. L., and Rodgers, K. S. 2016. Relative sensitivity of five Hawaiian coral species to high temperature under high-pCO_2 conditions. Coral Reefs, 35, 729–738.

Bailey-Brock, J. H. 2003. Coral reef polychaetes from Guam and Saipan, Mariana Islands. Micronesica, 35–36, 200–217.

Baker, R. H. 1951. The avifauna of Micronesia, its origin, evolution, and distribution. University of Kansas Publications, Museum of Natural History, 3, 1–359.

BioSystems Analysis, Inc. 1989. Natural Resources Survey for the U.S. Naval Magazine, Guam (NAVMAG). Prepared for NAVFAC Pacific. 31 January.

Bocanegra, G. 2017. Stray dogs persist. Pacific Daily News. 17 October.

Boone, John D. 2014. Baseline Survey for Street Dogs in Guam. Stray and Feral Animal Populations Collection. 4.

Bos, A. R., Bouma, T. J., de Kort, G. L. J., and van Katwijk, M. M. 2007. Ecosystem engineering by annual intertidal seagrass beds: Sediment accretion and modification. Estuarine Coastal and Shelf Science, 74, 344–348.

Brainard, R. E., Asher, J., Blyth-Skyrme, V., Coccagna, E. F., Dennis, K., Donovan, M. K., Gove, J. M., Kenyon, J., Looney, E. E., Miller, J. E., Timmers, M., Vargas-Ángel, B., Vroom, P. S., Vetter, O., and Zgliczynski, B. 2012. Coral Reef Ecosystem Monitoring Report of the Mariana Archipelago: 2003 to 2007 (PIFSC Special Publication No. SP-12-01). NOAA Fisheries, Pacific Islands Fisheries Science Center. Honolulu, HI. March.

Breitburg, D. L., Salisbury, J., Bernhard, J. M., Cai, W. J., Dupont, S., Doney, S. C., Kroeker, K. J., Levin, L. A., Long, W. C., Milke, L. M., S.H. Miller, Phelan, B., Passow, U., Seibel, B. A., Todgham, A. E., and Tarrant, A. M. 2015. And on top of all that... coping with ocean acidification in the midst of many stressors. Oceanography, 28, 48–61.

Brindock, K. 2015. Unpublished data regarding sea turtle tagging within Apra Harbor. NAVFAC Marianas, Environmental.

Brodie, J., Fabricius, K., Death, G., and Okaji, K. 2005. Are increased nutrient inputs responsible for more outbreaks of crown-of-thorns starfish? An appraisal of the evidence. Marine Pollution Bulletin, 51, 266–278.

Brooke, A. 2008. Mariana Fruit Bat Surveys on Navy Properties, Guam. NAVFAC Marianas Environmental.

Brooke, A. 2017. Potential impacts of scarab beetle (*Protaetia orientalis*) on ifit tree seed set. Personal communication via email from A. Brooke, Conservation Manager, NAVFAC Marianas to R. Spaulding, Senior Biologist/Project Manager, Cardno, Bainbridge Island, WA. February 10.

Brown, M. T. and Depledge, M. H. 1998. Determinants of Trace Metal Concentrations in Marine Organisms. Pages 185–217 *in* W. J. Langston and M. J. Bebianno (Eds.), Metal Metabolism in Aquatic Environments. Springer, Boston, MA.

Brown, V. 2015. Sightings of Threatened Corals around Guam. Personal communication via email from V. Brown, Fisheries Biologist, NOAA Fisheries PIRO HCD Guam Field Office to S. Hanser, Supervisory Marine Biologist, NAVFAC Pacific, Pearl Harbor, HI. February.

Bryan, P. G. 1973. Growth rate, toxicity and distribution of the encrusting sponge *Terpios* sp. (Hadromerida: Suberitidae) in Guam, Mariana Islands. Micronesica, 9, 237–242.

Burdick, D., Brown, V., Asher, J., Gawel, M., Goldman, L., Hall, A., Kenyon, J., Leberer, T., Lundblad, E., McIlwain, J., Miller, J., Minton, D., Nadon, M., Pioppi, N., Raymundo, L., Richards, B., Schroeder, R., Schupp, P., Smith, E., and Zgliczynski, B. 2008. The State of Coral Reef Ecosystems of Guam. Pages 465-509 *in* J.E. Waddell and A.M. Clarke (Eds.), The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2008. NOAA Technical Memorandum NOS NCCOS 73. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team, Silver Spring, MD. April.

Burkepile, D. E. and Hay, M. E. 2006. Herbivore vs. nutrient control of marine primary producers: content-dependent effects. Ecology, 87, 3128–3139.

California Department of Transportation. 2001. San Francisco – Oakland Bay Bridge East Span Seismic Safety Project, Pile Installation Demonstration Project, Fisheries Impact Assessment. August.

Campbell, J. A. 2015. Continued DON Informal Consultation with NMFS on the Effects of the Guam and CNMI Military Relocation (2012 Roadmap Adjustments) on Federally Listed Marine Species. Personal communication via letter from Capt. J.A. Campbell, Deputy Director JGPO, Washington, DC to M. Tosatto, Regional Administrator, NMFS, Pacific Islands Regional Office, Honolulu, HI. 13 April.

Carlson, C. and Hoff, P. J. 2003. The opisthobranchs of the Mariana Islands. Micronesica, 35–36, 271–293.

Carlson, T. J., Hastings, A., and Popper, A. N. 2007. Update on recommendations for revised sound exposure guidelines for fish during pile driving activities.

Caves, E. M., Jennings, S. B., Hille Ris Lambers, J., Teweksbury, J. J., and Rogers, H. S. 2013. Natural experiment demonstrates that bird loss leads to cessation of dispersal of native seeds from intact to degraded forests. PLOS ONE, 8(5), e65618.

Centre for Agriculture and Biosciences International. 2018. *Pimenta racemosa* datasheet in Invasive Species Compendium. CAB International, Wallingford, UK.

Chapman, J. W. and Carlton, J. T. 1991. A test of criteria for introduced species: the global invasion by the isopod *Synidotea laevidorsalis* (Miers, 1881). Journal of Crustacean Biology, 11, 386-400.

Chargualaf, A. 2017. Stray dog population on the rise. The Guam Daily Post. 25 September.

Cheung, W., Watson, R., Morato, T., Pitcher, T., and Pauly, D. 2007. Intrinsic vulnerability in the global fish catch. Marine Ecology Progress Series, 333, 1–12.

Christy, M. T., Clark, C. S., Gee II, D. E., Vice, D., Vice, D. S., Warner, M. P., Tyrrell, C. L., Rodda, G. H., and Savidge, J. A. 2007. Recent records of alien anurans on the Pacific island of Guam. Pacific Science, 61, 469–483.

Colgan, M. W. 1987. Coral reef recovery on Guam (Micronesia) after catastrophic predation by *Acanthaster planci*. Ecology, 68, 1592–1605.

CNMI DFW. 2023. Conservation and Management of Mariana Common Moorhen on the Tinian Military Lease Area (Interim Report). Saipan, MP.

Crain, C. M., Halpern, B. S., Beck, M. W., and Kappel, C. V. 2009. Understanding and Managing Human Threats to the Coastal Marine Environment. Pages 39-63 *in* R.S. Ostfeld and W.H. Schlesinger (Eds.), The Year in Ecology and Conservation Biology 2009 1162, 39-62. Blackwell Publishing, Oxford, UK.

Crampton, H. E. 1925. Studies on the variation, distribution and evolution of the genus Partula. The species of the Mariana Islands, Guam and Saipan. Carnegie Institution of Washington, 228a, 1–116.

Crombie, R. I. and Pregill, G. K. 1999. A checklist of the herpetofauna of the Palau Islands (Republic of Belau), Oceania. Herpetological Monographs, 13, 29–80.

Davis, A., Shafer, D., and Bourne, S. 2010. A Spatial Decision Support Tool for Identifying and Prioritizing Watersheds along the Southwestern Coast of Guam as Potential Sites for Remediation to Minimize Sedimentation Effects to Nearshore Coral Reefs. Prepared for NAVFAC Pacific, Pearl Harbor, HI.

DeNicola, A. 2015. Non-native Ungulate Management and Research: Andersen AFB. Prepared by White Buffalo, Inc., Moodus, CT. 11 September.

Department of the Army, DON, and USAF. 2006. SECNAVINST 6401.1B Veterinary Health Services.

Diong, C. H. 1982. Population biology and management of the feral pig (*Sus scrofa L.*) in Kipahulu Valley, Maui. Dissertation. University of Hawai‘i, Honolulu, HI.

DoD. 2014. 2014 Climate Change Adaptation Roadmap. Office of the Deputy Under Secretary of Defense for Installations and Environment (Science and Technology Directorate), Alexandria, VA.

DON. 2009. Interim Final Integrated Natural Resources Management Plan, Navy Base Guam, Plan Years 2009–2014. Prepared by Geo-Marine.

DON. 2015a. Regional Biosecurity Plan for Micronesia and Hawai‘i: 4 Volumes.

DON. 2015b. Final Supplemental Environmental Impact Statement Guam and the Commonwealth of the Northern Mariana Islands Military Relocation (2012 Roadmap Adjustments). Prepared by NAVFAC Pacific, Pearl Harbor, HI for Joint Guam Program Office, Washington, D.C.

DON. 2015c. Mariana Islands Training and Testing Activities Final Environmental Impact Statement/Overseas Environmental Impact Statement. Volume 1. Prepared by NAVFAC Pacific, Pearl Harbor, HI.

DON. 2017a. Revised Biological Assessment for the Marine Corps Relocation from Okinawa to Guam. Prepared for USFWS, Pacific Islands Fish and Wildlife Office, Honolulu, HI and NAVFAC Pacific.

DON. 2017b. Climate Change. Accessed 30 November 2017, from http://greenfleet.dodlive.mil/climate-change/.

DON. 2023. Sea Turtle Nesting Beach Monitoring and Nest Protection on Naval Base Guam. Joint Region Marianas, Guam. October 2023.

DON and USFWS. 2015a. Memorandum of Agreement between the Department of the Navy and the U.S. Fish and Wildlife Service Regarding Conservation of Guam Micronesian Kingfisher Recovery Habitat in Northern Guam.

DON and USFWS. 2015b. Modification to Memorandum of Agreement between the Department of the Navy and the U.S. Fish and Wildlife Service: Designation of Alternative Configuration for Guam Micronesian Kingfisher Recovery Habitat in Northern Guam.

Donaldson, T. J. 1995. Comparative analysis of reef fish distribution patterns in the northern and southern Mariana Islands. Natural History Museum and Institute, Chiba, Japan. Natural History Research, 3, 227–234.

Donaldson, T. J., Myers, R. F., Moyer, J. T., and Schupp, P. J. 1994. Zoogeography of the fishes of the Mariana, Ogasawara, and Izu Islands: a preliminary assessment. Natural History Museum and Institute, Chiba, Japan. Natural History Research Special Issue, 1, 303–332.

Donnegan, J. A., Butler, S. L., Grabowiecki, W., Hiserote, B. A., and Limtiaco, D. 2004. Guam’s Forest Resources, 2002 (Resource Bulletin No. PNW-RB-243). USDA, Forest Service, Pacific Northwest Research Station, Portland, OR.

Dryden, G. L. 1965. The food and feeding of *Varanus indicus* on Guam. Micronesica, 2, 72–76.

Dulvy, N. and Polunin, N. 2004. Using informal knowledge to infer human-induced rarity of a conspicuous reef fish. Animal Conservation, 7, 365–374.

Earthquaketrack.com. 2017. Recent Earthquakes near Mariana Islands – 7+ magnitude. Accessed 30 November 2017, from http://earthquaketrack.com/r/mariana-islands/recent?mag_filter=7.

Engbring, J. and Ramsey, F. L. 1984. Distribution and Abundance of the Forest Birds of Guam: Results of a 1981 Survey (No. FWS/OBS-84/20). U.S. Fish and Wildlife Service.

Englund, R. A. 2011. Guam and Palau Aquatic Insect Surveys. Prepared for Southeastern Ecological Science Center, USGS, Gainesville, FL. April.

Fabricius, K. E., Okaji, K., and Death, G. 2010. Three lines of evidence to link outbreaks of the crown-of-thorns seastar *Acanthaster planci* to the release of larval food limitation. Coral Reefs, 29, 593–605.

Feist, B. E., Anderson, J. J., and Miyamoto, R. 1996. Potential impacts of pile driving on juvenile pink (*Oncorhynchus gorbuscha*) and chum (*O. kept*) salmon behavior and distribution. University of Washington, Seattle.

Fonseca, M. S. and Olsen, J. L. 2016. The complex and emerging story of Johnson's seagrass. Environment Coastal and Offshore, 20–33.

Ford, M. A. and Grace, J. B. 1998. Effects of vertebrate herbivores on soil processes, plant biomass, litter accumulation and soil elevation changes in a coastal marsh. The Journal of Ecology, 86, 974–982.

Fosberg, F. R. 1960. The Vegetation of Micronesia 1. General description of vegetation of the Mariana Islands, and a detailed consideration of the vegetation of Guam. American Museum of Natural History Bulletin, 119, 1–76.

Fulling, G., Thorson, P., and Rivers, J. 2011. Distribution and abundance estimates for cetaceans in the waters off Guam and the Commonwealth of the Northern Mariana Islands. Pacific Science, 65, 321–343.

Furukawa, K., Wolanski, E., and Mueller, H. 1997. Currents and sediment transport in mangrove forests. Estuarine, Coastal and Shelf Science, 44, 301–310.

Gingerich, S. B. 2003. Hydrologic Resources of Guam (USGS Water-Resources Investigations Report No. 03–4126). Prepared in cooperation with the Water and Environmental Research Institute (WERI), UOG, Mangilao, GU.

Gingerich, S. B. 2013. The Effects of Withdrawals and Drought on Groundwater Availability in the Northern Guam Lens Aquifer, Guam. USGS Scientific Investigations Report 2013-5216.

GISD. 2005a. *Mikania micrantha* (vine, climber). Global Invasive Species Database. Accessed 30 November 2017, from http://issg.org/database/species/ecology.asp?si=42andfr=1andsts=sssandlang=EN. 24 January.

GISD. 2005b. *Coccinia grandis* (vine, climber). Global Invasive Species Database. Accessed 30 November 2017, from http://issg.org/database/species/ecology.asp?si=348andfr=1andsts=sssandlang=EN. 24 May.

GISD. 2006. *Urochloa maxima* (grass). Global Invasive Species Database. Accessed 30 November 2017, from http://issg.org/database/species/ecology.asp?si=398andfr=1andsts=sssandlang=EN. 26 January.

GISD. 2009. *Wasmannia auropunctata*. Global Invasive Species Database. Accessed 30 November 2017, from http://www.iucngisd.org/gisd/speciesname/Wasmannia+auropunctata. 31 October.

GISD. 2010. *Leucaena leucocephala*. Global Invasive Species Database. Accessed 30 November 2017, from http://issg.org/database/species/ecology.asp?si=23andfr=1andsts=sssandlang=EN. 16 August.

Glosser, J. and Yarnell, E. 1970. Rabies Control on Guam. Public Health Reports, 85, 1113–1120.

GovGuam. 2009. Endangered Species Regulation No. 9. Department of Agriculture, Mangilao, GU. 6 November.

Grimm, G. and Farley, J. 2008. Sea Turtle Nesting Activity on Navy Lands, Guam, 2007-2008. NAVFAC Marianas Environmental. November.

Guam DAWR. 2006. Comprehensive Wildlife Conservation Strategy (GCWCS). Department of Agriculture, Government of Guam, Mangilao, GU. 7 November.

Guam DAWR. 2008. Biological and Habitat Assessment of Surface Waters on Guam. Department of Agriculture, Government of Guam, Mangilao, GU. 12 September.

Guam DAWR. 2015. Draft State Wildlife Action Plan. Department of Agriculture, Government of Guam, Mangilao, GU. 20 January.

Guam Department of Agriculture. 2010. Guam Statewide Forest Resource Assessment and Resource Strategy, 2010-2015. Prepared by Watershed Professionals Network, Philomath, OR for the Guam Department of Agriculture, Forestry and Soil Resources Division, Mangilao, GU. 18 June.

Guam Homeland Security. 2014. 2014 Guam Hazard Mitigation Plan. Guam Office of Civil Defense. Prepared by URS Group. April.

Guampedia. 2018a. Mariana fruit bat (*Pteropus mariannus mariannus*). Accessed 3 August 2018, from https://www.guampedia.com/fanihi-mariana-fruit-bat/. 27 July.

Guampedia. 2018b. Guam rail (*Gallirallus owstoni*). Accessed 3 August 2018, from https://www.guampedia.com/guam-rail/. 27 July.

Harvey, C. 2016. 'I cried…right into my mask': Scientists say Guam's reefs have bleached four years straight. Washington Post. Accessed 21 May 2018, from https://www.washingtonpost.com/news/energy-environment/wp/2016/08/03/i-cried-right-into-my-mask-these-coral-reefs-have-seen-a-devastating-four-years-of-bleaching/?utm_term=.a330b8c4784c. 3 August.

Heenan, A., McCoy, K., Asher, J., Ayotte, P., Gorospe, K., Gray, A., Lino, K., Zamzow, J., and Williams, I. 2015. Pacific Reef Assessment and Monitoring Program Data Report: Ecological Monitoring 2014 – Stationary Point Count Surveys of Reef Fishes and Benthic Habitats of the Northwestern Hawaiian Islands, Mariana Islands, and Wake Atoll. NOAA PIFSC, Honolulu, HI.

Hill, M.C., Bendlin, A.R., Ü, A.C., Yano, K.M., Bradford, A.L., Ligon, A.D., and Oleson, E.M. 2017. Cetacean Monitoring in the Mariana Islands Range Complex, 2016. Prepared for the U.S. Pacific Fleet Environmental Readiness Office. PIFSC Data Report DR-17-002. 46 pp. doi:10.7289/V5/DR-PIFSC-17-002. 3 February.

Hill, M., Ligon, A., Deakos, M., Ü, A. C., Milette-Winfree, A., Oleson, E., and Bendlin, A. 2014. Cetacean surveys in the waters of the southern Mariana Archipelago (February 2010-April 2014) (PIFSC Data Report No. DR-14-013). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 2 September.

Hill, M., Oleson, E. M., Baumann-Pickering, S., VanCise, A. M., Ligon, A. D., Bendlin, A. R., Ü, A. C., Trickey, J. S., and Bradford, A. L. 2016. Cetacean Monitoring in the Mariana Islands Range Complex, 2015 (PIFSC Data Report No. DR-16-01). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 6 February.

Hoegh-Guldberg, O. and Bruno, J. F. 2010. The Impact of Climate Change on the World's Marine Ecosystems. Science, 328, 1523–1528.

Holland, B. and Rubinoff, D. 2014. Andersen AFB Guam EIS Tree Snail and Butterfly Field Surveys. June.

Holm, L. G., Plucknett, D. L., Pancho, J. V., and Herberger, J. P. 1977. The World's Worst Weeds: Distribution and Biology. University Press of Hawai'i, Honolulu, HI.

Hoot, W. and Burdick, D. 2017. Guam Coral Bleaching Response Plan. Contributions by the Guam Coral Reef Response Team. December.

Hopper, D. R. and Smith, B. 1992. Status of tree snails (Gastropoda: Partulidae) on Guam, with a resurvey of sites studied by H.E. Crampton in 1920. Pacific Science, 46, 77–85.

Horsley Witten Group, Inc. 2006. CNMI and Guam Stormwater Management Manual. Prepared for the CNMI and Territory of Guam. October.

Hughes, T., Baird, A., Bellwood, D., Card, M., Connolly, S., Folke, C., Grosberg, R., Hoegh-Guldberg, O., Jackson, J., Kleypas, J., Lough, J., Marshall, P., Nystroem, M., Palumbi, S., Pandolfi, J., Rosen, B., and Roughgarden, J. 2003. Climate change, human impacts, and the resilience of coral reefs. Science, 301, 929–933.

Hughes, T., Kerry, J., Álvarez-Noriega, M., Álvarez-Romero, J., Anderson, K., Baird, A., Babcock, R., Beger, M., Bellwood, D., Berkelmans, R., Bridge, T., Butler, I., Byrne, M., Cantin, N., Comeau, S., Connolly, S., Cumming, G., Dalton, S., Diaz-Pulido, G., Eakin, C., Figueira, W., Gilmour, J., Harrison, H., Heron, S., Hoey, A., Hobbs, J., Hoogenboom, M., Kennedy, E., Kuo, C., Lough, J., Lowe, R., Liu, G., McCulloch, M., Malcolm, H., McWilliam, M., Pandolfi, J., Pears, R., Pratchett, M., Schoepf, V., Simpson, T., Skirving, W., Sommer, B., Torda, G., Wachenfeld, D., Willis, B., and Wilson, S. 2017. Global warming and recurrent mass bleaching of corals. Nature, 543, 373-377.

Island Eco Services. 2021. Final Report N40192-20-P-5004: Threatened and Endangered Plants and Snails Survey Within Naval Base Guam.

Islam, M. Z. 2005. Minimizing Karst Related Risks in Highway Construction. Pages 551-555 *in* Proceedings of the 1st International Conference. Presented at the Geotechnical Engineering for Disaster Mitigation and Rehabilitation, Singapore. 12-13 December.

Jackson, J., Kirby, M., Berger, W., Bjorndal, K., Botsford, L., Bourque, B., Bradbury, R., Cooke, R., Erlandson, J., Estes, J., Hughes, T., Kidwell, S., Lange, C., Lenihan, H., Pandolfi, J., Peterson, C., Steneck, R., Tegner, M., and Warner, R. 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science, 293, 629–638.

Jenkins, J. M. 1983. The Native Forest Birds of Guam. Ornithological Monographs, 31, 1–61.

Jones, T. T., Martin, S. L., and Van Houtan, K. S. 2015. Sea Turtle Tagging in the Mariana Islands Range Complex (MIRC) Interim Progress Report (PIFSC Data Report No. DR-15-020). Prepared for U.S. Pacific Fleet Environmental Readiness Office, Pearl Harbor, HI. September.

Joos, F., Frolicher, T. L., Steinacher, M., and Plattner, G.K. 2011. Impact of Climate Change Mitigation on Ocean Acidification Projections. Pages 273-289 *in* J. Gattuso and L. Hansson (Eds.), Ocean Acidification. Oxford University Press, Oxford, UK.

JRM. 2013. Final Joint Region Marianas Integrated Natural Resources Management Plan. Prepared by HDR for Commander Joint Region Marianas, Guam, Hagatna, GU. December.

JRM. 2010. JRM-administered Lands GIS Data.

JRM. 2019. JRM-administered Submerged Lands GIS Data.

JRM, NAVFAC Marianas, and Andersen AFB 36 CES/CEV. 2012. Final Summary Report: Noise Study and Demographic Survey of Mariana Fruit Bats and Mariana Crows, Andersen AFB, Guam. Prepared by SWCA Environmental Consultants, Hagatna, GU. 11 May.

Kami, H. T. 1971. Checklist of Guam fishes. Micronesica, 7, 215–228.

Kappel, C. V. 2005. Losing pieces of the puzzle: threats to marine, estuarine, and diadromous species. Frontiers in Ecology and the Environment, 3, 275–282.

Karolle, B. G. 1993. Atlas of Micronesia (Second Edition). Bess Press Inc., Honolulu, HI.

Keener, V., D. Helweg, S. Asam, S. Balwani, M. Burkett, C. Fletcher, T. Giambelluca, Z. Grecni, M. Nobrega-Olivera, J. Polovina, and G. Tribble, 2018: Hawai'i and U.S.-Affiliated Pacific Islands. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1242–1308. doi: 10.7930/NCA4.2018.CH27

Kellman, M. and Tackaberry, R. 1997. Tropical Environments: The Functioning and Management of Tropical Ecosystems. Routledge, New York, NY.

Kelly, M., Hooper, J., Paul, V., Paulay, G., van Soest, R., and de Weerdt, W. 2003. Taxonomic inventory of the sponges (Porifera) of the Mariana Islands. Micronesica, 35, 100–120.

Kerr, A. M. 1990. Chamorro Fish Names. Micronesica, 23, 93–118.

Kerr, A. M. 2012. Fish Names of the Mariana Islands, Micronesia (UOG Marine Laboratory Technical Report No. 139). Mangilao, GU. February.

Kerr, A. M. 2013a. Illustrated Guide to the Reptiles and Amphibians of the Mariana Islands, Micronesia (UOG Marine Laboratory Technical Report No. 150). Mangilao, GU. March.

Kerr, A. M. 2013b. The Partulid Tree Snails (Partulidae: Stylommatophora) of the Mariana Islands, Micronesia (UOG Marine Laboratory Technical Report No. 152). Mangilao, GU. May.

Kerr, A. M. and Bauman, S. 2013. Annotated Checklist of the Land Snails of the Mariana Islands, Micronesia (UOG Marine Laboratory Technical Report No. 148). Mangilao, GU.

Klinck, H., Nieukirk, S. L., Fregosi, S., Klinck, K., Mellinger, D. K., Latuska, S., Shilling, B., and Luby, J. C. 2015. Cetacean Studies on the Mariana Islands Range Complex in September-November 2014: Passive Acoustic Monitoring of Marine Mammals Using Gliders. Final Report. Prepared for Commander, U.S. Pacific Fleet, Environmental Readiness Division, Pearl Harbor, HI. August.

Klinck, H., Nieukirk, S. L., Fregosi, S., Klinck, K., Mellinger, D. K., Latuska, S., Shilling, B., and Luby, J. C. 2016. Cetacean Studies on the Mariana Islands Range Complex in March – April 2015: Passive Acoustic Monitoring of Marine Mammals Using Gliders. Submitted by HDR, Inc., Honolulu, HI to Commander, U.S. Pacific Fleet.

Koenig, R. 2001. Researchers target deadly tsunamis. Science, 293, 1251–1253.

Kopp, D., Bouchon-Navaro, Y., Cordonnier, S., Haouisee, A., Louis, M., and Bouchon, C. 2010. Evaluation of algal regulation by herbivorous fishes on Caribbean coral reefs. Helgoland Marine Research, 64, 181–190.

Lander, J. F., Whiteside, L. S., and Hattori, P. 2002. The Tsunami History of Guam: 1849-1993. Science of Tsunami Hazards, 20, 158–174.

Lardner, B. 2016. Systematics of Guam reptiles and amphibians. Bjorn Lardner, Colorado State University, personal communication to M.J. Mazurek, JRM Natural Resource Specialist, Guam, via review comments to draft INRMP chapter. 16 August.

Lardner, B., Reed, R. N., Yackel Adams, A. A., Mazurek, M., Hinkle, T. J., Levasseur, P. M., Palmer, M. S., and Savidge, J. A. 2013. Selective predation by feral cats on a native skink on Guam. ICRF Reptiles and Amphibians, 20, 16–19.

LaRosa, A. M. 1992. The status of banana poka in Hawai‘i. Pages 271-299 *in* C. Stone, C. Smith, and J. T. Tunison (Eds.), Alien Plant Invasions in Native Ecosystems of HaHawai‘iwaii: Management and Research. University of Hawai‘i Cooperative National Park Resources Studies Unit, Manoa, HI. University of Hawai‘i Press, Honolulu, HI.

Leberer, T. 2003. Records of freshwater turtles on Guam, Marianas Islands. Micronesica, 35–36, 649–652.

Leong, J.-A., Marra, J. J., Finucane, M. L., Giambelluca, T., Merrifield, M., Miller, S. E., Polovina, J., Shea, E., Burkett, M., Campbell, J., Lefale, P., Lipschultz, F., Loope, L., Spooner, D., and Wang, B. 2014. Chapter 23: Hawai‘i and U.S. Affiliated Pacific Islands. Pages 537-556 *in* J. M. Melillo, T. C. Richmond, and G. W. Yohe (Eds.), Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program.

Liddle, D. T., Brook, B. W., Matthews, J., Taylor, S. M., and Caley, P. 2006. Threat and response: A decade of decline in a regionally endangered rainforest palm affected by fire and introduced animals. Biological Conservation, 132, 362–375.

Liske-Clark, J. 2015. Wildlife Action Plan for the Commonwealth of the Northern Mariana Islands, 2015-2025. CNMI DLNR-Division of Fish and Wildlife, Saipan, MP. 16 December.

Lobban, C. S. and Tsuda, R. T. 2003. Revised checklist of benthic marine macroalgae and seagrasses of Guam and Micronesia. Micronesica, 35, 54–99.

Lujan, D. 2017. Occurrences of *Partula radiolata* at Andersen South from USDA WS. Personal communication via email from D. Lujan, EV2, NAVFAC Marianas to R. Spaulding, Senior Biologist/Project Manager, Cardno, Bainbridge Island, WA. 21 February.

Lybolt, M. 2015. Listed Coral Sighting (Guam). Technical Memorandum from M. Lybolt, Marine Ecologist, Tetra Tech, Inc., Stuart, FL to S. Hanser, Supervisory Marine Biologist, NAVFAC Pacific, Pearl Harbor, HI. 4 May.

Maciolek, J. A. 1984. Exotic Fishes in Hawai‘i and Other Islands of Oceania. Pages 131-136 *in* W. R. Courtenay and J. R. Stauffer (Eds.), Distribution, Biology, and Management of Exotic Fishes. Johns Hopkins University Press, Baltimore, MD.

Marler, T. E. and Lawrence, J. H. 2012. Demography of *Cycas micronesica* on Guam following introduction of the armoured scale *Aulacaspis yasumatsui*. Journal of Tropical Ecology, 28, 233–242.

Marler, T. E. and Terry, L. I. 2011. Arthropod invasion disrupts (*Cycas micronesica*) seedling recruitment. Communicative and Integrative Biology, 4, 778–780.

Marshall, P. A. and Schuttenberg, H. 2006. A reef manager's guide to coral bleaching. Great Barrier Reef Marine Park Authority, Townsville, Queensland, AU.

Martin, S. L. and Jones, T. T. 2016. Sea Turtle Tagging in the Mariana Islands Training and Testing (MITT) Study Area (PIFSC Data Report No. DR-17-025). Prepared for the U.S. Pacific Fleet Environmental Readiness Office, Honolulu, HI. 15 December.

Martin, S. L. and Jones, T. T. 2017. Sea Turtle Tagging in the Naval Base Guam Area (PIFSC Data Report No. DR-17-026). Prepared for the U.S. Naval Base Guam. 25 January.

Martin, S. L., van Houtan, K. S., Jones, T. T., Aguon, C. F., Gutierrez, J. T., Tibbats, B. R., Wusstig, S. B., and Bass, J. D. 2016. Five decades of marine megafauna surveys from Micronesia. Frontiers in Marine Science, 2, 116.

McCoid, M. J., Rodda, G. H., and Fritts, T. H. 1995. Distribution and abundance of *Emoia slevini* (Scincidae) in the Mariana Islands. Herpetological Review, 26, 70–72.

McDonald, M. Q. 2002. Nitrate-Nitrogen Concentrations in the Northern Guam Lens and Potential Nitrogen Sources (Technical Report No. 95). Water and Environmental Research Institute of the Western Pacific, UOG. September.

McKenna, S. A., Richmond, R. H., and Roos, G. 2001. Assessing the effects of sewage on coral reefs: developing techniques to detect stress before coral mortality. Bulletin of Marine Science, 69, 517–523.

Milazzo, M., Cattano, C., Alonzo, S. H., Foggo, A., Gristina, M., Rodolfo-Metalpa, R., Sinopoli, M., Spatafora, D., Stiver, K. A., and Hall-Spencer, J. M. 2016. Ocean acidification affects fish spawning but not paternity at CO_2 seeps. Proceedings of the Royal Society B, 283.

Mildenstein, T. L. 2008. Population Viability Analysis of the Mariana Fruit Bat Metapopulation in the Mariana Islands. Prepared for Mariana Fruit Bat Recovery Team, United States Fish and Wildlife Service Office, Pacific Islands Office, Honolulu, HI.

Miller, M. W. and Hay, M. E. 1996. Coral-seaweed-grazer-nutrient interactions on temperate reefs. Ecological Monographs, 66, 323–344.

Miller, R. 2014. Guam Marine Biosecurity Action Plan. Prepared by the UOG Center for Island Sustainability for NOAA Coral Reef Conservation Program, as administered by the Office of Ocean and Coastal Resource Management and the Bureau of Statistics and Plans, Guam Coastal Management Program. September.

Miller, R. 2017. Recent distribution of little fire ant on Guam. Personal communication via email from R. Miller, Entomologist, College of Natural and Applied Sciences, UOG to R. Spaulding, Senior Biologist/Project Manager, Cardno, Bainbridge Island, WA. 19 March.

Monaco, M. E., Anderson, S. M., Battista, T. A., Kendall, M. S., Rohmann, S. O., Wedding, L. M., and Clarke, A. M. 2012. National Summary of NOAA's Shallow-water Benthic Habitat Mapping of U.S. Coral Reef Ecosystems (NOAA Technical Memorandum No. NOS NCCOS 122). NCCOS Center for Coastal Monitoring and Assessment Biogeography Branch, Silver Spring, MD.

Moore, A. 2007. Assessment of the Rhinoceros Beetle Infestation on Guam. UOG. 31 October.

Moore, A. 2011. Guam Coconut Rhinoceros Beetle (Final Report for USDA FS Grant No. 08-DG-11052021–146). UOG Cooperative Extension Service.

Moore, A. 2016. Update on the Guam Coconut Rhinoceros Beetle Situation for the Guam Invasive Species Council. College of Natural and Applied Sciences, UOG.

Moore, A., Jackson, T., Quitugua, R., Bassler, P., and Campbell, R. 2015. Coconut rhinoceros beetles (Coleoptera: Scarabaeidae) develop in arboreal breeding sites on Guam. Florida Entomologist, 98, 1012–1014.

Moore, C. J. 2008. Synthetic polymers in the marine environment: a rapidly increasing, long-term threat. Environmental Research, 108, 131–139.

Moutardier, G., Gereva, S., Mills, S. C., Adjeroud, M., Beldade, R., Ham, J., Kaku, R., and Dumas, P. 2015. Lime juice and vinegar injections as a cheap and natural alternative to control COTS outbreaks. PLOS ONE, 10, e0137605.

Mueller, C. S., Haller, K. M., Luco, N., Petersen, M. D., and Frankel, A. D. 2012. Seismic Hazard Assessment for Guam and the Northern Mariana Islands. Open-File Report No. 2012-1015. USGS, Reston, VA.

Mueller-Blenkle, C., McGregor, P. K., Gill, A. B., Andersson, M. H., Metcalfe, J., Bendall, V., Sigray, P., Wood, D., and Thomsen, F. 2010. Effects of Pile Driving Noise on the Behavior of Marine Fish. Technical Report COWRIE Ref: Fish 06-08. 31 March.

Mueller-Dombois, D. and Fosberg, F. R. 1998. Vegetation of the Tropical Pacific Islands. Springer-Verlag, Inc., New York, NY.

Muniappan, R. and Reddy, G. V. P. 2015. Biological Control Programs of Major Invasive Weeds in the Western Pacific. Page 39 *in* 2^{5t}h Asian-Pacific Weed Science Society Conference on Weed Science for Sustainable Agriculture, Environment and Biodiversity. Hyderabad, IN. 13-16 October.

Musick, J. A., Burgess, G., Cailliet, G., Camhi, M., and Fordham, S. 2000. Management of sharks and their relatives (*Elasmobranchii*). American Fisheries Society Policy Statement #31b. Fisheries, 25, 9–13.

Musick, J. A. and Limpus, C. J. 1997. Habitat utilization and migration in juvenile sea turtles. Pages 137-163 *in* P. Lutz and J.A. Musick (Eds.), The Biology of Sea Turtles. CRC Press, New York, NY.

Myers, R. F. and Donaldson, T. J. 2003. The fishes of the Mariana Islands. Micronesica, 35–36, 594–648.

Nagelkerken, I., Blaber, S., Bouillon, S., Green, P., Haywood, M., Kirton, L., Meynecke, J.-O., Pawlik, J., Penrose, H., and Sasekumar, A. 2008. The habitat function of mangroves for terrestrial and marine fauna: A review. Aquatic Botany, 89, 155–185.

National Institute of Informatics. 2016. Digital Typhoon: Typhoon Images and Information. Accessed 23 January 2023, from http://agora.ex.nii.ac.jp/digital-typhoon/. 7 August.

National Weather Service. 2023. Tiyan, Guam: NOWData – NOAA Online Weather Data. Guam Area, Monthly Summarized Data, Precipitation (por-2016). National Weather Service, Tiyan Guam: Climate Report. Accessed 23 January 2023, from https://www.weather.gov/wrh/Climate?wfo=gum.

NAVFAC Marianas. 2011. Seagrass Survey–- Dadi Beach, Naval Base Guam. Prepared by SWCA Environmental Consultants, Hagatna, Guam for NAVFAC Marianas, Navy Base Guam. 31 December.

NAVFAC Marianas. 2013. Threatened and Endangered Species and Migratory Birds Monitoring Report, Naval Support Activity Andersen, Guam. Prepared by HDR Inc., San Diego, CA. February.

NAVFAC Marianas. 2014a. Long-Term Vegetation Monitoring Report, Naval Base Guam. Prepared by PCR Environmental, Inc., Barrigada, GU. June.

NAVFAC Marianas. 2014b. Final Project Report: Federal Candidate Species Surveys on Guam. Prepared by D.P. Lindstrom and J.C. Benedict, College of Natural and Applied Sciences, UOG. 21 January.

NAVFAC Marianas. 2014c. Final Report for Haputo Partulid Snail Predation Study, Haputo Ecological Reserve Area, Finegayan, Guam. Prepared by Myounghee Noh and Associates, Environmental Studies and Consulting Services, Hilo, HI. 28 March.

NAVFAC Marianas. 2015a. Validation Report and Revision of Vegetation Maps, Naval Base Guam. Prepared by PCR Environmental, Inc., Barrigada, GU. December.

NAVFAC Marianas. 2015b. Federal Candidate Endangered Species Surveys at Andersen AFB. Prepared by B. Holland and D. Rubinoff, University of Hawai‘i, Manoa.

NAVFAC Marianas. 2015c. *Serianthes nelsonii* Monitoring – Final Report. Prepared by Isla Paraiso, Guam.

NAVFAC Marianas. 2016a. Land Use/Land Cover and Recovery Habitat Analysis for Lands Managed by Joint Region Marianas on Guam. Prepared by Cardno, Honolulu, HI. June.

NAVFAC Marianas. 2016b. Conservation and Management of Micronesian Cycads, Navy Leased Land, Tinian, Commonwealth of the Northern Mariana Islands. March.

NAVFAC Marianas. 2016c. Joint Region Marianas Integrated Natural Resources Management Plan (INRMP) Summary of FY2016 Actions and Projects. Prepared by Cardno, Honolulu, HI and Bainbridge Island, WA. October.

NAVFAC Marianas. 2016d. Memorandum for File – Subject: Pre-Construction High Value Tree (HVT) Surveys of J-001B Utilities and Site Improvements Phase I, Naval Base Guam Telecommunication Site, Guam. February.

NAVFAC Marianas. 2016e. Plant Surveys, Joint Region Marianas. Interim Report. Prepared by Guam Plant Extinction Prevention Program, UOG. 11 March.

NAVFAC Marianas. 2016f. Draft ESA-listed Plant Surveys, Andersen AFB. Prepared by the Center for Island Sustainability, UOG.

NAVFAC Marianas and Andersen AFB. 2015. Monitoring Mariana Fruit Bats on AFB 2015. Prepared by T. Mildenstein and R. Miller, Biology Program, UOG. July.

NAVFAC Marianas and Andersen AFB. 2017. Sea Turtle Management Plan for Andersen AFB, Guam. Prepared by UOG Marine Laboratory, Mangilao, GU. February.

NAVFAC Marianas and Andersen AFB. 2023. Sea Turtle Management Plan for Andersen Air Force Base, Guam. Prepared by University of Guam Sea Grant, Guam. Cooperative Agreement No.: N40192-18-2-8000. January.

NAVFAC Marianas and Naval Base Guam. 2023. Sea Turtle Nesting Beach Monitoring and Nest Protection on Naval Base Guam for the Period of August, 18, 2022 to August 31, 2023. October.

NAVFAC Marianas. 2022. Final Report, ESA-Listed Plant and Invertebrate Surveys at Naval Base Guam Naval Munitions Site. Prepared by Island Eco Services., Barrigada, Guam. August.

NAVFAC Marianas. 2023a. Monitoring Survival and Demography of the Micronesian Starlings on Andersen Air Force Base in a Brown Treesnake Controlled Environment. Iowa State University, Department of Ecology, Evolution and Organismal Biology, Ames, IA 50011. 13 November.

NAVFAC Marianas. 2023b. Final Report. Plant and Invertebrate Surveys Joint Region Marianas Areas of Responsibility and Areas Specified on Guam and CNMI. Cooperative Agreement N40192-19-2-8000. August.

NAVFAC Pacific. 2007. Ocean Current Study Ocean Dredged Material Disposal Site Apra Harbor, Guam. Final Report. Prepared by Weston Solutions, Inc., Carlsbad, CA. August.

NAVFAC Pacific. 2010. Final Natural Resource Survey Report in Support of the Environmental Impact Statement for the Marine Corps Relocation Initiative to Various Locations on Guam. Pearl Harbor, HI. 23 December.

NAVFAC Pacific. 2011a. Final Natural Resource Survey Report of Various Locations on Guam (Cabras, Lost River, GLUP 77, Dadi and Tipalao Beaches and Route 15 Valley). Prepared by AECOM, Bloomfield, NJ. 21 April.

NAVFAC Pacific. 2011b. Supplemental Marine Resource Surveys to Support the CVN Transient Pier, Apra Harbor, Guam. Task 1 – CVN Impact Area Surveys (Coral Reef Community). Prepared by HDR, Inc., Tamuning, Guam in collaboration with CSA International, Inc., Stuart, FL. May.

NAVFAC Pacific. 2012. Guam and Saipan Marine Species Monitoring: Winter-Spring Survey, 15 to 29 March 2012. Prepared by HDR, Inc. for Commander U.S. Pacific Fleet. 15 November.

NAVFAC Pacific. 2013a. Final Report: Biological Surveys – Report 1, Various Locations on Guam in Support of the Guam and Commonwealth of the Northern Mariana Islands Military Relocation (2012 Roadmap Adjustments) Supplemental Environmental Impact Statement. Prepared by TEC-AECOM Joint Venture for Joint Guam Program Office, Honolulu, HI. April.

NAVFAC Pacific. 2013b. Final Report: Biological Surveys – Report 2, Various Locations on Guam in Support of the Guam and Commonwealth of the Northern Mariana Islands Military Relocation (2012 Roadmap Adjustments) Supplemental Environmental Impact Statement. Prepared by TEC-AECOM Joint Venture for Joint Guam Program Office, Honolulu, HI. April.

NAVFAC Pacific. 2013c. Final Marine Resource Assessment for the Japan and Mariana Archipelagos. Prepared by Tetra Tech, Inc. for Naval Facilities Engineering Systems Command Pacific.

NAVFAC Pacific. 2015. Apra Harbor, Guam Coral Mitigation Site Feasibility Assessment; Offsite Watersheds Reconnaissance Assessment. Prepared by HDR, Inc., Hagatna, GU.

Nedwell, J., Turnpenny, A., Langworthy, J., and Edwards, B. 2003. Measurements of Underwater Noise During Piling at the Red Funnel Terminal, Southampton, and Observations of its Effect on Caged Fish. Report Reference 558 R 0207. Prepared by Subacoustech Ltd, Hampshire, UK for Red Funnel, Southampton, UK. 27 October.

Newman, L. J., Paulay, G., and Ritson-Williams, R. 2003. Checklist of polyclad flatworms (Platyhelminthes) from Micronesian coral reefs. Micronesica, 35–36, 189–199.

Nico, L. G. and Walsh, S. J. 2011. Non-indigenous Freshwater Fishes on Tropical Pacific Islands: A Review of Eradication Efforts. Pages 97-107 *in* C.R. Veitch, M.N. Clout, and D.R. Towns (Eds.), Island Invasives: Eradication and Management. IUCN, Gland, CH.

NMFS. 2011a. Endangered and Threatened Species; Determination of Nine Distinct Population Segments of Loggerhead Sea Turtles as Endangered or Threatened: Final Rule. Federal Register, 76, 58868–58952.

NMFS. 2011b. Annual Report to Congress on the Status of U.S. Fisheries-2010. NOAA, Silver Spring, MD.

NMFS. 2014a. Endangered and Threatened Wildlife and Plants: Final Listing Determinations on Proposal To List 66 Reef-Building Coral Species and To Reclassify Elkhorn and Staghorn Corals. Federal Register, 79, 53852–54123.

NMFS. 2014b. Endangered and Threatened Wildlife and Plants; Threatened and Endangered Status for Distinct Population Segments of Scalloped Hammerhead Sharks; Final Rule. Federal Register, 79, 38214–38242.

NMFS. 2015. Endangered and Threatened Species; Determination on the Designation of Critical Habitat for Three Scalloped Hammerhead Shark Distinct Population Segments. Federal Register, 80, 71774–71784.

NMFS. 2017. Crown-of-Thorns Seastar (*Acanthaster planci*). Accessed 30 November 2017, from https://pifsc-www.irc.noaa.gov/cred/crown-of-thorns_seastar.php.

NMFS. 2018a. Endangered and Threatened Wildlife and Plants: Listing the Oceanic Whitetip Shark as Threatened Under the Endangered Species Act. Federal Register, 83, 4153–4165.

NMFS. 2018b. Endangered and Threatened Wildlife and Plants; Final Rule To List the Giant Manta Ray as Threatened Under the Endangered Species Act. Federal Register, 83, 2916–2931.

NMFS. 2023. Pacific Islands Regional Action Plan to Implement the NOAA Fisheries Climate Science Strategy Through 2024. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-142, 35 p.

NMFS and USFWS. 2007. Olive Ridley Sea Turtle (*Lepidochelys olivacea*) 5-Year Review: Summary and Evaluation. NMFS, Office of Protected Resources, Silver Spring, MD and USFWS, Southeast Region, Jacksonville Ecological Services Field Office, Jacksonville, FL. August.

NMFS and USFWS. 2016. Endangered and Threatened Wildlife and Plants; Final Rule To List Eleven Distinct Population Segments of the Green Sea Turtle (*Chelonia mydas*) as Endangered or Threatened and Revision of Current Listings Under the Endangered Species Act. Federal Register, 81, 20058–20090.

NOAA. 2005. Environmental Sensitivity Index Map, Guam and the Commonwealth of the Northern Marianas Islands. National Ocean Service (NOS), Office of Response and Restoration, Hazardous Materials Response Division. August.

NOAA. 2017a. Online datasets for bathymetry and habitat mapping. Accessed 11 April 2018, from https://www.coris.noaa.gov/search/catalog/main/home.page.

NOAA. 2017b. #FieldWorkWin: Signing off from Saipan. NOAA Pacific Islands Fisheries Science Center Blog. Accessed 8 August 2018, from https://pifscblog.wordpress.com/2017/03/20/fieldworkwin-saipan/. 20 March.

NOAA NCCOS. 2005. American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands. Accessed 13 July 2018, from https://products.coastalscience.noaa.gov/collections/benthic/e99us_pac/.

NOAA National Centers for Environmental Information. 2023. Annual 2023 Tropical Cyclones Report. Accessed January 15 2024, from https://www.ncei.noaa.gov/access/monitoring/monthly-report/tropical-cyclones/202313

Nogales, M., Martin, A., Tershy, B., Donlan, C., Veitch, D., Puerta, N., Wood, B., and Alonso, J. 2004. A review of feral cat eradication on islands. Conservation Biology, 18, 310–319.

Oleson, E., Baumann-Pickering, S., Sirovic, A., Merkens, K., Munger, L., Trickey, J., and Fisher-Pool, P. 2015. Analysis of Long-term Acoustic Datasets for Baleen Whales and Beaked Whales within the Mariana Islands Range Complex (MIRC) for 2010 to 2013 (PIFSC Data Report No. DR-15-002). 18 February.

Orr, J. C., Fabry, V. J., and Yool, A. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature, 437, 681–686.

Paulay, G., Kirkendale, L., Lambert, G., and Meyer, M. 2002. Anthropogenic biotic interchange in a coral reef ecosystem: A case study from Guam. Pacific Science, 56, 403–422.

Paulay, G., Kirkendale, L., Meyer, C., Houk, P., Rongo, T., and Chang, R. 2001. Marine Biodiversity Resource Survey and Baseline Reef Monitoring Survey of the Southern Orote Peninsula and North Agat Bay Area. Prepared for Commander Naval Forces Marianas, Guam.

Pauly, D. and Palomares, M. L. 2005. Fishing down marine food webs: It is far more pervasive than we thought. Bulletin of Marine Science, 76, 197–211.

Perry, G. and Morton, J. M. 1999. Regeneration rates of the woody vegetation of Guam's Northwest Field following major disturbance: Land use patterns, feral ungulates, and cascading effects of the brown tree snake. Micronesica, 32, 125–142.

Pew Oceans Commission. 2003. America's Living Oceans. Charting a Course for Sea Change. Arlington, VA. May.

Plucer-Rosario, G. 1987. The effect of substratum on the growth of *Terpios*, an encrusting sponge which kills corals. Coral Reefs, 5, 197–200.

Polovina, J. J., Dreflak, K., Baker, J., Bloom, S., Brooke, S., Chan, V., Ellgen, S., Golden, D., Hospital, J., Van Houtan, K., Kolinski, S., Lumsden, B., Maison, K., Mansker, M., Oliver, T., Spalding, S., and Woodworth-Jefcoats, P. 2016. Pacific Islands Regional Action Plan. NOAA Fisheries Climate Science Strategy. NMFS, Pacific Islands Fisheries Science Center, Honolulu, HI. December.

Popper, A., Carlson, T. J., Hawkins, A. D., and Southall, B. L. 2006. Interim Criteria for Injury of Fish Exposed to Pile Driving Operations: A White Paper.

Popper, A. and Hastings, M. C. 2009. The effects of anthropogenic sources of sound on fishes. Journal of Fish Biology, 75, 455–489.

Popper, A., Hawkins, A., Fay, R., Mann, D., Bartol, S., Carlson, T., Coombs, S., Ellison, W., Gentry, R., Halvorsen, M., Løkkeborg, S., Rogers, P., Southall, B., Zeddies, D., and Tavolga, W. 2014. ASA S3/SC1.4 TR-2014 sound exposure guidelines for fishes and sea turtles: a technical report prepared

by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. Springer Cham, Cham, CH. April.

Porter, V., Leberer, T., Gawel, M., Gutierrez, J., Burdick, D., Torres, V., and Lujan, E. 2005. The State of Coral Reef Ecosystems of Guam. Pages 442-487 *in* J. E. Waddell and J. M. Clarke (Eds.), The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States. NOAA.

Pratt, L. W. 2011. Vegetation Assessment of Forests of Pagan Island, Commonwealth of the Northern Mariana Islands (Technical Report HCSU-023). Hawai'i Cooperative Studies Unit, University of Hawai'i, Hilo, HI. September.

Pregill, G. K. and Steadman, D. W. 2009. The prehistory and biogeography of terrestrial vertebrates of Guam, Mariana Islands. Diversity and Distributions, 15, 983–996.

Prouty, N. G., Storlazzi, C. D., McCutcheon, A. L., and Jenson, J. W. 2014. Historic impact of watershed change and sedimentation to reefs along west-central Guam. Coral Reefs, 33, 733–749.

Randall, J. E. 1972. Chemical pollution in the sea and the crown-of-thorns starfish (*Acanthaster planci*). Biotropica, 4, 132–144.

Randall, R. H. and Myers, R. F. 1983. The Corals (Vol. 2). UOG Press, Mangilao, GU.

Raulerson, L. and Rinehart, A. 1992. Ferns and orchids of the Mariana Islands. Self published.

Raulerson, L. 2006. Checklist of Plants of the Mariana Islands. UOG Herbarium Contribution, 37, 1–69.

Raymundo, L., Burdick, D., Lapacek, V. A., Miller, R., and Brown, V. 2017. Anomalous temperatures and extreme tides: Guam staghorn *Acropora* succumb to a double threat. Marine Ecology Progress Series, 564, 47–55.

Raymundo, M. and Miller, R. H. 2012. Little fire ant, *Wasmannia auropunctata* (Roger) (Hymenoptera: Formicidae), established at several locations on Guam. Proceedings of the Hawaiian Entomological Society, 44, 85–87.

Redding, J. E., Myers-Miller, R. L., Baker, D. M., Fogel, M., Raymundo, L., and Kim, K. 2013. Link between sewage-derived nitrogen pollution and coral disease severity in Guam. Marine Pollution Bulletin, 73, 57–63.

Reddy, G. V. P., Remolona, J. E., Legdesog, C. M., and McNassar, G. J. 2011. Effective Biological Control Programs for Invasive Plants on Guam. Pages 224-229 *in* Session 5: Prospects for Weed Biological Control in Pacific Islands. XIII International Symposium on Biological Control of Weeds.

Reed, R. N., Rodda, G. H., Siers, S. R., Wostl, E., and Adams, A. A. Y. 2010. Terrestrial Reptiles of Pagan Island, Commonwealth of the Northern Mariana Islands. In Marianas Expedition Wildlife Surveys 2010: Terrestrial Resource Surveys of Pagan, Commonwealth of the Northern Mariana Islands. Prepared by U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, HI for U.S. Marine Corps and Naval Facilities Engineering Systems Command, Pacific, Pearl Harbor, HI.

Resko, D. 2018. There's no actual proof that Sasa Bay is used as a hammerhead nursery, but there are several secondhand accounts of fishermen who have accidentally hooked young-of-the-year hammerheads near Sasa Bay. Personal communication via email from Devin Resko, UOG Marine Laboratory to Matt Lybolt, Marine Ecologist/Project Manager, Cardno, Honolulu, HI. 12 March.

Riegl, B., Purkis, S. J., Houk, P., Cabrera, G., and Dodge, R. 2008. Geologic Setting and Geomorphology of Coral Reefs in the Mariana Islands (Guam and Commonwealth of the Northern Mariana Islands). Page 691-718 *in* B. M. Riegl and R. E. Dodge (Eds.), Coral Reefs of the USA (Vol. 1). Springer Netherlands, Dordrecht.

Ritter, M. W. and Naugle, C. M. 1999. Population characteristics, germination and proposed management of *Elaeocarpus joga Merr.* on Guam: a regionally endemic tree. Micronesica, 31, 275–281.

Rivera-Posada, J., Caballes, C. F., and Pratchett, M. S. 2013. Lethal doses of oxbile, peptones and thiosulfate-citrate-bile-sucrose agar (TCBS) for *Acanthaster planci*; exploring alternative population control options. Marine Pollution Bulletin, 75, 133–139.

Rodda, G. H., Fritts, T. H., and Conry, P. J. 1992. Origin and population growth of the brown tree snake, *Boiga irregularis*, on Guam. Pacific Science, 46, 46–57.

Rodda, G. H. and Savidge, J. A. 2007. Biology and impacts of Pacific Island invasive species. 2. *Boiga irregularis* the brown treesnake (Reptilia: Colubridae). Pacific Science, 61, 307–324.

Rosario, C. A., Sablan, L. R., Miller, R. H., and Moore, A. 2016. Greater Banded Hornet *Vespa tropica* (Hymenoptera: Vespidae) (Guam New Invasive Species Alert No. 2016-01). 27 July.

Rubinoff, D. 2016. The Conservation Status of Two Endangered Mariana Butterflies, *Hypolimnas octocula marianensis* and *Vagrans egistina* (Nymphalidae). Unpublished report. Prepared for USFWS, Pacific Islands Fish and Wildlife Office, Honolulu, HI.

Ruetzler, K. and Muzik, K. 1993. *Terpios hoshinota*, a new cyanobacteriosponge threatening Pacific reefs. Scientia Marina, 57, 395–403.

Safford, W. 2009. The Chamorro Language of Guam. University of Michigan Library. 27 April.

Sampson, C. 1986. The *Hypolimnas octocula* complex, with notes on *H. inopinata* (Lepidoptera: Nymphalidae). Transactions of the Lepidopterological Society of Japan, 37, 15–43.

Savage, E. 2018. Micronesian Kingfisher. World-birds.com. Accessed 3 August 2018, from http://www.world-birds.com/birds/v/micronesian-kingfisher.

Savidge, J. 1987. Extinction of an island forest avifauna by an introduced snake. Ecology, 68, 660–668.

Schils, T. 2015. Restyling Guam's Reef Flats: Angel Hair alga on the rise. Man, Land, and Sea, 6–7.

Schreiner, I. H. 1997. Demography and recruitment of selected trees in limestone forest of Guam in relation to introduced ungulates. Micronesica, 30, 169–181.

Schreiner, I. H. and Nafus, D. M. 1986. Accidental introductions of insect pests to Guam, 1945-1985. Proceedings of the Hawaiian Entomological Society, 27, 45–52.

Smith, B. 2003. Prosobranch gastropods of Guam. Micronesica, 35–26, 244–270.

Soong, K., Yang, S. L., and Chen, C. A. 2009. A novel dispersal mechanism of a coral-threatening sponge, *Terpios hoshinota* (Suberitidae, Porifera). Zoological Studies, 48, 596.

Stone, B. 1970. The flora of Guam. A manual for the identification of the vascular plants of the island. Micronesica, 6, 1–659.

Stone, C., Cuddihy, L. W., and Tunison, J. T. 1992. Responses of Hawaiian Ecosystems to the Removal of Feral Pigs and Goats. Pages 666-704 *in* C.P. Stone, C.W. Smith, and J.T. Tunison (Eds.), Alien

Plant Invasions in Native Ecosystems of Hawai‘i: Management and Research. Cooperative National Park Resources Studies Unit, University of Hawai‘i, Honolulu.

Summers, T. M., Jones, T. T., Martin, S. L., Hapdei, J. R., Ruak, J. K., and Lepczyk, C. A. 2017. Demography of Marine Turtles in the Nearshore Environments of the Northern Mariana Islands. Pacific Science, 71, 269–286.

Sutton, A., Manzello, D., and Gintert, B. 2015. Coupling chemical and biological monitoring to understand the impact of ocean acidification on coral reef ecosystems. Oceanography, 28, 28–29.

Szmant, A. M. 2002. Nutrient enrichment on coral reefs: is it a major cause of coral reef decline? Estuaries, 25, 743–766.

Taborosi, D. 2004. Field Guide to Caves and Karst of Guam. Bess Press, Honolulu, HI.

Taborosi, D., Jenson, J. W., and Mylroie, J. E. 2005. Karst features of Guam, Mariana Islands. Micronesica, 38, 17–46.

Takano, L. L. and Haig, S. M. 2004. Seasonal movement and home range of Mariana common moorhen. Condor, 106, 652–663.

Tang, S. L., Hong, M. J., Liao, M. H., Jane, W. N., Chiang, P. W., Chen, C. B., and Chen, C. A. 2011. Bacteria associated with an encrusting sponge (*Terpios hoshinota*) and the corals partially covered by the sponge. Environmental Microbiology, 13, 1179–1191.

Tennent, W. J. 2006. A checklist of the butterflies of Melanesia, Micronesia, Polynesia and some adjacent areas. Zootaxa, 1178, 1–209.

Tep, P. and Gaines, K. 2003. Reversing the impacts of feral pig on the Hawaiian tropical rainforest ecosystem. Restoration and Reclamation Review, 8, 1–8.

Timmers, M. 2016. COTS surveys within Guam and CNMI waters. Personal communication via email from M. Timmers, Marine Ecosystems Research Project Manager, Coral Reef Ecosystem Program, Pacific Islands Fisheries Science Center, Honolulu, HI to H. Goodwin, Marine Resources Specialist, NAVFAC Marianas, Guam. 18 August.

Timmers, M., Bird, C. E., Skillings, D. J., Smouse, P. E., and Toonen, R. J. 2012. There’s no place like home: Crown-of-thorns outbreaks in the Central Pacific are regionally derived and independent events. PLOS ONE, 7, e31159.

Topping, D., Ogo, P., and Dungca, B. 1975. Chamorro-English Dictionary. University of Hawai‘i Press, Honolulu, HI.

Tracey, J. R., Schlanger, S. O., Stark, J. T., Doan, D. B., and May, H. G. 1964. General Geology of Guam. Geology and Hydrology of Guam, Mariana Islands (Geological Survey Professional Paper No. 403-A) U.S. Government Printing Office, Washington, D.C.

Tsuda, R. T. 1985. Gracilaria from Micronesia: key, list and distribution of the species. Taxonomy of Economic Seaweeds, 1, 91–92.

University of Guam (UOG). 2023. Tinian Cycad Scale Management Task. Unpublished data.

USDA. 1988. Soil Survey of Territory of Guam. USDA Soil Conservation Service, in cooperation with Guam Department of Commerce and UOG. Prepared by F.J. Young. May.

USDA NRCS. 2017. The PLANTS Database. Accessed 4 December 2017, from http://plants.usda.gov. 4 December.

USEPA. 2016. Climate Change: Basic Information. Accessed 19 December 2016, from https://www.epa.gov/climatechange/climatechangebasicinformation.

USFS. 2006. Guam Vegetation Mapping. Pacific Southwest Region, Forest Health Protection, McClellan, CA. October.

USFS. 2013. Pacific Island Ecosystems at Risk (PIER). Plant Threats to Pacific Ecosystems: PIER Plant Species Present in Guam Listed by Scientific Name. Accessed 30 November 2017, from http://www.hear.org/pier/locations/pacific/guam/specieslist.htm.

USFS. 2014. Pacific Islands Imagery Consortium Vegetation Mapping and Monitoring – Guam 2011-2014. Pacific Southwest Region, Forest Health Protection, McClellan, CA.

USFWS. 1990. Native Forest Birds of Guam and Rota of the Commonwealth of the Northern Mariana Islands Recovery Plan. Portland, OR.

USFWS. 1991. Recovery Plan for the Mariana Islands Population of the Vanikoro Swiftlet, *Aerodramus vanikorensis bartschi*. Pacific Region 1, Portland, OR.

USFWS. 2004a. Endangered and Threatened Wildlife and Plants; Removing the Mariana Mallard and the Guam Broadbill from the Federal List of Endangered and Threatened Wildlife; Final Rule, 69, 8116–8119.

USFWS. 2004b. Endangered And Threatened Wildlife And Plants; Designation of Critical Habitat for the Mariana Fruit Bat And Guam Micronesian Kingfisher on Guam and the Mariana Crow on Guam and in the Commonwealth of the Northern Mariana Islands; Final Rule. Federal Register, 69, 62944–62990.

USFWS. 2007. 5-Year Review, Short Form Summary: Mariana Fruit Bat (*Pteropus mariannus mariannus*).

USFWS. 2009a. Draft Revised Recovery Plan for the Mariana Fruit Bat or Fanihi (*Pteropus mariannus mariannus*). USFWS Region 1, Portland, OR. November.

USFWS. 2009b. Guam National Wildlife Refuge Comprehensive Conservation Plan. Prepared by Guam NWR, Yigo, Guam and USFWS, Pacific Islands Field Office, Honolulu, HI.

USFWS. 2010. Biological Opinion for the Joint Guam Program Office Relocation of the U.S. Marine Corps from Okinawa to Guam and Associated Activities on Guam and Tinian. Pacific Islands Fish and Wildlife Office, Honolulu, HI.

USFWS. 2014. 5-Year Review Short Form Summary for *Pteropus mariannus* (Mariana fruit bat). Pacific Islands Fish and Wildlife Office, Region 1, Honolulu, HI.

USFWS. 2015a. Endangered and Threatened Wildlife and Plants; Endangered Status for 16 Species and Threatened Status for 7 Species in Micronesia. Federal Register, 80, 59424–59497.

USFWS. 2015b. Environmental Conservation Online System: Listed Species Believed to or Known to Occur in Guam. Accessed 30 November 2017, from https://ecos.fws.gov/ecp0/reports/species-listed-by-state-report?state=gUandstatus=listed. 13 February.

USFWS. 2017. Reinitiation of the 2015 Biological Opinion on the Department of the Navy's Relocation of U.S. Marine Corps from Okinawa to Guam and Associated Activities on Guam (Consultation 01EPIF00-2015-F-0025 and 01EPIF00-2016-F-0185). Pacific Islands Fish and Wildlife Office, Honolulu, HI. 18 July.

U.S. Navy 2023a. Monitoring Mariana fruit bats on Andersen Air Force Base, 2022. Prepared for NAVFAC Marianas, Guam. Prepared by Tammy Mildenstein, University of Guam, under Cooperative Agreement Number N40192-22-2-8001. April.

U.S. Navy. 2023b. Monitoring Mariana fruit bats on Guam Naval Munitions Site and Tinian Military Lease Area, 2022-2023. Prepared for NAVFAC Marianas, Guam. Prepared by T. Mildenstein, University of Guam, under Cooperative Agreement Number N40192-22-2-8001. April.

Uyeyama, R. K. 2014. Compilation of incidental marine mammal and sea turtle sightings in the Mariana Islands Range Complex. Prepared by NAVFAC Pacific for Commander, U.S. Pacific Fleet, Pearl Harbor, HI.

van der Oost, R., Beyer, J., and Vermeulen, N. P. E. 2003. Fish bioaccumulation and biomarkers in environmental risk assessment: a review. Environmental Toxicology and Pharmacology, 3, 57–149.

Van Driesche, J. and Van Driesche, R. 2004. From endemic to generic: feral pigs and the destruction of Hawai'i's native forests. Pages 7-31 *in* Nature Out of Place, Biological Invasions in the Global Age. Island Press, Washington, D.C.

Vice, D.S., Vice, D.L., and Gibbons, J.C. 2005. Multiple Predations of Wild Birds by Brown Treesnakes (Boiga irregularis) on Guam. Micronesica 38(1):121–124.

Ward, L. 2003. The cephalopods of Guam. Micronesica, 35–36, 294–302.

Weaver, G., Anderson, N., Garrett, K., Thompson, A., and Yabsley, M. 2022. Ticks and Tick-Borne Pathogens in Domestic Animals, Wild Pigs, and Off-Host Environmental Sampling in Guam, USA. Frontiers in Veterinary Science. 8:803424.

Weijola, V., Vahtera V., Koch A., Schmitz A., Kraus F. 2020. Taxonomy of Micronesian monitors (Reptilia: Squamata: Varanus): endemic status of new species argues for caution in pursuing eradication plans. R. Soc. Open Sci. 7:200092. Accessed at: http://dx.doi.org/10.1098/rsos.200092

WERI and IREI. 2016. Digital Atlas of Southern and Northern Guam. Accessed 25 September 2017, from http://south.hydroguam.net/index.php and http://north.hydroguam.net/index.php.

Wiewel, A. S., Yackel Adams, A. A., and Rodda, G. H. 2009. Distribution, density, and biomass of introduced small mammals in the Southern Mariana Islands. Pacific Science, 63, 205–222.

Wiles, G. 1987. Current research and future management of Mariana fruit bats (Chiroptera: Pteropodidae) on Guam. Australian Mammalogy, 10, 93–95.

Wiles, G. 2005. A checklist of the birds and mammals of Micronesia. Micronesica, 38, 141–189.

Wiles, G., Aguon, C., and Davis, G. 1995. The status and distribution of endangered animals and plants in northern Guam. Micronesica, 28, 31–49.

Wiles, G., Bart, J., Beck Jr., R. E., and Aguon, C. F. 2003. Impacts of the brown treesnake: patterns of decline and species persistence in Guam's avifauna. Conservation Biology, 17, 1350–1360.

Wiles, G. and Brooke, A. 2009. Conservation Threats to Bats in the Tropical Pacific Islands and Insular Southeast Asia. Pages 405-459 *in* T.H. Fleming and P.A. Racey (Eds.), Island Bats: Evolution, Ecology, and Conservation. University of Chicago Press, IL.

Williams, I., Richards, B. L., Sandin, S. A., Baum, J. K., Schroeder, R. E., Nadon, M. O., Zgliczynski, B., Craig, P., McIlwain, J. I., and Brainard, R. E. 2011. Differences in reef fish assemblages between populated and remote reefs spanning multiple archipelagos across the Central and Western Pacific. Journal of Marine Biology, Article 826234.

Wolanski, E., Richmond, R. H., Davis, G., Deleersnijder, E., and Leben, R. 2003. Eddies around Guam, an island in the Mariana Islands group. Continental Shelf Research, 23, 991–1003.

Worldometers. 2018. Worldometers Elaboration of Data by United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospect: The 2015 Revision. (Medium-fertility variant). Accessed 12 April 2018, from www.worldometers.info.

Wostl, E., Smith, E., and Reed, R. N. 2016. Origin and identity of *Fejervarya* (Anura: Dicroglossidae) on Guam. Pacific Science, 70, 233–241.

WPRFMC. 2009a. Fishery Ecosystem Plan for the Mariana Archipelago. Honolulu, HI. 24 September.

WPRFMC. 2009b. Fishery Ecosystem Plan for Pacific Pelagic Fisheries of the Western Pacific Region. Honolulu, HI. 24 September.

WPRFMC. 2016a. Fishery Ecosystem Plan for the Mariana Archipelago. Working Draft. Honolulu, HI.

WPRFMC. 2016b. Can Past Glories of the Mariana Fishing Industry Be Revived? Pacific Island Fishery News, Spring, 3.

Young, C., Carlson, J., Hutchinson, M., Hutt, C., Kobayashi, D., McCandless, C., and Wraith, J. 2016. Status review report: oceanic whitetip shark (*Carcharhinius longimanus*) (Final Report). National Marine Fisheries Service, Office of Protected Resources. November.

Young, J., Olson, K. A., Reading, R. P., Amgalanbaatar, S., and Berger, J. 2011. Is wildlife going to the dogs? Impacts of feral and free-roaming dogs on wildlife populations. BioScience, 61, 125–132.

Zug, G. 2013. Reptiles and Amphibians of the Pacific Islands: A Comprehensive Guide. University of California Press, Los Angeles, CA.

15.5 CHAPTER 5 – NAVAL BASE GUAM MAIN BASE

Adams, J. 2018. Observations and photos of a scalloped hammerhead shark at Crevice dive site, Orote peninsula, Guam. Personal communication via email from J. Adams, PADI Course Director, Micronesian Diver's Associates to M. Lybolt, Marine Ecologist/Project Manager, Cardno, Honolulu, HI. 7 March.

Adey, W. H. and MacIntyre, I. 1973. Crustose coralline algae: a re-evaluation in the geological sciences. Geological Society of America Bulletin, 84, 883–904.

AECOS, Inc. and Wil Chee Planning, Inc. 2009. Final Guam and Tinian Wetlands Inventory. Honolulu, HI. September.

BioSystems Analysis, Inc. 1988. Natural Resources Survey for the U.S. Naval Station, Guam. Prepared for the U.S. Navy, Pearl Harbor, HI.

BioSystems Analysis, Inc. 1989. Natural Resources Survey for the U.S. Public Works Center, Guam (PWC). Prepared for Commander, Pacific Division, Naval Facilities Engineering Systems Command, Pearl Harbor, HI.

Blyth-Skyrme, V. J., Rooney, J. J., Parrish, F. A., and Boland, R. C. 2013. Mesophotic Coral Ecosystems – Potential Candidates as Essential Fish Habitat and Habitat Areas of Particular Concern (Administrative Report No. H-13-02). Pacific Islands Fisheries Science Center.

Brainard, R. E., Asher, J., Blyth-Skyrme, V., Coccagna, E. F., Dennis, K., Donovan, M. K., Gove, J. M., Kenyon, J., Looney, E. E., Miller, J. E., Timmers, M., Vargas-Ángel, B., Vroom, P. S., Vetter, O., and Zgliczynski, B. 2012. Coral Reef Ecosystem Monitoring Report of the Mariana Archipelago: 2003 to 2007 (PIFSC Special Publication No. SP-12-01). NOAA Fisheries, Pacific Islands Fisheries Science Center. Honolulu, HI. March.

Brindock, K. 2012. Migratory Bird Monitoring, Naval Base Guam. NAVFAC Marianas, Environmental. October.

Brindock, K. 2013. Migratory Bird Monitoring, Naval Base Guam. NAVFAC Marianas, Environmental. October.

Brindock, K. 2015. Unpublished data regarding sea turtle tagging within Apra Harbor. NAVFAC Marianas, Environmental. September.

Brooke, A. 2008. Mariana Fruit Bat Surveys on Navy Properties, Guam. NAVFAC Marianas Environmental. December.

Brown, V. 2015. Sightings of Threatened Corals around Guam. Personal communication via email from V. Brown, Fisheries Biologist, NOAA Fisheries PIRO HCD Guam Field Office to S. Hanser, Supervisory Marine Biologist, NAVFAC Pacific, Pearl Harbor, HI. February.

Brown, V. 2017. Sightings of adult male humphead wrasse (*Cheilinus undulatus*) observed on Orote ERA as recently as December 2016. Personal communication via email from V. Brown, Fisheries Biologist, NOAA Fisheries PIRO HCD Guam Field Office to JRM in a comment response matrix. 29 January.

Brown, V. 2018. COTS were reported in low numbers at Gabgab and San Luis beaches by Eyes of the Reef (EOR) Marianas in early 2018. Personal communication from V. Brown, Fisheries Biologist, NOAA Fisheries PIRO HCD Guam Field Office to M. Lybolt, Marine Ecologist, Cardno. 30 May.

Bruno, J. F., Precht, W. F., Vroom, P. S., and Aronson, R. B. 2014. Coral reef baselines: How much macroalgae is natural? Marine Pollution Bulletin, 80, 24–29.

Burdick, D. and Brown, V. 2011. Comprehensive Long-Term Monitoring at Permanent Sites in Guam. Prepared for NOAA Coral Reef Conservation Program (CRCP).

Burdick, D., Brown, V., Asher, J., Gawel, M., Goldman, L., Hall, A., Kenyon, J., Leberer, T., Lundblad, E., McIlwain, J., Miller, J., Minton, D., Nadon, M., Pioppi, N., Raymundo, L., Richards, B., Schroeder, R., Schupp, P., Smith, E., and Zgliczynski, B. 2008. The State of Coral Reef Ecosystems of Guam. Pages 465-509 *in* J. E. Waddell and J. M. Clarke (Eds.), The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2008. NOAA Technical Memorandum NOS NCCOS 73. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team, Silver Spring, MD. April.

Christy, M. T., Clark, C. S., Gee II, D. E., Vice, D., Vice, D. S., Warner, M. P., Tyrrell, C. L., Rodda, G. H., and Savidge, J. A. 2007. Recent records of alien anurans on the Pacific island of Guam. Pacific Science, 61, 469–483.

COMNAVMAR. 2001. Final Integrated Natural Resources Management Plan for Navy Lands, Guam. Plan Duration November 18, 2001 thru November 17, 2006. November.

COMNAVMAR. 2013. Instruction 3500.4A. Marianas Training Manual. Department of the Navy, Joint Region Marianas.

Crampton, H. E. 1925. Studies on the variation, distribution and evolution of the genus Partula. The species of the Mariana Islands, Guam and Saipan. Carnegie Institution of Washington, 228a, 1–116.

Crombie, R. I. and Pregill, G. K. 1999. A checklist of the herpetofauna of the Palau Islands (Republic of Belau), Oceania. Herpetological Monographs, 13, 29–80.

Deakos, M. H., Uyeyama, R. K., Richie, M. W., Richlen, M. F., and Aschettino, J. M. 2016. Guam Marine Species Monitoring Survey, Shore Station Study, May 2013 and March 2015. Final Field Report. Prepared for Commander, U.S. Pacific Fleet, Environmental Readiness Division, Pearl Harbor, HI. January.

DoD. 2011. Department of Defense Instruction (DoDI) 4715.03. 18 March.

Dollar, S. J., Hochberg, E., Hancock, H., LaPointe, C., and Doctor, M. 2009. Assessment of Benthic Community Structure in the Vicinity of the Proposed Turning Basin and Berthing Area for Carrier Vessels Nuclear (CVN) Apra Harbor, Guam. Prepared for TEC, Inc., Honolulu, HI.

DON. 2009. Interim Final Integrated Natural Resources Management Plan, Navy Base Guam, Plan Years 2009–2014. Prepared by Geo-Marine. September.

DON. 2010. Final Environmental Impact Statement. Guam and CNMI Military Relocation: Relocating Marines from Okinawa, Visiting Aircraft Carrier Berthing, and Army Air and Missile Defense Task Force. Volume 2: Marine Corps Relocation–- Guam. Prepared by NAVFAC Pacific, Pearl Harbor, HI for Joint Guam Program Office, Washington, D.C.

DON. 2013. Biological assessment for X-Ray Wharf Improvements, Milcon P-158 and p-519, August 2013.

DON. 2015a. Mariana Islands Training and Testing Activities Final Environmental Impact Statement/Overseas Environmental Impact Statement. Volume 2. Prepared by NAVFAC Pacific, Pearl Harbor, HI.

DON. 2015b. Regional Biosecurity Plan for Micronesia and Hawai‘i: 4 Volumes.

DON. 2015c. Biological evaluation for X-Ray Wharf Improvements, Milcon P-158 and p-519, March 2015.

DON. 2023. Sea Turtle Nesting Beach Monitoring and Nest Protection on Naval Base Guam. Joint Region Marianas, Guam. October 2023.

Donaldson, T. J., Smith, B., and Chau, L. 2009. Marine Biological Survey of Oscar and Papa Wharves, Inner Apra Harbor, Guam. Prepared by UOG Marine Laboratory, Mangilao for NAVFAC Pacific and AECOM, Inc., Mangilao, GU.

Dueñas and Associates. 1998. Wetland Delineation and Mapping COMNAVMARIANAS, M.I. August.

Eggleston, C. 2009. Migratory Bird Surveys, Navy Lands Guam (23 Sep 08 – 28 Apr 09). NAVFAC Marianas, Environmental.

Eldredge, L. G. 1983. Summary of environmental and fishing information on Guam and the Commonwealth of the Northern Mariana Islands: historical background, description of the islands, and review of climate, oceanography, and submarine topography. November.

Fabricius, K. E. 2009. Effects of terrestrial runoff on the ecology of corals and coral reefs: review and synthesis. Marine Pollution Bulletin, 50, 125–146.

Faye, E. J., Uchimura, M., Shimada, S., Inoue, T., and Nakamura, Y. 2008. *Pseudocodium okinawense* (Bryopsidales, Chlorophyta), a new species from Okinawa and the first report of the genus from eastern Asia. European Journal of Phycology, 43, 99–105.

Fenner, D. 2017. Expert taxonomic opinion on speciation among massive *Porites* and the relatively new admission among top taxonomists that generalizing to ‘massive Porites’ is preferable to - fruitless/superfluous species-level distinctions. Personal communication in person from D. Fenner, Taxonomist, Saipan CNMI to M. Lybolt, Marine Ecologist, Tetra Tech Inc., Saipan, CNMI. April.

Fritts, T. H. and Rodda, G. H. 1998. The role of introduced species in the degradation of island ecosystems: a case history of Guam. Annual Review of Ecology and Systematics, 29, 113–140.

Gailani, J. Z., Kim, S.-C., King, D. B., and Lackey, T. C. 2011. PTM Modeling of Dredged Suspended Sediment at Proposed Polaris Point and Ship Repair Facility CVN Berthing Sites–- Apra Harbor, Guam. Engineer Research and Development Center.

Gailani, J. Z., Lackey, T. C., King, D. B., Bryant, D., Kim, S.-C., and Shafer, D. J. 2016. Predicting dredging-associated effects to coral reefs in Apra Harbor, Guam–- Part 1: Sediment exposure modeling. Journal of Environmental Management, 168, 16–26.

Gill, F. and Donsker, D. 2017. International Ornithologists’ Union (IOC) World Bird List (v 7.3) (No. doi:10.14344/IOC.ML.7.3)

Gorrensen, Marcos P. et al. 2023. Videographic monitoring at caves to estimate population size of the endangered yåyaguak (Mariana swiftlet) on Guam.

GovGuam. 2009. Endangered Species Regulation No. 9. Department of Agriculture, Mangilao, GU. 6 November.

Grimm, G. 2015. Micronesian Starling. Accessed 21 March 2018, from www.guampedia.com/micronesian-starling. 8 April.

Guam DAWR. 2006. Comprehensive Wildlife Conservation Strategy (GCWCS). Department of Agriculture, Government of Guam, Mangilao, GU. 7 November.

Guam DAWR. 2008. Biological and Habitat Assessment of Surface Waters on Guam. Department of Agriculture, Government of Guam, Mangilao, GU. 12 September.

Guam DAWR. 2015. Draft State Wildlife Action Plan. Department of Agriculture, Government of Guam, Mangilao, GU. 20 January.

Guam DAWR. 2017. Interim Annual Performance Report: Sea Turtle Nest Monitoring. 30 December.

Guam EPA. 2000. Management of Contaminated Harbor Sediments of Guam. CZMA Section 309, Guam Harbor Sediment Project Phase III Final Report.

Guam Homeland Security. 2014. 2014 Guam Hazard Mitigation Plan. Guam Office of Civil Defense. Prepared by URS Group.

Hammer, D. H. 1947. Lion Six. United States Naval Institute, Annapolis, MD.

Hapdei, J. 2017. Recent green turtle nest sightings at Haputo Beach, NBG TS (Finegayan). Personal communication from J. Hapdei, Contract Biologist, CNMI DLNR, to T. Summers, Natural Resource Specialist, Navy Base Guam. 6 October.

Hartup, J. 2017. There is a micropopulation of reef manta rays (*Manta alfredi*) in Guam and research by Hartup has observed multi-species spawning areas that reef mantas feed on. Personal communication from J. Hartup, Director, Micronesian Conservation Coalition Manta Trust Project, Guam, to H. Goodwin, Marine Resources Specialist, NAVFFAC Marianas, Guam. 4 October.

Hartup, J., Marshell, A., Stevens, G., Kottermair, M., and Carlson, P. 2013. *Manta alfredi* target multispecies surgeonfish spawning aggregations. Coral Reefs, 32, 367.

Hill, M., Ligon, A., Deakos, M., Ü, A. C., Norris, E., and Oleson, E. 2012. Cetacean Surveys of Guam and CNMI Waters: August-September, 2011 (PIFSC Data Report No. DR-12-002). Pacific Islands Fisheries Science Center. 24 February.

Hill, M., Ligon, A., Deakos, M., Ü, A. C., Milette-Winfree, A., and Oleson, E. 2013a. Cetacean Surveys of Guam and CNMI Waters: May–July, 2012, Including Individual Photo-Identification of Pilot Whales, Spinner Dolphins and Bottlenose Dolphins (2010-2012) (No. PIFSC Data Report DR-13-001). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 8 February.

Hill, M., Ligon, A., Ü, A. C., Deakos, M., and Oleson, E. 2013b. Cetacean Surveys of Guam and CNMI Waters: June-July 2013 (PIFSC Data Report No. DR-13-019). Prepared for the U.S. Pacific Fleet Environmental Readiness Office.

Hill, M., Ligon, A., Deakos, M., Ü, A. C., Milette-Winfree, A., Oleson, E., and Bendlin, A. 2014. Cetacean surveys in the waters of the southern Mariana Archipelago (February 2010-April 2014) (PIFSC Data Report No. DR-14-013). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 2 September.

Hill, M., Oleson, E. M., Ligon, A. D., Martien, K. K., Archer, F. I., Baumann-Pickering, S., Bendlin, A. R., Dolar, L., Merkens, K. P. B., Milette-Winfree, A., Morin, P. A., Rice, A., Robertson, K. M., Trickey, J. S., Ü, A. C., Van Cise, A. M., and Woodman, S. M. 2015. Cetacean Monitoring in the Mariana Islands Range Complex, 2014 (PIFSC Data Report No. DR-15-003). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 27 March.

Hill, M., Oleson, E. M., Baumann-Pickering, S., VanCise, A. M., Ligon, A. D., Bendlin, A. R., Ü, A. C., Trickey, J. S., and Bradford, A. L. 2016. Cetacean Monitoring in the Mariana Islands Range Complex, 2015 (PIFSC Data Report No. DR-16-01). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 6 February.

Hill, M., Bendlin, A. R., Ü, A. C., Yano, K. M., Bradford, A. L., Ligon, A. D., and Oleson, E. M. 2017. Cetacean Monitoring in the Mariana Islands Range Complex, 2016 (PIFSC Data Report No. DR-17-002). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 3 February.

Hinderstein, L. M., Marr, F. A., Martinez, M., Dowgiallo, J., Puglise, K. A., Pyle, R. L., Zawada, D. G., and Appeldoorn, R. 2010. Theme section on mesophotic coral ecosystems: characterization, ecology, and management. Coral Reefs, 292, 247–251.

Hopper, D. R. and Smith, B. 1992. Status of tree snails (Gastropoda: Partulidae) on Guam, with a resurvey of sites studied by H.E. Crampton in 1920. Pacific Science, 46, 77–85.

Humphrey, C., Weber, M., Lott, C., Cooper, T., and Fabricius, K. 2008. Effects of suspended sediments, dissolved inorganic nutrients and salinity on fertilisation and embryo development in the coral *Acropora millepora* (Ehrenberg, 1834). Coral Reefs, 27, 837–850.

Jones, T. T., Martin, S. L., and Van Houtan, K. S. 2015. Sea Turtle Tagging in the Mariana Islands Range Complex (MIRC) Interim Progress Report (PIFSC Data Report No. DR-15-020). Prepared for U.S. Pacific Fleet Environmental Readiness Office, Pearl Harbor, HI. September.

JRM. 2010. JRM-administered Lands GIS Data.

JRM. 2013. Final Joint Region Marianas Integrated Natural Resources Management Plan. Prepared by HDR for Commander Joint Region Marianas, Guam, Hagatna, GU. December.

JRM. 2015. JRM-administered Lands GIS Data.

JRM. 2019. JRM-administered Submerged Lands GIS Data.

Kahng, S. E., Copus, J. M., and Wagner, D. 2014. Recent advances in the ecology of mesophotic coral ecosystems (MCEs). Current Opinion in Environmental Sustainability, 7, 72–81.

Kami, H. T. 1971. Checklist of Guam fishes. Micronesica, 7, 215–228.

Kerr, A. M. 1990. Chamorro Fish Names. Micronesica, 23, 93–118.

Kerr, A. M. 2012. Fish Names of the Mariana Islands, Micronesia (UOG Marine Laboratory Technical Report No. 139). Mangilao, GU. February.

Kerr, A. M. 2013. Illustrated Guide to the Reptiles and Amphibians of the Mariana Islands, Micronesia (UOG Marine Laboratory Technical Report No. 150). Mangilao, GU. March.

Khan, A. 2010. Relaying conversations among NAVFAC and NMFS biologists acknowledging the difficulty of identifying massive *Porites* to species, and the relevance of precise identifications.

Personal communication in person from A. Khan, Program Manager, HDR, Inc., Guam to M. Lybolt, Marine Ecologist, CSA, Guam. November.

Kolinski, S. P. 2001. Sea Turtles and their Marine Habitats at Tinian and Aguijan, with Projections on Resident Turtle Demographics in the Southern Arc of the Commonwealth of the Northern Mariana Islands (Southwest Fisheries Science Center Administrative Report No. H-01-06C). NOAA Southwest Fisheries Science Center. December.

Lagerloef, G. S. E., Mitchum, G. T., Lukas, R. B., and Niiler, P. P. 1999. Tropical Pacific near-surface currents estimated from altimeter, wind, and drifter data. Journal of Geophysical Research, 104, 23, 313–23, 326.

Lane, D. J. W. 2012. *Acanthaster planci* impact on coral communities at permanent transect sites on Bruneian reefs, with a regional overview and a critique on outbreak causes. Journal of the Marine Biological Association of the United Kingdom, 92, 803–809.

Liske-Clark, J. 2015. Wildlife Action Plan for the Commonwealth of the Northern Mariana Islands, 2015-2025. CNMI DLNR-Division of Fish and Wildlife, Saipan, MP. 16 December.

Lybolt, M. 2015. Listed Coral Sighting (Guam). Technical Memorandum from M. Lybolt, Marine Ecologist, Tetra Tech, Inc., Stuart, FL to S. Hanser, Supervisory Marine Biologist, NAVFAC Pacific, Pearl Harbor, HI. 4 May.

Marine Research Consultants. 2005. Marine Resource Assessment in the Entrance Channel of Inner Apra Harbor, Guam.

Martin, J. 2023. Observations of Cane toads, Barking frogs, Marbled Pygmy frogs and Taiwan Whipping frogs on NMS near Swiftlet caves. Personal communication via email from J. Dusty, Biosecurity Field Supervisor, Center for Environmental Management of Military Lands. NBS, Andersen AFB. Guam. December.

Martin, S. L. and Jones, T. T. 2016. Sea Turtle Tagging in the Mariana Islands Training and Testing (MITT) Study Area (PIFSC Data Report No. DR-17-025). Prepared for the U.S. Pacific Fleet Environmental Readiness Office, Honolulu, HI. 15 December.

Martin, S. L. and Jones, T. T. 2017. Sea Turtle Tagging in the Naval Base Guam Area (PIFSC Data Report No. DR-17-026). Prepared for the U.S. Naval Base Guam. 25 January.

Martin, S. L., van Houtan, K. S., Jones, T. T., Aguon, C. F., Gutierrez, J. T., Tibbats, B. R., Wusstig, S. B., and Bass, J. D. 2016. Five decades of marine megafauna surveys from Micronesia. Frontiers in Marine Science, 2, 116.

Matson, E. A. 2005. An Internal Island Effect: Subaquifer enrichment of seawater flowing through a tropical carbonate island, (Guam, USA) (Abstract of the Annual Meeting of the American Society of Limnology and Oceanography, Santiago de Compostela, Spain).

Maynard, J., McKagan, S., Raymundo, L., Johnson, S., Ahmadia, G., Johnston, L., Houk, P., Williams, G., Kendall, M., Heron, S., van Hooidonk, R., and Mcleod, E. 2015. Assessing relative resilience potential of coral reefs to inform management in the Commonwealth of the Northern Mariana Islands. NOAA Technical Memorandum CRCP 22. NOAA Coral Reef Conservation Program, Silver Spring, MD.

McManus, J. W. and McManus, L. C. 2012. Proposed Dredging for an Aircraft Carrier Turning Basin in Apra Harbor, Guam: Options for Assessment and Mitigation (Final).

Miller, R. 2014. Guam Marine Biosecurity Action Plan. Prepared by the UOG Center for Island Sustainability for NOAA Coral Reef Conservation Program, as administered by the Office of Ocean and Coastal Resource Management and the Bureau of Statistics and Plans, Guam Coastal Management Program. September.

Minton, D., Brown, V., Dugger, K., Flores, T., Foster, K., Houk, P., Iguel, J., Kessler, C., Kolinski, S., Schols, T., Starmer, J., Suhkraj, N., Tenorio, M., and Trianni, M. 2009. Draft Report. Marine Resource Surveys of Tinian, Commonwealth of the Northern Mariana Islands. Volume I. UOG Marine Laboratory, Mangilao, GU. January.

Moore, P., Raulerson, L., Chernin, M., and McMakin, P. 1977. Inventory and Mapping of Wetland Vegetation in Guam, Tinian and Saipan, Mariana Islands. UOG, Mangilao, GU.

Moribe, J. 2017. Based on 2016 records, there are 24 known occurrences of *A. globiceps*, two occurrences of *A. retusa*. Personal communication via comments in response to draft INRMP review from J. Moribe, NOAA NMFS, Honolulu Hawai‘i to S. Hanser, Supervisory Natural Resources Management Specialist for Marine Resources, NAVFAC Pacific, Honolulu, HI. 15 October.

Myers, M. F. 1999. Micronesian Reef Fishes: A Comprehensive Guide to the Coral Reef Fishes of Micronesia. Coral Graphics, Barrigada, GU.

Myers, R. F. and Donaldson, T. J. 2003. The fishes of the Mariana Islands. Micronesica, 35–36, 594–648.

Myers, R. L. and Raymundo, L. 2009. Coral disease in Micronesian reefs: a link between disease prevalence and host abundance. Diseases of Aquatic Organisms, 87, 97–104.

NAVFAC Marianas. 2010a. Guam DoD Land Inventory. Prepared by NAVFAC Marianas Asset Management Business Line. 22 December.

NAVFAC Marianas. 2010b. Orote Peninsula Ecological Reserve Area General Management Plan, Naval Base Guam. Prepared by SWCA Environmental Consultants, Hagatna, GU. 30 August.

NAVFAC Marianas. 2010c. Guam Marine Monitoring Surveys, Final Revision: Orote Peninsula Ecological Reserve Area, North Agat Bay and Vicinity (OPERA) and Haputo Ecological Reserve Area and Vicinity (HERA). Prepared by UOG Marine Laboratory, Mangilao and SWCA Environmental Consultants, Hagatna, GU. March.

NAVFAC Marianas. 2011a. Botanical Inventory and Vegetation Survey of the Haputo and Orote Peninsula Ecological Reserve Areas and Proposed Buffer Zones, Guam. Prepared by SWCA Environmental Consultants, Hagatna, GU. 31 January.

NAVFAC Marianas. 2011b. Haputo and Orote Peninsula Ecological Reserve Area Marine Unit, Naval Base Guam, Visitor Use and Crown-of-Thorns Starfish Surveys. Prepared by SWCA Environmental Consultants, Hagatna, GU. 31 December.

NAVFAC Marianas. 2011c. Seagrass Survey–- Dadi Beach, Naval Base Guam. Prepared by SWCA Environmental Consultants, Hagatna, Guam for NAVFAC Marianas, Navy Base Guam. 31 December.

NAVFAC Marianas. 2013. Final Establishment Report, Orote Ecological Reserve Area Expansion. September.

NAVFAC Marianas. 2014a. Final Project Report: Federal Candidate Species Surveys on Guam. Prepared by D.P. Lindstrom and J.C. Benedict, College of Natural and Applied Sciences, UOG. 21 January.

NAVFAC Marianas. 2014b. Wet-Season Survey Report: Mariana Common Moorhen Wetland Use and Population Survey. Prepared by Allied Pacific Environmental Consulting, Inc., Agana, GU. November.

NAVFAC Marianas. 2016a. Land Use/Land Cover and Recovery Habitat Analysis for Lands Managed by Joint Region Marianas in Guam. Prepared by Cardno, Honolulu, HI. June.

NAVFAC Marianas. 2016b. Joint Region Marianas Integrated Natural Resources Management Plan (INRMP) Summary of FY2016 Actions and Projects. Prepared by Cardno, Honolulu, HI and Bainbridge Island, WA. October.

NAVFAC Marianas. 2022. Ungulate Control, Eradication, and Basic Research on Naval Base Guam and Andersen Air Force Base for Joint Region Marianas, Guam Area of Responsibility. Draft. Submitted by White Buffalo Inc., 6B Kings Highway, Chester, CT 06412. May.

NAVFAC Marianas. 2023. Monitoring Survival and Demography of the Micronesian Starlings on Andersen Air Force Base in a Brown Treesnake Controlled Environment. Iowa State University, Department of Ecology, Evolution and Organismal Biology, Ames, IA 50011. 13 November.

NAVFAC Marianas and Andersen AFB. 2023. Sea Turtle Management Plan for Andersen Air Force Base, Guam. Prepared by University of Guam Sea Grant, Guam. Cooperative Agreement No.: N40192-18-2-8000. January.

NAVFAC Marianas and Naval Base Guam. 2023. Sea Turtle Nesting Beach Monitoring and Nest Protection on Naval Base Guam for the Period of August, 18, 2022 to August 31, 2023. October.

NAVFAC Pacific. 1993. Final Environmental Impact Statement for Proposed Facilities Development and Relocation of Navy Activities to the Territory of Guam from the Republic of the Philippines.

NAVFAC Pacific. 2006. Sediment Characterization Study for Construction Dredging Feasibility Study at Charlie, Sierra and SRF Wharves, Apra Harbor, Guam. Final Report. Prepared by Weston Solutions. August.

NAVFAC Pacific. 2010a. Final Natural Resource Survey Report in Support of the Environmental Impact Statement for the Marine Corps Relocation Initiative to Various Locations on Guam. Pearl Harbor, HI. 23 December.

NAVFAC Pacific. 2010b. Additional Dredged Material Chemical Characterization at Polaris Point, the Former SRF Wharf, and the Turning Basin for Proposed CVN Wharf Alternatives, Apra Harbor, Guam. Final Report. Prepared by Weston Solutions, Inc. March.

NAVFAC Pacific. 2011a. Supplemental Marine Resource Surveys to Support the CVN Transient Pier, Apra Harbor, Guam. Task 1 – CVN Impact Area Surveys (Coral Reef Community). Prepared by HDR, Inc., Tamuning, Guam in collaboration with CSA International, Inc., Stuart, FL. May.

NAVFAC Pacific. 2011b. Supplemental Marine Resource Surveys to Support the CVN Transient Pier, Apra Harbor, Guam. Task 2 – Potential Mitigation Sites Surveys (Coral Reef Community). Prepared by CSA International, Inc., Stuart, FL.

NAVFAC Pacific. 2011c. Guam Marine Species Monitoring Survey. Vessel-Based Monitoring Surveys. Winter 2011. Prepared by HDR, Inc. December.

NAVFAC Pacific. 2012a. Final Terrestrial Natural Resources Surveys Lockwood/San Luis Ponds, Guam. Prepared by HDR, Inc., Hagatna, GU. April.

NAVFAC Pacific. 2012b. Guam and Saipan Marine Species Monitoring: Winter-Spring Survey, 15 to 29 March 2012. Prepared by HDR, Inc. for Commander U.S. Pacific Fleet. 15 November.

NAVFAC Pacific. 2013a. Moorhen Habitat Wetland Restoration Feasibility Study, Camp Covington, Naval Base, Guam. Task 2 – Technical Memorandum. Prepared by HDR, Inc., Hagatna, GU. May.

NAVFAC Pacific. 2013b. Final Report: Biological Surveys – Report 2, Various Locations on Guam in Support of the Guam and Commonwealth of the Northern Mariana Islands Military Relocation (2012 Roadmap Adjustments) Supplemental Environmental Impact Statement. Prepared by TEC-AECOM Joint Venture for Joint Guam Program Office, Honolulu, HI. April.

NAVFAC Pacific. 2013c. Coral Mitigation Site Feasibility Assessment for the CVN Pier Construction Site in Apra Harbor, Guam. Task 14 – Abo Cove Wetlands Reconnaissance Study. Prepared by HDR, Inc., Hagatna, GU. June.

NAVFAC Pacific. 2015a. Apra Harbor, Guam Coral Mitigation Site Feasibility Assessment; Offsite Watersheds Reconnaissance Assessment. Prepared by HDR, Inc., Hagatna, GU.

NAVFAC Pacific. 2015b. Apra Harbor, Guam Coral Mitigation Site Feasibility Assessment; Atantano River Sub-Watershed Feasibility Assessment. Prepared by HDR, Inc., Hagatna, GU.

NAVFAC Pacific. 2015c. Apra Harbor, Guam Coral Mitigation Site Feasibility Assessment; Artificial Reefs Reconnaissance Assessment. Prepared by HDR, Inc., Hagatna, GU.

NAVFAC Pacific. 2015d. Apra Harbor, Guam Coral Mitigation Site Feasibility Assessment; Mangrove Forests Reconnaissance Assessment. Prepared by HDR, Inc., Hagatna, GU.

NAVFAC Pacific, in review. 2017. Coral Translocation Experiment from X-Ray Wharf in Inner Apra Harbor, Guam. Prepared by HDR, CSA and SPAWAR Systems Center Pacific.

NBG. 2016. Naval Base Guam Installation Development Plan – Final. Prepared by Helber, Hastert, and Fee, Inc., Honolulu, HI. February.

NBG. 2018. Sea turtle emergence and nesting database for DoD lands on Guam, in custody of T. Summers, Natural Resource Specialist, Navy Base Guam.

NMFS. 2014a. Endangered and Threatened Wildlife and Plants: Final Listing Determinations on Proposal To List 66 Reef-Building Coral Species and To Reclassify Elkhorn and Staghorn Corals. Federal Register, 79, 53852–54123.

NMFS. 2014b. Endangered and Threatened Wildlife and Plants; Threatened and Endangered Status for Distinct Population Segments of Scalloped Hammerhead Sharks; Final Rule. Federal Register, 79, 38214–38242.

NMFS. 2015a. Endangered and Threatened Species; Determination on the Designation of Critical Habitat for Three Scalloped Hammerhead Shark Distinct Population Segments. Federal Register, 80, 71774–71784.

NMFS. 2015b. Species of Concern: Bumphead Parrotfish *Bolbometopon muricatum*. Accessed 16 January 2018, from http://www.nmfs.noaa.gov/pr/pdfs/species/bumpheadparrotfish_detailed.pdf. 30 October.

NMFS. 2015c. Species of Concern: Humphead Wrasse *Cheilinus undulatus*. Accessed 16 January 2018, from http://www.nmfs.noaa.gov/pr/pdfs/species/humpheadwrasse_detailed.pdf. 30 October.

NMFS. 2017a. Endangered and Threatened Wildlife; 90-Day Finding on a Petition To List 10 Species of Giant Clams as Threatened or Endangered Under the Endangered Species Act. Federal Register, 82, 28946–28977.

NMFS. 2017b. 12-Month Finding on a Petition To List Giant and Reef Manta Rays as Threatened or Endangered Under the Endangered Species Act. Federal Register, 82, 3694–3715.

NMFS. 2018a. Endangered and Threatened Wildlife and Plants: Listing the Oceanic Whitetip Shark as Threatened Under the Endangered Species Act. Federal Register, 83, 4153–4165.

NMFS. 2018b. Endangered and Threatened Wildlife and Plants; Final Rule To List the Giant Manta Ray as Threatened Under the Endangered Species Act. Federal Register, 83, 2916–2931.

NMFS. 2020. Endangered Species Act Section 7 Consultation Biological Opinion and Conference Report for the U.S. Military Mariana Islands Training and Testing Activities. 10 July.

NMFS and NAVFAC Pacific. 2017. Observation of *Acropora globiceps* near Dadi Beach, NBG, September 2016. Personal communication via email from J. Moribe, Marine Biologist, Protected Resources Division, Pacific Islands Regional Office, NMFS, Pearl Harbor, HI and Dr. S. Hanser, Supervisory Natural Resources Management Specialist for Marine Resources, NAVFAC Pacific, Pearl Harbor, HI to R. Spaulding, Senior Biologist/Project Manager, Cardno, Bainbridge Island, WA. 29 March.

NMFS and USFWS. 2007. Green Sea Turtle (*Chelonia mydas*) 5-Year Review: Summary and Evaluation. NMFS, Office of Protected Resources, Silver Spring, MD and USFWS, Southeast Region, Jacksonville Ecological Services Field Office, Jacksonville, FL. August.

NMFS and USFWS. 2016. Endangered and Threatened Wildlife and Plants; Final Rule To List Eleven Distinct Population Segments of the Green Sea Turtle (*Chelonia mydas*) as Endangered or Threatened and Revision of Current Listings Under the Endangered Species Act. Federal Register, 81(66), 20058–20090.

NOAA. 2005. Environmental Sensitivity Index Map, Guam and the Commonwealth of the Northern Marianas Islands. National Ocean Service (NOS), Office of Response and Restoration, Hazardous Materials Response Division.

NOAA. 2017. Ocean Watch. Accessed 15 October 2017, from http://oceanwatch.pifsc.noaa.gov/.

NOAA. 2022. Sea Turtle Tagging in the Naval Base Guam Area. Draft Final Report. Prepared for U.S. Naval Base Guam. September.

NOAA NCCOS. 2005. American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands. Accessed 13 July 2018, from https://products.coastalscience.noaa.gov/collections/benthic/e99us_pac/.

Oleson, E. M. and Hill, M. C. 2010. 2010 Report to PACFLT: Report of Cetacean Surveys in Guam, CNMI, and the High-seas and Follow up on 2009 Main Hawaiian Islands Cetacean Survey. NOAA-NMFS-Pacific Islands Fisheries Science Center.

OPNAV M. 2021. Chapter 12: Natural Resources Conservation in Environmental Readiness Program Manual. In OPNAV Manual 5090.1 (OPNAV M-5090.1), Washington, D.C. 25 June.

OPNAVINST. 2021. OPNAV Instruction (OPNAVINST) 5090.1. Environmental Readiness Program. Office of the Chief of Naval Operations, Washington, D.C. 25 June.

Pacific Islands Benthic Habitat Mapping Center. 2012. Gridded Multibeam Bathymetry of Apra Harbor, Guam U.S. Territory. Online Dataset. Accessed 16 January 2018, from https://www.coris.noaa.gov/metadata/records/html/apra_bty_1m.html.

Paulay, G., Kirkendale, L., Lambert, G., and Starmer, J. A. 1997. The Marine Invertebrate Biodiversity of Apra Harbor: Significant Areas and Introduced Species, with Focus on Sponges, Echinoderms and Ascidians. Draft Report. Prepared for U.S. Department of Defense, COMNAVMARIANAS.

Paulay, G., Kirkendale, L., Meyer, C., Houk, P., Rongo, T., and Chang, R. 2001. Marine Biodiversity Resource Survey and Baseline Reef Monitoring Survey of the Southern Orote Peninsula and North Agat Bay Area. Prepared for Commander Naval Forces Marianas, Guam.

Paulay, G., Kirkendale, L., Lambert, G., and Meyer, M. 2002. Anthropogenic biotic interchange in a coral reef ecosystem: A case study from Guam. Pacific Science, 56, 403–422.

Porter, V., Leberer, T., Gawel, M., Gutierrez, J., Burdick, D., Torres, V., and Lujan, E. 2005. The State of Coral Reef Ecosystems of Guam. Pages 442-487 *in* J. E. Waddell and J. M. Clarke (Eds.), The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States. NOAA.

Pregill, G. K. and Steadman, D. W. 2009. The prehistory and biogeography of terrestrial vertebrates of Guam, Mariana Islands. Diversity and Distributions, 15, 983–996.

Pyle, R. L., Boland, R., Bolick, H., Bowen, B., Bradley, C., Kane, C., Kosaki, R. K., Langston, R., Longenecker, K., Montgomery, A., Parrish, F. A., Bopp, B. N., Rooney, J., Smith, C., Wagner, D., and Spalding, H. L. 2016. A comprehensive investigation of mesophotic coral ecosystems in the Hawaiian Archipelago. PeerJ, 4, e2475.

Randall, J. E. 1972. Chemical pollution in the sea and the crown-of-thorns starfish (*Acanthaster planci*). Biotropica, 4, 132–144.

Randall, J. E. and Holloman, J. 1974. Coastal Survey of Guam (UOG Marine Laboratory Technical Report No. 14). Mangilao, GU.

Randall, R. H. and Myers, R. F. 1983. The Corals (Vol. 2). UOG Press, Mangilao, GU.

Raymundo, L., Burdick, D., Lapacek, V. A., Miller, R., and Brown, V. 2017. Anomalous temperatures and extreme tides: Guam staghorn *Acropora* succumb to a double threat. Marine Ecology Progress Series, 564, 47–55.

Raymundo, L., Malay, M. C. D., and Williams, A. N. 2016. Stony Coral Health Status, Community Structure, and Macrobioeroder Density within Apra Harbor Guam. Final Report. Prepared for NAVFAC Marianas, Guam by UOG Marine Laboratory, Mangilao, GU. 26 May.

Redding, J. E., Myers-Miller, R. L., Baker, D. M., Fogel, M., Raymundo, L., and Kim, K. 2013. Link between sewage-derived nitrogen pollution and coral disease severity in Guam. Marine Pollution Bulletin, 73, 57–63.

Resko, D. 2018. There's no actual proof that Sasa Bay is used as a hammerhead nursery, but there are several secondhand accounts of fishermen who have accidentally hooked young-of-the-year hammerheads near Sasa Bay. Personal communication via email from Devin Resko, UOG Marine Laboratory to Matt Lybolt, Marine Ecologist/Project Manager, Cardno, Honolulu, HI. 12 March.

Rubinoff, D. and Haines, W. 2012. Report for Surveys Conducted on Guam and Rota October 10-20, 2012. Assessing the Conservation Status of *Hypolimnas octocula* and *Vagrans egistina*, Candidates for ESA listing.

Safford, W. 2009. The Chamorro Language of Guam. University of Michigan Library. 27 April.

Schils, T. 2015. Restyling Guam's Reef Flats: Angel Hair alga on the rise. Man, Land, and Sea, 6–7.

Schils, T., Houk, P., Biggs, J. S., Donaldson, T. J., Kense, A., and McLean, M. 2017. Marine Resources Surveys of Naval Base Guam and Naval Support Activity Andersen AFB. Mangilao, Guam.

Schils, T., Schupp, P., Raymundo, L., Halford, A., Caballes, C., Devillers, A., and Rohde, S. 2011. Final Report, Coral Reef Monitoring, Kilo Wharf Extension, Apra Harbor, Guam. Prepared by UOG Marine Laboratory, Mangilao, Guam for TEC Inc., Charlottesville, VA. April.

Schreiner, I. H. and Nafus, D. M. 1996. Survey of Rare Butterflies in the Mariana Islands. Preliminary report to USFWS.

Schreiner, I. H. and Nafus, D. M. 1997. Butterflies of Micronesia. Agricultural Experiment Station College of Agriculture and Life Sciences, UOG.

Sea Engineering. 2010. Physical Oceanographic Monitoring of Dredging and Construction Activities at Kilo Wharf: September 2008 – December 2009; Apra Harbor, Guam. Prepared for TEC, Inc., Charlottesville, VA.

Semmler, R. F., Hoot, W. C., and Reaka, M. L. 2016. Are mesophotic coral ecosystems distinct communities and can they serve as refugia for shallow reefs? Coral Reefs, 36, 433–444.

Shannon, in preparation. n.d. Report regarding recent video surveys of reef habitat in the channel connecting Inner and Outer Apra Harbor.

Sinniger, F., Morita, M., and Harii, S. 2012. "Locally extinct" coral species *Seriatopora hystrix* found at upper mesophotic depths in Okinawa. Coral Reefs, 32, 153.

Smith, B., Braulik, G., Strindberg, S., Mansur, R., Diyan, M. A. A., and Ahmed, B. 2009. Habitat selection of freshwater-dependent cetaceans and the potential effects of declining freshwater flows and sea level rise in waterways of the Sundarbans mangrove forest, Bangladesh. Aquatic Conservation: Marine and Freshwater Ecosystems, 19, 209–225.

Smith, B., Donaldson, T., Schils, T., Reyes, A., Chop, K., and Dugger, K. 2008. Marine Biological Survey of Inner Apra Harbor, Guam. Review Draft. Prepared for Earth Tech, Inc., Mangilao, GU. October.

Smith, S. 2004. Report No. 1: March 2004 Ecological Assessment of the Marine Community in the Vicinity of Kilo Wharf, Apra Harbor Guam; and Report No. 2: Field Support of Supplemental Reconnaissance Level Observations in the Vicinity of Kilo Wharf, Apra Harbor, Guam. June.

Smith, S. 2007. Ecological Assessment of Stony Corals and Associated Organisms in the Eastern Portions of Apra Harbor, Guam. Prepared for NAVFAC Pacific, HI. August.

Smith, S. and Marx Jr., D. 2006. Assessment of Stony Corals Between Orote Point and Sumay Cove, Apra Harbor, Guam.

Smith, S., Marx Jr., D., and Shannon, L. H. 2013. Calendar Year 2012 Review of Marine Natural Resources in Apra Harbor. Site Specific Report SSR-NAVFAC-EXWC-EV-1312. Prepared for Naval

Facilities Engineering Systems Command, Engineering and Expeditionary Warfare Center, Port Hueneme, CA.

Summers, T. M., Jones, T. T., Martin, S. L., Hapdei, J. R., Ruak, J. K., and Lepczyk, C. A. 2017. Demography of Marine Turtles in the Nearshore Environments of the Northern Mariana Islands. Pacific Science, 71, 269–286.

SWCA and TNWRE. 2007. Proposed supplemental water supply for the Fena Reservoir System, Naval Magazine, Guam. Prepared for SAIC and U.S. Joint Region Marianas.

Takano, L. L. and Haig, S. M. 2004. Seasonal movement and home range of Mariana common moorhen. Condor, 106, 652–663.

Taylor, B. M., Halford, A. R., Marshell, A. L., and Priest, M. A. 2009. Quantitative Assessment of the Reef Fish Communities in Apra Harbor, Guam. Prepared by UOG Marine Laboratory. Prepared for NAVFAC Pacific.

Tibbatts, B. 2017. Scalloped hammerhead sightings. Personal communication via email from B. Tibbatts, Biologist, Guam DAWR, Guam to J. Farley, NAVFAC EV2 and CNIC N41 Natural Resources Specialist Environmental Planning and Conservation Division Environmental Directorate (EV), NAVFAC Headquarters, Washington, D.C. 5 October.

Timmers, M. 2016. COTS surveys within Guam and CNMI waters. Personal communication via email from M. Timmers, Marine Ecosystems Research Project Manager, Coral Reef Ecosystem Program, Pacific Islands Fisheries Science Center, Honolulu, HI to H. Goodwin, Marine Resources Specialist, NAVFAC Marianas, Guam. 18 August.

Tomczak, M. and Godfrey, J. S. 2003. Regional Oceanography: An Introduction (^{2n}d ed.). Daya Publishing House, Delhi, India.

Topping, D., Ogo, P., and Dungca, B. 1975. Chamorro-English Dictionary. University of Hawai‘i Press, Honolulu, HI.

U.S. Navy. 2006. Naval Ships’ Technical Manual, Chapter 081, Revision 5, Waterborne Underwater Hull Cleaning of Navy Ships.

U.S. Navy. 2023. Monitoring Mariana fruit bats on Guam Naval Munitions Site and Tinian Military Lease Area, 2022-2023. Prepared for NAVFAC Marianas, Guam. Prepared by T. Mildenstein, University of Guam, under Cooperative Agreement Number N40192-22-2-8001. April.

USACE and Wil Chee. 2007. Draft Environmental Impact Statement for the Master Plan for Deep-draft Wharf and Fill Improvements at Apra Harbor. July.

USDA. 1988. Soil Survey of Territory of Guam. USDA Soil Conservation Service, in cooperation with Guam Department of Commerce and UOG. Prepared by F.J. Young.

USDA APHIS Wildlife Services. 2014. Naval Base Guam Main Base Feral Pig Control Project, FY 2015 First Quarter Report (01 October – 30 December 2014). HI/GU/Pacific Island Program, Barrigada District Office, Barrigada, GU.

USDA APHIS Wildlife Services. 2015a. Naval Base Guam Main Base Feral Pig Control Project, FY 2015 Second Quarter Report (01 January – 31 March 2015). HI/GU/Pacific Island Program, Barrigada District Office, Barrigada, GU.

USDA APHIS Wildlife Services. 2015b. Naval Base Guam Main Base Feral Pig Control Project, FY 2015 Third Quarter Report (01 April – 30 June 2015). HI/GU/Pacific Island Program, Barrigada District Office, Barrigada, GU.

USEPA and USACE. 1991. Evaluation of Dredged Material Proposed for Ocean Disposal – Testing Manual. EPA 503/8-91/001. February.

USEPA and USACE. 1998. Evaluation of Dredged Material Proposed For Discharge in Waters of the U.S. – Testing Manual. EPA-823-B-98-004. February.

USFS. 2006. Guam Vegetation Mapping. Pacific Southwest Region, Forest Health Protection, McClellan, CA. October.

USFWS. 1986. Fish and Wildlife Resources of the Orote Ecological Reserve Area. Prepared for NAVFAC Pacific, Pearl Harbor, HI by USFWS, Office of Environmental Services, Honolulu, HI. September.

USFWS. 1988. Fish and Wildlife Resources of the Orote Ecological Reserve Area. Prepared for NAVFAC Pacific, Pearl Harbor, HI by USFWS, Office of Environmental Services, Honolulu, HI. September.

USFWS. 1992. Recovery Plan, Mariana Islands Common Moorhen, (*Gallinula chloropus guami*). Portland, OR. September.

USFWS. 2010. Biological Opinion for the Joint Guam Program Office Relocation of the U.S. Marine Corps from Okinawa to Guam and Associated Activities on Guam and Tinian. Pacific Islands Fish and Wildlife Office, Honolulu, HI. 8 September.

USFWS. 2011. Guam and Commonwealth of the Northern Mariana Islands Animals and Plants: Updated February 2, 2011. Listed Species, as Designated under the U.S. Endangered Species Act.

USFWS. 2015a. Biological Opinion for the Mariana Islands Testing and Training Program. Pacific Islands Fish and Wildlife Office, Honolulu, HI. 20 February.

USFWS. 2015b. U.S. Fish and Wildlife Service Guidelines for Coordination on Integrated Natural Resource Management Plans. June.

USFWS. 2016. Reducing Bird Collisions with Buildings and Glass, Best Practices. Division of Migratory Bird Management, Falls Church, VA. January, updated July 2016.

USFWS. 2017. Reinitiation of the 2015 Biological Opinion on the Department of the Navy's Relocation of U.S. Marine Corps from Okinawa to Guam and Associated Activities on Guam (Consultation 01EPIF00-2015-F-0025 and 01EPIF00-2016-F-0185). Pacific Islands Fish and Wildlife Office, Honolulu, HI. 18 July.

USGS. 1998. U.S. Geological Survey Circular 1156. Accessed 30 November 2017, from https://water.usgs.gov/pubs/circ1156.

USGS. 2018. NAS – Nonindigenous Aquatic Species database. Accessed 30 November 2017, from https://nas.er.usgs.gov/. 31 January.

Veron, J. E. N. 2000. Corals of the World. (M. Stafford-Smith, Ed.) (Vol. Volumes 1-3). Australian Institute of Marine Science, Townsville, Queensland, AU.

Vogt, S. 2017. Skinks less abundant on islands with shrews. Personal communication from S. Vogt, Natural Resources Specialist, Public Works Department, NBG to J. Ford, Pacific Operations Manager, Cardno, Honolulu, HI. 27 September.

Vogt, S. 2018. Trail camera results for feral pigs at NBG Main Base. Personal communication via comment response matrix from S. Vogt to Cardno, Honolulu, HI. 17 March.

Wenninger, P. 2015. Hawksbill sea turtles at NBG Main Base. Personal communication via email from P. Wenninger, Natural Resources Specialist, Public Works Department, NBG to R. Spaulding, Senior Biologist/Project Manager, Cardno, Bainbridge Island, WA.

Wenninger, P. 2016a. Migratory Bird Surveys, Navy Lands Guam. Personal communication via email from P. Wenninger, Natural Resources Specialist, Public Works Department, NBG and R. Spaulding, Senior Biologist/Project Manager, Cardno, Bainbridge Island, WA.

Wenninger, P. 2016b. Nesting Sea Turtle Survey Raw Data for NBG Main Base, 2009-2016. Personal communication via email from P. Wenninger, Natural Resources Specialist, Public Works Department, NBG to R. Spaulding, Senior Biologist/Project Manager, Cardno, Bainbridge Island, WA.

WERI and IREI. 2016. Digital Atlas of Southern and Northern Guam. Accessed 25 September 2017, from http://south.hydroguam.net/index.php and http://north.hydroguam.net/index.php.

Wheeler, M. W. 1979. The Marianas fruit bat: Management history, current status and future plans. Cal Neva Wildlife Transactions, 1979, 149–165.

Wiewel, A., Adams, A. A. Y., and Rodda, G. H. 2009. Rodents on Tinian. In Terrestrial Resource Surveys of Tinian and Aguiguan, Mariana Islands, 2008 – Final Report (Pages 240–257). Prepared by USFWS Pacific Islands Fish and Wildlife Office, Honolulu, HI for Marine Forces Pacific and NAFVAC Pacific, Pearl Harbor, HI.

Wiles, G. 2005. A checklist of the birds and mammals of Micronesia. Micronesica, 38, 141–189.

Wiles, G., Bart, J., Beck Jr., R. E., and Aguon, C. F. 2003. Impacts of the brown treesnake: patterns of decline and species persistence in Guam's avifauna. Conservation Biology, 17, 1350–1360.

Wiles, G. and Ritter, M. 1993. Country Report: Guam. In D. A. Scott (Ed.), A Directory of Wetlands in Oceania. IWRB, Slimbridge, UK and AWB, Kuala Lumpur, MY.

Williams, I., Zamzow, J., Lino, K., Ferguson, M., and Donham, E. 2012. Status of Coral Reef Fish Assemblages and Benthic Condition Around Guam: A Report Based on Underwater Visual Surveys in Guam and the Mariana Archipelago, April-June 2011 (No. NMFS-PIFSC-33). Pacific Islands Fisheries Science Center.

Williams, L. 2007. Terrestrial Biological Resources Assessment for Kilo Wharf Area, Apra Harbor, Guam. Prepared by I Tano Services, LLC, Saipan, CNMI for Helber, Hastert, and Fee, Inc., Honolulu, HI. January.

Wolanski, E., Richmond, R. H., Davis, G., and Bonito, V. 2003. Water and fine sediment dynamics in transient river plumes in a small, reef-fringed bay, Guam. Estuarine, Coastal and Shelf Science, 56, 1029–1040.

WPRFMC. 2009. Fishery Ecosystem Plan for the Mariana Archipelago. Honolulu, HI. 24 September.

15.6 CHAPTER 6 – NAVAL BASE GUAM NAVAL MUNITIONS SITE

Aaron, J. 2011. Regional Cold War History for Department of Defense Installations in Guam and the Northern Mariana Islands. Department of Defense Legacy Resource Management Program.

AECOS, Inc. and Wil Chee Planning, Inc. 2009. Final Guam and Tinian Wetlands Inventory. Honolulu, HI. September.

Ames. 1914. *Bulbophyllum guamense*. Philippine Journal of Science, C9, 13.

Atkinson, I. E. 1985. The Spread of Commensal Species of Rattus to Oceanic Islands and Their Effects on Island Avifaunas. Pages 36-81 *in* P.J. Moors (Ed.) Conservation of Island Birds. International Council for Bird Preservation, Cambridge, UK.

BioSystems Analysis, Inc. 1989. Natural Resources Survey for the U.S. Public Works Center, Guam (PWC). Prepared for Commander, Pacific Division, Naval Facilities Engineering Systems Command, Pearl Harbor, HI.

Brindock, K. 2010. Mariana Gray Swiftlet Count Observer Bias Study. Naval Munitions Site, Naval Base Guam. Prepared for Public Works Department, Environmental Division. June.

Brindock, K. 2012. Migratory Bird Monitoring, Naval Base Guam. NAVFAC Marianas, Environmental. October.

Brindock, K. 2013. Migratory Bird Monitoring, Naval Base Guam. NAVFAC Marianas, Environmental. October.

Brindock, K. 2014. Mariana Common Moorhen Monitoring at Fena Reservoir, Naval Base Guam. NAVFAC Marianas, Environmental. October.

Brindock, K. 2015. Unpublished data regarding sea turtle tagging within Apra Harbor. NAVFAC Marianas, Environmental.

Brooke, A. 2008. Mariana Fruit Bat Surveys on Navy Properties, Guam. NAVFAC Marianas Environmental. December.

Brooke, A. and Grimm, G. 2008. Mariana Common Moorhen Surveys on Fena Reservoir, Naval Munitions Site, Guam (FY2004-2008). NAVFAC Marianas Environmental, Guam. December.

Christy, M. T., Clark, C. S., Gee II, D. E., Vice, D., Vice, D. S., Warner, M. P., Tyrrell, C. L., Rodda, G. H., and Savidge, J. A. 2007. Recent records of alien anurans on the Pacific island of Guam. Pacific Science, 61, 469–483.

COMNAVMAR. 2013. Instruction 3500.4A. Marianas Training Manual. Department of the Navy, Joint Region Marianas.

Concepcion, G. B. and Nelson, S. G. 1999. Effects of a dam and reservoir on the distributions and densities of macrofauna in tropical streams of Guam (Mariana Islands). Journal of Freshwater Ecology, 14, 447–454.

Costion, C. M. and Lorence, D. H. 2012. The endemic plants of Micronesia: A geographical checklist and commentary. Micronesica, 43, 51–100.

Cota, M. 2008. *Varanus indicus* and its presence on the Mariana Islands: Natural geographic distribution vs. introduction. Biawak, 2, 18–27.

Crampton, H. E. 1925. Studies on the variation, distribution and evolution of the genus Partula. The species of the Mariana Islands, Guam and Saipan. Carnegie Institution of Washington, 228a, 1–116.

DeNicola, A. 2015. Non-native Ungulate Management and Research: Andersen AFB. Prepared by White Buffalo, Inc., Moodus, CT. 11 September.

DON. 2009. Interim Final Integrated Natural Resources Management Plan, Navy Base Guam, Plan Years 2009–2014. Prepared by Geo-Marine.

DON. 2010. Final Environmental Impact Statement. Guam and CNMI Military Relocation: Relocating Marines from Okinawa, Visiting Aircraft Carrier Berthing, and Army Air and Missile Defense Task Force. Volume 2: Marine Corps Relocation–- Guam. Prepared by NAVFAC Pacific, Pearl Harbor, HI for Joint Guam Program Office, Washington, D.C. July.

DON. 2014. Biological Assessment of Military Training Activities in the Mariana Islands Training and Testing Study Area: Terrestrial Species and Habitats; Re-initiation of Consultation 2009-F-0345 Military Training within the Mariana Islands Range Complex, Guam and the Commonwealth of the Northern Mariana Islands. Prepared by Commander, U.S. Pacific Fleet, Pearl Harbor, HI. August.

DON. 2015a. Joint Region Marianas Integrated Natural Resources Management Plan Summary of FY2015 Actions and Projects. Prepared by Cardno, Honolulu, HI and Bainbridge Island, WA. 22 October.

DON. 2015b. Regional Biosecurity Plan for Micronesia and Hawai‘i: 4 Volumes.

DON. 2017. Revised Biological Assessment for the Marine Corps Relocation from Okinawa to Guam. Prepared for USFWS, Pacific Islands Fish and Wildlife Office, Honolulu, HI and NAVFAC Pacific. March.

Dueñas, Camacho, and Associates, Inc. 2013. Evaluation of Erosion Control Plantings at Naval Munitions Site, Naval Base Guam. Prepared for DZSP 21 LLC – Guam BOSC, Santa Rita, GU. March.

Eggleston, C. 2009. Migratory Bird Surveys, Navy Lands Guam (23 Sep 08 – 28 Apr 09). NAVFAC Marianas, Environmental. May.

Englund, R. A. 2011. Guam and Palau Aquatic Insect Surveys. Prepared for Southeastern Ecological Science Center, USGS, Gainesville, FL. April.

Fitzsimons, J. M., Parham, J. E., and Nishimoto, R. T. 2002. Similarities in Behavioral Ecology among Amphidromous and Catadromous Fishes on the Oceanic Islands of Hawai‘i and Guam. Environmental Biology of Fishes, 65, 123–129.

Ford, J. and Kinzie, III, R. 1982. Life crawls upstream. Natural History Magazine, 91, 61–66.

Fritts, T. H. and Leasman-Tanner, D. 2001. The Brown Treesnake on Guam. How the Arrival of One Invasive Species Damaged the Ecology, Commerce, Electrical Systems, and Human Health on Guam: A Comprehensive Information Source (USGS Information and Technology Report No. 2002-0009). Fort Collins Science Center, Fort Collins, CO.

Gill, F. and Donsker, D. 2017. International Ornithologists' Union (IOC) World Bird List (v 7.3) (No. doi:10.14344/IOC.ML.7.3).

Gingerich, S. B. 2003. Hydrologic Resources of Guam (USGS Water-Resources Investigations Report No. 03–4126). Prepared in cooperation with the WERI, UOG, Mangilao, GU.

Gorresen et al. 2023. Videographic monitoring at caves to estimate population size of the endangered yayaguak (Mariana swiftlet) on Guam. Hawai‘i Cooperative Studies Unit, University of Hawai‘i at Hilo, Hawai‘i National Park, HI, USA.

GovGuam. 2009. Endangered Species Regulation No. 9. Department of Agriculture, Mangilao, GU. 6 November.

Guam Plant Extinction Prevention Program. 2021. Recovery and Sustainment Partnership Initiative - *Tuberolabium guamense* Summary Report: September 2019 – August 2020.

Guam DAWR. 2006. Comprehensive Wildlife Conservation Strategy (GCWCS). Guam DAWR. 2006. Comprehensive Wildlife Conservation Strategy (GCWCS). Department of Agriculture, Government of Guam, Mangilao, GU. 7 November.

Guam DAWR. 2015. Draft State Wildlife Action Plan. Department of Agriculture, Government of Guam, Mangilao, GU. 20 January.

Guam DAWR. 2019. Guam Wildlife Action Plan. Government of Guam. January.

Hopper, D. R. and Smith, B. 1992. Status of tree snails (Gastropoda: Partulidae) on Guam, with a resurvey of sites studied by H.E. Crampton in 1920. Pacific Science, 46, 77–85.

Johnson N.C., Haig S.M., Mosher S.M. (2018). Assessment of distribution and abundance estimates for Mariana Swiftlets (*Aerodramus bartschi*) via examination of survey methods. March.

JRM. 2010. JRM-administered Lands GIS Data.

JRM. 2013. Final Joint Region Marianas Integrated Natural Resources Management Plan. Prepared by HDR for Commander Joint Region Marianas, Guam, Hagatna, GU. December.

Kerr, A. M. 2012. Fish Names of the Mariana Islands, Micronesia (UOG Marine Laboratory Technical Report No. 139). Mangilao, GU. February.

Kerr, A. M. 2013. Annotated Checklist of the Aquatic snails of the Mariana Islands, Micronesia (Technical Report No. 147). UOG Marine Laboratory, Mangilao, GU.

Klug, P. E., Brindock, K. M., Reed, R. N., Yackel Adams, A. A., Mazurek, M. J., Pitt, W. C., and Stricker, C. A. 2014. Protection of Caves Important to the Endangered Mariana Swiftlet Through Effective Deployment of Control Tools Based on Brown Treesnake Behavior. National Military Fish and Wildlife Association. March.

Leberer, T. 2003. Records of freshwater turtles on Guam, Marianas Islands. Micronesica, 35–36, 649–652.

Leberer, T. and Cai, Y. 2003. Shrimps of the family Atyidae from Guam, Mariana Islands. Micronesica, 35–36, 355–358.

Liske-Clark, J. 2015. Wildlife Action Plan for the Commonwealth of the Northern Mariana Islands, 2015-2025. CNMI DLNR-Division of Fish and Wildlife, Saipan, MP. 16 December.

Lujan, D. 2017. BTS Survey Data at Mariana Swiftlet Caves, NMS, 2017. Personal communication via email from D. Lujan, EV2, JRM to J. Ford, Project Manager, Cardno, Honolulu, HI. 15 September.

Maciolek, J. A. 1984. Exotic Fishes in Hawai‘i and Other Islands of Oceania. Pages 131-136 *in* W. R. Courtenay and J. R. Stauffer (Eds.), Distribution, Biology, and Management of Exotic Fishes. Johns Hopkins University Press, Baltimore, MD.

Marineau, M. D. and Wright, S. A. 2017. Daily reservoir sedimentation model: Case study from the Fena Valley Reservoir, Guam. Journal of Hydraulic Engineering, 143.

Marler, T. E. and Lawrence, J. H. 2012. Demography of *Cycas micronesica* on Guam following introduction of the armoured scale *Aulacaspis yasumatsui*. Journal of Tropical Ecology, 28, 233–242.

McDowall, R. M. 1988. Diadromy in Fishes Migrations between Freshwater and Marine Environments. Timber Press, Portland, OR.

Morton, J. M. and Wiles, G. 2002. Observations of Mariana fruit bats (*Pteropus mariannus*) in the upper Talofofo watershed on southern Guam. Micronesica, 34, 155–163.

NAVFAC Marianas. 2014a. Wet-Season Survey Report: Mariana Common Moorhen Wetland Use and Population Survey. Prepared by Allied Pacific Environmental Consulting, Inc., Agana, GU. November.

NAVFAC Marianas. 2014b. Final Project Report: Federal Candidate Species Surveys on Guam. Prepared by D.P. Lindstrom and J.C. Benedict, College of Natural and Applied Sciences, UOG. 21 January.

NAVFAC Marianas. 2015. Final Survey Report Mariana Common Moorhen Wetland Use and Population Survey. Prepared by Allied Pacific Environmental Consulting, Inc., Agana, GU. March.

NAVFAC Marianas. 2016a. Land Use/Land Cover and Recovery Habitat Analysis for Lands Managed by Joint Region Marianas on Guam. Prepared by Cardno, Honolulu, HI. June.

NAVFAC Marianas. 2016b. Joint Region Marianas Integrated Natural Resources Management Plan (INRMP) Summary of FY2016 Actions and Projects. Prepared by Cardno, Honolulu, HI and Bainbridge Island, WA. October.

NAVFAC Marianas. 2016c. Mariana Swiftlet Survey Data, Naval Base Guam NMS, 1986-2017. Personal communication via email from Dr. A. Brooke, Conservation Program Manager, NAVFAC Marianas to R. Spaulding, Senior Biologist/Project Manager, Cardno, Bainbridge Island, WA. 19 December.

NAVFAC Marianas. 2017a. Joint Region Marianas Integrated Natural Resources Management Plan Summary of FY2017 Projects. Prepared by Cardno, Honolulu, HI and Bainbridge Island, WA. September.

NAVFAC Marianas. 2017b. Basewide plant surveys GIS data. Collected by UOG.

NAVFAC Marianas. 2017c. Mariana Fruit Bat Management Plan for Andersen AFB, Guam (Cooperative Agreement No. N40192-15-2-8001). Prepared by Mildenstein, T. and N. Johnson. UOG.

NAVFAC Marianas. 2021. Final Report. Plant and Invertebrate Surveys Joint Region Marianas Areas of Responsibility and Areas Specified on Guam and CNMI. Cooperative Agreement N40192-19-2-8000. October.

NAVFAC Marianas. 2022a. Ungulate Control, Eradication, and Basic Research on Naval Base Guam and Andersen Air Force Base for Joint Region Marianas, Guam Area of Responsibility. Draft. Submitted by White Buffalo Inc., 6B Kings Highway, Chester, CT 06412. May.

NAVFAC Marianas. 2022b. Final Report, ESA-Listed Plant and Invertebrate Surveys at Naval Base Guam Naval Munitions Site. Prepared by Island Eco Services., Barrigada, Guam. August.

NAVFAC Marianas. 2023a. Final Report. Plant and Invertebrate Surveys Joint Region Marianas Area of Responsibility and Areas Specified on Guam and CNMI. Cooperative Agreement N40192-19-2-8000. August.

NAVFAC Marianas. 2023b. Final Report (N40192-12-P-5004). ESA-Listed Plant and Invertebrate Surveys at Naval Base Guam Naval Munitions Site and Rota. Prepared by Island Eco Services, Mangilao, Guam. October.

NAVFAC Pacific. 2010. Final Natural Resource Survey Report in Support of the Environmental Impact Statement for the Marine Corps Relocation Initiative to Various Locations on Guam. Pearl Harbor, HI.

NAVFAC Pacific. 2011. Final Natural Resource Survey Report of Various Locations on Guam (Cabras, Lost River, GLUP 77, Dadi and Tipalao Beaches and Route 15 Valley). Prepared by AECOM, Bloomfield, NJ. 21 April.

NAVFAC Pacific. 2013. Final Report: Biological Surveys – Report 1, Various Locations on Guam in Support of the Guam and Commonwealth of the Northern Mariana Islands Military Relocation (2012 Roadmap Adjustments) Supplemental Environmental Impact Statement. Prepared by TEC-AECOM Joint Venture for Joint Guam Program Office, Honolulu, HI. April.

Nico, L. G. and Walsh, S. J. 2011. Non-indigenous Freshwater Fishes on Tropical Pacific Islands: A Review of Eradication Efforts. Pages 97-107 *in* C. R. Veitch, M. N. Clout, and D. R. Towns (Eds.), Island Invasives: Eradication and Management. IUCN, Gland, CH.

Paulay, G., Kropp, P. K. L., and Eldredge, L. G. 2003. The crustaceans and pycnogonids of the Mariana Islands. Micronesica, 35–36, 456–513.

Perez, G. 1972. Observations of Guam bats. Micronesica, 8, 141–149.

Pratt, L. W. 2011. Vegetation Assessment of Forests of Pagan Island, Commonwealth of the Northern Mariana Islands (Technical Report HCSU-023). Hawai‘i Cooperative Studies Unit, University of Hawai‘i, Hilo, HI. September.

Pregill, G. K. and Steadman, D. W. 2009. The prehistory and biogeography of terrestrial vertebrates of Guam, Mariana Islands. Diversity and Distributions, 15, 983–996.

Raulerson, L. 2006. Checklist of Plants of the Mariana Islands. UOG Herbarium Contribution, 37, 1–69.

Raulerson, L. and Rinehart, A. 1991. Trees and Shrubs of the Northern Mariana Islands. Coastal Resources Management, Office of the Governor.

Raulerson, L. and Rinehart, A. 1992. Ferns and orchids of the Mariana Islands. Self published.

Rodda, G. H. and Fritts, T. H. 1996. Reptiles of the Ordnance Annex, Naval Activities Guam. Prepared for U.S. Fish and Wildlife Service, Honolulu, HI by National Biological Service, Fort Collins, CO. July.

Rodda, G. H., Fritts, T. H., and Reichel, J. D. 1991. The distributional patterns of reptiles and amphibians in the Mariana Islands. Micronesica, 24, 195–210.

Sabol, B., Melton, E., Johnson, W., Britzke, E., Claiborne, J., and Brindock, K. 2011. Assessment of Techniques for Censusing Endangered Mariana Gray Swiftlets at Navy Base Guam. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi and U.S. Navy, Navy Base Guam, Santa Rita, GU.

Safford, W. 2009. The Chamorro Language of Guam. University of Michigan Library. 27 April.

Schreiner, I. H. and Nafus, D. M. 1996. Survey of Rare Butterflies in the Mariana Islands. Preliminary report to USFWS.

Scott, D. A. (Ed.). 1993. A Directory of Wetlands in Oceania. IWRB, Slimbridge, UK and AWB, Kuala Lumpur, MY.

Smith, B., Cooper-Nurse, R., and Gawel, A. M. 2008. Survey of Endangered Tree Snails on Navy-Owned Land in Guam. Draft. Prepared by UOG, Marine Laboratory for the U.S. Navy, Mangilao, GU.

Stinson, D. W., Ritter, M. W., and Reichel, J. D. 1991. The Mariana Common Moorhen: decline of an island endemic. Condor, 93, 38–43.

SWCA and TNWRE. 2007. Proposed supplemental water supply for the Fena Reservoir System, Naval Magazine, Guam. Prepared for SAIC and U.S. Joint Region Marianas.

Taborosi, D. 2004. Field Guide to Caves and Karst of Guam. Bess Press, Honolulu, HI.

Taborosi, D. 2006. Karst Inventory of Guam, Mariana Islands (No. 112). Water and Environmental Research Institute of the Western Pacific, UOG.

Takano, L. L. and Haig, S. M. 2004. Seasonal movement and home range of Mariana common moorhen. Condor, 106, 652–663.

Topping, D., Ogo, P., and Dungca, B. 1975. Chamorro-English Dictionary. University of Hawai‘i Press, Honolulu, HI.

Tracey, J. R., Schlanger, S. O., Stark, J. T., Doan, D. B., and May, H. G. 1964. General Geology of Guam. Geology and Hydrology of Guam, Mariana Islands (Geological Survey Professional Paper No. 403-A) U.S. Government Printing Office, Washington, D.C.

USDA. 1988. Soil Survey of Territory of Guam. USDA Soil Conservation Service, in cooperation with Guam Department of Commerce and UOG. Prepared by F.J. Young. May.

U.S. Navy. 2023a. Monitoring Mariana fruit bats on Guam Naval Munitions Site and Tinian Military Lease Area, 2022-2023. Prepared for NAVFAC Marianas, Guam. Prepared by T. Mildenstein, University of Guam, under Cooperative Agreement Number N40192-22-2-8001. April.

U.S. Navy. 2023b. Status Report. Monitoring Mariana fruit bats on the Naval Munitions Storage Area (Naval Base Guam) and the Military Leased Area (Tinian). Prepared for NAVFAC Marianas, Guam. Prepared by T. Mildenstein, University of Guam, under Cooperative Agreement Number N40192-22-2-8001. July.

USFWS. 1992. Recovery Plan, Mariana Islands Common Moorhen, (*Gallinula chloropus guami*). Portland, OR. September.

USFWS. 1998. Letter ELG. Informal Consultation under Section 7 of the Endangered Species Act for Firebucket and Drone Training Exercises at Fena Lake, Guam, by Helicopter Combat Support Squadron Five. Pacific Islands Ecoregion, Honolulu, HI. 30 October.

USFWS. 2009. Mariana Common Moorhen (*Gallinula chloropus guami*): 5-Year Review Summary and Evaluation. Honolulu, HI. 29 July.

USFWS. 2011. Guam and Commonwealth of the Northern Mariana Islands Animals and Plants: Updated February 2, 2011. Listed Species, as Designated under the U.S. Endangered Species Act.

USFWS. 2014. Endangered and Threatened Wildlife and Plants; Proposed Endangered Status for 21 Species and Proposed Threatened Status for 2 Species in Guam and the Commonwealth of the Northern Mariana Islands; Proposed Rule. Federal Register, 79(190), 59364–59413.

USFWS. 2015a. Endangered and Threatened Wildlife and Plants; Endangered Status for 16 Species and Threatened Status for 7 Species in Micronesia. Federal Register, 80(190), 59424–59497.

USFWS. 2015b. Biological Opinion for the Mariana Islands Testing and Training Program. Pacific Islands Fish and Wildlife Office, Honolulu, HI. 20 February.

USFWS. 2016. Reducing Bird Collisions with Buildings and Glass, Best Practices. Division of Migratory Bird Management, Falls Church, VA. January, updated July 2016.

USFWS. 2017. Reinitiation of the 2015 Biological Opinion on the Department of the Navy's Relocation of U.S. Marine Corps from Okinawa to Guam and Associated Activities on Guam (Consultation 01EPIF00-2015-F-0025 and 01EPIF00-2016-F-0185). Pacific Islands Fish and Wildlife Office, Honolulu, HI. 18 July.

USFWS. 2019. Amendment to the Recovery Plan for Mariana Islands Population of the Vanikoro Swiftlet (*Aerodramus vanikorensis bartschi)*. Pacific Region 1, Portland, OR.

USGS. 2018. NAS – Nonindigenous Aquatic Species database. Accessed 30 November 2017, from https://nas.er.usgs.gov/. 31 January.

Vogt, S. 2017a. Mariana Swiftlet Survey Data, Naval Base Guam NMS, 2017. Personal communication via email from S. Vogt, Biologist, NBG to R. Spaulding, Senior Biologist/Project Manager, Cardno, Bainbridge Island, WA. 19 September.

Vogt, S. 2017b. Estimated carabao population estimates within the NMS. Unpublished field notes. Personal communication from S. Vogt, Biologist , NBG to J. Ford, Pacific Operations Manager, Cardno, Honolulu, HI. December.

Vogt, S. 2017c. Nesting platforms in Fena Valley Reservoir within NMS. Personal communication in person from S. Vogt, Biologist, NBG to J. Ford, Pacific Operations Manager, Cardno, Honolulu, HI. December.

Wen, Y., Khosrowpanah, S., and Heitz, L. F. 2009. Watershed Land Cover Change on Guam (Technical Report No. 124). Water and Environmental Research Institute of the Western Pacific, UOG.

Wenninger, P. 2016. Migratory Bird Surveys, Navy Lands Guam. Personal communication via email from P. Wenninger, Natural Resources Specialist, Public Works Department, NBG and R. Spaulding, Senior Biologist/Project Manager, Cardno, Bainbridge Island, WA.

WERI. 2008. Guam Hydrologic Survey (GHS) and Comprehensive Water Monitoring Program (CMP). FY 2008 Status Report. UOG. October.

Wiewel, A. S., Yackel Adams, A. A., and Rodda, G. H. 2009. Distribution, density, and biomass of introduced small mammals in the Southern Mariana Islands. Pacific Science, 63, 205–222.

Wiles, G. 1987. The Status of Fruit Bats on Guam. Pacific Science, 41, 148–157.

Wiles, G., Bart, J., Beck Jr., R. E., and Aguon, C. F. 2003. Impacts of the brown treesnake: patterns of decline and species persistence in Guam's avifauna. Conservation Biology, 17, 1350–1360.

Zarones, L., Liske-Clark, J., Willsey, T., and Ulloa, R. 2015. Preliminary survey of three Mariana Island endemic epiphytic orchids *Dendrobium guamense*, *Bulbophyllum guamense* and *Tuberolabium guamense* on Rota, CNMI DFW and DLNR Report.

Zug, G. 2013. Reptiles and Amphibians of the Pacific Islands: A Comprehensive Guide. University of California Press, Los Angeles, CA.

15.7 CHAPTER 7 – APRA HEIGHTS, SASA VALLEY AND TENJO VISTA TANK FARMS, NCTS BARRIGADA AND BARRIGADA TRANSMITTER SITE, AND MCBCB URBAN TRAINING COMPLEX

AECOS, Inc. and Wil Chee Planning, Inc. 2009. Final Guam and Tinian Wetlands Inventory. Honolulu, HI. September.

Alexander, I. 2015. Photos of treesnail observed at Sasa Tank Farm. Personal communication via email from I. Alexander, Biological Scientist, APEC, Guam to D. Janecke, Wildlife Biologist, HDR, Inc., San Diego, CA.

Bedford, G. 1980. Biology, Ecology, and Control of Palm Rhinoceros Beetles. Annual Review of Entomology, 25, 309–339.

BioSystems Analysis, Inc. 1989. Natural Resources Survey for the U.S. Naval Magazine, Guam (NAVMAG). Prepared for NAVFAC Pacific, Pearl Harbor, HI.

COMNAVMAR. 2013. Instruction 3500.4A. Marianas Training Manual. Department of the Navy, Joint Region Marianas.

DON. 2010a. Final Environmental Impact Statement. Guam and CNMI Military Relocation: Relocating Marines from Okinawa, Visiting Aircraft Carrier Berthing, and Army Air and Missile Defense Task Force. Volume 2: Marine Corps Relocation–- Guam. Prepared by NAVFAC Pacific, Pearl Harbor, HI for Joint Guam Program Office, Washington, D.C. July.

DON. 2010b. Mariana Islands Range Complex Final Environmental Impact Statement/Overseas Environmental Impact Statement. Volume 1. Prepared by NAVFAC Pacific, Pearl Harbor, HI. May.

DON. 2014. Biological Assessment of Military Training Activities in the Mariana Islands Training and Testing Study Area: Terrestrial Species and Habitats; Re-initiation of Consultation 2009-F-0345 Military Training within the Mariana Islands Range Complex, Guam and the Commonwealth of the Northern Mariana Islands. Prepared by Commander, U.S. Pacific Fleet, Pearl Harbor, HI. August.

DON. 2015a. Mariana Islands Training and Testing Activities Final Environmental Impact Statement/Overseas Environmental Impact Statement. Volume 1. Prepared by NAVFAC Pacific, Pearl Harbor, HI. May.

DON. 2015b. Final Supplemental Environmental Impact Statement Guam and the Commonwealth of the Northern Mariana Islands Military Relocation (2012 Roadmap Adjustments). Prepared by NAVFAC Pacific, Pearl Harbor, HI for Joint Guam Program Office, Washington, D.C. July.

DON. 2015c. Regional Biosecurity Plan for Micronesia and Hawai‘i: 4 Volumes.

Gill, F. and Donsker, D. 2017. International Ornithologists' Union (IOC) World Bird List (v 7.3) (No. doi:10.14344/IOC.ML.7.3).

GovGuam. 2009. Endangered Species Regulation No. 9. Department of Agriculture, Mangilao, GU. 6 November.

Guam DAWR. 2006. Comprehensive Wildlife Conservation Strategy (GCWCS). Guam DAWR. 2006. Comprehensive Wildlife Conservation Strategy (GCWCS). Department of Agriculture, Government of Guam, Mangilao, GU. 7 November.

Guam DAWR. 2017a. Unpublished data: "a single Mariana fruit bat (*Pteropus mariannus mariannus*) was observed in the Aplacho River ravine flying in the direction of east-northeast behind the housing area." Comment received from Guam DAWR during review of draft INRMP. August.

Guam DAWR. 2017b. Unpublished data. "Migratory birds are known to occur at the mowed, open-fields at the Apra Housing areas. Cattle egret, golden plover, curlew and whimbrel have been seen in these areas from 2010-2015." Comment received from Guam DAWR during review of draft INRMP. August.

Guam DAWR. 2017c. Unpublished data. "Guam DAWR biologists speculate that the habitat found in the Sasa Valley and Tenjo Vista areas support bat roosting and foraging." Comment received from Guam DAWR during review of draft INRMP. August.

Guam DAWR. 2017d. Unpublished data. "Barrigada Transmitter Site is known to harbor migratory birds during wintering months Plover, egrets, whimbrel and yellow bittern" Comment received from Guam DAWR during review of draft INRMP. August.

Guam DAWR. 2017e. Unpublished data. "In 2014, the native white-throated ground dove, and in 2016 the native Micronesian starling were observed at NCTS Barrigada." Comment received from Guam DAWR during review of draft INRMP. August.

Guam DAWR. 2017f. Unpublished data. In 2013, Mariana fruit bat was observed between Barrigada Hill (historic colony site) and NCTS Barrigada pipeline road. Roosted on dukduk tree between pipeline and golf course perimeter road. Comment received from Guam DAWR during review of draft INRMP. August.

Guam DAWR. 2017g. Unpublished data. "On Dec 2012 and May 2016, a single fruit bat was observed circling above east area of Andy South, location where dukduk occurs. DAWR staff was not able to confirm location due to safety from a wild dog pack in the area. The fruit bat was only observed once at both times". Comment received from Guam DAWR during review of draft INRMP. August.

Guam DAWR. 2017h. Unpublished data. In May 2016, the native Micronesian starling was observed during DAWR's annual spring bird count. Comment received from Guam DAWR during review of draft INRMP. August.

Guam DAWR. 2017i. Unpublished data. "…the white-throated ground dove […] have been reported, some of which, observed relatively adjacent to Andy South proper, since 2008 to present." Comment received from Guam DAWR during review of draft INRMP. August.

Hopper, D. R. and Smith, B. 1992. Status of tree snails (Gastropoda: Partulidae) on Guam, with a resurvey of sites studied by H.E. Crampton in 1920. Pacific Science, 46, 77–85.

JRM. 2010. JRM-administered Lands GIS Data.

Liske-Clark, J. 2015. Wildlife Action Plan for the Commonwealth of the Northern Mariana Islands, 2015-2025. CNMI DLNR-Division of Fish and Wildlife, Saipan, MP. 16 December.

Marler, T. E. and Lawrence, J. H. 2012. Demography of *Cycas micronesica* on Guam following introduction of the armoured scale *Aulacaspis yasumatsui*. Journal of Tropical Ecology, 28, 233–242.

MCAG. 2017. Unpublished data. Technical memorandum on results of field surveys for listed endangered orchids within DoD installations on Guam, provided by N. Olmsted, MCAG to R. Spaulding, Senior Biologist/Project Manager, Cardno. May.

NAVFAC Marianas. 2014a. Final Project Report: Federal Candidate Species Surveys on Guam. Prepared by D.P. Lindstrom and J.C. Benedict, College of Natural and Applied Sciences, UOG. 21 January.

NAVFAC Marianas. 2014b. Wet-Season Survey Report: Mariana Common Moorhen Wetland Use and Population Survey. Prepared by Allied Pacific Environmental Consulting, Inc., Agana, GU. November.

NAVFAC Marianas. 2015. Federal Candidate Endangered Species Surveys at Andersen AFB. Prepared by B. Holland and D. Rubinoff, University of Hawai‘i, Manoa.

NAVFAC Marianas. 2016. Land Use/Land Cover and Recovery Habitat Analysis for Lands Managed by Joint Region Marianas on Guam. Prepared by Cardno, Honolulu, HI. June.

NAVFAC Marianas. 2017. *Psychotria* Criteria Review and Evaluation. Prepared by L. Gutierrez, Botanist, MCAG. 23 January.

NAVFAC Marianas and Andersen AFB. 2015. Monitoring Mariana Fruit Bats on AFB 2015. Prepared by T. Mildenstein and R. Miller, Biology Program, UOG. July.

NAVFAC Pacific. 2010a. Preliminary Wetland Identification for Various Locations on Guam In Support of the Guam Military Buildup EIS. Prepared by TEC, Inc. Joint Venture, Honolulu, HI. June.

NAVFAC Pacific. 2010b. Final Natural Resource Survey Report in Support of the Environmental Impact Statement for the Marine Corps Relocation Initiative to Various Locations on Guam. Pearl Harbor, HI.

NAVFAC Pacific. 2013. Biological Surveys – Report 2, Various Locations on Guam in Support of the Guam and Commonwealth of the Northern Mariana Islands Military Relocation (2012 Roadmap Adjustments) Supplemental Environmental Impact Statement. Prepared by TEC-AECOM Joint Venture for Joint Guam Program Office, Honolulu, HI. April.

NAVFAC Pacific. 2017. Final Natural Resources Survey Report in Support of the Environmental Assessment for Proposed Munitions Storage Igloo Construction, Andersen AFB, Guam. Prepared by Cardno, Inc., Honolulu, HI. February.

NBG. 2016. Naval Base Guam Installation Development Plan – Final. Prepared by Helber, Hastert, and Fee, Inc., Honolulu, HI. February.

Olmsted, N. 2016. GIS Data for Plant Surveys and General Handling Requirements of High Value Trees (HVTs) to Support Project J755 at Andersen South. Personal communication via email from N. Olmsted, Natural Resources Specialist, DPRI Environmental, NAVFAC Marianas, Guam to R. Spaulding, Senior Biologist/Project Manager, Cardno, Bainbridge Island, WA. December.

Raymundo, M. and Miller, R. H. 2012. Little fire ant, *Wasmannia auropunctata* (Roger) (Hymenoptera: Formicidae), established at several locations on Guam. Proceedings of the Hawaiian Entomological Society, 44, 85–87.

Ritter, M. W. and Savidge, J. A. 1999. A predictive model of wetland habitat use of Guam by endangered Mariana Common Moorhens. Condor, 101, 282–287.

Safford, W. 2009. The Chamorro Language of Guam. University of Michigan Library. 27 April.

Smith, S. and Moore, A. 2008. Early detection pest risk assessment: coconut rhinoceros beetle (No. R5-FHP-2008-01). March.

Topping, D., Ogo, P., and Dungca, B. 1975. Chamorro-English Dictionary. University of Hawai‘i Press, Honolulu, HI.

USDA. 1988. Soil Survey of Territory of Guam. USDA Soil Conservation Service, in cooperation with Guam Department of Commerce and UOG. Prepared by F.J. Young.

USFS. 2006. Guam Vegetation Mapping. Pacific Southwest Region, Forest Health Protection, McClellan, CA. October.

USFS. 2014. Current Forest Conditions in the U.S.-Affiliated Pacific Islands (Pacific Islands Forest Health Report). Prepared by R. Neville.

USFWS. 2014. Endangered and Threatened Wildlife and Plants; Proposed Endangered Status for 21 Species and Proposed Threatened Status for 2 Species in Guam and the Commonwealth of the Northern Mariana Islands; Proposed Rule. Federal Register, 79(190), 59364–59413.

USFWS. 2015a. Endangered and Threatened Wildlife and Plants; Endangered Status for 16 Species and Threatened Status for 7 Species in Micronesia. Federal Register, 80(190), 59424–59497.

USFWS. 2015b. Biological Opinion for the Mariana Islands Testing and Training Program. Pacific Islands Fish and Wildlife Office, Honolulu, HI.

USFWS. 2016. Reducing Bird Collisions with Buildings and Glass, Best Practices. Division of Migratory Bird Management, Falls Church, VA. January, updated July 2016.

USFWS. 2017. Reinitiation of the 2015 Biological Opinion on the Department of the Navy's Relocation of U.S. Marine Corps from Okinawa to Guam and Associated Activities on Guam (Consultation 01EPIF00-2015-F-0025 and 01EPIF00-2016-F-0185). Pacific Islands Fish and Wildlife Office, Honolulu, HI. 18 July.

Vanderwoude, C. 2014. Managing the impacts of the little fire ant (*Wasmannia auropunctata*) in French Polynesia. Secretariat of the Pacific Regional Environment Programme (SPREP), Apia, WS.

Vogt, S. and Farley, J. O. 2013. Marianas Fruit Bat (*Pteropus mariannus*) Surveys on Andersen South, Andersen AFB, Guam. NAVFAC Marianas. March.

WERI. 2008. Guam Hydrologic Survey (GHS) and Comprehensive Water Monitoring Program (CMP). FY 2008 Status Report. UOG. October.

WERI and IREI. 2016. Digital Atlas of Southern and Northern Guam. Accessed 25 September 2017, from http://south.hydroguam.net/index.php and http://north.hydroguam.net/index.php.

Wiewel, A. S., Yackel Adams, A. A., and Rodda, G. H. 2009. Distribution, density, and biomass of introduced small mammals in the Southern Mariana Islands. Pacific Science, 63, 205–222.

Wiles, G. 2005. A checklist of the birds and mammals of Micronesia. Micronesica, 38, 141–189.

Wiles, G., Bart, J., Beck Jr., R. E., and Aguon, C. F. 2003. Impacts of the brown treesnake: patterns of decline and species persistence in Guam's avifauna. Conservation Biology, 17, 1350–1360.

15.8 CHAPTER 8 – ANDERSEN AIR FORCE BASE

Albert, S., O'Neil, J. M., Udy, J. W., Ahern, K. S., O'Sullivan, C. M., and Dennison, W. C. 2005. Blooms of the cyanobacterium *Lyngbya majusculta* in coastal Queensland, Australia: disparate sites, common factors. Marine Pollution Bulletin, 51, 428–437.

Amesbury, S. S., Chirichetti, P. R., and Dutka-Gianelli, J. 1995a. Andersen AFB Marine Resources Preserve Baseline Survey of Marine Resources: Sixth Survey, March-April 1995.

Amesbury, S. S., Chirichetti, P. R., and Dutka-Gianelli, J. 1995b. Andersen AFB Marine Resources Preserve Baseline Survey of Marine Resources: Seventh Survey, May 1995.

Amesbury, S. S., Chirichetti, P. R., and Dutka-Gianelli, J. 1995c. Andersen AFB Marine Resources Preserve Baseline Survey of Marine Resources: Fifth Survey, January 1995.

Amesbury, S. S., Chirichetti, P. R., and Dutka-Gianelli, J. 1995d. Andersen AFB Marine Resources Preserve Baseline Survey of Marine Resources: Fourth Survey, September-October 1994.

Andersen AFB. 2008. The Effects of Flight Operations on Endangered Mariana Fruit Bats and Mariana Crows: A Monitoring Program for Andersen AFB, Guam. Prepared for 3^{6t}h Civil Engineering Squadron, Environmental Flight, Andersen AFB, Guam and Air Force Center for Engineering and the Environment, Brooks City-Base, TX. May.

Andersen AFB. 2014. *Serianthes* Monitoring, Final Report. Prepared by Isla Paraiso, Barrigada, Guam for Natural Resources Conservation Program, 36 CES/CEVN, Andersen AFB. April.

Bergman, D. L., Breck, S. W., and Bender, S. C. 2009. Dogs Gone Wild: Feral Dog Damage in the United States. Pages 177-183 *in* J.R. Boulanger, ed. Proceedings of the 1^{3t}h Wildlife Damage Management Conference. Nebraska City, NE.

Brainard, R. E., Asher, J., Blyth-Skyrme, V., Coccagna, E. F., Dennis, K., Donovan, M. K., Gove, J. M., Kenyon, J., Looney, E. E., Miller, J. E., Timmers, M., Vargas-Ángel, B., Vroom, P. S., Vetter, O., and Zgliczynski, B. 2012. Coral Reef Ecosystem Monitoring Report of the Mariana Archipelago: 2003 to 2007 (PIFSC Special Publication No. SP-12-01). NOAA Fisheries, Pacific Islands Fisheries Science Center. Honolulu, HI. March.

Brown, V. 2015. Sightings of Threatened Corals around Guam. Personal communication via email from V. Brown, Fisheries Biologist, NOAA Fisheries PIRO HCD Guam Field Office to S. Hanser, Supervisory Marine Biologist, NAVFAC Pacific, Pearl Harbor, HI. February.

Bryan, P. G. 1973. Growth rate, toxicity and distribution of the encrusting sponge *Terpios* sp. (Hadromerida: Suberitidae) in Guam, Mariana Islands. Micronesica, 9, 237–242.

Burdick, D. 2018. COTS have now eaten many of their preferred prey species and are switching to non-preferred prey in Guam. Personal communication via email from D. Burdick, UOG Marine Laboratory, Mangilao, Guam to M. Lybolt, Marine Ecologist/Project Manager, Cardno, Honolulu, HI. 8 February.

Burdick, D. and Brown, V. 2011. Comprehensive Long-Term Monitoring at Permanent Sites in Guam. Prepared for NOAA Coral Reef Conservation Program (CRCP).

Burdick, D., Brown, V., Asher, J., Gawel, M., Goldman, L., Hall, A., Kenyon, J., Leberer, T., Lundblad, E., McIlwain, J., Miller, J., Minton, D., Nadon, M., Pioppi, N., Raymundo, L., Richards, B., Schroeder, R., Schupp, P., Smith, E., and Zgliczynski, B. 2008. The State of Coral Reef Ecosystems of Guam. Pages 465-509 *in* J. E. Waddell and J. M. Clarke (Eds.), The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2008. NOAA Technical Memorandum NOS NCCOS 73. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team, Silver Spring, MD. April.

Carilli, J. E., Norris, R. D., Black, B. A., Walsh, S. M., and McField, M. 2009. Local Stressors Reduce Coral Resilience to Bleaching. PLOS ONE, 4, e6324. July.

Caves, E. M., Jennings, S. B., Hille Ris Lambers, J., Teweksbury, J. J., and Rogers, H. S. 2013. Natural experiment demonstrates that bird loss leads to cessation of dispersal of native seeds from intact to degraded forests. PLOS ONE, 8, e65618.

Chesher, R. H. 1969a. Destruction of Pacific corals by the sea star *Acanthaster planci*. Science, 165, 280–283.

Chesher, R. H. 1969b. *Acanthaster planci* Impact on Pacific Coral Reefs. Final Report. Prepared by Research Laboratories Westinghouse Electric Corporation, Pittsburgh, PA for U.S. Department of Interior, Washington, D.C. 15 October.

COMNAVMAR. 2013. Instruction 3500.4A. Marianas Training Manual. Department of the Navy, Joint Region Marianas.

Crampton, H. E. 1925. Studies on the variation, distribution and evolution of the genus Partula. The species of the Mariana Islands, Guam and Saipan. Carnegie Institution of Washington, 228a, 1–116.

Crombie, R. I. and Pregill, G. K. 1999. A checklist of the herpetofauna of the Palau Islands (Republic of Belau), Oceania. Herpetological Monographs, 13, 29–80.

Crosby, M. P. and Reese, E. S. 1996. A Manual for Monitoring Coral Reefs with Indicator Species: Butterflyfishes as Indicators of Change on Indo-Pacific Reefs. Office of Ocean and Coastal Resource Management, NOAA, Silver Spring, MD.

Crosby, M. P., Reese, E. S., and Berumen, M. L. 2013. Corallivorous Butterflyfishes as Ambassadors of Coral Reefs. Pages 246-268 *in* M. S. Pratchett, M. L. Berumen, and B. G. Kapoor (Eds.), Biology of Butterflyfishes. CRC Press, Boca Raton, FL.

Davis, G. W. 1992. Sea Turtle Monitoring Annual Report (Unpublished report). Guam Division of Aquatic and Wildlife Resources, Mangilao, GU.

Deakos, M. H., Uyeyama, R. K., Richie, M. W., Richlen, M. F., and Aschettino, J. M. 2016. Guam Marine Species Monitoring Survey, Shore Station Study, May 2013 and March 2015. Final Field Report. Prepared for Commander, U.S. Pacific Fleet, Environmental Readiness Division, Pearl Harbor, HI. January.

DeNicola, A. 2015. Non-native Ungulate Management and Research: Andersen AFB. Prepared by White Buffalo, Inc., Moodus, CT. 11 September.

DoD. 2010. Quadrennial Defense Review Report.

DoD. 2014. Quadrennial Defense Review Report 2014.

DoD. 2018. 2018 National Defense Strategy of the United States of America.

DON. 2009. Interim Final Integrated Natural Resources Management Plan, Navy Base Guam, Plan Years 2009–2014. Prepared by Geo-Marine.

DON. 2010. Final Environmental Impact Statement. Guam and CNMI Military Relocation: Relocating Marines from Okinawa, Visiting Aircraft Carrier Berthing, and Army Air and Missile Defense Task Force. Volume 2: Marine Corps Relocation–Guam. Prepared by NAVFAC Pacific, Pearl Harbor, HI for Joint Guam Program Office, Washington, D.C. July.

DON. 2015a. Record of Decision for the Final Supplemental Environmental Impact Statement for Guam and Commonwealth of the Northern Mariana Islands Military Relocation. 28 August.

DON. 2015b. Mariana Islands Training and Testing Activities Final Environmental Impact Statement/Overseas Environmental Impact Statement. Volume 2. Prepared by NAVFAC Pacific, Pearl Harbor, HI. May.

DON. 2015c. Final Supplemental Environmental Impact Statement Guam and the Commonwealth of the Northern Mariana Islands Military Relocation (2012 Roadmap Adjustments). Prepared by NAVFAC Pacific, Pearl Harbor, HI for Joint Guam Program Office, Washington, D.C. July.

DON. 2015d. Joint Region Marianas Integrated Natural Resources Management Plan Summary of FY2015 Actions and Projects. Prepared by Cardno, Honolulu, HI and Bainbridge Island, WA. 22 October.

DON. 2015e. Regional Biosecurity Plan for Micronesia and Hawai‘i: 4 Volumes.

DON and USFWS. 2015a. Memorandum of Agreement between the Department of the Navy and the U.S. Fish and Wildlife Service Regarding Conservation of Guam Micronesian Kingfisher Recovery Habitat in Northern Guam. 11 June.

DON and USFWS. 2015b. Modification to Memorandum of Agreement between the Department of the Navy and the U.S. Fish and Wildlife Service: Designation of Alternative Configuration for Guam Micronesian Kingfisher Recovery Habitat in Northern Guam. 22 December.

Donaldson, T. J. 1989. Facultative monogamy in obligate coral-dwelling hawkfishes (Cirrhitidae). Environmental Biology of Fishes, 26, 295–302. January.

Donaldson, T. J. 1990. Reproductive behavior and social organization of some Pacific hawkfishes (Cirrhitidae). Japanese Journal of Ichthyology, 36, 439–458. December.

Downs, C. A., Kramarsky-Winter, E., Segal, R., Fauth, J., Knutson, S., Bronstein, O., Ciner, F. R., Jeger, R., Lichtenfeld, Y., Woodley, C. M., Pennington, P., Cadenas, K., Kushmaro, A., and Loya, Y. 2016. Toxicopathological effects of the sunscreen UV filter, oxybenzone (benzophenone-3), on coral planulae and cultured primary cells and its environmental contamination in Hawai‘i and the U.S. Virgin Islands. Archives of Environmental Contamination and Toxicology, 70, 265–288.

Fenner, D. 2014. Fishing down the largest coral reef fish species. Marine Pollution Bulletin, 84, 9–16.

Fulling, G., Thorson, P., and Rivers, J. 2011. Distribution and abundance estimates for cetaceans in the waters off Guam and the Commonwealth of the Northern Mariana Islands. Pacific Science, 65, 321–343.

Gill, F. and Donsker, D. 2017. International Ornithologists' Union (IOC) World Bird List (v 7.3) (No. doi:10.14344/IOC.ML.7.3).

Gingerich, S. B. 2003. Hydrologic Resources of Guam (USGS Water-Resources Investigations Report No. 03–4126). Prepared in cooperation with the WERI, UOG, Mangilao, GU.

Gottdenker, N. L., Walsh, T., Vargas, H., Merkel, J., Jimenez, G. U., Miller, R. E., Dailey, M., and Parker, P. G. 2005. Assessing the risks of introduced chickens and their pathogens to native birds in the Galapagos Archipelago. Biological Conservation, 126, 429–439.

GovGuam. 2009. Endangered Species Regulation No. 9. Department of Agriculture, Mangilao, GU. 6 November.

GovGuam, U.S. Air Force, U.S. Navy, and U.S. Fish and Wildlife Service. 1993. Memorandum of Understanding among the Government of Guam and the U.S. Air Force and the U.S. Navy and the U.S. Fish and Wildlife Service for the Establishment and Management of the Guam National Wildlife Refuge, Guam. December.

Graham, K. S., Boggs, C. H., DeMartini, E. E., Schroeder, R. E., and Trianni, M. S. 2015. Status review report: humphead wrasse (*Cheilinus undulatus*) (NOAA Technical Memo No. NOAA-TM-NMFS-PIFSC-48). Honolulu, HI. October.

Guam DAWR. 2006. Comprehensive Wildlife Conservation Strategy (GCWCS). Guam DAWR. 2006. Comprehensive Wildlife Conservation Strategy (GCWCS). Department of Agriculture, Government of Guam, Mangilao, GU. 7 November,

Guam DAWR. 2015. Draft State Wildlife Action Plan. Department of Agriculture, Government of Guam, Mangilao, GU. 20 January.

Guam Homeland Security. 2014. 2014 Guam Hazard Mitigation Plan. Guam Office of Civil Defense. Prepared by URS Group. April.

Harmelin-Vivien, M. L. and Bouchon-Navaro, Y. 1983. Feeding diets and significance of coral feeding among Chaetodontid fishes in Moorea (French Polynesia). Coral Reefs, 2, 119–127. August.

Hartzell, P. 2018a. Personal communication from P. Hartzell, 3^{6t}h Wing Environmental Flight, Andersen AFB to J. Ford, Cardno-GS, Honolulu via email. 3 March.

Hartzell, P. 2018b. Personal Communication via email from P. Hartzell to J. Ford. 26 March.

Harvey, C. 2016. 'I cried…right into my mask': Scientists say Guam's reefs have bleached four years straight. Washington Post. Accessed 21 May 2018, from https://www.washingtonpost.com/news/energy-environment/wp/2016/08/03/i-cried-right-into-my-mask-these-coral-reefs-have-seen-a-devastating-four-years-of-bleaching/?utm_term=.a330b8c4784c. 3 August.

Heenan, A., Ayotte, P., McCoy, K., Williams, I., and Zamzow, J. 2015. Coral Reef Ecosystem Program Standard Operating Procedures: Data Collection for Rapid Ecological Assessment Fish Surveys (Administrative Report No. H-15-07). Pacific Islands Fisheries Science Center, National Marine Fisheries Service, NOAA, Honolulu, HI. December.

Heyward, A. J. and Negri, A. P. 1999. Natural inducers for coral larval metamorphosis. Coral Reefs, 18, 273–279.

Hill, M., Ligon, A., Deakos, M., Ü, A. C., Norris, E., and Oleson, E. 2012. Cetacean Surveys of Guam and CNMI Waters: August-September, 2011 (PIFSC Data Report No. DR-12-002). Pacific Islands Fisheries Science Center. 24 February.

Hill, M., Ligon, A., Deakos, M., Ü, A. C., Milette-Winfree, A., and Oleson, E. 2013. Cetacean Surveys of Guam and CNMI Waters: May–July, 2012, Including Individual Photo-Identification of Pilot Whales, Spinner Dolphins and Bottlenose Dolphins (2010-2012) (PIFSC Data Report No. DR-13-001). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 8 February.

Hill, M., Ligon, A., Deakos, M., Ü, A. C., Milette-Winfree, A., Oleson, E., and Bendlin, A. 2014. Cetacean surveys in the waters of the southern Mariana Archipelago (February 2010-April 2014) (PIFSC Data Report No. DR-14-013). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 2 September.

Hill, M., Oleson, E. M., Ligon, A. D., Martien, K. K., Archer, F. I., Baumann-Pickering, S., Bendlin, A. R., Dolar, L., Merkens, K. P. B., Milette-Winfree, A., Morin, P. A., Rice, A., Robertson, K. M., Trickey, J. S., Ü, A. C., Van Cise, A. M., and Woodman, S. M. 2015. Cetacean Monitoring in the Mariana Islands Range Complex, 2014 (PIFSC Data Report No. DR-15-003). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 27 March.

Hill, M., Oleson, E. M., Baumann-Pickering, S., VanCise, A. M., Ligon, A. D., Bendlin, A. R., Ü, A. C., Trickey, J. S., and Bradford, A. L. 2016. Cetacean Monitoring in the Mariana Islands Range Complex, 2015 (PIFSC Data Report No. DR-16-01). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 6 February.

Hill, M., Bendlin, A. R., Ü, A. C., Yano, K. M., Bradford, A. L., Ligon, A. D., and Oleson, E. M. 2017. Cetacean Monitoring in the Mariana Islands Range Complex, 2016 (PIFSC Data Report No. DR-17-002). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 3 February.

Hoot, W. and Burdick, D. 2017. Guam Coral Bleaching Response Plan. Contributions by the Guam Coral Reef Response Team. December.

Hopper, D. R. and Smith, B. 1992. Status of tree snails (Gastropoda: Partulidae) on Guam, with a resurvey of sites studied by H.E. Crampton in 1920. Pacific Science, 46, 77–85.

Horeg, J. 2017. Unpublished data on green turtle nesting at Andersen AFB in 2017. Personal communication from J. Horeg, Natural Resources Specialist, JRM Guam, to J. Ford, Pacific Operations Manager, Cardno-GS, Honolulu via email. 5 November.

Houk, P. and Starmer, J. 2010. Constraints on the diversity and distribution of coral reef assemblages in the volcanic Northern Mariana Islands. Coral Reefs, 29, 59–70.

Houk, P. and van Woesik, R. 2008. Dynamics of shallow-water assemblages in the Saipan Lagoon. Marine ecology progress series, 356, 39–50.

Janeke, D., Amar, A., and Esselstyn, J. A. 2006. Impact of post-typhoon hunting on Mariana fruit bats (*Pteropus mariannus*). Pacific Science, 60, 531–539.

Jocson, J. M. U., Jenson, J. W., and Contractor, D. N. 2002. Recharge and aquifer response: Northern Guam lens aquifer, Guam, Mariana Islands. Journal of Hydrology, 260, 231–254.

Johnson, N. 2016a. Information regarding *Bulbophyllum guamense* observation at Andersen AFB. Personal communication via email from N. Johnson, Biologist, Cardno, Saipan, CNMI to R. Spaulding, Senior Biologist/Project Manager, Cardno, Bainbridge Island, WA. 1 September.

Johnson, N. 2016b. Occurrence of *Bulbophyllum guamense* Northwest of Andersen AFB Flightline, 1 September 2016. Personal communication via email from N. Johnson, Biologist, Cardno, Saipan, CNMI to R. Spaulding, Senior Biologist/Project Manager, Cardno, Bainbridge Island, WA. 1 September.

Jones, T. T., Martin, S. L., and Van Houtan, K. S. 2015. Sea Turtle Tagging in the Mariana Islands Range Complex (MIRC) Interim Progress Report (PIFSC Data Report No. DR-15-020). Prepared for U.S. Pacific Fleet Environmental Readiness Office, Pearl Harbor, HI. September.

JRM. 2010. JRM-administered Lands GIS Data.

JRM. 2013. Final Joint Region Marianas Integrated Natural Resources Management Plan. Prepared by HDR for Commander Joint Region Marianas, Guam, Hagatna, GU. December.

JRM. 2019. JRM-administered Submerged Lands GIS Data.

JRM and Andersen AFB. 2016. Area Development Plan MSA 1 Earth Covered Magazines. Draft Report prepared by Jacobs. 11 November.

JRM, NAVFAC Marianas, and Andersen AFB 36 CES/CEV. 2012. Final Summary Report: Noise Study and Demographic Survey of Mariana Fruit Bats and Mariana Crows, Andersen AFB, Guam. Prepared by SWCA Environmental Consultants, Hagatna, GU. 11 May.

Kendall, M. S. and Poti, M. 2015. Transport Pathways of Marine Larvae Around the Mariana Archipelago (NOAA Technical Memorandum NOS NCCOS 193). Silver Spring, MD.

Kerr, A. M. 1990. Chamorro Fish Names. Micronesica, 23, 93–118.

Kerr, A. M. 2012. Fish Names of the Mariana Islands, Micronesia (UOG Marine Laboratory Technical Report No. 139). Mangilao, GU. February.

Klinck, H., Kindermann, L., and Boebel, O. 2016. PALAOA: The Perennial Acoustic Observatory in the Antarctic Ocean – Real-time Eavesdropping on the Antarctic Underwater Soundscape. Pages 207-219 *in* Listening in the Ocean. Springer, New York, NY.

Klinck, H., Nieukirk, S. L., Fregosi, S., Klinck, K., Mellinger, D. K., Latuska, S., Shilling, B., and Luby, J. C. 2015. Cetacean Studies on the Mariana Islands Range Complex in September-November 2014: Passive Acoustic Monitoring of Marine Mammals Using Gliders. Final Report. Prepared for Commander, U.S. Pacific Fleet, Environmental Readiness Division, Pearl Harbor, HI. August.

Lagerloef, G. S. E., Mitchum, G. T., Lukas, R. B., and Niiler, P. P. 1999. Tropical Pacific near-surface currents estimated from altimeter, wind, and drifter data. Journal of Geophysical Research, 104, 23, 313–23, 326.

Lardner, B., Reed, R. N., Yackel Adams, A. A., Mazurek, M., Hinkle, T. J., Levasseur, P. M., Palmer, M. S., and Savidge, J. A. 2013. Selective predation by feral cats on a native skink on Guam. ICRF Reptiles and Amphibians, 20, 16–19.

Ligon, A., Deakos, M., and Ü, A. C. 2011. Small-Boat Cetacean Surveys Off Guam and Saipan, Mariana Islands, February–- March 2010. Pacific Island Fisheries Science Center. February.

Liske-Clark, J. 2015. Wildlife Action Plan for the Commonwealth of the Northern Mariana Islands, 2015-2025. CNMI DLNR-Division of Fish and Wildlife, Saipan, MP. 16 December.

Loss, S. R., Will, T., and Marra, P. P. 2013. The impact of free-ranging domestic cats on wildlife in the United States. Nature Communications, 4, 1396.

Lybolt, M. 2015. Listed Coral Sighting (Guam). Technical Memorandum from M. Lybolt, Marine Ecologist, Tetra Tech, Inc., Stuart, FL to S. Hanser, Supervisory Marine Biologist, NAVFAC Pacific, Pearl Harbor, HI. 4 May.

Marler, T. E. 2017. Diel root extension patterns of three *Serianthes* species are modulated by plant size. Plant Signaling and Behavior, 12.

Marler, T. E. and Cascasan, A. N. 2015. Number of emerged seedlings and seedling longevity of the non-recruiting, critically endangered Hayun Lagu tree *Serianthes nelsonii Merr.* (Fabales: Leguminosaw) are influenced by month of emergence. Journal of Threatened Taxa, 7, 8221–8225.

Marler, T. E., Cascasan, A. N., and Lawrence, J. H. 2015. Threatened native trees in Guam: short-term seed storage and shade conditions influence emergence and growth of seedlings. HortScience, 50, 1049–1054.

Marler, T. E. and Lawrence, J. H. 2012. Demography of *Cycas micronesica* on Guam following introduction of the armoured scale *Aulacaspis yasumatsui*. Journal of Tropical Ecology, 28, 233–242.

Marler, T.E. and Musser, C. 2015. Potential stressors leading to seedling mortality in the endemic Hayun lagu tree (*Serianthes nelsonii* Merr.) in the island of Guam. Tropical Conservation Science 8(3): 738-744.

Martin, S. L., van Houtan, K. S., Jones, T. T., Aguon, C. F., Gutierrez, J. T., Tibbats, B. R., Wusstig, S. B., and Bass, J. D. 2016. Five decades of marine megafauna surveys from Micronesia. Frontiers in Marine Science, 2, 116.

Maynard, J., McKagan, S., Raymundo, L., Johnson, S., Ahmadia, G., Johnston, L., Houk, P., Williams, G., Kendall, M., Heron, S., van Hooidonk, R., and Mcleod, E. 2015. Assessing relative resilience potential of coral reefs to inform management in the Commonwealth of the Northern Mariana Islands. NOAA Technical Memorandum CRCP 22. NOAA Coral Reef Conservation Program, Silver Spring, MD.

McManus, J. W. and McManus, L. C. 2012. Proposed Dredging for an Aircraft Carrier Turning Basin in Apra Harbor, Guam: Options for Assessment and Mitigation (Final).

Miller, R. 2014. Guam Marine Biosecurity Action Plan. Prepared by the UOG Center for Island Sustainability for NOAA Coral Reef Conservation Program, as administered by the Office of Ocean and Coastal Resource Management and the Bureau of Statistics and Plans, Guam Coastal Management Program. September.

Myers, M. F. 1999. Micronesian Reef Fishes: A Comprehensive Guide to the Coral Reef Fishes of Micronesia. Coral Graphics, Barrigada, GU.

NAVFAC Marianas. 2013. Threatened and Endangered Species and Migratory Birds Monitoring Report, Naval Support Activity Andersen, Guam. Prepared by HDR Inc., San Diego, CA. February.

NAVFAC Marianas. 2014. Final Project Report: Federal Candidate Species Surveys on Guam. Prepared by D.P. Lindstrom and J.C. Benedict, College of Natural and Applied Sciences, UOG. 21 January.

NAVFAC Marianas. 2015a. Federal Candidate Endangered Species Surveys at Andersen AFB. Prepared by B. Holland and D. Rubinoff, University of Hawai‘i, Manoa. July.

NAVFAC Marianas. 2015b. *Serianthes nelsonii* Monitoring – Final Report. Prepared by Isla Paraiso, Guam.

NAVFAC Marianas. 2016a. Federal Candidate Endangered Species Management Plan at Andersen AFB. Prepared by B. Holland and D. Rubinoff, University of Hawai‘i, Manoa.

NAVFAC Marianas. 2016b. Land Use/Land Cover and Recovery Habitat Analysis for Lands Managed by Joint Region Marianas on Guam. Prepared by Cardno, Honolulu, HI. June.

NAVFAC Marianas. 2017a. Basewide plant surveys GIS data. Collected by UOG.

NAVFAC Marianas. 2017b. Plant Surveys, Joint Region Marianas Munitions Storage Area Survey Report. January.

NAVFAC Marianas and Andersen AFB. 2015. Monitoring Mariana Fruit Bats on AFB 2015. Prepared by T. Mildenstein and R. Miller, Biology Program, UOG. July.

NAVFAC Marianas and Andersen AFB. 2017a. Restoration Plan for the Habitat Management Unit, Naval Support Activity Andersen, Guam. Prepared by S.H. Siers and J.A. Savidge, Colorado State University, CO.

NAVFAC Marianas and Andersen AFB. 2017b. Sea Turtle Management Plan for Andersen AFB, Guam. Prepared by UOG Marine Laboratory, Mangilao, GU. February.

NAVFAC Marianas and Andersen AFB. 2017c. Monitoring Mariana fruit bats on Andersen AFB (Cooperative Agreement No. N40192-15-2-8001). Prepared by T. Mildenstein and R. Miller. January.

NAVFAC Marianas and Andersen AFB. 2017d. Sea Turtle Conservation, Outreach, and Education on Andersen AFB, Guam. Mangilao, Guam: Prepared by UOG Marine Laboratory. February.

NAVFAC Marianas. 2022. Ungulate Control, Eradication, and Basic Research on Naval Base Guam and Andersen Air Force Base for Joint Region Marianas, Guam Area of Responsibility. Draft. Submitted by White Buffalo Inc., 6B Kings Highway, Chester, CT 06412. May.

NAVFAC Marianas. 2023a. Annual Project Report. Butterfly and Snail Monitoring at Andersen Air Force Base Guam. Prepared by G.C. Fiedler, University of Guam, under Cooperative Agreement Cooperative Agreement N40192-20-2-8006.

NAVFAC Marianas. 2023b. Final Report. Plant and Invertebrate Surveys Joint Region Marianas Area of Responsibility and Areas Specified on Guam on CNMI. August.

NAVFAC Marianas. 2023c. Monitoring Survival and Demography of the Micronesian Starlings on Andersen Air Force Base in a Brown Treesnake Controlled Environment. Iowa State University, Department of Ecology, Evolution and Organismal Biology, Ames, IA 50011. 13 November.

NAVFAC Marianas and Andersen AFB. 2023. Sea Turtle Management Plan for Andersen Air Force Base, Guam. Prepared by University of Guam Sea Grant, Guam. Cooperative Agreement No.: N40192-18-2-8000. January.

NAVFAC Pacific. 2010. Final Natural Resource Survey Report in Support of the Environmental Impact Statement for the Marine Corps Relocation Initiative to Various Locations on Guam. Pearl Harbor, HI.

NAVFAC Pacific. 2011. Guam Marine Species Monitoring Survey. Vessel-Based Monitoring Surveys. Winter 2011. Prepared by HDR, Inc. December 2011.

NAVFAC Pacific. 2013. Moorhen Habitat Wetland Restoration Feasibility Study, Camp Covington, Naval Base, Guam. Task 2 – Technical Memorandum. Prepared by HDR, Inc., Hagatna, GU. May.

NAVFAC Pacific. 2014. Biological Evaluation of Military Training and Testing (MITT) Activities in the Mariana Islands Training and Testing Study Area: Marine Species and Habitats. Prepared by SRS-Parsons Joint Venture, Arlington, VA.

NAVFAC Pacific. 2017. Final Natural Resources Survey Report in Support of the Environmental Assessment for Proposed Munitions Storage Igloo Construction, Andersen AFB, Guam. Prepared by Cardno, Inc., Honolulu, HI. February.

NAVFAC Pacific. 2020. Mariana Islands Training and Testing Activities. Final Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement. Volume 1. June.

NMFS. 2010. Programmatic biological opinion on military readiness activities the U.S. Navy proposes to conduct on the Mariana Islands Range Complex from June 2010 to June 2015 and the Permits Division's proposal to issue regulations to authorize the U.S. Navy to "take" marine mammals incidental to those training activities. Silver Spring, MD. 28 June.

NMFS. 2014a. Endangered and Threatened Wildlife and Plants: Final Listing Determinations on Proposal To List 66 Reef-Building Coral Species and To Reclassify Elkhorn and Staghorn Corals. Federal Register, 79, 53852–54123.

NMFS. 2014b. Endangered and Threatened Wildlife and Plants; Threatened and Endangered Status for Distinct Population Segments of Scalloped Hammerhead Sharks; Final Rule. Federal Register, 79, 38214–38242.

NMFS. 2015a. Species of Concern: Bumphead Parrotfish *Bolbometopon muricatum*. Accessed 16 January 2018, from http://www.nmfs.noaa.gov/pr/pdfs/species/bumpheadparrotfish_detailed.pdf. 30 October.

NMFS. 2015b. Species of Concern: Humphead Wrasse *Cheilinus undulatus*. Accessed 16 January 2018, from http://www.nmfs.noaa.gov/pr/pdfs/species/humpheadwrasse_detailed.pdf. 30 October.

NMFS. 2018a. Endangered and Threatened Wildlife and Plants: Listing the Oceanic Whitetip Shark as Threatened Under the Endangered Species Act. Federal Register, 83, 4153–4165.

NMFS. 2018b. Endangered and Threatened Wildlife and Plants; Final Rule To List the Giant Manta Ray as Threatened Under the Endangered Species Act. Federal Register, 83, 2916–2931.

NMFS. 2020. Endangered Species Act Section 7 Consultation Biological Opinion and Conference Report for the U.S. Military Mariana Islands Training and Testing Activities. 10 July.

NOAA. 2009. Coral Reef Habitat Assessment for U.S. Marine Protected Areas: U.S. Territory of Guam. Prepared by National Ocean Service Management and Budget Office.

NOAA. 2017a. Ocean Watch. Accessed 15 October 2017, from http://oceanwatch.pifsc.noaa.gov/.

NOAA. 2017b. Online datasets for bathymetry and habitat mapping. Accessed 11 April 2018, from https://www.coris.noaa.gov/search/catalog/main/home.page.

NOAA. 2023. National Centers for Environmental Information. Annual 2023 Tropical Cyclones Report. Accessed on 23 January 2023, from https://www.ncei.noaa.gov/access/monitoring/monthly-report/tropical-cyclones/202313#west-pacific.

Oleson, E., Baumann-Pickering, S., Sirovic, A., Merkens, K., Munger, L., Trickey, J., and Fisher-Pool, P. 2015. Analysis of Long-term Acoustic Datasets for Baleen Whales and Beaked Whales within the Mariana Islands Range Complex (MIRC) for 2010 to 2013 (PIFSC Data Report No. DR-15-002). 18 February.

Olmsted, N. 2016. GIS Data for Plant Surveys and General Handling Requirements of High Value Trees (HVTs) to Support Project J755 at Andersen South. Personal communication via email from N. Olmsted, Natural Resources Specialist, DPRI Environmental, NAVFAC Marianas, Guam to R. Spaulding, Senior Biologist/Project Manager, Cardno, Bainbridge Island, WA. December.

OPNAVINST. 2021. OPNAV Instruction (OPNAVINST) 5090.1. Environmental Readiness Program. Office of the Chief of Naval Operations, Washington, D.C. 25 June.

Pacific Air Forces. 2006. Environmental Impact Statement for Establishment and Operation of Intelligence Reconnaissance and Strike Capability at Andersen AFB. Department of the Air Force, Hickam AFB, HI. November.

Paulay, G., Kirkendale, L., Lambert, G., and Meyer, M. 2002. Anthropogenic biotic interchange in a coral reef ecosystem: A case study from Guam. Pacific Science, 56, 403–422.

Plucer-Rosario, G. 1987. The effect of substratum on the growth of *Terpios*, an encrusting sponge which kills corals. Coral Reefs, 5, 197–200.

Pratchett, M. S., Berumen, M. L., and Kapoor, B. G. (Eds.). 2014. Chapter 13. Pages 310-344 *in* Biology of Butterflyfishes. CRC Press, Boca Raton, FL.

Pregill, G. K. and Steadman, D. W. 2009. The prehistory and biogeography of terrestrial vertebrates of Guam, Mariana Islands. Diversity and Distributions, 15, 983–996.

Raulerson, L. and Rinehart, A. 1992. Ferns and orchids of the Mariana Islands. Self published.

Reese, E. S. 1981. Predation on corals by fishes of the family Chaetodontidae: implications for conservation and management of coral reef systems. Bulletin of Marine Science, 31, 594–604.

Reese, E. S. 1991. How behavior influences community structure of butterflyfishes (family Chaetodontidae) on Pacific coral reefs. Ecology International Bulletin, 19, 29–41.

Reimer, J. D., Nozawa, Y., and Hirose, E. 2011. Domination and disappearance of the black sponge: a quarter century after the initial *Terpios* outbreak in southern Japan. Zoological Studies, 50, 394.

Roberts, H. H., Aharon, P., and Phipps, C. V. 1988. Morphology and sedimentology of Halimeda bioherms from the eastern Java Sea (Indonesia). Coral Reefs, 6, 161–172.

Rodda, G. H., Fritts, T. H., Clark, C. S., Gotte, S. W., and Chizar, D. 1999. A state-of-the-art trap for the brown treesnake. Pages 268-305 *in* G.H. Rodda, Y. Sawai, D. Chiszar, and H. Tanaka (Eds.), Problem Snake Management: The Habu and the Brown Treesnake. Cornell University Press, Ithaca, NY.

Rosario, C. A., Sablan, L. R., Miller, R. H., and Moore, A. 2016. Greater Banded Hornet *Vespa tropica* (Hymenoptera: Vespidae) (Guam New Invasive Species Alert No. 2016-01). 27 July.

Rubinoff, D. and Haines, W. 2012. Report for Surveys Conducted on Guam and Rota October 10-20, 2012. Assessing the Conservation Status of *Hypolimnas octocula* and *Vagrans egistina*, Candidates for ESA listing.

Safford, W. 2009. The Chamorro Language of Guam. University of Michigan Library. 27 April.

Savidge, J. 2016. Developing a Predator-resistant Nest Box for Micronesian Starlings with Application to Endangered Guam Micronesian Kingfishers (Work Plan, Amendment 1). Prepared for Joint Region Marianas.

Schils, T. 2015. Restyling Guam's Reef Flats: Angel Hair alga on the rise. Man, Land, and Sea, 6–7.

Schils, T. and Houk, P. 2017. Management Plan. Marine Resources Surveys of Naval Base Guam and Naval Support Activity Andersen AFB. Mangilao, GU.

Schils, T., Houk, P., Biggs, J. S., Donaldson, T. J., Kense, A., and McLean, M. 2017. Marine Resources Surveys of Naval Base Guam and Naval Support Activity Andersen AFB. Mangilao, GU.

Schreiner, I. H. and Nafus, D. M. 1997. Butterflies of Micronesia. Agricultural Experiment Station College of Agriculture and Life Sciences, UOG.

Staman, M. 2015. Andersen AFB Sea Turtle Historical Report. UOG. March, revised in June.

Stevens, T. 1973. Air Force established huge nature preserve. Pacific Daily News. Hagatna, GU. 26 May.

Thacker, R. W. and Paul, V. J. 2001. Are benthic cyanobacteria indicators of nutrient enrichment? Relationships between cyanobacterial abundance and environmental factors on the reef flats of Guam. Bulletin of Marine Science, 69, 497–508.

Timmers, M., Bird, C. E., Skillings, D. J., Smouse, P. E., and Toonen, R. J. 2012. There's no place like home: Crown-of-thorns outbreaks in the Central Pacific are regionally derived and independent events. PLOS ONE, 7, e31159.

Topping, D., Ogo, P., and Dungca, B. 1975. Chamorro-English Dictionary. University of Hawai'i Press, Honolulu, HI.

Tsuda, R. T. 2004. Checklist and Bibliography of the Marine Benthic Algae from the Mariana Islands (Guam and CNMI) (Technical Report No. 107). UOG Marine Laboratory, Mangilao, GU. March, revised in June.

UOG. 2007. Survey of *Tabernaemontana rotensis* on Andersen AFB. Final Report. Prepared for 36 CES/CEVN, Andersen AFB. February.

UOG. 2022. Distance transect surveys for threatened and endangered species inside the Habitat Management Unit on Andersen Air Force Base, Guam.

U.S. Army. 2015. Environmental Assessment for Terminal High-Altitude Area Defense (THAAD) Permanent Stationing in Guam. U.S. Army Space and Missile Command/Army Forest Strategic Command (USASMDC/ARSTRAT), Huntsville, AL. June.

U.S. Navy. 2006. Naval Ships' Technical Manual, Chapter 081, Revision 5, Waterborne Underwater Hull Cleaning of Navy Ships.

U.S. Navy 2023. Monitoring Mariana fruit bats on Andersen Air Force Base, 2022. Prepared for NAVFAC Marianas, Guam. Prepared by Tammy Mildenstein, University of Guam, under Cooperative Agreement Number N40192-22-2-8001. April.

USAF. 2009. Final Integrated Natural Resources Management Plan and Environmental Assessment. Prepared for Andersen AFB, Guam. July.

USAF. 2017. Unpublished USDA APHIS data on ungulate removal from Andersen AFB, Guam, between 2014-2017.

USAF and USFWS. 1994. Cooperative Agreement between the U.S. Air Force and the U.S. Fish and Wildlife Service for the Establishment and Management of the Guam National Wildlife Refuge, Guam. March.

USFS. 2006. Guam Vegetation Mapping. Pacific Southwest Region, Forest Health Protection, McClellan, CA. October.

USFWS. 1994a. Endangered and Threatened Wildlife and Plants; Withdrawal of Proposed Rule to Designate Critical Habitat for the Little Mariana Fruit Bat, Mariana Fruit Bat, Guam Broadbill, Mariana Crow, Guam Micronesian Kingfisher, and Guam Bridled White-Eye, 59, 15696–15700.

USFWS. 1994b. Recovery Plan for *Serianthes nelsonii*. Region 1, Portland, OR. February.

USFWS. 2006. Biological Opinion on the Establishment and Operation of an Intelligence, Surveillance, Reconnaissance, and Strike Capability Project on Andersen AFB, Guam.

USFWS. 2011. Guam and Commonwealth of the Northern Mariana Islands Animals and Plants: Updated February 2, 2011. Listed Species, as Designated under the U.S. Endangered Species Act.

USFWS. 2014a. Endangered and Threatened Wildlife and Plants; Proposed Endangered Status for 21 Species and Proposed Threatened Status for 2 Species in Guam and the Commonwealth of the Northern Mariana Islands; Proposed Rule. Federal Register, 79(190), 59364–59413.

USFWS. 2014b. GIS Data for Species Proposed for Listing on Guam. Pacific Islands Fish and Wildlife Office, Honolulu, HI.

USFWS. 2015a. Biological Opinion for the Mariana Islands Testing and Training Program. Pacific Islands Fish and Wildlife Office, Honolulu, HI. 20 February.

USFWS. 2015b. Endangered and Threatened Wildlife and Plants; Endangered Status for 16 Species and Threatened Status for 7 Species in Micronesia. Federal Register, 80(190), 59424–59497.

USFWS. 2017a. 5-Year Review Short Form Summary for *Serianthes nelsonii* (Hayun lagu or Tronkon guafi). Pacific Islands Fish and Wildlife Office, Region 1, Honolulu, HI.

USFWS. 2017b. Reinitiation of the 2015 Biological Opinion on the Department of the Navy's Relocation of U.S. Marine Corps from Okinawa to Guam and Associated Activities on Guam (Consultation 01EPIF00-2015-F-0025 and 01EPIF00-2016-F-0185). Pacific Islands Fish and Wildlife Office, Honolulu, HI. 18 July.

Vermeij, M. J. A., van Moorselaar, I., Engelhard, S., Hornlein, C., Vonk, S. M., and Visser, P. M. 2010. The effects of nutrient enrichment and herbivore abundance on the ability of turf algae to overgrow coral in the Caribbean. PLOS ONE, 5, e14312.

Veron, J. E. N. 2000. Corals of the World. (M. Stafford-Smith, Ed.) (Vol. Volumes 1-3). Australian Institute of Marine Science, Townsville, Queensland, AU.

Wall, M., Buerger, P., Schmidt, G. M., Held, C., and Richter, C. 2015. Temperature tolerance of the coral *Porites lutea* exposed to simulated large amplitude internal waves (LAIW). Journal of Experimental Marine Biology and Ecology, 471, 232–239.

Weijola, V., Vahtera V., Koch A., Schmitz A., Kraus F. 2020. Taxonomy of Micronesian monitors (Reptilia: Squamata: Varanus): endemic status of new species argues for caution in pursuing eradication plans. R. Soc. Open Sci. 7:200092. Accessed at: http://dx.doi.org/10.1098/rsos.200092

WERI and IREI. 2016. Digital Atlas of Southern and Northern Guam. Accessed 25 September 2017, from http://south.hydroguam.net/index.php and http://north.hydroguam.net/index.php.

Wheeler, M. E. and Aguon, C. F. 1978. The Current Status and Distribution of the Marianas Fruit Bat on Guam (Aquatic and Wildlife Resources Division Technical Report No. 1). Guam Department of Agriculture, Division of Aquatic and Wildlife Resources, Mangilao, GU.

Widlanski, M. J., Timmerman, A., and Cai, W. 2015. Future extreme sea level seesaws in the tropical Pacific. Science Advances, 1.

Wiewel, A. S., Yackel Adams, A. A., and Rodda, G. H. 2009. Distribution, density, and biomass of introduced small mammals in the Southern Mariana Islands. Pacific Science, 63, 205–222.

Wiles, G. 1987a. Current research and future management of Mariana fruit bats (Chiroptera: Pteropodidae) on Guam. Australian Mammalogy, 10, 93–95.

Wiles, G. 1987b. The Status of Fruit Bats on Guam. Pacific Science, 41, 148–157.

Wiles, G. 1987c. Natural History, Biology, and Habitat Protection for the Mariana Fruit Bats. Pages 124-135 *in* G. Grimm and L. Mariano (Eds.), Aquatic and Wildlife Resources Division Annual Report. Guam Department of Agriculture, Division of Aquatic and Wildlife Resources, Mangilao, GU.

Wiles, G. 2005. A checklist of the birds and mammals of Micronesia. Micronesica, 38, 141–189.

Wiles, G., Bart, J., Beck Jr., R. E., and Aguon, C. F. 2003. Impacts of the brown treesnake: patterns of decline and species persistence in Guam's avifauna. Conservation Biology, 17, 1350–1360.

Williams, I., Zamzow, J., Lino, K., Ferguson, M., and Donham, E. 2012. Status of Coral Reef Fish Assemblages and Benthic Condition Around Guam: A Report Based on Underwater Visual Surveys in Guam and the Mariana Archipelago, April-June 2011 (No. NMFS-PIFSC-33). Pacific Islands Fisheries Science Center.

Wolanski, E., Richmond, R. H., Davis, G., Deleersnijder, E., and Leben, R. 2003. Eddies around Guam, an island in the Mariana Islands group. Continental Shelf Research, 23, 991–1003.

Young, J., Olson, K. A., Reading, R. P., Amgalanbaatar, S., and Berger, J. 2011. Is wildlife going to the dogs? Impacts of feral and free-roaming dogs on wildlife populations. BioScience, 61, 125–132.

15.9 CHAPTER 9 – MARINE CORPS BASE CAMP BLAZ

Albert, S., O'Neil, J. M., Udy, J. W., Ahern, K. S., O'Sullivan, C. M., and Dennison, W. C. 2005. Blooms of the cyanobacterium *Lyngbya majusculta* in coastal Queensland, Australia: disparate sites, common factors. Marine Pollution Bulletin, 51, 428–437.

Amesbury, S., Bonito, V., Chang, R., Kirkendale, L., Meyer, C., Paulay, G., Ritson-Williams, R., and Rongo, T. 2001. Marine Biodiversity Resource Survey and Baseline Reef Monitoring Survey of the Haputo Ecological Reserve Area, COMNAVMARIANAS. Prepared for U.S. Department of the Navy.

Andersen AFB. 2008a. Basewide Vegetation Survey, Mapping, and Report of Andersen AFB, Guam. Contract report prepared by e2M. August.

Andersen AFB. 2008b. The Effects of Flight Operations on Endangered Mariana Fruit Bats and Mariana Crows: A Monitoring Program for Andersen AFB, Guam. Prepared for 3^{6t}h Civil Engineering Squadron, Environmental Flight, Andersen AFB, Guam and Air Force Center for Engineering and the Environment, Brooks City-Base, TX. May.

Bergman, D. L., Breck, S. W., and Bender, S. C. 2009. Dogs Gone Wild: Feral Dog Damage in the United States. Pages 177-183 *in* J.R. Boulanger, ed. Proceedings of the 1^{3t}h Wildlife Damage Management Conference. Nebraska City, NE.

Birkeland, C. and Lucas, J. S. 1990. *Acanthaster Planci*: Major Management Problem of Coral Reefs. CRC Press, Inc., Boca Raton, FL.

Brainard, R. E., Asher, J., Blyth-Skyrme, V., Coccagna, E. F., Dennis, K., Donovan, M. K., Gove, J. M., Kenyon, J., Looney, E. E., Miller, J. E., Timmers, M., Vargas-Ángel, B., Vroom, P. S., Vetter, O., and Zgliczynski, B. 2012. Coral Reef Ecosystem Monitoring Report of the Mariana Archipelago: 2003 to 2007 (PIFSC Special Publication No. SP-12-01). NOAA Fisheries, Pacific Islands Fisheries Science Center. Honolulu, HI. March.

Brooke, A. 2008. Mariana Fruit Bat Surveys on Navy Properties, Guam. NAVFAC Marianas Environmental. December.

Brooke, A. 2009. Deer densities at NCTS Finegayan and NMS. Personal communication via email from A. Brooke, Natural Resources Program Manager, Naval Base Guam to R. Spaulding, Senior Biologist/Project Manager, Cardno, Honolulu, HI. 22 October.

Brown, V. 2015. Sightings of Threatened Corals around Guam. Personal communication via email from V. Brown, Fisheries Biologist, NOAA Fisheries PIRO HCD Guam Field Office to S. Hanser, Supervisory Marine Biologist, NAVFAC Pacific, Pearl Harbor, HI. February.

Bryan, P. G. 1973. Growth rate, toxicity and distribution of the encrusting sponge *Terpios* sp. (Hadromerida: Suberitidae) in Guam, Mariana Islands. Micronesica, 9, 237–242.

Burdick, D. 2006. Guam Coastal Atlas. Technical Report 114. Prepared by UOG Marine Laboratory, Mangilao, for NOAA and Department of the Interior, Office of Insular Affairs.

Burdick, D. and Brown, V. 2011. Comprehensive Long-Term Monitoring at Permanent Sites in Guam. Prepared for NOAA Coral Reef Conservation Program (CRCP).

Caves, E. M., Jennings, S. B., Hille Ris Lambers, J., Teweksbury, J. J., and Rogers, H. S. 2013. Natural experiment demonstrates that bird loss leads to cessation of dispersal of native seeds from intact to degraded forests. PLOS ONE, 8, e65618.

Chesher, R. H. 1969. Destruction of Pacific corals by the sea star *Acanthaster planci*. Science, 165, 280–283.

Christy, M. T., Clark, C. S., Gee II, D. E., Vice, D., Vice, D. S., Warner, M. P., Tyrrell, C. L., Rodda, G. H., and Savidge, J. A. 2007. Recent records of alien anurans on the Pacific island of Guam. Pacific Science, 61, 469–483.

Colgan, M. W. 1987. Coral reef recovery on Guam (Micronesia) after catastrophic predation by *Acanthaster planci*. Ecology, 68, 1592–1605.

COMNAVMAR. 2001. Final Integrated Natural Resources Management Plan for Navy Lands, Guam. Plan Duration November 18, 2001 thru November 17, 2006. November.

COMNAVMAR. 2007. Ecological Reserve Feasibility Study. Commander, Joint Region Marianas. Prepared by Helber, Hastert, and Fee, Inc. for NAVFAC Pacific.

COMNAVMAR. 2013. Instruction 3500.4A. Marianas Training Manual. Department of the Navy, Joint Region Marianas.

Crombie, R. I. and Pregill, G. K. 1999. A checklist of the herpetofauna of the Palau Islands (Republic of Belau), Oceania. Herpetological Monographs, 13, 29–80.

Darling, E. S., Alvarez-Filip, L., Oliver, T. A., McClanahan, T. R., and Cote, I. M. 2012. Evaluating life-history strategies of reef corals from species traits. Ecology Letters, 15, 1378–1386.

Deakos, M. H., Uyeyama, R. K., Richie, M. W., Richlen, M. F., and Aschettino, J. M. 2016. Guam Marine Species Monitoring Survey, Shore Station Study, May 2013 and March 2015. Final Field Report. Prepared for Commander, U.S. Pacific Fleet, Environmental Readiness Division, Pearl Harbor, HI. January.

DON. 2009. Interim Final Integrated Natural Resources Management Plan, Navy Base Guam, Plan Years 2009–2014. Prepared by Geo-Marine.

DON. 2010. Final Environmental Impact Statement. Guam and CNMI Military Relocation: Relocating Marines from Okinawa, Visiting Aircraft Carrier Berthing, and Army Air and Missile Defense Task Force. Volume 2: Marine Corps Relocation–- Guam. Prepared by NAVFAC Pacific, Pearl Harbor, HI for Joint Guam Program Office, Washington, D.C. July.

DON. 2015a. Joint Region Marianas Integrated Natural Resources Management Plan Summary of FY2015 Actions and Projects. Prepared by Cardno, Honolulu, HI and Bainbridge Island, WA. 22 October.

DON. 2015b. Record of Decision for the Final Supplemental Environmental Impact Statement for Guam and Commonwealth of the Northern Mariana Islands Military Relocation. 28 August.

DON. 2015c. Mariana Islands Training and Testing Activities Final Environmental Impact Statement/Overseas Environmental Impact Statement. Volume 2. Prepared by NAVFAC Pacific, Pearl Harbor, HI. May.

DON. 2015d. Regional Biosecurity Plan for Micronesia and Hawai‘i: 4 Volumes.

DON. 2015e. Joint Region Marianas Integrated Natural Resources Management Plan Summary of FY2015 Actions and Projects. Prepared by Cardno, Honolulu, HI and Bainbridge Island, WA. 22 October.

DON and Department of the Army. 2010. Record of Decision for Guam and CNMI Military Relocation including Relocating Marines from Okinawa, Transient Nuclear Aircraft Carrier Berth, Air and Missile Defense Task Force. 21 September.

DON and USFWS. 1994. Cooperative Agreement between the U.S. Navy and the U.S. Fish and Wildlife Service for the Establishment and Management of the Guam National Wildlife Refuge, Guam. March.

DON and USFWS. 2015a. Memorandum of Agreement between the Department of the Navy and the U.S. Fish and Wildlife Service Regarding Conservation of Guam Micronesian Kingfisher Recovery Habitat in Northern Guam. 11 June.

DON and USFWS. 2015b. Modification to Memorandum of Agreement between the Department of the Navy and the U.S. Fish and Wildlife Service: Designation of Alternative Configuration for Guam Micronesian Kingfisher Recovery Habitat in Northern Guam. 22 December.

Engbring, J. and Ramsey, F. L. 1984. Distribution and Abundance of the Forest Birds of Guam: Results of a 1981 Survey (No. FWS/OBS-84/20). U.S. Fish and Wildlife Service.

Fenner, D. 2014. Fishing down the largest coral reef fish species. Marine Pollution Bulletin, 84, 9–16.

Fulling, G., Thorson, P., and Rivers, J. 2011. Distribution and abundance estimates for cetaceans in the waters off Guam and the Commonwealth of the Northern Mariana Islands. Pacific Science, 65, 321–343.

Gill, F. and Donsker, D. 2017. International Ornithologists' Union (IOC) World Bird List (v 7.3) (No. doi:10.14344/IOC.ML.7.3).

Gingerich, S. B. 2003. Hydrologic Resources of Guam (USGS Water-Resources Investigations Report No. 03–4126). Prepared in cooperation with the WERI, UOG, Mangilao, GU.

Gingerich, S. B. 2013. The Effects of Withdrawals and Drought on Groundwater Availability in the Northern Guam Lens Aquifer, Guam. USGS Scientific Investigations Report 2013-5216.

Goetz, S., Hileman, E., Yackel Adams, A., Reed, R., Siers, S., Nafus M. (2022). Assessment of brown treesnake fates after toxicant delivery to the Habitat Management Unit. February.

Gottdenker, N. L., Walsh, T., Vargas, H., Merkel, J., Jimenez, G. U., Miller, R. E., Dailey, M., and Parker, P. G. 2005. Assessing the risks of introduced chickens and their pathogens to native birds in the Galapagos Archipelago. Biological Conservation, 126, 429–439.

GovGuam. 2009. Endangered Species Regulation No. 9. Department of Agriculture, Mangilao, GU. 6 November.

GovGuam, U.S. Air Force, U.S. Navy, and U.S. Fish and Wildlife Service. 1993. Memorandum of Understanding among the Government of Guam and the U.S. Air Force and the U.S. Navy and the U.S. Fish and Wildlife Service for the Establishment and Management of the Guam National Wildlife Refuge, Guam. December.

Graham, K. S., Boggs, C. H., DeMartini, E. E., Schroeder, R. E., and Trianni, M. S. 2015. Status review report: humphead wrasse (*Cheilinus undulatus*) (NOAA Technical Memo No. NOAA-TM-NMFS-PIFSC-48). Honolulu, HI. October.

Guam DAWR. 2006. Comprehensive Wildlife Conservation Strategy (GCWCS). Guam DAWR. 2006. Comprehensive Wildlife Conservation Strategy (GCWCS). Department of Agriculture, Government of Guam, Mangilao, GU. 7 November.

Guam DAWR. 2015. Draft State Wildlife Action Plan. Department of Agriculture, Government of Guam, Mangilao, GU. 20 January.

Guam Homeland Security. 2014. 2014 Guam Hazard Mitigation Plan. Guam Office of Civil Defense. Prepared by URS Group. April.

Harvey, C. 2016. 'I cried…right into my mask': Scientists say Guam's reefs have bleached four years straight. Washington Post. Accessed 21 May 2018, from https://www.washingtonpost.com/news/energy-environment/wp/2016/08/03/i-cried-right-into-my-mask-these-coral-reefs-have-seen-a-devastating-four-years-of-bleaching/?utm_term=.a330b8c4784c. 3 August.

Heyward, A. J. and Negri, A. P. 1999. Natural inducers for coral larval metamorphosis. Coral Reefs, 18, 273–279.

Hill, M., Ligon, A., Deakos, M., Ü, A. C., Milette-Winfree, A., and Oleson, E. 2013. Cetacean Surveys of Guam and CNMI Waters: May–July, 2012, Including Individual Photo-Identification of Pilot Whales, Spinner Dolphins and Bottlenose Dolphins (2010-2012) (PIFSC Data Report No. DR-13-001). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 8 February.

Hill, M., Ligon, A., Deakos, M., Ü, A. C., Milette-Winfree, A., Oleson, E., and Bendlin, A. 2014. Cetacean surveys in the waters of the southern Mariana Archipelago (February 2010-April 2014) (PIFSC Data Report No. DR-14-013). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 2 September.

Hill, M., Oleson, E. M., Ligon, A. D., Martien, K. K., Archer, F. I., Baumann-Pickering, S., Bendlin, A. R., Dolar, L., Merkens, K. P. B., Milette-Winfree, A., Morin, P. A., Rice, A., Robertson, K. M., Trickey, J. S., Ü, A. C., Van Cise, A. M., and Woodman, S. M. 2015. Cetacean Monitoring in the Mariana Islands Range Complex, 2014 (PIFSC Data Report No. DR-15-003). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 27 March.

Hill, M., Oleson, E. M., Baumann-Pickering, S., VanCise, A. M., Ligon, A. D., Bendlin, A. R., Ü, A. C., Trickey, J. S., and Bradford, A. L. 2016. Cetacean Monitoring in the Mariana Islands Range Complex, 2015 (PIFSC Data Report No. DR-16-01). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 6 February.

Hill, M., Bendlin, A. R., Ü, A. C., Yano, K. M., Bradford, A. L., Ligon, A. D., and Oleson, E. M. 2017. Cetacean Monitoring in the Mariana Islands Range Complex, 2016 (PIFSC Data Report No. DR-17-002). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 3 February.

Hoot, W. and Burdick, D. 2017. Guam Coral Bleaching Response Plan. Contributions by the Guam Coral Reef Response Team. December.

Hopper, D. R. and Smith, B. 1992. Status of tree snails (Gastropoda: Partulidae) on Guam, with a resurvey of sites studied by H.E. Crampton in 1920. Pacific Science, 46, 77–85.

Janeke, D., Amar, A., and Esselstyn, J. A. 2006. Impact of post-typhoon hunting on Mariana fruit bats (*Pteropus mariannus*). Pacific Science, 60, 531–539.

Jenkins, J. M. 1983. The Native Forest Birds of Guam. Ornithological Monographs, 31, 1–61.

Jocson, J. M. U., Jenson, J. W., and Contractor, D. N. 2002. Recharge and aquifer response: Northern Guam lens aquifer, Guam, Mariana Islands. Journal of Hydrology, 260, 231–254.

Johnson, A. G. 2012. A Water-Budget Model and Estimates of Groundwater Recharge for Guam (No. 2012–5028). USGS.

Johnson, N. 2016a. Information regarding *Bulbophyllum guamense* observation at Andersen AFB. Personal communication via email from N. Johnson, Biologist, Cardno, Saipan, CNMI to R. Spaulding, Senior Biologist/Project Manager, Cardno, Bainbridge Island, WA. 1 September.

Jones, T. T., Martin, S. L., and Van Houtan, K. S. 2015. Sea Turtle Tagging in the Mariana Islands Range Complex (MIRC) Interim Progress Report (PIFSC Data Report No. DR-15-020). Prepared for U.S. Pacific Fleet Environmental Readiness Office, Pearl Harbor, HI. September.

JRM. 2010. JRM-administered Lands GIS Data.

JRM. 2013. Final Joint Region Marianas Integrated Natural Resources Management Plan. Prepared by HDR for Commander Joint Region Marianas, Guam, Hagatna, GU. December.

JRM. 2019. JRM-administered Submerged Lands GIS Data.

JRM, NAVFAC Marianas, and Andersen AFB 36 CES/CEV. 2012. Final Summary Report: Noise Study and Demographic Survey of Mariana Fruit Bats and Mariana Crows, Andersen AFB, Guam. Prepared by SWCA Environmental Consultants, Hagatna, GU. 11 May.

Kahng, S. E., Copus, J. M., and Wagner, D. 2014. Recent advances in the ecology of mesophotic coral ecosystems (MCEs). Current Opinion in Environmental Sustainability, 7, 72–81.

Kahng, S. E., Garcia-Sais, J. R., Spaulding, H. L., Brokovich, E., Wagner, D., Weil, E., Hinderstein, L., and Toonen, R. J. 2010. Community ecology of mesophotic coral reef ecosystems. Coral Reefs, 29, 255–275.

Kerr, A. M. 1990. Chamorro Fish Names. Micronesica, 23, 93–118.

Kerr, A. M. 2012. Fish Names of the Mariana Islands, Micronesia (UOG Marine Laboratory Technical Report No. 139). Mangilao, GU. February.

Kerr, A. M. and Bauman, S. 2013. Annotated Checklist of the Land Snails of the Mariana Islands, Micronesia (UOG Marine Laboratory Technical Report No. 148). Mangilao, GU.

Klinck, H., Nieukirk, S. L., Fregosi, S., Klinck, K., Mellinger, D. K., Latuska, S., Shilling, B., and Luby, J. C. 2015. Cetacean Studies on the Mariana Islands Range Complex in September-November 2014: Passive Acoustic Monitoring of Marine Mammals Using Gliders. Final Report. Prepared for Commander, U.S. Pacific Fleet, Environmental Readiness Division, Pearl Harbor, HI. August.

Klinck, H., Nieukirk, S. L., Fregosi, S., Klinck, K., Mellinger, D. K., Latuska, S., Shilling, B., and Luby, J. C. 2016. Cetacean Studies on the Mariana Islands Range Complex in March – April 2015: Passive Acoustic Monitoring of Marine Mammals Using Gliders. Submitted by HDR, Inc., Honolulu, HI to Commander, U.S. Pacific Fleet.

Lagerloef, G. S. E., Mitchum, G. T., Lukas, R. B., and Niiler, P. P. 1999. Tropical Pacific near-surface currents estimated from altimeter, wind, and drifter data. Journal of Geophysical Research, 104, 23, 313–23, 326.

Lander, J. F., Whiteside, L. S., and Hattori, P. 2002. The Tsunami History of Guam: 1849-1993. Science of Tsunami Hazards, 20, 158–174.

Lardner, B. 2016. Systematics of Guam reptiles and amphibians. Bjorn Lardner, Colorado State University, personal communication to M.J. Mazurek, JRM Natural Resource Specialist, Guam, via review comments to draft INRMP chapter. 16 August.

Lardner, B., Reed, R. N., Yackel Adams, A. A., Mazurek, M., Hinkle, T. J., Levasseur, P. M., Palmer, M. S., and Savidge, J. A. 2013. Selective predation by feral cats on a native skink on Guam. ICRF Reptiles and Amphibians, 20, 16–19.

Ligon, A., Deakos, M., and Ü, A. C. 2011. Small-Boat Cetacean Surveys Off Guam and Saipan, Mariana Islands, February–- March 2010. Pacific Island Fisheries Science Center. February.

Liske-Clark, J. 2015. Wildlife Action Plan for the Commonwealth of the Northern Mariana Islands, 2015-2025. CNMI DLNR-Division of Fish and Wildlife, Saipan, MP. 16 December.

Loss, S. R., Will, T., and Marra, P. P. 2013. The impact of free-ranging domestic cats on wildlife in the United States. Nature Communications, 4, 1396.

Lybolt, M. 2015. Listed Coral Sighting (Guam). Technical Memorandum from M. Lybolt, Marine Ecologist, Tetra Tech, Inc., Stuart, FL to S. Hanser, Supervisory Marine Biologist, NAVFAC Pacific, Pearl Harbor, HI. 4 May.

Marler, T. E., Lindstrom, A. J., and Terry, L. I. 2012. *Chilades pandava* damage among 85 *Cycas* species in a common garden setting. HortScience, 47, 1832–1836.

Marshall, S. D. G., Moore, A., and Vaqalo, M. 2016. A New Coconut Rhinoceros Beetle Biotype Threatens Coconut and Oil Palms in Southeast Asia and the Pacific. Western Integrated Pest Management Center. July.

Martin, S. L., van Houtan, K. S., Jones, T. T., Aguon, C. F., Gutierrez, J. T., Tibbats, B. R., Wusstig, S. B., and Bass, J. D. 2016. Five decades of marine megafauna surveys from Micronesia. Frontiers in Marine Science, 2, 116.

Maynard, J., McKagan, S., Raymundo, L., Johnson, S., Ahmadia, G., Johnston, L., Houk, P., Williams, G., Kendall, M., Heron, S., van Hooidonk, R., and Mcleod, E. 2015. Assessing relative resilience potential of coral reefs to inform management in the Commonwealth of the Northern Mariana Islands. NOAA Technical Memorandum CRCP 22. NOAA Coral Reef Conservation Program, Silver Spring, MD.

McManus, J. W. and McManus, L. C. 2012. Proposed Dredging for an Aircraft Carrier Turning Basin in Apra Harbor, Guam: Options for Assessment and Mitigation (Final).

Miller, R. 2014. Guam Marine Biosecurity Action Plan. Prepared by the UOG Center for Island Sustainability for NOAA Coral Reef Conservation Program, as administered by the Office of Ocean and Coastal Resource Management and the Bureau of Statistics and Plans, Guam Coastal Management Program. September.

Moore, A. 2014. CRB mitigation and conservation of rare snails and butterflies and Haputo Beach. Unpublished. UOG Cooperative Extension Service, Mangilao, GU.

Moore, A. 2016. Update on the Guam Coconut Rhinoceros Beetle Situation for the Guam Invasive Species Council. College of Natural and Applied Sciences, UOG. 5 March.

Moore, A., Marler, T. E., Miller, R., and Muniappan, R. 2005. Biological control of cycad Aulacaspis scale on Guam. The Cycad Newsletter, 28, 6–8.

Mueller, C. S., Haller, K. M., Luco, N., Petersen, M. D., and Frankel, A. D. 2012. Seismic Hazard Assessment for Guam and the Northern Mariana Islands. Open-File Report No. 2012-1015. USGS, Reston, VA.

Nafus et al. 2022. Demographic response of brown treesnakes to extended population suppression. The Journal of Wildlife Management. Office of Insular Affairs; U.S. Geological Survey Biological Threats and Invasive Species Program; Department of Navy Joint Region Marianas.

NAVFAC Marianas. 2010a. Haputo Ecological Reserve Area General Management Plan, Naval Base Guam. Prepared by SWCA Environmental Consultants, Hagatna, GU. August.

NAVFAC Marianas. 2010b. Guam DoD Land Inventory. Prepared by NAVFAC Marianas Asset Management Business Line. 22 December.

NAVFAC Marianas. 2010c. Guam Marine Monitoring Surveys, Final Revision: Orote Peninsula Ecological Reserve Area, North Agat Bay and Vicinity (OPERA) and Haputo Ecological Reserve Area and Vicinity (HERA). Prepared by UOG Marine Laboratory, Mangilao and SWCA Environmental Consultants, Hagatna, GU. March.

NAVFAC Marianas. 2011a. Botanical Inventory and Vegetation Survey of the Haputo and Orote Peninsula Ecological Reserve Areas and Proposed Buffer Zones, Guam. Prepared by SWCA Environmental Consultants, Hagatna, GU. 31 January.

NAVFAC Marianas. 2011b. Haputo and Orote Peninsula Ecological Reserve Area Marine Unit, Naval Base Guam, Visitor Use and Crown-of-Thorns Starfish Surveys. Prepared by SWCA Environmental Consultants, Hagatna, GU. 31 December.

NAVFAC Marianas. 2013a. Final Establishment Report, Orote Ecological Reserve Area Expansion. September.

NAVFAC Marianas. 2013b. Threatened and Endangered Species and Migratory Birds Monitoring Report, Naval Support Activity Andersen, Guam. Prepared by HDR Inc., San Diego, CA. February.

NAVFAC Marianas. 2014a. Long-Term Vegetation Monitoring Report, Naval Base Guam. Prepared by PCR Environmental, Inc., Barrigada, GU.

NAVFAC Marianas. 2014b. Final Report for Haputo Partulid Snail Predation Study, Haputo Ecological Reserve Area, Finegayan, Guam. Prepared by Myounghee Noh and Associates, Environmental Studies and Consulting Services, Hilo, HI. 28 March.

NAVFAC Marianas. 2014c. Final Project Report: Federal Candidate Species Surveys on Guam. Prepared by D.P. Lindstrom and J.C. Benedict, College of Natural and Applied Sciences, UOG. 21 January.

NAVFAC Marianas. 2014d. Wet-Season Survey Report: Mariana Common Moorhen Wetland Use and Population Survey. Prepared by Allied Pacific Environmental Consulting, Inc., Agana, GU. November.

NAVFAC Marianas. 2015. Federal Candidate Endangered Species Surveys at Andersen AFB. Prepared by B. Holland and D. Rubinoff, University of Hawai‘i, Manoa. July.

NAVFAC Marianas. 2016a. Land Use/Land Cover and Recovery Habitat Analysis for Lands Managed by Joint Region Marianas on Guam. Prepared by Cardno, Honolulu, HI. June.

NAVFAC Marianas. 2016b. Land Use/Land Cover and Recovery Habitat Analysis for Lands Managed by Joint Region Marianas on Guam. Prepared by Cardno, Honolulu, HI. June.

NAVFAC Marianas. 2016c. Federal Candidate Endangered Species Management Plan at Andersen AFB. Prepared by B. Holland and D. Rubinoff, University of Hawai‘i, Manoa.

NAVFAC Marianas and Andersen AFB. 2015. Monitoring Mariana Fruit Bats on AFB 2015. Prepared by T. Mildenstein and R. Miller, Biology Program, UOG. July.

NAVFAC Marianas and Andersen AFB. 2017a. Restoration Plan for the Habitat Management Unit, Naval Support Activity Andersen, Guam. Prepared by S.H. Siers and J.A. Savidge, Colorado State University, CO.

NAVFAC Marianas and Andersen AFB. 2017b. Sea Turtle Management Plan for Andersen AFB, Guam. Prepared by UOG Marine Laboratory, Mangilao, GU. February.

NAVFAC Marianas. 2019. Biomonitor Support for Natural Resource Management Surveys at Joint Region Marianas Area of Responsibility. Prepared by Fiedler G., Demeulenaere E., Putnam M. University of Guam. May.

NAVFAC Pacific. 2010a. Preliminary Wetland Identification for Various Locations on Guam In Support of the Guam Military Buildup EIS. Prepared by TEC, Inc. Joint Venture, Honolulu, HI.

NAVFAC Pacific. 2010b. Final Natural Resource Survey Report in Support of the Environmental Impact Statement for the Marine Corps Relocation Initiative to Various Locations on Guam. Pearl Harbor, HI.

NAVFAC Pacific. 2012. Guam and Saipan Marine Species Monitoring: Winter-Spring Survey, 15 to 29 March 2012. Prepared by HDR, Inc. for Commander U.S. Pacific Fleet.

NAVFAC Pacific. 2013a. Final Report: Biological Surveys – Report 2, Various Locations on Guam in Support of the Guam and Commonwealth of the Northern Mariana Islands Military Relocation (2012 Roadmap Adjustments) Supplemental Environmental Impact Statement. Prepared by TEC-AECOM Joint Venture for Joint Guam Program Office, Honolulu, HI. April.

NAVFAC Pacific. 2013b. Moorhen Habitat Wetland Restoration Feasibility Study, Camp Covington, Naval Base, Guam. Task 2 – Technical Memorandum. Prepared by HDR, Inc., Hagatna, GU. May.

NAVFAC Pacific. 2017. Final Natural Resources Survey Report in Support of the Environmental Assessment for Proposed Munitions Storage Igloo Construction, Andersen AFB, Guam. Prepared by Cardno, Inc., Honolulu, HI. February.

NMFS. 2014a. Endangered and Threatened Wildlife and Plants: Final Listing Determinations on Proposal To List 66 Reef-Building Coral Species and To Reclassify Elkhorn and Staghorn Corals. Federal Register, 79, 53852–54123.

NMFS. 2014b. Endangered and Threatened Wildlife and Plants; Threatened and Endangered Status for Distinct Population Segments of Scalloped Hammerhead Sharks; Final Rule. Federal Register, 79, 38214–38242.

NMFS. 2015a. Species of Concern: Bumphead Parrotfish *Bolbometopon muricatum*. Accessed 16 January 2018, from http://www.nmfs.noaa.gov/pr/pdfs/species/bumpheadparrotfish_detailed.pdf. 30 October.

NMFS. 2015b. Species of Concern: Humphead Wrasse *Cheilinus undulatus*. Accessed 16 January 2018, from http://www.nmfs.noaa.gov/pr/pdfs/species/humpheadwrasse_detailed.pdf. 30 October.

NMFS. 2018a. Endangered and Threatened Wildlife and Plants: Listing the Oceanic Whitetip Shark as Threatened Under the Endangered Species Act. Federal Register, 83, 4153–4165.

NMFS. 2018b. Endangered and Threatened Wildlife and Plants; Final Rule To List the Giant Manta Ray as Threatened Under the Endangered Species Act. Federal Register, 83, 2916–2931.

NMFS. 2020. Endangered Species Act Section 7 Consultation Biological Opinion and Conference Report for the U.S. Military Mariana Islands Training and Testing Activities. 10 July.

NOAA. 2012. Endangered and Threatened Wildlife and Plants: Notice of 12-Month Finding on a Petition To List the Bumphead Parrotfish as Threatened or Endangered Under the Endangered Species Act (ESA). Federal Register, 77, 66799–66818.

NOAA. 2017a. Ocean Watch. Accessed 15 October 2017, from http://oceanwatch.pifsc.noaa.gov/.

NOAA. 2017b. Online datasets for bathymetry and habitat mapping. Accessed 11 April 2018, from https://www.coris.noaa.gov/search/catalog/main/home.page.

Oleson, E., Baumann-Pickering, S., Sirovic, A., Merkens, K., Munger, L., Trickey, J., and Fisher-Pool, P. 2015. Analysis of Long-term Acoustic Datasets for Baleen Whales and Beaked Whales within the Mariana Islands Range Complex (MIRC) for 2010 to 2013 (PIFSC Data Report No. DR-15-002). 18 February.

Olmsted, N. 2016. GIS Data for Plant Surveys and General Handling Requirements of High Value Trees (HVTs) to Support Project J755 at Andersen South. Personal communication via email from N. Olmsted, Natural Resources Specialist, DPRI Environmental, NAVFAC Marianas, Guam to R. Spaulding, Senior Biologist/Project Manager, Cardno, Bainbridge Island, WA. December.

Pacific Air Forces. 2006. Environmental Impact Statement for Establishment and Operation of Intelligence Reconnaissance and Strike Capability at Andersen AFB. Department of the Air Force, Hickam AFB, HI. November.

Paulay, G., Kirkendale, L., Meyer, C., Houk, P., Rongo, T., and Chang, R. 2001. Marine Biodiversity Resource Survey and Baseline Reef Monitoring Survey of the Southern Orote Peninsula and North Agat Bay Area. Prepared for COMNAVMAR, Guam.

Paulay, G., Kirkendale, L., Lambert, G., and Meyer, M. 2002. Anthropogenic biotic interchange in a coral reef ecosystem: A case study from Guam. Pacific Science, 56, 403–422.

Perez, G. 1972. Observations of Guam bats. Micronesica, 8, 141–149.

PIFSC. 2014. Pacific Reef Assessment and Monitoring Program. Fish Monitoring Brief: Northern Mariana Archipelago 2014 (PIFSC Data Report No. DR-14-010). NOAA NMFS PIFSC. 23 May.

Plucer-Rosario, G. 1987. The effect of substratum on the growth of *Terpios*, an encrusting sponge which kills corals. Coral Reefs, 5, 197–200.

Pregill, G. K. and Steadman, D. W. 2009. The prehistory and biogeography of terrestrial vertebrates of Guam, Mariana Islands. Diversity and Distributions, 15, 983–996.

Quinata, C. 2018. Coconut rhinoceros beetle and *Cycas*. Personal communication via email from C. Quintana, Natural Resource Specialist, DPRI, Guam to J. Ford, Pacific Operations Manager, Cardno, Honolulu, HI. 27 February.

Randall, R. H. and Myers, R. F. 1983. The Corals (Vol. 2). UOG Press, Mangilao, GU.

Raulerson, L. and Rinehart, A. 1991. Trees and Shrubs of the Northern Mariana Islands. Coastal Resources Management, Office of the Governor.

Raymundo, L., Burdick, D., Lapacek, V. A., Miller, R., and Brown, V. 2017. Anomalous temperatures and extreme tides: Guam staghorn *Acropora* succumb to a double threat. Marine Ecology Progress Series, 564, 47–55.

Raymundo, L., Malay, M. C. D., and Williams, A. N. 2016. Stony Coral Health Status, Community Structure, and Macrobioeroder Density within Apra Harbor Guam. Final Report. Prepared for NAVFAC Marianas, Guam by UOG Marine Laboratory, Mangilao, GU. 26 May.

Raymundo, M. and Miller, R. H. 2012. Little fire ant, *Wasmannia auropunctata* (Roger) (Hymenoptera: Formicidae), established at several locations on Guam. Proceedings of the Hawaiian Entomological Society, 44, 85–87.

Redding, J. E., Myers-Miller, R. L., Baker, D. M., Fogel, M., Raymundo, L., and Kim, K. 2013. Link between sewage-derived nitrogen pollution and coral disease severity in Guam. Marine Pollution Bulletin, 73, 57–63.

Reimer, J. D., Nozawa, Y., and Hirose, E. 2011. Domination and disappearance of the black sponge: a quarter century after the initial *Terpios* outbreak in southern Japan. Zoological Studies, 50, 394.

Reynolds, T. C., Burdick, D., Houk, P., Raymundo, L., and Johnson, S. 2014. Unprecedented coral bleaching across the Marianas Archipelago. Coral Reefs, 33, 499–499.

Rodda, G. H., Fritts, T. H., Clark, C. S., Gotte, S. W., and Chizar, D. 1999. A state-of-the-art trap for the brown treesnake. Pages 268-305 *in* G.H. Rodda, Y. Sawai, D. Chiszar, and H. Tanaka (Eds.), Problem Snake Management: The Habu and the Brown Treesnake. Cornell University Press, Ithaca, NY.

Rosario, C. A., Sablan, L. R., Miller, R. H., and Moore, A. 2016. Greater Banded Hornet *Vespa tropica* (Hymenoptera: Vespidae) (Guam New Invasive Species Alert No. 2016-01). 27 July.

Rubinoff, D. 2016. The Conservation Status of Two Endangered Mariana Butterflies, *Hypolimnas octocula marianensis* and *Vagrans egistina* (Nymphalidae). Unpublished report. Prepared for USFWS, Pacific Islands Fish and Wildlife Office, Honolulu, HI.

Rubinoff, D. and Haines, W. 2012. Report for Surveys Conducted on Guam and Rota October 10-20, 2012. Assessing the Conservation Status of *Hypolimnas octocula* and *Vagrans egistina*, Candidates for ESA listing.

Safford, W. 2009. The Chamorro Language of Guam. University of Michigan Library. 27 April.

Savidge, J. 1987. Extinction of an island forest avifauna by an introduced snake. Ecology, 68, 660–668.

Schils, T. 2015. Restyling Guam's Reef Flats: Angel Hair alga on the rise. Man, Land, and Sea, 6–7.

Schils, T. and Houk, P. 2017. Management Plan. Marine Resources Surveys of Naval Base Guam and Naval Support Activity Andersen AFB. Mangilao, GU.

Schils, T., Houk, P., Biggs, J. S., Donaldson, T. J., Kense, A., and McLean, M. 2017. Marine Resources Surveys of Naval Base Guam and Naval Support Activity Andersen AFB. Mangilao, GU.

Schreiner, I. H. and Nafus, D. M. 1996. Survey of Rare Butterflies in the Mariana Islands. Preliminary report to USFWS.

Schreiner, I. H. and Nafus, D. M. 1997. Butterflies of Micronesia. Agricultural Experiment Station College of Agriculture and Life Sciences, UOG.

Smith, B., Cooper-Nurse, R., and Gawel, A. M. 2008. Survey of Endangered Tree Snails on Navy-Owned Land in Guam. Draft. Prepared by UOG, Marine Laboratory for the U.S. Navy, Mangilao, GU.

Smith, B. and Hopper, D. R. 1994. The Partulidae of the Mariana Islands: Continued threats and declines. Hawaiian Shell News, 42, 10–11.

Sonoda, K. and Paul, V. J. 1993. Effect of stony corals extracts on feeding by *Acanthaster planci*. Marine Ecology Progress Series, 102, 161–168.

Summers, T. M., Martin, S. L., Hapdei, J. R., Ruak, J. K., and Jones, T. T. 2018. Endangered Green Turtles (*Chelonia mydas*) of the Northern Mariana Islands: Nesting ecology, poaching, and climate concerns. Frontiers in Marine Science, 4, 428.

Thacker, R. W. and Paul, V. J. 2001. Are benthic cyanobacteria indicators of nutrient enrichment? Relationships between cyanobacterial abundance and environmental factors on the reef flats of Guam. Bulletin of Marine Science 69: 497-508.

Timmers, M., Bird, C. E., Skillings, D. J., Smouse, P. E., and Toonen, R. J. 2012. There's no place like home: Crown-of-thorns outbreaks in the Central Pacific are regionally derived and independent events. PLOS ONE, 7, e31159.

Topping, D., Ogo, P., and Dungca, B. 1975. Chamorro-English Dictionary. University of Hawai'i Press, Honolulu, HI.

U.S. Navy. 2006. Naval Ships' Technical Manual, Chapter 081, Revision 5, Waterborne Underwater Hull Cleaning of Navy Ships.

USAF. 2009. Final Integrated Natural Resources Management Plan and Environmental Assessment. Prepared for Andersen AFB, Guam. July.

USAF and USFWS. 1994. Cooperative Agreement between the U.S. Air Force and the U.S. Fish and Wildlife Service for the Establishment and Management of the Guam National Wildlife Refuge, Guam. March.

USDA. 1988. Soil Survey of Territory of Guam. USDA Soil Conservation Service, in cooperation with Guam Department of Commerce and UOG. Prepared by F.J. Young. May.

USFS. 2006. Guam Vegetation Mapping. Pacific Southwest Region, Forest Health Protection, McClellan, CA. October.

USFWS. 1986. Fish and Wildlife Resources of the Orote Ecological Reserve Area. Prepared for NAVFAC Pacific, Pearl Harbor, HI by USFWS, Office of Environmental Services, Honolulu, HI. September.

USFWS. 1994. Endangered and Threatened Wildlife and Plants; Withdrawal of Proposed Rule to Designate Critical Habitat for the Little Mariana Fruit Bat, Mariana Fruit Bat, Guam Broadbill, Mariana Crow, Guam Micronesian Kingfisher, and Guam Bridled White-Eye, 59, 15696–15700.

USFWS. 2001. Assessment of the Coconut Crab (*Birgus latro*) Population on the Naval Computer and Telecommunications Master Station. Unpublished report. Prepared for Commander, U.S. Naval Forces, Marianas.

USFWS. 2006. Biological Opinion on the Establishment and Operation of an Intelligence, Surveillance, Reconnaissance, and Strike Capability Project on Andersen AFB, Guam.

USFWS. 2009. Guam National Wildlife Refuge Comprehensive Conservation Plan. Prepared by Guam NWR, Yigo, Guam and USFWS, Pacific Islands Field Office, Honolulu, HI.

USFWS. 2010. Biological Opinion for the Joint Guam Program Office Relocation of the U.S. Marine Corps from Okinawa to Guam and Associated Activities on Guam and Tinian. Pacific Islands Fish and Wildlife Office, Honolulu, HI. 8 September.

USFWS. 2011. Guam and Commonwealth of the Northern Mariana Islands Animals and Plants: Updated February 2, 2011. Listed Species, as Designated under the U.S. Endangered Species Act.

USFWS. 2014. Endangered and Threatened Wildlife and Plants; Proposed Endangered Status for 21 Species and Proposed Threatened Status for 2 Species in Guam and the Commonwealth of the Northern Mariana Islands; Proposed Rule. Federal Register, 79(190), 59364–59413.

USFWS. 2015a. Endangered and Threatened Wildlife and Plants; Endangered Status for 16 Species and Threatened Status for 7 Species in Micronesia. Federal Register, 80(190), 59424–59497.

USFWS. 2015b. Biological Opinion for the Mariana Islands Testing and Training Program. Pacific Islands Fish and Wildlife Office, Honolulu, HI. 20 February.

USFWS. 2016. Reducing Bird Collisions with Buildings and Glass, Best Practices. Division of Migratory Bird Management, Falls Church, VA. January, updated July 2016.

USFWS. 2017. Reinitiation of the 2015 Biological Opinion on the Department of the Navy's Relocation of U.S. Marine Corps from Okinawa to Guam and Associated Activities on Guam (Consultation 01EPIF00-2015-F-0025 and 01EPIF00-2016-F-0185). Pacific Islands Fish and Wildlife Office, Honolulu, HI. 18 July.

USGS. 2006. Final Integrated Trip Report—Site Visits to Area 50, Andersen AFB, Guam National Wildlife Refuge, War in the Pacific National Historic Park, Guam, Rota and Saipan, CNMI, 2004-2005. Prepared by S.C. Hess and L.W. Pratt.

Waddell, J. E. 2005. The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2005 (NOAA Technical Memorandum No. NOS NCCOS 11). NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team, Silver Spring, MD.

Weijola, V., Vahtera V., Koch A., Schmitz A., Kraus F. 2020. Taxonomy of Micronesian monitors (Reptilia: Squamata: Varanus): endemic status of new species argues for caution in pursuing eradication plans. R. Soc. Open Sci. 7:200092.

WERI. 2017. Northern Guam Geospatial Server. Digital Atlas of Northern Guam. Accessed 25 September 2017, from http://north.hydroguam.net/geographic-geology.php.

Wheeler, M. E. and Aguon, C. F. 1978. The Current Status and Distribution of the Marianas Fruit Bat on Guam (Aquatic and Wildlife Resources Division Technical Report No. 1). Guam Department of Agriculture, Division of Aquatic and Wildlife Resources, Mangilao, GU.

White Buffalo Inc. 2023. Monthly Progress Report for Ungulate Control, Eradication and Basic Research of Naval Base Guam, Andersen Air Force Base and Marine Corps Camp Blaz for Joint Region Marianas Guam area of Responsibility. 6B Kings Highway, Chester, CT 06412. November.

Widlanski, M. J., Timmerman, A., and Cai, W. 2015. Future extreme sea level seesaws in the tropical Pacific. Science Advances, 1.

Wiles, G. 1987a. The Status of Fruit Bats on Guam. Pacific Science, 41, 148–157.

Wiles, G. 1987b. Current research and future management of Mariana fruit bats (Chiroptera: Pteropodidae) on Guam. Australian Mammalogy, 10, 93–95.

Wiles, G. 1987c. Natural History, Biology, and Habitat Protection for the Mariana Fruit Bats. Pages 124-135 *in* G. Grimm and L. Mariano (Eds.), Aquatic and Wildlife Resources Division Annual Report. Guam Department of Agriculture, Division of Aquatic and Wildlife Resources, Mangilao, GU.

Wiles, G. 2005. A checklist of the birds and mammals of Micronesia. Micronesica, 38, 141–189.

Wiles, G., Bart, J., Beck Jr., R. E., and Aguon, C. F. 2003. Impacts of the brown treesnake: patterns of decline and species persistence in Guam's avifauna. Conservation Biology, 17, 1350–1360.

Wiles, G. and Ritter, M. 1993. Country Report: Guam. *In* D. A. Scott (Ed.), A Directory of Wetlands in Oceania. IWRB, Slimbridge, UK and AWB, Kuala Lumpur, MY.

Williams, I., Zamzow, J., Lino, K., Ferguson, M., and Donham, E. 2012. Status of Coral Reef Fish Assemblages and Benthic Condition Around Guam: A Report Based on Underwater Visual Surveys in Guam and the Mariana Archipelago, April-June 2011 (No. NMFS-PIFSC-33). Pacific Islands Fisheries Science Center.

Wolanski, E., Richmond, R. H., Davis, G., and Bonito, V. 2003. Water and fine sediment dynamics in transient river plumes in a small, reef-fringed bay, Guam. Estuarine, Coastal and Shelf Science, 56, 1029–1040.

WPRFMC. 2009. Fishery Ecosystem Plan for the Mariana Archipelago. Honolulu, HI. 24 September.

Yackel Adams, A., Hanslowe E.B., Nafus M.G., Siers, S.R. (2022). Monitoring demographic and ecological effects of sustained Automated Delivery System treatment in the Habitat Management Unit, Andersen Air Force Base, Guam. March.

Young, J., Olson, K. A., Reading, R. P., Amgalanbaatar, S., and Berger, J. 2011. Is wildlife going to the dogs? Impacts of feral and free-roaming dogs on wildlife populations. BioScience, 61, 125–132.

15.10 CHAPTER 10 – OVERVIEW OF THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS

Abraham, T., Beger, M., Burdick, D., Cochrane, E., Craig, P., Didonato, G., Fenner, D., Green, A., Globuu, Y., Gutierrez, J., Hasurmai, H., Hawkins, C., Houk, P., Idip, D., Jacobson, D., Joseph, E., Keju, T., Juartei, J., Palik, S., and Penland, L. 2004. Status of the coral reefs in Micronesia and American Samoa. Pages 381-409 *in* C. Wilkinson (Ed.), Status of Coral Reefs of the World 2004. Australian Institute of Marine Science, Townsville, Queensland, AU.

Amesbury, S. and Myers, R. 2001. Guide to the Coastal Resources of Guam, Volume 1 – The Fishes (Contribution No.173). UOG Marine Laboratory, Mangilao, GU.

Amidon, F. 2009. Vegetation Surveys on Tinian and Aguiguan. Pages 8-18 *in* Terrestrial Resource Surveys of Tinian and Aguiguan, Mariana Islands, 2008 – Final Report. Prepared by USFWS, Pacific Islands Fish and Wildlife Office for Marine Forces Pacific and NAVFAC Pacific, Pearl Harbor, HI. December.

Andersson, A. J., Kline, D. I., Edmunds, P. J., Archer, S. D., Bednaršek, N., Carpenter, R. C., Chadsey, M., Goldstein, P., Grottoli, A. G., Hurst, T. P., King, A. L., Kübler, J. E., Kuffner, I. B., Mackey, K. R. M., Menge, B. A., Paytan, A., Riebesell, U., Schnetzer, A., Warner, M. E., and Zimmerman, R. C. 2015. Understanding ocean acidification impacts on organismal to ecological scales. Oceanography, 28, 16–27.

Appeltans, W., Bouchet, P., Boxshall, G. A., Fauchald, K., Gordon, D. P., Hoeksema, B. W., Poore, G. C. B., van Soest, R. W. M., Stöhr, S., Walter, T. C., and Costello, M. J. 2010. World Register of Marine Species. Accessed 6 September 2010, from http://www.marinespecies.org/index.php.

Avibase. 2017. Bird Checklists of the World. Accessed 20 November 2017, from https://avibase.bsc-eoc.org/checklist.jsp?lang=EN.

Berger, G. M., Gourley, J., and Schroer, G. 2005. Comprehensive Wildlife Conservation Strategy for the Commonwealth of the Northern Mariana Islands. Prepared by CNMI Department of Lands and Natural Resources, Division of Fish and Wildlife, Saipan, CNMI for National Advisory Acceptance Team, Migratory Birds and State Programs, USFWS, Portland, OR. September.

Bonaccorso, F. and Allison, A. 2008. *Emballonura semicaudata*. 2008 IUCN Red List of Threatened Species. Accessed 15 November 2017, from http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T7669A12841889.en.

Bourquin, O. 2002. Invertebrates Recorded from the Northern Marianas Islands, Status 2002. Cooperative Research Extension and Education Service, Northern Marianas College, Saipan, MP. December.

Brainard, R. E., Birkeland, C., Eakin, C. M., McElhany, P., Miller, M. W., Patterson, M. E., and Piniak, G. A. 2011. Status review report of 82 candidate coral species petitioned under the U.S. Endangered Species Act (NOAA Technical Memorandum No. NOAA-TM-NMFS-PIFSC-27). U.S. Department of Commerce, Honolulu, HI. September.

Brainard, R. E., Asher, J., Blyth-Skyrme, V., Coccagna, E. F., Dennis, K., Donovan, M. K., Gove, J. M., Kenyon, J., Looney, E. E., Miller, J. E., Timmers, M., Vargas-Ángel, B., Vroom, P. S., Vetter, O., and Zgliczynski, B. 2012. Coral Reef Ecosystem Monitoring Report of the Mariana Archipelago: 2003 to 2007 (PIFSC Special Publication No. SP-12-01). NOAA Fisheries, Pacific Islands Fisheries Science Center. Honolulu, HI. March.

Breitburg, D. L., Salisbury, J., Bernhard, J. M., Cai, W. J., Dupont, S., Doney, S. C., Kroeker, K. J., Levin, L. A., Long, W. C., Milke, L. M., S.H. Miller, Phelan, B., Passow, U., Seibel, B. A., Todgham, A. E., and Tarrant, A. M. 2015. And on top of all thaI. coping with ocean acidification in the midst of many stressors. Oceanography, 28, 48–61.

Brown, M. T. and Depledge, M. H. 1998. Determinants of Trace Metal Concentrations in Marine Organisms. Pages 185-217 *in* W. J. Langston and M. J. Bebianno (Eds.), Metal Metabolism in Aquatic Environments. Springer, Boston, MA.

Bryant, D. G., Burke, L., McManus, J., and Spalding, M. 1998. Reefs at risk: a map-based indicator of threats to the world's coral reefs. World Resources Institute, Washington, D.C.

Burdick, D., Brown, V., Asher, J., Gawel, M., Goldman, L., Hall, A., Kenyon, J., Leberer, T., Lundblad, E., McIlwain, J., Miller, J., Minton, D., Nadon, M., Pioppi, N., Raymundo, L., Richards, B., Schroeder, R., Schupp, P., Smith, E., and Zgliczynski, B. 2008. The State of Coral Reef Ecosystems of Guam. Pages 465-509 *in* J. E. Waddell and J. M. Clarke (Eds.), The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2008. NOAA Technical Memorandum NOS NCCOS 73. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team, Silver Spring, MD. April.

Bureau of Environmental and Coastal Quality Division of Coastal Resources Management. 2016. 2016-2020 Section 309 Assessment and Strategy Report. May.

Burke, L. and Maidens, J. 2004. Reefs at Risk in the Caribbean. World Resources Institute, Washington, D.C.

Burkepile, D. E. and Hay, M. E. 2006. Herbivore vs. nutrient control of marine primary producers: content-dependent effects. Ecology, 87, 3128–3139.

California Department of Transportation. 2001. San Franci–co - Oakland Bay Bridge East Span Seismic Safety Project, Pile Installation Demonstration Project, Fisheries Impact Assessment. August.

Caribbean Fishery Management Council. 1994. Fishery Management Plan, Regulatory Impact Review and Final Environmental Impact Statement for Corals and Reef Associated Plants and Invertebrates of Puerto Rico and the U. S. Virgin Islands. Caribbean Fishery Management Council, San Juan, PR.

Carilli, J. E., Norris, R. D., Black, B. A., Walsh, S. M., and McField, M. 2009. Local Stressors Reduce Coral Resilience to Bleaching. PLOS ONE, 4, e6324.

Carlson, T. J., Hastings, A., and Popper, A. N. 2007. Update on recommendations for revised sound exposure guidelines for fish during pile driving activities.

Cheung, W., Watson, R., Morato, T., Pitcher, T., and Pauly, D. 2007. Intrinsic vulnerability in the global fish catch. Marine Ecology Progress Series, 333, 1–12.

Cloud, Jr., P. E., Schmidt, R. G., and Burke, H. W. 1956. Geology of Saipan Mariana Islands. Part 1. General Geology (Geological Survey Professional Paper No. 280-A). U.S. Government Printing Office, Washington, D.C.

CNMI DFW. 2008. Freshwater Invasive Species Project. August.

CNMI DFW. 2018. Personal communication via comment response matrix between CNMI DFW, JRM, and Cardno. 25 May.

CNMI DLNR. 2015. Letter report addressed to the USFWS headquarters, signed by R. B. Seman and M. M. Pangelinan, with agency review comments on the proposed rule for listed 21 species and threatened and endangered in Guam and the Commonwealth of the Northern Mariana Islands.

Coastal Resources Management Office of the Governor CNMI. 1985. A Preliminary Study of the Technical Feasibility of Aquaculture in the Islands of Saipan, Tinian, and Rota Commonwealth of the Northern Mariana Islands. Prepared by Coastal Resources Management Office of the Governor Commonwealth of the Northern Mariana Islands. Prepared under contract by The Northern Islands Company, Saipan, CM. March.

Cohen, A. L., McCorkle, D. C., de Putron, S., Gaetani, G. A., and Rose, K. A. 2009. Morphological and compositional changes in the skeletons of new coral recruits reared in acidified seawater: Insights into the biomineralization response to ocean acidification. G3: Geochemistry Geophysics Geosystems, 10.

Commonwealth Law Revision Commission. 2016. Northern Marianas Islands Administrative Code. Title 85: Department of Lands and Natural Resources. Chapter 85-30, Division of Fish and Wildlife. Subchapter 30.1, Non-Commercial Fish and Wildlife Regulations (No. Part 001, 85-30.1).

Cortés, N. J. and Risk, M. J. 1985. A reef under siltation stress: Cahuita, Costa Rica. Bulletin of Marine Science, 36, 339–356.

Costion, C. M. and Lorence, D. H. 2012. The endemic plants of Micronesia: A geographical checklist and commentary. Micronesica, 43, 51–100.

Crain, C. M., Halpern, B. S., Beck, M. W., and Kappel, C. V. 2009. Understanding and Managing Human Threats to the Coastal Marine Environment. Pages 39-62 *in* R.S. Ostfeld and W.H. Schlesinger (Eds.), The Year in Ecology and Conservation Biology (Vol. 1162). Blackwell Publishing, Oxford, UK.

Crombie, R. I. and Pregill, G. K. 1999. A checklist of the herpetofauna of the Palau Islands (Republic of Belau), Oceania. Herpetological Monographs, 13, 29–80.

Cuetos-Bueno, J. and Houk, P. 2015. Re-estimation and synthesis of coral reef fishery landings in the Commonwealth of the Northern Mariana Islands since the 1950s suggests the decline of a common resource. Reviews in Fish Biology and Fisheries, 25, 179–194.

Cuetos-Bueno, J., Hernandez-Ortiz, D. & Houk, P. Co-evolution of "race-to-fish" dynamics and declining size structures in an expanding commercial coral-reef fishery. *Rev Fish Biol Fisheries* 29, 147–160 (2019). https://doi.org/10.1007/s11160-018-9542-1

Denton, G. R., Emborski, C. A., Hachero, A. A., Masga, R. S., and Starmer, J. A. 2016. Impact of WWII dumpsites on Saipan (CNMI): heavy metal status of soils and sediments. Environ Sci Pollut Res Int, 23, 11339–48.

Denton, G. R. W., Bearden, B. G., Concepcion, L. P., Wood, H. R., and Morrison, R. J. 2006. Contaminant assessment of surface sediments from Tanapag Lagoon, Saipan, Commonwealth of the Northern Mariana Islands. Marine Pollution Bulletin, 52, 703–710.

Denton, G. R. W., Morrison, R. J., Bearden, B. G., Houk, P., Starmer, J. A., and Wood, H. R. 2009. Impact of a coastal dump in a tropical lagoon on trace metal concentrations in surrounding marine biota: A case study from Saipan, CNMI. Marine Pollution Bulletin, 58, 424–431.

DoD. 2014. Quadrennial Defense Review Report 2014. 20 July.

DON. 2010a. Final Environmental Impact Statement. Guam and CNMI Military Relocation: Relocating Marines from Okinawa, Visiting Aircraft Carrier Berthing, and Army Air and Missile Defense Task Force. Volume 2: Marine Corps Relocat–on - Guam. Prepared by NAVFAC Pacific, Pearl Harbor, HI for Joint Guam Program Office, Washington, D.C. July

DON. 2010b. Update of Integrated Natural Resources Management Plans for Navy Leased Lands on Tinian and Farallon de Medinilla, Plan Years 2010-2015. Prepared by SWCA Environmental Consultants, Hagatna, GU. 29 May.

DON. 2014a. Final Survey Report. Terrestrial Biological Surveys on Tinian in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement. NAVFAC Pacific, Pearl Harbor, HI. July.

DON. 2014b. Final (Version 3) Sea Turtle Marine Resources Survey Report in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement. NAVFAC Pacific, Pearl Harbor, HI. March.

DON. 2014c. Final Coral Marine Resources Survey Report in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement. Prepared by Tetra Tech, Inc. for U.S. Navy, NAVFAC Pacific.

DON. 2015a. Regional Biosecurity Plan for Micronesia and Hawai‘i: 4 Volumes.

DON. 2015b. Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement (Draft). Prepared by U.S. Marine Corps Forces Pacific. April.

DON. 2017a. Tinian Reef Marine Resource Survey Rep–rt - in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement. Prepared by Tetra Tech, Inc. for U.S. Navy, NAVFAC Pacific.

DON. 2017b. Climate Change. Accessed 30 November 2017, from http://greenfleet.dodlive.mil/climate-change/.

Downs, C. A., Kramarsky-Winter, E., Woodley, C. M., Downs, A., Winters, G., Loya, Y., and Ostrander, G. K. 2009. Cellular pathology and histopathology of hypo-salinity exposure on the coral *Stylophora pistillata.* Science of the Total Environment, 407, 4838–4851.

Dulvy, N. and Polunin, N. 2004. Using informal knowledge to infer human-induced rarity of a conspicuous reef fish. Animal Conservation, 7, 365–374.

Esselstyn, J. A., Wiles, G., and Amar, A. 2004. Habitat use of the Pacific Sheath-tailed bat (*Emballonura semicaudata*) on Aguiguan, Mariana Islands. Acta Chiropterologica, 6, 303–308.

Falanruw, M. C., Cole, T. G., and Ambacher, A. H. 1989. Vegetation Survey of Rota, Tinian, and Saipan, Commonwealth of the Northern Mariana Islands (No. PSW-27). U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA. July.

Feist, B. E., Anderson, J. J., and Miyamoto, R. 1996. Potential impacts of pile driving on juvenile pink (*Oncorhynchus gorbuscha*) and chum (*O. kept*) salmon behavior and distribution. University of Washington, Seattle.

Fonseca, M. S. and Olsen, J. L. 2016. The complex and emerging story of Johnson’s seagrass. Environment Coastal and Offshore, 20–33.

Fosberg, F. R. 1960. The Vegetation of Micronesia 1. General description of vegetation of the Mariana Islands, and a detailed consideration of the vegetation of Guam. American Museum of Natural History Bulletin, 119, 1–76.

Furukawa, K., Wolanski, E., and Mueller, H. 1997. Currents and sediment transport in mangrove forests. Estuarine, Coastal and Shelf Science, 44, 301–310.

Galloway, S. B., Bruckner, A. W., and Woodley, C. M. (Eds.). 2009. Coral Health and Disease in the Pacific: Vision for Action. NOAA Technical Memorandum NOS NCCOS 97 and CRCP 7. NOAA, Silver Spring, MD.

Gingerich, S. B. 2002. Geohydrology and Numerical Simulation of Alternative Pumping Distributions and the Effects of Drought on the Ground-Water Flow System of Tinian, Commonwealth of the Northern Mariana Islands (USGS Water-Resources Investigations Report No. 02-4077). Prepared by the USGS in cooperation with the Commonwealth Utilities Corporation, CNMI.

GovGuam. 2009. Endangered Species Regulation No. 9. Department of Agriculture, Mangilao, GU. 6 November.

Hawaiian Agronomics International, Inc. 1985. Final Report for Flora and Fauna Survey of Tinian, Northern Mariana Islands. Prepared for Commander, Pacific Division, Naval Facilities Engineering Systems Command, Honolulu, HI.

Hayes, J. A. 1990. Distribution, movement and impact of the corallivorous gastropod *Coralliophila abbrevteiata* (Lamarck) on a Panamanian patch reef. Journal of Experimental Marine Biology and Ecology, 142, 25–43.

Heenan, A., McCoy, K., Asher, J., Ayotte, P., Gorospe, K., Gray, A., Lino, K., Zamzow, J., and Williams, I. 2015. Pacific Reef Assessment and Monitoring Program Data Report: Ecological Monitoring 2–14 - Stationary Point Count Surveys of Reef Fishes and Benthic Habitats of the Northwestern Hawaiian Islands, Mariana Islands, and Wake Atoll. NOAA PIFSC, Honolulu, HI.

Helgen, K. M. and Flannery, T. F. 2002. Distribution of the endangered Pacific sheathtail bat *Emballonura semicaudata*. Aust Mammal, 24, 209–212.

Hill, M.C., Bendlin, A.R., Ü, A.C., Yano, K.M., Bradford, A.L., Ligon, A.D., and Oleson, E.M. 2017. Cetacean Monitoring in the Mariana Islands Range Complex, 2016. Prepared for the U.S. Pacific Fleet Environmental Readiness Office. PIFSC Data Report DR-17-002. 46 pp. doi:10.7289/V5/DR-PIFSC-17-002. 3 February.

Hoegh-Guldberg, O. and Bruno, J. F. 2010. The Impact of Climate Change on the World's Marine Ecosystems. Science, 328, 1523–1528.

Houk, P., Musburger, C., and Wiles, P. 2010. Water quality and herbivory interactively drive coral reef recovery patterns in American Samoa. PLOS ONE, 5, e13913.

Houk, P. and Starmer, J. 2010. Constraints on the diversity and distribution of coral reef assemblages in the volcanic Northern Mariana Islands. Coral Reefs, 29, 59–70.

Houk, P. and van Woesik, R. 2010. Coral assemblages and reef growth in the Commonwealth of the Northern Mariana Islands (Western Pacific Ocean). Marine Ecology-an Evolutionary Perspective, 31, 318–329.

Hughes, T., Baird, A., Bellwood, D., Card, M., Connolly, S., Folke, C., Grosberg, R., Hoegh-Guldberg, O., Jackson, J., Kleypas, J., Lough, J., Marshall, P., Nystroem, M., Palumbi, S., Pandolfi, J., Rosen, B., and Roughgarden, J. 2003. Climate change, human impacts, and the resilience of coral reefs. Science, 301, 929–933.

Hughes, T., Kerry, J., Álvarez-Noriega, M., Álvarez-Romero, J., Anderson, K., Baird, A., Babcock, R., Beger, M., Bellwood, D., Berkelmans, R., Bridge, T., Butler, I., Byrne, M., Cantin, N., Comeau, S., Connolly, S., Cumming, G., Dalton, S., Diaz-Pulido, G., Eakin, C., Figueira, W., Gilmour, J., Harrison, H., Heron, S., Hoey, A., Hobbs, J., Hoogenboom, M., Kennedy, E., Kuo, C., Lough, J., Lowe, R., Liu, G., McCulloch, M., Malcolm, H., McWilliam, M., Pandolfi, J., Pears, R., Pratchett, M., Schoepf, V., Simpson, T., Skirving, W., Sommer, B., Torda, G., Wachenfeld, D., Willis, B., and Wilson, S. 2017. Global warming and recurrent mass bleaching of corals. Nature, 543, 373–377.

Hunt, B. and Vincent, A. C. J. 2006. Scale and Sustainability of Marine Bioprospecting for Pharmaceuticals. Ambio, 35, 57–64.

Jackson, J., Kirby, M., Berger, W., Bjorndal, K., Botsford, L., Bourque, B., Bradbury, R., Cooke, R., Erlandson, J., Estes, J., Hughes, T., Kidwell, S., Lange, C., Lenihan, H., Pandolfi, J., Peterson, C., Steneck, R., Tegner, M., and Warner, R. 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science, 293, 629–638.

Jones, T. T., Martin, S. L., and Van Houtan, K. S. 2015. Sea Turtle Tagging in the Mariana Islands Range Complex (MIRC) Interim Progress Report (PIFSC Data Report No. DR-15-020). Prepared for U.S. Pacific Fleet Environmental Readiness Office, Pearl Harbor, HI. September.

Joos, F., Frolicher, T. L., Steinacher, M., and Plattner, G. K. 2011. Impact of Climate Change Mitigation on Ocean Acidification Projections. Pages 273-289 *in* J. Gattuso and L. Hansson (Eds.), Ocean Acidification. Oxford University Press, Oxford, UK.

Juan C. Tenorio and Associates. 1979. Ornithological Survey of Wetlands in Guam, Saipan, Tinian and Pagan. Prepared for the Corps of Engineers, Pacific Ocean Division, Department of the Army.

Kappel, C. V. 2005. Losing pieces of the puzzle: threats to marine, estuarine, and diadromous species. Frontiers in Ecology and the Environment, 3, 275–282.

Keener, V., D. Helweg, S. Asam, S. Balwani, M. Burkett, C. Fletcher, T. Giambelluca, Z. Grecni, M. Nobrega-Olivera, J. Polovina, and G. Tribble, 2018: HaIai‘i and U.S.-Affiliated Pacific Islands. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1242–1308. doi: 10.7930/NCA4.2018.CH27

Kellman, M. and Tackaberry, R. 1997. Tropical Environments: The Functioning and Management of Tropical Ecosystems. Routledge, New York, NY.

Kelly, M., Hooper, J., Paul, V., Paulay, G., van Soest, R., and de Weerdt, W. 2003. Taxonomic inventory of the sponges (Porifera) of the Mariana Islands. Micronesica, 35, 100–120.

Kendall, M. S. and Poti, M. 2015. Transport Pathways of Marine Larvae Around the Mariana Archipelago (NOAA Technical Memorandum NOS NCCOS 193). Silver Spring, MD.

Kerr, A. M. 1990. Chamorro Fish Names. Micronesica, 23, 93–118.

Kerr, A. M. 2012. Fish Names of the Mariana Islands, Micronesia (UOG Marine Laboratory Technical Report No. 139). Mangilao, GU. February.

Kerr, A. M. 2013. Illustrated Guide to the Reptiles and Amphibians of the Mariana Islands, Micronesia (UOG Marine Laboratory Technical Report No. 150). Mangilao, GU. March.

Kerr, A. M. and Bauman, S. 2013. Annotated Checklist of the Land Snails of the Mariana Islands, Micronesia (UOG Marine Laboratory Technical Report No. 148). Mangilao, GU.

Kessler, C. C. 2009. Feral Goats on Tinian and Aguiguan. Pages 279-281 *in* Terrestrial Resource Surveys of Tinian and Aguiguan, Mariana Islands, 2008 – Final Report. Prepared by USFWS, Pacific Islands Fish and Wildlife Office, Honolulu, HI for U.S. Marine Force Pacific and NAVFAC, Pearl Harbor, HI.

Kessler, C. C. 2011. Status of Feral Ungulates on Pagan Island, CNMI: Marianas Expedition Wildlife Surveys 2010. Prepared by USFWS Pacific Islands Office, Honolulu, HI for USMC and NAVFAC Pacific, Pearl Harbor, HI.

Kobayashi, D., Cheng, I.-J., Parker, D. M., Polovina, J. J., Kamezaki, N., and Balazs, G. H. 2011. Loggerhead turtle (*Caretta caretta*) movement off the coast of Taiwan: characterization of a hotspot in the East China Sea and investigation of mesoscale eddies. ICES Journal of Marine Science, 68, 707–718.

Kopp, D., Bouchon-Navaro, Y., Cordonnier, S., Haouisee, A., Louis, M., and Bouchon, C. 2010. Evaluation of algal regulation by herbivorous fishes on Caribbean coral reefs. Helgoland Marine Research, 64, 181–190.

Lander, J. F., Whiteside, L. S., and Hattori, P. 2002. The Tsunami History of Guam: 1849-1993. Science of Tsunami Hazards, 20, 158–174.

Lardner, B., Reed, R. N., Yackel Adams, A. A., Mazurek, M., Hinkle, T. J., Levasseur, P. M., Palmer, M. S., and Savidge, J. A. 2013. Selective predation by feral cats on a native skink on Guam. ICRF Reptiles and Amphibians, 20, 16–19.

Lesser, M. P., Bythell, J. C., Gates, R. D., Johnstone, R. W., and Hoegh-Guldberg, O. 2007. Are infectious diseases really killing corals? Alternative interpretations of the experimental and ecological data. Journal of Experimental Marine Biology and Ecology, 346, 36–44.

Liske-Clark, J. 2015. Wildlife Action Plan for the Commonwealth of the Northern Mariana Islands, 2015-2025. CNMI DLNR-Division of Fish and Wildlife, Saipan, MP. 16 December.

Liske-Clark, J., Zarones, L., Ulloa, R., and Willsey, T. 2015. Preliminary survey of *Maesa waudubolkeri* on Rota, CNMI. CNMI DFW and DLNR Report.

Lobban, C. S. and Tsuda, R. T. 2003. Revised checklist of benthic marine macroalgae and seagrasses of Guam and Micronesia. Micronesica, 35, 54–99.

Marler, T. E. and Lawrence, J. H. 2012. Demography of *Cycas micronesica* on Guam following introduction of the armoured scale *Aulacaspis yasumatsui*. Journal of Tropical Ecology, 28, 233–242.

Martin, S. L. and Jones, T. T. 2016. Sea Turtle Tagging in the Mariana Islands Training and Testing (MITT) Study Area (PIFSC Data Report No. DR-17-025). Prepared for the U.S. Pacific Fleet Environmental Readiness Office, Honolulu, HI. 15 December.

Maynard, J., McKagan, S., Raymundo, L., Johnson, S., Ahmadia, G., Johnston, L., Houk, P., Williams, G., Kendall, M., Heron, S., van Hooidonk, R., and Mcleod, E. 2015. Assessing relative resilience potential of coral reefs to inform management in the Commonwealth of the Northern Mariana Islands. NOAA Technical Memorandum CRCP 22. NOAA Coral Reef Conservation Program, Silver Spring, MD.

McCoid, M. J., Rodda, G. H., and Fritts, T. H. 1995. Distribution and abundance of *Emoia slevini* (Scincidae) in the Mariana Islands. Herpetological Review, 26, 70–72.

Mildenstein, T. L. 2008. Population Viability Analysis of the Mariana Fruit Bat Metapopulation in the Mariana Islands. Prepared for Mariana Fruit Bat Recovery Team, USFWS Office, Pacific Islands Office, Honolulu, HI.

Miller, M. P., Mullins, T. D., Haig, S. M., Takano, L., and Garcia, K. 2015. Genetic structure, diversity, and interisland dispersal in the endangered Mariana Common Moorhen (*Gallinula chloropus guami*). Condor, 117, 660–669.

Miller, M. W. and Hay, M. E. 1996. Coral-seaweed-grazer-nutrient interactions on temperate reefs. Ecological Monographs, 66, 323–344.

Minton, D., Brown, V., Dugger, K., Flores, T., Foster, K., Houk, P., Iguel, J., Kessler, C., Kolinski, S., Schols, T., Starmer, J., Suhkraj, N., Tenorio, M., and Trianni, M. 2009. Draft Report. Marine Resource Surveys of Tinian, Commonwealth of the Northern Mariana Islands. Volume I. UOG Marine Laboratory, Mangilao, GU.

Moore, C. J. 2008. Synthetic polymers in the marine environment: a rapidly increasing, long-term threat. Environmental Research, 108, 131–139.

Mueller, C. S., Haller, K. M., Luco, N., Petersen, M. D., and Frankel, A. D. 2012. Seismic Hazard Assessment for Guam and the Northern Mariana Islands. Open-File Report No. 2012-1015. USGS, Reston, VA.

Mueller-Blenkle, C., McGregor, P. K., Gill, A. B., Andersson, M. H., Metcalfe, J., Bendall, V., Sigray, P., Wood, D., and Thomsen, F. 2010. Effects of Pile Driving Noise on the Behavior of Marine Fish. Technical Report COWRIE Ref: Fish 06-08. 31 March.

Mueller-Dombois, D. and Fosberg, F. R. 1998. Vegetation of the Tropical Pacific Islands. Springer-Verlag, Inc., New York, NY

Musick, J. A., Burgess, G., Cailliet, G., Camhi, M., and Fordham, S. 2000. Management of sharks and their relatives (*Elasmobranchii*). American Fisheries Society Policy Statement #31b. Fisheries, 25, 9–13.

Myers, R. F. and Donaldson, T. J. 2003. The fishes of the Mariana Islands. Micronesica, 35–36, 594–648.

Nagelkerken, I., Blaber, S., Bouillon, S., Green, P., Haywood, M., Kirton, L., Meynecke, J.-O., Pawlik, J., Penrose, H., and Sasekumar, A. 2008. The habitat function of mangroves for terrestrial and marine fauna: A review. Aquatic Botany, 89, 155–185.

National Research Council. 1997. The Scientific Basis for Preservation of the Mariana Crow. The National Academies Press, Washington, D.C.

NAVFAC Marianas. 2011. Seagrass Su–vey - Dadi Beach, Naval Base Guam. Prepared by SWCA Environmental Consultants, Hagatna, Guam for NAVFAC Marianas, Navy Base Guam. 31 December.

NAVFAC Marianas. 2016. Plant Surveys, Joint Region Marianas. Interim Report. Prepared by Guam Plant Extinction Prevention Program, UOG.

NAVFAC Marianas and USMC. 2013. Mariana Fruit Bat Conservation through Research and Local Capacity Building. Final Report. Prepared by T. Mildenstein and L.S. Mills, Wildlife Biology Program, Department of Ecosystem and Conservation Sciences, University of Montana, Missoula.

NAVFAC Pacific. 2014. Final Survey Report. Terrestrial Biological Surveys on Tinian in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement. Joint Base Pearl Harbor-Hickam, HI. July.

NAVFAC Pacific. 2018. Final Survey Report (V3). Endangered Species Act-listed Plant Surveys on Tinian in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement. NAVFAC Pacific, Pearl Harbor, HI.

Nedwell, J., Turnpenny, A., Langworthy, J., and Edwards, B. 2003. Measurements of Underwater Noise During Piling at the Red Funnel Terminal, Southampton, and Observations of its Effect on Caged Fish. Report Reference 558 R 0207. Prepared by Subacoustech Ltd, Hampshire, UK for Red Funnel, Southampton, UK.

NMFS. 2010. Endangered and Threatened Wildlife; Notice of 90-Day Finding on a Petition to List 83 Species of Corals as Threatened or Endangered Under the Endangered Species Act (ESA). Federal Register, 75, 6616–6621.

NMFS. 2011. Annual Report to Congress on the Status of U.S. Fisheries-2010. NOAA, Silver Spring, MD.

NMFS. 2014a. Endangered and Threatened Wildlife and Plants: Final Listing Determinations on Proposal To List 66 Reef-Building Coral Species and To Reclassify Elkhorn and Staghorn Corals. Federal Register, 79, 53852–54123.

NMFS. 2014b. Endangered and Threatened Wildlife and Plants; Threatened and Endangered Status for Distinct Population Segments of Scalloped Hammerhead Sharks; Final Rule. Federal Register, 79, 38214–38242.

NMFS. 2018a. Endangered and Threatened Wildlife and Plants: Listing the Oceanic Whitetip Shark as Threatened Under the Endangered Species Act. Federal Register, 83, 4153–4165.

NMFS. 2018b. Endangered and Threatened Wildlife and Plants; Final Rule To List the Giant Manta Ray as Threatened Under the Endangered Species Act. Federal Register, 83, 2916–2931.

NMFS. 2020. Endangered Species Act Section 7 Consultation Biological Opinion and Conference Report for the U.S. Military Mariana Islands Training and Testing Activities. 10 July.

NMFS. 2023. Pacific Islands Regional Action Plan to Implement the NOAA Fisheries Climate Science Strategy Through 2024. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-142, 35 p.

NMFS and USFWS. 2016. Endangered and Threatened Wildlife and Plants; Final Rule To List Eleven Distinct Population Segments of the Green Sea Turtle (*Chelonia mydas*) as Endangered or Threatened

and Revision of Current Listings Under the Endangered Species Act. Federal Register, 81(66), 20058–20090.

NOAA. 2010. Oil Spills in Coral Reefs: Planning and Response Considerations. U.S. Department of Commerce, NOAA, National Ocean Service, Office of Response and Restoration, Hazardous Materials Response Division, Silver Spring, MD.

NOAA. 2014. Pacific Reef Assessment and Monitoring Program Fish Monitoring Brief: Southern Mariana Archipelago 2014.

NOAA. 2019. Spatial Analysis of the Invasive Striped Eel Catfish in the Saipan Lagoon. Accessed 19 November 2020. Available at: https://dukeuniv.maps.arcgis.com/apps/MapSeries/index.html?appid=7095da58439943bca93c74bae2a3bb39

NOAA NCCOS. 2004. Mapping of Benthic Habitats for U.S. Pacific Territories: American Samoa, Guam, and The Commonwealth of the Northern Mariana Islands.

Nogales, M., Vidal, E., Medina, F., Bonnaud, E., Tershy, B., Campbell, K., and Zavaleta, E. 2013. Feral cats and biodiversity conservation: the urgent prioritization of islands management. BioScience, 63, 804–810.

Orr, J. C., Fabry, V. J., and Yool, A. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature, 437, 681–686.

Oyler-McCance, S. J., Valdez, E. W., O'Shea, T. J., and Fike, J. A. 2013. Genetic characterization of the Pacific sheath-tailed bat (*Emballonura semicaudata rotensis*) using mitochondrial DNA sequence data. Journal of Mammalogy, 94, 1030–1036.

Pacific Daily News. 2018. Election of Lou Leon Guerrero, typhoons Yutu and Mangkhut top stories of 2018. Accessed 19 November 2020. Available at: https://www.guampdn.com/story/news/2018/12/30/leon-guerrero-election-typhoons-yuta-and-mangkhut-top-stories-2018/2412316002/

Pacific Islands Climate Education Partnership. 2016. Climate Change in Hawai'i.

Pandolfi, J., Bradbury, R., Sala, E., Hughes, T., Bjorndal, K., Cooke, R., McArdle, D., McClenachan, L., Newman, M., Paredes, G., Warner, R., and Jackson, J. 2003. Global trajectories of the long-term decline of coral reef ecosystems. Science, 301, 955–958.

Pauly, D. and Palomares, M. L. 2005. Fishing down marine food webs: It is far more pervasive than we thought. Bulletin of Marine Science, 76, 197–211.

Pew Oceans Commission. 2003. America's Living Oceans. Charting a Course for Sea Change. Arlington, VA.

Polovina, J. J., Dreflak, K., Baker, J., Bloom, S., Brooke, S., Chan, V., Ellgen, S., Golden, D., Hospital, J., Van Houtan, K., Kolinski, S., Lumsden, B., Maison, K., Mansker, M., Oliver, T., Spalding, S., and Woodworth-Jefcoats, P. 2016. Pacific Islands Regional Action Plan. NOAA Fisheries Climate Science Strategy. NMFS, Pacific Islands Fisheries Science Center, Honolulu, HI. December.

Popper, A. and Hastings, M. C. 2009. The effects of anthropogenic sources of sound on fishes. Journal of Fish Biology, 75, 455–489.

Popper, A. N., Carlson, T. J., Hawkins, A. D., Southall, B. L., and Gentry, R. L. 2006. Interim Criteria for Injury of Fish Exposed to Pile Driving Operations: A White Paper.

Porter, J. W., Dustan, P., Jaap, W. C., Patterson, K. L., Kosmynin, V., Meier, O. W., Patterson, M. E., and Parsons, M. 2001. Patterns of spread of coral disease in the Florida Keys. Hydrobiologia, 460, 1–24.

Pratt, L. W. 2011. Vegetation Assessment of Forests of Pagan Island, Commonwealth of the Northern Mariana Islands (Technical Report HCSU-023). Hawai'i Cooperative Studies Unit, University of Hawai'i, Hilo, HI. September.

Pregill, G. K. and Steadman, D. W. 2009. The prehistory and biogeography of terrestrial vertebrates of Guam, Mariana Islands. Diversity and Distributions, 15, 983–996.

Quinn, N. J. and Kolis, B. L. 2003. The dynamics of coral reef community structure and recruitment patterns around Rota, Saipan, and Tinian, Western Pacific. Bulletin of Marine Science, 72, 979–996.

Randall, R. H. 1995. Biogeography of reef-building corals in the Mariana and Palau Islands in relation to back-arc rifting and the formation of the Eastern Philippine Sea. Natural History Museum and Institute, Chiba, Japan. Natural History Research, 3, 193–210.

Randall, R. H. 2003. An annotated checklist of hydrozoan and scleractinian corals collected from Guam and other Mariana Islands. Micronesica, 35–36, 121–137.

Raulerson, L. 2006. Checklist of Plants of the Mariana Islands. UOG Herbarium Contribution, 37, 1–69.

Raulerson, L. and Rinehart, A. 1991. Trees and Shrubs of the Northern Mariana Islands. Coastal Resources Management, Office of the Governor.

Raulerson, L. and Rinehart, A. 1992. Ferns and orchids of the Mariana Islands. Self published.

Richards, B. L., Williams, I., Vetter, O. J., and Williams, G. J. 2012. Environmental Factors Affecting Large-Bodied Coral Reef Fish Assemblages in the Mariana Archipelago. PLoS ONE, 7.

Richardson, M., Lee, S., and Campora, C. 2009. General Insect Surveys on Tinian and Aguiguan. *In* Terrestrial Resource Surveys of Tinian and Aguiguan, Mariana Islands, 2008 – Final Report. Prepared by USFWS Pacific Islands Fish and Wildlife Office, Honolulu, HI for Marine Force Pacific and NAVFAC, Pearl Harbor, HI. December.

Richmond, R., Houk, P., Trianni, M., Wolanski, E., Davis, G., Bonito, V., and Paul, V. 2008. Aspects of Biology and Ecological Functioning of Coral Reefs in Guam and the Commonwealth of the Northern Mariana Islands. Pages 719-739 *in* B. Riegl and R. Dodge (Eds.), Coral Reefs of the USA (Vol. 1). Springer Netherlands, Dordrecht.

Riegl, B. and Dodge, R. (Eds.). 2008. Coral Reefs of the World, Volume I. Coral Reefs of the USA. Springer-Verlag, Berlin.

Riegl, B., Purkis, S. J., Houk, P., Cabrera, G., and Dodge, R. 2008. Geologic Setting and Geomorphology of Coral Reefs in the Mariana Islands (Guam and Commonwealth of the Northern Mariana Islands). Pages 691-718 *in* B. Riegl and R. Dodge (Eds.), Coral Reefs of the USA (Vol. 1). Springer Netherlands, Dordrecht.

Risk, M. 2009. The reef crisis and the reef science crisis: Nitrogen isotopic ratios as an objective indicator of stress. Marine Pollution Bulletin, 58, 787–788.

Rodda, G. H., Fritts, T. H., and Reichel, J. D. 1991. The distributional patterns of reptiles and amphibians in the Mariana Islands. Micronesica, 24, 195–210.

Rodda, G. H., Reed, R. N., Siers, S. R., Hinke, T. J., Fritts, T. H., and Reynolds, R. P. 2009. Reptiles and Amphibians of Tinian. Pages 79-130 *in* Terrestrial Resource Surveys of Tinian and Aguiguan, Mariana Islands, 2008 – Final Report. Prepared by USFWS Pacific Islands Fish and Wildlife Office, Honolulu, HI for Marine Force Pacific and NAVFAC, Pearl Harbor, HI.

Safford, W. 2009. The Chamorro Language of Guam. University of Michigan Library. 27 April.

Sako, M. K., Truesdell, F. A., Koyanagi, R. Y., Kojima, G., and Moore, R. B. 1995. Volcanic investigations in the Commonwealth of the Northern Mariana Islands, April to May 1994 (Open-File Report No. 94–705). USGS.

Schils, T. 2015. Restyling Guam's Reef Flats: Angel Hair alga on the rise. Man, Land, and Sea, 6–7.

Smith, S. and Marx Jr., D. 2016. De-facto marine protection from a Navy bombing range: Farallon De Medinilla, Mariana Archipelago, 1997 to 2012. Marine Pollution Bulletin, 102, 187–198.

Spalding, M. D., Ravilious, C., and Green, E. P. 2001. World Atlas of Coral Reefs. University of California Press, Ltd., London, England.

Stafford, K. W., Mylroie, J. E., Jenson, J. B., and Taborosi, D. 2005. Karst development on Tinian, Commonwealth of the Northern Mariana Islands: Controls on dissolution in relation to the Carbonate Island Karst Model. Journal of Cave and Karst Studies, 67, 14–27.

Starmer, J., Asher, J., Castro, F., Gochfeld, D., Gove, J., Hall, A., Houk, P., Keenan, E., Miller, J., Moffit, R., Nadon, M., Schroeder, R., Smith, E., Trianni, M., Vroom, P., Wong, K., and Yuknavage, K. 2008. The State of Coral Reef Ecosystems of the Commonwealth of the Northern Mariana Islands. Pages 437-464 *in* J. Waddell and J. Clarke (Eds.), The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2008. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team, Silver Spring, MD.

Starmer, J., Bearden, C., Brainard, R. E., de Cruz, T., Hoeke, R., Houk, P., Holzwarth, S., Kolinski, S., Miller, J., Schroeder, R., Timmers, M., Trianni, M., and Vroom, P. 2005. The State of Coral Reef Ecosystems of the Commonwealth of the Northern Mariana Islands. Pages 399-441 *in* J. Waddell (Ed.), The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2005. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team, Silver Spring, MD.

Stone, B. 1970. The flora of Guam. A manual for the identification of the vascular plants of the island. Micronesica, 6, 1–659.

Tomczak, M. and Godfrey, J. S. 2003. Regional Oceanography: An Introducti^{on} (2nd ed.). Daya Publishing House, Delhi, India.

Topping, D., Ogo, P., and Dungca, B. 1975. Chamorro-English Dictionary. University of Hawai'i Press, Honolulu, HI.

Trianni, M. S. 2002. Summary of data collected from the sea cucumber fishery on Rota, Commonwealth of the Northern Mariana Islands. Bêche-de-Mer Information Bulletin, 16, 5–11.

Trianni, M. S. and Tenorio, M. C. 2012. Summary of recorded cetacean strandings in the Commonwealth of the Northern Mariana Islands. Micronesica, 43(1), 1–13.

Uda, M. 1970. Fishery Oceanographic Studies of Frontal Eddies and Transport Associated with the Kuroshio System Including the 'Subtropical Countercurrent.' Pages 593-604 *in* J.C. Marr (Ed.) The Kuroshio: A Symposium on the Japan Current. East-West Center Press, Honolulu, HI.

UOG. 2007. Survey of *Tabernaemontana rotensis* on Andersen AFB. Final Report. Prepared for 36 CES/CEVN, Andersen AFB, Guam. February.

USACE. 1979. Draft Detailed Project Report and Environmental Statement. Susupe-Chalan Kanoa Flood Control Study. Pacific Ocean Division, Honolulu District, Fort Shafter, HI.

USDA. 1989. Soil Survey of the Islands of Aguijan, Rota, Saipan, and Tinian, Commonwealth of the Northern Mariana Islands. United States Department of Agriculture Soil Conservation Service.

USEPA. 2016. Climate Change: Basic Information. Accessed 19 December 2016, from https://www.epa.gov/climatechange/climatechangebasicinformation. 29 September.

USFS. 2006. Guam Vegetation Mapping. Pacific Southwest Region, Forest Health Protection, McClellan, CA.

USFWS. 1984. Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for Seven Birds and Two Bats of Guam and the Northern Mariana Islands. Final Rule. Federal Register, 49, 33881–33885.

USFWS. 1996. Wildlife Research Report for Navy Leased Lands on the Island of Tinian, Commonwealth of the Northern Mariana Islands. Prepared by USFWS, Pacific Islands Ecoregion, Honolulu, HI for NAVFAC Pacific, Pearl Harbor, HI.

USFWS. 1997. Availability of Draft Recovery Plan for the Micronesian megapode (*Megapodius laperouse laperouse*) for Review and Comment. Federal Register, 62, 50398–50399.

USFWS. 2004a. Endangered and Threatened Wildlife and Plants; Final Rule to Remove the Tinian Monarch from the Federal List of Endangered and Threatened Wildlife. Federal Register, 69, 56367–56371.

USFWS. 2004b. Endangered and Threatened Wildlife and Plants; Determination of Endangered Status and Prudency Determination for Designation of Critical Habitat for Two Plant Species From the Commonwealth of the Northern Mariana Islands. Federal Register, 69, 18499–18507.

USFWS. 2004c. Endangered And Threatened Wildlife And Plants; Designation of Critical Habitat for the Mariana Fruit Bat And Guam Micronesian Kingfisher on Guam and the Mariana Crow on Guam and in the Commonwealth of the Northern Mariana Islands; Final Rule. Federal Register, 69, 62944–62990.

USFWS. 2005. Post-delisting Monitoring Plan for the Tinian monarch (*Monarcha takatsukasae*). Endangered Species Division, Pacific Islands Fish and Wildlife Office, Honolulu, HI.

USFWS. 2006. Designation of Critical Habitat for the Rota Bridled White-Eye (*Zosterops rotensis*). Federal Register, 71, 53589–53605.

USFWS. 2007a. Recovery Plan for Two Plants From Rota (*Nesogenes rotensis* and *Osmoxylon mariannense*). Federal Register, 72, 24597. 3 May.

USFWS. 2007b. 5-Year Review, Short Form Summary: Mariana Fruit Bat (*Pteropus mariannus mariannus*).

USFWS. 2009. Draft Revised Recovery Plan for the Mariana Fruit Bat or Fanihi (*Pteropus mariannus mariannus*). USFWS Region 1, Portland, OR. November.

USFWS. 2010. Biological Opinion for the Joint Guam Program Office Relocation of the U.S. Marine Corps from Okinawa to Guam and Associated Activities on Guam and Tinian. Pacific Islands Fish and Wildlife Office, Honolulu, HI. 8 September.

USFWS. 2012. Endangered Species in the Pacific Islands: Mariana Common Moorhen/*Gallinula chloropus guami*/Pulattat. Accessed 2 March 2018, from http://www.fws.gov/pacificislands/fauna/marianamoorhen.html. 20 September.

USFWS. 2014a. Endangered and Threatened Wildlife and Plants; Proposed Endangered Status for 21 Species and Proposed Threatened Status for 2 Species in Guam and the Commonwealth of the Northern Mariana Islands; Proposed Rule. Federal Register, 79(190), 59364–59413. 1 October.

USFWS. 2014b. 5-Year Review Short Form Summary for *Pteropus mariannus* (Mariana fruit bat). Pacific Islands Fish and Wildlife Office, Region 1, Honolulu, HI.

USFWS. 2015. Endangered and Threatened Wildlife and Plants; Endangered Status for 16 Species and Threatened Status for 7 Species in Micronesia. Federal Register, 80(190), 59424–59497.

U.S. Navy. 2023. Monitoring Mariana fruit bats on Guam Naval Munitions Site and Tinian Military Lease Area, 2022-2023. Prepared for NAVFAC Marianas, Guam. Prepared by T. Mildenstein, University of Guam, under Cooperative Agreement Number N40192-22-2-8001. April.

van der Oost, R., Beyer, J., and Vermeulen, N. P. E. 2003. Fish bioaccumulation and biomarkers in environmental risk assessment: a review. Environmental Toxicology and Pharmacology, 3, 57–149.

Vermeij, M. J. A., Marhaver, K. L., Huijbers, C. M., Nagelkerken, I., and Simpson, S. D. 2010. Coral Larvae Move toward Reef Sounds. PLoS One, 5, e10660.

Vogt, S. and Williams, L. L. 2004. Common Flora and Fauna of the Mariana Islands.

Vroom, P. S. and Zgliczynski, B. J. 2011. Effects of volcanic ash deposits on four functional groups of a coral reef. Coral Reefs, 30, 1025–1032.

Whistler, W. A. 1996. Botanical Survey of Farallon de Medinilla, Commonwealth of the Northern Mariana Islands. Prepared for Belt Collins and Associates, Honolulu, HI.

Wiewel, A. S., Yackel Adams, A. A., and Rodda, G. H. 2009. Distribution, density, and biomass of introduced small mammals in the Southern Mariana Islands. Pacific Science, 63, 205–222.

Wiles, G. 2003. A checklist of birds recorded in Guam's marine habitats. Micronesica, 35–36, 661–675.

Wiles, G. 2005. A checklist of the birds and mammals of Micronesia. Micronesica, 38, 141–189.

Wiles, G. and Brooke, A. 2009. Conservation Threats to Bats in the Tropical Pacific Islands and Insular Southeast Asia. Pages 405-459 *in* T. H. Fleming and P. A. Racey (Eds.), Island Bats: Evolution, Ecology, and Conservation. University of Chicago Press, IL.

Wiles, G. and Glass, P. O. 1990. Interisland Movements of Fruit Bats (*Pteropus mariannus*) in the Mariana Islands (Atoll Research Bulletin No. 343). National Museum of Natural History, Smithsonian Institution, Washington, D.C. September.

Wiles, G., Lemke, T. O., and Payne, N. H. 1989. Population estimates of fruit bats (*Pteropus mariannus*) in the Mariana Islands. Conservation Biology, 3, 66–76.

Wilkinson, C. 2002. Executive Summary. Pages 7-31 *in* Status of Coral Reefs of the World: 2002. C. Wilkinson (Ed.) Australian Institute of Marine Science, Townsville, Queensland, AU.

Williams, I., Richards, B. L., Sandin, S. A., Baum, J. K., Schroeder, R. E., Nadon, M. O., Zgliczynski, B., Craig, P., McIlwain, J. I., and Brainard, R. E. 2011. Differences in reef fish assemblages between populated and remote reefs spanning multiple archipelagos across the Central and Western Pacific. Journal of Marine Biology, Article 826234.

Wolanski, E., Richmond, R. H., Davis, G., Deleersnijder, E., and Leben, R. 2003. Eddies around Guam, an island in the Mariana Islands group. Continental Shelf Research, 23, 991–1003.

Wooldridge, S. A. 2009. Water quality and coral bleaching thresholds: Formalising the linkage for the inshore reefs of the Great Barrier Reef, Australia. Marine Pollution Bulletin, 58, 745–751.

Worldometers. 2018. Worldometers Elaboration of Data by United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospect: The 2015 Revision. (Medium-fertility variant). Accessed 12 April 2018, from www.worldometers.info.

WPRFMC. 2009a. Fishery Ecosystem Plan for the Mariana Archipelago. Honolulu, HI. 24 September.

WPRFMC. 2009b. Fishery Ecosystem Plan for Pacific Pelagic Fisheries of the Western Pacific Region. Honolulu, HI. 24 September.

WPRFMC. 2016a. Fishery Ecosystem Plan for the Mariana Archipelago. Working Draft. Honolulu, HI.

WPRFMC. 2016b. Can Past Glories of the Mariana Fishing Industry Be Revived? Pacific Island Fishery News, Spring, 3.

WPRFMC. 2016c. Annual Stock Assessment and Fishery Evaluation Report: Mariana Archipelago Fishery Ecosystem Plan. Honolulu, HI.

Zarones, L., Liske-Clark, J., Willsey, T., and Ulloa, R. 2015a. Preliminary survey of three Mariana Island endemic epiphytic orchids *Dendrobium guamense*, *Bulbophyllum guamense* and *Tuberolabium guamense* on Rota, CNMI DFW and DLNR Report.

Zarones, L., Liske-Clark, J., Willsey, T., and Ulloa, R. 2015b. Preliminary survey of *Nervilia jacksoniae* on Rota, CNMI DFW and DLNR Report.

15.11 CHAPTER 11 – TINIAN MILITARY LEASE AREA

AECOS, Inc. and Wil Chee Planning, Inc. 2009. Final Guam and Tinian Wetlands Inventory. Honolulu, HI. September.

Amidon, F. 2009. Vegetation Surveys on Tinian and Aguiguan. Pages 8-18 *in* Terrestrial Resource Surveys of Tinian and Aguiguan, Mariana Islands, 2008 – Final Report. Prepared by USFWS, Pacific Islands Fish and Wildlife Office for Marine Forces Pacific and NAVFAC Pacific, Pearl Harbor, HI. December.

Amidon, F. A., Metevier, M., Miller, S. E. 2017. Vegetation Mapping of the Mariana Islands: Commonwealth of the Northern Mariana Islands and Territory of Guam. U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, HI. November

Ault, J. S., Smith, S., Bohnsack, J. A., Luo, J., Harper, D. E., and McClellan, D. B. 2006. Building sustainable fisheries in Florida's coral reef ecosystem: positive signs in the dry Tortugas. Bulletin of Marine Science, 78, 633–654.

Baker, R. H. 1951. The avifauna of Micronesia, its origin, evolution, and distribution. University of Kansas Publications, Museum of Natural History, 3, 1–359.

Benavente, D. 2018. Outbreak of Chaetomorpha in Laolao Bay, Saipan. Personal communication via e-mail from D. Benavente, Lead Biologist, CNMI BECQ to A. Reyes, Marine Resource Specialist, NAVFAC Marianas, Guam. 8 October.

Berger, G. M., Gourley, J., and Schroer, G. 2005. Comprehensive Wildlife Conservation Strategy for the Commonwealth of the Northern Mariana Islands. Prepared by CNMI Department of Lands and Natural Resources, Division of Fish and Wildlife, Saipan, CNMI for National Advisory Acceptance Team, Migratory Birds and State Programs, USFWS, Portland, OR. September.

Bowers, N. M. 1950. Problems of Resettlement on Saipan, Tinian, and Rota. CNMI Division of Historic Preservation.

Brainard, R. E., Asher, J., Blyth-Skyrme, V., Coccagna, E. F., Dennis, K., Donovan, M. K., Gove, J. M., Kenyon, J., Looney, E. E., Miller, J. E., Timmers, M., Vargas-Ángel, B., Vroom, P. S., Vetter, O., and Zgliczynski, B. 2012. Coral Reef Ecosystem Monitoring Report of the Mariana Archipelago: 2003 to 2007 (PIFSC Special Publication No. SP-12-01). NOAA Fisheries, Pacific Islands Fisheries Science Center. Honolulu, HI. March.

Brooke, A. 2009. Mariana Fruit Bat on Tinian and Aguiguan. Pages 269-272 *in* Terrestrial Resource Surveys of Tinian and Aguiguan, Mariana Islands, 2008 – Final Report. Prepared by U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office for Marine Forces Pacific and Naval Facilities Engineering Systems Command Pacific, Pearl Harbor, HI.

Brown Treesnake Technical Working Group. 2013. Draft Brown Treesnake Strategic Plan (v1).

Camp, R. J., Amidon, F. A., Marshall, A. P., and Pratt, T. K. 2012. Bird populations on the island of Tinian: Persistence despite wholesale loss of native forests. Pacific Science, 66, 283–298.

Camp, R. J., Leopold, C., Brink, K. W., and Juola, F. 2014. Farallon de Medinilla Seabird and Tinian Moorhen Analyses (Technical Report No. HCSU-060). Prepared by Hawai'i Cooperative Studies Unit, University of Hawai'i at Hilo.

Carilli, J.E., Norris, R. D., Black, B. A., Walsh, S. M., and McField, M. 2009. Local Stressors Reduce Coral Resilience to Bleaching. PLOS ONE, 4, e6324.

Carpenter, K. E. and Niem, V. H. (Eds.). 1998. Gecarcinidae – Land Crabs. In FAO Species Identification Guide for Fishery Purposes: The Living Marine Resources of the Western Central Pacific. Volume 2: Cephalopods, Crustaceans, Holothurians and Sharks. United Nations, Rome, IT.

Center for Biological Diversity. 2013. Petition to List the Tinian Monarch (*Monarcha takatsukasae*) as Threatened or Endangered under the Endangered Species Act. Accessed 11 December 2013, from http://www.biologicaldiversity.org/species/birds/Tinian_monarch/pdfs/Tinian_Monarch_Petition.pdf.

Chesher, R. H. 1969. Destruction of Pacific corals by the sea star *Acanthaster planci*. Science, 165, 280–283.

Clark, C. 2014. U.S. Department of Agriculture. Possible Brown Tree Snake in HHG shipped from Guam to Los Angeles, California. Personal communication via email from C. Clark, Acting Assistant State Director, HI/GU/Pacific Islands, USDA APHIS, Barrigada, Guam to S. Mosher, Brown Treesnake Program Manager, NAVFAC Marianas, Guam. 19 August.

CNMI DFW. 2015. Project 3: Avian Monitoring on Saipan, Tinian, and Rota. Annual Performance Report, CNMI Wildlife Restoration Grant Program. (Reporting Period October 1, 2013 through September 30, 2014).

CNMI DFW. 2016. Guguan Expedi–ion - May –016 - Translocating Birds. Facebook. Accessed 7 June 2016, from https://www.facebook.com/media/set/?set=a.485856648279452.1073741841.315301702001615andtype=3. May.

CNMI DFW. 2017. Final Performance Report FY 2017: Pittman-Robertson Wildlife Restoration F16AF01021.

CNMI DFW. 2021. Final Performance Report FY 2021: Pittman-Robertson Wildlife Restoration. F19AF00969.

CNMI DFW. 2023. Conservation and Management of Mariana Common Moorhen on the Tinian Military Lease Area (Interim Report). Saipan, MP.

CNMI DLNR DFW. 2022. Wildlife Restoration Grant Program Final Performance Report: Avian Monitoring and Management. December.

Commonwealth of the Northern Marianas Islands Law Revision Commission. 2009. Public Notice of Certification and Adoption of Regulations of the Department of Lands and Natural Resources, Division of Fish and Wildlife. Commonwealth Register, 31, 29532. 20 May.

COMNAVMAR. 2013. Instruction 3500.4A. Marianas Training Manual. Department of the Navy, Joint Region Marianas.

Connell, J. H. 1997. Disturbance and recovery of coral assemblages. Coral Reefs, 16.

Costion, C. M. and Lorence, D. H. 2012. The endemic plants of Micronesia: A geographical checklist and commentary. Micronesica, 43, 51–100.

Crombie, R. I. and Pregill, G. K. 1999. A checklist of the herpetofauna of the Palau Islands (Republic of Belau), Oceania. Herpetological Monographs, 13, 29–80.

Cruz, J., Arriola, L., Johnson, N., and Beauprez, G. 2000. Wildlife and Vegetation Surveys in the Tinian Proposed Conservation Area. Unpublished (Technical Report No. 1). CNMI DFW.

Cuetos-Bueno, J. and Houk, P. 2015. Re-estimation and synthesis of coral reef fishery landings in the Commonwealth of the Northern Mariana Islands since the 1950s suggests the decline of a common resource. Reviews in Fish Biology and Fisheries, 25, 179–194.

Doan, D. B., Burke, H. W., May, H. G., and Stensland, C. H. 1960. Military Geology of Tinian, Mariana Islands. Prepared under the direction of the Chief of Engineers, U.S. Army by the Intelligence Division, Office of the Engineer Headquarters Unites States Army Pacific with personnel of the United States Geological Survey.

DoD. 1999. Marianas Training Effects of LCAC Landings on Coral Reefs. Prepared by Marine Research Consultants.

DON. 2001. A Quantitative Survey and Inventory of the Micronesian Megapode and Its Habitat on Tinian, CNMI. Prepared by G.J. Witteman, Ph.D., Division of Natural Sciences, UOG, Mangilao for URS Corp. Honolulu, HI for Department of the Navy, U.S. Public Works Center.

DON. 2010. Update of Integrated Natural Resources Management Plans for Navy Leased Lands on Tinian and Farallon de Medinilla, Plan Years 2010-2015. Prepared by SWCA Environmental Consultants, Hagatna, GU. 29 May.

DON. 2011. Annual Report for Biological Opinion for the Mariana Islands Range Complex (MIRC), Guam and the Commonwealth of the Northern Mariana Islands 2010-2015 (2009-F-0345), 1 SEP 2010 – 1 SEP 2011. Prepared by NAVFAC Pacific and NAVFAC Marianas, Pearl Harbor, HI.

DON. 2012. Annual Report for Biological Opinion for the Mariana Islands Range Complex (MIRC), Guam and the Commonwealth of the Northern Mariana Islands 2010-2015 (2009-F-0345), 01 October 2011 – 30 September 2012. Prepared by Naval Facilities Engineering Systems Command, Pacific and Naval Facilities Engineering Systems Command Marianas, Pearl Harbor, HI.

DON. 2013a. Final Wetlands Management Plan for the Mariana Common Moorhen, Tinian Military Lease Area, Commonwealth of the Northern Mariana Islands. NAVFAC Pacific, Pearl Harbor, HI. December.

DON. 2013b. Annual Report for Biological Opinion for the Mariana Islands Range Complex (MIRC), Guam and the Commonwealth of the Northern Mariana Islands 2010-2015 (2009-F-0345), 01 October 2012 – 30 September 2013. Prepared by NAVFAC Pacific and NAVFAC Marianas, Pearl Harbor, HI.

DON. 2014a. Final Survey Report. Terrestrial Biological Surveys on Tinian in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement. NAVFAC Pacific, Pearl Harbor, HI. July.

DON. 2014b. Final (Version 3) Sea Turtle Marine Resources Survey Report in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement. NAVFAC Pacific, Pearl Harbor, HI. March.

DON. 2014c. Final Coral Marine Resources Survey Report in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement. Prepared by Tetra Tech, Inc. for U.S. Navy, NAVFAC Pacific.

DON. 2015a. Mariana Islands Training and Testing Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) (Vols. 1, 2, and 3). Prepared for NAVFAC Pacific, Pearl Harbor, HI.

DON. 2015b. Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement (Draft). Prepared by U.S. Marine Corps Forces Pacific.

DON. 2015c. Final Supplemental Environmental Impact Statement Guam and the Commonwealth of the Northern Mariana Islands Military Relocation (2012 Roadmap Adjustments). Prepared by NAVFAC Pacific, Pearl Harbor, HI for Joint Guam Program Office, Washington, D.C.

DON. 2015d. Regional Biosecurity Plan for Micronesia and Hawai‘i: 4 Volumes.

DON. 2017a. Final Survey Report. Migratory Bird Treaty Act-listed Species Surveys within the Proposed Alternative Amphibious Landing Ramp Sites on Tinian in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement. NAVFAC Pacific, Pearl Harbor, HI.

DON. 2017b. Tinian Reef Marine Resource Survey Re–ort - in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement. Prepared by Tetra Tech, Inc. for U.S. Navy, NAVFAC Pacific.

Donnegan, J. A., Butler, S. L., Grabowiecki, W., Hiserote, B. A., and Limtiaco, D. 2004. Guam’s Forest Resources, 2002 (Resource Bulletin No. PNW-RB-243). USDA, Forest Service, Pacific Northwest Research Station, Portland, OR.

Downs, T. 1946. Birds on Tinian in the Marianas. Transactions of the Kansas Academy of Science, 49, 87–106.

Dryden, G. L. 1965. The food and feeding of *Varanus indicus* on Guam. Micronesica, 2, 72–76.

Eldredge, L. G. 1988. Case studies of the impacts of introduced animal species on renewable resources in the U.S.-affiliated Pacific islands. Pages 118-146 *in* Topic Reviews in Insular Resource Development and Management in the Pacific U.S.-affiliated Islands (Technical Report No. 88). UOG Marine Laboratory.

Engbring, J., Ramsey, F., and Wildman, V. J. 1986. Micronesian Forest Bird Survey, 1982: Saipan, Tinian, Agiguan, and Rota. USFWS, Honolulu, HI.

Falanruw, M. C., Cole, T. G., and Ambacher, A. H. 1989. Vegetation Survey of Rota, Tinian, and Saipan, Commonwealth of the Northern Mariana Islands (No. PSW-27). U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA.

Fosberg, F. R. 1960. The Vegetation of Micronesia 1. General description of vegetation of the Mariana Islands, and a detailed consideration of the vegetation of Guam. American Museum of Natural History Bulletin, 119, 1–76.

Freary, D. A., Cinner, J. C., Graham, N. A. J., and Januchowsks-Hartley, F. A. 2010. Effects of customary marine closures on fish behavior, spearfishing success, and underwater visual surveys. Conservation Biology, 25, 341–349.

Fulling, G., Thorson, P., and Rivers, J. 2011. Distribution and abundance estimates for cetaceans in the waters off Guam and the Commonwealth of the Northern Mariana Islands. Pacific Science, 65, 321–343.

Gilbert, Haidee E. 2018. Humanitarian crisis looms after Super Typhoon Yutu flattens parts of Saipan and Tinian. Pacific Daily News. Accessed November 19, 2020. Available at https://www.usatoday.com/story/news/2018/10/25/super-typhoon-yutu-leaves-1-dead-crisis-looms-saipan-and-tinian/1771400002/

Gill, F. and Donsker, D. 2017. International Ornithologists' Union (IOC) World Bird List (v 7.3) (No. doi:10.14344/IOC.ML.7.3).

Gingerich, S. B. 2002. Geohydrology and Numerical Simulation of Alternative Pumping Distributions and the Effects of Drought on the Ground-Water Flow System of Tinian, Commonwealth of the Northern Mariana Islands (USGS Water-Resources Investigations Report No. 02-4077). Prepared by the USGS in cooperation with the Commonwealth Utilities Corporation, CNMI.

Gleize, D. A. 1945. Birds of Tinian. Bulletin of the Massachusetts Audubon Society, 29, 220.

Government of CNMI and United States of America. 1999. Dedication of Tinian Military Retention Area Land for Wildlife Conservation.

GovGuam. 2009. Endangered Species Regulation No. 9. Department of Agriculture, Mangilao, GU. 27 April.

Hawaiian Agronomics International, Inc. 1985. Final Report for Flora and Fauna Survey of Tinian, Northern Mariana Islands. Prepared for Commander, Pacific Division, NAVFAC, Honolulu, HI.

Heenan, A., McCoy, K., Asher, J., Ayotte, P., Gorospe, K., Gray, A., Lino, K., Zamzow, J., and Williams, I. 2015. Pacific Reef Assessment and Monitoring Program Data Report: Ecological Monitoring –014 - Stationary Point Count Surveys of Reef Fishes and Benthic Habitats of the Northwestern Hawaiian Islands, Mariana Islands, and Wake Atoll. NOAA PIFSC, Honolulu, HI.

Hill, M., Ligon, A., Ü, A. C., Deakos, M., and Oleson, E. 2013. Cetacean Surveys of Guam and CNMI Waters: June-July 2013 (PIFSC Data Report No. DR-13-019). Prepared for the U.S. Pacific Fleet Environmental Readiness Office.

Hill, M., Ligon, A., Deakos, M., Ü, A. C., Milette-Winfree, A., Oleson, E., and Bendlin, A. 2014. Cetacean surveys in the waters of the southern Mariana Archipelago (February 2010-April 2014) (PIFSC Data Report No. DR-14-013). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 2 September.

Hill, M., Oleson, E. M., Ligon, A. D., Martien, K. K., Archer, F. I., Baumann-Pickering, S., Bendlin, A. R., Dolar, L., Merkens, K. P. B., Milette-Winfree, A., Morin, P. A., Rice, A., Robertson, K. M., Trickey, J. S., Ü, A. C., Van Cise, A. M., and Woodman, S. M. 2015. Cetacean Monitoring in the Mariana Islands Range Complex, 2014 (PIFSC Data Report No. DR-15-003). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 27 March.

Hill, M., Oleson, E. M., Baumann-Pickering, S., VanCise, A. M., Ligon, A. D., Bendlin, A. R., Ü, A. C., Trickey, J. S., and Bradford, A. L. 2016. Cetacean Monitoring in the Mariana Islands Range Complex, 2015 (PIFSC Data Report No. DR-16-01). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 6 February.

Hill, M., Bendlin, A. R., Ü, A. C., Yano, K. M., Bradford, A. L., Ligon, A. D., and Oleson, E. M. 2017. Cetacean Monitoring in the Mariana Islands Range Complex, 2016 (PIFSC Data Report No. DR-17-002). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 3 February.

Holland, B. S. and Sischo, D. S. 2013. Terrestrial Biological Surveys on Tinian in Support of the Commonwealth of the Northern Marianas Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement. Prepared for Cardno TEC.

Hopper, D. R. and Smith, B. 1992. Status of tree snails (Gastropoda: Partulidae) on Guam, with a resurvey of sites studied by H.E. Crampton in 1920. Pacific Science, 46, 77–85.

Houk, P., Benavente, D., Iguel, J., Johnson, S., and Okano, R. 2014. Coral Reef Disturbance and Recovery Dynamics Differ across Gradients of Localized Stressors in the Mariana Islands. PLoS ONE, 9.

Hughes, T. 1994. Catastrophes, Phase-Shifts, and Large-Scale Degradation of a Caribbean Coral Reef. Science, 265, 1547–1551.

Hughes, T., Graham, N., Jackson, J., Mumby, P., and Steneck, R. 2010. Rising to the challenge of sustaining coral reef resilience. Trends in Ecology and Evolution, 25, 633–642.

Johnson, N. 2016. Drought causing the water at North Pond in Lake Hagoi to completely dry up. Personal communication via email from N. Johnson, Biologist, Cardno, Saipan, CNMI to R. Spaulding, Senior Biologist/Project Manager, Cardno, Bainbridge Island, WA. 6 May.

Jones, T. T., Martin, S. L., and Van Houtan, K. S. 2015. Sea Turtle Tagging in the Mariana Islands Range Complex (MIRC) Interim Progress Report (PIFSC Data Report No. DR-15-020). Prepared for U.S. Pacific Fleet Environmental Readiness Office, Pearl Harbor, HI. September.

JRM. 2010. JRM Leased Lands and Submerged Lands GIS Data.

JRM. 2013. Final Joint Region Marianas Integrated Natural Resources Management Plan. Prepared by HDR for Commander Joint Region Marianas, Guam, Hagatna, GU. December.

JRM. 2017a. Marine Turtle Surveys on Military Leased Lands, Tinian, CNMI, for the Period of May 13, 2016 through May 12, 2017.

JRM. 2017b. JRM Leased Submerged Lands GIS Data for Tinian.

Kendall, M. S. and Poti, M. 2015. Transport Pathways of Marine Larvae Around the Mariana Archipelago (NOAA Technical Memorandum NOS NCCOS 193). Silver Spring, MD.

Kerr, A. M. 1990. Chamorro Fish Names. Micronesica, 23, 93–118.

Kerr, A. M. 2012. Fish Names of the Mariana Islands, Micronesia (UOG Marine Laboratory Technical Report No. 139). Mangilao, GU. February.

Kerrigan, K. 2014. Brown treesnake found on Rota; officials continue the battle against the invasive snake. Pacific News Center. September.

Kessler, C. C. 2009. Feral Goats on Tinian and Aguiguan. Pages 279-281 *in* Terrestrial Resource Surveys of Tinian and Aguiguan, Mariana Islands, 2008 – Final Report. Prepared by USFWS, Pacific Islands Fish and Wildlife Office, Honolulu, HI for U.S. Marine Force Pacific and NAVFAC, Pearl Harbor, HI. December.

Kessler, C. C. and Amidon, F. 2009. Micronesian megapode on Tinian and Aguiguan. Pages 201-218 *in* U.S. Fish and Wildlife Ser–ice - Pacific Islands Fish and Wildlife Office (Ed.), Terrestrial resource surveys of Tinian and Aguiguan, Mariana Islands, 2008. USFWS, Honolulu, HI.

Kieran-Vast, A. 2018. The Center for Biological Diversity filed suit against the USFWS on 25 January 2018 for failing to act on the listing petition. USFWS is currently finalizing a Special Status Assessment for the Tinian monarch and will be making a decision regarding the relisting in the near future. Personal communication via comment response matrix from A. Kieran-Vast, Natural Resource Specialist, NAVFAC Pacific, Honolulu, HI, to Cardno. 16 February.

Klinck, H., Nieukirk, S. L., Fregosi, S., Klinck, K., Mellinger, D. K., Latuska, S., Shilling, B., and Luby, J. C. 2015. Cetacean Studies on the Mariana Islands Range Complex in September-November 2014: Passive Acoustic Monitoring of Marine Mammals Using Gliders. Final Report. Prepared for Commander, U.S. Pacific Fleet, Environmental Readiness Division, Pearl Harbor, HI. August.

Klinck, H., Nieukirk, S. L., Fregosi, S., Klinck, K., Mellinger, D. K., Latuska, S., Shilling, B., and Luby, J. C. 2016. Cetacean Studies on the Mariana Islands Range Complex in March – April 2015: Passive Acoustic Monitoring of Marine Mammals Using Gliders. Submitted by HDR, Inc., Honolulu, HI to Commander, U.S. Pacific Fleet.

Kobayashi, D., Cheng, I.-J., Parker, D. M., Polovina, J. J., Kamezaki, N., and Balazs, G. H. 2011. Loggerhead turtle (*Caretta caretta*) movement off the coast of Taiwan: characterization of a hotspot in the East China Sea and investigation of mesoscale eddies. ICES Journal of Marine Science, 68, 707–718.

Kolinski, S. P. 2001. Sea Turtles and their Marine Habitats at Tinian and Aguijan, with Projections on Resident Turtle Demographics in the Southern Arc of the Commonwealth of the Northern Mariana Islands (Southwest Fisheries Science Center Administrative Report No. H-01-06C). NOAA Southwest Fisheries Science Center. December.

Kolinski, S. P., Ilo, L. I., and Manglona, J. M. 2004. Green Turtles and Their Marine Habitats at Tinian and Aguijan, with Projections on Resident Turtle Demographics in the Southern Arc of the Commonwealth of the Northern Mariana Islands. Micronesica, 37, 97–118.

Kuffner, I., Andersson, A. J., Jokiel, P. L., Rodgers, K. S., and Mackenzie, F. T. 2008. Decreased abundance of crustose coralline algae due to ocean acidification. Nature Geoscience, 1, 114–117.

Lagerloef, G. S. E., Mitchum, G. T., Lukas, R. B., and Niiler, P. P. 1999. Tropical Pacific near-surface currents estimated from altimeter, wind, and drifter data. Journal of Geophysical Research, 104, 23, 313–23, 326.

Lander, M. A. and Guard, C. P. 2003. Creation of a 50-Year Rainfall Database, Annual Rainfall Climatology, and Annual Rainfall Distribution Map for Guam (No. 102). Water and Environmental Research Institute of the Western Pacific, UOG, Mangilao, GU.

Ligon, A., Deakos, M., and Ü, A. C. 2011. Small-Boat Cetacean Surveys Off Guam and Saipan, Mariana Islands, Febr–ary - March 2010. Pacific Island Fisheries Science Center. February.

Lindfield, S. J., McIlwain, J. L., and Harvey, E. S. 2014. Depth Refuge and the Impacts of SCUBA Spearfishing on Coral Reef Fishes. PLOS ONE, 9, e92628.

Liske-Clark, J. 2015. Wildlife Action Plan for the Commonwealth of the Northern Mariana Islands, 2015-2025. CNMI DLNR-Division of Fish and Wildlife, Saipan, MP. 16 December.

Lobban, C. S. and Tsuda, R. T. 2003. Revised checklist of benthic marine macroalgae and seagrasses of Guam and Micronesia. Micronesica, 35, 54–99.

Lusk, M., Hess, S., Reynolds, M., and Johnston, S. 2000. Population status of the Tinian Monarch (*Monarcha takatsukasae*) on Tinian, Commonwealth of the Northern Mariana Islands. Micronesica, 32, 181–190.

Marler, T. E. and Lawrence, J. H. 2012. Demography of *Cycas micronesica* on Guam following introduction of the armoured scale *Aulacaspis yasumatsui*. Journal of Tropical Ecology, 28, 233–242.

Marshall, A. P., Amidon, F. A., Radley, P., Martin, G., and Camp, R. J. 2009. Nightingale Reed-Warbler on Aguiguan. Pages 219-226 *in* Terrestrial Resource Surveys of Tinian and Aguiguan, Mariana Islands, 2008 – Final Report. Prepared by USFWS, Pacific Islands Fish and Wildlife Office, Honolulu, HI for U.S. Marine Forces and NAVFAC Pacific, Pearl Harbor, HI.

Marshall, J. 1949. The endemic avifauna of Saipan, Tinian, Guam, and Palau. Condor, 5, 220–221.

Martin, S. L. and Jones, T. T. 2016. Sea Turtle Tagging in the Mariana Islands Training and Testing (MITT) Study Area (PIFSC Data Report No. DR-17-025). Prepared for the U.S. Pacific Fleet Environmental Readiness Office, Honolulu, HI. 15 December.

McKagan, S. 2017. Cyan bacteria mats on several CNMI islands. Personal communication in person from S. McKagan, NOAA NMFS, Saipan, CNMI, to M. Lybolt, Marine Ecologist, Tetra Tech, Inc. 15 April.

Miller, R. 2014. Guam Marine Biosecurity Action Plan. Prepared by the UOG Center for Island Sustainability for NOAA Coral Reef Conservation Program, as administered by the Office of Ocean and Coastal Resource Management and the Bureau of Statistics and Plans, Guam Coastal Management Program. September.

Minton, D., Brown, V., Dugger, K., Flores, T., Foster, K., Houk, P., Iguel, J., Kessler, C., Kolinski, S., Schols, T., Starmer, J., Suhkraj, N., Tenorio, M., and Trianni, M. 2009. Draft Report. Marine Resource Surveys of Tinian, Commonwealth of the Northern Mariana Islands. Volume I. UOG Marine Laboratory, Mangilao, GU.

Morton, J. M., Amidon, F. A., and Quinata, L. R. 2000. Structure of a limestone forest on Northern Guam. Micronesica, 32, 229–244.

Mosher, S. 2018. NAVFAC Marianas. Photo documentation of Philippine deer tracks on Tinian outside the MLA. Steve has also seen live deer, and received corroborating deer sightings from P. Wenninger. Personal communication via email from S. Mosher, EV2.2, Brown Treesnake Program Manager Natural Resources Specialist, NAVFAC Marianas, Guam to L. Shaughnessy, Terrestrial Biologist, Cardno, Honolulu, HI. 20 March.

Mueller-Dombois, D. and Fosberg, F. R. 1998. Vegetation of the Tropical Pacific Islands. Springer-Verlag, Inc., New York, NY.

Myers, R. F. and Donaldson, T. J. 2003. The fishes of the Mariana Islands. Micronesica, 35–36, 594–648.

Nakajima, F. 1944. A Treatise on Water Supply, Tinian, Marianas. Pacific Geological Surveys, Military Geology Branch, USGS, Tokyo, JP.

NAVFAC Marianas. 2016a. Land Use/Land Cover and Recovery Habitat Analysis for Lands Managed by Joint Region Marianas on Guam. Prepared by Cardno, Honolulu, HI. June.

NAVFAC Marianas. 2016b. Conservation and Management of Micronesian Cycads, Navy Leased Land, Tinian, Commonwealth of the Northern Mariana Islands. March.

NAVFAC Marianas. 2017. Annual Report: June 2016-May 2017, Mariana Common Moorhen Surveys, Tinian, Commonwealth of the Northern Mariana Islands. Contract report prepared by Micronesian Environmental Services. May.

NAVFAC Marianas and USMC. 2013. Mariana Fruit Bat Conservation through Research and Local Capacity Building. Final Report. Prepared by T. Mildenstein and L.S. Mills, Wildlife Biology Program, Department of Ecosystem and Conservation Sciences, University of Montana, Missoula.

NAVFAC Marianas. 2022a. Interim Project Report, Forest Bird Monitoring and Assessment on Tinian Joint Region Marianas Leased Lands. Prepared by Micronesian Environmental Services. Saipan, MP. May.

NAVFAC Marianas. 2022b. Annual Report. Sea Turtle Monitoring of Tinian Military Leased Area Beaches. Prepared by J. Hapdei, Jessy's Tag Services, Saipan, MP. January.

NAVFAC Marianas. 2023a. Final Survey Report. 2023 Micronesian Megapode (*Megapodius laperouse laperouse*) Playback Surveys in the Tinian Military Lease Area. Prepared by N. Johnson and J. Gourley, Micronesian Environmental Services. Saipan, MP. June.

NAVFAC Marianas. 2023b. Final Report for Endangered Snail Monitoring on the Tinian Military Lease Area, Tinian. Prepared by Sundance Consulting, Inc. March.

NAVFAC Pacific. 1997. Natural Resources Management Plan, Military Lease Area, Tinian. Prepared by Belt Collins Hawai'i.

NAVFAC Pacific. 2004. Environmental Assessment Farallon de Medinilla and Tinian Military Lease Areas Commonwealth of the Northern Mariana Islands Integrated Natural Resources Management Plan. July.

NAVFAC Pacific. 2010. Final Natural Resource Survey Report in Support of the Environmental Impact Statement for the Marine Corps Relocation Initiative to Various Locations on Guam. Pearl Harbor, HI.

NAVFAC Pacific. 2011. Final Natural Resource Survey Report of Various Locations on Guam (Cabras, Lost River, GLUP 77, Dadi and Tipalao Beaches and Route 15 Valley). Prepared by AECOM, Bloomfield, NJ.

NAVFAC Pacific. 2012. Guam and Saipan Marine Species Monitoring: Winter-Spring Survey, 15 to 29 March 2012. Prepared by HDR, Inc. for Commander U.S. Pacific Fleet.

NAVFAC Pacific. 2013a. Final Report: Biological Surveys – Report 1, Various Locations on Guam in Support of the Guam and Commonwealth of the Northern Mariana Islands Military Relocation (2012 Roadmap Adjustments) Supplemental Environmental Impact Statement. Prepared by TEC-AECOM Joint Venture for Joint Guam Program Office, Honolulu, HI.

NAVFAC Pacific. 2013b. Final Report: Biological Surveys – Report 2, Various Locations on Guam in Support of the Guam and Commonwealth of the Northern Mariana Islands Military Relocation (2012 Roadmap Adjustments) Supplemental Environmental Impact Statement. Prepared by TEC-AECOM Joint Venture for Joint Guam Program Office, Honolulu, HI.

NAVFAC Pacific. 2014a. Final Survey Report. Terrestrial Biological Surveys on Tinian in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement. Joint Base Pearl Harbor-Hickam, HI. July.

NAVFAC Pacific. 2014b. Final (V2) Coastal Process Re–ort - Unai Babui and Unai Chulu, Tinian, CNMI.

NAVFAC Pacific. 2015. Final Survey Report, Surveys of Potential Wetland Sites on Tinian in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/ Overseas Environmental Impact Statement. Prepared by Micronesian Environmental Services, Saipan, CNMI and Cardno, Honolulu, HI. March.

NAVFAC Pacific. 2018a. Final Survey Report (V3). Endangered Species Act-listed Plant Surveys on Tinian in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement. NAVFAC Pacific, Pearl Harbor, HI.

NAVFAC Pacific. 2018b. Tinian AAV Ramp Oceanographic and Sediment Transport Study in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement. Prepared by Sea Engineering, Inc., Waimanalo, HI.

NBG. 2017. Marine Turtle Surveys on Military Leased Lands, Tinian, CNMI for the Period of May 13, 2016 through May 12, 2017.

NBG. 2018. Sea turtle emergence and nesting database for DoD lands on Guam, in custody of T. Summers, Natural Resource Specialist, Navy Base Guam.

NMFS. 2014a. Endangered and Threatened Wildlife and Plants: Final Listing Determinations on Proposal To List 66 Reef-Building Coral Species and To Reclassify Elkhorn and Staghorn Corals. Federal Register, 79, 53852–54123.

NMFS. 2014b. Endangered and Threatened Wildlife and Plants; Threatened and Endangered Status for Distinct Population Segments of Scalloped Hammerhead Sharks; Final Rule. Federal Register, 79, 38214–38242.

NMFS. 2015a. Endangered Species Act Section 7 Consultation Biological Opinion and Conference Report for the U.S. Military Mariana Islands Training and Testing Activities. 12 June.

NMFS. 2015a. Species of Concern: Humphead Wrasse *Cheilinus undulatus*. Accessed 16 January 2018, from http://www.nmfs.noaa.gov/pr/pdfs/species/humpheadwrasse_detailed.pdf. 30 October.

NMFS. 2015b. Species of Concern: Bumphead Parrotfish *Bolbometopon muricatum*. Accessed 16 January 2018, from http://www.nmfs.noaa.gov/pr/pdfs/species/bumpheadparrotfish_detailed.pdf. 30 October.

NMFS. 2018a. Endangered and Threatened Wildlife and Plants: Listing the Oceanic Whitetip Shark as Threatened Under the Endangered Species Act. Federal Register, 83, 4153–4165.

NMFS. 2018b. Endangered and Threatened Wildlife and Plants; Final Rule To List the Giant Manta Ray as Threatened Under the Endangered Species Act. Federal Register, 83, 2916–2931.

NMFS. 2020. Endangered Species Act Section 7 Consultation Biological Opinion and Conference Report for the U.S. Military Mariana Islands Training and Testing Activities. 10 July.

NMFS and USFWS. 1998. Recovery Plan for U.S. Pacific Populations of the Hawksbill Turtle (*Eretmochelys imbricata*). Prepared by Pacific Sea Turtle Recovery Team for National Marine Fisheries Service, Silver Spring, MD and USFWS Pacific Region, Portland, OR.

NMFS and USFWS. 2007. Olive Ridley Sea Turtle (*Lepidochelys olivacea*) 5-Year Review: Summary and Evaluation. NMFS, Office of Protected Resources, Silver Spring, MD and USFWS, Southeast Region, Jacksonville Ecological Services Field Office, Jacksonville, FL. August.

NOAA. 2017a. Ocean Watch. Accessed 15 October 2017, from http://oceanwatch.pifsc.noaa.gov/.

NOAA. 2017b. Online datasets for bathymetry and habitat mapping. Accessed 11 April 2018, from https://www.coris.noaa.gov/search/catalog/main/home.page.

O'Daniel, D. and Kreuger, S. 1999. Recent sightings of the Micronesian Megapode on Tinian, Mariana Islands. Micronesica, 31, 301–307.

Oleson, E., Baumann-Pickering, S., Sirovic, A., Merkens, K., Munger, L., Trickey, J., and Fisher-Pool, P. 2015. Analysis of Long-term Acoustic Datasets for Baleen Whales and Beaked Whales within the Mariana Islands Range Complex (MIRC) for 2010 to 2013 (PIFSC Data Report No. DR-15-002). 18 February.

OPNAV M. 2021. Chapter 12: Natural Resources Conservation in Environmental Readiness Program Manual. In OPNAV Manual 5090.1 (OPNAV M-5090.1), Washington, D.C. 25 June.

OPNAVINST. 2021. OPNAV Instruction (OPNAVINST) 5090.1. Environmental Readiness Program. Office of the Chief of Naval Operations, Washington, D.C. 25 June.

Pacific Daily News. 2018. Election of Lou Leon Guerrero, typhoons Yutu and Mangkhut top stories of 2018. Accessed 19 November 2020. Available at: https://www.guampdn.com/story/news/2018/12/30/leon-guerrero-election-typhoons-yuta-and-mangkhut-top-stories-2018/2412316002/

Pratt, H. S., Bruner, P. L., and Berrett, D. G. 1979. America's unknown avifauna: the birds of the Mariana Islands, 33, 227–235.

Pratt, L. W. 2011. Vegetation Assessment of Forests of Pagan Island, Commonwealth of the Northern Mariana Islands (Technical Report HCSU-023). Hawai'i Cooperative Studies Unit, University of Hawai'i, Hilo, HI. September.

Pratt, T. K. 2017. Th^{e} 117th CBC in Hawai'i and the Pacific Islands. Audubon. Accessed 17 December 2017, from http://www.audubon.org/news/th^{e-}117th-cbc-hawaii-and-pacific-islands.

Pregill, G. K. and Steadman, D. W. 2009. The prehistory and biogeography of terrestrial vertebrates of Guam, Mariana Islands. Diversity and Distributions, 15, 983–996.

Quinn, N. J. and Kolis, B. L. 2003. The dynamics of coral reef community structure and recruitment patterns around Rota, Saipan, and Tinian, Western Pacific. Bulletin of Marine Science, 72, 979–996.

Randall, R. H. and Myers, R. F. 1983. The Corals (Vol. 2). UOG Press, Mangilao, GU.

Raulerson, L. 2006. Checklist of Plants of the Mariana Islands. UOG Herbarium Contribution, 37, 1–69.

Reichel, J. D. and Glass, P. O. 1991. Checklist of the birds of the Mariana Islands. Elepaio, 51, 3–10.

Reynolds, T. C., Burdick, D., Houk, P., Raymundo, L., and Johnson, S. 2014. Unprecedented coral bleaching across the Marianas Archipelago. Coral Reefs, 33, 499–499.

Richards, B. L., Williams, I., Vetter, O. J., and Williams, G. J. 2012. Environmental Factors Affecting Large-Bodied Coral Reef Fish Assemblages in the Mariana Archipelago. PLoS ONE, 7, e31374.

Riegl, B. and Dodge, R. (Eds.). 2008. Coral Reefs of the World, Volume I. Coral Reefs of the USA. Springer-Verlag, Berlin.

Rodda, G. H., Fritts, T. H., & Conry, P. J. 1992. Origin and population growth of the brown tree snake, *Boiga irregularis*, on Guam. Pacific Science, 46, 46–57.

Rodda, G. H., Reed, R. N., Siers, S. R., Hinke, T. J., Fritts, T. H., and Reynolds, R. P. 2009. Reptiles and Amphibians of Tinian. Pages 79-130 *in* Terrestrial Resource Surveys of Tinian and Aguiguan, Mariana Islands, 2008 – Final Report. Prepared by USFWS Pacific Islands Fish and Wildlife Office, Honolulu, HI for Marine Force Pacific and NAVFAC, Pearl Harbor, HI.

Rodda, G. H. and Savidge, J. A. 2007. Biology and impacts of Pacific Island invasive species. 2. *Boiga irregularis* the brown treesnake (Reptilia: Colubridae). Pacific Science, 61, 307–324.

Safford, W. 2009. The Chamorro Language of Guam. University of Michigan Library. 27 April.

Smith, S. 2012. Field Note of Sea Turtle Surveys and Roving Diver Rapid Ecological Assessment off Unai Babui, Unai Chulu, and Unai Dangkolo Tinian, Commonwealth of the Northern Mariana Islands. Naval Facilities Engineering Service Center Scientific Diving Services.

Smith, S. 2017. During 1944 and 1945, the Twentieth Air Force flew hundreds of missions from North Field with Boeing B-29 Superfortress bomber aircraft. At least six of these crashed after take-off and are located off the northeast coast of Tinian at depths of slightly over 100 feet (30 meters). Personal communication from S. Smith, Marine Ecologist, SPAWAR SSC Scientific Diving Services, Pearl City, HI.

Smith, S. and Marx Jr., D. 2016. De-facto marine protection from a Navy bombing range: Farallon De Medinilla, Mariana Archipelago, 1997 to 2012. Marine Pollution Bulletin, 102, 187–198.

Spaulding, R.L., Camp, R.J., Banko, P.C., Johnson, N.C., and Anders, A.D. 2022. Status of Forest Birds on Tinian Island, Commonwealth of the Northern Mariana Islands, with an Emphasis on the Tinian Monarch (*Monarcha takatsukasae*) (Passeriformes; Monarchidae). *Pacific Science*, Vol 76; 2:209-228.

Starmer, J., Bearden, C., Brainard, R. E., de Cruz, T., Hoeke, R., Houk, P., Holzwarth, S., Kolinski, S., Miller, J., Schroeder, R., Timmers, M., Trianni, M., and Vroom, P. 2005. The State of Coral Reef Ecosystems of the Commonwealth of the Northern Mariana Islands. Pages 399-441 *in* J. Waddell (Ed.), The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2005. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team, Silver Spring, MD.

Stinson, D. W., Ritter, M. W., and Reichel, J. D. 1991. The Mariana Common Moorhen: decline of an island endemic. Condor, 93, 38–43.

Stinson, D. W., Wiles, G., and Reichel, J. D. 1997. Occurrence of migrant shorebirds in the Mariana Islands. Journal of Field Ornithology, 68, 42–55.

Stohler, R. and Cooling, A. 1945. Toads in the Marianas (*Bufo marinus*). Science, 101, 678.

Stone, B. 1970. The flora of Guam. A manual for the identification of the vascular plants of the island. Micronesica, 6, 1–659.

Summers, T. M., Jones, T. T., Martin, S. L., Hapdei, J. R., Ruak, J. K., and Lepczyk, C. A. 2017. Demography of Marine Turtles in the Nearshore Environments of the Northern Mariana Islands. Pacific Science, 71, 269–286.

Summers, T. M., Martin, S. L., Hapdei, J. R., Ruak, J. K., and Jones, T. T. 2018. Endangered Green Turtles (*Chelonia mydas*) of the Northern Mariana Islands: Nesting ecology, poaching, and climate concerns. Frontiers in Marine Science, 4, 428.

Swift K., F. Moore, N. Johnson, and B. Gardner. 2023. Breeding biology and habitat use of the Tinian Monarch (*Monarcha takatsukasae*). Final Report prepared for NAVFAC Marianas. Seattle, WA. May.

Takano, L. L. and Haig, S. M. 2004a. Distribution and Abundance of the Mariana Subspecies of the Common Moorhen. Waterbirds, 27, 245–250.

Takano, L. L. and Haig, S. M. 2004b. Seasonal movement and home range of Mariana common moorhen. Condor, 106, 652–663.

Tang, J. W., Lu, X. T., Yin, J. X., and Qi, J. F. 2011. Diversity, composition and physical structure of tropical forest over limestone in Xishuangbanna, south-west China. Journal of Tropical Forest Science, 23, 425–433.

Timmers, M., Bird, C. E., Skillings, D. J., Smouse, P. E., and Toonen, R. J. 2012. There's no place like home: Crown-of-thorns outbreaks in the Central Pacific are regionally derived and independent events. PLOS ONE, 7, e31159.

Topping, D., Ogo, P., and Dungca, B. 1975. Chamorro-English Dictionary. University of Hawai'i Press, Honolulu, HI.

Townes, H. K. 1946. Part I. Non-agricultural plants. Economic Survey of Micronesia, 12, 1–53.

Tran, D. S. C., Langel, K. A., Thomas, M. J., and Blumstein, D. T. 2016. Spearfishing-induced behavioral changes of an unharvested species inside and outside a marine protected area. Current Zoology, 62, 39–44.

Trianni, M. S. 2002. Summary of data collected from the sea cucumber fishery on Rota, Commonwealth of the Northern Mariana Islands. Bêche-de-Mer Information Bulletin, 16, 5–11.

Trianni, M. S. and Tenorio, M. C. 2012. Summary of recorded cetacean strandings in the Commonwealth of the Northern Mariana Islands. Micronesica, 43, 1–13.

Tsuda, R. T. 2004. Checklist and Bibliography of the Marine Benthic Algae from the Mariana Islands (Guam and CNMI) (Technical Report No. 107). UOG Marine Laboratory, Mangilao, GU. March, revised in June.

University of Guam (UOG). 2023. Tinian Cycad Scale Management Task. Unpublished data.

U.S. Navy. 2006. Naval Ships' Technical Manual, Chapter 081, Revision 5, Waterborne Underwater Hull Cleaning of Navy Ships.

U.S. Navy. 2023. Monitoring Mariana fruit bats on Guam Naval Munitions Site and Tinian Military Lease Area, 2022-2023. Prepared for NAVFAC Marianas, Guam. Prepared by T. Mildenstein, University of Guam, under Cooperative Agreement Number N40192-22-2-8001. April.

U.S. Pacific Fleet Environmental. 2015. Year 2014 Annual Report. Wildlife Surveys on Military Leased Lands, Tinian CNMI, Mariana Common Moorhen. Contract Report by Micronesian Environmental Services.

USDA. 1989. Soil Survey of the Islands of Aguijan, Rota, Saipan, and Tinian, Commonwealth of the Northern Mariana Islands. United States Department of Agriculture Soil Conservation Service.

USDA. 1994. Island Resource Study. Tinian, Commonwealth of the Northern Mariana Islands. U.S. Department of Agriculture, Soil Conservation Service.

USFS. 2006. Guam Vegetation Mapping. Pacific Southwest Region, Forest Health Protection, McClellan, CA.

USFWS. 1996. Wildlife Research Report for Navy Leased Lands on the Island of Tinian, Commonwealth of the Northern Mariana Islands. Prepared by USFWS, Pacific Islands Ecoregion, Honolulu, HI for NAVFAC Pacific, Pearl Harbor, HI.

USFWS. 1998. Recovery plan for the Micronesian megapode (*Megapodius laperouse laperouse*). Portland, OR.

USFWS. 2004. Endangered and Threatened Wildlife and Plants; Final Rule to Remove the Tinian Monarch from the Federal List of Endangered and Threatened Wildlife. Federal Register, (69), 56367–56371.

USFWS. 2005. Post-delisting Monitoring Plan for the Tinian monarch (*Monarcha takatsukasae*). Endangered Species Division, Pacific Islands Fish and Wildlife Office, Honolulu, HI.

USFWS. 2009. Terrestrial Resource Surveys of Tinian and Aguiguan, Mariana Islands, 2008 – Final Report. Prepared by USFWS Pacific Islands Fish and Wildlife Office, Honolulu, HI for Marine Forces Pacific and NAVFAC, Pearl Harbor, HI. December.

USFWS. 2010. Biological Opinion for the Joint Guam Program Office Relocation of the U.S. Marine Corps from Okinawa to Guam and Associated Activities on Guam and Tinian. Pacific Islands Fish and Wildlife Office, Honolulu, HI. 8 September.

USFWS. 2012a. Species Assessment and Listing Priority Assignment Form: *Partula gibba*, Humped Tree Snail. Pacific Islands Fish and Wildlife Office Honolulu, HI. 2 March.

USFWS. 2012b. Endangered Species in the Pacific Islands: Mariana Common Moorhen/*Gallinula chloropus guami*/Pulattat. Accessed 2 March 2018, from http://www.fws.gov/pacificislands/fauna/marianamoorhen.html. 20 September.

USFWS. 2013. General Provisions; Revised List of Migratory Birds: Final Rule 2013. Federal Register, 78, 65844–65864.

USFWS. 2015a. Endangered and Threatened Wildlife and Plants; Endangered Status for 16 Species and Threatened Status for 7 Species in Micronesia. Federal Register, 80(190), 59424–59497.

USFWS. 2015b. Biological Opinion for the Mariana Islands Testing and Training Program. Pacific Islands Fish and Wildlife Office, Honolulu, HI. 20 February.

Vargas-Angel, B. 2010. Crustose coralline algal diseases in the US-Affiliated Pacific Islands. Coral Reefs, 29, 943–956.

Villanueva-Dizon, F. 2016. Extreme Drought Expanding, Worsening Across Micronesia. Pacific Islands Report. Accessed 13 August 2018, from http://www.pireport.org/articles/2016/03/18/extreme-drought-expanding-worsening-across-micronesia. 18 March.

Vogt, S. 2008a. Micronesian Megapode (*Megapodius laperouse laperouse*) Surveys on Tinian and Aguijan, Commonwealth of the Northern Mariana Islands (Draft). NAVFAC Pacific, Honolulu, HI,

Vogt, S. 2008b. Fiscal Years 2007 and 2008 Report for 61755NR410. Wildlife Surveys on Military Leased Lands, Tinian, CNMI. NAVFAC Pacific, Honolulu, HI.

Vogt, S. 2009a. Coconut Crab Surveys on Military Lease Lands on Tinian. Pages 61-78 *in* Terrestrial Resource Surveys of Tinian and Aguiguan, Mariana Islands, 2008 – Final Report. Prepared by USFWS Pacific Islands Fish and Wildlife Office, Honolulu, HI for Marine Forces Pacific and NAVFAC, Pearl Harbor, HI. December.

Vogt, S. 2009b. Fiscal Years 2006 and 2007 Report for 61755NR410: Wildlife Surveys on Military Leased Lands, Tinian CNMI (Draft). U.S. Navy NAVFAC Pacific, Honolulu, HI.

Vogt, S. and Williams, L. L. 2004. Common Flora and Fauna of the Mariana Islands. Saipan, MP.

Whittall, D. R., Mason, A., Johnson, S., Okano, R., and Iguel, J. 2016. Chemical contaminants in corals (*Pocillopora damicornis*) in Tinian, CNMI (NOAA Technical Memo No. NOS NCCOS 219). NOAA NCCOS, Center for Costal Monitoring and Assessment, Silver Spring, MD.

Widlanski, M. J., Timmerman, A., and Cai, W. 2015. Future extreme sea level seesaws in the tropical Pacific. Science Advances, 1.

Wiewel, A., Adams, A. A. Y., and Rodda, G. H. 2009. Rodents on Tinian. Pages 240-257 *in* Terrestrial Resource Surveys of Tinian and Aguiguan, Mariana Islands, 2008 – Final Report. Prepared by USFWS Pacific Islands Fish and Wildlife Office, Honolulu, HI for Marine Forces Pacific and NAFVAC Pacific, Pearl Harbor, HI. December.

Wiles, G., Bart, J., Beck Jr., R. E., and Aguon, C. F. 2003. Impacts of the brown treesnake: patterns of decline and species persistence in Guam's avifauna. Conservation Biology, 17, 1350–1360.

Wiles, G. and Glass, P. O. 1990. Interisland Movements of Fruit Bats (*Pteropus mariannus*) in the Mariana Islands (Atoll Research Bulletin No. 343). National Museum of Natural History, Smithsonian Institution. Washington, D.C. September.

Wiles, G., Lemke, T. O., and Payne, N. H. 1989. Population estimates of fruit bats (*Pteropus mariannus*) in the Mariana Islands. Conservation Biology, 3, 66–76.

Williams, I., Richards, B. L., Sandin, S. A., Baum, J. K., Schroeder, R. E., Nadon, M. O., Zgliczynski, B., Craig, P., McIlwain, J. I., and Brainard, R. E. 2011. Differences in reef fish assemblages between populated and remote reefs spanning multiple archipelagos across the Central and Western Pacific. Journal of Marine Biology, Article 826234.

Wolanski, E., Richmond, R. H., Davis, G., Deleersnijder, E., and Leben, R. 2003. Eddies around Guam, an island in the Mariana Islands group. Continental Shelf Research, 23, 991–1003.

WPRFMC. 2016. Can Past Glories of the Mariana Fishing Industry Be Revived? Pacific Island Fishery News, Spring, 3.

15.12 CHAPTER 12 – FARALLON DE MEDINILLA

Amidon, F. A., Marshall, A. P., and Kessler, C. C. 2011. Status of the Micronesian megapode in the Commonwealth of the Northern Mariana Islands. U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, HI. July.

Amidon, F. A., Metevier, M., Miller, S. E. 2017. Vegetation Mapping of the Mariana Islands: Commonwealth of the Northern Mariana Islands and Territory of Guam. U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, HI. November

Amori, G. and Clout, M. N. 2003. Rodents on Islands: A Conservation Challenge. Pages 63-68 *in* G. R. Singleton, C. A. Hinds, C. J. Krebs, and D. M. Spratt (Eds.), Rats, Mice and People: Rodent Biology and Management. ACIAR, Canberra.

Babcock, R. C., Dambacher, J. M., Morello, E. B., Plaganyi, E. E., Hayes, K. R., Sweatman, H. P. A., and Pratchett, M. S. 2016. Assessing different causes of crown-of-thorns starfish outbreaks and appropriate responses for management on the Great Barrier Reef. PLOS ONE, 11, e0169048.

Berger, G. M., Gourley, J., and Schroer, G. 2005. Comprehensive Wildlife Conservation Strategy for the Commonwealth of the Northern Mariana Islands. Prepared by CNMI Department of Lands and Natural Resources, Division of Fish and Wildlife, Saipan, CNMI for National Advisory Acceptance Team, Migratory Birds and State Programs, USFWS, Portland, OR. September.

Brainard, R. E., Asher, J., Blyth-Skyrme, V., Coccagna, E. F., Dennis, K., Donovan, M. K., Gove, J. M., Kenyon, J., Looney, E. E., Miller, J. E., Timmers, M., Vargas-Ángel, B., Vroom, P. S., Vetter, O., and Zgliczynski, B. 2012. Coral Reef Ecosystem Monitoring Report of the Mariana Archipelago: 2003 to 2007 (PIFSC Special Publication No. SP-12-01). NOAA Fisheries, Pacific Islands Fisheries Science Center. Honolulu, HI. March.

CABI Digital Library. Chamorro plant names. December 2023

Camp, R. J., Leopold, C., Brink, K. W., and Juola, F. 2014. Farallon de Medinilla Seabird and Tinian Moorhen Analyses (Technical Report No. HCSU-060). Prepared by Hawai‘i Cooperative Studies Unit, University of Hawai‘i at Hilo.

Carilli, J.E., Norris, R. D., Black, B. A., Walsh, S. M., and McField, M. 2009. Local Stressors Reduce Coral Resilience to Bleaching. PLOS ONE, 4, e6324.

Castro, F., Rucinski, M., and Tibbatts, B. 2020. Sea Turtle Aerial Surveys in Farallon de Medinilla (FDM) Nearshore Waters. Prepared by University of Guam Sea Grant for Naval Facilities Engineering Command Marianas 19 pp.

DeMattia, E. A., Curran, L. M., and Rathke, B. J. 2004. Effects of small rodents and large mammals on neotropical seeds. Ecology, 85, 2161–2170.

DON. 2001. Year 2001 Assessment of Marine and Fisheries Resources Farallon de Medinilla, Commonwealth of the Northern Mariana Islands. Prepared by Belt Collins Hawai‘i.

DON. 2003. Year 2002 Assessment of Marine and Fisheries Resources Farallon de Medinilla, Commonwealth of the Northern Mariana Islands. Prepared by Belt Collins Hawai‘i.

DON. 2009. Interim Final Integrated Natural Resources Management Plan, Navy Base Guam, Plan Years 2009–2014. Prepared by Geo-Marine.

DON. 2010. Mariana Islands Range Complex Final Environmental Impact Statement/Overseas Environmental Impact Statement. Volume 1. Prepared by NAVFAC Pacific, Pearl Harbor, HI. May.

DON. 2014a. Biological Assessment of Military Training Activities in the Mariana Islands Training and Testing Study Area: Terrestrial Species and Habitats; Re-initiation of Consultation 2009-F-0345 Military Training within the Mariana Islands Range Complex, Guam and the Commonwealth of the Northern Mariana Islands. Prepared by Commander, U.S. Pacific Fleet, Pearl Harbor, HI. August.

DON. 2014b. Final Coral Marine Resources Survey Report in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement. Prepared by Tetra Tech, Inc. for U.S. Navy, NAVFAC Pacific.

DON. 2015a. Joint Region Marianas Integrated Natural Resources Management Plan Summary of FY2015 Actions and Projects. Prepared by Cardno, Honolulu, HI and Bainbridge Island, WA. 22 October.

DON. 2015b. Mariana Islands Training and Testing Activities Final Environmental Impact Statement/Overseas Environmental Impact Statement. Volume 2. Prepared by NAVFAC Pacific, Pearl Harbor, HI. May.

DON. 2015c. Mariana Islands Training and Testing Activities Final Environmental Impact Statement/Overseas Environmental Impact Statement. Volume 1. Prepared by NAVFAC Pacific, Pearl Harbor, HI. May.

DON. 2015d. Regional Biosecurity Plan for Micronesia and Hawai‘i: 4 Volumes.

DON. 2017. Tinian Reef Marine Resource Survey Report in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement. Prepared by Tetra Tech, Inc. for U.S. Navy, NAVFAC Pacific.

Earthquaketrack.com. 2017. Recent Earthquakes near Mariana Islands – 7+ magnitude. Accessed 30 November 2017, from http://earthquaketrack.com/r/mariana-islands/recent?mag_filter=7.

FAA. 2017. Modification of Restricted Area R-7201; Farallon De Medinilla Island, Mariana Islands; Final Rule. Federal Register, 82, 13389–13390.

Fenner, D. 2017. Expert taxonomic opinion on speciation among massive *Porites* and the relatively new admission among top taxonomists that generalizing to ‘massive Porites’ is preferable to - fruitless/superfluous species-level distinctions. Personal communication in person from D. Fenner, Taxonomist, Saipan CNMI to M. Lybolt, Marine Ecologist, Tetra Tech Inc., Saipan, CNMI. April.

Fulling, G., Thorson, P., and Rivers, J. 2011. Distribution and abundance estimates for cetaceans in the waters off Guam and the Commonwealth of the Northern Mariana Islands. Pacific Science, 65, 321–343.

Gill, F. and Donsker, D. 2018. International Ornithologists’ Union (IOC) World Bird List (v 7.2) (No. 10.14344/IOC).

GovGuam. 2009. Endangered Species Regulation No. 9. Department of Agriculture, Mangilao, GU. 27 April.

Hill, M., Ligon, A., Deakos, M., Ü, A. C., Milette-Winfree, A., Oleson, E., and Bendlin, A. 2014. Cetacean surveys in the waters of the southern Mariana Archipelago (February 2010-April 2014)

(PIFSC Data Report No. DR-14-013). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 2 September.

Hill, M., Oleson, E. M., Ligon, A. D., Martien, K. K., Archer, F. I., Baumann-Pickering, S., Bendlin, A. R., Dolar, L., Merkens, K. P. B., Milette-Winfree, A., Morin, P. A., Rice, A., Robertson, K. M., Trickey, J. S., Ü, A. C., Van Cise, A. M., and Woodman, S. M. 2015. Cetacean Monitoring in the Mariana Islands Range Complex, 2014 (PIFSC Data Report No. DR-15-003). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 27 March.

Hill, M., Oleson, E. M., Baumann-Pickering, S., VanCise, A. M., Ligon, A. D., Bendlin, A. R., Ü, A. C., Trickey, J. S., and Bradford, A. L. 2016. Cetacean Monitoring in the Mariana Islands Range Complex, 2015 (PIFSC Data Report No. DR-16-01). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 6 February.

Hill, M., Bendlin, A. R., Ü, A. C., Yano, K. M., Bradford, A. L., Ligon, A. D., and Oleson, E. M. 2017. Cetacean Monitoring in the Mariana Islands Range Complex, 2016 (PIFSC Data Report No. DR-17-002). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. 3 February.

Jones, T. T., Martin, S. L., and Van Houtan, K. S. 2015. Sea Turtle Tagging in the Mariana Islands Range Complex (MIRC) Interim Progress Report (PIFSC Data Report No. DR-15-020). Prepared for U.S. Pacific Fleet Environmental Readiness Office, Pearl Harbor, HI. September.

JRM. 2010. JRM Leased Lands and Submerged Lands GIS Data.

JRM. 2013. Final Joint Region Marianas Integrated Natural Resources Management Plan. Prepared by HDR for Commander Joint Region Marianas, Guam, Hagatna, GU. December.

Kendall, M. S. and Poti, M. 2015. Transport Pathways of Marine Larvae Around the Mariana Archipelago (NOAA Technical Memorandum NOS NCCOS 193). Silver Spring, MD.

Kerr, A. M. 1990. Chamorro Fish Names. Micronesica, 23, 93–118.

Kerr, A. M. 2012. Fish Names of the Mariana Islands, Micronesia (UOG Marine Laboratory Technical Report No. 139). Mangilao, GU. February.

Klinck, H., Nieukirk, S. L., Fregosi, S., Klinck, K., Mellinger, D. K., Latuska, S., Shilling, B., and Luby, J. C. 2015. Cetacean Studies on the Mariana Islands Range Complex in September-November 2014: Passive Acoustic Monitoring of Marine Mammals Using Gliders. Final Report. Prepared for Commander, U.S. Pacific Fleet, Environmental Readiness Division, Pearl Harbor, HI. August.

Klinck, H., Nieukirk, S. L., Fregosi, S., Klinck, K., Mellinger, D. K., Latuska, S., Shilling, B., and Luby, J. C. 2016. Cetacean Studies on the Mariana Islands Range Complex in March – April 2015: Passive Acoustic Monitoring of Marine Mammals Using Gliders. Submitted by HDR, Inc., Honolulu, HI to Commander, U.S. Pacific Fleet.

Kobayashi, D., Cheng, I.-J., Parker, D. M., Polovina, J. J., Kamezaki, N., and Balazs, G. H. 2011. Loggerhead turtle (*Caretta caretta*) movement off the coast of Taiwan: characterization of a hotspot in the East China Sea and investigation of mesoscale eddies. ICES Journal of Marine Science, 68, 707–718.

Lagerloef, G. S., Lukas, R., Bonjean, F., Gunn, J. T., Mitchum, G. T., Bourassa, M., and Busalacchi, A. J. 2003. El Nino tropical Pacific Ocean surface current and temperature evolution in 2002 and outlook for early 2003. Geophysical Research Letters, 30, 1514.

Liske-Clark, J. 2015. Wildlife Action Plan for the Commonwealth of the Northern Mariana Islands, 2015-2025. CNMI DLNR-Division of Fish and Wildlife, Saipan, MP. 16 December.

Lusk, M., Bruner, P., and Kessler, C. 2000. The avifauna of Farallon de Medinilla, Mariana Islands. Journal of Field Ornithology, 71, 22–33.

Martin, S. L. and Jones, T. T. 2016. Sea Turtle Tagging in the Mariana Islands Training and Testing (MITT) Study Area (PIFSC Data Report No. DR-17-025). Prepared for the U.S. Pacific Fleet Environmental Readiness Office, Honolulu, HI. 15 December.

Marti-Puig, P., Forsman, Z. H., Haverkort-Yeh, R. D., Knapp, I. S. S., Maragos, J. E., and Toonen, R. J. 2014. Extreme phenotypic polymorphism in the coral genus Pocillopora; micro-morphology corresponds to mitochondrial groups, while colony morphology does not. Bulletin of Marine Science, 90, 211–231.

Miller, I., Sweatman, H., Cheal, A., Emslie, M., Johns, K., Jonker, M., and Osborne, K. 2015. Origins and implications of a primary crown-of-thorns starfish outbreak in the southern great barrier reef. Journal of Marine Biology, Article ID 809624.

Minton, D., Brown, V., Dugger, K., Flores, T., Foster, K., Houk, P., Iguel, J., Kessler, C., Kolinski, S., Schols, T., Starmer, J., Suhkraj, N., Tenorio, M., and Trianni, M. 2009. Draft Report. Marine Resource Surveys of Tinian, Commonwealth of the Northern Mariana Islands. Volume I. UOG Marine Laboratory, Mangilao, GU.

Mydlarz, L. D., Jones, L. E., and Harvell, C. D. 2006. Innate immunity, environmental drivers, and disease ecology of marine and freshwater invertebrates. Annual Review of Ecology, Evolution, and Systematics, 37, 251–288.

NAVFAC Marianas. 2013. Threatened and Endangered Species and Migratory Birds Monitoring Report, Naval Support Activity Andersen, Guam. Prepared by HDR Inc., San Diego, CA. February.

NAVFAC Marianas. 2016. Joint Region Marianas Integrated Natural Resources Management Plan (INRMP) Summary of FY2016 Actions and Projects. Prepared by Cardno, Honolulu, HI and Bainbridge Island, WA.

NAVFAC Marianas. 2019a. Micronesian Megapode (*Megapodius laperouse laperouse*) Survey on Farallon de Medinilla, Commonwealth of the Northern Mariana Islands, 12 April 2019. Unpublished report.

NAVFAC Marianas. 2019b. Habitat Change Analysis of Farallon de Medinilla, Commonwealth of the Northern Mariana Islands, 12 April 2019. Unpublished report.

NAVFAC Marianas. 2023. Draft. Seabird surveys on Farallon de Medinilla, Commonwealth of the Northern Mariana Islands. Santa Rita, GU: Department of Navy, NAVFAC Marianas. Unpublished Report.

NAVFAC Pacific. 2003. Year 2003 Assessment of Marine and Fisheries Resources Farallon de Medinilla, Commonwealth of the Northern Mariana Islands. Prepared by TEC, Inc.

NAVFAC Pacific. 2004. Environmental Assessment Farallon de Medinilla and Tinian Military Lease Areas Commonwealth of the Northern Mariana Islands Integrated Natural Resources Management Plan. July.

NAVFAC Pacific. 2005. Year 2004 Assessment Marine and Fisheries Resources: Final – Farallon de Medinilla Commonwealth of the Northern Mariana Islands. Prepared by TEC, Inc.

NAVFAC Pacific. 2010. Final Natural Resource Survey Report in Support of the Environmental Impact Statement for the Marine Corps Relocation Initiative to Various Locations on Guam. Pearl Harbor, HI. 23 December.

NMFS. 2014a. Endangered and Threatened Wildlife and Plants; Threatened and Endangered Status for Distinct Population Segments of Scalloped Hammerhead Sharks; Final Rule. Federal Register, 79, 38214–38242.

NMFS. 2014b. Endangered and Threatened Wildlife and Plants: Final Listing Determinations on Proposal To List 66 Reef-Building Coral Species and To Reclassify Elkhorn and Staghorn Corals. Federal Register, 79, 53852–54123.

NMFS. 2015a. Species of Concern: Humphead Wrasse *Cheilinus undulatus*. Accessed 16 January 2018, from http://www.nmfs.noaa.gov/pr/pdfs/species/humpheadwrasse_detailed.pdf. 30 October.

NMFS. 2015b. Species of Concern: Bumphead Parrotfish *Bolbometopon muricatum*. Accessed 16 January 2018, from http://www.nmfs.noaa.gov/pr/pdfs/species/bumpheadparrotfish_detailed.pdf. 30 October.

NMFS. 2017. Reinitiated Biological Opinion on Mariana Islands Training and Testing and Issuance of an MMPA Rule and LOA. 13 September.

NMFS. 2018a. Endangered and Threatened Wildlife and Plants: Listing the Oceanic Whitetip Shark as Threatened Under the Endangered Species Act. Federal Register, 83, 4153–4165.

NMFS. 2018b. Endangered and Threatened Wildlife and Plants; Final Rule To List the Giant Manta Ray as Threatened Under the Endangered Species Act. Federal Register, 83, 2916–2931.

NMFS. 2020. Endangered Species Act Section 7 Consultation Biological Opinion and Conference Report for the U.S. Military Mariana Islands Training and Testing Activities. 10 July.

NOAA. 2017a. Ocean Watch. Accessed 15 October 2017, from http://oceanwatch.pifsc.noaa.gov/.

NOAA. 2017b. #FieldWorkWin: Signing off from Saipan. NOAA Pacific Islands Fisheries Science Center Blog. Accessed 8 August 2018, from https://pifscblog.wordpress.com/2017/03/20/fieldworkwin-saipan/. 20 March.

Oleson, E., Baumann-Pickering, S., Sirovic, A., Merkens, K., Munger, L., Trickey, J., and Fisher-Pool, P. 2015. Analysis of Long-term Acoustic Datasets for Baleen Whales and Beaked Whales within the Mariana Islands Range Complex (MIRC) for 2010 to 2013 (PIFSC Data Report No. DR-15-002). 18 February.

OPNAV M. 2014. Chapter 12: Natural Resources Conservation in Environmental Readiness Program Manual. In OPNAV Manual 5090.1 (OPNAV M-5090.1), Washington, D.C. 10 January.

Quinn, N. J. and Kolis, B. L. 2003. The dynamics of coral reef community structure and recruitment patterns around Rota, Saipan, and Tinian, Western Pacific. Bulletin of Marine Science, 72, 979–996.

Reichel, J. D. and Glass, P. O. 1991. Checklist of the birds of the Mariana Islands. Elepaio, 51, 3–10.

Richmond, R., Houk, P., Trianni, M., Wolanski, E., Davis, G., Bonito, V., and Paul, V. 2008. Aspects of Biology and Ecological Functioning of Coral Reefs in Guam and the Commonwealth of the Northern

Mariana Islands. Pages 719-739 *in* B. Riegl and R. Dodge (Eds.), Coral Reefs of the USA (Vol. 1). Springer Netherlands, Dordrecht.

Safford, W. 2009. The Chamorro Language of Guam. University of Michigan Library. 27 April.

Schils, T. 2012. Episodic eruptions of volcanic ash trigger a reversible cascade of nuisance species outbreaks in pristine coral habitats. PLOS ONE, 7, e46639.

Schroeder, R., Trianni, M. S., Moots, K. A., Laughlin, J. L., Zgliczynski, B. J., and Tibbatts, B. R. 2006. Status of fishery target species on coral reefs in the Mariana Archipelago. Pages 1016–1027 *in* Proceedings of the 10th International Coral Reef Symposium, Okinawa, Japan, June 28-July 2, 2004.

Smith, S. 2017. Number of stony coral species at FDM. Personal communication from S. Smith, Marine Ecologist, SPAWAR SSC Scientific Diving Services, Pearl City, HI.

Smith, S. and Marx Jr., D. 2009. Assessment of Near Shore Marine Resources at Farallon de Medinilla: 2006, 2007, and 2008, Commonwealth of the Northern Mariana Islands. Prepared for Commander U.S. Pacific Fleet.

Smith, S. and Marx Jr., D. 2016. De-facto marine protection from a Navy bombing range: Farallon De Medinilla, Mariana Archipelago, 1997 to 2012. Marine Pollution Bulletin, 102, 187–198.

Smith, S., Marx Jr., D., and Shannon, L. H. 2013. Calendar Year 2012 Assessment of Near Shore Marine Resources at Farallon de Medinilla, Commonwealth of the Northern Mariana Islands. Prepared for Pacific Fleet Environmental.

Topping, D., Ogo, P., and Dungca, B. 1975. Chamorro-English Dictionary. University of Hawai‘i Press, Honolulu, HI.

Trianni, M. S. and Tenorio, M. C. 2012. Summary of recorded cetacean strandings in the Commonwealth of the Northern Mariana Islands. Micronesica, 43, 1–13.

Tsuda, R. T. 2004. Dictyota (Phaeophyceae) from Micronesia. Pages 41-55 *in* I. A. Abbott and K. J. McDermid (Eds.), Taxonomy of Economic Seaweeds with Reference to the Pacific and Other Locations, Volume IX. University of Hawai‘i Sea Grant College Program, Honolulu, HI.

USFWS. 1970. Conservation of Endangered Species and Other Fish and Wildlife. Federal Register, 35, 8491–8498.

USFWS. 1984. Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for Seven Birds and Two Bats of Guam and the Northern Mariana Islands. Final Rule. Federal Register, 49, 33881–33885.

USFWS. 1998. Recovery plan for the Micronesian megapode (*Megapodius laperouse laperouse*). Portland, OR.

USFWS. 2005. Endangered and Threatened Wildlife and Plants; Mariana Fruit Bat (*Pteropus mariannus mariannus*): Reclassification from Endangered to Threatened in the Territory of Guam and Listing as Threatened in the Commonwealth of the Northern Mariana Islands. Federal Register, 70, 1190–1210.

USFWS. 2007. Migratory Bird Permits; Take of Migratory Birds by the Armed Forces; Final Rule. Federal Register, 72, 8931–8950.

USFWS. 2009. Draft Revised Recovery Plan for the Mariana Fruit Bat or Fanihi (*Pteropus mariannus mariannus*). USFWS Region 1, Portland, OR.

USFWS. 2010. Biological Opinion for the Joint Guam Program Office Relocation of the U.S. Marine Corps from Okinawa to Guam and Associated Activities on Guam and Tinian. Pacific Islands Fish and Wildlife Office, Honolulu, HI.

USFWS. 2015a. Biological Opinion for the Mariana Islands Testing and Training Program. Pacific Islands Fish and Wildlife Office, Honolulu, HI. 20 February.

USFWS. 2015b. Endangered and Threatened Wildlife and Plants; Endangered Status for 16 Species and Threatened Status for 7 Species in Micronesia. Federal Register, 80(190), 59424–59497.

Uyeyama, R. K. 2014. Compilation of incidental marine mammal and sea turtle sightings in the Mariana Islands Range Complex. Prepared by NAVFAC Pacific for Commander, U.S. Pacific Fleet, Pearl Harbor, HI.

Vogt, S. 2009. Micronesian Megapode (*Megapodius laperouse laperouse*) Surveys on Tinian and Aguijan, Commonwealth of the Northern Mariana Islands. NAVFAC Pacific, Honolulu, HI.

Vogt, S. 2017. Location of breeding seabirds on FDM. Personal communication via email from S. Vogt, Biologist, NBG to R. Spaulding, Senior Biologist/Project Manager, Cardno, Bainbridge Island, WA. 9 April.

Wanless, R. M., Angel, A., Cuthbert, R. J., Hilton, G. M., and Ryan, P. G. 2007. Can predation by invasive mice drive seabird extinctions? Biology Letters, 3, 241–244.

Wenninger, P. 2013. FY 2013 Annual Report. Wildlife Surveys on Military Leased Lands, Farallon de Medinilla CNMI.

Whistler, W. A. 1996. Botanical Survey of Farallon de Medinilla, Commonwealth of the Northern Mariana Islands. Prepared for Belt Collins and Associates, Honolulu, HI.

Widlanski, M. J., Timmerman, A., and Cai, W. 2015. Future extreme sea level seesaws in the tropical Pacific. Science Advances, 1.

Wiles, G. 1987. Natural History, Biology, and Habitat Protection for the Mariana Fruit Bats. Pages 124-135 *in* G. Grimm and L. Mariano (Eds.), Aquatic and Wildlife Resources Division Annual Report. Guam Department of Agriculture, Division of Aquatic and Wildlife Resources, Mangilao, GU.

Wiles, G., Bart, J., Beck Jr., R. E., and Aguon, C. F. 2003. Impacts of the brown treesnake: patterns of decline and species persistence in Guam's avifauna. Conservation Biology, 17, 1350–1360.

Wiles, G., Lemke, T. O., and Payne, N. H. 1989. Population estimates of fruit bats (*Pteropus mariannus*) in the Mariana Islands. Conservation Biology, 3, 66–76.

15.13 CHAPTER 13 – PLANNING, INTEGRATION, AND IMPLEMENTATION

DoD. 2009. Department of Defense Environmental Management Systems Compliance Management Plan. November.

DoD. 2011. Department of Defense Instruction (DoDI) 4715.03.

DoD. 2013. Department of Defense Manual (DoDM) 4715. Integrated Natural Resources Management Plan (INRMP) Implementation Manual. 25 November 2013, incorporating Change 1, December 13, 2017.

DON. 2006. Integrated Natural Resources Management Program Guidance for Navy Installations: How to Prepare, Implement, and Revise Integrated Natural Resource Management Plans (INRMP). Chief of Naval Operations (OPNAV N41).

DON. 2013. Secretary of the Navy Instruction (SECNAVINST) 11011.47C. Acquisition, Management, and Disposal of Real Property and Real Property Interests by the Department of the Navy and NAVFAC.

JRM. 2013. Final Joint Region Marianas Integrated Natural Resources Management Plan. Prepared by HDR for Commander Joint Region Marianas, Guam, Hagatna, GU. December.

JRM. 2016. Joint Region Marianas Environmental Review Board Charter.

NAVFAC Asset Management. n.d. P-73 – NAVFAC Real Estate Procedural Manual. Section 13.4.2.

NAVFAC Pacific. 2011. Final Guam Landscaping Guidelines. Prepared in cooperation with NAVFAC Marianas, Naval Base Guam, Pearl Harbor, HI.

NBG. 2016. Environmental Management System (EMS) Manual. Revision 5.

NOAA. 2018. Laws and Policies. Accessed 11 July 2018, from https://www.fisheries.noaa.gov/topic/laws-policies#magnuson-stevens-act.

OPNAV M. 2021. Chapter 12: Natural Resources Conservation in Environmental Readiness Program Manual. In OPNAV Manual 5090.1 (OPNAV M-5090.1), Washington, D.C. 25 June.

OPNAVINST. 2021. OPNAV Instruction (OPNAVINST) 5090.1. Environmental Readiness Program. Office of the Chief of Naval Operations, Washington, D.C. 25 June.

SECNAV. 2006. SECNAV Instructions (SECNAVINST) 5090.8A. Policy for Environmental Protection, Natural Resources, and Cultural Resources Programs.