4. Current Conditions

4.1 Guam

4.1.1 General Physical Environment

4.1.1.1 Climate

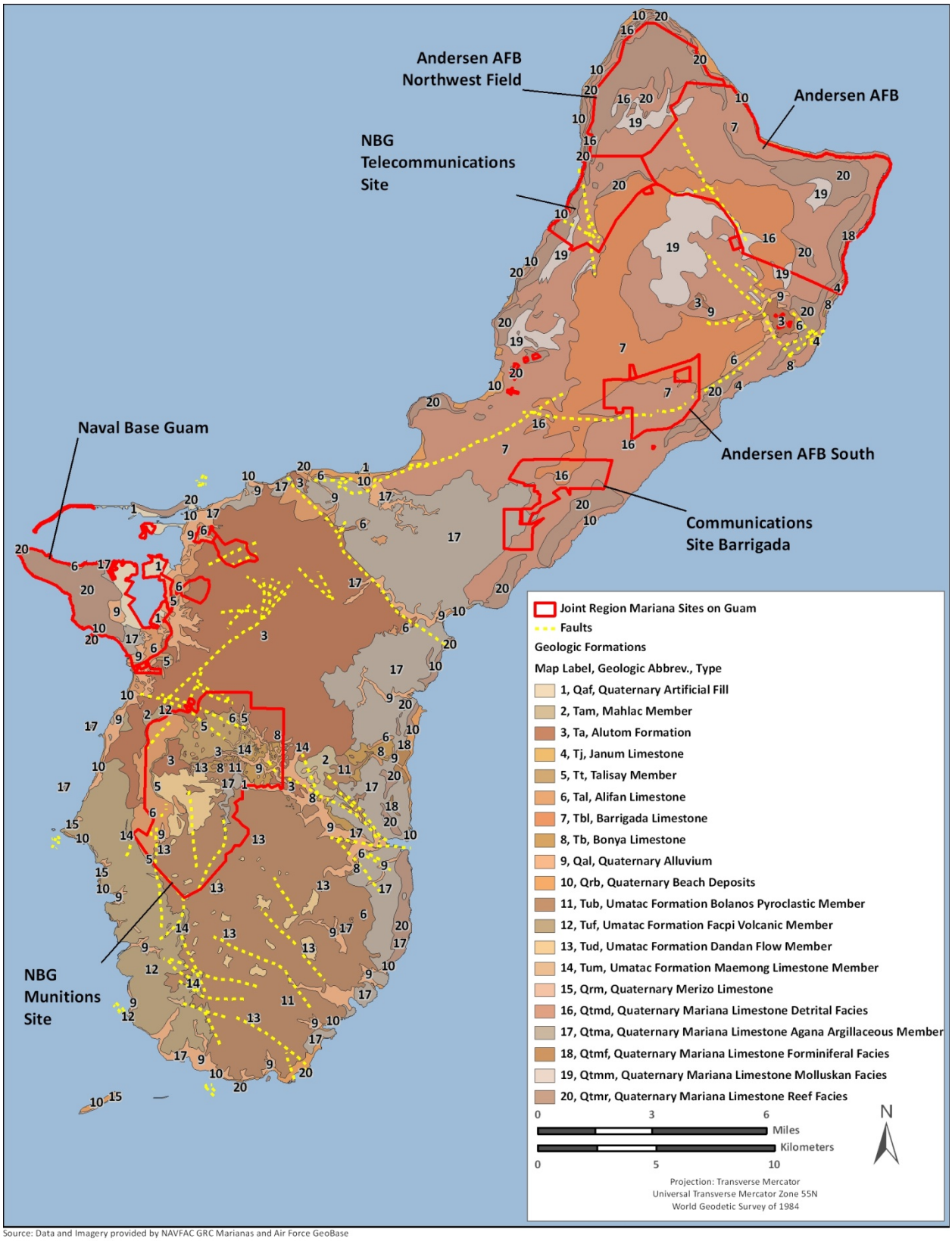
Guam is located in the low-latitudes zone (between 13º and 14º North) and has a maritime tropical climate with mean average temperatures of 81 degrees Fahrenheit (°F). Relative humidity during the day remains about 75 percent and typically increases at night. Daily temperatures do not vary much throughout the year, averaging 84 °F.

Seasonal variation in precipitation is strongly influenced by the position of the Inter-tropical Convergence Zone (ITCZ) and the subtropical high-pressure zones (Kellman and Tackaberry 1997). These zones shift latitudinally in a seasonal cycle resulting in two distinct climatic seasons. Monthly precipitation increases when the ITCZ shifts northward. Approximately 65 percent of the annual precipitation occurs July through October and precipitation declines significantly January through May when only 25 percent of the annual rainfall occurs. Mean annual rainfall varies considerably among years, although it typically averages 89 inches (226 centimeters [cm]) a year. Drought conditions can be experienced during periods of low precipitation. Rainfall can be intense during storms; the maximum 24-hour recorded rainfall was 27 inches (69 cm) in 1976. 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 Oscillations (ENSO) (Kellman and Tackaberry1997). During periods of ENSO, rainfall levels can decline significantly resulting in extended periods of drought.

Persistent easterly surface airflow dominates 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 [km/h]), but are variable in late summer. Trade winds are disrupted when storms approach Guam. Based on data from the 60-year period of 1945 to 2004, an average of three tropical storms (40 to 75 mph winds [64 to 120 km/h]) or typhoons (greater than 75 mph [120 km/h]) pass within 180 nautical miles of Guam every year (NRLM 2007). Based on historical data, the probability of a tropical storm or typhoon passing within 180 miles (290 kilometers) of Guam is one every 7 years, although a higher frequency has been noted in recent years with storms recorded in 1990, 1991, 1992, 1997, 2002 (two storms), 2004, and 2007. Typhoon Pongsona passed within 19 nautical miles (35 kilometers) of Apra Harbor and Typhoon Kong-rey, the most recent storm, passed through the Mariana Islands on April 6, 2007.

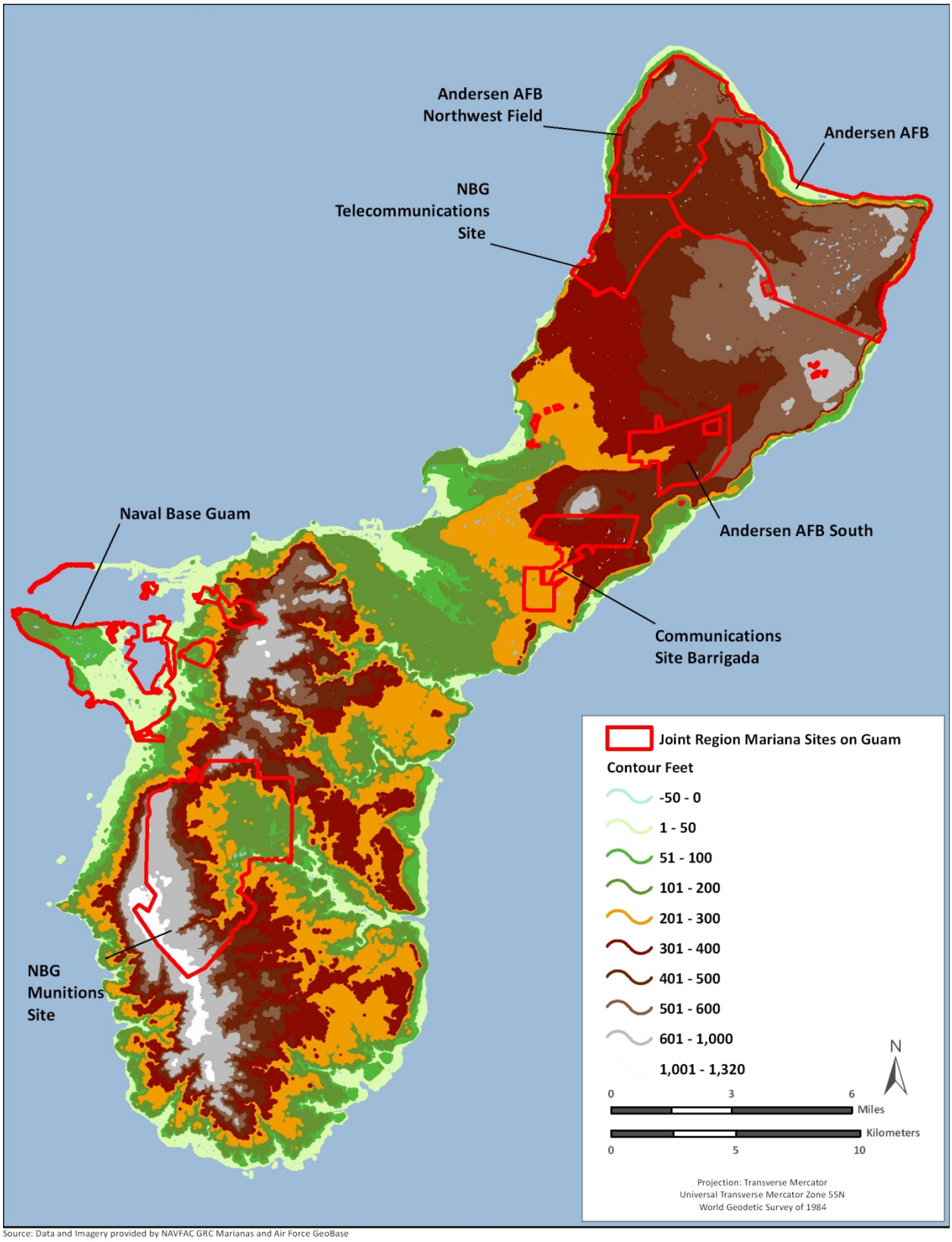
4.1.1.2 Geology and Topography

Guam is the largest and the southernmost island in the Mariana Islands archipelago. The Mariana Islands are a volcanic island archipelago resulting from subduction of the Pacific tectonic plate beneath the Philippine 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 and formed 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. Rivers cut through this terrain and create several high waterfalls. The central and northern sections of the island consist of a limestone plateau as high as 600 feet (183 meters) 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). The oldest exposed rocks on the island are from the Oligocene age (25–35 million years before present). See **Figures 4-1** and **4-2** for maps of the geology and topography of Guam, respectively.



Source: Data and Imagery provided by NAVFAC GRC Marianas and Air Force GeoBase

Figure 4-1. Geology of Guam



Source: Data and Imagery provided by NAVFAC GRC Marianas and Air Force GeoBase

Figure 4-2. Topography of Guam

The island is separated into three main structural provinces: northern, central, and southern. The northern structural province is composed of the limestone plateau of northern Guam, the central structural province consists of the folded volcanic rocks of central Guam, and the southern province includes the east-dipping volcanic rock of southern Guam (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) that was formed from the growth of coral carbonate reefs. Smaller areas of the island are covered in older limestone of the Neogene Period (2 to 25 million years old). 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.

The southern half of the island is predominately volcanic in origin and is underlain by highly weathered basalt and tuff-derived sedimentary rocks. The island has two major fault zones, the 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.

Geologic Formations

Volcanic rock forms the foundation of the island and is exposed over about 35 percent of the island's surface, predominantly in southern Guam. Neogene limestone overlies the volcanic rock and is exposed over about 60 percent 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), summarized as follows.

The **Facpi** and **Alutom Formations** contain the oldest exposed rocks, are of Eocene and Oligocene age, (34–56 and 25–35 million years before present, respectively), and underlie all other exposed rock units (Tracey et al. 1964, Reagan and Meijer 1984). These units crop out in the highlands from central to southern Guam and in the highest elevations of northern Guam. These exposures cover about 20 percent of the surface of the island. The maximum thickness of each unit is at least 1,000 feet (305 meters) (Reagan and Meijer 1984). The formations contain a series of pillow basalts and water-laid pyroclastic rocks of volcanic origin ranging from tuffaceous shale to coarse boulder conglomerate and breccia.

The **Umatac Formation** of the Oligocene to late Miocene age is separated from the underlying Alutom Formation by a structural unconformity (Tracey et al. 1964). The Umatac Formation crops out over about 15 percent of the land surface, principally in the south-central highlands and plateaus. The unit thickens to the south away from the Alutom Formation and is at least 1,050 feet (320 meters) thick along the southwest side of the island (Tracey et al. 1964). Here, the Umatac Formation is composed (from oldest to youngest) of about 250 feet (76 meters) of reef and fore reef limestone (Maemong Limestone Member), about 750 feet (229 meters) of tuff breccia and volcanic conglomerate (Bolanos Pyroclastic Member and Schroeder Flow Member), and about 50 feet (15 meters) of basalt flows (Dandan Flow Member) (Meijer et al. 1983, Reagan and Meijer 1984).

Three limestone units, which locally overlie the Alutom and Umatac Formations, are grouped together as **Older Limestone**. These three units, from Miocene to Pliocene age, are the Bonya Limestone, Alifan Limestone, and Janum Formation. These three units are facies with distinctions of limestone of the same age. Together, these units cover only about 5 percent of the island's surface and, individually, the units are each only about 70 to 200 feet (21 to 61 meters) thick.

The **Barrigada Limestone** of the late Miocene to Pliocene age covers about 9 percent of the island's surface, but forms the bulk of the aquifer underlying northern Guam. This formation consists of fine-grained, pure foraminiferal detrital limestone with a thickness of greater than 540 feet (165 meters) (Tracey et al. 1964). In places, the Barrigada Limestone grades upward and outward into the overlying Mariana Limestone.

The **Mariana Limestone** is of Pliocene to Pleistocene age and is the most extensive unit at the surface. The Mariana Limestone composes about 45 percent of the surface area, covering most of the northern half and parts of southeast Guam. The maximum thickness of the formation is at least 500 feet (152 meters) and can thin to zero inland. The Mariana Limestone is composed of reef and lagoonal limestone containing a wide range of lithologies (Tracey et al. 1964). The limestone is clay-rich near the older volcanic uplands.

Minor **reef beach deposits**, **reef limestone**, and **alluvium** are of Holocene age (11,770 years ago to the present). These deposits cover about 7 percent of the surface of Guam and can reach thicknesses of 200 feet (61 meters) at the mouths of some rivers. The beach deposits are composed of poorly consolidated sediments, mostly calcareous sand and gravel thrown onto beaches by waves; however, some deposits of volcanic sand can be found where streams drain volcanic uplands (Tracey et al. 1964). The Merizo Limestone is a reef limestone up to 12 feet (4 meters) thick. Deposits of alluvial clay fill stream valleys and cover the inner parts of coastal lowlands.

4.1.1.3 Seismology

Guam is located on the eastern edge of the Philippine 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 1849 and 1911, four earthquakes with a magnitude of 7.0 or greater on the Richter scale occurred in the vicinity of Guam. The most recent large-magnitude earthquake was recorded on August 8, 1993, and measured 7.8 on the Richter scale (GHS 2008). Liquefaction and lateral spreading caused major damage to commercial and naval port facilities (GHS 2008). According to the Guam Hazard Mitigation Plan, the areas on Guam determined to be susceptible to a large tsunami include all landmasses below 16 feet (5 meters) in mean sea elevation, which incorporates 10 square miles (26 square kilometers), or 4.7 percent, of the island (GHS 2008).

4.1.1.4 Soils

The soils on Guam are in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the island. The NRCS (formerly the Soil Conservation Service) published the Soil Survey of the Territory of Guam in 1988 (NRCS 1988). The Soil Survey grouped Guam soils into three broad classes: soils on bottomlands, soils on volcanic uplands, and soils on limestone uplands. Within these broad classes, the soils that occupied similar natural landscapes were defined as map units for broad interpretive purposes. Soils on bottomlands consist of a single map unit that occupies 4 percent of the island. Soils on volcanic uplands consist of two map units covering about 35 percent of the island and soils on limestone uplands consist of five map units covering 61 percent of the island (NRCS 1988).

4.1.1.5 Hydrology

The movement and storage of water on Guam is greatly influenced by the island's geology. Water is held in the soil pore space by cohesive attraction between water molecules and the mineral and organic components of the soil. The limestone geology of northern Guam is soluble and very porous. Dissolution of the limestone by percolating rainwater has resulted in complex underground drainage systems,

including caves and depressions. The large pore spaces and fractures in limestone rock result in water percolating rapidly downward through the soil profile; therefore, no surface water flow occurs and little water is stored in the upper soil profile. The limestone in northern Guam is underlain with impervious volcanic rock at varying depths. Where the underlain volcanic rock is situated below sea level, salt water permeates laterally through the porous limestone. The downward movement of water through the limestone continues until the water encounters an impervious mineral layer of volcanic rock or the higher density salt water. If the downward percolating water encounters impervious mineral rock, parabasal water is stored in the porous limestone rock above the impervious rock (U.S. Navy 2009). The following description of Guam's hydrology (i.e., groundwater and surface water) has been adapted from Gingerich (2003), unless otherwise noted. Freshwater wetlands are discussed in this INRMP in **Section 4.2.1**, Terrestrial Ecosystems, and estuarine wetlands are discussed in **Section 4.2.3**, Estuarine Ecosystems.

Groundwater. The primary aquifer on 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 was designated as a sole-source aquifer in 1978 because it supplies drinking water to approximately 80 percent of the island's residents. The NGLA is composed of six distinct subbasins: the Agana, Mangilao, Andersen, Agafa-Gumas, Finegayan, and Yigo-Tumon. 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 feet (0.2 meters) 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 runoff occur. Seasonal water level variations in the most permeable parts of the NGLA are less than 10 feet (3 meters). In the southern part of the NGLA, the seasonal water level variations can exceed 20 feet (6 meters) (JGPO 2010).

In northern Guam, water is obtained from wells that tap the upper part of a fresh groundwater lens in an aquifer composed mainly of limestone. Approximately 180 wells, nearly all in the north, withdraw about 35 million gallons per day (MGD) of water with chloride concentrations ranging from 6 to 585 milligrams per liter. In southern Guam, the main source of fresh water is from surface water, which runs off the weathered volcanic rocks that are exposed over much of the area. Approximately 10 MGD of fresh water are obtained from surface reservoirs.

Freshwater-lens System. On oceanic islands such as Guam, fresh water commonly forms a body of water called a freshwater lens that floats on salt water and is separated from the salt water by a transition zone of brackish water. The fresh water, brackish water, and salt water 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 salt water.

Transition zone thickness depends on the extent of mixing between fresh water and salt water and is generally dozens of feet thick in northern Guam. Mixing in the transition zone results from tidal and pumping fluctuations superimposed on the gravity-driven flow of fresh water toward the shore. Under conditions of steady recharge and no pumping, the lens would ultimately have a fixed size. In reality, rainfall is episodic and seasonal, and 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.

On Guam, freshwater-lens systems are found in limestone and volcanic rocks. The most important sources of groundwater are from the freshwater parts of these systems in the high-permeability limestone rocks of northern Guam. In the most permeable limestone, the water table is no more than a few feet above mean sea level (msl), and the slope of the water table is nearly flat. The freshwater lens in these rocks is relatively thin and is commonly referred to as basal water after similar occurrences in Hawai‘i (Meinzer 1930). Wells and springs in this part of the system generally have water level altitudes less than

8 feet (2 meters). In some areas, the freshwater lens is thick enough to extend into the low-permeability volcanic rocks underlying the limestone. The fresh water in the limestone is commonly referred to as parabasal water, where it is in contact with the underlying poorly permeable volcanic basement (Mink 1974). Ward et al. (1965) recognized that the low-permeability volcanic rocks must be saturated below the water table. Therefore, groundwater in the limestone and the underlying volcanic rocks is all part of a freshwater-lens system, but the depth of fresh water in the volcanics is unknown.

Freshwater-lens systems are recharged by direct infiltration of rainfall and by inflow from perched groundwater systems. 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, much of the fresh groundwater discharges directly to stream valleys above sea level where the ground surface intersects the water table. In highly permeable rocks, freshwater flow is mainly horizontal and toward the coast, but in low-permeability rocks, vertical flow can be significant where there are substantial vertical head gradients.

Perched Groundwater Systems. 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. Discharge from a perched system can be to springs, streams, downward to a lower water table, or to the atmosphere by evaporation.

Surface Water. Surface water resources consist of lakes, rivers, and streams. Surface water is important for its contributions to the economic, ecological, recreational, and human health of a community or locale. Storm water is an important component of surface water systems because of its potential to introduce sediments and other contaminants that could degrade lakes, rivers, and streams. Storm water flows, which might be exacerbated by high proportions of impervious surfaces associated with buildings, roads, and parking lots, are important to the management of surface water. Storm water systems convey precipitation away from developed sites to appropriate receiving surface waters. Various systems and devices might be used to slow the movement of water. For instance, a large, sudden flow could scour a streambed and harm biological resources. Storm water systems provide the benefit of reducing sediments and other contaminants that would otherwise flow directly into surface waters. Failure to size storm water systems appropriately to hold or delay conveyance of the largest predicted precipitation event often leads to downstream flooding and the environmental and economic damages associated with flooding. Higher densities of development require greater degrees of storm water management because of the higher proportions of impervious surfaces.

Guam has 97 rivers and streams, ranging in length from 0.6 miles (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. Northern Guam does not have perennial streams due to the karst geology of this area. Due to the high permeability of the limestone, water in this area does not flow at the surface, but instead infiltrates quickly into the subsurface, recharging the freshwater groundwater lens. Because of the lack of perennial streams, there are no estuaries in the north. In southern Guam, a mountain ridge runs along the western coast and creates small, steep drainage basins to the west. To the east, broader floodplains drain into longer, larger rivers. Forty-six of Guam's rivers and streams drain into the ocean, five drain into lakes, and the remainder feed into other rivers (JGPO 2010).

4.1.1.6 Wildland Fire

Wildland fire has been a perennial problem and periodic threat on Guam. Fire history records available from 1979 to 2002 indicate that over this 23-year period more than 16,000 fires occurred (averaging more

than 700 per year) that burned in excess of 100,000 acres (40,469 hectares) (about 4,500 acres [1,821 hectares] per year) on Guam. For the same period on NBG the number of fires was 477 (just over 21 per year) burning more than 9,800 acres (3,966 hectares) (about 427 acres [173 hectares] per year). **Table 4-1** provides the number of fires and acres burned on Guam and NBG during 1991–2002.

Table 4-1. Number of Fires and Acres Burned by Year for Guam and NBG, 1991 through 2002

Year	Acres JRM	No. Fires JRM	Acres Guam	No. Fires Guam
1991	67	11	1,541	475
1992	1,353	73	9,912	1,037
1993	82	23	3,256	1,138
1994	3	3	327	181
1995	1,801	22	5,628	598
1996	50	11	634	280
1997	174	17	972	524
1998	914	65	13,312	1,943
1999	41	15	625	527
2000	478	43	3,368	981
2001	56	39	1,178	1,245
2002	133	18	2,434	492
Total	**5,152**	**340**	**43,187**	**9,427**

Source: Wildland Fire Management Plan for Naval Base Guam, 2007

Records indicate that almost all wildland fires have occurred in the savanna grasslands on Guam. These areas are defined as grasslands with scattered or clumps of trees, such as pandanas, tangantangan, and ironwood that cover extensive areas in southern Guam. The savanna communities, which, if left undisturbed, would gradually include an increasing number of woody trees and shrubs, and would convert into a ravine or limestone forest depending on the soil. Review of aerial photography taken over several decades indicates that, while the acreage of savanna grasslands has not appreciably increased, the continued wildland fires has accelerated erosion which is degrading inherent site productivity, reducing the capacity of Fena Reservoir, and causing damage to coral reefs.

4.1.2 General Biotic Environment

4.1.2.1 Terrestrial Ecosystems

Flora

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. Fosberg 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, and (9) weed communities.

These vegetation types can be grouped into the following five general plant communities: (1) limestone, (2) ravine, (3) wetland, (4) strand, and (5) savanna (U.S. Navy 2009). Mangrove swamps are more appropriately described in the estuarine environment. Argillaceous limestone vegetation is generally restricted to moist bottomlands and is floristically similar to the ravine communities. Coconut (known as niyok in Chamorro) groves are planted communities and are present in limestone, ravine, and strand communities. Weed communities are generally the result of recent disturbance (U.S. Navy 2009). The five general plant communities occurring on Guam are discussed in greater detail in the following paragraphs.

Limestone Communities. Limestone communities are situated on elevated limestone terraces, plateaus, and slopes. Limestone plant communities are diverse and highly variable, containing both native and nonnative woody plants, ferns, and herbaceous plants adapted to excessively drained, shallow limestone soils. In their least disturbed state, these plant communities have a stratified canopy consisting of scattered, large, emergent trees, such as breadfruit (*Artocarpus mariannensis*) (dukduk in Chamorro) and strangler fig (*Ficus prolixa*) (nunu in Chamorro), with a maximum height of 60 to 70 feet (18 to 21 meters). Other dominant species composing both the upper canopy and mid-canopy layers include *Aglaia mariannensis* (mapunao in Chamorro), *Ochrosia marianensis* (langiti in Chamorro), *Premna obtusifolia* (ahgao in Chamorro), *Elaeocarpus joga* (yoga in Chamorro), *Intsia bijuga* (ifil in Chamorro), *Pisonia grandis* (umumu in Chamorro), *Pandanus dubius*, and *Pandanus tectorius* (U.S. Navy 2009, NAVFAC Pacific 2010b). Mid-canopy layers can be 30 to 45 feet (9 to 14 meters) in height. Smaller individuals of the above species and species such as *Guamia mariannae* (paipai in Chamorro), *Cycas micronesica* (fadang in Chamorro), and *Morinda citrifolia* (lada in Chamorro) are often present as an understory layer. The floristic composition of a limestone forest can be quite variable depending on location and the history of disturbance (U.S. Navy 2009).

Two subtypes of the limestone community type are recognized: disturbed limestone forest and halophytic-xerophytic scrub. Disturbed limestone plant communities are usually dominated by nonnative woody species of relatively short heights. The floristic composition represents subclimax seral stages following human-induced disturbances, such as land clearing. The canopy of disturbed limestone forest is fairly open, which allows abundant sunlight to reach the forest floor. The majority of the woody biomass in the disturbed areas is derived from nonnative species including *Leucaena leucocephala* (tangantangan), *Triphasia trifolia* (lemon de china in Chamorro), and *Carica papaya* (papaya). Some areas of disturbed limestone forest are dominated by larger, nonnative trees such as African tulip (*Spathodea campanulata*) and Mohave chaste-tree (*Vitex parviflora*). Scattered coconuts are common overstory components of disturbed limestone forests. Native species can be present in the understory, including *Pandanus* spp. *Scaevola sericea* (nanaso in Chamorro), *Guettarda speciosa* (panao in Chamorro), and *Ficus* sp. The open understory is occupied by various nonnative grasses, vines, and weeds. Chromolaena (*Chromolaena odorata*) (masiksik in Chamorro), a nonnative shrub, is common in recently disturbed areas (U.S. Navy 2009).

The halophytic-xerophytic scrub subtype of the limestone community is a unique plant community that exists on limestone terraces and cliff edges. 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 diversity in these communities varies from low to high. Common species in halophytic-xerophytic scrub communities include *Pemphis acidula* (nigas in Chamorro), *S. sericea*, *G. speciosa*, *Mammea odorata* (chopak in Chamorro), *Tournefortia argentea* (hunik in Chamorro), *Clerodendrum inerme*, *Pandanus* spp., *Hibiscus tiliaceous* (pago in Chamorro), *Ochrosia mariannense* (langiti in Chamorro), *Ficus* sp., *Colubrina asiatica*., *Jasminum marianum*., and *Cynometra ramiflora* (gulos in Chamorro) (U.S. Navy 2009).

Ravine Communities. Fosberg (1960) classified the forest vegetation in valleys and ravines in southern Guam as ravine forests. Although the floristic composition of the ravine communities is similar to the limestone communities, these forests generally occur on volcanic soils or on argillaceous or clayey limestone soils, and are quite variable in floristic composition. Plant communities are often defined by the variability in soil moisture. Valley bottoms and ravines often have higher soil moisture than on the upper slopes. The canopies of ravine forest are structurally complex with multiple layers. Species present often include *H. tiliaceus*, *Pandanus* spp., strangler fig, *Glochidion mariannensis*, *P. obtusifolia*, *Artocarpus mariannenis*, *Neisosperma oppositifolia* (fagot in Chamorro), *O. mariannensis*, and *Calophyllum inophyllum* (da'ok in Chamorro). Because of their proximity to freshwater streams in southern Guam, these plant communities contain many species of cultivated plants such as coconut, betelnut palm (*Areca catechu*), alangilang (*Cananga odorata)*, and banana (*Musa* spp.). Epiphytes and common woody climbers (i.e., lianas) are also present (U.S. Navy 2009).

A disturbed ravine forest subtype is also recognized. Disturbed ravine plant communities are usually dominated by nonnative woody species with a more open canopy. The floristic composition represents subclimax seral stages following human-induced disturbances, such as agriculture. The majority of the woody biomass in the disturbed ravine forest is usually derived from nonnative species. *V. parviflora* and alangilang are common components of disturbed ravine forests on Guam. The open understory is occupied by various nonnative grasses, vines, and weeds (U.S. Navy 2009).

Ravine forests and disturbed ravine forests are limited to the NBG Main Base and the NMS.

Wetland Communities. Wetlands are areas that are subject to permanent or periodic inundation by surface or groundwater with a frequency sufficient to support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. The surface or subsurface water must be sufficient for the establishment of hydrophytes or the development of hydric soils or substrates. Wetlands generally include swamps, marshes, bogs, and similar areas, such as sloughs, potholes, wet meadows, river overflows, mud flats, and natural ponds (U.S. Navy 2009). The northern limestone plateau of Guam is generally lacking in substantial wetlands (U.S. Navy 2009).

Fosberg (1960) described seven subtypes of the wetland plant communities based on their dominant floristic composition. Fosberg defined swamps as supporting plant communities with a predominance of woody species, and marshes as supporting herbaceous plant communities (Fosberg 1960). Marshes are generally situated in low places along the coast, along streams, in depressions and sinkholes with argillaceous limestones, or in poorly drained areas with volcanic soils. Marshes can be inundated with freshwater or brackish water if near the ocean. Swamps are generally situated along rivers, especially near the coast or along river valleys if inland, and are usually designated as ravine communities rather than as wetland communities (U.S. Navy 2009).

Natural freshwater marshes are also common on Guam. Most marshes on Guam are floristically simple with few dominant plant species. Tall reed (*Phragmites karka)*, a tall, reedy perennial grass, is the most common marsh species, often forming a dense monocultural plant community. *Scirpus littoralis*, a perennial sedge with rhizomes, is also found in dense pure stands along stream banks and in estuaries. Golden leather fern (*Acrostichum aureum*), a large fern, can dominate some marshes. Other floristic components of wetland plant communities on Guam can include *Cyperus* spp., *Paspalum vaginatum*, and *Brachiaria mutica* (U.S. Navy 2009).

Freshwater swamps on Guam are the largest category of wetland and can be found on the edges of marshes, along river courses, and in wet depressions in forests. The native *Hibiscus tiliaceus* is usually the dominant species, although the largest tract of swamp forest on the island, the Talofofo River Valley to the east of the NMS, is dominated by *Barringtonia racemosa*. Other trees that might be present are

screwpine (*Pandanus tectorius*) (kafu in Chamorro), cynometra (*C. ramiflora*), and the betelnut palm (GDAWR 2006a). Vegetation in man-made freshwater habitats is variable, but *P. karka* and *H. tiliaceus* are usually present (GDAWR 2006a).

Strand Communities. Strand vegetation is adapted to excessively drained soils and salt spray from the adjacent coastal waters. Many of the beach areas on Guam are occasionally inundated with salt water during storms, which imposes a controlling influence on all biota. Strand communities vary floristically and in diversity. Some of the common overstory species found in strand plant communities include coconut, ironwood (*Casuarina equisetifolia*) (gago in Chamorro), *Hernandia peltata* (nonag in Chamorro), and *C. inophyllum*. Where the overstory is lacking or the canopy is open shrub species often occur including *S. sericea, T. argentea*, and *H. tiliaceus*. Vines, including *Ipomoea* spp. or *Vigna marina*, are often present. Grass species on these coastal strands can include bunchgrass (*Lepturus repens*) and *Paspalum distichum* (U.S. Navy 2009). Strand plant communities are limited to narrow strips in coastal areas within NBG, Main Cantonment Area, and Andersen AFB.

Savanna Communities. Savannas, which are defined as grasslands with scattered individual or clumps of trees, cover extensive areas in southern Guam. Savannas are predominately found on volcanic soils and are maintained by periodic burning initiated by humans (U.S. Navy 2009). If left undisturbed, the savanna communities would gradually include an increasing number of woody trees and shrubs, and convert into a ravine or limestone forest depending on the soil type (U.S. Navy 2009). Fosberg (1960) recognized five savanna plant communities: (1) *Miscanthus*, (2) *Dimeria*, (3) erosion scar, (4) *Phragmites*, and (5) weed.

The ***Miscanthus* community** is dominated by the tall grass, Pacific Island silvergrass (*Miscanthus floridulus*), which can grow to heights of 10 to 15 feet (3 to 5 meters). In the absence of fire, scattered woody plants including Indian mulberry (ladda'in Chamorro), *S. sericea*, and ironwood become established. Following burning, Pacific Island silvergrass sprouts vigorously from underground tissue. Pacific Island silvergrass is a bunch grass, leaving 30 to 40 percent of the ground surface as exposed mineral soil. Pacific Island silvergrass is suspected of producing and releasing a chemical that inhibits the germination and growth of competing plant species (i.e., allelopathy) (U.S. Navy 2009).

The ***Dimeria* community** is dominated by the shorter grass species, *Dimeria chloridiformis*, a soft, tufted grass that grows to heights of approximately 2 feet (0.5 meters) (Fosberg 1960). This community is usually more open and includes Pacific Island silvergrass and other species adapted to the low pH and high aluminum content of the highly weathered volcanic soils. Woody shrubs and trees are uncommon (U.S. Navy 2009).

The **erosion scar community** has sparse plant growth. These bare sites are the result of water and wind erosion in which all of the top soil has been eroded. The exposed subsoil usually has a very low pH, lacks organic matter, and many essential plant nutrients. *Gleichenia linearis* is one of few plant species that can tolerate the low pH and lack of nutrients. Active erosion can prevent other plant species from becoming established in the erosion scar community (U.S. Navy 2009).

***Phragmites* communities** within savannas usually indicate the presence of higher soil moisture resulting from seeps. Tall reed can dominate these wetter sites excluding most other plant species (U.S. Navy 2009).

The **weed community** within savannas usually indicates recent disturbance and is dominated by nonnative pioneer plant species. Disturbance can be the result of fire, grazing, cultivation, or clearing. Some common species in the weed community include *Stachytarpheta urticifolia*, *Elephantopus mollis*,

Hyptis spp., *Mitracarpum hirtum*, and *Chrysopogon aciculatus*. Lantana (*Lantana camara*) and chromolaena are becoming more common in these weed communities (U.S. Navy 2009).

Fauna

Birds. Four endemic bird species from the Mariana Islands occur in small populations on Guam. Three of these species are federally and Guam-listed as endangered and the fourth is Guam-listed as endangered. The Mariana common moorhen persists in low numbers throughout Guam and on JRM lands. The Mariana swiftlet was once common throughout the island but is now restricted to three caves on JRM lands in southern Guam. The Mariana crow (*Corvus kubaryi*), a bird relocated from Rota, has occurred in northern Guam on Andersen AFB in critically low numbers. However, the species has not survived in the wild on Guam and could soon be extirpated. The Micronesian starling (*Aplonis opaca guami*), listed as endangered by Guam but not by the Federal government, was nearly extirpated in the early 1990s; however, it currently appears to be making a modest recovery and occurs in small numbers on Andersen AFB, Cocos Island, parts of Hagatña, Apra Harbor, and some coastal areas in southern Guam (U.S. Navy 2009). A detailed treatment of these federally and Guam-listed birds can be found in **Section 4.1.2.5.**

Two other native terrestrial avian species are still found on JRM lands, neither of which is listed as threatened or endangered, but both are protected by the MBTA. These are the yellow bittern (*Ixobrychus sinensis*) and Pacific reef heron (*Egretta sacra*). The yellow bittern is the only native land bird that is still considered to be common on Guam (U.S. Navy 2009).

Common seabird species seen on Guam include the brown noddy (*Anous stolidus*) (fahang dankolo in Chamorro), white terns (*Gygis alba*) (chunge'in Chamorro), black noddy (*Anous minutus*) (fahang dikike' in Chamorro), and brown boobies (*Sula leucogaster*) (lu'ao in Chamorro). Brown noddies nest and roost on steep cliffs and on rocky offshore islets, and on channel makers in Outer Apra Harbor. There has been a nesting colony of some 150 birds located just off the end of Orote Peninsula on NBG Main Base for many years and it is thought that this is the largest colony remaining on Guam. Additionally this species roosts on at least two small emergent rock islands off the north and south coast of Orote Peninsula. Brown boobies also nested on Orote Island previous to the construction of Kilo Wharf, but no longer nest on Guam. The coastal islets, reef flats, grassy fields, and other open areas on Guam provide seasonal foraging habitat to any number of migratory avian species. To date, more than 80 migrant and vagrant species have been recorded on Guam, most of which are protected under the MBTA. Most common among the annual visitors to the island are the Pacific golden-plover (*P. fulva*), Mongolian plover (*Charadrius mongolus*), gray-tailed tattler (*Heteroscelus brevipes*), whimbrel (*Numenius phaeopus*), ruddy turnstone (*Arenaria interpre*s), and cattle egret (*Bubulcus ibis*) (U.S. Navy 2009).

Several nonnative bird species are also present on Guam, which were either unintentionally introduced or intentionally introduced to provide hunting resources. Commonly observed introduced avian species include the island collared dove (*Streptopelia bitorquatat bitorquata*), Eurasian tree sparrow (*Passer montanus*), black francolin (*Francolinus francolinus*), and the black drongo (*Dicrurus macrocercus harterti*). In 1999, the GDAWR reported that the population of the island collared dove, which was introduced by the Spanish in 1771, was declining due to predation by the brown treesnake. GDAWR officially closed the dove hunting season in 1987 (U.S. Navy 2009). The island collared dove is present on all JRM lands on Guam (NAVFAC Pacific 2010b). The Eurasian tree sparrow is commonly observed in small flocks, usually in close proximity to man-made structures. Black francolins were introduced to southern Guam as a game bird by the USFWS in 1961 and currently inhabit savanna plant communities. The black drongo was introduced to the Marianas by the Japanese in the 1930s and is considered a nuisance species that can be hunted at any time of the year. The black drongo occurs mostly in developed areas (U.S. Navy 2009).

Mammals. Three species of bats, the Mariana fruit bat (*Pteropus mariannus mariannus*), the little Mariana fruit bat (*P. tokudae*), and the Pacific sheath-tailed bat (*Emballonura semicaudata rotensis*) were historically the only native mammals on Guam. The Pacific sheath-tailed bat has been extirpated from the island, while the little Mariana fruit bat is thought to be extinct. The Mariana fruit bat is federally listed as threatened. See **Section 4.1.2.5** for additional information regarding threatened and endangered mammals on Guam.

Spanish introductions included Asiatic water buffalo (carabao in Chamorro) (*Bubalus bubalis*), Philippine deer (*Cervus mariannus*) (binådu in Chamorro), dogs (*Canis familiaris*), cats (*Felis catus*), feral pigs (*Sus scrofa*) (babuis in Chamorro), goats (*Capra hircus*), and cattle (*Bos taurus*). Three of these introduced species, the Asiatic water buffalo, Philippine deer, and feral pigs, have feral populations that are damaging natural resources on Guam (U.S. Navy 2009). Other introduced species include several rodent species and the Indian musk shrew (*Suncus murinus*).

Reptiles and Amphibians. Numerous native reptile species are still found in the wild on Guam (GDAWR 2006a). GovGuam lists eight species as endangered under its endangered species regulation. Native reptile species that are known to exist still on Guam include stump-toed (mutilating) gecko (*Gehyra mutilata*), blue-tailed skink (*Emoia caeruleocauda*), Slevin's skink (*Emoia slevini*), moth skink (*Lipinia noctua*), Pacific slender-toed gecko (*Nactus pelagicus*), mourning gecko (*Lepidodactylus lugubris*), oceanic gecko (*Gehyra oceanica*), Micronesian gecko (*Perochirus ateles*), snake-eyed skink (*Cryptoblepharus poecilopleurus*), green sea turtle (*Chelonia mydas*), and hawksbill sea turtle (*Eretmochelys imbricata*). The monitor lizard (*Varanus indicus*), which is common in some areas on Guam, is now considered a native species. The introduced Chinese softshell turtle (*Pelodiscus sinensis*) also occurs in Fena Reservoir. The leatherback sea turtle (*Dermochelys coriacea*) and loggerhead sea turtles (*Caretta caretta*) are also likely present in the waters around Guam, but their occurrence on Guam is unknown. These turtles have not been documented to nest on Guam.

Both green and hawksbill sea turtles occur in the two JRM estuaries of Sasa Bay and Inner Apra Harbor (U.S. Navy 2009). Threatened green sea turtles nest on beaches around Guam including beaches within the NBG and Andersen AFB. Most nesting by this species occurs on the southern end of Guam. Endangered hawksbill sea turtles have nested on beaches in northern and central Guam. Sumay Cove on NBG has supported hawksbill sea turtle nesting on the cobble and sand beach near the mangroves (U.S. Navy 2009). See **Section 4.1.2.5** for additional information regarding threatened and endangered reptiles on Guam.

There are no native amphibian species on Guam, however, several nonnative amphibians have been introduced, including the marine toad (*Chaunus marinus*), greenhouse frog (*Eleutherodactylus planirostris*), eastern dwarf tree frog (*Litoria fallax*), Guenther's Amoy frog (*Rana guntheri*), Hong Kong whipping frog (*Polypedates megacephalus*), Pacific chorus frog (*Pseudacris regilla*), slender-digit chorus frog (*Kaloula picta*), white-lipped tree frog (*Polypedates leucomystax),* grass frog (*Fejervarya cf. limnocharis*), crab-eating frog (*Fejervarya cancrivora*) and marbled pygmy frog (*Microhyla pluchra*) (Christy et al. 2007). Incidental occurrences of the Malaysian narrowmouth toad (*Kaloula pulchra*) and coqui (*Eleutherodactylus coqui*) have been recorded but neither species has become established on Guam (Christy et al. 2007).

The primary cause of the decline in native reptile populations on Guam is probably predation by introduced animals including the musk shrew (*Suncus murinus*), brown treesnakes, cats, and rats (*Rattus* ssp.). The population of blue-tailed skink has declined in response to predation or competition from the brown skink; however, it is relatively common in appropriate habitat. The stump-toed gecko has also declined, apparently in response to predation by introduced vertebrate predators including rats, cats, shrews, and the brown treesnake. The mourning gecko is relatively common (U.S. Navy 2009).

Invertebrates. Guam is home to dozens of endemic invertebrate species, many of which are rare or have extremely limited ranges. Endemic invertebrate species include the Mariana eight-spot butterfly (*Hypolimnas octocula marianensis*), a Federal candidate species, and an undescribed Catacanthus species, the bronze boonie Additionally, Guam has a number of endemic invertebrate cave species that are likely extremely limited in their distribution. Among these are the Almagosa Cave amphipod (*Melita* sp.), at least three Almagosa isopods (*Isabelloscia* spp.), and the Guam karst katydid (*Salomona guamensis*). Three native tree snails (humped tree snail [*Partula gibba*], fragile tree snail [*Samoana fragilis*], and Guam tree snail [*Partula radiolata*]) are candidate species for listing under the ESA. Population declines of native tree snails are likely due to predation by introduced vertebrate predators including cats, musk shrew, rats, predatory carnivorous snails such as *Euglandia rosea*, overgrazing of vegetation by ungulates, and the introduced terrestrial flatworm (*Platydemus manokwari*) (U.S. Navy 2009).

The native mangrove crab (*Cardisoma carnifex*), land hermit crab (*Coenobita brevimanus*) and coconut crab (*Birgus latro*) (ayuyu in Chamorro) 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 African land snail (*Achatina fulica*). Coconut crabs are the largest terrestrial land arthropod on earth. They initially borrow shells, but then develop their own hard exoskeleton. Coconut crabs hide in holes during the day and, like the land hermit crab, forage at night. Land crabs are omnivorous and eat foods such as fruits, seeds, plants, rotting wood, dead insects, and carrion. Both species are found on JRM. Threats to these species include rats, feral pigs, dogs, monitor lizards, and humans (U.S. Navy 2009).

4.1.2.2 Freshwater Ecosystems

Freshwater communities include lentic (i.e., standing-water) habitats and lotic (i.e., running-water) habitats. Lentic habitats differ from wetlands in that the water depth is sufficient to preclude the establishment of terrestrial plant communities.

Southern Guam has many freshwater communities including numerous streams and water impoundments created by dams such as the Masso and Fena Reservoirs (U.S. Navy 2009). In contrast, the karstic characteristics of the limestone plateau in northern Guam results in rapid infiltration of water, and consequently only a few freshwater communities exist in the vicinity of Mount Santa Rosa (GDAWR 2006a). While freshwater ecosystems occupy a relatively small portion of Guam's land area, these ecosystems are important as sources of water and wildlife habitat, and are integral to the hydrological cycle. Surficial freshwater habitats on JRM are limited to NBG Main Base and the NMS (U.S. Navy 2009). The largest freshwater body on Guam is Fena Lake (200 acres [81 hectares]), which functions as an important reservoir for drinking water. Other sites are much smaller and tend to have deeper, more open water than natural marshes. These include ponds dug for aquaculture purposes. A number of these sites are crucial to the preservation of the Mariana common moorhen and are very important to migratory species (GDAWR 2006a).

Flora

Guam has at least three species of native freshwater aquatic plants (see **Table 4-2**). Two of the three species have wide distributions. One pondweed species, *Potamogeton mariannensis*, might be endemic to Guam. *Potamogeton* spp. are flowering plants, and can produce both sexually and vegetatively. *Ceratopteris thalictroides* is a fern, and reproduces via airborne spores. While none of these plants are abundant, they all have a fairly wide distribution on Guam. *Potamogeton* spp. and *C. thalictroides* have relatively soft, submerged leaves, and are at risk from overfeeding by exotic snails and herbivorous fish (GDAWR 2006a).

Table 4-2. Native Freshwater Aquatic Plants of Guam

Family	Species	Habitat
Potamogetonaceae	*Potamogeton lucens*	Slow moving water, soft substrates
	Potamogeton mariannensis	Slow moving water, soft substrates
Parkeriaceae	*Ceratopteris thalictroides*	Sluggish water, mainly lakes and ponds

Source: GDAWR 2006a

Fauna

Birds. More than 100 species of birds have been documented on Guam including migrant, wetland, seabird, grassland, and forest birds (GDAWR 2006a). The Mariana common moorhen is the only native freshwater obligate bird species still found on Guam. Extirpation of the Mariana mallard (*Anas platyrhynchos oustaleti*), white-browed crake (*Porzana cinerea*), and nightingale reed-warbler (*Acrocephalus luscinia*) occurred between 1945 and 1970 (Ritter and Savidge 1999). The Mariana common moorhen was listed as endangered in 1984 due to loss of wetland habitat. In 2001, the moorhen population was estimated to be 287, with 154, 41, 2, and 90 adult moorhens on Saipan, Tinian, Rota, and Guam, respectively (Takano and Haig 2004). Results suggest an overall increase in birds on Saipan and Tinian, although moorhen numbers on Guam could be declining (Takano and Haig 2004).

Fish. Guam's freshwater ecosystems have not been well studied. All of the indigenous fish found on Guam are diadromous, requiring access to both salt water and fresh water during their life cycles. Prominent among Guam stream fauna are numerous species of native gobies (family Gobiidae), all of which are amphidromous (i.e., migrates between fresh water and salt water, but not for breeding) (U.S. Navy 2009).

Macroinvertebrates. Aquatic macroinvertebrates are organisms that live in or on water for all or part of their life cycle, do not have a backbone, and are large enough to be seen without the aid of a microscope. Crustaceans, including Tahitian prawn (*Macrobrachium lar*) and several species of mollusks (i.e., snails) are present in freshwater streams on Guam. Macroinvertebrates have not been extensively studied in freshwater streams on Navy lands (U.S. Navy 2009).

Guam has 17 species of native freshwater snails, belonging to two families (i.e., Nertidae and Thiaridae). The only freshwater invertebrates of concern on Guam are *Stenomelania plicaria*, a thiarid snail, and *Neritodryas subsulcata*, a nertid snail. *S. plicaria* has a limited distribution on Guam, being found in a few rivers. *N. subsulcata* is very uncommon on Guam (GDAWR 2006a). Neritids have an amphidromous life history, similar to that of the fish. Eggs are deposited in fresh water, the young hatch, and are swept to the ocean. After a marine larval stage, they return to fresh water to mature. Thiarids are normally found on sand or other soft substrates, where they spend a good portion of the day buried. Thiarids live their entire life cycle in fresh water (GDAWR 2006a).

Guam has at least 12 species of freshwater crustaceans: 9 species of freshwater shrimp, and at least 3 species of freshwater crab. All of these crustacean species are apparently amphidromous, with a marine larval stage, and a freshwater adult stage (GDAWR 2006a). Two families of shrimp are represented on 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 on Guam in rivers, reservoirs, and caves. They are able to survive in intermittent pools in the headwaters of streams, and are frequently the only fauna of such habitats (GDAWR 2006a). The freshwater crabs of Guam are poorly known and form a rather

inconspicuous part of the freshwater fauna. Three species are known to occur on Guam: *Ptychognathus* sp., *Sesarma* sp., and *Varuna* cf. *littorata* (GDAWR 2006a).

Reptiles and Amphibians. Three species of introduced freshwater turtles are believed to have breeding populations on Guam and include the soft-shell turtle (*Pelodiscus sinensis*), red-eared slider (*Trachemys scripta elegans*), and the common snapping turtle (*Chelydra serpentina*) (Leberer 2003). Soft-shelled turtles have been found in Fena reservoir.

4.1.2.3 Estuarine Ecosystems

Estuarine communities are transitional areas between terrestrial and marine communities. An estuary is a semi-enclosed coastal body of water that has a free connection with the open sea. Estuarine communities are strongly influenced by tidal action. Within estuaries, seawater mixes with fresh water from land drainage resulting in the dilution of sea water. On Guam, estuarine communities are present at the mouths of the larger rivers and the inner waters of Apra Harbor (U.S. Navy 2009).

Estuarine wetlands occur in areas of tidal intrusion or brackish water, and consist primarily of mangroves and the lower channels of rivers. These habitats are facilitated by a daily tidal variation of about 30 to 35 inches (75 to 90 cm). Although they only total about 6 acres (2 hectares), Guam's mangroves are the most extensive and diverse in the Mariana Islands (GDAWR 2006a). Nine of the island's 46 rivers that empty into the ocean have true estuarine zones. The lower channels of these rivers, which are typically only 16 to 66 feet (5 to 20 meters) wide and 3 to 13 feet (1 to 4 meters) deep, have elevated salinity levels that extend 0.3 to 1 mile (0.5 to 1.6 kilometers) upstream (GDAWR 2006a).

Flora

Estuarine environments are uniquely stressful for plants due to the waterlogged soils and the relatively high salt content of estuary waters. These physical stresses strongly influence the species composition in estuarine communities. Mangroves are the predominant woody trees that are adapted to tidal estuarine communities (U.S. Navy 2009). The largest concentrations of mangroves exist along the eastern shores of Apra Harbor, with smaller zones present in Merizo and Inarajan. Plant species include Asiatic mangrove (*Rhizophora mucronata*), Indo-West Pacific stilt mangrove (*R. apiculata*), large-leafed mangrove (*Bruguiera gymnorrhiza*), gray mangrove (*Avicennia marina*), teruntum merah (*Lumnitzera littorea*), nipa palms (*Nypa fruticans*), *Xylocarpus moluccensis*, looking-glass-tree (*Heritiera littoralis*), sea hibiscus, and golden leather fern (GDAWR 2006a).

Nipa palms are found on Guam only in the lower reaches of rivers that exhibit a true estuarine habitat. Nipa palms are found along only ten rivers on Guam. Due to overharvesting and habitat loss, the nipa palm has become uncommon, and is now a protected species in Guam. Estuarine marshes dominated by bulrushes (*Schoenoplectus littoralis*) are also found at several locations in Apra Harbor (GDAWR 2006a).

Fauna

Birds. Two indigenous avian species, yellow bittern and Pacific reef heron, rely on food resources within estuarine ecosystems on Guam. Neither species is listed as threatened or endangered. Exposed tidal mudflats and estuarine banks provide seasonal foraging and loafing habitat to migratory and vagrant avian species. There is incidental use of resources within estuarine systems by the endangered Mariana common moorhen, usually during low tides on NBG. Most common among the annual visitors to the island that could use estuarine habitats include Pacific golden-plover, lesser sand (Mongolian) plover, whimbrel, ruddy turnstone, and cattle egret (U.S. Navy 2009).

Mammals. The majority of the introduced mammalian species currently established on Guam use resources within estuarine communities, especially during low tides. These include Philippine deer, dogs, cats, feral pigs, musk shrew, and four species of rats and mice (Norway rat [*Rattus norvegicus*], black rat [*R. rattus*], Pacific rat [*R. exulans*], and house mouse [*Mus musculus*]). All of these naturalized mammalian species are deleterious to the remaining native floral and faunal resources. Rats, shrews, cats, and dogs prey on birds, eggs, lizards, and insects. Additionally, rats and mice eat seeds, roots, and new growth of native plants adversely affecting regeneration of native plants (U.S. Navy 2009).

Fish. Estuarine ecosystems play an important part in the life cycles of Guam's indigenous freshwater fish, which are all diadromous, requiring access to both salt water and fresh water during their lives. Estuarine areas are the gateway to the open ocean and to the streams in which these fish spend most of their adult lives. Estuarine waters also provide seasonal foraging resources and sanctuary to many of the 900 or so species of saltwater fish found in Guam's near shore waters. Maintaining high-quality estuarine ecosystems is imperative for the sustainability of near-shore fish populations (U.S. Navy 2009).

Reptiles and Amphibians. Little work has been done to address the distribution and abundance of terrestrial reptiles within estuarine ecosystems on JRM lands on Guam. It is expected that several introduced and indigenous lizards currently found on Guam use resources within estuarine communities. Two species of marine turtles use resources within the near-shore, estuarine, and beach zones on Guam. Threatened green sea turtles forage in offshore waters and nest on beaches around Guam, including Navy installation beaches at NBG TS. Most nesting by this species occurs in northern Guam. Endangered hawksbill sea turtles have nested on beaches in northern and central Guam and forage in certain estuaries, such as Sasa Bay. Grimm and Farley (2008) report that hawksbills are frequently sighted in the nearshore waters surrounding Guam. However, they are less common than green sea turtles (NMFS and USFWS 2007). According to Wiles et al. (1995), hawksbills represent about 13 percent of turtles sighted around Guam. The Sumay Marina Cove located in NBG Main Base has supported endangered hawksbill sea turtle nesting attempts on the cobble and sand beach near the mangroves. Introduced established amphibians on Guam, including the marine toad and the eastern dwarf tree frog (*Litoria fallax*), use resources in the estuarine ecosystem (U.S. Navy 2009). Gunther's Amoy frog (*Rana guentheri*) also uses estuarine habitats associated with the San Luis Ponds on NBG Main Base.

Macroinvertebrates. The estuarine communities on Guam support a diverse assemblage of macroinvertebrates, including numerous species of crabs, mollusks, insects, and other arthropod species. None of the invertebrate species present are listed as either threatened or endangered by the USFWS. Estuarine areas are particularly important to both the native land hermit crabs and coconut crabs. Adult females return to the sea to lay eggs. After a planktonic larval stage, small crabs emerge from the ocean to live on land (U.S. Navy 2009).

4.1.2.4 Submerged Lands

JRM-managed submerged lands are areas in coastal waters extending from the Guam coastline into the ocean 3 nautical miles, including the seabed below and the airspace above, and the interface between terrestrial and aquatic habitats, known as the intertidal zone. The shoreline of the intertidal zone of the Mariana Islands is very narrow because of the narrow tidal ranges. The approximate tidal range on Guam is 1.6 feet (0.48 meters) (NOAA 2006). The coastline consists of exposed rocky shores and an intertidal bench providing habitat for many intertidal invertebrate species including octopus, sea cucumbers, swimming crabs, slipper lobster (*Parribaccus antarcticus*), and spiny lobsters (Panulirus spp.) (JGPO 2010).

JRM manages 79,260 acres (32,075 hectares) of submerged lands (52,731 acres on Navy and 26,529 acres on Andersen AFB). The resources described in the following paragraphs are found in submerged lands around Guam, but vary slightly in prevalence based on the specific location.

Fishery Resources and Essential Fish Habitat

The MSFCMA (16 U.S.C. 1801–1883) calls for direct actions to stop or reverse the continued loss of fish habitats. Toward this end, Congress mandated the identification of habitats essential to managed species and measures to conserve and enhance this habitat. Under the MSFCMA, Congress directs NMFS and the eight regional Fishery Management Councils (FMCs) (under the authority of the Secretary of Commerce) to describe and identify EFH in Fishery Management Plans (FMPs); minimize, to the extent practicable, the adverse effects of fishing on EFH; and identify other actions to encourage the conservation of EFH. EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.

The MSFCMA requires cooperation among NMFS, the FMCs; fishing participants; and Federal, territorial, and state agencies to protect, conserve, and enhance EFH. Section 305(b) of the MSFCMA mandates that Federal agencies must consult with the Secretary of Commerce on all proposed activities authorized, funded, or undertaken by the agency that might adversely affect EFH. NMFS recommends consolidated EFH consultations with interagency coordination procedures required by other statutes, such as NEPA or the ESA, to reduce duplication and improve efficiency (50 Code of Federal Regulations [CFR] 600.920[e][1).

The Mariana Islands are within the jurisdiction of the WPRFMC, which has designated the marine waters around Guam, Tinian, and Pagan as EFH, and adopted a precautionary approach to EFH designation due to the lack of scientific data (JGPO 2010). The WPRFMC currently manages fisheries in the Western Pacific under five FMPs: (1) coral reef ecosystems, (2) bottomfish and seamount groundfish, (3) crustaceans, (4) precious corals, and (5) pelagic species. Each of these FMPs identifies areas of EFH and HAPC for different life stages of species managed under the respective plan.

EFH habitats in Guam include the following:

- *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 patches within Outer and Inner Apra Harbor and other isolated areas around Guam (e.g., Agat Bay).
- *Macroalgae.* Macroalgae habitats occur within most areas around Guam.
- *Mangrove Forests/Wetlands.* These forests occur in the intertidal zone along the coast of Outer and Inner Apra Harbor.
- *Coral Reefs and Colonized Hardbottom.* Coral reefs are located on shoals (e.g., Big Blue Reef, Western Shoals, Middle Shoals, and Jade Shoals) and the coasts of Outer and Inner Apra Harbor.
- *Estuarine Water Column.* This habitat includes the open water areas within Sasa Bay and river mouth areas.
- *Marine Water Column.* Many managed species occur in this habitat and rely on this for development, dispersal, or feeding.
- *Unconsolidated Bottom.* This habitat includes benthic substrates along the coast or within Apra Harbor such as clay and silt, sand, gravel, rubble and boulders.

Within the EFH, Habitat Areas of Particular Concern (HAPC) are specific areas that are essential to the life cycle of important coral reef 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 2005).

Flora

Tropical seagrass meadows typically occur in most 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 also important in their interactions with mangroves and coral reefs. Seagrasses trap sediment and slow water movement, causing suspended sediment to fall out. This trapping of sediment benefits coral by reducing sediment loads in the water. All of these systems exert a stabilizing effect on the environment, resulting in important physical and biological support for the other communities. Seagrasses are unique amongst flowering plants in that all but one genus can live entirely immersed in sea water (JGPO 2010).

There are three species of sea grass found on Guam; the dominant one is *Enhalus acaroids*. *Halophila minor* and *Haldule uninervis* are physically smaller and somewhat seasonal. Andersen AFB has a large bed of *H. minor* and *H. uninervis* off Tarague beach.

Fauna

Bottomfish. Seventeen species of bottomfish are managed by the WPRFMC through the *Bottomfish and Seamount Groundfish Fishery Management Plan* and subsequent amendments. In Guam, the Bottomfish Management Unit Species (BMUS) are divided into a shallow-water complex and a deepwater complex based on depth and species composition (DoN 2005).

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. The total extent and geographic distribution of the preferred habitat of bottomfish is not well known. Bottomfish populations are not evenly distributed within their natural habitat; instead, they are found dispersed in a non-random, patchy fashion. Deepwater snappers tend to aggregate in association with prominent underwater features, such as headlands and promontories.

In the Northern Mariana Islands, the bottomfish fishery can be divided into two distinct fisheries: a shallow- and a deepwater bottomfish fishery, based on species and depth. The shallow-water (0 to 328 feet [0 to 100 meters]) bottomfish complex comprises groupers, snappers, and jacks in the genera *Lethrinus*, *Lutjanus*, *Epinephelus*, *Aprion*, *Caranx*, *Variola*, and *Cephalopholis*. The deepwater (328 to 1,300 feet [100 to 400 meters]) bottomfish complex comprises primarily snappers and groupers in the genera *Pristipomoides*, *Etelis*, *Aphareus*, *Epinephelus*, and *Cephalopholis*.

The eggs and larvae of all BMUS are pelagic, floating at the surface until hatching, and subject thereafter to advection by the prevailing ocean currents. There have been few taxonomic studies of these life stages of snappers (lutjanids) and groupers (epinepheline serranids). Presently, few larvae can be identified to species. As snapper and grouper larvae are rarely collected in plankton surveys, it is extremely difficult to study their distribution.

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 [200 fathoms]) 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). HAPC for bottomfish includes all slopes and escarpments between 131 and 919 feet (40 and 280 meters).

Pelagics. Thirty-three pelagic species are currently managed as Pelagic Management Unit Species (PMUS) by the WPRFMC through the *Fishery Management Plan for Pelagic Fisheries 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*], northern bluefin tuna [*T. thynnus*], and albacore tuna [*T. alalunga*]). Additionally, a squid PMUS consisting of three flying squid species was incorporated into the existing Pelagics FMP.

The pelagic management unit species 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, 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]) (DoN 2005).

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 northern bluefin and albacore 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 (DoN 2005).

Crustaceans. Crustaceans are currently managed by the WPRFMC and include spiny and slipper lobsters, Kona crabs (*Ranina ranina*), and deepwater shrimp. Four species are managed as the spiny and slipper lobster complex: spiny lobsters (*Panulirus penicillatus* and *Panulirus* spp.), ridgeback spiny lobster (*Scyllarides haani*), and Chinese slipper lobster (*Parribacus antarcticus*). The Kona crab is managed as a single species. Deepwater shrimp includes several species including, *Heterocarpus ensifer*, *H. laevigatus* and *H. longirostris*, *H. tricarinatus*, *H. gibbosus*, and *H. sibogae* (DoN 2005, WPRFMC 2009).

Spiny lobsters are found throughout the Indo-Pacific region. All spiny lobsters in the Western Pacific Region belong to the family Palinuridae. The slipper lobsters belong to the closely related family, Scyllaridae. There are 13 species of the genus *Panulirus* distributed in the tropical and subtropical Pacific between 35° N and 35° S. *P. penicillatus* is the most widely distributed, the other three species are absent

from the waters of many island nations of the region. Spiny lobsters are typically found on rocky substrates in well-protected areas, in crevices, and under rocks. Unlike many other species of *Panulirus*, the juveniles and adults of *P. marginatus* are not found in separate habitats apart from one another. Juvenile *P. marginatus* recruit directly to adult habitat; they do not use a separate shallow-water nursery habitat apart from the adults as do many palinurid lobsters. Similarly, juvenile and adult *P. penicillatus* also share the same habitat. *P. marginatus* is found seaward of the reefs and within the lagoons and atolls of the islands. The reported depth distribution of *P. marginatus* is 9 to 656 feet (3 to 200 meters). While this species is found down to depths of 656 feet (200 meters), it usually inhabits shallower waters. *P. marginatus* is most abundant in waters of 295 feet (90 meters) or less. Large adult spiny lobsters are captured at depths as shallow as 9 feet (3 meters) (WPRFMC 2009).

In the southwestern Pacific, spiny lobsters are typically found in association with coral reefs. Coral reefs provide shelter and a diverse and abundant supply of food items. *P. penicillatus* inhabits the rocky shelters in the windward surf zones of oceanic reefs and moves on to the reef flat at night to forage (WPRFMC 2009).

Very little is known about the planktonic phase of the phyllosoma larvae of *P. marginatus*. Evidence (found in Hawai‘i) suggests that fine-scale oceanographic features, such as eddies and currents, serve to retain phyllosoma larvae (WPRFMC 2009).

Non-Coralline Invertebrates. 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.

4.1.2.5 Coral Reef Ecosystems

Guam is almost entirely surrounded by fringing reefs, is entirely surrounded by fore reefs, and has barrier reefs at Apra Harbor, Luminao Barrier Reef (at the western end of Guam), and Cocos Lagoon (southern end of Guam). The fringing reef is interrupted at several locations along the coastline by bays and channels (JGPO 2010). From Pagat Point south to Taguan Point coral reefs and colonized hard bottom (live coral) (10 to 50 percent) and coralline algae (10 to 50 percent) are present seaward of the exposed wave-cut platforms. Corals found above the 100-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 and would recover if damaged (DoN 2005).

Definition of coral and 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- The term “coral” means 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- The term “coral reef” means any reefs or shoals composed primarily of corals.

CORAL REEF ECOSYSTEM- The term "coral reef ecosystem" means 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."

To clarify the definition of coral and coral reef further, the following definition is provided. It is not intended to alter the legal definition provided in the Act, but to facilitate taxonomic comparisons.

CORAL- The term "coral" means species of the phylum Cnidaria, including the following:

- Class Hydrozoa Order Milleporina (fire corals also known as Hydrocorallina)
- Class Hydrozoa Order Stylasterina (lace corals also known as Hydrocorallina)
- Class Anthozoa, Subclass Hexacorallia, Order Scleractinia (stony corals)
- Class Anthozoa, Subclass Ceriantipatharia, Order Antipatharia (black corals and wire corals)
- Class Anthozoa, Subclass Octocorallia, Order Alcyonacea (soft corals and Tubipora corals)
- Class Anthozoa, Subclass Octocorallia, Order Gorgonacea (horny corals/sea fans)
- Class Anthozoa, Subclass Octocorallia, Order Helioporacea (blue corals).

Distribution of Corals

All major coral taxa are present in Guam. There are approximately 5 species of the Order Milleporina (fire corals), 21 species of the Order Stylasterina (lace corals), 375 species of the Order Scleractinia (stony corals), 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) (Paulay et al. 2001, Riegl et al. 2008).

In addition to supporting a very diverse mix of corals, Guam also has five of the six the major reef types: fringing reefs, patch reefs, submerged reefs, offshore banks, and barrier reefs. Atolls are the only major reef type missing from Guam and the Mariana Islands.

Proposed Listing of Species of Coral

The Center for Biological Diversity (CBD) submitted a petition to add 83 species of coral to the Federal list of Threatened and Endangered Species and to designate Critical Habitat for those species. NOAA conducted an initial review of the CBD petition. This project is being performed in response to NOAA's 10 February 2010 Federal Register Status Review notice to further evaluate 82 of the 83 species of coral and associated critical habitat. NOAA's review is currently being conducted.

In response to the Federal Register Status Review, the DoN prepared and distributed language that is intended to preclude critical habitat designation and is to be included in INRMPs of affected installations (NAVFAC ESC 2010). The JRM current conditions from the DoN required text are incorporated as follows, and additional background information is included in **Appendix N**.

U.S. Navy INRMPs and relevant literature were reviewed to identify which Navy installations and lease areas in the near-shore zone and within U.S. Territory have, or might have, one or more of the 82 coral species proposed for listing. Near-shore is defined as all submerged marine lands titled to the military and all other submerged lands that are adjacent to installations that extend from the mean high water level, offshore to the boundary of any security areas controlled by the Navy. Non-Navy DOD facilities, such as Marine Corps Base Hawaii, and Anderson AFB Guam have not been addressed.

Forty-four of the 82 species being evaluated by NOAA occur or potentially occur within Navy installations, training ranges, and Operating Areas (OPAREAs) in the United States or U.S. territories.

Most of the stony coral species (84 percent) that are being petitioned are found within the Pacific Ocean region; seven of the petitioned species occur within the western Atlantic and Caribbean.

It is Navy policy to preclude designation of critical habitat, when appropriate, by demonstrating special management of a listed species. Special management or protection is a term that originates in the definition of occupied critical habitat in Section 3 of the ESA. The ESA does not require additional special management/critical habitat designation if adequate management and protection is already in place. Adequate special management or protection is provided by a legally operative INRMP and addresses the maintenance and improvement of the primary constituent elements important to the species and manages the long-term conservation of the species. Three criteria are used to determine if such special management and protection 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. This INRMP documents that these three criteria have been met and therefore, designation of critical habitat is neither necessary nor legally required.

Table 4-3 lists all proposed species that may be present at NBG and CNMI.

Land and Jurisdictional Issues

Land and jurisdictional issues are more complex at Guam than at any of the other locations being addressed by the DoN. The key guidance documents are (1) P.L. 93-435(b)(ii) effective October 5, 1974, and (2) Presidential Proclamation 4347 effective February 1, 1975. The public law authorizes the Navy to retain title of submerged lands adjacent to property owned by the United States above the mean high tide. The Presidential Proclamation authorizes the Navy to retain title of submerged lands within Inner and Outer Apra Harbor and submerged lands adjacent to several other upland areas. **Figure 4-3** shows the JRM Submerged Lands off Guam. It is important to note that the Commercial Port Authority's jurisdiction covers the commercial port portion of Apra Harbor and part of Sasa Bay. Also of significance is the fact that the JRM Managed Submerged Lands extend offshore for 3 geographical/statute miles.

Two ecological reserve areas (ERAs) are superimposed on top of the JRM Submerged Lands, the OPERA and the HERA (see **Figure 4-3**). The HERA supports some of the healthiest and most complex coral reefs on Guam.

The WPRFMC has designated all the waters surrounding Guam as EFH from the shoreline to depths of 1,300 feet, for one or more of the managed species (Western Pacific Regional Fishery Management Council 1998). The Council has also designated HAPC for Coral Reef Ecosystem Management Unit Species at five locations in Guam: Jade Shoals, Ritidian Point, HERA, OERA, and Cocos Lagoon. All of these HAPC sites are located on JRM Submerged Lands, except for Cocos Lagoon (see **Figure 4-3**). It is noteworthy that the OPERA and HERA have dual designations as HAPCs and as ERAs.

Key Factors Influencing Corals – Natural Stressors

The corals and reefs of the Mariana Archipelago have not sustained serious widespread impacts related to climate change or coral bleaching, which have impacted other Indo-Pacific reefs since 1998 (Burdick et al. 2008). Minor to moderate bleaching did occur in August and September 2007. This was a regional event that extended from southern Japan to the Republic of Palau (Smith and Marx 2009). If sea surface temperatures continue to rise, more serious bleaching events are likely to occur. The archipelago is located within one of the world's most active tropical storm/cyclone regions in the world (Smith and Marx 2009). For example, between 1945 and 1993, 84 tropical storms or typhoons passed through the Mariana Islands. The large waves produced by these storms have a tremendous impact on shaping and structuring the reefs in this region.

Table 4-3. Occurrence of Proposed Coral Species at Naval Base Guam, Farallon De Medinilla and Tinian Military Lease Areas

Coral Species	Pacific
Acanthastrea brevis	Naval Base Guam and CNMI
Acanthastrea ishigakiensis	Naval Base Guam and CNMI
Acropora aculeus	Naval Base Guam and CNMI
Acropora acuminata	Naval Base Guam and CNMI
Acropora aspera	Naval Base Guam and CNMI
Acropora palmerae	Naval Base Guam and CNMI
Acropora striata	Naval Base Guam and CNMI
Acropora vaughani	Naval Base Guam and CNMI
Acropora verweyi	Naval Base Guam and CNMI
Alveopora fenestrata	Naval Base Guam and CNMI
Anacropora puertogalerae	Naval Base Guam and CNMI
Anacropora spinosa	Naval Base Guam and CNMI
Barabattoia laddi	Naval Base Guam and CNMI
Euphyllia cristata	Naval Base Guam and CNMI
Heliopora coerulea	Naval Base Guam and CNMI
Leptoseris incrustans	Naval Base Guam and CNMI
Millepora foveolata	Naval Base Guam and CNMI
Millepora tuberosa	Naval Base Guam and CNMI
Montipora caliculata	Naval Base Guam and CNMI
Montipora lobulata	Naval Base Guam and CNMI
Pavona cactus	Naval Base Guam and CNMI
Pavona decussata	Naval Base Guam and CNMI
Pavona diffluens	Naval Base Guam and CNMI
Pavona venosa	Naval Base Guam and CNMI
Pectinia alcicornis	Naval Base Guam and CNMI
Pocillopora danae	Naval Base Guam and CNMI
Pocillopora elegans	Naval Base Guam and CNMI
Porites horizontalata	Naval Base Guam and CNMI
Psammocora stellata	Naval Base Guam and CNMI
Seriatopora aculeata	Naval Base Guam and CNMI
Turbinaria reniformis	Naval Base Guam and CNMI
Turbinaria stellula	Naval Base Guam and CNMI

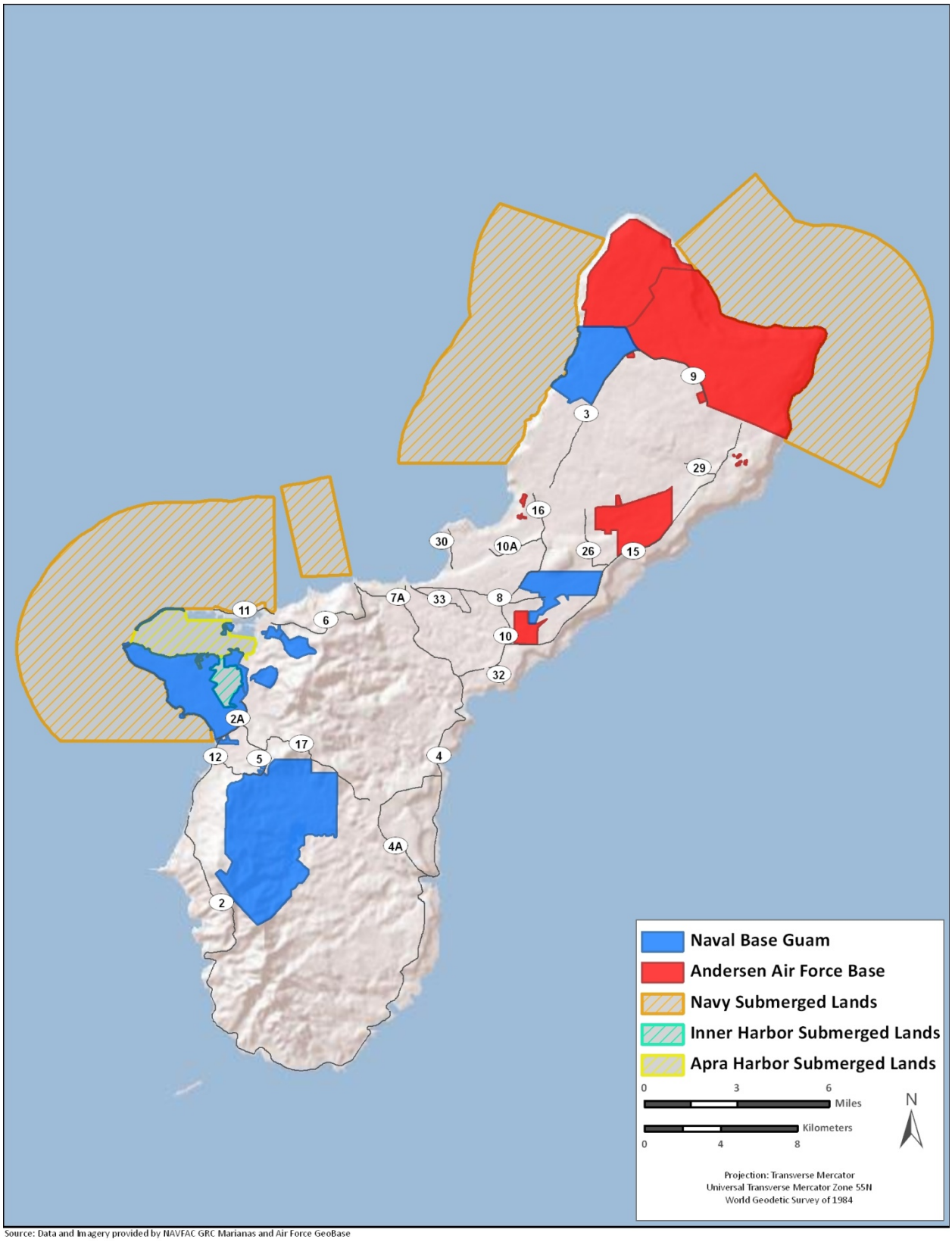


Figure 4-3. JRM Submerged Lands

The Mariana Archipelago is also located within an extremely active seismic area and some of the islands are active volcanoes (e.g., Anatahan, which is only 60 miles from FDM). Between 1999 and 2008, the USGS recorded 232 earthquakes, some with magnitudes up to 5.7. Tsunamis are produced by fault movements caused by earthquakes and volcanic activity. The Mariana Islands have been impacted by both locally generated tsunamis and tsunamis originating from Indonesia, the Philippines, and Japan. Micro-tsunamis can be produced by surface wave or moment magnitudes (Mw) greater than 6.5 and a depth on 60 miles or less, or an event for which a Tsunami Information Bulletin, Expanding Regional Warning, Indian Ocean Bulletin, or Japan Meteorological Agency Tsunami Watch Information was issued (Smith and Marx 2009).

These extreme natural events play a major role in shaping the distribution of coral and coral reefs within the Mariana Archipelago. There are no other island groups in the world that are routinely subject to more extreme events than the Mariana Islands.

The crown of thorns sea star (*Acanthaster planci*) is a coral-eating starfish found throughout the Indo-Pacific. Outbreaks of the crown of thorns sea star have occurred since at least 2004. Burdick et al. (2008) found that "the widespread, persistent nature of these outbreaks, as well as observations of high crown of thorns sea star 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."

Key Factors Influencing Corals - Anthropogenic Stressors

The three most significant anthropogenic stressors in the archipelago are (1) sedimentation of the nearshore environment due to severe upland erosion, (2) coastal pollution from microbial organisms and hydrocarbons, and (3) overfishing. Within the archipelago, these stressors are the most severe on Guam. Virtually all of these anthropogenic stressors are a result of actions taken by local residents and not JRM personnel or employees.

Public wastewater treatment systems are generally not adequate or not operating at optimal levels. GEPA recreational water quality monitoring, based upon *Enterococcus* bacteria levels, have shown that water quality has not improved since 2003 when 27 percent of all samples exceeded standards (Burdick et al. 2008). It should be noted, however, that there is debate on the appropriateness of using this bacteria as an indicator since it occurs naturally in tropical soils.

Local residents intentionally light upland fires to clear vegetation and to improve hunting. Between 1979 and 2006, there was an average of 700 intentionally set fires per year on Guam (Burdick et al. 2008). The result is that large areas on Guam are denuded or have lost their natural vegetation. This has greatly increased soil runoff into the nearshore environment.

Unsustainable fishing practices are commonly used (e.g., night spear fishing with scuba to capture parrotfishes, which sleep at night and become easy targets). Parrotfishes, a key species within Indo-Pacific coral reef ecosystems, were once very abundant in Guam; they are now severely depleted. The widespread use of monofilament gill nets has also had destructive results. Most of the Pacific islands have banned both of these fishing practices, but Guam has not.

A fourth stressor of significance in Guam is tourism, and associated water sport activities, which are very popular. Burdick et al. (2008) estimated that more than 300,000 dives per year are made in Guam. Tourist scuba divers and snorkelers impact corals and coral reefs by accidentally scraping and breaking coral. Dive boat anchors cause substantial long-term damage, even though some of the dive sites use permanent moorings. Jet skis and speedboats create noise and water pollution. Even the sunblock lotions

used by tourists can adversely impact corals when very large numbers of people using sunblock swim near the reefs (NAVFAC ESC 2010).

Operational and Training Requirements

Assuming the standard JRM environmental protection protocols are followed, there are no routine operational and training requirements that are conducted in Guam that are likely to result in adverse impacts on corals or coral reefs. In fact, the reefs and associated organisms that are within JRM "off-limits zones," such as the Kilo ammunition wharf and the fuel pier, are superior to those in areas accessible to the general public. This superiority is based on the health of corals, diversity of corals, fish, and associated invertebrates, and the biomass of fishery target species such as top shells (*Trochus niloticus*), surgeonfishes (Acanthuridae), and snappers (Lutjanidae) (Smith 2004, 2006, 2007, Smith and Marx 2006).

Additional Practices which Benefit Corals and Associated Organisms

NBG has funded, and continues to fund, a wide range of studies to assess and monitor corals and coral reefs. These studies have been and are being performed by marine ecologists; personnel from the UOG; contractors; and personnel from the USFWS, NOAA, and GovGuam. The focus of these studies is how to avoid, to the maximum extent possible, any adverse impacts on corals, coral reefs, and associated organisms. In addition, NBG has funded afforestation programs to improve nearshore water quality.

4.1.2.6 Protected Species

Under the Federal ESA, an "endangered species" is defined as any species that is in danger of extinction throughout all or a significant portion of its range. A "threatened species" is defined as any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. The ESA of Guam (5 Guam Code Annotated 63208, P.L. 15-36) provides authorization to conserve and manage threatened and endangered species to achieve the purposes of the Federal ESA. It provides for the creation of a local endangered and threatened species list, and extends local protection to all federally listed species. Under the ESA of Guam, an "endangered species" is defined as any species which is in danger of extirpation on Guam and has been so designated by the Guam Department of Agriculture or that has been determined to be an endangered species pursuant to the Federal ESA. A "threatened species" is defined as any species of plant or wildlife which appears likely, within the foreseeable future, to become endangered and which has been so designated by the Guam Department of Agriculture or that has been determined to be a threatened species pursuant to the Federal ESA. Species listed as threatened or endangered by the Federal ESA or the Guam ESA and have the potential to occur on Guam are listed in **Table 4-4** and discussed in the following sections. Species listed as threatened or endangered by the Federal ESA, Guam ESA, or the CNMI Fish, Game and Endangered Species Act (CNMI P.L. 2-51), and have the potential to occur in the CNMI, are discussed in the *Update of Integrated Natural Resources Management Plans for Navy Leased Lands on Tinian and Farallon de Medinilla*, 2010 (see **Appendix D**). Species with a former range that includes Guam and that are listed by the Guam ESA but have no current potential to occur on Guam are listed in **Table 4-4,** but are not discussed further in this document. There are 19 federally threatened and endangered species on and around Guam, including 6 species of cetaceans, 2 terrestrial mammals, 6 birds, 4 sea turtles, and 1 plant. One mammal (the little Mariana fruit bat) and one bird (Guam bridled white-eye) are likely extinct; and two Guam endemic birds (Guam rail and Guam Micronesian kingfisher) survive only in zoos or in an experimental population outside its native range (Guam rail). The Guam ESA lists 37 species as endangered and one species as threatened.

Table 4-4. Federal, GovGuam, and CNMI Listed Threatened and Endangered Species

Common Name (Chamorro Name)*	Scientific Name	Federal Status	GovGuam Status	Habitat	Presence on JRM Lands (current known population)	Current Occurrence on Guam
Mammals						
Sei whale	*Balaenoptera borealis*	E	-	Subtropical to subpolar waters on the continental shelf edge.	Unknown	Information Not Available
Blue whale	*Balaenoptera musculus*	E	-	Subtropical to subpolar waters.	Unknown	Information Not Available
Fin whale	*Balaenoptera physalus*	E	-	Deep offshore water in temperate to polar latitudes.	Unknown	Information Not Available
North Pacific right whale	*Eubalaena japonica*	E	-	Coastal to shelf waters in temperate to subpolar latitudes	Unknown	Information Not Available
Humpback whale	*Megaptera novaeangliae*	E	-	Feed in cold productive coastal waters, calve in warm water.	Unknown	Information Not Available
Sperm whale	*Physeter macrocephalus*	E		In waters > 1,968 feet (600 meters).	Unknown	Information Not Available
Pacific sheath-tailed bat (payesyes)[a]	*Emballonura semicaudata rotensis*	C	E	Native limestone forest for foraging and caves for roosting.	None	Extirpated
Mariana fruit bat (fanihi)	*Pteropus mariannus mariannus*	T	E	Native limestone forest.	Andersen AFB (25) NMS (>5) NBG TS (>5)	Present
Little Mariana fruit bat (fanihi)[a]	*Pteropus tokudae*	E	E	Native limestone forest.	None	Presumed Extinct

Common Name (Chamorro Name)*	Scientific Name	Federal Status	GovGuam Status	Habitat	Presence on JRM Lands (current known population)	Current Occurrence on Guam
Birds						
Mariana swiftlet (Yayaguak)	*Aerodramus bartschi*	E	E	Mahlac Cave, Fachi Cave, and Maemong Cave.	NMS (1,100 to 1,500)	Present
Micronesian starling (Såli)	*Aplonis opaca guami*	--	E	Native limestone forest.	Andersen AFB NBG Main Base	Present
Mariana crow (Åga)	*Corvus kubaryi*	E	E	Native limestone forest.	Andersen AFB (1)	Present
White-throated ground-dove (Paluman apåka'/fache')	*Gallicolumba xanthonura*	--	E	Native limestone forest.	Andersen AFB (2)	Occasional vagrants
Mariana Common Moorhen (Pulattat)	*Gallinula chloropus guami*	E	E	Fresh and brackish wetlands.	NBG Main Base NMS	Present
Guam rail (Ko'Ko')	*Gallirallus owstonii*	E	E	Edge and secondary growth.	None	Occurs only in captivity or experimental release population (Rota) and Cocos Island
Guam Micronesian kingfisher (Sihek)	*Halcyon cinnamomina cinnamomina*	E	E	Native limestone forest.	None	Occurs only in captivity
Guam Broadbill (Chuguangguang)	*Myiagra freycineti*	--[a]	--	Formerly all habitats except southern savannas. Extinct.	None	Extinct
Micronesian Honeyeater (Egigi)	*Myzomela rubratra saffordi*	--	E	Beach strand, mangroves, upland forest, suburban, and disturbed areas.	None	Extirpated from Guam
Mariana fruit-dove (Tottot)	*Ptilinopus roseicapilla*	--	E	Native limestone forest.	None	Extirpated from Guam

Common Name (Chamorro Name)*	Scientific Name	Federal Status	GovGuam Status	Habitat	Presence on JRM Lands (current known population)	Current Occurrence on Guam
Birds (continued)						
Rufous fantail (Chichirika)	*Rhipidura rufifrons uraniae*	--	E	Native limestone forest.	None	Extirpated from Guam
Guam bridled white-eye (Nosa')	*Zosterops conspicillatus conspicillatus*	E	E	Native limestone forest.	None	Presumed Extinct
Reptiles						
Loggerhead sea turtle	*Caretta caretta*	T	--	Offshore waters.	Unknown	Unknown
Green sea turtle (Haggan)	*Chelonia mydas*	T	T	Offshore waters and nesting beaches.	Andersen AFB NBG Main Base NBG TS	Present (nesting)
Snake-eyed skink (Guali'ek halom tåno')	*Cryptoblepharus poecilopleurus*	--	E	Coastal strand in rocky beach areas in loose sandy soils.	None	Unknown
Leatherback sea turtle	*Dermochelys coriacea*	E	E	Offshore waters and nesting beaches.	Unknown	Unknown
Tide-pool skink (Guali'ek kanton tåsi)	*Emoia atrocostata*	--	E	Intertidal zone in rock crevices, mangroves, and tree holes.	None	Present
Azure-tailed skink (Guali'ek halom tåno')	*Emoia cyanura*	--	E	Forest edge in loose ground cover.	None	Present
Slevin's skink (Guali'ek halom tåno')	*Emoia slevini*	--	E	Native limestone forest.	None	Unknown
Hawksbill sea turtle (Haggan karai)	*Eretmochelys imbricata*	E	E	Offshore waters and nesting beaches.	Andersen AFB NBG Main Base	Present (nesting)
Moth skink (Guali'ek halom tåno')	*Lipinia noctua*	--	E	Native limestone forest.	Andersen AFB NMS NBG TS	Present

Common Name (Chamorro Name)*	Scientific Name	Federal Status	GovGuam Status	Habitat	Presence on JRM Lands (current known population)	Current Occurrence on Guam
Reptiles (continued)						
Pacific slender-toed gecko (Guali'ek)	*Nactus pelagicus*	--	E	Native limestone forest.	Andersen AFB NBG TS NMS	Present
Micronesian gecko (Guali'ek)	*Perochirus ateles*	--	E	Native limestone forest.	None	Unknown
Invertebrates						
Mariana eight-spot (Ababang)	*Hypolimnas octucula marianensis*	C	--	Native limestone forest.	NBG Main Base Andersen AFB NBG TS	Present
Humped tree snail (Akaleha')	*Partula gibba*	C	E	Native limestone forest and ravine forest, only known populations occur in the HERA along the northwest coast and the GNWR.	NBG TS	Present
Guam tree snail (Akaleha')	*Partula radiolata*	C	E	Native limestone and ravine forest, endemic to the Island of Guam.	NBG TS NMS NBG Main Base Andersen AFB	Present
Mount Alifan tree snail (Akaleha')	*Partula salifana*	--	E	Native limestone forest near Mount Alifan. Endemic to the Island of Guam, presumed extinct.	None	Presumed Extinct
Fragile tree snail (Akaleha')	*Samoana fragilis*	C	E	Native limestone and ravine forest.	NBG TS Andersen AFB	Present
Mariana wandering butterfly (Ababang)	*Vagrans egistina*	C	--	Native limestone forest.	None	Presumed Extirpated

Common Name (Chamorro Name)*	Scientific Name	Federal Status	GovGuam Status	Habitat	Presence on JRM Lands (current known population)	Current Occurrence on Guam
Vascular Plants						
Tree fern (Såtsa)	*Cyathea lunulata*	--	E	Native limestone forest.	NMS	Possible
No common name (Ufa-halomtåno')	*Heritiera longipetiolata*	--	E	Native limestone forest.	NBG Main Base Andersen AFB	Present
Fire Tree (Hayun lågo)	*Serianthes nelsonii*	E	E	Native limestone forest.	Andersen AFB	Present

Sources: USFWS 2008, USEPA 2004, USGS 2008, and GDAWR 2006a
Note: *Chamorro Names from Government of Guam, Department of Agriculture Endangered Species Regulation No. 8 (2003)
Key:
E = Federal- or GovGuam-listed as endangered
T = Federal- or GovGuam-listed as threatened
C = Federal candidate for listing
[a] = extinct, delisted.

Fauna

Terrestrial Species

Mammals

Mariana fruit bat. The Mariana fruit bat, *Pteropus marianus marianus*, (fanihi in Chamorro) is a medium-sized bat measuring 7 to 10 inches (18 to 25 cm) from head to rump, with a wingspan of 34 to 42 inches (86 to 107 cm). The males are slightly larger than the females. The abdomen and wings are dark brown to black with individual gray hairs intermixed throughout the fur. The mantle and sides of the neck are bright gold on most animals but in some individuals, this region can be pale gold or pale brown. The color of the head varies from brown to dark brown. The Mariana fruit bat forages and roosts in native limestone forest and occasionally in coconut groves and strand vegetation (Perez 1972, Wheeler 1979, USFWS 1990b). The bats roost in strangler fig, *M. odorata*, and *N. oppositifolia*, but have been known to roost in *Macaranga thompsonii* (pengua in Chamorro) and *G. speciosa* (Wiles 1987a). This species feeds on a variety of plant material but fruit makes up the majority of its diet (frugivorous) (Wiles 1987a, USFWS 1990b). Fruit bats are important components of tropical forest ecosystems because they disperse plant seeds as they consume fruit, contribute to forest regeneration following disturbance events, and sustain forest diversity (Shilton and Whittaker 2009, Whittaker and Jones 1994, Cox et al. 1992).

Historically, the Mariana fruit bat inhabited the native limestone forests throughout all the Mariana Islands except Uracas (Wiles 1989). No known historical records exist to document the status of the fruit bat throughout the Mariana Islands prior to the 20th century. However, research indicates that the Mariana fruit bat occasionally moves from one island to another in the Mariana archipelago (Perez 1972, Wiles 1987b, Wiles and Glass 1990). On Guam, population estimates in 2006 indicate fewer than 100 individuals (Janeke 2006). A survey conducted by SWCA Environmental Consultants from December 2010 to November 2011 observed 25 individual fruit bats on Andersen AFB (SWCA 2012).

Three additional bats were sighted on NBG lands in 2008 during 90 hours of fruit bat surveys at 14 survey locations on or near NBG lands. It is likely that a small number of solitary-roosting fruit bats (> 10) also occur on NBG lands but were not observed. Solitary individuals can move to and from areas during the year. A survey of the Pati Point colony in 2010 resulted in a count of only 10 fruit bats and an estimate of fewer than 25 individuals islandwide (A. Brooke, Navy, personal communication). The majority of fruit bats remaining on Guam likely reside on Andersen AFB. Among all the islands of the CNMI, population estimates (2010) are variable but range from approximately 11 individuals on Maug to 1,017 individuals on Pagan for a total of 3,078 individuals (USGS 2010).

The Mariana fruit bat population has experienced a significant decline in the past century due to several factors. Fruit bats are an important cultural delicacy to the Chamorros' and were served at weddings, christenings, and holidays (Sheeline 1991). Guam's population of these bats was probably reduced greatly during the early 1900s when the expanding human population on Guam at that time probably fueled the demand for bats while an increased use of firearms might have made hunting more successful (Wiles 1987b, 1990). Territorial legislation that criminalized bat harvest in 1966, the designation of Pati Point as a protected area by the USAF in 1973, and the listings as an endangered species by Guam in 1981 and the United States in 1984 have helped bats to survive on Guam, although the population was likely sustained by migration from Rota (Wiles and Glass 1990). Illegal hunting, however, continues to be a serious threat to fruit bats in the Mariana Islands (Wiles et al. 1995, Esselstyn et al. 2006, and Wiles and Brooke 2009).

Other factors that have likely contributed to the decline of the Mariana fruit bat include predation, loss of habitat, and natural disturbances (Wiles 1987a, 1987b). Predation by brown treesnakes has very likely contributed to declining populations on Guam since the 1950s and prevented recovery despite legal protection (Wiles 1987a, Wiles et al. 1995). Mariana fruit bats are extremely sensitive to new or unaccustomed disturbances, or close proximity of humans, and have been known to abandon roost sites during even minor interference events. Clear-cutting of native forest for conversion to agriculture and construction of housing and other development in the central and northern parts of the island have removed potential roosting and foraging habitat. Destruction of habitat by feral ungulates is also considered a contributing factor (Wiles 1989). Lastly, the effects of natural disturbance events, like typhoons common in the Western Pacific Ocean, might be responsible for denuding bat roosting and foraging habitat (Wiles 1987b) and making them more vulnerable to poaching (Esselstyn et al. 2006).

The Guam population of the Mariana fruit bat was federally listed as endangered in 1984 (USFWS 1984). No Federal protection was afforded the species outside of Guam. In 2005, the USFWS published a final rule listing the Mariana fruit bat as a threatened species throughout the Mariana Islands. This change reflected the view that the fruit bats in the CNMI and Guam were a single population, and the threats to this species should be managed rangewide (USFWS 2005a). This view was further supported by genetic analysis that indicated that the Mariana fruit bats in the Mariana Islands were a single population (Brown et al. 2011). The Mariana fruit bat is listed as an endangered species by the Guam ESA.

Little Mariana fruit bat. The Little Mariana fruit bat, *Pteropus tokudae*, (fanihi in Chamorro) is much smaller than the Mariana fruit bat and has never been known to be common. The following description is from the original treatment by Tate (1934). The little Mariana fruit bat measures 5.5 to 6 inches (14 to 15 cm) head to rump, with a wingspan of 26 to 28 inches (65 to 71 cm). The belly and wings are dark brown with few gray hairs interspersed. The mantle is brown in color blending to russet on the sides, the top of the head is mottled brown and gray, a cinnamon buff neck, and the throat and chin are dark brown. The little Mariana fruit bat has always been considered rare; only three specimens have been collected (Tate 1934, Perez 1972). The last reported observation of a specimen was a female collected in 1968 (Perez 1972). Unlike the Mariana fruit bat that ranges throughout the Mariana Islands, the little Marina fruit bat has not been observed on other islands and is considered endemic to Guam. The same basic habitat and behavior is seen in this species as the Mariana fruit bat.

The little Mariana fruit bat was listed as endangered in August 1984 (USFWS 1984). Considering the species has not been observed since the 1968 record by Perez (a possible observation was made by Wheeler [1979]), the species is likely extinct. Designation of critical habitat for this species was considered twice by the USFWS, once in 1991 (USFWS 1991a) and once in October 2002 (USFWS 2002a), but it was found not to be prudent because the species is likely extinct. A recovery plan for the little Mariana fruit bat was published in 1990 (USFWS 1990b), however, because the species is likely extinct, no recovery objectives were established. The little Mariana fruit bat is listed as an endangered species by the Guam ESA.

Birds

Mariana swiftlet. The Mariana swiftlet (Yayaguak in Chamorro) is a narrow-winged bird, dark gray above, and grayish brown on its underside. It is endemic to the Mariana Islands and known historically from Guam, Rota, Aguiguan, Tinian, and Saipan, but it is currently found only on Guam, Saipan, and Aguiguan. The Mariana swiftlet can be confused with the Asian barn swallow (*Hirundo rustica*), a vagrant species occasionally sighted on northern Guam. The Asian barn swallow is distinguished from the Mariana swiftlet by its pale underparts, the ability to perch, and a long forked tail. Swiftlets are known to forage over grassy areas and along cliff lines, feeding on insects caught in flight (USFWS 1991b), but studies conducted in 1996 indicate a preference for foraging in the Talofofo River Valley (Morton and Amidon 1996) which is composed of native forest, riparian forest, agricultural lands, and

savanna. Foraging usually occurs in the early morning or early evening. They nest and roost colonially in caves, using moss and saliva to construct a nest on the cave wall. A single egg is laid between January and July. The Mariana swiftlet is an acrobatic flyer and uses a form of echolocation to navigate the dark interior of caves, though it is not as advanced as the echolocation of many bats. The reasons for the decline of the endangered Mariana swiftlet are not completely understood, but human disturbance of nesting and roosting caves and predation on swiftlets by brown treesnakes (Guam) have contributed to their current status.

The Mariana swiftlet was listed as endangered in August 1984 (USFWS 1984). A recovery plan for the species was published in 1991 (USFWS 1991b). Critical habitat has not been proposed, or designated for the species. The Mariana swiftlet is listed as an endangered species by the Guam ESA.

Micronesian starling. The Micronesian starling (Såli in Chamorro) is an endemic subspecies found in the southern Mariana Islands of Guam, Rota, Tinian, and Saipan (Baker 1951, Jenkins 1983). The Micronesian starling is a large starling with black plumage and a greenish-blue gloss. It has a heavy, slightly curved black bill, black feet, and yellow eyes (Jenkins 1983). It is considerably smaller than the Mariana crow and can be distinguished from the introduced black drongo by the latter's red irises and long forked tail. Micronesian starlings form small to moderate size flocks, but can also be found alone, or in pairs. The starlings use scrub, secondary growth, mixed woodland, and mature forest for habitat and feed primarily on the fruit and seeds of ripe papayas (Baker 1951, Jenkins 1983). They were often seen in urban areas but are generally more abundant in forested areas (Jenkins 1983). This species, unlike other starlings, is not an agricultural pest. Nesting has been observed from January through June. Starlings are cavity nesters and have been found nesting in the cavities of trees and rocky cliffs. Two green eggs spotted with drab rust- and purple-colored spots are laid per clutch (Baker 1951).

At one time, Micronesian starling were found throughout Guam but predation by the brown treesnake has restricted them primarily to Cocos Island, NBG Apra Harbor in buildings, Andersen AFB, parts of Hagatña and certain coastal areas in the south, and birds have been seen on the wing carrying nesting material in the vicinity of Sumay Marina. These birds are important because they help disperse seeds, which is vital for perpetuation of the native forests.

Populations of Micronesian starling on Guam have declined, but it is not a federally listed species and no recovery plan has been drafted. Due to the declining populations on Guam, GovGuam has listed the species as endangered.

Mariana crow. The Mariana crow (Åga in Chamorro) is a small black crow with a greenish-black sheen on the head and bluish-black sheen on the back, wings, and tail (Baker 1951). The crow, which is endemic to Guam and Rota, prefers native limestone forest for breeding and foraging, but it will forage in other habitats such as beach strand vegetation and coconut groves (Baker 1951, USFWS 2005b). This species is an omnivorous, opportunistic feeder that is known to feed on insects, lizards, bird eggs, hermit crabs, fruits, and seeds. On both Guam and Rota, Mariana crow nests have been found exclusively in the native tree species, such as *Elaeocarpus joga* and *Ficus prolixa*, which also serve as the primary sources for foraging. Nesting is reported to occur year-round on Rota with a peak between August and February, but typhoons have a significant effect on the breeding season (Morton et al. 1999). Nesting on Guam was generally recorded from October to mid-April (Morton 1996, USFWS 2005b).

On Guam, Mariana crows have historically been found throughout forested areas and were considered common enough to be agricultural pests, even into the early 1960s (Seale 1901, Baker 1951). A USFWS survey in 1981, however, estimated only 357 crows, mostly in the northern limestone forest and mixed forest areas (USFWS 2010a). The last native Mariana crow on Guam likely disappeared between 2002 and 2003 (USFWS 2005b). In 2007, 10 crows translocated from nearby Rota or mainland zoos, remained on Guam, restricted in distribution to the northern cliff forests on Andersen AFB (USFWS 2010a). A

survey conducted by SWCA from June 2007 until April 2008 indicated the Mariana crow population diminished from an estimated 10 individuals observed in 2006 to two males and one female. The female was sighted only once during the study (SWCA 2008). Surveys in 2010–2011 by SWCA found only a single male on Andersen AFB.

The Mariana crow is listed as endangered under the Federal ESA, and the ESA of Guam (USFWS 1984); critical habitat has been designated for this species (USFWS 2004a) at the GNWR. Forested habitats on JRM lands are important to the long-term conservation of the Mariana crow. In 2004, 10,838 acres (4,386 hectares) of Air Force lands, and 7,977 acres (3,228 hectares) of Navy lands were identified as important to the recovery of the species, but were excluded from critical habitat designation under Section 4(a)(3) of the ESA, as amended by Section 318 of the fiscal year (FY) 2004 National Defense Authorization Act (P.L. No: 108–136) (USFWS 2004a). Predation by introduced brown treesnakes, rats, and monitor lizards; habitat loss and destruction; and human persecution are responsible for the dramatic decline of the crows (USFWS 2005b). Further loss of habitat, particularly of the native tree species *E. joga* and *F. prolix*, could lead to a total decline of this species on Guam.

White-throated ground-dove. The white-throated ground-dove (Paluman apåka' (male)/ Paluman fache' (female) in Chamorro) is roughly the size of a domestic pigeon. Males and females are dimorphic in coloration as described by Baker (1951). The male forehead, face, chin, throat, and upper breast is white, washed with a pale buff, and sides of the head and nape are rusty- to pale-brown. The rest of the upper body is brown as are the underparts. Females are smaller, their head and neck are brown, and darker than the underparts with more rufus coloration. The underparts are more of a tawny cinnamon-brown. This species prefers the deep jungle and feeds on small seeds and berries found on the ground. Because of the difference in appearance between male and female ground doves, there are two Chamorro names for this species. The white-throated ground-dove has been recorded on every island in the Mariana from Guam to Asuncion; however, the population on Guam has been extirpated due to predation by the brown treesnake. Occasional individuals have been observed in recent years and are likely a result of immigration from neighboring Rota. The white-throated ground-dove is not a federally endangered species, but it has been listed as endangered by the Guam ESA.

Mariana common moorhen. The Mariana Island subspecies of the common moorhen (Pulattat in Chamorro) resembles other moorhen subspecies found throughout the world. Moorhens in the Mariana Islands are found primarily in freshwater man-made and natural wetlands that are both seasonal and permanent. Occasionally, they are recorded in brackish water wetlands. Wetlands that support about equal amounts of emergent, submergent, or floating vegetation and open water are more suitable to moorhens for feeding and nesting than wetlands that are predominately open water, or that support mostly emergent wetland vegetation. It should be noted, however, that the amount of emergent vegetation preferred by Mariana common moorhens depends on the size of the wetland, not just a preference for equal amounts of emergent vegetation and open water.

Islandwide surveys for the endangered moorhen were conducted on Guam and the CNMI from May through September 2001. Based on these counts, the total adult moorhen population was estimated to be 287, with 154, 41, 2, and 90 adult moorhens on Saipan, Tinian, Rota, and Guam, respectively. The results suggested an overall increase in birds on Saipan and Tinian, although moorhen numbers on Guam could be declining (Takano and Haig 2004). On Guam, this species occurs or potentially occurs at Fena Reservoir and other seasonal and perennial wetlands (Takano and Haig 2004).

The Mariana common moorhen was listed as endangered in 1984 (USFWS 1984); no critical habitat has been designated for this species. Declines in the moorhen population are attributable to invasive vegetation, introduced predators, and degradation of wetlands by feral ungulates and humans (USFWS 1991b). Recent changes to the nonnative and invasive aquatic vegetation at Fena Reservoir have caused a decrease in the number of moorhen at the reservoir (A. Brooke, Navy, personal communication).

Guam rail. The Guam rail (ko'ko'in Chamorro) is fast-running and flightless, and is characterized by a laterally compressed, elongated body, allowing it to escape into dense vegetative cover (Baker 1951, Jenkins 1979). This species was widely distributed across various habitats on Guam, including forest, savanna, scrub, secondary grassland, fern thickets, and agricultural areas (but not in freshwater wetland habitats). The Guam rail is an omnivorous feeder, consuming snails, slugs, insects, geckos, vegetable matter, seeds, and flowers from low grasses and shrubs, but it appears to prefer animal over vegetable food (Jenkins 1979).

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). By July 1985, only one rail could be located in the flightline area of Andersen AFB; by 1987, the species had been extirpated from the wild (USFWS 1990a). Captive breeding started in 1984. Since 1987, efforts have been underway to establish a self-sustaining, experimental population on the nearby brown treesnake-free Island of Rota. In 1999, birds bred there for the first time. Guam rails were experimentally released in 1998 and again in 2003 on Andersen AFB. This population of rails was preyed upon by feral cats, and the small size of the release area resulted in an approximately 80 percent mortality rate for the population. On November 16, 2010, 16 Guam rails were released on Cocos Island by GDAWR. Rats have been eradicated from the island, and there are no known cats or snakes on the island. In addition, the forest has been enhanced by removing invasive vines. These factors make successful establishment of a population of the birds on Cocos Island more viable.

The Guam rail was listed as endangered under the Federal ESA and the ESA of Guam in 1984 (USFWS 1984), critical habitat has not be designated for this species. The experimental population of Guam rails on Rota is designated nonessential under the ESA.

Guam Micronesian kingfisher. The Guam Micronesian kingfisher (Sihek in Chamorro) is a medium-sized bird with short legs and a straight, heavy beak. Males and females are dimorphic. Males have a rusty-brown head, neck, upper back, and underparts. Females are similar to the males except their chin, throat, and upper breast are paler, and the rest of their underparts and underwing coverts are white. Both sexes have blue-green back feathers, lesser wing-coverts and tail, and a dark-colored orbital ring that encircles the head behind the eyes (Baker 1951). Kingfishers are noted for their raucous calls, used to defend their territories, which cover several acres. The Guam Micronesian kingfisher preys on insects and small vertebrates and builds nests in cavities of rotting mature trees, such as umumu (*Pisonia grandis*), breadfruit, and coconut.

The Guam Micronesian kingfisher is endemic to Guam and inhabited mature limestone forests, mixed woodlands, secondary growth stands, and scrub forests of the northern plateau (Jenkins 1983), coconut forest, and riparian forest (USFWS 1990a). The population was estimated at 3,000 birds in a 1981 survey (Engbring and Ramsey 1984), but rapidly declined due to predation by the brown treesnake. By 1988, the Guam Micronesian kingfisher was extirpated and held in captivity (Wiles et al. 2003). As of 2008, 60 male, 36 female and 4 unsexed kingfishers were living in 17 captive propagation facilities on the mainland United States and Guam (USFWS 2008). The Guam Micronesian kingfisher was listed as an endangered species under the Federal ESA in 1984 (USFWS 1984) and is also listed as endangered under the ESA of Guam (Guam Public Law 15-36). Forested habitats on Andersen AFB are important to the long-term conservation of the Guam Micronesian kingfisher. In 2004, 10,838 acres (4,386 hectares) of Air Force lands, and 7,977 acres (3,228 hectares) of Navy lands were identified as important to recovery of the species, but were excluded from critical habitat designation under Section 4(a)(3) of the ESA, as amended by Section 318 of the FY 2004 National Defense Authorization Act (P.L. No: 108–136) (USFWS 2004a). However, critical habitat for the Guam Micronesian kingfisher is present on the GNWR.

Guam broadbill. This Guam broadbill (Chuguangguang in Chamorro) was a small flycatcher weighing approximately 0.4 ounces (12 grams) that was endemic to the Island of Guam. Although once widespread in all but grassland habitats, by 1983 the Guam broadbill was restricted to a small area on the north coast and was estimated at fewer than 100 individuals. The primary cause of the decline was predation by the brown treesnake. The last sighting of this species was in 1984. The Guam broadbill was federally listed as endangered in August 1984 (USFWS 1984), but was proposed for delisting in January 2002 due to extinction (USFWS 2002b). Designation of critical habitat for the species was proposed by the USFWS in 1991 (USFWS 1991a) and withdrawn in 1994 (USFWS 1994a). A recovery plan for the Guam broadbill was published in 1990 (USFWS 1990a); however, because the species is likely extinct, no recovery objectives were established other than to capture donor stock and establish a captive breeding population, if possible. The Guam broadbill was delisted on February 24, 2004, because all available information indicates that it is extinct (USFWS 2004a).

Guam bridled white-eye. The Guam subspecies of the bridled white-eye (Nosa'in Chamorro) was endemic to Guam and was one of two subspecies in the Mariana Islands. It weighed approximately 0.3 ounces (10 grams). The bridled white-eye was recorded historically in virtually all habitats at all elevations on Guam. By 1983, however, the population was restricted to northern Guam and was thought to have dropped below 50 individuals. The last family group was observed in 1982, and the last individual observed in 1983. The primary cause of the decline was predation by the brown treesnake.

The Guam subspecies of the bridled white-eye was listed as endangered in August 1984 (USFWS 1984), however, there is a likely possibility that this species is extinct (USFWS 2002a). Designation of critical habitat for this species was considered twice by the USFWS, once in 1991 (USFWS 1991a) and again in October 2002 (USFWS 2002a), but found not to be prudent because the Guam subspecies is likely to be extinct. A recovery plan for the species was published in 1990 (USFWS 1990a), however, because the subspecies is likely extinct, no recovery objectives were established other than to capture donor stock and establish a captive breeding population if possible.

Reptiles

Snake-eyed skink. The snake-eyed skink (Guali'ek halom tåno'in Chamorro) is a slender tan to brown skink with a snout-to-vent length (SVL) of 1.75 inches (45 millimeters). It has a mottled pattern, sometimes appearing as spots or lines (Vogt and Williams 2004); sides are dark with light-colored flecks. It's known from most of the Mariana Islands, and is found mostly near the coast. It is found on the ground, in bushes, or in trees depending on location. The common name for the skink comes from the clear, immovable eyelids that make it snake-like in appearance. It prefers loose or sandy soil, so the eyes might be an adaptation to burrowing (Vogt and Williams 2004). Diet consists of small insects. The snake-eyed skink is not a federally listed species, but it is listed as endangered by the Guam ESA.

Tide-pool skink. The tidepool skink (Guali'ek kanton tåsi in Chamorro) is a larger skink with an SVL of 3.3 inches (85 millimeters) and a black-and-tan coloration in a mottled pattern. It is recorded from Guam, Aguiguan, Rota, Saipan, and Alamagan. On Guam, it is currently only known from Cocos Island off the southern coast where it is reported to be abundant, but it is seldom observed on the south side of the island (Vogt and Williams 2004). It can be found along coastal areas, climbing on rocks and strand vegetation. It will often jump into saltwater pools to escape predators. Diet likely consists of insects and small invertebrates. The tide-pool skink is not a federally listed species, but it is listed as an endangered species by the Guam ESA.

Azure-tailed skink. The azure-tailed skink (Guali'ek halom tåno' in Chamorro) is similar in appearance to the more common blue-tailed skink (*Emoia caeruleocauda*). This species is reported to be endemic to Guam, having been formerly reported from the Geus River watershed in southern Guam (GDAWR 2006a). Currently, this species is only found on Cocos Island, off the southern coast of Guam. The

current status of the population is not known. The azure-tailed skink is not a federally listed species, but it is listed as an endangered species by the Guam ESA.

Slevin's skink. Slevin's skink (Guali'ek halom tåno' in Chamorro) is a large skink with a SVL of 3 inches (75 millimeters) and an olive- or brown-colored body with black flecks on the back. The belly is orange-tinted in larger specimens. It is a skink of the forest floor, and has been recorded on most of the Mariana Islands. Slevin's skink is the only reptile species endemic to the Mariana Islands. On Guam, this species was last recorded on Cocos Island, but has not been recorded there or elsewhere on Guam since the 1990s (Vogt and Williams 2004). Archaeological evidence suggests that this species was once one of the more common species in the Mariana Islands. It is speculated that the introductions of nonnative lizards and predators are the cause for this species' decline. The disappearance of Slevin's skink from Cocos Island roughly correlates with the arrival of the nonnative curious skink (*Carlia fusca*); however, there is no firm evidence to support that correlation (Vogt and Williams 2004). Slevin's skink is not a federally listed species, but it is listed as an endangered species by the Guam ESA.

Moth skink. The moth skink (Guali'ek halom tåno' in Chamorro) is a small brown to tan skink with a SVL of 2 inches (55 millimeters). There is a dark line with light colored flecks on either side of the body to the hind limbs. A yellow spot on the head continues down the back in the form of a light-colored strip ending at the base of the tail. Belly coloration is yellow to orange. This species is found across much of the western Pacific, but Guam is the only island this species has been recorded from in the Mariana Islands. It is found on the ground or low trees in native forest, often near *Pandanus* sp. It is the only lizard in the Mariana Islands to give birth to live young (Vogt and Williams 2004). Diet consists primarily of ants. The moth skink is not a federally listed species, but it is listed as an endangered species by the Guam ESA.

Pacific slender-toed gecko. The Pacific slender-toed gecko (Guali'ek in Chamorro) is a grayish-colored gecko with dark cross banding and a large head in relation to its body. It has straight toes that lack toe pads and has a series of bumps in lengthwise rows running down the back. It has an SVL of 2.75 inches (70 millimeters). It is nocturnal and terrestrial, preferring rocky areas, but will climb tree trunks (Vogt and Williams 2004). This species is entirely female, reproducing by parthenogenesis (essentially cloning itself). It is known to occur throughout the western Pacific, and in the Mariana Islands it has been recorded on Guam, Rota, Anatahan, Alamagan, and Sarigan. It is not a federally listed species, but it is listed as an endangered species by the Guam ESA.

Micronesian gecko. The Micronesian gecko (Guali'ek in Chamorro) is a large species with a SVL of 3.5 inches (90 millimeters). It has a greenish-mottled appearance. The tail is flattened laterally with small spines along the lateral edges. The fifth toe on each foot is reduced, giving the appearance of having four toes (Vogt and Williams 2004); this is a key identifying feature for this species. This species was one of the more common lizards in the Mariana Islands in prehistory; declines are thought to be a result of the introduction of competing species like the Oceanic Gecko (*Gehyra oceanica*), or predatory species like the brown treesnake. This species prefers native limestone forest, but has been documented around man-made structures. The diet is composed of insects. In the Mariana Islands, this species has been recorded from Guam, Rota, Tinian, and Saipan, but might occur on other northern islands in the archipelago. The Micronesian gecko is not a federally listed species, but it is listed as an endangered species by the Guam ESA.

Invertebrates

Insects

Mariana eight-spot butterfly. The Mariana eight-spot butterfly (Ababang in Chamorro) was first described as *Diadema octocula* by Butler in 1869 and subsequently renamed to the current nomenclature

by Fruhstorfer in 1912 (Sweezy 1942). The parent species, *Hypolimnas octocula*, has been divided into eight subspecies occurring in the south and west Pacific Islands (Sampson 1986, Tennent 2006). The subspecies, *H. o. marianensis,* the Mariana eight-spot butterfly, is endemic to the Micronesian Islands of Guam and Saipan. Male butterflies are mostly black with a vertical orange stripe across both the fore- and hind-wing. The stripe on the hind-wing exhibits a series of black spots arranged vertically within the orange stripe. Females are overall more orange in color with the same basic pattern.

Habitat requirements for the Mariana eight-spot butterfly have not been described in detail. Schreiner and Nafus (1997) describe this species as inhabiting forest and forest clearings. Campora and Lee (2009) observed an adult butterfly in the upper sunlit canopy of limestone forest. Both host plant species, *Procris pedunculata* and *Elatostema calcareum,* are low-growing herbaceous plants found in limestone forest habitats.

Results of surveys conducted in 1996 found adult Mariana eight-spot butterflies at 3 of 12 survey locations on Guam: Orote Point, Tweeds Cave, and the lower Pagat area. Eggs, larvae, and pupae consistent with those of the Mariana eight-spot butterfly were observed on host plants at these and three additional locations, including Fadian Cove, Hilaan, and the Mangilao Golf Course. Eggs, larvae, and pupae of the Mariana eight-spot butterfly are difficult to differentiate from those of other *Hypolimnas* species on Guam; however, because other *Hypolimnas* on Guam are not host-specific to *P. pedunculata* and *E. calcareum*, life stages found on these host species are likely to be Mariana eight-spot butterfly (Campora and Lee 2009). Surveys conducted in 2009 identified at least one adult Mariana eight-spot butterfly along with eggs, larvae, and pupae in limestone forest along Route 15 in the Pagat area (Campora and Lee 2009). Additional surveys conducted on Andersen AFB in 2011 found 7 adult butterflies, 96 larvae, and 35 eggs within 73 host plant patches on the installation (HDR 2012).

The current population of the Mariana eight-spot butterfly is threatened by habitat alteration, predation, and parasitism. Host plant distribution on Guam has been significantly altered as a result of feral deer and pig browsing. Where feral ungulates are present, host plant populations are generally limited to limestone exposures out of reach of ungulate browsing, typically in "tower karst" areas near cliff edges (D. Janeke, personal observation). Ants were found to be major predators of the Mariana eight-spot butterfly and other *Hypolimnas* species on Guam (Schreiner and Nafus 1996), causing more than 90 percent mortality of Mariana eight-spot butterflies over the course of a one-year study. Native parasitoids have been observed parasitizing the eggs of the Mariana eight-spot butterfly (Schreiner and Nafus 1996) and introduced parasitoids have been found parasitizing related *Hypolimnas* species (Nafus 1992).

The current population of this species has not been established quantitatively (USFWS 2010b); however, the rarity of this species is alluded to by Schreiner and Nafus (1996) where they state that the maximum number of this butterfly observed in a single day was six. Schreiner and Nafus (1997) later refer to this species as "rare," and Sweezy (1942) was only able to collect a single specimen during his 1936 collection on Guam. The Mariana eight-spot butterfly was designated a candidate for listing as an endangered or threatened species with a priority number of three in 1997 (USFWS 1997). In 2009, the candidate listing status under the ESA for the Mariana eight-spot butterfly was reaffirmed (HDR 2011).

Mariana wandering butterfly. The Mariana wandering butterfly (Ababang in Chamorro) is endemic to the islands of Guam and Rota in the Mariana Archipelago. The overall color of this species is black with an irregular patch of orange color originating at the basal portion of the fore- and hind-wing, extending roughly halfway across the wing. There are no stripes or spots of note on the wings. Larvae of the Mariana wandering butterfly feed on the Mariana endemic shrub luluhut (*Maytenus thompsonii*) (Sweezy 1942).

The butterfly was last collected in Guam in the 1970s and last observed on Rota in 1995 (Schreiner and Nafus 1996) despite the widespread abundance of the host plant luluhut. The decline of the Mariana

wandering butterfly populations is not well understood, but alien ants have been found to be major predators of both eggs and larvae of other butterfly species on Guam. In addition, butterfly parasites, some introduced intentionally, might have also contributed to the species' decline (USFWS 2010c). The Mariana wandering butterfly was designated a candidate for listing as an endangered or threatened species with a priority number of two (2) in 1997 (USFWS 1997). It is currently still a candidate for listing as an endangered or threatened species with a listing priority number of two (2) (USFWS 2010c).

Gastropods

Humped tree snail. The humped tree snail (Akaleha' in Chamorro) is so named for the last whorl of its shell which is somewhat enlarged into a hump. This snail has a conical-shaped shell with four to four and a half whorls, and is chestnut brown to whitish yellow or occasionally purple with a white or brown line along the suture between the shell whorls. According to Cowie (1992), the life span of a Partulid tree snail is about 5 years, with reproduction occurring after the first 12 months. Unlike many terrestrial snails that lay eggs, Partulid tree snails bear up to 18 live young a year. Adults are hermaphroditic. Crampton (1925) describes the habitat of Partulid tree snails in the Mariana Islands as having "sufficiently high and dense growth to provide shade, to conserve moisture and to effect the production of a rich humus." Partulids are found in forests of low and high growth, but could be present in any vegetation type which provides the requisite environmental conditions (Crampton 1925). Within the forest structure, snails are typically found within 3 to 9 feet (1 to 3 meters) of the forest floor (Hopper and Smith 1992). They rest on the leaves and stems of bushes and trees during the day, coming out at night to feed on dead and decaying plant material.

The humped tree snail was originally known from nine of the Mariana Islands where it was widespread and abundant. Presently, it is thought to be extirpated from Tinian and Anatahan, the latter due to volcanic activity between 2003 and 2005 (USFWS 2010d). The total population in the Mariana Islands is estimated to number fewer than 2,600 snails (USFWS 2010d). Once the most numerous tree snail species on Guam, humped tree snails continue to decline, currently occurring only at the HERA on the northwestern coast of Guam.

The native snails of the Mariana Islands continue to decline and are threatened by deforestation, introduced predatory snails and flatworms, and alteration of the habitat by feral ungulates (Hopper and Smith 1992, Smith and Hopper 1994, Cowie 2000, Cowie and Cook 2001). The humped tree snail was designated a candidate to be listed as an endangered or threatened species in 1994 (USFWS 1994b) and is still a candidate for listing with a listing priority number of two (2).

Guam tree snail. The Guam tree snail (Akaleha'in Chamorro) has five whorls to its shell and is a pale straw yellow with darker axial rays and brown lines. The species is endemic to the Island of Guam where it was once the second most abundant tree snail species (Crampton 1925). Its biology is similar to that of the humped tree snail and once commonly co-occurred with the humped tree snail (Crampton 1925). Currently, there are 22 known populations of these snails remaining on Guam (USFWS 2010e).

The native snails of the Mariana Islands continue to decline and are threatened by deforestation, introduced predatory snails and flatworms, and alteration of the habitat by feral ungulates (Hopper and Smith 1992, Smith and Hopper 1994, Cowie 2000, Cowie and Cook 2001). The Guam tree snail was designated a candidate to be listed as an endangered or threatened species in 1994 (USFWS 1994b) and is currently still a candidate for listing with a listing priority number of two (2).

Mount Alifan tree snail. The Alifan tree snail (Akaleha'in Chamorro) was first collected in 1920 and described by Crampton (1925). Subsequent surveys in the 1940s indicated that this species was endemic to the west-central highlands of Guam in the area of Mount Alifan. It had a thick, heavy shell, more like the Society Island partulid tree snails than the species known from Guam, with 5 to 5.25 whorls. It was

chestnut brown in color, turning to purple with age. Surveys for partulid tree snails in 1989 failed to find any living Alifan tree snails in the west-central highlands or elsewhere and the authors considered the species to be extinct (Hopper and Smith 1992).

The native snails of the Mariana Islands continue to decline and are threatened by deforestation, introduced predatory snails and flatworms, and alteration of the habitat by feral ungulates (Hopper and Smith 1992, Smith and Hopper 1994, Cowie 2000, Cowie and Cook 2001). The Mount Alifan tree snail was designated a candidate to be listed as an endangered or threatened species in 1994 (USFWS 1994b) and is currently still a candidate for listing with a listing priority number of two. There are no known sightings of the species since 1963 (USFWS 1994b).

Fragile tree snail. The fragile tree snail (Akaleha'in Chamorro) has a thin, semitransparent shell with four whorls. The background is buff-colored and tinted by narrow darker maculations and whitish banding derived from the internal organs of the animal that are visible through the shell. Biology of the fragile tree snail is similar to other partulid tree snails in the Mariana Islands except that sexual maturity is reached before maximum shell size and they have relatively large, tough calcareous-shelled eggs which are reabsorbed before giving birth to live young (Crampton 1925). This snail was originally known as a widespread but uncommon species, endemic to Guam and Rota. Only as single colony of fragile tree snails are known to exist on Guam at Pugua Point (Smith et al. 2008). The location of the original fragile tree snail colony observation on Rota has been converted to agricultural fields and no tree snail habitat remains. A new colony was located on Rota by Bauman (1996).

The native snails of the Mariana Islands continue to decline and are threatened by deforestation, introduced predatory snails and flatworms, and alteration of the habitat by feral ungulates (Hopper and Smith 1992, Smith and Hopper 1994, Cowie 2000, Cowie and Cook 2001). The fragile tree snail was designated a candidate to be listed as an endangered or threatened species in 1994 (USFWS 1994b) and is currently still a candidate for listing with a listing priority number of two.

Marine Species

Marine Mammals

All marine mammals are protected under the MMPA as amended in 1994. In addition to the MMPA, the ESA provides protection to those marine mammals that have been federally listed as endangered or threatened. Federal agency actions that reasonably have the potential to "take" a marine mammal require permission from the appropriate regulatory agency. Take of marine mammals includes harassment. Two levels of harassment were defined in the 1994 amendments to the MMPA: Level A and Level B. *Harassment* is defined in the MMPA as any act of pursuit, torment, or annoyance that has the potential to injure marine mammal stock in the wild (Level A); or has the potential to disturb marine mammal stock in the wild by disrupting behavioral patterns, including migration, breathing, nursing, breeding, feeding, or sheltering (Level B).

Thirty-two marine mammal species have confirmed or possible occurrence in Guam and CNMI (DoN 2005, DoN 2004, DoN 2010), 23 of which are considered to have a regular occurrence in the area (regardless of their abundance); these are all cetaceans. The 23 marine mammal species include the ESA-listed blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*), humpback whale (*Megaptera novaeangliae*), sei whale (*B. borealis*), and sperm whale (*Physeter macrocephalus*). The ESA-listed baleen whale species have a seasonal occurrence (mid-November thru mid-May) in the Mariana Archipelago, making migrations to feeding areas in higher latitudes (DoN 2005, DoN 2010). Since deep waters come close to shore around Guam and CNMI, it is possible that deepwater marine mammal species (those occurring along and seaward of the shelf break) would make their way into waters within a few kilometers of shore. For example, a group of sperm whales, including calves and a large male, was

seen within 1.9 miles (3 kilometers) of Apra Harbor (DoN 2005, DoN 2010) and a large group of melon-headed whales (*Peponocephala electra*) were observed within Sasanhaya Bay (Rota) (DoN 2005, DoN 2010).

Bottlenose and spinner dolphins (*Tursiops truncatus* and *Stenella longirostris*, respectively) are the most likely marine mammal species to be encountered in the submerged lands offshore out to the 164 feet (50 meters) isobath (e.g., JGPO 2010).

The U.S. Navy prepared a comprehensive compilation of data and literature concerning the protected and managed marine resources for the Mariana Operating Area. The area assessed was south of Pagan and included the waters off of Guam, Tinian, and FDM. Prior to 2007, there was little information available on the abundance and density of marine mammals in the Mariana Islands (DoN 2005, DoN 2004, 2010). The Mariana Islands Sea Turtle and Cetacean Survey (MISTCS) conducted from January through April 2007 in waters around Guam and the Northern Mariana Islands was the first systematic survey effort for marine mammals in this region (DoN 2004, DoN 2010). The surveyed area included waters off Guam and Tinian; however, the northern boundary of the MISTCS survey area was south of Pagan (DoN 2004). Other recent data from this region include marine mammal monitoring efforts associated with Navy training exercises south of Saipan and east of Guam and Rota, and recent (2008) marine mammal sightings off Tinian reported by Minton et al. (2009). A large school of spinner dolphins was sighted in mid-July 2010 during a flyover of the eastern shore of Pagan.

Sei whale. Adult sei whales are up to 60 feet (18 meters) in length and are mostly dark gray in color with a lighter belly (Jefferson et al. 1993). There is a single prominent ridge on the rostrum and a slightly arched rostrum with a downturned tip (Jefferson et al. 1993). Sei whales are most often found in deep, oceanic waters of the cool temperate zone. They appear to prefer regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins situated between banks and ledges (Kenney and Winn 1987, Schilling et al. 1992, Gregr and Trites 2001, Best and Lockyer 2002). Sei whales have a worldwide distribution, but are found primarily in cold temperate to subpolar latitudes, rather than in the tropics or near the poles (Horwood 1987). Sei whales are also known for occasional irruptive occurrences in areas followed by disappearances for sometimes decades (Horwood 1987, Schilling et al. 1992). Scientists estimate that the current worldwide population is about 80,000 individuals. After commercial whaling exhausted all known populations of this species, sei whales in the North Atlantic and North Pacific are considered to be relatively abundant by scientists, but the population in the Southern Ocean remains greatly depleted. During the 19th and 20th centuries, sei whales were targeted (along with blue and fin whales) and greatly depleted by commercial hunting and whaling, with an estimated 300,000 animals killed for their meat and oil. Other threats that affect sei whale populations are ship strikes and interactions with fishing gear, such as traps/pots. The sei whale was listed as an endangered species under Title 50 CFR, Part 17 Appendix A in 1970 (DOI 1970) and under the Federal ESA since its inception in 1973.

Marine mammal surveys were conducted in the waters off of Guam in the winter and spring of 2007, during which eight sei whales were observed (SRS-Parsons 2007).

Blue whale. Blue whales are the largest living animals. Adults in the northern hemisphere reach 75 to 92 feet (23 to 28 meters) in length (Jefferson et al. 1993). Blue whales inhabit both coastal and oceanic waters in temperate and tropical areas (Yochem and Leatherwood 1985). Feeding grounds have been identified in coastal upwelling zones off the coast of California (Croll et al. 1998, Fiedler et al. 1998, Burtenshaw et al. 2004), Baja California (Reilly and Thayer 1990), and off southern Australia (Gill 2002). Blue whales are distributed from the ice edges to the tropics in both hemispheres (Jefferson et al. 1993). Blue whales as a species are thought to summer in high latitudes and move into the subtropics and tropics during the winter (Yochem and Leatherwood 1985). Blue whales were significantly depleted by commercial whaling activities worldwide. In the Southern Hemisphere, preexploitation population

estimates range from 150,000 to 210,000 whales; recent abundance estimates range between 400 and 1,400 whales (NMFS 2008). The primary threats currently facing blue whales are vessel strikes and fisheries interactions. Additional threats that have not been documented but could affect these populations include natural mortality, anthropogenic noise, competition for prey resources, habitat degradation, and vessel disturbance. The blue whale was listed as an endangered species under Title 50 CFR, Part 17 Appendix A in 1970 (DOI 1970) and under the Federal ESA since its inception in 1973.

There is only one known occurrence of blue whale off the coast of Guam near Cocos, but this area is within the known distribution range with a higher probability of occurrence from November to May.

Fin whale. The fin whale is the second-largest whale species, with adults reaching 90 feet (27 meters) in length (Jefferson et al. 1993). Fin whales have a very sleek body, with a pale, V-shaped chevron on the back, just behind the head. The dorsal fin is prominent, but with a shallow leading edge and is set back two-thirds of the body length from the head (Jefferson et al. 1993). The fin whale is found in continental shelf and oceanic waters (Gregr and Trites 2001, Reeves et al. 2002). Globally, this species tends to be aggregated in locations where populations of prey are most plentiful, irrespective of water depth, though those locations can shift seasonally or annually (Payne et al. 1986, Kenney et al. 1997, Notarbartolo-di-Sciara et al. 2003). Fin whales are broadly distributed throughout the world's oceans, usually in temperate to polar latitudes, and less commonly in the tropics (Reeves et al. 2002). Fin whales are distributed across the North Pacific during the summer (May through October) from the southern Chukchi Sea (69° N) south to the Subarctic Boundary (approximately 42° N) and to 30° N in the California Current (Mizroch et al. 1999). During the winter (November through April), fin whales are sparsely distributed from 60° N, south to the northern edge of the tropics, near which it is assumed that mating and calving take place (Mizroch et al. 1999). The population appears to be declining due to ship strikes, entanglements, and harvesting. The fin whale was listed as an endangered species under Title 50 CFR, Part 17 Appendix A in 1970 (DOI 1970) and under Federal ESA since its inception in 1973. A recovery plan for the fin whale was drafted in 2010 (NMFS 2010b). Critical habitat for the fin whale has not been designated.

There are no occurrence records for the fin whale in the Guam area, but Guam is within the known distribution range for this species.

North Pacific right whale. North Pacific right whales have a robust body shape with an overall body color of black, although many individuals also have irregular white patches on their undersides (Reeves and Kenney 2003). There is no dorsal fin on the broad back. The largest recorded North Pacific right whales are 60 feet (18.3 meters) for females and 54 feet (16.4 meters) for males (Omura et al. 1969). Feeding habitat for right whales is defined by the presence of sufficiently high densities of prey, especially calanoid copepods (Reeves and Kenney 2003). Right whales occur in subpolar to temperate waters. The North Pacific right whale is perhaps the world's most endangered large whale species (Perry et al. 1999, IWC 2001). The North Pacific right whale historically occurred across the Pacific Ocean north of 35° N, with concentrations in the Gulf of Alaska, eastern Aleutian Islands, south-central Bering Sea, Sea of Okhotsk, and the Sea of Japan (Omura et al. 1969, Scarff 1986, Clapham et al. 2004). There are no reliable estimates of current abundance or trends for right whales in the North Pacific. However, the preexploitation size of this stock exceeded 11,000 animals. In the North Pacific, ship strikes and entanglements can pose a threat to right whales. However, because of their rare occurrence and scattered distribution, it is impossible to assess the threat of ship strikes or entanglement to North Pacific right whales at this time. Thus, the estimated annual rate of human-caused mortality and serious injury appears minimal. The reasons for the apparent lack of recovery for right whales in this region are unknown. The right whale was listed as an endangered species under Title 50 CFR, Part 17 Appendix A in 1970 (DOI 1970) and under the Federal ESA since its inception in 1973. In 2008, NMFS separated northern right whales into two endangered species; the North Pacific right whale and the North Atlantic right whale. A

recovery plan is being developed for the North Pacific right whale, and critical habitat was designated for northern right whales in the Pacific in 2006 and redefined for North Pacific right whales in 2008.

There are no confirmed records of the North Pacific right whale in the Micronesia region; however, Reeves et al. (1999) noted the remote possibility of encountering this species here. The highly endangered status of this species necessitates an extremely conservative determination of its occurrence in the Mariana area. There is a low or unknown occurrence of right whales from the coastline to seaward of Guam. Sightings have been made both in waters on and seaward of the shelf off the Hawaiian Islands (Herman et al. 1980, Rowntree et al. 1980, Salden and Mickelsen 1999); the predicted occurrence for the Mariana area reflects the possibility that right whales might be encountered close to shore and in much deeper waters. Right whales are not expected to make their way into lagoons or busy harbors such as Apra Harbor. Right whale occurrence patterns are assumed to be similar throughout the year.

Humpback whale. Humpback whales generally are found during the summer on high-latitude feeding grounds and during the winter in the tropics and subtropics around islands, over shallow banks, and along continental coasts, where calving occurs. There is a low occurrence of humpback whales near the coastlines (excluding harbors and lagoons) in the Mariana Islands. These occurrence patterns are applicable throughout the year, but they are not expected in the area from June through September. Humpback whales in other locales during the breeding season are typically found in insular shelf waters, but can also be found in deeper waters during the breeding season. Potential threats include ship strikes, entanglements, and other anthropogenic impacts. The humpback whale was listed as an endangered species under Title 50 CFR, Part 17 Appendix A in 1970 (DOI 1970) and under the Federal ESA since its inception in 1973. A recovery plan has been drafted for this species (NMFS 1991).

The winter range of the Western North Pacific stock of humpback whales extends, at least occasionally, into the Mariana region (Taitano 1991, Darling and Mori 1993).

Sperm whale. The sperm whale is the largest toothed whale species. Adult females can reach 40 feet (12 meters) in length, while adult males measure as much as 60 feet (18 meters) in length (Jefferson et al. 1993). Sperm whales show a strong preference for deep waters (Rice 1989), especially areas with high sea floor relief. Sperm whale distribution is associated with waters over the continental shelf edge, over the continental slope, and into deeper waters (Hain et al. 1985, Kenney and Winn 1987, Waring and Finn 1995, Gannier 2000, Gregr and Trites 2001, Waring et al. 2001). Sperm whales are found from tropical to polar waters in all oceans of the world between approximately 70° N and 70° S latitudes. During the past two centuries, commercial whalers took about 1,000,000 sperm whales. Despite this high level of "take," the sperm whale remains the most abundant of the large whale species. Currently, there is no good estimate for the total number of sperm whales worldwide. The best estimate, that there are between 200,000 and 1,500,000 sperm whales, is based on extrapolations from only a few areas that have useful estimates. The primary threats to sperm whales include predation by killer whales, whaling, shipping and fishing operations, and anthropogenic noise. The sperm whale was listed as an endangered species under Title 50 CFR, Part 17 Appendix A in 1970 (DOI 1970) and under the Federal ESA since its inception in 1973. A recovery plan has been drafted for this species (NMFS 2010c), and critical habitat has not been designated.

Whaling records demonstrate sightings year-round in the Mariana (Townsend 1935). In June 2001, a group of sperm whales that included a newborn calf was sighted off the west coast of Guam (Eldredge 2003). Sperm whale occurrence patterns are assumed to be similar throughout the year. During the 2007 marine mammal surveys off of Guam, 11 sperm whales were observed (SRS-Parsons 2007).

Sea Turtles

All sea turtle species are listed under the ESA. No critical habitat has been designated for any sea turtles on Guam. NMFS has jurisdiction over sea turtles while they are in the water and the USFWS has

jurisdiction over sea turtles on land, including sea turtle eggs, nesting females, and hatchlings on the beach.

Only the threatened green sea turtle and endangered hawksbill sea turtle occur regularly in the nearshore marine region of the Mariana Islands (JGPO 2010). Leatherback sea turtles are infrequently sighted in waters off Guam. Sea turtles are expected to occur year-round in all waters off Guam and CNMI, with the highest concentrations of sea turtles occurring in waters less than 165 feet (50 meters) deep around Guam (DoN 2005).

Estimates for sea turtles at Guam are generally lacking. GDAWR conducts aerial surveys that indicate the presence of a year-round population of green sea turtles in Guam's nearshore waters (DoN 2010, JGPO 2010). Aggregations of foraging and resting green turtles are often seen in close proximity to Guam's well-developed seagrass beds and reef flats, which are found in Cocos Lagoon, Apra Harbor, along Tarague Beach and Hilaan, in deeper waters south of Falcona Beach, and at several other locations throughout the island's shelf (DoN 2005). Hawksbill sea turtles have been observed via aerial surveys near river mouths and inside Apra Harbor (DoN 2005). These are areas where sponges, the preferred food of hawksbills, are common. Hawksbill turtles have been sighted in Sasa Bay inside Apra Harbor (DoN 2005, DoN 2010).

There is regular, low-density green turtle nesting on Guam (DoN 2005). Sporadic nesting by hawksbills is documented for this island (e.g., DoN 2005, JGPO 2010). Tarague, Falcona, Ritidian, Asiga, Urunao point, and the beaches along Cocos Island and Sella Bay are the most used nesting beaches on Guam (DoN 2005). GDAWR initiated a sea turtle program in 1999 to monitor nesting activity and collect population data (JGPO 2010). Currently, Haggan-watch, a community-based volunteer network administered by GDAWR, opportunistically documents nesting activity.

Loggerhead sea turtle. There are no sighting, stranding, or nesting records for loggerhead turtles around Guam. The nearest occurrences of this species are from the waters off Palau and the Philippines (Sagun et al. 2005). This species is more apt to be found in temperate waters of the North Pacific Ocean (i.e., north of 25° N) off of countries such as Japan, China, Taiwan, northwestern Mexico, and the southwestern United States including Hawai'i (Polovina et al. 2001, 2004), although Guam is identified as being within the species' overall range.

The westward flowing current of the North Pacific Subtropical Gyre system, which late juvenile stage loggerheads use when returning to the western Pacific, passes through the Marianas region (Pickard and Emery 1982, Polovina et al. 2000). As a result, the occurrence of the loggerhead turtle is low/unknown throughout the year in all oceanic waters off the coast of Guam. Since loggerhead occurrences in the waters off Guam would most likely involve transient individuals, occurrence is not expected.

Data are needed for an accurate determination on the trend of this species. The loggerhead turtle is currently listed as a threatened species by the Federal ESA. NMFS and USFWS are proposing to divide loggerhead turtles into nine distinct population segments with two segments to be listed as threatened and seven segments to be listed as endangered (NMFS and USFWS 2010). On September 22, 2011, NMFS and USFWS designated loggerhead turtles in the North Pacific Ocean as a distinct population segment (DPS), and listed that DPS as endangered (76 FR 58868).

Green sea turtle. Green turtles are by far the most abundant sea turtle found throughout the Mariana Archipelago. Aerial surveys conducted by GDAWR indicate the presence of a year-round resident population in Guam's near shore waters (NMFS and USFWS 1998a). From 1989 to 1991, green turtles accounted for at least 65.8 percent of all aerial survey sightings around the island (Davis undated). Aggregations of foraging and basking green turtles are often seen in close proximity to Guam's well-developed seagrass beds and reef flats (Davis undated, Wiles et al. 1995, DoN 2003, Abraham et al. 2004). Green turtle nesting on Guam is most prevalent at the northern and southern ends of the island.

The population of green sea turtles appears to be stable but data are needed for an accurate determination. Threats to the green sea turtle on Guam include loss of nesting habitat, nest destruction by feral ungulates and dogs, artificial lighting in nesting areas, vehicle use on beaches, and exotic vegetation. The green sea turtle was listed as a threatened species in 1978 under the Federal ESA (NMFS and USFWS 1998a). A recovery plan has been drafted for the Pacific Ocean population (NMFS and USFWS 1998a) and critical habitat has been designated for the species in the Caribbean (NMFS 1998).

Leatherback sea turtle. The leatherback turtle is the least common (NMFS and USFWS 1998b). This species is occasionally encountered in the deep, pelagic waters of the Mariana archipelago, although only a few occurrence records exist (Eckert 1993, Wiles et al. 1995). In 1978, a 113-kilogram (249 pound) leatherback was rescued from waters southeast of Cocos Island, Guam (Eldredge 2003). Leatherbacks do not nest at any of the islands in Micronesia. As a result, leatherback turtles are not expected to occur in coastal (i.e., shelf) waters around any of the islands of the Mariana chain. In oceanic waters beyond the shelf break, leatherback occurrence is low/unknown due to a lack of survey effort in those waters, the weak association between leatherbacks and insular regions of the North Pacific Ocean, and the belief that any leatherbacks encountered in the area would be transient individuals (Eckert 1993, Kolinski 2001). Data are needed for an accurate determination on the trend of this species. The leatherback sea turtle is listed as an endangered species under the Federal ESA (NMFS and USFWS 1998b).

Hawksbill sea turtle. Although there are only a few recent hawksbill occurrence records for Guam (DoN 2005, Michael 2004), historical records indicate a likely presence of this species in the coastal waters surrounding all the islands of the southern Mariana arc (Wiles et al. 1989, 1990, 1995; Kolinski 2001, Gutierrez 2004). As a result, hawksbill turtles are expected to occur in waters located inside the shelf break, including within Guam's Apra Harbor and Sasa Bay; however, since the species is highly endangered and does not occur in large numbers anywhere within the region, there are no areas of concentrated occurrence around Guam. Only one hawksbill was observed during a 3-month survey effort off the coast of Guam in 2007 (SRS-Parsons 2007). Grimm and Farley (2008) reported that hawksbills are frequently sighted in the nearshore waters surrounding Guam. However, they are less common than green sea turtles (NMFS and USFWS 2007b). According to Wiles et al. (1995), as reported in the Navy Biological Assessment, hawksbills represent about 13 percent of turtles sighted around Guam. In deeper waters beyond the shelf break, the occurrence of the hawksbill turtle is low/unknown. In these waters, the preferred habitat of the hawksbill is scarce and survey effort is minimal. Around Guam, hawksbill sea turtles feed primarily on sponges and can be seen in coral reefs, harbors, and lagoons where sponges are abundant.

Data are needed for an accurate determination of hawksbill sea turtles. The hawksbill sea turtle is threatened by loss of nesting habitat, nest destruction by feral ungulates and dogs, artificial lighting in nesting areas, vehicle use on beaches, and exotic vegetation. The hawksbill sea turtle is listed as an endangered species under the Federal ESA (NMFS and USFWS 1998c). A recovery plan for the U.S. Pacific populations of hawksbill turtles has been drafted (NMFS and USFWS 1998c) and critical habitat has been designated in the Caribbean (NMFS 1998).

Flora

***Cyathea lunulata* (no English common name).** *Cyathea lunulata* (known as Såtsa in Chamorro) is a tree fern native to Guam. 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 Reinhart 1992). Såtsa occurs on volcanic clay soils in southern Guam, typically near the edge of ravine forest and savanna habitats. Mature ferns grow to 16 feet (5 meters) tall with 6.5-foot- (2-meter-) long fronds. Såtsa is not federally endangered, but is listed as endangered by the Guam ESA.

***Heritiera longipetiolata* (no English common name).** *Heritiera longipetiolata* (ufa-halomtåno in Chamorro) is a buttressed tree growing to a height of 40 feet (12 meters). It grows from limestone, often in the rough limestone terrain of terrace cliffs. This species achieves its greatest height where it occurs in a sheltered location, but typically they are wind-stunted or broken by typhoons (Raulerson and Reinhart 1991). Ufa-halomtåno' is endemic to the Mariana Islands and is an important canopy tree in limestone forests. This species is not federally listed as threatened or endangered, but it is listed as endangered by the Guam ESA. Primary threats include deforestation and feral ungulate impacts on ufa-halomtåno' seeds and young trees.

Fire tree. The fire tree, or Serianthes, (Hayun lågo in Chamorro) is native to Guam and Rota and can reach 66 feet (20 meters) or more in height with a trunk diameter of nearly 6 feet (2 meters). Leaves are twice pinnate and superficially resemble tangantangan when young. Flowers have numerous prominent stamens, typical of the Mimosoideae subfamily. Fruits are pods, 3 to 5 inches (7 to 12 cm) long, brown in color with constrictions (Raulerson and Rinehart 1991). Type specimens collected in 1916 by Peter Nelson originated in Upe District and Abu. Both locations are now military installations, Andersen AFB and NBG, respectively. Only six adult trees have been recorded on Guam since the 1970s, located in the areas of Ritidian Point, Pati Point, and Tarzan River. At the time of listing as a federally endangered species there were at least two known mature (seed-bearing) trees on Guam in limestone forest at Andersen AFB. In 1992, super typhoon Omar killed one mature tree, but five wild seedlings were observed near the felled native adult tree (Wiles 1992). Protective fencing was erected around the seedlings in an effort to protect them from feral ungulates, but by 1994 only one seedling had survived (USFWS 1994c). In 2002, super typhoon Pongsona partially uprooted this young tree. This tree suffered regular heavy herbivory from butterfly larvae (an unidentified yellow butterfly with green larvae) but was still alive in 2006 (D. Janeke, personal observation). The tree has since died. The remaining original Serianthes is fenced and monitored. Seeds are collected by the Refuge staff and UOG who hold permits. In 1999, 20 fire trees seedlings from Rota were planted as a joint effort by USFWS, UOG, and Andersen AFB in limestone forest along a utility access road in Tarague Basin. Each seedling was protected from ungulate browsing with a wire enclosure. As of 2010, four of the original 20 seedlings survive, surrounded by a wire exclosure fence. As many as six fire trees could survive on the Island of Guam as of 2010.

Threats to the fire tree include typhoons, herbivory by feral ungulates, insect infestations, loss of genetic diversity, wildland fire, and damage from other wildlife such as strangler figs and birds or bats that might break branches or strip bark from the trees.

4.1.2.7 Other Species of Interest

Fauna

Pacific golden-plover. The Pacific golden-plover (*Pluvialis fulva*) (dulili in Chamorro) is Guam's most common shorebird. Each year, this bird arrives by the hundreds from August to October to spend the winter on Guam and then migrates back to Alaska and Russia in April. These birds will eat marine invertebrates and terrestrial insects, and are often found on expansive grassy areas or on beaches throughout Guam. The Pacific golden-plover is the most abundant common shorebird in the Pacific (Engilis and Naughton 2004), and migratory bird surveys on JRM lands indicate that it is common on Guam (NAVFAC PAC 2010b). Populations of Pacific golden-plover appear to be stable.

Brown noddy. The brown noddy (*Anous stolidus*) (fåhang in Chamorro) is a seabird. These birds nest primarily at Orote Point, on buoys in Apra Harbor, and small islets along Guam's southwest and northeast coasts. The birds build their nests of sticks on limestone rocks, cliff faces, and in trees. Since the introduction of the brown treesnake and various rat species, brown noddy populations and nesting have declined. Recent efforts to reduce invasive species on the Glass Breakwater within NBG have provided

opportunity for natural resources managers to enhance the habitat for brown noddy. The combination of habitat enhancement and invasive species eradication in this area could lead to the reestablishment of other seabird colonies on Guam. Populations of brown noddy on Guam appear to be in decline. The brown treesnake is the primary threat to brown noddy.

Yellow bittern. The yellow bittern (*Ixobrychus sinensis*) (kakkak in Chamorro) is the only native bird still commonly found on Guam. These are fairly common in Guam's southern savanna, northern forests, and even urban areas. They are excellent hunters and eat mostly geckos, snails, skinks, and insects. These birds serve an important function in controlling reptile and amphibian populations. Populations of yellow bittern on Guam appear to be stable. The brown treesnake has not impacted this species as much as others, but still poses a threat to its viability.

Coconut crab. The coconut crab (*Birgus latro*) (ayuyu in Chamorro) is the largest land-dwelling arthropod in the world, weighing up to 9 pounds (4 kilograms), measuring almost 16 inches (41 cm) in length, with a leg span of 3.3 feet (1 meter). Active mainly at night, they are solitary, living in burrows dug in sand, or in rock crevices near the coastline. Breeding occurs on land from May to September, and eggs are carried by females and released into the ocean in October and November during high tide. Their diet consists mainly of fruit, but they will also eat seeds, rotting wood, and carrion. The coconut crab is a regulated species; however, they are often illegally poached throughout Guam. Bait stations are set using coconuts to attract crabs. The current population of coconut crab on Guam is unknown. The primary threat to the coconut crab is overharvesting. Coconut crabs are regulated by GovGuam and harvesting is restricted. In addition to harvesting by humans, feral pigs have been documented to forage on coconut crabs.

Humphead wrasse. The humphead wrasse (*Cheilinus undulates*) (tangison in Chamorro) is one of the largest coral reef fishes and occurs patchily throughout much of the Indo-Pacific region. Its late maturity, longevity, predictable spawning sites, sequential hermaphroditism (the fish is born as one sex and changes into the other sex later in its life) and natural rarity make it highly vulnerable to overexploitation. The species has been subjected to largely unmanaged fisheries that have resulted in consistent marked population declines in fished areas where the species is both protected and unprotected, and with localized extirpations at the edges of its range. The population is in decline due to intensive removal for the live reef food fish trade.

Bumphead parrotfish. Bumphead parrotfish (*Bolbometopon muricatum*) (atuhong in Chamorro) are the largest of all parrotfishes, growing to 4 feet (1.2 meters) in length and 100 pounds (45 kilograms) in weight. Adults are a dull green, with the front of the head pale yellowish to pink, while juveniles are greenish to brown with five vertical rows of small whitish spots (Randall 2005). The species has a very large range, but population sizes have been declining throughout due to overexploitation. The species has nearly disappeared from Guam's reefs. They are highly desired throughout their range and have declined from overharvesting in most places. Overfishing by net and spear is the primary threat to this species. Loss of habitat is also attributable to their decline.

Giant clam. Giant clams (*Tridacna* spp.) (hima in Chamorro) are culturally significant and are considered a prized delicacy. Guam is known to have had at least six kinds of giant clam: *Tridacna maxima*, *T. derasa*, *T. crocea*, *T. squamosa*, *T. gigas*, and *Hippopus hippopus*. The latter two species are believed to be extirpated on Guam, probably due to overharvesting. On Guam, giant clams can only be taken for consumption from April through July in designated areas, and commercial harvest is prohibited by law. Despite the demise of these species, harvesting still occurs. These clams are important for coral reef health because they help stabilize the substrate and improve water quality. A relocation program for giant clams was attempted in Apra Harbor; however, the clams were quickly taken by recreational divers. More data are needed; however, the population appears to be in decline. Human harvesting is the primary threat to this species.

Flora

***Tabernaemontana rotensis* (no common name).** *Tabernaemontana rotensis* is a small native tree to Guam and Rota that was proposed as federally listed endangered in June 2000 (USFWS 2000). In May 2004, based in part on a public comment by the USAF, the USFWS reexamined the basis of recognition of *T. rotensis* as a distinct endemic species on Rota and Guam, and decided to not list this species as endangered (USFWS 2004b). The USFWS discovered that in an authoritative monographic work on the genus in the Old World, *T. rotensis* was submerged in an expansive interpretation of the widespread species *T. pandacaqui*, which was originally described from the Philippines, but that in Leeuwenberg's interpretation ranges from southern China to Australia and includes several dozen previously recognized species (Leeuwenberg 1991). Differences of this sort are not uncommon regarding species or groups of related species that have broad and discontinuous ranges. The USFWS reexamined the basis for recognition of *T. rotensis* as a distinct endemic species and now considers Leeuwenberg's treatment to be the most credible taxonomic interpretation of the native *Tabernaemontana* of Guam and Rota. Based on the current USFWS understanding of its taxonomy, it does not qualify for protection under the Federal ESA. If further information becomes available that supports recognition of an endemic taxon, the USFWS will reconsider the need to list (USFWS 2004b).

Habitat for this species (or habitat necessary for the species survival) occurs in limestone forests on Guam and lowland dry forest on Rota. It grows to heights of 20 feet (6 meters) and is rather weak and spindly in appearance. A comprehensive survey of T. rotensis on Andersen AFB in 2006 indicated that 40 to 80 percent of the trees observed were in some stage of flowering throughout the year in the absence of typhoon disturbance (UOG 2007). An increase in flowering was noted in August and October.

A survey conducted by the UOG identified 21,669 *Tabernaemontana* individuals throughout Andersen AFB. These individuals occurred in an aggregated spatial distribution, revealing a clumped pattern within 265 specific sites. The average number of individuals at each site was approximately 80, with one site containing 850 individuals (UOG 2007).

The primary threat to this species on Guam is the lack of reproductive vigor and seed distribution due to a reduced number of individuals and reduced number of potential bird pollinators. Other key threats include competition with nonnative vines such as bitter melon (*Momordica charantia*), mile-a-minute (*Mikania micrantha*), and wild passionfruit (*Passiflora suberosa*); insect infestations; and browsing or trampling by feral ungulates.

Seeded Breadfruit. The seeded breadfruit (*Artocarpus marianensis*) (dukduk in Chamorro) is native to the Mariana Islands and Palau and is closely related to the seedless breadfruit (*A. altilis*). It is found in limestone and ravine forests from coastal to lower mountain slopes. The seeded breadfruit is distributed through its natural range primarily by fruit bats. The tree is single-trunked with a rounded, spreading evergreen canopy. The tree forms buttresses at its base. This species is an important canopy tree in limestone forests. Censuses conducted from 1989 to 1999 showed a dramatic decline of 65 percent in the population as a result of typhoon damage and a nearly complete lack of recruitment due to excessive seed predation and herbivory by feral deer and pigs (Wiles 2005).

Blue Marble Tree. The blue marble tree (*Elaeocarpus joga*) (known as joga in Chamorro) is a large tree up to 45 feet tall (14 meters) with distinctive horizontal and pagoda-like branching. It grows in limestone soils in open areas, or in forests and has a spherical bright blue fruit. This species is one of the dominant trees in the remaining limestone forest. The population appears to be stable or declining, but more information is needed to make an accurate assessment. Primary threats include deforestation, feral ungulates, and invasive species.

Cycad. Guam's native cycad, (*Cycas micronesica*) (fadang in Chamorro), was the most abundant tree in Guam's forest in 2002. Cycad aulcaspis scale arrived on Guam in late 2003 on ornamental plants and rapidly moved to plants in the native forest. By 2009 no seedlings or young cycad plants survived and 75 percent of mature trees had died. A bio-control beetle (*Rhyzobius lophanthae*) that preys on cycad scale (*Aulacaspis yasumatsui*) was introduced in 2005 and initially appeared to control the scale. However, the cycad blue butterfly also arrived on Guam in 2005. The combined attack from cycad aulcaspis scale and cycad blue butterfly elicited such rapid plant mortality that the species went from being the most abundant to listed as endangered by GovGuam and the International Union for Conservation of Nature. Few seeds are now produced by the weakened plants, no new seedlings survive and the population is approaching extirpation. The scale and butterfly have spread throughout Guam's forest and to the islands of Rota and Palau.

Screwpine. Screwpine (*Pandanus tectorius*) is native to Micronesia, and is found throughout the islands of the tropical Pacific to Hawaii. Trees grow to 25 feet (8 meters) tall and produce round, edible fruits, which are eaten and dispersed by fruit bats. This species has been used by native peoples for food, dental floss, flavoring for sweet dishes, medicine, thatch roofs, and clothing. In other regions, hermit crabs, scales, fungus, and loss of habitat all pose threats to kafu. More data are needed to assess the threats to this species on Guam.

4.1.2.8 Invasive Species

An invasive species is defined in EO 13112, *Invasive Species*, as a species that is nonnative (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, or 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 Guam. Attributes of island biota include small geographic ranges and population size, low reproductive rates, and lack of the ability to coevolve with 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 Guam have resulted in replacement of many island species by exotic and invasive species (Wiles et al. 2003).

Many of the native species on Guam are imperiled due to introduced predators, such as the brown treesnake, feral cats and dogs, and introduced ungulates such as the Philippine deer and feral pig. Other species such as the black drongo are competitors for nesting and foraging sites and also prey on other birds. Several species of rats, including the brown rat, black rat, and Polynesian rat, have colonized the island and also prey on the eggs and young of native species and destroy native flora (USAF 2009).

NAVFACPAC is developing a Bio Security Plan to address adverse impacts to installation natural resources and mission as a result of invasive species. The INRMP will be updated to reflect the Bio Security Plan when it is completed. Details regarding several invasive flora and fauna species are given in the following paragraphs.

Flora

Invasive plant species have impacted all terrestrial environments 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. Disturbances due to human activity, feral ungulates, or other causes create areas vulnerable to the establishment of invasives. Although many invasive plant species are present on Guam, a few species are of particular concern to JRM natural resources staff due to their abundance, aggressive growth, and invasion of native habitats. All of the species discussed in the

following paragraphs are abundant on Guam and are threatening native species and habitats (U.S. Navy 2009).

Chromolaena. Chromolaena (*Chromolaena odorata*), also known as Siam weed, grows in dense stands, outcompeting native species. It also prevents the establishment of other species via allopathy. Chromolaena is a skin irritant and an allergen. The establishment of this species can lead to uncontrollable brushfires (U.S. Navy 2009).

Indian snakeweed. Indian snakeweed (*Stachytarpeta indica*) grows aggressively in disturbed areas, such as along roadsides. It is also known to grow in rice fields and coconut plantations (U.S. Navy 2009).

Giant sensitive plant. Giant sensitive plant (*Mimosa diplotricha)* is more of a problem for cultivated areas and grasslands. It smothers other plants by growing over the top of them. Once established, giant sensitive plant can prevent animals from using the natural forage (U.S. Navy 2009).

Mile-a-minute vine. Mile-a-minute vine (*Mikania micrantha*) grows at rates up to one inch (3 cm) per day. It overtakes other plant communities by smothering them and blocking out sunlight. It also releases chemicals to inhibit other plants growth (U.S. Navy 2009).

Chain-of-love vine. Chain-of-love vine (*Antigonon leptopus*) 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 (U.S. Navy 2009).

Mission grass. Mission grass (*Pennisetum polystachion)* competes with native plant species, especially on open hillsides. Mission grass can act as a host for the maize streak virus. Well-established populations can serve as a fuel source for brushfires (U.S. Navy 2009).

Common bamboo. Common bamboo (*Bambusa vulgris*) grows in very dense clumps displacing native vegetation. It also spreads rapidly by its rhizomes (U.S. Navy 2009).

Burr marigold. Burr marigold (*Bidens alba*) is abundant in disturbed areas on 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. Burr grass (*Cenchrus echinatus*) 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).

Seaside clerodendrum. Seaside clerodendrum (*Clerodendron inerme*) has aggressive growth characteristics, produces numerous seeds, and can naturalize in places where it is planted. It has the potential to form dense brambles smothering other plants. Invasion is most likely to occur in coastal sites, where it thrives (U.S. Navy 2009).

Tall reed. Tall reed (*Phragmites karka)* is a native species that acts like an invasive species by invading wetlands and river banks, forming dense, monotypic stands (U.S. Navy 2009).

Tangantangen. The tangantangen tree **(***Leucaena leucocephala***)** grows in dense thickets, often so thick that it replaces naturally occurring ecosystems, leaving disturbed ground areas unusable and inaccessible. This species is wind-dispersed and spreads and establishes easily on disturbed soils such as road edges and clearings (U.S. Navy 2009).

African tulip tree. The African tulip tree (*Spathodea campanulata*) invades agricultural areas and natural ecosystems. This evergreen smothers other trees and crops, often becoming the dominant plant in the area. It rapidly spreads by sending up shoots from its roots and is considered one of the 100 most invasive plants worldwide (U.S. Navy 2009).

Vitex. Vitex (*Vitex parviflora*) is a Philippine species that was introduced to Guam prior to 1970 (Stone 1970) and has since become a common component of its forests (NAVFAC Pacific 2010b). Vitex quickly establishes in disturbed areas displacing native vegetation. This tree produces numerous seeds which are spread by birds, Philippine deer, feral pigs, and other animals.

Limeberry. Limeberry (*Triphasa trifolia*) is a common, naturalized shrub of limestone forests, often forming dense, spiny thickets of undergrowth. This species flowers on Guam and spreads by sprouting from roots (U.S. Navy 2009).

Bay rum. Bay rum (*Pimenta racemosa*) occurs in dry and moist forests, and in open areas. The tree produces berries, which when dry, are eaten by birds and dispersed through droppings (U.S. Navy 2009).

Custard apple. Custard apple (*Annona squamos*) forms dense, monotypic stands which displace native vegetation. It also is a prolific fruit bearer, accelerating seed dispersal (U.S. Navy 2009).

Hydrilla. Hydrilla sp. is a submerged aquatic plant that can grow to the surface and form dense mats. Hydrilla can grow in almost any freshwater environment, in water depths ranging from a few inches to more than 20 feet (6 meters). Hydrilla outcompetes native submerged plants by shading or crowding out these species. It can greatly slow water flow and interferes with boating and fishing. Dense hydrilla infestations can alter water chemistry and oxygen levels (Ramey 2001). Hydrilla occurs in freshwater bodies on Guam, including the Fena Reservoir and several streams (U.S. Navy 2009).

Fauna

Birds

Black drongo. The black drongo was introduced to the Island of Saipan to control agricultural insect pests and immigrated to the Island of Guam where it has become a nuisance species. It can be taken by any legal means during regulated times, in accordance with Guam law, year round. The black drongo occurs in developed areas (U.S. Navy 2009).

Black francolin. The black francolin was introduced to Guam from India in 1961. Francolins are a type of game bird, which means they are hunted for sport and food. The black francolin has done well on Guam. They are found throughout the southern and central portions of the island and parts of the north. They live in fields with tall grass and are most common in savanna and agricultural areas of southern Guam. They eat seeds and insects, including those that damage crops (GDAWR 2012).

Blue-breasted quail. This species was formerly raised as a hobby by residents of Guam. Due to predation by the brown treesnake, the hobby has generally been abandoned (USGS 2012).

Eurasian tree-sparrow. The Eurasian tree-sparrow lives in highly disturbed, urban areas surrounded by automobiles, predatory domesticated animals, and fragmented habitat. Its numbers are relatively low due to predation by the brown treesnake (USGS 2012).

Chestnut manikin. The chestnut manikin is a small grassland bird that has persisted on Guam but in low population numbers (USGS 2012).

Rock dove. Rock doves were at one time abundant in urban and commercial areas; today they are considered uncommon on Guam (USGS 2012).

Island collard dove or Phillipine turtle dove. The island collard dove is a habitat generalist that has been found to suffer nest losses of 74–93 percent attributed to brown treesnakes. Its high reproductive output and ability to use a wide spectrum of nest sites and feeding ranges has allowed the island collard dove to persist on Guam. Poor nesting success demonstrated by studies done in 1984 and 1986, raise doubts as to this species' continued survival on Guam. Population levels have declined 80–90 percent or more throughout Guam (USGS 2012).

Red junglefowl. The red junglefowl is a feral chicken once commonly found on several Pacific islands. It is sometimes raised by residents as a fighting chicken, but its population has diminished due to predation by brown treesnakes.

Mammals

Feral ungulates are responsible for destroying wetland and forest vegetation and habitat, increasing erosion, and degrading water quality on Guam. Ungulate Management Plans have been developed for NBG and Andersen AFB, and are included in **Appendix O** of this INRMP. Feral ungulates occurring on Guam and other invasive mammal species are discussed in the following paragraphs.

Asiatic water buffalo. The Asiatic water buffalo (carabao in Chamorro) was introduced to Guam in the 1600s for use as draft animals in agriculture. These are the largest mammals on Guam, weighing up to 1,500 pounds. These ungulates feed on herbaceous vegetation primarily during the morning and evening hours. During the heat of the day, carabao rest in shade and create mud wallows in order to keep cool. Feral carabao can live up 25 years and the females can reproduce at 2 to 3 years of age. Females can breed year round. There are at least two feral herds of carabao, the largest on the NMS and another in the Bubulao watershed adjacent to the NMS (U.S. Navy 2009). Carabao also occur as individuals or in small groups at several locations on Guam.

Philippine deer. Philippine deer were introduced to Guam in the late 1700s by the Spanish and a population of the deer is still present throughout most of the undeveloped lands on Guam. Philippine deer inhabit limestone, ravine, and savanna plant communities; and graze on herbaceous vegetation and young shoots of woody plants. Females can breed as early as 6 months of age, and breed year-round, generally having one offspring at a time. Adult Philippine deer live for approximately 8 years (U.S. Navy 2009).

Since the Philippine deer is a nonnative species with no natural predators, its population is high and has become stable due to carrying capacity (U.S. Navy 2009). Philippine deer grazing on native tree seedlings adversely affect native tree regeneration. Grazing on the herbaceous understory plant species also exposes the soil to accelerated erosion (U.S. Navy 2009). Philippine deer are also a major reason for the near extirpation of the endangered tree species *Serianthes nelsonii* from Guam (USFWS 1994c). Andersen AFB has an organized hunting program for Philippine deer. The hunting program is currently being revised.

Feral pig. Feral pigs (babuis in Chamorro) inhabit similar habitat as Philippine deer (limestone, ravine, and savanna plant communities). Feral pigs average 86 pounds for males, and 67 pounds for females. Feral pigs are omnivorous, consuming a variety of food items including fruit, seeds, vegetation, young birds and eggs, reptiles and their eggs, and will scavenge other animal carcasses. The staple food of feral pigs on Guam is earthworms. Feral pigs forage for their food by digging up the soil (i.e., rooting). Similar to water buffalo, feral pigs create mud wallows to keep cool during the heat of the day. Females can breed as young as 6 months of age and have an average litter size of five (U.S. Navy 2009).

Feral pigs rooting for food decrease native tree regeneration. One feral pig can root up or till 270 square feet (25 square meters) of soil in one night (Conry 1988). This causes erosion, roots up native plants, and provides optimum conditions for invasion by alien plants. All ungulates increase the spread of exotic plants and edge effect. Ungulates facilitate the spread of invasive plants into the native forest interior by creating open trails (edges) and spreading seeds through their feces. Similar to water buffalo and Philippine deer, feral pigs have no natural predators. Hunting, both legal and poaching, has had minimal effect on the overall population of feral pigs. Andersen AFB has an organized hunting program for feral pigs (U.S. Navy 2009). The hunting program is currently being revised.

Other species. Other established invasive mammals that potentially affect the natural resources on Guam include feral dogs, cats, musk shrew, and four species of rats and mice. All of these naturalized introduced mammal species currently found on Guam are deleterious to the remaining native fauna. Rats, shrews, cats, and dogs prey on birds, eggs, lizards, and insects (U.S. Navy 2009).

Reptiles and Amphibians

Several introduced reptiles are established on Guam, including the house gecko (*Hemidactylus frenatus*), curious skink (*Carlia fusca*), brahminy blind snake, and brown treesnake. Although all of these species are of concern, the brown treesnake is responsible for catastrophic changes to the Guam's ecosystem. The curious skink is ubiquitous on Guam and inhabits disturbed sites such as suburban lawns and secondary forests. The introduced house gecko is the most common gecko observed on Guam (U.S. Navy 2009).

Brown treesnake. The brown treesnake is a nocturnal, arboreal snake that was accidentally introduced to Guam from the Admiralty Island group of northern Papua New Guinea following World War II. Its native range includes northern Australia, eastern Indonesia, New Guinea, and the Solomon Islands. Brown treesnakes inhabit all habitats in Guam, including developed areas. The snake is a vertebrate generalist feeding on small prey items including mammals, birds and their eggs, reptiles (skinks and geckos) and their eggs, and amphibians. Brown treesnakes first reproduce at about the age of 3 years, when they are 4 to 5 feet (1 to 1.5 meters) long. Females lay 2 to 12 leathery-shelled eggs, and can lay two clutches per year. Large adults can be 10 feet (3 meters) long and weigh up to 5 pounds (U.S. Navy 2009).

The lack of predators and competition on Guam has allowed the snake population to increase to the highest densities in the world, and, as a result, has devastated Guam's native fauna. The brown treesnake is responsible for the extinction or extirpation of 9 of the 12 native forest birds and 2 of 11 native lizards on Guam. The rapid nature of the decline of the birds was especially dramatic in the early to middle 1980s. Native fruit bats also have experienced similar declines. Although bird populations have dramatically declined, other food sources have become available for the brown treesnake, such as the recent introductions of several frog species that have established and developed breeding populations. The brown treesnake is the single greatest factor preventing the recovery of terrestrial ecosystems in Guam (Colvin et al. 2005). Brown treesnakes are also a serious urban pest causing widespread power outages and concerns for human safety (USAF 2009).

Reduction of the brown treesnake population on Guam has proven to be extremely difficult and expensive; however, some success has been achieved on JRM lands. For example, brown treesnake trapping outside of swiftlet caves in the NMS appears to be improving swiftlet numbers (U.S. Navy 2009).

Efforts to control the brown treesnake on a landscape level on Guam are priority for wildlife managers. Of equal importance is the prevention of the spread of the brown treesnake to other Pacific islands including the Mariana Islands archipelago and Hawai'i. The Brown Treesnake Technical Working Group

is managed by Federal legislation to coordinate interagency efforts for brown treesnake control. Ongoing research by the USGS Biological Resources Division (BRD) includes development of snake control methods, establishment of snake-free areas, and study of basic snake ecology. The USDA-WS is contracted by DOD to conduct brown treesnake control and interdiction efforts on NBG and AAFB to prevent snakes from getting into the DOD transportation network. In addition, several projects addressing brown treesnake control and eradication have either been initiated, or are planned for future implementation on DOD lands on Guam. Examples of these projects include targeted aerial application of acetaminophen, research on large-scale population suppression efforts, investigating use of a protein substrate for treesnake attraction and as bait, and development of non-prey bait for delivery of acetaminophen. A detailed description of these projects, including the agency performing the project, project time frame, funding source, project location, and the project purpose, can be found in **Appendix O**.

Frogs. Since 1937, 13 species of nonnative anurans have been recorded on Guam (Christy et al. 2007). Eight of these species were recorded for the first time in Guam in the period from May 2003 to December 2005, all apparently the result of arrivals to the island since 2000 (Christy et al. 2007). Three of the eight species (*Rana guentheri,* Hong Kong whipping frog, and greenhouse frog) had well-established breeding populations by 2005, and as many as six species are believed to currently have breeding populations (Christy et al. 2007). A further three (*Fejervarya* cf. *limnocharis*, the crab-eating frog, and *Microhyla pulchra*) were recorded from a number of individuals, but it is not known whether these species have established breeding populations. Two species (*Kaloula pulchra* and coqui) appear to be incidental transportations to the island that have not established. In addition, a single specimen of *Pseudacris regilla* was recently discovered. The species had been transported to Guam on two previous occasions. Prior to 2003, five anuran species, all introductions, had been recorded on Guam. Three of these, *Polypedates leucomystax*, *Pseudacris regilla*, and *Kaloula picta*, were detected on Guam in incoming cargo and destroyed. Two species were established: marine toads were deliberately introduced and the eastern dwarf tree frog was probably an accidental introduction (U.S. Navy 2009).

Invertebrates

Scarab beetles. Two species of scarab beetle, *Protaetia orientalis* and *P. pryeri*, were first noted on Guam in 1976 and 1990, respectively. Both scarab beetle species are present on JRM lands and continue to be a threat to native vegetation. These species can lead to reduced or dead leaves, decreased plant production or regeneration, disease, or death of plants. In addition, these insects are impacting species that are concurrently affected by habitat loss and reduced recruitment including the fadang, and Erythrina trees (U.S. Navy 2009). 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 tassles, silk, and occasionally kernels of corn (Schreiner and Nafus 1986). More recently, this species has also become a threat to native plant species. Feeding by adult *P. orientalis* on flowering ifil trees, reduced the seed set of this important native forest tree on JRM lands on Guam by almost 98 percent in 2003 (U.S. Navy 2009).

Coconut rhinoceros beetle. The coconut rhinoceros beetle (CRB) (*Oryctes rhinoceros*), an introduced, invasive species, was first detected on Guam in the Tumon Bay on September 12, 2007 (Moore 2007). This large scarab beetle is a serious pest of palm trees, including coconut and betelnut, and also *Pandanus*. The beetle is also known to attack banana, taro, pineapple, and sugar cane. This species can lead to reduced or dead leaves, decreased plant production or regeneration, disease, or death of plants (U.S. Navy 2009). Adult coconut rhinoceros beetles damage palms by boring into the center of the crown, where they injure the young, growing tissues and feed on the exuded sap. As they bore into the crown, they cut through developing leaves (Moore 2007). When the leaves grow out and unfold, the damage appears as V-shaped cuts in the fronds or holes through the midrib. Adult feeding damage to

young palms is often lethal, either through direct injury to the growing tip, or from secondary infections of bacteria and fungi. Immature stages (eggs, grubs, and pupae) are found in dead coconuts and piles of rotting vegetation such as sawdust and leaf litter (Moore 2007).

An initial delimiting survey conducted by the Guam Department of Agriculture and the UOG indicated that as of October 2007, the CRB infestation was limited to Tumon Bay and Faifai Beach on Guam's northwest coast, an area encompassing approximately 1,000 acres (405 hectares) (Moore 2007). Following the survey, the Guam CRB Eradication project was launched. Two tactics were employed including mass trapping of adults using a commercially available pheromone, oryctalure (ethyl 4-methyloctanoate), and sanitation of breeding sites by removal and destruction of decaying vegetation, wherever grubs were found. Mass trapping has been ineffective, but there are currently about 700 traps across Guam that are now used to monitor flight activity and geographical spread of the CRB population (Moore 2011). Sanitation has been successful in limiting population growth, slowing spread of the beetle, and reducing damage in the Tumon Bay hotel area. Detected breeding sites are removed and destroyed by physically removing decaying logs, stumps, and other dead vegetation. The material is transported outside of the infested area where it is either disposed of by burial or used in a composting operation (Moore 2011).

A quarantine regulation has been imposed by the Guam Department of Agriculture, which prohibits transport of green waste from within a prescribed quarantine zone without inspection or treatment. The area of the quarantine zone has been extended several times since the beginning of the CRB infestation. The extent of the quarantine area set on September 24, 2010, is 28,360 acres (11,477 hectares). Quarantine might have slowed down the initial spread of the CRB, but there are current CRB sites that are outside the quarantine area that extends north from the southern end of Tumon Bay and includes Andersen AFB, and Andersen South (Moore 2011).

As of 2011, the only conventional insecticides that have proven effective against CRB on Guam are the fumigants methyl bromide and phosphine. Biological controls have also been considered. An insect virus attacking CRB has been used successfully for suppressing CRB populations on other Pacific Islands, but several laboratory bioassays indicate that the Guam CRB are not susceptible to several strains of virus that have been tested (Moore 2011).

Cycad scale. The cycad scale is native to Southeast Asia and is rapidly spreading worldwide. The scale has destroyed in excess of 70 percent of the endemic cycads on Guam. Initial damage appears as chlorotic spots. Scale populations quickly reach high densities causing necrosis of fronds and eventually plant death. Cycads in JRM are a very important component of the forest that is rapidly being lost.

The UOG has conducted several studies to determine the impact of cycad scale to the endemic cycads on Guam. A few of these studies include research on the relationship between insects and reproduction in seed-bearing plants (including cycads); injecting chemicals directly into the cycad to control not only Asian cycad scale, but also the cycad blue butterfly (*Chilades pandava*); and studies into using a scale-eating ladybug beetle as a form of biocontrol.

The Navy also has a Cycad Collection located at the base of Mount Lasu on Tinian. In 2005, Navy Region Marianas contracted surveys and collected viable seed for propagation from habitats throughout Guam. More than 3,000 cycad 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 seedlings were planted in a mapped experimental design on Tinian. The plants have been monitored monthly and encroaching vines and weed-like vegetation is removed. As a preventative measure, young plants are sprayed twice monthly to eliminate any infestations of cycad blue butterfly larvae.

Little Fire Ant. Little Fire Ant (*Wasmannia auropunctata*) was confirmed on Guam in November 2011, The first sighting was on Yigo, followed by subsequent discoveries in Dededo, Nimitz Hill, Piti, Santa Rita, Umatac, and Malesso. This species is highly destructive to the local ecology, is a generalist in its diet and life history, occurring in trees, on plants, in the grass or under leaf debris and stones. Occurring in the hundreds where found, it bites en masse if disturbed by an animal or human, causing a rash and severe itching. It is particularly problematic for children. Experts on ants in Australia, New Zealand, and the United States suggest that this ant has been on Guam for up to 10 years. Eradication measures include proper management of green waste, destruction of existing colonies, and reducing plant movement on Guam. No information on mode of entry and distribution of this species is available (RISC 2012, UFL 2012).

4.2 Naval Base Guam Main Base

4.2.1 General Physical Environment

4.2.1.1 Climate

The climate at NBG Main Base is the same as the climate for Guam as a whole. See **Section 4.1.1.1** for a description of the climate on Guam.

4.2.1.2 Geology and Topography

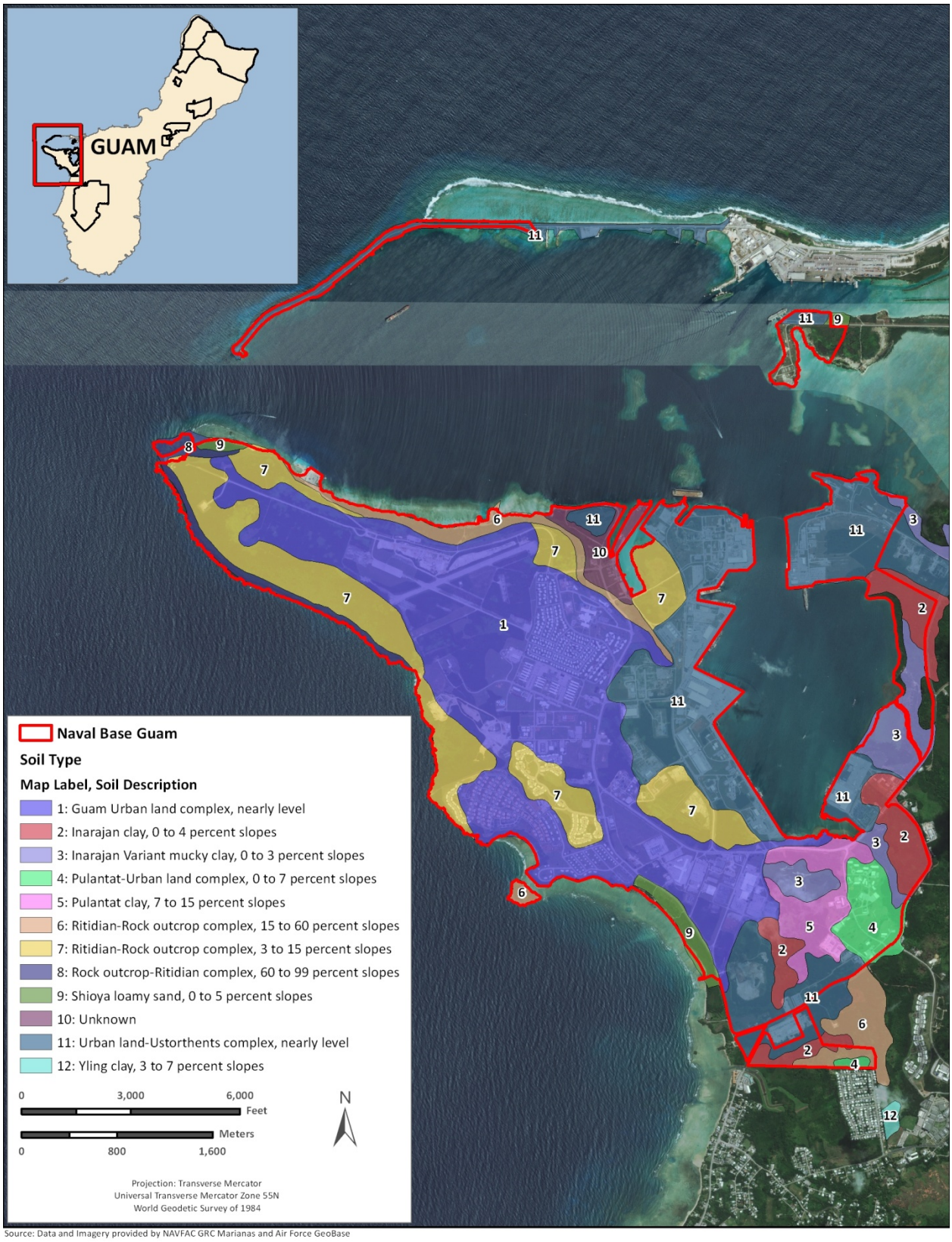
Geologically, NBG Main Base is closer aligned with the northern structural province (see **Figure 4-1**). The underlying rocks are composed of coral limestone. Orote Peninsula is a raised limestone plateau reaching 190 feet (58 meters) in elevation above mean sea level (msl) (see **Figure 4-2**). The plateau slopes eastward to near sea level. Much of the land area has been substantially altered by shaping, dredging, and filling. The Dry Dock Island Peninsula, Polaris Point, and sections of the shoreline are the result of dredging and filling (U.S. Navy 2009).

4.2.1.3 Seismology

The lands surrounding Apra Harbor and the Inner Harbor on NBG are considered to be susceptible to inundation from a large tsunami (GHS 2008). Portions of the Main Base on NBG are susceptible to tsunami inundation from distances of 0.5 to more than 1 mile (2 kilometers) inland from the Inner Harbor (GHS 2008).

4.2.1.4 Soils

NBG Main Base is dominated by shallow, well-drained limestone soils; however, areas of soils formed on bottomlands and soils formed on volcanic plateaus are also present in specific areas. Large areas of the Orote Peninsula have highly disturbed soils classified as urban, and extensive areas along Apra Harbor consist of coastal fill and are covered by roads, buildings, and parking lots. Coastal and depressional areas often include poorly drained soils formed from a variety of sources (i.e., limestone, volcanic, and beach deposits). Upland soils are dominated by highly weathered shallow, well-drained volcanic soils (see **Figure 4-4**).



Source: Data and Imagery provided by NAVFAC GRC Marianas and Air Force GeoBase

Figure 4-4. Soils on Naval Base Guam Main Base

4.2.1.5 Hydrology

Groundwater. NBG Main Base is approximately 4 miles (6.4 kilometers) south of the southern extent of the NGLA. It is located primarily on porous coralline limestone and disturbed or created land. Infiltration in the coralline limestone is rapid and groundwater occurs at base level. There is no named aquifer system under NBG.

Surface Water. NBG Main Base is within the Apra Watershed. Several rivers flow from a general east-to-west direction across NBG (see **Figure 4-5**). The Masso River is adjacent to the northern boundary of NBG and is just north of the Apra Watershed boundary. The river flows into the Philippine Sea. The Sasa River flows from east to west in the northern section of NBG and discharges to Sasa Bay. The Aguada River is south of the Sasa River and also flows from east to west and discharges to Sasa Bay. The Atantano River is south of the Aguada River and flows from east to west into Inner Apra Harbor after being joined by the Tenjo River to the east of NBG. See **Section 4.2.2.2** for additional information regarding freshwater ecosystems on NBG.

4.2.2 General Biotic Environment

4.2.2.1 Terrestrial Ecosystems

Flora

Vegetation communities on NBG Main Base include limestone, ravine, and wetland communities. See **Figure 4-6** for a map of the terrestrial vegetation communities occurring on NBG.

Limestone Communities. Limestone communities are situated on slopes found within NBG Main Base. Relatively large disturbed limestone communities are present on the lower slopes of Orote Peninsula and a narrow band of halophytic-xerophytic scrub communities exists on the cliff faces (U.S. Navy 2009).

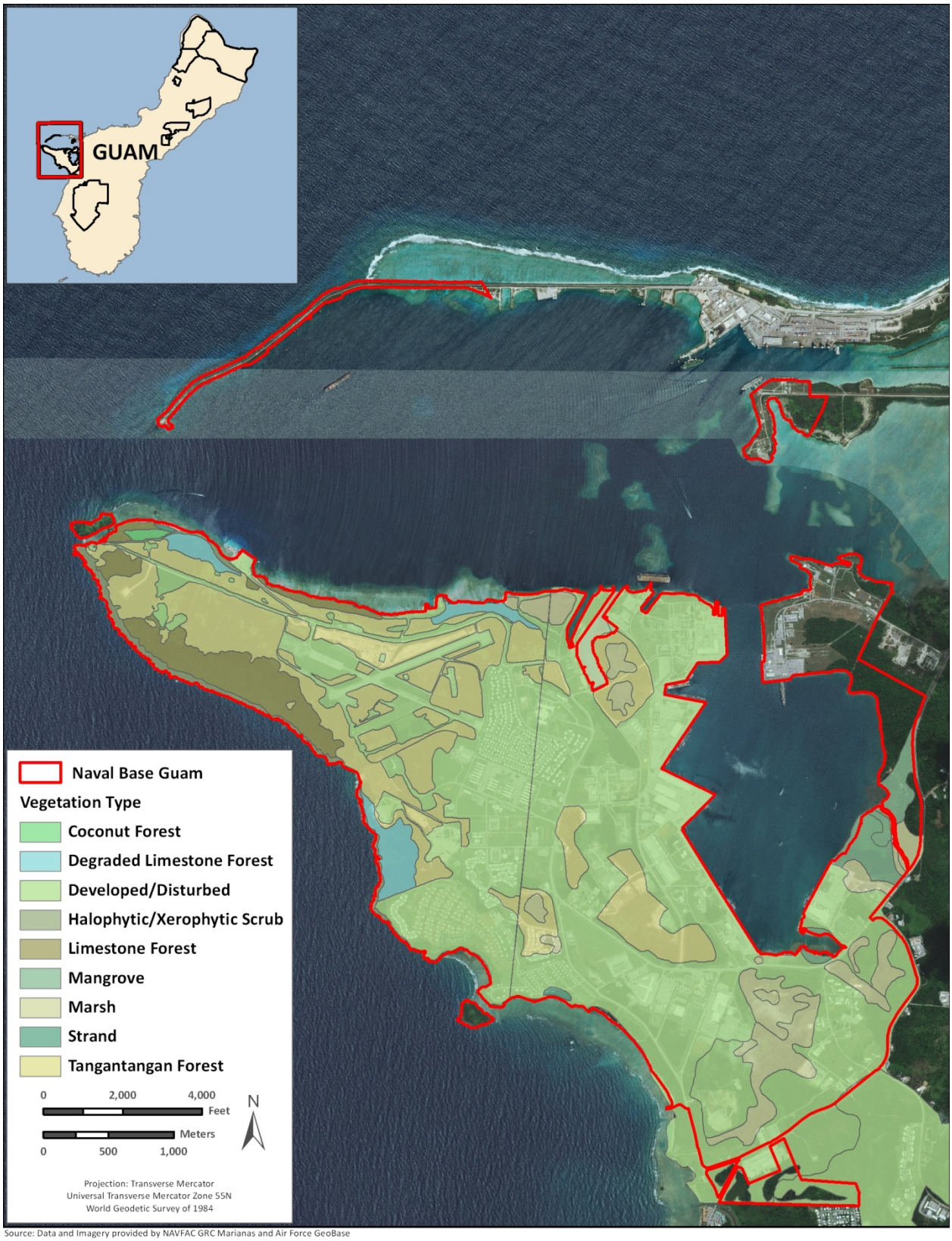
Vegetation surveys were performed along a transect in the upper plateau to the west of the old runway in the southern sector of Orote in 2008. The area has rugged limestone karst topography. The limestone forest was characterized by native *Neisosperma oppositifolia* (fagot in Chamorro), which composed 28 percent of the relative density. Collectively, approximately one-third of the relative tree density within this transect were composed of introduced understory tree species (i.e., tangantangan, limeberry, and papaya). The remaining two-thirds of the relative density are composed of native species, including the Mariana Islands endemic species *Aglaia marianennsis* and *Tabernaemontana rotensis*. Absolute cover was highest for native upper canopy tree species including *Ficus rolix*, *Pisonia grandis*, and *Tristiropsis acutangula* (NAVFAC Pacific 2010b). Based on a 2008 vegetation survey on Polaris Point, tangantangan composed 88 percent of the tree layer within the transect (NAVFAC Pacific 2010b).

Ravine Communities. Within NBG Main Base, ravine forests are restricted to narrow strips along the few freshwater drainages near the coast (U.S. Navy 2009).

Wetland Communities. The wetland areas of NBG Main Base were originally delineated and mapped in 1998 (Dueñas and Associates 1998). In March, May, and September 2007, biologists revisited the wetlands areas delineated in 1998 and found that the 1998 boundaries had not changed in most locations (AECOS and Wil Chee 2009). In 2010, a wetland study was conducted in specific project areas to identify wetlands that could be affected by the proposed alternatives analyzed in the Guam and CNMI Military Relocation Environmental Impact Statement (EIS) (JGPO 2010).

Source: Data and Imagery provided by NAVFAC GRC Marianas and Air Force GeoBase

Figure 4-5. Surface Water and Wetlands on NBG Main Base



Source: Data and Imagery provided by NAVFAC GRC Marianas and Air Force GeoBase

Figure 4-6. Vegetation Communities on NBG Main Base

Based on the original 1998 survey and the recent 2007 survey, there are approximately 343 acres (139 hectares) of wetlands in 48 separate wetlands within and adjacent to NBG Main Base. These wetlands range in size from 0.04 to 88.73 acres (0.02 to 35.90 hectares) and include freshwater and brackish water habitats. Estuarine wetlands (i.e., brackish water wetlands) on NBG are discussed in **Section 4.2.2.3**. In addition, there is a large 100-acre (40.5-hectare) wetland complex in Camp Covington. **Figure 4-5** presents wetland areas as delineated in 2007 (AECOS and Wil Chee 2009). Jurisdictional determinations were not obtained from the USACE for the wetlands that were delineated in 2007 (JGPO 2010).

Palustrine wetlands on NBG Main Base are the result of closed-basin features or lowlands isolated by fill as the military base developed (AECOS and Wil Chee 2009). Palustrine wetland communities are situated southeast of Sumay Cove, North Tipalao, and in Camp Covington (see **Figure 4-5**).

The Sumay Cove wetland (Wetland C) is southeast of Sumay Cove and is separated from it by coral-gravel fill for a roadway. The wetland is primarily a marsh (i.e., herbaceous vegetation) with *Hibiscus tiliaceus* swamp areas to the west and south (AECOS and Wil Chee 2009). The herbaceous vegetation includes *Urochloa mutica*, *Scirpus littoralis*, *Acrostichuim aureum*, *Saccharum spontaneum*, and *Thelypteris interupta* (Dueñas and Associates 1998).

The North Tipalao wetlands, on the western side of the installation, occur on a limestone plateau with typical karst topography consisting of shallow depressions of various sizes. Two palustrine wetlands, encompassing 10 acres (4 hectares) (Wetland G), and 0.3 acres (0.1 hectares) (Wetlands M), were delineated in this area. The larger wetland is surrounded by growth of pago and the fern association of *Acrostichum aureum* and *Thelypteris interrupta* occupies most of the area (Dueñas and Associates 1998). In the smaller wetland, Dueñas and Associates (1998) found *Polygonum minus* fringing a shallow open water area, and typical weedy vegetation consisting of *Saccharum spontaneum*, *Urochloa muticum*, and *Cyperus ligularis* occurring around the perimeter.

The Camp Covington wetland is comprised of several palustrine habitats including Wetland L (33 acres [13 hectares]), N (4 acres [2 hectares]), J(37 acres [15 hectare]), K(1 acre [0.4 hectare]), and I (1 acre [0.4 hectare]). *Phragmites karka* is the dominant vegetation in most of these wetlands. Wetland K is characterized as a swamp with *Hibiscus tiliaceus*, swamp fern, *Clerodendrum inerme* (known as lodugao in Chamorro),*Acrostichum aureum*, *Rhizophora apiculata*, and duckweed (*Lemna*) characterizing the vegetation in the habitat. The presence of *Rhizophora* is somewhat unusual as the wetland appears to be palustrine and unconnected to the harbor (AECOS and Wil Chee 2009, Dueñas and Associates 1998).

The wetland located east of Abo Cove (Wetland H), on the inland side of Marine Corps Drive is part of the larger 100-acre (40.5-hectare) open surface water and wetland complex located in Camp Covington. The wetland is approximately 24.7 acres (10 hectares) and contains both estuarine and palustrine systems. The estuarine portion is a conspicuous open mud flat surrounded by mangrove on the southeast side of Marine Corps Drive just inside the Main Gate. Since the site contains both estuarine and palustrine systems, it exhibits some of the more diverse wetland vegetation within JRM. The area fronting Marine Corps Drive is dominated by a mangrove swamp (*Rhizophora mucronata* and *Avicennia marina*) and reed marsh (*Scirpus littoralis*). The adjacent forest includes rare looking-glass (*Heritiera littoralis*) and ifil trees, and some specimens have encroached into the wetland. Further inland, the palustrine vegetation encompasses *Phragmites karka* intermixed with wild cane (*Saccharum spontaneum*) and pago trees in tangled stands (Dueñas and Associates 1998).

There is a small, 0.10-acre (0.04-hectare) palustrine emergent, persistent, seasonal wetland (Wetland X) on the east side of Marine Corps Drive that extends parallel to the road along a Navy pipeline easement. Vegetation in the wetland is characterized by an elongated patch of *Phragmites karka* (Dueñas and Associates 1998).

There is a 2.02-acre (0.82-hectare) wetland (Wetland SVO) located at the southwestern corner of the Fleet and Industrial Supply Center (i.e., tank farm) perimeter fence line and Marine Corps Drive. The wetland is a palustrine emergent, seasonal habitat (Dueñas and Associates 1998, AECOS and Wil Chee 2009). The wetland is characterized by*Phragmites karka* bordered by a forest on the south and east (AECOS and Wil Chee 2009). The north boundary of the wetland might be fill-related to the early development of the tank farm (AECOS and Wil Chee 2009). The highway or west side of the wetland is also fill-related to the construction of the road, and this side of the wetland is dominated by para grass, mile-a-minute vine, and ferns (AECOS and Wil Chee 2009).

Fauna

Birds. Avian surveys were conducted on the NBG Main Base on Orote Point and Polaris Point from 2008 to 2010. The following avian species were identified during the 2008–2010 roadside and forest bird surveys performed on Orote Point: Pacific golden-plover, black francolin, whimbrel, island collared dove, black drongo, and yellow bittern. The Pacific golden-plover, a common nonbreeding visitor to Guam, was the most common species observed on Orote Point (NAVFAC Pacific 2010b). The black francolin, island collared dove, and black drongo are common, introduced, breeding residents on Guam (NAVFAC Pacific 2010b). The whimbrel is a common nonbreeding visitor to Guam and the yellow bittern is a common, native, breeding resident on Guam (NAVFAC Pacific 2010b). Avian species documented on Polaris Point during the 2008–2010 surveys included the yellow bittern, black drongo, island collared dove, and brown noddy. The brown noddy is an uncommon, native resident of Guam that nests on Cocos Island (NAVFAC Pacific 2010b).

The Mariana common moorhen has been known to occur occasionally within the wetlands on NBG (U.S. Navy 2009). See **Section 4.2.2.5** for additional information on the common Mariana moorhen on NBG.

Mammals. Pigs, colonized from individuals at Camp Covington, were discovered on Orote Point in 2011; however, no deer or Carbao have been observed. In addition, surveys conducted in 2011 on Orote Peninsula did not detect any fruit bats. See **Section 4.1.2.1** for additional mammal species that are likely to occur on NBG Main Base. Specific species present on NBG Main Base will be included in the next update of INRMP following completion of surveys prescribed by this INRMP.

Reptiles and Amphibians. The 2008–2009 herpetofauna surveys on NBG Main Base were conducted on Orote Point and Polaris Point. Nine herpetofauna species (five native and four introduced) were documented on NBG Main Base. Seven herpetofauna species were documented on Orote Point. Of these, four species are native: Pacific blue-tailed skink, mourning gecko, stump-toed gecko, and monitor lizard; and three species are introduced: curious skink, house gecko, and brown treesnake (NAVFAC Pacific 2010b).

Eight herpetofauna species were documented on Polaris Point during the 2008–2009 herpetofauna surveys. Of these, four species are native: Pacific blue-tailed skink, moth skink (Guam listed as endangered), monitor lizard, and stump-toed gecko; and four species are introduced: curious skink, house gecko, brown treesnake, and marine toad (NAVFAC Pacific 2010b). The continued widespread presence of the brown treesnake, the curious skink, and other introduced amphibian species is of concern because of each species' potential deleterious impacts on Guam's native fauna. Of particular concern is the potential for introduced species to serve as additional food sources for the brown treesnake (NAVFAC Pacific 2010b).

The blue-tailed skink, curious skink, marine toad, Gunther's Amoy frog, and monitor lizard were also identified on NBG during site characterizations of the San Luis ponds conducted in October 2010 and

February 2011. Monitor lizards, curious skinks, and Gunther's Amoy frogs were commonly observed or heard during the site characterizations.

Invertebrates. Invertebrate species on NBG Main Base are similar in composition to those occurring on nearby areas of Guam. Specific species present on NBG Main Base will be included in the next update of INRMP following completion of surveys prescribed by this INRMP.

4.2.2.2 Freshwater Ecosystems

Six freshwater rivers cross portions of NBG Main Base (i.e., Masso, Sasa, Laguas, Aguada, Gautau, and Atanatano) (U.S. Navy 2009).

Flora

At the Route 1 (Marine Corps Drive) crossing, the Atantano River is approximately 43 feet wide and 6 feet deep (13 meters wide and 2 meters) at the downstream location on the NBG Main Base. Immediately downstream of Route 1, the river's banks consist of vertical sheet piling encrusted with marine life. Further downstream, woody vegetation is present to the edge of the bank. The benthic substrate consists of silty sand with some isolated rocks. No submerged aquatic vegetation was observed within the Atantano River during 2009–2010 natural resources surveys (NAVFAC Pacific 2010b).

At the Route 1 crossing, the Aguada River is approximately 30 feet wide and 10 feet deep (9 meters wide and 3 meters deep) at the downstream location on NBG. Approximately 50 feet (15 meters) upstream of the bridge, the river narrows to less than 3 feet (1 meter) wide and less than 1 foot (0.3 meters) deep. At the time of natural resources surveys conducted in 2009–2010, the stream had an imperceptible flow and was choked with vegetation due to a downstream logjam that had backed up the flow. Downstream of the bridge, the river pools. The pool is approximately 30 feet (9 meters) wide and 50 feet (15 meters) long. The pool then empties into a swiftly flowing stream that is less than 3 feet (1 meter) wide. On the southern bank of the pool, a strip of hydrophytic vegetation is present. Downstream of the pool, the river is swift flowing and clear, with a rocky bottom. This portion of the river flows through a forested area dominated by palms and bamboo (NAVFAC Pacific 2010b).

The Sasa River crosses the Sasa Valley Tank Farm and flows along the boundary of the Main Base before it empties into the Apra Harbor. Forested areas occur along the Sasa River upstream and downstream of the Route 1 crossing. Downstream of the bridge within NBG, the vegetation is low and denser. Upstream of the bridge, large bamboo stands line the riverbanks. No submerged aquatic vegetation was observed in the study area during the 2009–2010 natural resources surveys, although some filamentous green algae were observed on rocks immediately downstream of the bridge (NAVFAC Pacific 2010b).

Fauna

Birds. Bird species observed during the 2009 natural resources survey on NBG Main Base that could use the freshwater habitats include the yellow bittern and Pacific golden-plover (NAVFAC Pacific 2010b). Mariana common moorhens have also been observed in freshwater habitats on NBG Main Base.

Fish. Snorkel surveys were performed in the Atanatano River in January 2010. The benthic substrate consists of silty sand with some isolated rocks. No submerged aquatic vegetation was observed within the study area. Marbled eel (*Anguilla marmorata*) and rock flagtail (*Kuhlia rupestris*) were the only fish observed within the river. Both species are native to Guam and also use estuarine habitats at the mouth of the river and marine habitats (NAVFAC Pacific 2010b).

Biological and habitat assessments were performed in 2008 by GDAWR on the Atanatano, Aguada, and Sasa rivers on NBG Main Base. Species on NBG Main Base within these 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 observed within the Atanatano River during the 2008 survey include common glass fish (*Ambassis buruensis*), dusky sleeper (*Eleotris fusca*), rock flagtail, 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*). Introduced species observed within the Atanatano River included the mosquitofish (*Gambusia affinis*) and guppy (*Poecilia reticulata*) (GDAWR 2008a, NAVFAC Pacific 2010b).

Native fish species observed within the Aguada River during the 2008 habitat assessment conducted by GDAWR included the marbled eel and goby. Native species observed within the Sasa River during the 2008 survey included Engel's mullet (*Moolgarda engeli*), bandfin mullet goby, mudskipper, and feathered river-garfish. Invasive species observed within the Sasa River included the Mozambique tilapia (*Oreochromis mossambicus*) (GDAWR 2008a, NAVFAC Pacific 2010b).

Macroinvertebrates. Similar to the fish species occurring within the portions of rivers crossing NBG Main Base, the macroinvertebrates within these waters use a combination of freshwater, estuarine, and marine environments. GDAWR identified macroinvertebrates occurring within the Atanatano and Aguada rivers during the 2008 biological and habitat assessments. Native macroinvertebrates within the Atanatano River include ninja shrimp (*Caridina serratirostris*), shrimp (*Caridina* sp.), Tahitian prawn, the snail *Neritina squamipicta*, and *Thiara granifera*. Invasive macroinvertebrate species included leeches (Class Clitellata). Native macroinvertebrates observed within the Aguada River include green lace shrimp (*Atyoida pilipes*), shrimp (*Caridina* sp.), Malaysian trumpet snail (*Melanoides tuberculata*), the snail *Neritina pettiti*, mayfly larvae (order Ephemeroptera), dragonfly larvae (order Odonata), and pyralid caterpillars (family Pyralidae) (GDAWR 2008a, NAVFAC Pacific 2010b).

4.2.2.3 Estuarine Ecosystems

Estuarine communities are present on NBG Main Base at the mouths of the larger rivers and the inner waters of Apra Harbor (U.S. Navy 2009). Within Apra Harbor, marine investigations were conducted in 2009 along the wharves of Polaris Point; Oscar and Papa Wharves; Abo Cove; and Wharves S, T, U, V, and X (NAVFAC Pacific 2010b).

Estuarine wetlands under JRM control at NBG Main Base occur scattered along the western shore of Inner Apra Harbor, at the mouth of the Atantano River, and along the shores and inland of Sasa Bay (see **Figure 4-7**). Most estuarine wetlands have a hydrological connection to the Harbor and are, thus, tide lands. However, the San Luis Ponds and the wetland behind Rizal Beach appear isolated from a surface water connection to the sea, but are influenced by a saline groundwater connection. These ponds are therefore brackish (estuarine) and show a much attenuated tidal response (AECOS and Wil Chee 2009). Naval Station Marsh occurs on NBG Main Base at the base of Orote Peninsula near the coast in Apra Harbor. This marsh is listed as a wetland of primary importance for Mariana common moorhens (USFWS 1992, UNEP-WCMC undated).

Flora

Much of inner Apra Harbor supported mangrove communities prior to the dredging and filling of the Inner Apra 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 (U.S. Navy 2009).

Source: Data and Imagery provided by NAVFAC GRC Marianas and Air Force GeoBase

Figure 4-7. Wetlands on NBG Main Base

The mangrove forest present in Sasa Bay is the largest native mangrove community on U.S. land in the Pacific. Estuarine mangrove communities on NBG Main Base include the following plant species: Asiatic mangrove, large-leafed mangrove, *Avicennia* sp., *Xylocarpus moluccensis*, *Lumnitzera coccinea*, looking glass tree, sea hibiscus, and golden leather fern (U.S. Navy 2009). Estuarine marshes dominated by bulrushes are also found at several locations in Apra Harbor. The largest estuarine marsh area is the artificial San Luis Ponds. This habitat type is important for many species of migratory shorebirds, native aquatic and terrestrial invertebrates, and aquatic vertebrates (GDAWR 2006a).

The San Luis Ponds are composed of two wetland areas (Wetland 1, is saline and 18.15 acres [7 hectares] and Wetland 2, is fresh water and 2.15 acres [0.871 hectares]) located off San Luis Point (NAVFAC Pacific 2010c). These wetlands are each characterized by a pond and marsh component and are influenced by saline groundwater and seepage through the limestone fill barrier that separates the ponds from the harbor (NAVFAC Pacific 2010c, AECOS and Wil Chee 2009). Marsh vegetation in Wetland 1 is dominated by *Scirpus littoralis*, with golden leather fern, sea hibiscus, and *Pluchea indica* along the margins (see **Figure 4-8**). Marsh vegetation in Wetland 2 is also dominated by *S. littoralis*, with golden leather fern, *P. indica*, sea hibiscus, and *Phragmites karka* along the margins (AECOS and Wil Chee 2009). Mariana common moorhens were observed using the San Luis Ponds during the wetland delineation and site characterizations and surveys conducted in October 2010 and February 2011 by HDR. Yellow bittern were also observed to be common during the site characterizations.

Figure 4-8. Photograph of Marsh Vegetation in Wetland 1 of San Luis Ponds

Wetlands O, P, Q, and R, as delineated in 2007 (AECOS and Wil Chee 2009), are located on the southern and eastern shores of Inner Apra Harbor (see **Figure 4-5**). Wetland O, located at the southernmost extent of Inner Apra Harbor, is a 1.65-acre (0.67-hectare) estuarine, intertidal, scrub/shrub, broad leaved evergreen, regular tidal water regime wetland (AECOS and Wil Chee 2009). Wetland P, located along

the southern shore of Abo Cove, is a 2-acre (0.81-hectare) estuarine, intertidal, scrub/shrub, broad-leaved evergreen, regular tidal regime wetland (AECOS and Wil Chee 2009). Wetland Q, located along the northern shore of Abo Cove is a 2.53-acre (1.02-hectare) estuarine, intertidal, scrub/shrub, broad-leaved evergreen, regular tidal regime wetland (AECOS and Wil Chee 2009). Wetland R, commonly known as the Atantano Wetlands, is located along the eastern shore and inland of Inner Apra Harbor and consists 88.73 acres (35.90 hectares) of various wetland types. The Atantano Wetland is 54.75 acres (22.15 hectares) and encompasses the mouth of the Atantano River, which drains the Guatali, Tenjo, and Alpacho rivers. The wetland has been cited as containing the best-developed and most mature mangrove swamp on Guam (JGPO 2010). The most dominant classification in the Atantano Wetlands is estuarine, intertidal, scrub/shrub, broad-leaved evergreen, regular tidal (AECOS and Wil Chee 2009).

Wetlands T, S, U, W, and V2 are located along the shores and inland of Sasa Bay (see **Figure 4-5**). Wetland T, inside the southern shore of Sasa Bay, consists of 1.09 acres (0.44 hectares) of estuarine, intertidal, scrub/shrub, broad-leaved evergreen, regular tidal wetland. Wetland S, just east of Wetland T, consists of 1.45 acres (0.59 hectares) of estuarine, intertidal, scrub/shrub, broad-leaved evergreen, regular tidal wetland (AECOS and Wil Chee 2009). Wetland U is in and adjacent to the eastern shoreline of Sasa Bay and consists of 37.8 acres (15.3 hectares) of predominantly estuarine, intertidal, scrub/shrub, broad-leaved evergreen, regular tidal wetland (AECOS and Wil Chee 2009). Wetland W, at the top of a small inlet in the north of Sasa Bay, consists of 0.24 acres (0.10 hectares) of estuarine, intertidal, scrub/shrub, broad-leaved evergreen, regular tidal wetland (AECOS and Wil Chee 2009). Wetland V2 is along and adjacent to the northern shore of Sasa Bay and consists of a 3.23-acre (1.31-hectare) predominantly estuarine, intertidal, scrub/shrub, broad-leaved evergreen, regular tidal wetland (AECOS and Wil Chee 2009).

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 pressure. The distribution of the seagrass species *Halophila japonica* also seems to be restricted to Abo Cove in the inner harbor (NAVFAC Pacific 2010b).

Fauna

Birds. Two indigenous avian species, the yellow bittern and Pacific reef heron, feed the in estuaries of NBG Main Base. Exposed tidal mudflats and estuarine banks provide seasonal foraging and loafing habitat to any number of migratory and extralimital avian species. To date, more than 80 migrant and vagrant species have been recorded from Guam, most of which are protected under the MBTA. Most common among the annual visitors to the island are Pacific golden-plover, intermediate egret, Mongolian plover, gray-tailed tattler, whimbrel, ruddy turnstone, and cattle egret (U.S. Navy 2009).

Mammals. Introduced mammalian species currently established on Guam, including Philippine deer, dogs, cats, feral pigs, musk shrew, rats, and mice, would be expected to use resources within estuarine communities on NBG Main Base, especially during low tides (U.S. Navy 2009).

Fish. In 2008, a Biological and Habitat Assessment of the Atantano River conducted by GDAWR indicated that the river has the largest and best developed mangrove swamp on Guam (GDAWR 2008a, NAVFAC Pacific 2010b). Species occurring within the rivers on NBG Main Base generally use the freshwater and estuarine components of the rivers, and many spend a portion of their life cycle within the ocean. Native species observed within the Atanatano River during the 2008 survey include the following: common glass fish, dusky sleeper, rock flagtail, snappers, silver moony, bluespot mullet, bandfin mullet goby, mudskipper, bigmouth goby, gobies, and feathered river-garfish. Introduced species include mosquitofish and guppy.

Reptiles and Amphibians. The Sumay marina cove on NBG Main Base has supported endangered hawksbill sea turtle nesting attempts on the cobble and sand beach near the mangroves. Both of the introduced established amphibians on Guam, the marine toad and the eastern dwarf tree frog, use resources in estuarine ecosystems and likely occur on NBG Main Base (U.S. Navy 2009). Gunther's Amoy frog uses estuarine habitats associated with the San Luis Ponds on NBG Main Base.

Macroinvertebrates. Similar to the fish species occurring within the portions of rivers crossing NBG Main Base, the macroinvertebrates within these waters use a combination of freshwater, estuarine, and marine environments. GDAWR identified macroinvertebrates occurring within the Atanatano and Aguada rivers during the 2008 Biological and Habitat Assessments. Native macroinvertebrates within the Atanatano River include the following: ninja shrimp, shrimp, Tahitian prawn, snail, and *Thiara granifera*. Invasive macroinvertebrate species include leeches. Native macroinvertebrates observed within the Aguada River include the following: green lace shrimp, shrimp, Malaysian trumpet snail, snail, mayfly larvae, dragonfly larvae, and pyralid caterpillars (GDAWR 2008a, NAVFAC Pacific 2010b).

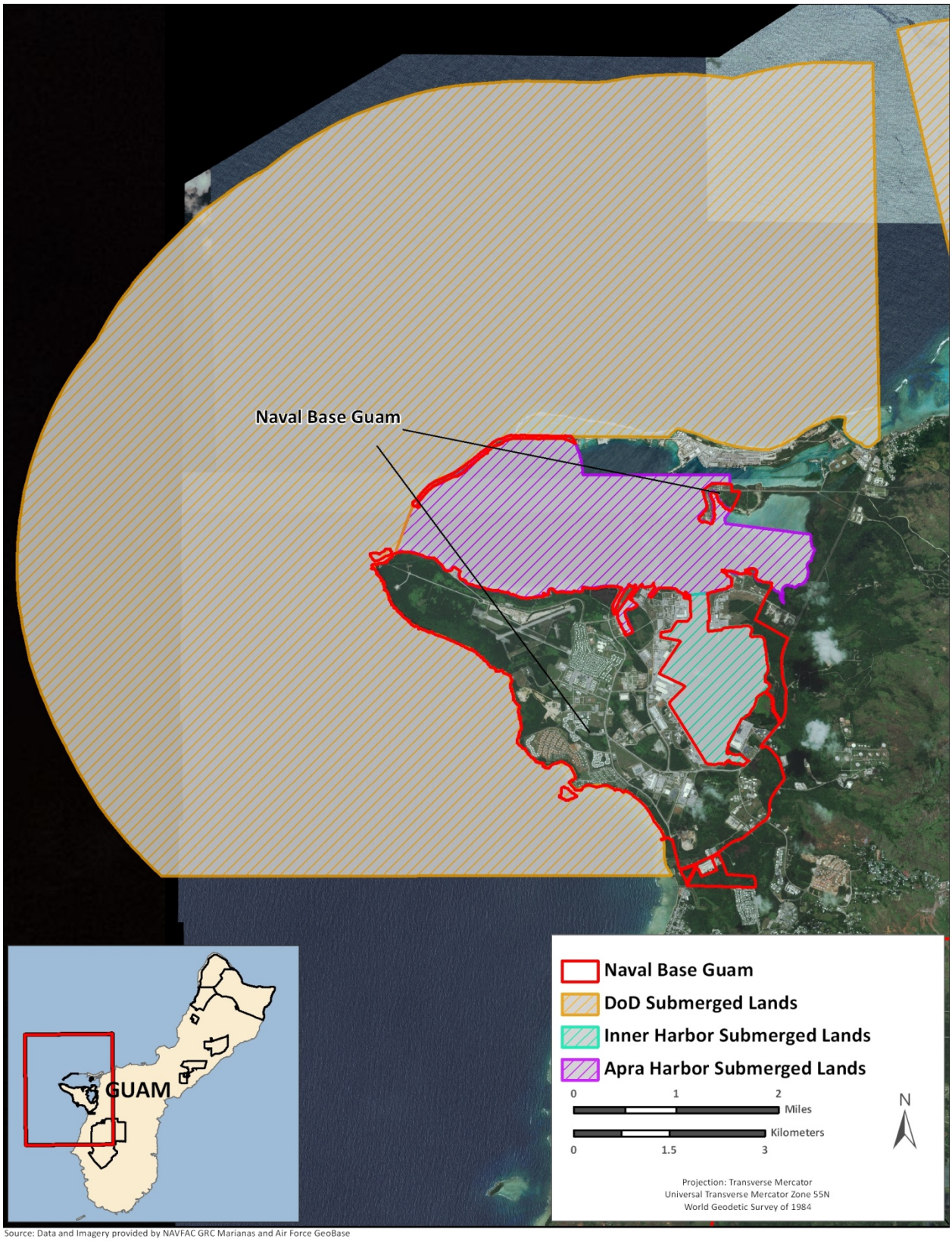
During the 2009 natural resources survey, 29 species of solitary macroinvertebrates were recorded within the Oscar and Papa wharves within the Inner Apra Harbor estuary and 30 species of solitary macroinvertebrates were recorded within the Abo Cove and Wharves S, T, U, V, and X (NAVFAC Pacific 2010b). All macroinvertebrates encountered within the Inner Apra Harbor during this survey were suspension feeders (i.e., filter feeders). Bivalve mollusks (seven species) and solitary ascidians (eight species) dominated the macroinvertebrate fauna at the Oscar and Papa wharves, and mean densities were generally greater at Papa Wharf. Sponges were the predominant biotic cover organisms at Oscar Wharf. The bivalves *Malleus decurtatus* and *Spondylus squamosus* were remarkably more abundant at Papa Wharf, as was the ascidian *Rhopalaea circula*. Spondylid bivalves occurred at the greatest densities of all species at both sites.

Within the transects performed in Abo Cove and Wharves S, T, U, V, and X, the greatest diversity of species (16 species) was found on the vertical face at Wharf V. The lowest diversity of macroinvertebrates occurred within the coral reef at Abo Cove. Bivalve mollusks and ascidians dominated the macroinvertebrate fauna in terms of both diversity and density within Abo Cove and Wharves S, T, U, V, and X. All but 3 of the 30 species within this study site were suspension feeders; the others are detritus feeders. The predominance of suspension feeders in lagoonal environments, such as the inner harbor, could be a result of nutrient enrichment by terrestrial runoff and the extended residence time of waters in the lagoon (NAVFAC Pacific 2010b).

Corals are the main constituents of the biotic assemblages at Abo Cove. Twenty-eight species of corals and related organisms, representing 11 families and 13 genera, were observed at the study site in Abo Cove in 2009. These included 26 species of scleractinian corals and 2 species of non-scleractinian anthozoans. Six coral species were documented in Oscar Wharf in 2009 and three species were documented in Papa Wharf. Species documented at both wharves include *Leptastrea purpurea*, *Pocillopora damicornis*, and *Porites lobata*. *Dendrophyllia* sp., and *Psammocora haimeana*; and *Porites rus* were documented only at Oscar Wharf (NAVFAC Pacific 2010b).

4.2.2.4 Submerged Lands

JRM-managed submerged lands which extend 3 miles from shore on NBG Main Base include portions of Agat Bay, Orote Point, Apra Harbor, and Piti Bay, as illustrated in **Figure 4-9**. Other designations for those JRM-managed submerged lands, including ERAs, HAPCs, and Marine Preserves, are summarized in **Table 4-5**.



Source: Data and Imagery provided by NAVFAC GRC Marianas and Air Force GeoBase

Figure 4-9. JRM Managed Submerged Lands at NBG Main Base

Table 4-5. JRM Managed Submerged Lands and Dual Designations

Installation	JRM Managed Submerged Land	Dual Designation (DOD)	Dual Designation (WP FMC)[1]	Dual Designation (GovGuam)	Dual Designation (USFWS)
Naval Base Guam Main Base	Apra Harbor				
	Inner Apra Harbor				
	Sasa Bay			Sasa Bay Marine Preserve	
	Eastern Apra Harbor				
	Commercial Port				
	Outer Apra Harbor		Jade Shoals HAPC		
	Agat Bay				
	Piti Bay			Piti Bomb Holes Marine Preserve	
	Orote Point	OPERA	OPERA HAPC		
NBG TS	Tanguisson Beach Park				
	Tanguisson Point to Urunao Point	HERA	HERA HAPC		
Andersen AFB	Ritidian Point		Ritidian Point HAPC		Ritidian Point NWR[2]
	Tarague Bay	Andersen AFB Marine Resources Preserve			
	Pati Point			Pati Point Marine Preserve	

Source: NAVFAC ESC 2010

Notes:

1. Guam is also surrounded by WPRFMC EFH, which is dually designated on all JRM-managed submerged lands which extend 3 nautical miles seaward from the coastline.
2. Ritidian Point National Wildlife Refuge (NWR) is a 100-foot (30-meter) isobath that is not a JRM-managed submerged land, but is surrounded by JRM-managed submerged lands which extend three nautical miles seaward from the coastline.

The majority of the Navy's activities with the potential to impact corals and coral reefs occur within Apra Harbor. Located midway along Guam's west coast, it is the archipelago's only deep lagoon with depths exceeding 150 feet. Apra Harbor was drastically altered during and after World War II. The harbor can be divided into five major components: Inner Apra Harbor, Sasa Bay, Eastern Apra Harbor, the

Commercial Port, and Outer Apra Harbor (see **Figure 4-9**). Apra Harbor is the busiest commercial port in all of Micronesia; it also supports substantial recreational/tourist water sports activities and is the Apra Harbor Naval Complex. In spite of all this activity, Apra Harbor "…holds a vibrant and thriving marine community, including well developed reefs with some of the highest coral cover on Guam, and a diverse biota of algae, invertebrates and fish. In this regard, the harbor is unlike most other major ports, which tend to become greatly degraded for marine life" (Paulay et al. 1997). Paulay's statements are still true; as of September 2010, there are still world-class reefs within Apra Harbor. This rating is based upon the percentage of sea floor covered by coral (more than 90 percent in many areas), the physical complexity and rugosity of the reefs, health of the coral, and diversity of corals and associated organisms (NAVFAC ESC 2010). In most of Apra Harbor, *Porites rus* is strongly dominant, based upon frequency of occurrence and percentage of total sea floor covered (Smith 2004, 2006, 2007; Smith and Marx 2006). This species is very tolerant to high levels of turbidity and is seldom, if ever, attacked by the crown of thorns sea star. *Porites rus* exhibits striking growth patterns of thin spires and wide plates, and stout knobs. The dominance of *Porites rus* is less pronounced on the deeper knolls in Outer Apra Harbor and near the mouth of the harbor (NAVFAC ESC 2010).

Outer Apra Harbor, most of the submerged knolls in the Outer Apra Harbor, the Western Shoals complex, Jade Shoals, and the western edge of Dry Dock Island all support well-developed complex reefs. It is essential to note that not all of Apra Harbor qualifies for such high ratings. Inner Apra Harbor was artificially created during and after World War II. Inner Apra Harbor and the Commercial Port do not support any coral reefs and nearly all the corals present are located on steel sheet piles or pilings. Sasa Bay, Polaris Bay, the Turning Basin, and the remaining portions of Eastern Apra Harbor contain corals and coral reefs; however, the reefs in these areas are inferior to those in the other portions of Apra Harbor based upon the percentage of sea floor covered by coral, the physical complexity and rugosity of the reefs, health of the corals, diversity of corals, and associated organisms (Smith 2007).

Additionally, a coral reef assessment for Guam was completed by the UOG Marine Laboratory in 2005, and included reefs on NBG in Apra Harbor, off Orote Point, and within the Haputo and Orote ERAs. Their findings show that the patch and fringing reefs in the southern portions of Apra Harbor are in good condition; however, those in the west and northwestern portions of the harbor have been impacted by sedimentation, recreational diving, and thermal discharges. The reefs within the Orote ERA were determined to be in fair condition (Porter et al. 2005). A General Management Plan for Orote Peninsula was prepared in 2010 (SWCA 2010a).

4.2.2.5 Protected Species

The federally endangered Mariana common moorhen and hawksbill sea turtle, the federally threatened green sea turtle, and the Guam endangered *Heritiera longipetiolata* have been documented on NBG Main Base. Potential habitat is present on NBG for six other federally endangered, threatened, or candidate species. Six federally listed cetaceans and one additional federally listed sea turtle have the potential to occur in the JRM-managed submerged lands that extend 3 nautical miles seaward from the coastline off NBG.

Flora

There are several populations of *H. longipetiolata*, a forest tree species Guam-listed as endangered by GovGuam, within the OPERA, as well as *Cycas micronesia* (NAVFAC Pacific 2010b). H. longipetiolata also occurs in the limestone forest adjacent to the San Luis Ponds.

Fauna

Terrestrial Species

Birds

Mariana common moorhen. Wetland habitat suitable for the Mariana common moorhen exists on NBG Main Base. Moorhens are known to occupy these wetlands at least during the wet season, and possibly also in the dry season if open water habitat remains present. Two Mariana common moorhens were observed at the San Luis Ponds during a recent survey in 2010 and 2011. Moorhens are not known to nest at any of the wetlands on NGB. Wetlands I and J of the Camp Covington wetlands are designated as a Mariana common moorhen sanctuary (AECOS and Wil Chee 2009). The Camp Covington wetland on NBG was identified as a habitat requiring species-specific surveys to determine whether the Mariana common moorhen is present. Eleven listening survey stations were placed within the Camp Covington wetland during a 2009 endangered species survey. No Mariana common moorhens were detected during this survey (NAVFAC Pacific 2010b). See **Section 4.1.2.5** for additional information on the Mariana common moorhen.

Mammals

Mariana fruit bat. Historic fruit bat colony roosts have been reported from forested cliffline habitat on NBG Main Base at Orote Point. Between January and April 1966, between 100 and 300 bats were observed at Orote Point, and by June of that year the total had increased to 600 (Wheeler 1979). In 1971, a colony of 150 fruit bats was observed at Orote Point (Wheeler 1979); this is the last record of a large fruit bat aggregation on NBG Main Base or anywhere in southern Guam. Incidental sightings of single fruit bats or pairs of bats have been made on NBG Main Base; but 4 days of fruit bat surveys conducted at the OERA in 2008 did not detect any fruit bats (Brooke 2008). Limited forested cliffline habitat suitable for Mariana fruit bats exists on NBG Main Base in the Orote Point Area.

Invertebrates

Insects

Mariana eight-spot butterfly. Three adult Mariana eight-spot butterflies and four larvae were observed in the Spanish Steps area of Orote Point in 1995 (Schreiner and Nafus 1996). Larvae were observed on the host plant *Elatostema calcareum*. Surveys conducted by SWCA did not find any larvae in the HERA. The Mariana eight-spot butterfly has two host plants, *E. calcareum* and *Procris pedunculata*; both species are present on NBG in the OREA. The current status of the Mariana eight-spot butterfly on NBG Main Base is not known.

Gastropods

Guam tree snail. Surveys conducted in 1920 by Crampton (1925) detected two species of partulid tree snail in the Orote Point area, the humped tree snail and the Guam tree snail. The population was skewed heavily toward the Guam tree snail. In 1989, Hopper and Smith resurveyed Crampton's former Orote Point site and found only one species, the Guam tree snail (Hopper and Smith 1992). The current status of this population is not known. The humped tree snail was observed in strand vegetation at Gab Gab Beach during site characterizations conducted at the San Luis Ponds in 2011.

Marine Species

Marine Mammals

In 2007, SRS-Parsons et al. (2007) conducted a marine mammal and sea turtle survey covering 170,500 square nautical miles around Guam and the CNMI. The survey area was bounded by 10°–18° N Latitude and 142°–148° E longitude. Nine unique marine mammal species were identified, including the federally endangered sei, sperm, and humpback whales. Sperm whales were the most commonly observed whales during the study. Marine mammals have the potential to occur in JRM-managed submerged lands that extend 3 nautical miles seaward from the coastline at NBG Main Base.

Sea Turtles

Green sea turtle. Green sea turtles are known to use the nearshore and Apra Harbor waters, and can nest on the beaches within NBG Main Base. A young green sea turtle was sighted during natural resources surveys in 2008 between Abo Cove and the south end of Victor Wharf (DoN 2010). Sea turtle nesting has been observed on the beaches of Andersen AFB, Cocos Island, and at the Spanish Steps on NBG Main Base. The Navy monitors for sea turtle nesting on selected beaches throughout the year.

Hawksbill sea turtle. Hawksbill sea turtles are known to use the nearshore and Apra Harbor waters, and can nest on the beaches within NBG Main Base. Nesting of hawksbill sea turtles has been recorded on a small beach within the Sumay inlet; however nesting has not been observed since 1995. The majority of sea turtle nesting on Guam occurs on the beaches of Andersen AFB to the north, or on Cocos Island to the south; however, the Navy monitors for sea turtle nesting on selected beaches throughout the year.

4.2.2.6 Invasive Species

Flora

Vegetated areas that have been disturbed by clearing, construction, and other activities on NBG Main Base are dominated by nonnative and invasive plant species, and include a number of invasive weeds (U.S. Navy 2009). During the 2008 vegetation survey on Polaris Point, tangantangan composed 88 percent of the tree layer within the transect (NAVFAC Pacific 2010b). Common introduced understory tree species documented on NBG Main Base include tangantangan, limeberry, and papaya. The Camp Covington Wetlands L, N, J, and I are dominated by *Phragmites karka*. Large common bamboo stands occur along the banks of portions of the Aguada and Sasa rivers on NBG Main Base (NAVFAC Pacific 2010b).

Fauna

The black francolin, island collared dove, and black drongo occur on NBG Main Base (NAVFAC Pacific 2010b). These species are common, introduced, breeding residents on Guam (NAVFAC Pacific 2010b). Four exotic species were documented on Polaris Point at NBG Main Base during the 2008–2009 herpetofauna surveys: curious skink, house gecko, brown treesnake, and marine toad (NAVFAC Pacific 2010b). Gunther's Amoy frog was detected in the estuarine habitats associated with the San Luis Ponds on NBG Main Base during surveys conducted in November 2010 and February 2011.