Chapter 3

AFFECTED
ENVIRONMENT

Elkhorn Coral

Buck Island Reef National Monument
Draft General Management Plan/
Environmental Impact Statement

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CHAPTER 3
AFFECTED ENVIRONMENT

NATURAL RESOURCES

This section describes the characteristics of the existing environment that could be affected by the management alternatives. The description of the affected environment focuses on only those environmental aspects potentially subject to the effects resulting from the proposed management alternatives. This is done in compliance with the guidelines contained in the National Environmental Policy Act and Section 1502.15 of the regulations for implementing that act developed by the Council on Environmental Quality (1978). As discussed in Chapter 1, Purpose and Need for a General Management Plan, the NPS has identified impact topics that may be affected by the proposed actions or the no action alternative. This section establishes the basis for Chapter 4, Environmental Consequences, which addresses the effects the alternatives may have on the impact topics. Each impact topic addressed is as listed in Chapter 1.

Units for data presented in this plan are provided as published by individual references.

SOIL / SAND

Buck Island, situated off the north-eastern side of St. Croix, is 6,000 feet long, oriented in an east-west direction. The island is 2,000 feet wide at its widest point and rises in a single east-west ridge to an elevation of 340 feet. It covers a land area of about 176 acres, with 90 percent of its landmass consisting of slopes steeper than 30 percent. On the island's eastern two-thirds the shore is gravelly or rocky, falling steeply into the sea.

The coastal areas of the U.S. Virgin Islands vary widely. The St. Croix/Buck Island complex developed from volcanic ash deposited on the sea floor, which through plate tectonics has been pushed up, folded, and tilted, creating a very rugged coastline that exhibits a variety of substrate types. Rocky coralline materials dominate most beaches; Buck Island's sands consist of rounded remains of calcite composed of the skeletons of organisms that live between the beach and the reef. The action of waves, storms, grazing of parrotfish, snails, and sea urchins reduces the coral reef to sand size pieces. This coral sand mixes with shells, sponge spicules, sea urchin spines, calcified algae, and "foraminifera." Forams cause the pink color in the beaches. The dark red skeletal animals in particular, *Homotrema rubrum*, grow on the underside of coral reefs and when the red forams die, the skeletons drop to the ocean floor. Wave action erodes the forams and mixes them with fragments of coral, shells, and algae, and coral sand is created. Beach sand depth above the bedrock varies, depending on the wave action and current.

Running east to west along the southern side of Buck Island is a narrow sandy beach; toward the southwestern end, the beach expands into a large seasonal sand spit. Along the island's south shore (from Turtle Bay to the Diedrich's Point picnic area) the coastline consists of coral cobble and narrow coralline sand in front of the beach forest. At West Beach, sand fringes an eroded shoreline and manchineel-dominated beach forest for about 1,000 feet. West Beach is backed by sand dunes and beach grasses to the east and wraps around the western end of the island from the southwest side to the North Shore, covering a moderately level area of about 10 acres.

West Beach is the primary beach used by visitors to the island, and is a dynamic, high energy environment due to wave action, currents, wind, and storm events. This wide open beach changes in shape and size with seasonal sand transport (NPS 2000b). West Beach sands build in the winter, typically peaking in March, with sand loss occurring during summer months as a result of oceanographic conditions. In addition, sand bottoms near the beach can be removed by storms, leaving bare limestone pavement and bedrock. The greatest loss of permanent beach occurred during hurricane Hugo in 1989, in addition to destroying a conch midden (600-1200 A.D.) that was located on the southwestern corner of West Beach. Increased frequency and intensity of hurricane and tropical storm activity continues to erode this section of West Beach, directly affecting the space available for picnic and other recreational use. Storms also cause soil erosion in other areas of Buck Island. Trail stabilization measures have been used to address soil erosion caused by Hurricane Omar in 2008.

Upland soils of the U.S. Virgin Islands consist of shallow, gravelly loams and clayey loams (USDA 2002). Buck Island upland soils are dominated by shallow, well-drained, stony soils that cover the slopes and summits. The soils are generally 10 inches deep or less, with weathered bedrock found at depths from 10 to 30 inches (USDA 2002). The general soil map of St. Croix produced by the U.S. Department of Agriculture Natural Resources Conservation Service indicates that the majority of Buck Island is characterized by the Southgate-Victory-Cramer general soil map unit, while a very small parcel of the northeastern tip of Buck Island is characterized by the Annaberg-Cramer-Southgate soil map unit. Both units are described as well-drained, steep to very steep soils on summits and side slopes of volcanic hills and mountains. The Southgate-Victory-Cramer unit is described as shallow and moderately deep while the Annaberg-Cramer-Southgate is described as shallow. Both units are associated with rugged hills that are dissected by very narrow valleys that have dendritic drainage patterns (USDA 1998).

A small, rain-fed salt pond is located on the south side of Buck Island slightly east of Diedrich's Point picnic area. Saline marshes in this region are characterized by very deep, very poorly drained soils that have formed by alluvial and marine sediments and the remains of hydrophytic plants. These soils are high in organic matter and would commonly be called muck (USDA 2002).

WATER RESOURCES

Freshwater resources are limited in the U.S. Virgin Islands. There are no large freshwater lakes, ponds, or perennial streams on any of the islands. Gullies, or "guts" as they are locally called, flow intermittently in response to rain and storm events. The absence of large freshwater resources and perennial streams means that guts form the basis for watershed management in the territory (DPNR 2006a).

Watersheds have a high percentage of steep slopes and rocky, well-drained soils. This results in runoff rushing from the mountains to valley bottoms and the sea. Short-duration, localized flooding is a concern on the islands, especially in the event of a tropical storm or hurricane. Drought is also a concern on the islands, affecting some part of the islands each year. Because of the shallow, rocky soils and lack of freshwater supplies, these dry periods can adversely affect plant communities (USDA 2002).

Saltwater ponds may develop at the mouth of guts where corals grow across the mouth near the shoreline. As materials are deposited on these shallow shoreline coral reefs, they build up a ridge that traps run-off water. In high tides or storms, there may be water exchange between the pond and the sea. These ponds support mangrove stands and also serve as important habitats for wildlife. The salt pond located on the south side of Buck Island is no longer connected to the sea; it typically remains dry, but can remain wet for weeks at a time during rainy periods.

Groundwater resources are also limited in the territory and are subject to saltwater intrusion and pollution by wastewater and petroleum products. Most of the potable water supply for the islands comes from stored rainwater and/or desalination plants, which provide water for the urban and residential communities throughout St. Croix. There is no potable water supply on Buck Island.

Water Quality Standards

Waters of the U.S. Virgin Islands are classified into three groups based on designated uses: Class A, B, and C. Class A waters are defined as being for the preservation of natural phenomena requiring special conditions with existing natural conditions that shall not be changed. Class A water standards are the most stringent of the three classes because of its pristine or near-pristine state. The waters surrounding Buck Island are designated as Class A. Class B and C waters are for the propagation of desirable species of marine life and for primary contact recreation. Class C waters have less stringent water quality standards than Class B (DPNR 2006a). Appendix C includes a summary of the water quality standards for each of these classes.

U.S. Virgin Islands water quality standards do not address drinking water use attainment. Since most of the drinking water supply comes from reverse osmosis and flash desalinization plants or from traditional rainwater cisterns, most drinking water issues directed at surface or groundwater resources are not applicable in the territory. There are no water quality standards available for organic compounds, inorganic compounds, unregulated chemicals, and radiological contaminants that apply to the ocean surrounding the territory as a drinking water source because ocean water does not fit the definition of surface water under the Safe Drinking Water Act (DPNR 2006a).

The territory is enhancing and strengthening its Water Pollution Control Act and revising its water quality standards. Draft revised standards, regulations, and related requirements were published for comment in December 2008. Final water quality standards were pending at the time of publication of this plan (DPNR 2008).

The Virgin Islands Beach Monitoring Program was established pursuant to requirements of the Beach Environmental Assessment and Coastal Health Act of 2000. Major goals of the Virgin Islands Beach Monitoring Program are to increase and improve water quality monitoring at local beaches, expand notification to the public of beach warnings or closings, and identify and eliminate threats to local beach water quality. While twenty beaches in St. Croix have been selected for routine monitoring for fecal coliform, the beach at Buck Island is no longer included (DPNR 2006c).

Sources of Pollution

Marine waters that encircle the U.S. Virgin Islands and Buck Island Reef National Monument are generally of good quality and support a variety of sensitive habitats, from mangroves to seagrasses to coral reefs. However, periodic reductions in local water quality result from ongoing erosion from rapid development and continued use of unpaved roads and releases of sediment during heavy rainfall events (USGS 2004; UVI 2004). Discharge of untreated or partially treated sewage can occur as chronic, low-level contamination from individual septic systems, recreational boaters, or municipal systems that are improperly maintained or inundated during tropical storm events. In addition, water quality in high boat traffic areas such as harbors and marinas can be degraded by petroleum products and industrial waste (UVI 2004).

Non-point Source Pollution. Non-point source pollution, especially from urban development, impairs more water bodies than any other source of pollution in the U.S. Virgin Islands. The physical processes by which urban development adversely affect water quality are storm water runoff, erosion, and sedimentation. Because of the scarcity of flat land, development in the territory has taken place in areas that far exceed the typical environmental constraint of 15 percent slope. Slopes in excess of 45 percent have been developed in the territory, further increasing the potential for erosion (DPNR 2006a). According to data summarized in the 2002 Virgin Islands Environmental Protection Handbook developed by the University of the Virgin Islands Cooperative Extension Service (Wright 2002), sediment is the most prevalent pollutant, by volume, polluting surface waters in the U.S. Virgin Islands. Uncontrolled construction site sediment loads have been reported to average 35 to 45 tons/acre/year in the continental United States (Novotny and Chesters 1981). However, a 1986 study of erosion rates on St. Thomas and St. Croix estimated erosion from a disturbed dirt road site to be 591 tons/acre/year (Wernicke, et al. 1986). Studies of erosion rates in the Fish Bay watershed on St. John have soil loss from dirt roads of between 100 to 600 tons per year (MacDonald, et al. 1997; Sampson 1997). Sediment has many harmful impacts on aquatic ecosystems, including increased turbidity, reduced light penetration (which inhibits coral and seagrass growth), smothering coral reefs, reduced prey capture for sight-feeding fish, clogging of gills and filters in fish and shellfish, reduced spawning and juvenile fish survival, and decline of commercial and recreational fishing success (Schueler 1987, Rogers 1990) (see also “Marine and Coastal Resources” subsection of Chapter 3).

The pumping of bilge water (water that does not drain off the side of the deck but drains down into the boat and accumulates) from vessels in the park is a concern, since this water may contain oil, grease, fuel, or other materials. Water quality can also be seriously affected by oil spills resulting from accidental vessel groundings on reefs, and vessel discharge from tankers that may lighten their load east of the park prior to entry to the major oil refinery, Hess Oil Venezuela South America (HOVENSA), and/or the Wilfred "Bomba" Allick Port and Transshipment Center (locally known as "The Containerport") on the south shore of St. Croix, and/or into the Christiansted harbor, Port Authority terminal, southwest of the park.

Other forms of potential water pollution include paint from the bottoms of boats, insect repellant, and/or sunscreens worn by park visitors. Studies involving personal care products, including sunscreens, show that sunscreens promote viral infection in corals, potentially playing a role in coral bleaching in areas prone to high levels of recreational use (Danovaro, et al. 2008). Sunscreen products are also reported to bioaccumulate in aquatic animals (Giokas, et al. 2007 in Danovaro, et al. 2008).

The Department of Planning and Natural Resources established a Non-Point Source Program that administers grants and sets policies to mitigate non-point source pollution. The Program is supported by the Non-Point Source Pollution steering committee, a diverse group of individuals from the public and private sectors. The Program funds such initiatives as the *Environmental Protection Handbook* (Wright 2002) which serves as a guide for best management practices that should be used for all new construction. In addition, the Division of Environmental Protection added an Environmental Education and Outreach program that has been involved in numerous outreach projects, including: used oil drives, elementary and high school presentations, environmental public service announcements, and Non-Point Source Conferences.

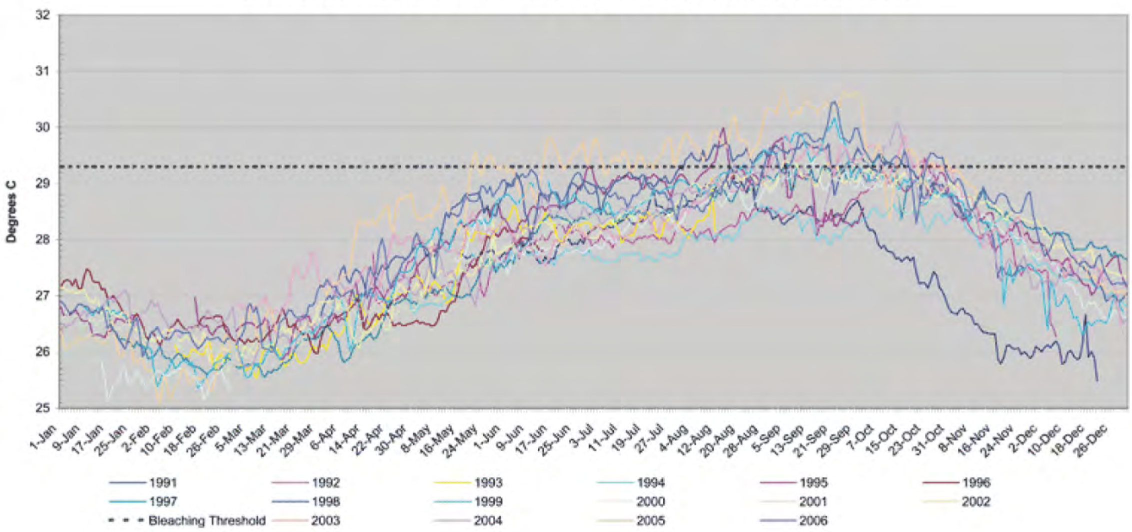
Point Source Pollution. U.S. Virgin Islands Code defines a point source as “any discernable, confined and discrete conveyance, including, but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft from which pollutants are or may be discharged” (VI Code T.12 §182(j)) (DPNR 2006c). Other regulated point source discharges in St. Croix include point source discharges from inadequate industrial commercial pretreatment operations (Manning Bay/Estate Anguilla Beach–public dump); municipal point source discharges (Hovensa, west treatment plant); and industrial point sources (rum plant outfall and Carlton Beach) (DPNR 2008). The locations of these point source outfalls are on the southwest end of St. Croix, and do not directly affect water quality within the park.

Water Quality Assessment within Park Boundaries

The most recent comprehensive inventory of water quality within the park boundary was published by the NPS Water Resources Division and Servicewide Inventory and Monitoring Program in 1999 (NPS 1999a). This document consists of a summary of surface-water-quality data retrievals from several databases from stations located within Buck Island Reef National Monument, Christiansted National Historical Site, and Salt River Bay National Historical Park and Ecological Preserve. The majority of data was obtained from the U.S. Environmental Protection Agency’s Storage and Retrieval (STORET) database. A total of 129 monitoring stations were queried, of which six were located within the boundary of Buck Island Reef National Monument with a record spanning from 1968 to 1996. Reported parameters included, but are not limited to, temperature, transparency (secchi depth), dissolved oxygen, pH, salinity, fecal coliform, phosphorus, and total Kjeldahl nitrogen. The six stations located within the park are shown in Appendix C.

Additionally, the park has collected water temperature data from two to four long term monitoring stations within the park since 1988. The "Marine and Coastal Resources" Section of this Chapter, Coral Bleaching subsection provides information on the relationship between temperature and coral bleaching events. Temperature data recorded from 1991 through 2006 near the underwater trail are plotted as shown on Figure 9 (Lundgren 2008).

Figure 9. Buck Island Reef National Monument Temp Logger, 10m Depth Forereef Underwater Trail



VEGETATION

The flora of Buck Island Reef National Monument includes both terrestrial and marine communities. The terrestrial plant communities are those found on the island from the water line landward, including mangroves, but dominated by coastal and tropical dry forest plants. Marine plant communities include substantial seagrass beds that occur in shallow waters that extend from the south side of Buck Island Channel to depths of 50 to 75 feet. Seagrass communities are discussed in the "Marine and Coastal Resources" subsection. Descriptions of terrestrial plant communities discussed in the following paragraphs are based on information contained in *The Flora of St. John* (Acevedo-Rodriguez 1996) and the park's vascular plant inventory report (Ray 2003).

The composition of terrestrial plant communities within the park has been affected by numerous historical changes, resulting primarily from colonial-era land use activities. During the early days of the Danish colonial period (the eighteenth century), the original dense tropical forests described in earliest accounts were cleared for lumber, creating rough grazing for goats and sheep that remained on the island through the first quarter of the twentieth century. The tropical hardwood trees, particularly lignum vitae, were logged for timber for construction and export, and for conversion into charcoal, the main fuel source for the early settlers. The introduction of non-native animal species such as goats, Indian mongoose, tree rats, and the common house mouse, interrupted the ecological balance on the island and contributed to the decline and extirpation of native wildlife species like many ground-nesting birds and lizards. Non-native pest species also affected seed dispersal and success by consuming all mast production season after season. The introduction of non-native invasive plants resulted in the decline of certain native plant species due to the competition for light, nutrients, moisture, and space. Natural occurrences, such as extreme prolonged drought, periodic flooding, fires, and hurricanes, also affected composition of the plant community on Buck Island.

Terrestrial vegetation can be described as consisting of six distinct vegetation classifications: seasonal deciduous forest, beach forest, mangrove forest, thorn/cactus scrub, thicket scrub, and coastal thicket (Gibney 1996).

The **seasonal deciduous forest** community is found in guts and ravines, on the landward edge of beach forests, and on portions of the north-facing slopes of hills. Trees that dominate the canopy in this community include gumbo-limbo (*Bursera simaruba),* chinkwood *(Bourreria succulenta),* fish-poison tree *(Piscidia carthagenensis),* water mampoo *(Pisonia subcordata),* white manjack *(Cordia dentata),* and wild lime (*Adelia ricinella)*. Areas that provide more moisture include black cedar (*Tabebuia heterophylla),* black mampoo *(Guapira discolor)*, and ebony (*Krugiodendron ferreum)* in the tree layer. Gibney (1996) describes *Bursera* and *Guapira* trees that are over 100 years old in this vegetation community. Shrubs present in the understory include guayabilla (*Samyda dodecandra),* boxwood *(Schaefferia frutescens)*, and broom bush (*Croton betulinus)* (Gibney 1996).

The **beach forest** occurs on the coastline around the perimeter of much of the island, but is most prevalent on the west end. The dominant tree in the beach forest canopy is the manchineel tree *(Hippomane manchinella*). Vegetation on Buck Island may be considered dangerous by visitors not familiar with the habitats. For example, the manchineel tree is poisonous; contact with this tree causes painful blisters, and eating the fruit can be deadly. Standing under the tree when it rains is also hazardous, as the water passing through the leaves and fruit can cause burns and blisters if it comes in contact with skin. Several hurricanes have altered the island coastal vegetation. Two major (category 4-5) hurricanes, Hugo (1989) and Marilyn/Luis (1995), severely damaged the manchineel beach forest along North Shore and West Beach and killed mature trees comprising a 30 to 40-foot high canopy. As of 2006, the manchineel beach forest has substantially recovered along with various other trees and shrubs, including water mampoo, white stopper (*Eugenia axillaris),* sea grape *(Coccoloba uvifera)*, pink cedar (*Tabebuia heterphylia*) and orange manjack (*Cordia ricksickeri*).

The **thorn/cactus scrub** vegetation community is an open shrubland that provides a transition between the seasonal deciduous dry-forest and the thicket scrub, and is found predominantly on the southwestern slope of the island. The community is characterized by spiny shrubs of simple leaf bushweed (*Flueggea acidoton)*, with casha (*Acacia tortuosa)* and greenheart ebony (*Rochefortia acanthophora)* and the tree-like forms of organ pipe cactus (*Pilosocereus royenii*). The thorn/cactus community is located predominantly on the southwestern slope of the island, and transitions into the scrub-thicket (dense shrubland) on the eastern end. Gibney (1996) speculated that the dominance of thorny plants evolved due to the grazing habitats of the imported goats and sheep that once inhabited the island; they avoided grazing on the thorny or toxic species, which flourished without competition from the more palatable species.

The **thicket/scrub** vegetation community is found predominantly on the east side of the island, and to a lesser degree, on the south slopes. This community is also believed to have occurred as a result of decades of grazing by goats and sheep and their preferential grazing on plants without thorns, spines, toxins, and other unpalatable attributes. Predominant species in this community include mainly shrubby species such as *Croton* sp., sage (*Lantana involucrate)*, white manjack, bushy heliotrope (*Heliotropium ternatum)*, and prickly bush (*Oplonia spinosa)*. These shrubs are intertwined with vines such as monarch amazonvine (*Stigmaphyllon emarginatum)* and cluster vines (*Jacquemontia* spp.), creating dense, impenetrable stands. Two cactus species are frequently found as ground cover, including brittle-jointed "sucker" cactus (*Opuntia repens*) and turk's cap cactus (*Melocactus intortus*).

The **coastal thicket** forms a narrow band of vegetation landward from the upper beach and berm on the south and west shores. The few woody species in this habitat include sea grape (*Cocoloba uvifera*), black torch (*Erithalis fruticosa)*, and bitter ash (*Rauvolfia viridis)* as the dominant shrubby species present, with false button weed (*Spermacoce prostrata),* beach berry *(Scaevola plumieri),* sea purslane *(Sesuvium portulacastrum)*, and bay bean (*Canavalia rosea)* comprising the understory.

There are no shallow estuarine areas or embayments on Buck Island to support a mangrove forest. However, white (*Laguncularia racemosa*) and black (*Avicennia germinans*) mangroves are present around the salt pond on the southern side of the island, forming a shallow band around its perimeter (Ray 2003). Buttonwood (*Conocarpus erectus*) was observed in 1976 (Woodbury, et al. 1976) but not in 1996 (Gibney 1996).

Infestations of non-native plant species on Buck Island are not as extensive as they are on neighboring islands. Most infestations are mixed with native plant communities and do not form mono-cultures, as is the case in other areas of the Caribbean. Seventeen species of non-native plants were observed in 1976 (Woodbury, et al. 1976), and two additional species were noted by Gibney (1996). The 2002 vascular plant inventory identified a total of 20 non-native plants, or 13 percent of 163 documented species (Ray 2003). Beginning in 2002, the NPS Exotic Plant Management Program identified 10 target non-native invasive species for island-wide eradication and control. The dominant species present at that time included tamarind (*Tamarindus indica*), genip (*Melicoccus bijugatus*), guinea grass (*Urochloa maxima*), ginger Thomas (*Tecoma stans*), wild pineapple, penguin (*Boerhavia erecta*), aloe (*Aloe vera*) and tan-tan (*Leucaena leucocephala*). Many of these species have been or are in the process of being eradicated from the island by the NPS; the park's non-native invasive plant control was at 60-80 percent for target species group by 2009. The invasive non-native vegetation on Buck Island is discussed in detail in the *Exotic Plant Management Plan Environmental Impact Statement for the South Florida and Caribbean National Parks* (NPS 2006b; 2010).

WILDLIFE

Approximately 10,000 years ago, St. Croix and Buck Island comprised a single land mass with similar floral communities (Woodbury, et al. 1976). When the ice caps began to melt and the Caribbean Sea rose, the two land masses were separated and became individual islands, but the flora on the islands did not significantly change. Based on this natural history it is assumed that the fauna communities of both islands would also be just as similar. Therefore, recent surveys of St. Croix faunal species were used to make assumptions regarding wildlife found in the park. On the other hand, no similar assumptions can be made with the fauna of St. Thomas, St. John, and Puerto Rico because these islands are on different oceanic plates and have been separated from St. Croix and Buck Island by a deep, wide channel for millions of years, which may have limited some species from colonizing.

Inventories were undertaken for most faunal species on the larger islands of the U.S. Virgin Islands and for Buck Island; those for Buck Island were completed and are included in the NPS National Inventory and Monitoring Program Vascular Plant and Vertebrate Inventories. Separate field surveys for Buck Island herpetofauna and bats were also completed (NPS 2008a).

Reptiles and Amphibians

Eight species of reptiles are known to occur on Buck Island, three of which are lizards (*Anolis acutus, Hemidactylus mabouia*, *Sphaerodactylus beattyi*), and four are sea turtles (leatherback, loggerhead, hawksbill, and green) (Waddell and Rice 2002). The only species previously reported from the island that was not detected was the St. Croix ameiva or ground lizard (*Ameiva polops*), a globally endangered lizard native to St. Croix (see Species of Concern section). Only one introduced species was detected, the tropical house gecko (*Hemidactylus mabouia*). No amphibians occur on the island.

Although the herpetofauna of Buck Island is small, it is important. Three of the island's lizards are endemic to St. Croix and the surrounding cays. The island has now become a significant refuge for the globally endangered St. Croix ground lizard since its successful reintroduction in 2007 (see Species of Concern). The only introduced species detected on Buck Island, the tropical house gecko, is ubiquitous throughout the West Indies (NPS 2008b). It is easily transported on boats and in building materials, the likely source of introduction onto Buck Island. This species has not been shown to interact negatively with the native herpetofauna elsewhere.

Eradication of the Indian mongoose *(Herpestes javanicus)* (1980-1985) and tree rat (*Rattus rattus*) (1999-2001) from Buck Island has been advantageous to the herpetofauna, eliminating a significant source of nest predation on sea turtles and reducing predation on the lizards. The current resource management strategy of maintaining rodent eradication should allow native fauna to thrive.

Birds

Birds species observed in the park include those that frequent the salt pond behind Diedrich's Point, like herons (*Ardea* sp.), egrets (*Egretta* sp.) and ducks, including Bahama white-cheeked pintail ducks (*Anas bahamiensis*). Other birds that frequent the beaches and shoreline coastal areas include sandpipers *(Calidris, Tringa,* and *Actitis* spp.); rarely noted are gulls (*Larus* sp.), plovers (*Charadrius* sp.), yellowlegs (*Tringa* sp.), terns (*Sterna* sp.), and stilts (*Himantopus mexicanus*). Birds known to be permanent residents or breeders on the island include bananaquit (*Coereba flaveola*), the Antillean crested hummingbird (*Orthorhyncus cristatus*), the green throated carib (*Eulampis holosericeus*), seasonal warblers (*Dendroic*a sp.), the black-throated grass quit (*Tiaris bicolor*), mangrove cuckoo (*Coccyzus minor*), white crowned pigeon (*Patagioenas leucocephala*), common ground dove (*Columbia passerina*), pearly–eyed thrasher (*Maragarops fuscatus*), and belted kingfisher (*Cerle alcyon*). There is a roosting area for the magnificent frigate bird (*Fregata magnificens*), although there is no record of them nesting on the island. Several raptors have been observed on Buck Island, including the red-tailed hawk (*Buteo jamaicensis*), peregrine falcon (*Falco peregrinus*), and more frequently the osprey (*Pandion haliaetus*). There are several other protected species listed by the territory including the brown pelican (*Pelecanus occidentalis*) rookery, the largest for the St. Croix island group located on the island's north side; these species are discussed in greater detail in the *Species of Concern* section (DPNR 2005b). The least tern (*Sterna antillarum)*, a protected migratory species, has been documented using the sand spit at West Beach as a seasonal nesting area. Seasonally adults continue to attempt nesting, laying eggs, however there has not been a successful nest fledged from 2005-2010.

The park maintains a complete bird species list. Future investigations regarding the island's species composition, breeding, habitat use, and nesting success, since the rat eradication is planned.

Mammals

At one time, the non-native roof or tree rat and Indian mongoose were the only mammals known to occur on Buck Island. These destructive pests were introduced by man and were severely altering the flora and fauna on the island; they were responsible for the nearly 100 percent destruction of endangered hawksbill sea turtle nests, destroying migratory least tern nesting colonies, and negatively affecting native vegetation and visitor experience. The NPS, in collaboration with the U.S. Fish and Wildlife Service and the Virgin Islands Division of Fish and Wildlife, began a mongoose control program in 1980 that ultimately removed 85 percent of the pests. In the mid-1990s, due to the absence of the mongoose, the tree rat population exploded, becoming another menace to the eggs and hatchlings of the threatened and endangered sea turtles. In 1999, an island-wide effort was undertaken by the NPS and the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services to rid the island of the invasive tree rat (NPS, 2002a). By December 2001, the project to control the rat population was declared a success, and bi-annual monitoring continues today. Following decline of the tree rat, there was an increase in the presence of the European house mouse (*Mus musculus*) whose population had previously been limited by the tree rats (Witmer, et al. 2007).

The National Park Service Vascular Plant Survey and Vertebrate Inventory and Monitoring Program began to survey Buck Island to confirm the presence of an elusive bat population. Conducted between 2003 and 2007, these bat surveys found few bats in residence, but some were observed foraging in the park during the wet season. The presence of both the velvety free-tailed bat (*Molossus molossus*) and Mexican free-tailed bat (*Tadarida brasiliensis*) were confirmed on Buck Island. Most bats require open bodies of fresh water for drinking and foraging, and there are no freshwater wetlands present in the park (NPS 2008a).

Terrestrial Invertebrates

Invertebrates are the dominant terrestrial life form in the U.S. Virgin Islands (DPNR 2005b). Buck Island, like the rest of the Virgin Islands, has an abundance of invertebrates such as snails, crabs, spiders, scorpions, centipedes, millipedes, beetles, and insects. Beetles are prevalent at Buck Island, prompting a beetle fauna survey from 1993-1997 that resulted in the identification of over 126 species of beetles (coleopteran), including several endemic species and two new species of Chrysomelidae (*Longitaris milleri* and *Longitaris zandae*) and *Curculionidae Decuanellus brevicrus* (Pollock and Ivie 1996).

The NPS conducted a short-term, terrestrial invertebrate fauna survey in 1996 that assessed the invertebrate species present at Buck Island and their susceptibility to a variety of capture methods. The survey recorded several invertebrate groups, including Blattaria (cockroaches), Millipede (millipedes and centipedes), Orthoptera (grasshoppers and crickets), Lepidoptera (moths and butterflies), Dipteria (flies), Hemiptera (aphids, cicadids, and true bugs), Acari (mites and ticks), Hymenoptera (ants, wasps, and bees), Neuropteran (ant lions, lacewings), Odonata (dragonflies and damselflies), and Arachnida (spiders and scorpions).

Several species of crabs are present, including the most commonly seen Soldier (hermit) crab (*Coenobita clypeatus*), which have been observed across the island, from the shoreline to the ridgeline. These species are terrestrial (except during their breeding phases), occur in coastal scrub, mangrove forests, and upland forests, and utilize abandoned shells primarily from the West Indian top shell or "whelk" (*Cittarium pica*). Ghost crabs (*Ocypode quadrata*) are frequently observed along the sand shoreline in burrows in the wet sand at or above the high tide line. Ghost and hermit crabs provide valuable food resources for wetland and shorebirds. The great land crab (*Cardisoma guanhumi*) is infrequently encountered in the beach forest. Land crabs (*Gecarcinus ruricola*) are more frequently encountered in the beach forest, and semi-aquatic mangrove crabs (*Aratus pisonii*) are common along shoreline rocks and the pier (NPS 2000b).

MARINE AND COASTAL RESOURCES

The following section provides a description of the existing conditions of marine and coastal resources in the park, a summary of how these conditions developed over time, and an analysis of the numerous factors that affect the ecological health of the park's resources. When the park was established in 1961, it encompassed 176-acre Buck Island and 704 acres of marine habitat surrounding it. The park proclamation describes the park and its "adjoining shoals, rocks, and undersea coral reef formations" as "one of the finest marine gardens in the Caribbean Sea," which are of "great scientific interest and educational value to students of the sea and to the public." The original legislation allowed for multiple uses within the park's boundaries, even allowing fishing in some areas while protecting others within the "Marine Garden" area including the east end of the lagoon and underwater trail . In 2001, the park was expanded to 19,015 acres, and all forms of resource extraction were prohibited, making it the first fully protected marine area in the national park system.

In a tropical marine ecosystem, coral reef communities live in complex and often fragile, interdependent relationships. The expansion of Buck Island Reef National Monument added essential types of coral reef habitats (patch, spur and groove, deep and wall), seagrass beds, and sand communities, as well as algal plains, shelf edge, deep and dimly lit reefs, and deep oceanic habitats not originally within the park boundary. These additional habitats preserve ecological links that help sustain the park and its resources. Another important effect of the boundary expansion was to place a vast reef shelf area for the recently listed species, of elkhorn coral (*Acropora palmata*), a major reef-building species, within the park; this shelf includes unusual "haystack" formations.

There are numerous agencies and organizations that have conducted and are conducting marine and fisheries related research near St. Croix in addition to the NPS, including:

- National Oceanic and Atmospheric Administration's National Ocean Service/ National Centers for Coastal Ocean Science / Center for Coastal Monitoring and Assessments / Biogeography Branch,
- United States Geological Survey-Biological Resources Division,
- The former West Indies Laboratory of Fairleigh Dickinson University,
- University of Virgin Islands-Virgin Island Marine Advisory Service,
- Coastal Zone Management-St. Croix East End Marine Park,
- Virgin Islands Department of Planning and Natural Resource-Division of Fish and Wildlife, Division of Environmental Protection, Water Quality,
- The Nature Conservancy,
- Ocean Conservancy, and
- Individual researchers from various universities.

The baseline conditions presented in this section are based on available information from these sources unless otherwise noted. A summary of on-going monitoring programs as tabulated in the NPS Vital Signs Monitoring Plan (NPS 2008a). The information presented herein represents a snapshot in time of these resources; therefore, caution should be taken when referencing this document as new research results will inevitably refine, change or update the reported findings.

This section covers the following two impact topics: *Coral Reefs and Other Marine Communities* and *Fish / Aquatic Life*. Because marine and coastal resources are a major issue in this general management plan, more detail is provided on these systems than other impact topics. This is consistent with the requirements of the National Environmental Policy Act of 1969 (as amended). The following outlines the contents of this section:

Coral Reefs and Other Marine Communities

- Shallow coral reef communities
- Seagrass community and algal plains
- Sand bottom community
- Deep reefs and wall reefs
- Deep water abyssal bottom community
- Deep water oceanic/pelagic community
- Factors affecting the health of coral reefs and marine communities

Fish / Aquatic Life

- Fish
- Essential Fish Habitat
- Other Marine Animals
  - Lobsters
  - Conch
  - Long-spined sea urchins

The first part of this discussion is organized primarily according to ecological community, which is defined as all the interacting organisms living together in a specific habitat. A habitat is defined as the place where organisms live, grow, feed and reproduce. In the park, habitats occur along gradients that form relatively distinct ecological zones. For nearly 40 years, researchers have defined communities, habitats and ecological zones in the park in a variety of ways. The terms used in this summary are therefore taken from the individual authors as they were reported in the literature.

Both common and scientific names are provided for plants and animals in the sections that follow. In some cases, however, two common names were provided in the literature for the same scientific name. Where possible, these differences were reconciled, but in some cases this was not possible, and where needed, both common names were provided. Where differences appeared, common names were obtained from the National Oceanic and Atmospheric Administration on-line database (NOAA 2006b), or from the Integrated Taxonomic Information System (ITIS 2006).

Coral Reefs and Other Marine Communities

This section provides a description of coral reefs and other marine communities in the park, and the factors known to affect their ecological condition. The ecological communities and habitats in the park form a dynamic and complex mosaic that has developed over thousands of years and is the result of a large number of physical, chemical, and biological factors (Hubbard, et al. 2005). Figure 10 illustrates this concept, and how various factors are thought to relate to organisms, biological processes, and communities. The following specific examples are provided to illustrate some of these interrelationships between the different components of the ecosystem of the park:

Fish with planktonic larvae are known to reproduce in deeper offshore waters.

Algal plains and seagrass beds may serve as nursery areas (Rogers and Taytaud 1988).

As juveniles, lobsters rely on habitat that occurs on the east end of St. Croix and then migrate to areas within Buck Island Reef National Monument where they mature and live on reefs and deeper rock bottom areas (Rogers and Teytaud 1988). The presence of adult, reproductive, and juvenile lobsters within both the park and Teague Bay was recently verified (Cox, et al. 2009).

Several species of reef fish, including parrotfish and grunts, migrate nightly from the protection of the reef to more open seagrass beds to feed. In turn, seagrass beds produce dead plant material that is exported to adjacent areas where it can be utilized and consumed by small animals (Kendall 2003).

Conch feed primarily on algae in seagrass beds and also ingest seagrass blades (Rogers and Teytaud 1988). Queen conch (*Strombus gigas*) larvae settle in sandy areas and, as they grow, move into shallow seagrass beds and eventually to deeper water coral reefs, algal plains, and seagrass beds (Drayton, et al. 2004). Large predatory fish, such as spotted rays, sharks, and queen triggerfish, all prey on conch, and spiny lobsters feed on juvenile conch (Rogers and Teytaud 1988).

Parrotfish graze directly on coral, which breaks down the calcareous coral skeletons and produces large amounts of sediment that contributes to the structure of the reef and nourishes sandy beaches. Nutrients from fish waste are essential inputs to a relatively nutrient-poor reef system, increasing productivity (Rogers and Teytaud 1988).

Sea urchins (such as the long-spined urchin) feed on marine macro-algae on the reef and have been shown to control algal population structure (Ogden and Lobel 1978). Loss of the long-spined urchin 20 years ago has resulted in increases of algae on some reefs (Rogers and Teytaud 1988).

Changes in one component of the system caused by natural or man-made factors can therefore affect other components. In the park, the major factors include storm damage, coral disease, elevated sea water temperatures, and the effects of physical damage on seagrasses, corals, and other communities from recreational use, vessel groundings, and inappropriate anchoring (Figure 10). These factors are discussed in more detail in this section for each community and major groups of organisms.

Figure 10. Depiction of Key Interrelationships Between Marine Organisms, Processes, and Communities and the Factors That Influence Them

Shallow Water Coral Reef Communities

Coral reefs are valuable coastal resources that support a wide variety of plants and animals, many of which have commercial or recreational importance (Mac et al. 1998; Goenaga and Boulon 1991; Bohnsack 1992, *in* Mac, et al. 1998). Coral reefs and associated marine habitats are among the most productive ecosystems on earth, supporting more biological diversity than any other ecosystem, with the exception of tropical rain forests. They serve as breeding grounds, nurseries, feeding grounds, and refugia for a variety of protected and other species. They dissipate wave energy and protect inshore and lagoon areas. Coral reefs exist in a delicate balance that requires a relatively narrow range of depth, temperature, salinity, currents, wave action, and water clarity, and coral reef communities occur in zones along physical gradients and depths (NPS 1974a).

Shallow water coral reef communities in the park are defined as those which occur to a depth of roughly 40 meters. This depth is the approximate boundary of the shelf edge, a predominant geological feature on the north side of Buck Island. Another major shallow water coral reef feature of the park is a single, magnificent barrier reef formed by large stands of elkhorn coral, which parallels the shoreline for nearly two-thirds of the length of Buck Island and encloses an extensive shallow lagoon. Well-developed shallow coral reefs also occur outside the lagoon on the southeastern, northern (especially at the North Bar), and northwestern ends of Buck Island.

Bythell, et al. (1989) investigated changes in the shallow coral reefs in the park between 1976 and 1985. This study summarized the major characteristics of the coral community structure in five transects radiating out from shoreline to 15 meters placed at various locations around Buck Island. Major community types described included lagoon pavement, lagoon, lagoon patch reefs, bank barrier reef, mixed coral/gorgonian bank, and bank patch reefs (haystacks). The overall conclusion was that there had been a major reduction in live coral coverage in almost all areas of the Buck Island reef system during this period (Bythell, et al. 1989). The major change was the staghorn coral and especially elkhorn coral, which was previously the dominant species throughout the park. By 1985, staghorn coral had also almost disappeared completely from the northern reef and was significantly depleted on the south reef. Some signs of recovery of elkhorn and staghorn corals had been observed, but total cover was still much lower in 1985 than in 1976. It was uncertain if the root cause of these changes was attributed to man-made or natural causes, including the massive loss of elkhorn coral due to white-banded disease in 1976 (Gladfelter 1982), and long-term monitoring of the reef at Buck Island was recommended (Bythell, et al. 1989). After Hurricane Lenny in 1999, Bythell, et al. 2000 conducted a status of the reef survey and found the reef in flux, with patchy recovery.

The unprecedented number of hurricanes in 1989, 1995, 1999 and the 1998 bleaching event caused serious disturbances to the Buck Island reef system, including reduction of live coral cover by more than 10 percent, an abundance of macroalgae, and impacts to star coral populations (as a result of the bleaching event). However, elkhorn coral recruitment was documented along the heavily devastated south forereef (Note the 2005 bleaching event is addressed in subsequent paragraphs).

The National Park Service, the National Oceanic and Atmospheric Administration Biogeography Branch, the Government of the Virgin Islands and other organizations have cooperated on many subsequent monitoring projects of shallow coral reefs in the park.

The NPS South Florida Inventory and Monitoring Program's Aquamap Monitoring Program is being conducted at two coral reef sites within the park (NPS 2003). The western spur and groove and south forereef sites have been monitored annually since 2000 using the sonar-based relocation system, Aquamap, that was spatially referenced to the terrestrial global positioning system (NPS 2003). This video sampling method evaluates the condition and change of the benthic (bottom) community over time.

In a separate monitoring program the NPS monitored coral colony survivorship and trends at selected locations in the park, most located within the original 1961 boundary. In 1988, approximately 450 coral colonies of three coral species, brain coral (*Diploria strigosa*), mustard hill coral (*Porites astreoides*), and boulder star coral (*Montastraea annualaris*), were individually tagged at 13 locations throughout the park. In 2000, a new site was established to monitor re-growth of elkhorn coral along the south forereef, an area completely destroyed by Hurricane Hugo in 1989. Twenty-five young colonies were randomly selected along the depth gradient, tagged, and videotaped. Initially the colonies were monitored annually. Data on colony condition, percent live versus dead tissue, and disease presence was collected.

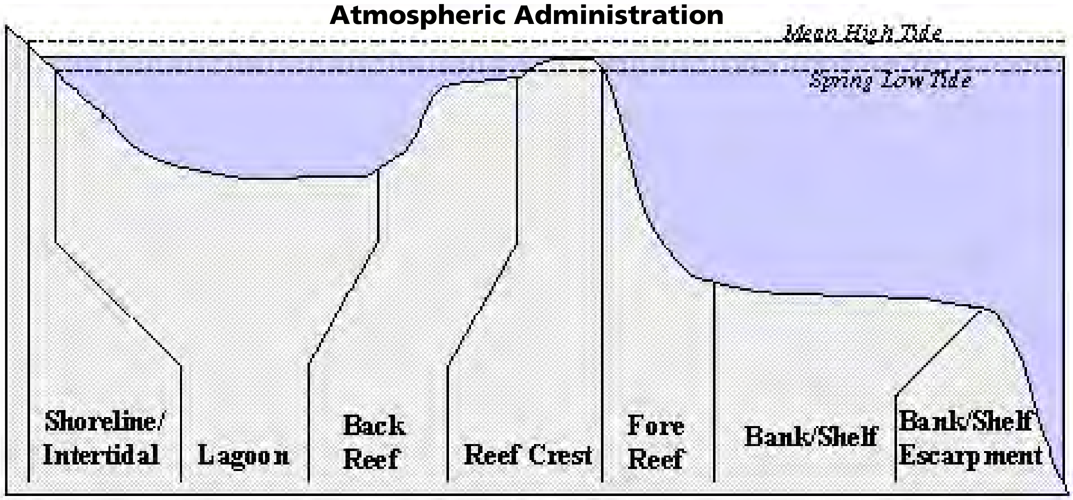
Outside of the annual monitoring, colonies are also checked during bleaching events to determine the impact bleaching might have on the colonies. From 2001 through today, colony monitoring occurs when staff are available. Park staff conducted colony monitoring during the bleaching events of 2003 and 2005; in 2005, a sub-set of colonies were photographed and/or videoed to establish impact of bleaching on tagged colonies. Over 60 percent of colonies observed were affected by the bleaching events. Monitoring of tagged colonies has been sporadic since 2005 due to staffing limitations.

Beginning in 1987, the NPS conducted linear chain transects monitoring of the coral benthic community at three locations in the park: one on the south forereef and two in the north lagoon (NPS 2003). A fourth set of transects was established in the northwestern lagoon after Hurricane Lenny in 1999. Eight 10-meter transects were established at each location, and data were collected by both video and chain. Data collected provides information on species, percent live cover and algae, and changes over time.

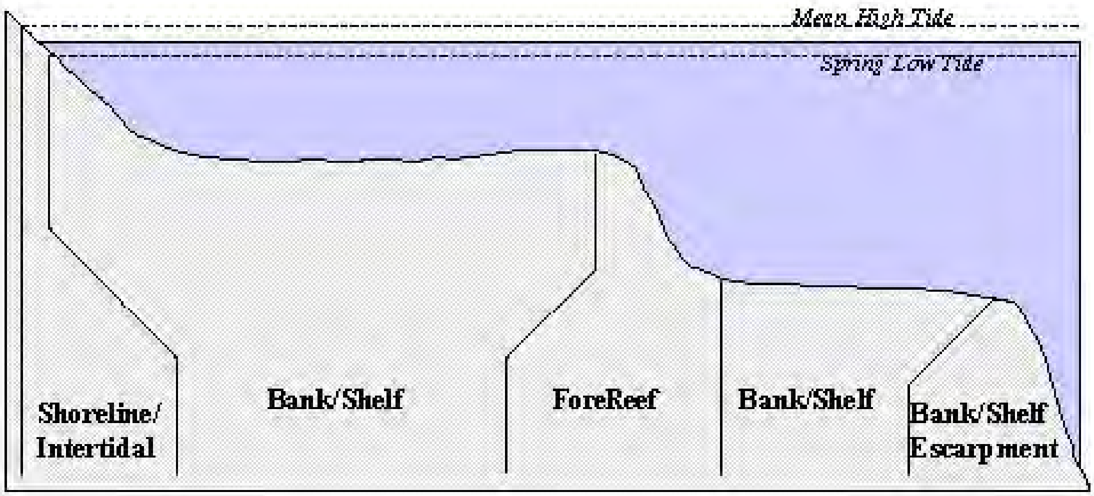
Since 2001, the National Oceanic and Atmospheric Administration has conducted benthic habitat mapping in the park (NOAA 2001a; NOAA 2006b; Kendall, et al. 2001). The program is ongoing and includes mapping of benthic zones and habitats, and quantitative assessments of corals and other benthic animals, such as conch, spiny lobsters, and long spined sea urchins. Results of the benthic surveys conducted from 2001 to 2006 are published in both a searchable database on the Internet (NOAA 2006b) and the NOAA Technical Memorandum NOS NCCOS 71. Methods employed in the surveys are provided in the metadata files for the on-line database (NOAA 2006b). A summary of the majority of the habitats is provided in the following paragraph and figures.

The first part of this mapping project was creation of a set of benthic habitat maps of the park using aerial photographs taken in 1999 (Kendall, et al. 2001). For this mapping effort, a system of habitats that are distributed across ecological zones was developed as shown in Figures 11 and 12 (note – zone descriptions do not match those provided by Bythell, et al. 1989). These ecological zones are an ecological designation, and are not to be confused with the NPS management zones described in Chapter 2. Twenty-one benthic habitat types within eight zones were mapped using a geographic information system (Figure 13). Coral reef and hardbottom covers the majority of the shallow water areas within the portion of the park surveyed, and predominates the northwest and southeast of the island. Sand areas are most common on the west end of Buck Island, to the south and southwest, but occur in other areas as well.

Figure 11. System of Ecological Zones Developed by the National Oceanic and Atmospheric Administration



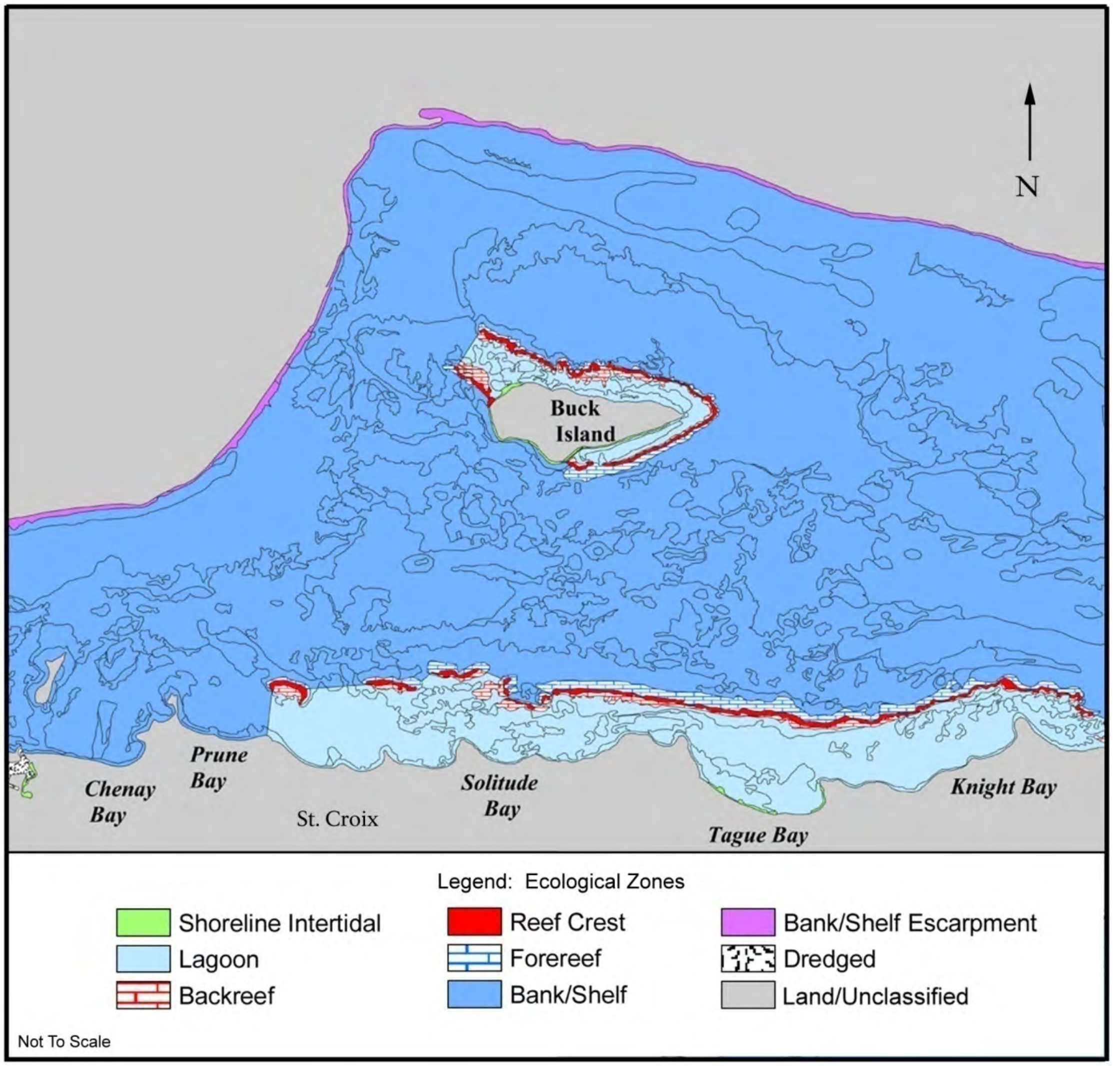
Cross-section of ecological zones where an emergent reef crest is present.



Cross-section of ecological zones where no emergent reef crest is present.

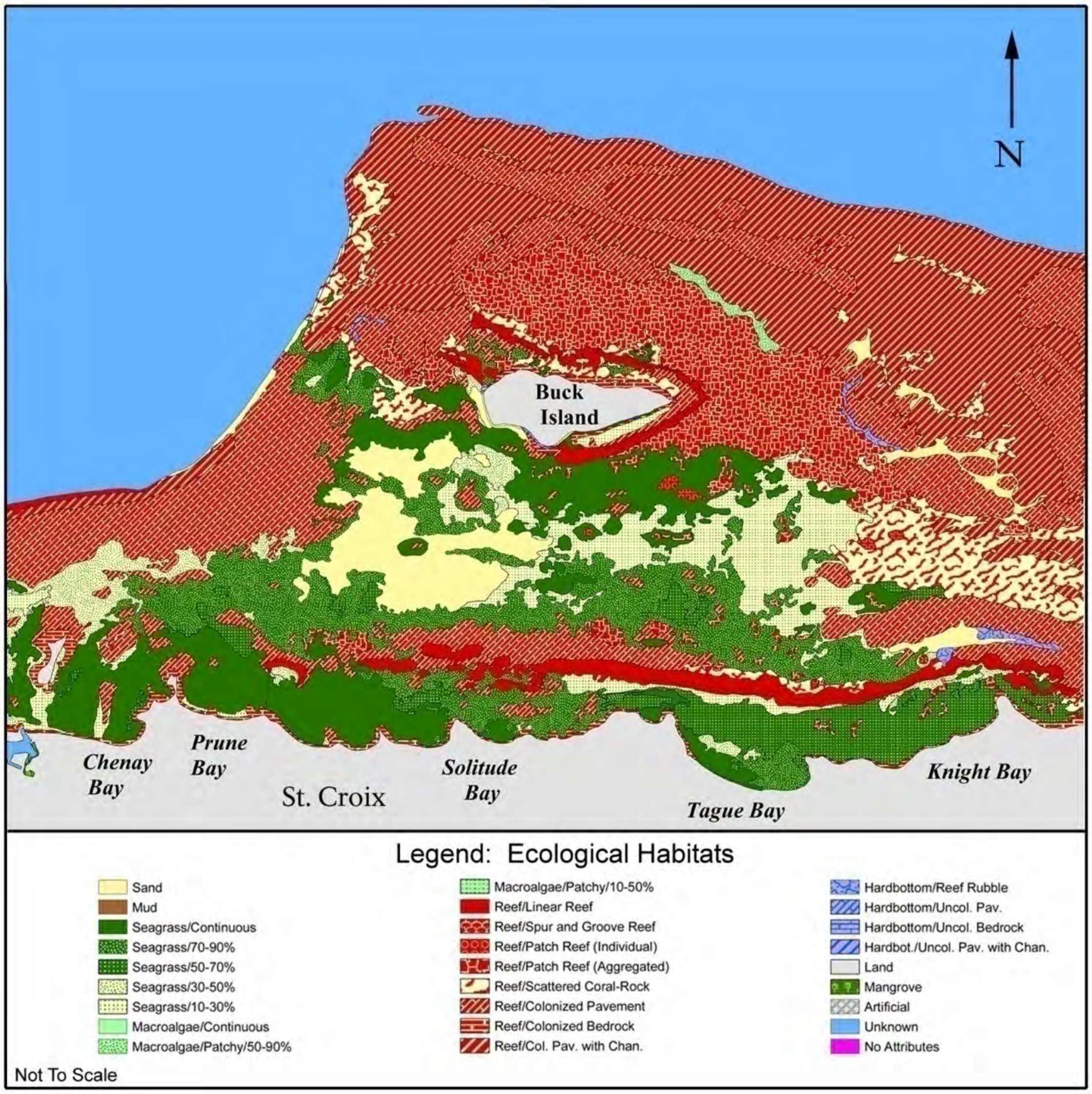
Source: Kendall, et al. 2001

Figure 12. Ecological Zones of Buck Island Reef National Monument and Surrounding Area Mapped by the National Oceanic and Atmospheric Administration



Source: Kendall, et al. 2001

Figure 13 Habitats in Buck Island Reef National Monument Mapped by the National Oceanic and Atmospheric Administration



Source: Kendall, et al. 2001

Table 10 presents a summary of all plants and animals observed during the 2001-2006 surveys by the National Oceanic and Atmospheric Administration (NOAA 2006b). A total of 49 species of corals was observed (including all genera, species, or combined taxa as provided in the National Oceanic and Atmospheric Association database [NOAA 2006b]). Three types of gorgonians, 58 types of marine benthic algae and seagrasses, three types of micro-invertebrates, and three types of sponges were reported. Conch and lobster data were also obtained. These data are summarized in the *Fish / Aquatic Life* section. Table 10 also summarizes the physical (non-living habitat) cover data for all of the 2001-2006 assessments.

Table 10. List of Plants and Animals Observed by the National Oceanic and Atmospheric Administration at all Stations Between 2001 and 2006

Category/Percent Cover [1]	Genus/Species	Common Name
Corals (49 taxonomic units) • Grand mean percent cover from 2001 to 2006 was 1.44% • Grand mean percent cover of diseased coral from 2001 to 2006 was 0.02% • Grand mean percent bleached coral cover was 0.08%	*Stephanocoenia mechelinii*	Blushing star coral
	Acropora cervicornis	Staghorn coral
	Acropora palmata	Elkhorn coral
	Agaricia agaricites	Lettuce coral
	Agaricia grahamae	Graham's sheet coral
	Agaricia lamarcki	Lamarck's sheet coral
	Agaricia spp	Agaricia spp.
	Colpophyllia natans	Boulder brain coral
	Dendrogyra cylindrus	Pillar coral
	Dichocoenia stokesii	Elliptical star coral
	Diploria clivosa	Knobby brain coral
	Diploria labyrinthiformis	Grooved brain coral
	Diploria spp.	Diploria spp.
	Diploria strigosa	Symmetrical brain coral
	Eusmilia fastigiata	Smooth flower coral
	Favia fragum	Golfball coral
	Helioceris cucullata	Sunray lettuce coral
	Isophyllastrea rigida	Rough star coral
	Isophyllia sinuosa	Sinuous cactus coral
	Madracis decactis	Ten-Ray star coral
	Madracis mirabilis	Yellow pencil coral
	Madracis pharensis	Star coral
	Madracis spp.	Madracis spp.
	Manicina areolata	Rose coral
	Meandrina meandrites	Maze coral
	Millepora alcicornis	Branching fire coral
	Millepora complanata	Blade fire coral
	Millepora spp.	Fire coral (spp.)
	Millepora squarrosa	Box fire coral

Table 10. List of Plants and Animals Observed by the National Oceanic and Atmospheric Administration at all Stations Between 2001 and 2006 (Continued)

Category/Percent Cover [1]	Genus/Species	Common Name
Corals (49 taxonomic units)	*Montastraea annularis*	Boulder star coral
	Montastraea cavernosa	Great star coral
	Montastraea spp.	Montastraea spp
	Mussa angulosa	Spiny flower coral
	Mycetophyllia aliciae	Knobby cactus coral
	Mycetophyllia danaana	Lowridge cactus coral
	Mycetophyllia ferox	Rough cactus coral
	Mycetophyllia reesi	Ridgeless cactus coral
	Mycetophyllia spp.	Mycetophyllia spp
	Porites astreoides	Mustard hill coral
	Porites porites	Finger coral
	Porites spp.	Porites spp.
	Scleractinia spp.	Unknown coral
	Scolymia cubensis	Artichoke coral
	Scolymia spp.	Scolymia spp
	Siderastrea radians	Lesser starlet coral
	Siderastrea siderea	Massive starlet coral
	Siderastrea spp.	Starlett coral
	Solenastrea bournoni	Smooth star coral
	Solenastrea spp.	Solenastrea spp
Gorgonians (3 taxonomic units) • Grand mean percent cover from 2001 to 2006 was 1.78 percent	*Erythropodium caribaeorum*	Encrusting gorgonian
	Gorgonacea fan	Sea fans
	Gorgonacea prw	Sea plumes, Sea rods and Sea whips
Marine Plants, Algae (58 taxonomic units) • Grand mean percent cover from 2001 to 2006 was 9.63 percent	*Acanthophora* spp.	Acanthophora spp.
	Acetabularia spp.	Mermaid's wine glass (sp.)
	Algae fil spp.	Filamentous algae (sp.)
	Algae spp.	Algae
	Amphiroa spp.	Amphiroa spp.
	Asparagopsis spp.	Asparagopsis spp.
	Avrainvillea spp.	Avrainvillea spp.
	Bryothamnion spp.	Bryothamnion spp.
	Caulerpa spp.	Caulerpa spp.
	Centroceras spp.	Centroceras spp.
	Ceramium spp.	Ceramium spp.
	Champia salicornioides	Champia salicornioides
	Chlorophyta fil. spp.	Filamentous algae, green
	Chondria spp.	Chondria spp.
	Cladophora spp.	Cladophora spp.

Table 10. List of Plants and Animals Observed by the National Oceanic and Atmospheric Administration at all Stations Between 2001 and 2006 (Continued)

Category/Percent Cover [1]	Genus/Species	Common Name
Marine Plants, Algae (58 taxonomic units)	*Cladosiphon* spp.	Cladosiphon spp.
	Codium spp.	Codium spp.
	Cyanophyta spp.	Blue-green algae
	Dasya spp.	Dasya spp.
	Dictyopteris spp.	Dictyopteris spp.
	Dictyota spp.	Y branched algae
	Digenea spp.	Digenea spp.
	Galaxaura spp.	Tubular thicket algae
	Gelidium pusillum	Gelatin algae
	Gracilaria spp.	Gracilaria spp.
	Griffithsia spp.	Griffithsia spp.
	Halimeda spp.	Halimeda
	Halodule wrightii	Halodule wrightii
	Halophila decipiens	Halophila decipiens
	Halymenia floresia	Halymenia floresia
	Hypnea spp.	Hypnea spp.
	Jania spp.	Jania spp.
	Laurencia spp.	Laurencia spp.
	Liagora spp.	Liagora spp.
	Lobophora spp.	Encrusting fan-leaf algae
	Magnoliophyta spp.	Seagrass
	Neomeris spp.	Neomeris spp.
	Padina spp.	Padina spp.
	Penicillus spp.	Penicillus spp.
	Phaeophyta fil. spp.	Filamentous algae, brown
	Porolithon pachydermum	Reef cement
	Rhodophyta cru. spp.	Crustose coralline algae
	Rhodophyta fil. spp.	Filamentous algae, red
	Rhodophyta mac. spp.	Macro algae, red
	Sargassum spp.	Sargassum algae
	Schizothrix spp.	Schizothrix spp.
	Scinaia spp.	Scinaia spp.
	Spyridia spp.	Spyridia spp.
	Stypopodium spp.	Stypopodium spp.
	Syringodium filiforme	Manatee grass
	Thalassia testudinum	Turtle grass
	Trichogloea spp.	Trichogloea spp.
	Turbinaria spp.	Turbinaria spp.
	Turf Algae	Turf algae
	Udotea spp.	Mermaid's fans (unknown)
	Valonia spp.	Valonia spp.
	Ventricaria spp.	Ventricaria spp.
	Wrangelia spp.	Wrangelia spp.

Table 10. List of Plants and Animals Observed by the National Oceanic and Atmospheric Administration at all Stations Between 2001 and 2006 (Continued)

Category/Percent Cover [1]	Genus/Species	Common Name
Micro-invertebrates (3 taxonomic units) • Grand mean percent cover from 2001 to 2006 was 1.29 percent	*Actiniaria* spp.	Anemones
	Ascidiacea spp.	Tunicates
	Zoanthidea spp.	Zoanthids (unknown)
Sponges (three taxonomic units) • Grand mean percent cover from 2001 to 2006 was 1.33 percent	*Porifera btv.* spp.	Barrel/Tube sponge [Upright/Erect sponge]
	Porifera enc. spp.	Encrusting sponge
	Porifera spp.	Sponge

Source: (NOAA 2006b)
[1] Grand mean percent cover calculated from NOAA database (2006b) and is based on best available data.

Results summarized in Table 10 and Figure 12 show how the bottom habitats in the park form a complex and highly diverse physical and biological mosaic of hard and soft bottom areas, characterized by living and non-living components.

Seagrass Community and Algal Plains

Seagrasses include species such as turtle grass *(Thalassia testudinum),* manatee grass (*Syringodium filiforme),* and shoal grass (*Halodule wrightii).* Seagrasses inhabit shallow water areas generally less than 10 to 15 meters deep and are found in soft-bottom habitats on the south and southwest side of the island, the relatively protected waters between St. Croix and Buck Island. Seagrasses are true flowering plants that reproduce both sexually, via underwater pollination, and asexually, by horizontal spread of buried stems called rhizomes. The buried stems are extensive and serve to stabilize sediments and minimize erosion of shorelines. These functions help shield adjacent coral reefs from the potential effects of sedimentation (Ward, et al. 1984 and Kenworthy, et al. 1988 in Kendall, et al. 2004a).

Seagrasses are important members of the marine community because of their high levels of primary productivity (Kenworthy and Schwarzchild 1998 *in* Kendall, et al. 2004a). Seagrasses produce large amounts of green photosynthetic plant material that is eaten by sea turtles. Decaying plant material enters a detritus food chain that supports invertebrates and fish. Much of this dead plant material is also exported to adjacent systems where it helps support numerous associated marine animals (Hubbard, et al. 1981).

Seagrasses provide important habitat for numerous fish and invertebrates and are important as feeding, nursery, and spawning areas for various fish and shellfish (Kenworthy et al., 1988; Nagelkerken, et al. 2000 *in* Kendall et al. 2004a). For example, snappers and grunts move from adjacent reefs into seagrass beds at night to feed (Rogers and Teytaud 1988). Spiny lobster (*Panulirus argus*) are strongly reliant on seagrass habitats, and are important for the brooding of eggs and for fish with demersal eggs (demersal eggs are heavier than water and are laid in prepared spawning sites on the sea bed). Many fish reside only temporarily in seagrass beds, to forage, spawn, or escape predation. Economically-important species which use these habitats for nursery and/or spawning grounds include: grunts (haemulids), snook (*Centropomus* spp.*),* tarpon (*Megalops atlanticus*) and several species of snapper and grouper (CFMC 2004).

Seagrass beds are also primary habitat for queen conch, which feeds on algae that grow on the blades of seagrasses (Rogers and Teytaud 1988). Fish and sea urchins grazing on seagrasses create bare halos around patch reefs (Rogers and Teytaud 1988).

The Kendall, et al. 2004a study shows that seagrass has become much more abundant in the Buck Island Channel over the last several decades. Using aerial photographs, this study shows that seagrass coverage in this area increased from 1.33 square kilometers to 4.34 square kilometers between 1971 and 1999. The study also concluded that seed dispersal, germination, and seed growth were the primary mechanisms for the observed increase. Seagrasses were also observed to be concentrated around reef areas, but beyond the usual sand halo typical of reef - seagrass interfaces. The study suggested that higher frequency of hurricanes enhanced the distribution of seagrass fragments.

Individual seagrasses and associated species form biological and physical areas known as seagrass meadows (CFMC 2004). Meadows vary in size from small, isolated patches of plants less than a meter in diameter, to a continuous distribution of grass such as the area identified within the Buck Island Channel, or off Buck Island's West Beach. Despite the life stage or type of species, different growth and mortality rates can cause seagrasses, patches, and/or meadows to shift in location and time, the rate of which can vary from hours to decades depending on site conditions. According to the Caribbean Fisheries Management Council (2004), seagrass habitats must be recognized as including not only continuously vegetated perennial beds, but also patchy environments that include unvegetated areas between patches. Patchy habitats provide many ecological functions similar to continuous meadows.

Patchy seagrass beds occur in the vicinity of the anchoring area off West Beach. In higher energy areas, qualitative observations by park staff indicate that seagrass densities adjacent to the beach can change relatively quickly as a result of storms, especially in the area off West Beach. Anchoring can destroy the seagrass rhizomes and lead to bare areas that are more subject to effects of winds, currents and wave action.

Green, red, and brown benthic marine algae occur in seagrass beds as well as in other areas such as reefs and open hard bottom habitats. Many benthic algae occur in what has been defined as algal plains, which occur mainly in the shallow water landward of the backreef zones. These areas are inhabited by calcareous green algae such as *Halimeda* sp., *Udotea* sp, *Penicillus* sp., and *Rhipocephalus* sp. that are important sources of calcium carbonate. A variety of species of non-calcareous red and brown benthic marine algae also occur in the algal plains, and additionally on hardbottom reefs. The ecology of the algal plain is not well known, but Earle (1972) observed 154 species of plants and 35 species of herbivorous fish from the algal plain located on the south shore of St. John (Rogers and Teytaud 1988). Earle concluded that fish had a greater influence on plant distribution than invertebrates in that area (Earle 1972, *in* Rogers and Teytaud 1988). Threatened hawksbill and green sea turtles utilize some benthic algae species as food. This habitat is also inhabited by invertebrates including mollusks and crustaceans, which are eaten by fish (CFMC 2004).

Sand Bottom Community

A sand bottom community generally occurs between a coral reef and shallow shore area. In the park, a sand community occurs in the lagoon between the elkhorn coral barrier reef and the shoreline, while the most extensive sand bottom community occurs off the southwest end of the island nearshore. Here, deep sand deposits form an arc around West Beach that moves seasonally, building in the winter months and wasting in the late summer/fall. Late winter storms can alter this sand beach and associated sand spit dramatically, either by removing the beach and leaving a 2 meter high berm or by building 10-20 meters of beach overnight (Hillis-Starr, pers. communication, 2009). A more extensive sand/seagrass community exists between Buck Island and St. Croix in the Buck Island Channel where there are also large areas of sand without seagrass at depths between 30 to 50 feet.

Although the density and diversity of benthic plants and animals of the sand community are lower than neighboring reef and seagrass communities, numerous species inhabit this community type (The Ocean Conservancy 2006). Nova University conducted a study of fish in sandy habitats from 24 stations in the park during April and October 2005 (Nova University unpublished). A total of 39 fish species were recorded (Table 11). The most abundant fish were rosy razorfish (*Xyrichtys martinicensis, Xyrichtys sp.),* pipehorse (*Xyrichtys* sp.*),* peacock flounder (*Bothus lunatus)*, bluelip parrotfish (*Cryptotomus roseus),* pugnose pipefish (*Syngnathus dunckeri),* and redtail parrotfish (*Sparisoma chrysopterum).*

Table 11. Results of Fish Sampling from 24 Stations Located in Sandy Habitats in the Park (April and October 2005).

Habitat	Common Name	Scientific Name	Abundance (Number)
Date: 5 April 2005 Latitude: 17° 46.964 Longitude: 064° 38.255			
Sand	Rosy razorfish	*Xyrichtys martinicensis*	>50
Sand	Barbfish	*Scorpaena brasiliensis*	1
Sand	Pipehorse	*Acentronura dendritica*	1
Sand		*Xyrichtys* sp.	>50
Sand	Stripe eel	*Aprognathodon platyventris*	3
Sand	Brown garden eel	*Heteroconger longissimus*	6
Sand	Surf eel	*Ichthyapus ophioneus*	1
Sand	Peacock flounder	*Bothus lunatus*	29
Sand		*Ophidion* sp.	5
Sand		*Monacanthidae* sp.	1
Sand		*Chaenopsis* sp.	2
Sand	Bluestriped lizardfish	*Synodus saurus*	1
Date: 5 April 2005 Latitude: 17° 46.959 Longitude: 064° 38.231			
Sand	Rosy razorfish	*Xyrichtys martinicensis*	>50
Sand		*Xyrichtys* sp.	>50
Sand	Stripe eel	*Aprognathodon platyventris*	1
Sand	Brown garden eel	*Heteroconger longissimus*	3
Sand	Peacock flounder	*Bothus lunatus*	19
Sand	Margintail conger	*Paraconger caudilimbatus*	1
Sand	Surf eel	*Ichthyapus ophioneus*	1
Sand	Yellowface pikeblenny	*Chaenopsis limbaughi*	1
Sand		*Ophidion* sp.	2
Sand	Mushroom scorpionfish	*Scorpaena inermis*	1
Sand		*Callionymidae* sp.	1
Date: 9 October 2005 Latitude: 17° 46.953 Longitude: 064° 37.749			
Seagrass / Sand	Seagrass eel	*Chilorhinus suensonii*	1
Seagrass / Sand	Stripe eel	*Aprognathodon platyventris*	7
Seagrass / Sand	Slippery dick	*Halichoeres bivittatus*	2
Seagrass / Sand	Academy eel	*Apterichtus ansp*	5
Seagrass / Sand	Lantern bass	*Serranus baldwini*	1
Seagrass / Sand	Goldspot goby	*Gnatholepis thompsoni*	1

Table 11. Results of Fish Sampling from 24 Stations Located in Sandy Habitats in the Park (April and October 2005) (Continued).

Habitat	Common Name	Scientific Name	Abundance (Number)
Seagrass / Sand	Green razorfish	*Xyrichtys splendens*	4
Seagrass / Sand	Lancer dragonet	*Paradiplogrammus bairdi*	1
Seagrass / Sand	Bluethroat pikeblenny	*Chaenopsis ocellata*	1
Seagrass / Sand	Eyed flounder	*Bothus ocellatus*	1
Seagrass / Sand	Shortfin pipefish	*Syngnathus elucens*	2
Seagrass / Sand	Fringed filefish	*Monacanthus ciliatus*	4
Seagrass / Sand	Pugnose pipefish	*Syngnathus dunckeri*	6
Seagrass / Sand		*Neomerinthe beanorum*	2
Seagrass / Sand	Bluelip parrotfish	*Cryptotomus roseus*	15
Seagrass / Sand	Redtail parrotfish	*Sparisoma chrysopterum*	9
Seagrass / Sand	Redband parrotfish	*Sparisoma aurofrenatum*	1
Seagrass / Sand	Seagrass eel	*Chilorhinus suensonii*	3
Seagrass / Sand	Stripe eel	*Aprognathodon platyventris*	5
Seagrass / Sand	Slippery dick	*Halichoeres bivittatus*	1
Seagrass / Sand	Rosy razorfish	*Xyrichtys martinicensis*	11
Seagrass / Sand	Academy eel	*Apterichtus ansp*	1
Seagrass / Sand	Goldspot goby	*Gnatholepis thompsoni*	1
Seagrass / Sand	Finless eel	*Apterichtus kendalli*	3
Seagrass / Sand	Key Worm Eel	*Ahlia egmontis*	2
Seagrass / Sand		*Gillellus jacksoni*	6
Seagrass / Sand	Bluethroat pikeblenny	*Chaenopsis ocellata*	2
Seagrass / Sand	Shortfin pipefish	*Syngnathus elucens*	1
Seagrass / Sand	Pugnose pipefish	*Syngnathus dunckeri*	14
Seagrass / Sand	Bluelip parrotfish	*Cryptotomus roseus*	5
Seagrass / Sand	Bucktooth parrotfish	*Sparisoma radians*	3
Seagrass / Sand	Redtail parrotfish	*Sparisoma chrysopterum*	14
Seagrass / Sand		*Scorpaenidae* sp.	1
Seagrass / Sand	Reef squirrelfish	*Sargocentron coruscum*	1
Seagrass / Sand	Longjaw squirrelfish	*Neoniphon marianus*	1

Source: Nova University, unpublished.

Deep Reefs and Wall Reefs

Deep reefs and wall reefs occur below depths of 40 meters and are located to the north and west of Buck Island. Two National Oceanic and Atmospheric Administration (2006b) surveys of deepwater benthic habitats were completed from 2003 to 2006 within the park. These surveys focused on deepwater habitats north of Buck Island, and extended to depths of approximately 100 to 300 meters.

The Biogeography Branch at NOAA's National Centers for Coastal Ocean Science has been developing (2004 onward) detailed bathymetric models of the U.S. Caribbean seafloor, including the park, as well as continued benthic habitat characterizations and ecological inventories that go beyond the depth limits (30 meters) of optical remote sensing. The Biogeography Branch has created a series of habitat maps from the shoreline to 1000 meters water depth. This information will help provide a better understanding of the marine resources within the surveyed areas by filling in data gaps and providing valuable information regarding marine species and habitat use for the following communities: deep reefs and wall reefs, the deep water abyssal bottom, and deep water ocean/pelagic.

A wide diversity of habitat types were characterized during this mapping project, such as rock precipices, ledges, limestone caves, boulders, rock outcroppings, flat mud, deep channels wider than one kilometer in mud, and shallow channels thinner than one meter in mud. The biota below 200 meters, never visually characterized before, included Lophelia coral, black coral sea whips, feather stars, sea pens, sea anemones, starfish, brittlestars, urchins, sponges, isopods, sea cucumbers, lobsters, shrimps, crabs, conch, orange roughy (*Hoplostethus atlanticus*), roundnose grenadier (*Coryphaenoides rupestris*), tripod fish (*Bathypterois grallator*) and several types of snappers.

Deep Water Abyssal Bottom Community

The abyssal benthic community includes the bottom habitats at depths greater than 275 to 375 meters north and west of Buck Island. This deepwater area is inhabited by fish, benthic invertebrates, and other marine animals. This area is relatively steep and extends to a depth of over 1,500 meters. This area has been mapped and inventoried by NOAA's seafloor mapping program described above.

Deep Water Oceanic/Pelagic Community

The oceanic/pelagic community is an open, deep water area located on the north side of Buck Island that extends from the shelf edge out to the northern boundary of the park. This area includes the entire water column from the surface to a depth of over 1,500 meters. Few studies have been conducted of the open water pelagic area. This community is inhabited by fish adapted to water in the open ocean, and is characterized by relatively low levels of nutrients and primary productivity, and patchy distribution of plants and animals (CFMC 2004). Pelagic fish such as dolphin and juvenile flying fish congregate in and among floating *Sargassum* weed or drifting mats of turtle grass (*Thallassia*). Eggs and larval stages of migratory fish and invertebrates are also known to drift in pelagic areas. Pelagic areas are also inhabited by billfish, tuna, jacks, mackerel, and by sharks and rays (CFMC 2004). On rare occasions a whaleshark (*Rhincodon typus)* has been found basking on the surface by sport fishers. Additionally, several species of whales have been documented in the northern portion of the park, including humpbacks (*Megaptera novaeangliae*) during seasonal (January - February) reproductive migrations to the south, killer whales or Orca (*Orcinus orca*) following humpbacks migration, and pilot whales (*Globicephala*).

Factors Affecting the Health of Coral Reefs and Marine Communities

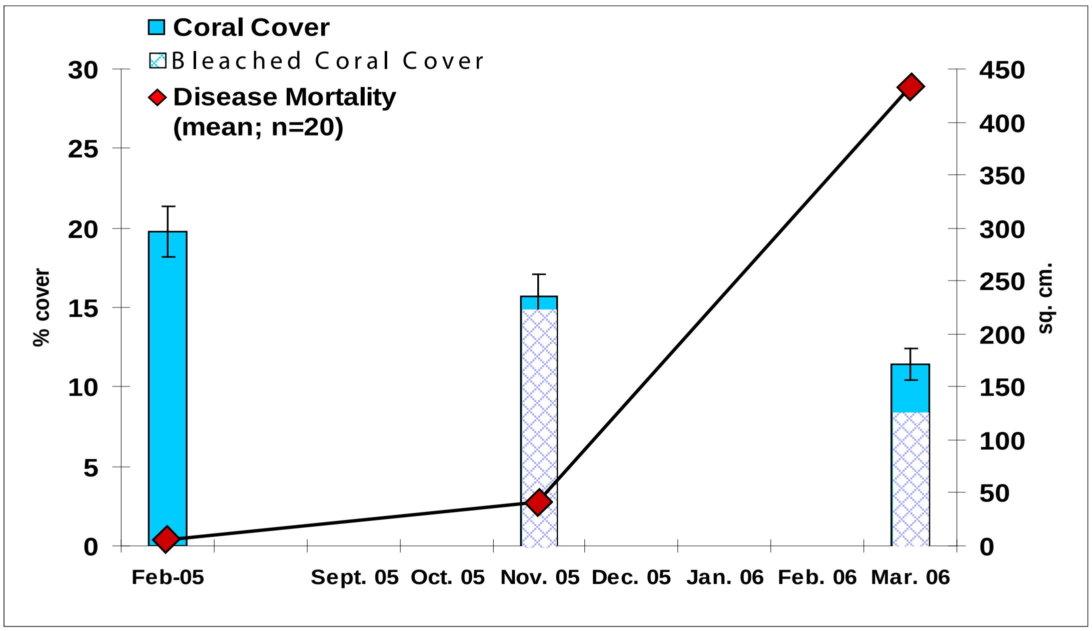
A number of factors affect the health of coral reef and other marine communities in the park. An overview of some of the man-made and natural stresses on coral reefs is summarized in the text that follows.

Coral Bleaching: Elevated water temperatures are shown to adversely affect coral reefs in the park (NPS 2006c; NOAA 2006d; Lundgren and Starr 2008; Clark et al. 2005; Miller et al. 2009) and throughout the Caribbean (Lundgren 2008). Scientific evidence to date indicates that greenhouse gas emissions produced by man are responsible for the most recently observed increases in the temperature of the earth's atmosphere and oceans (Hansen, et al. 2006, Stern, et al. 2006). When water temperatures are elevated above the bleaching threshold of 29.5° Celsius (83.3 ° Fahrenheit) for a sufficient duration, the brown colored symbiotic algae in the coral are expelled, leaving a white coral exoskeleton and polyps (Waddell, et al. 2005). This can ultimately lead to death of the coral polyps themselves or make the coral susceptible to numerous types of disease.

In 1998-1999, a severe Caribbean-wide bleaching event was reported (Waddell, et al. 2005). According to the NPS (2006c), the 1998 bleaching event coincided with the highest recorded surface sea temperatures in the U.S. Virgin Islands up to that time. Bleaching was probably less severe in 1999 because water temperatures were slightly lower (28.8°C) during that year. The 1999 bleaching event did not result in extensive coral colony mortality because most colonies recovered within six months of being bleached (Nemeth and Sladek-Nowlis 2001; Nemeth et al., 2003c; in Waddell et al. 2005).

A mild bleaching event was observed by NPS staff and scientists from October through November 2003. Then, in the late summer of 2005, the largest bleaching event in the Virgin Islands' recorded history was observed (Lundgren and Starr 2008; Miller et al. 2009). NPS documented the impact of the bleaching event at several sites, including NPS Aquamap coral monitoring sites and three elkhorn coral tag sites. NPS Aquamap sites were monitored, including roughly 40,000 square meters of the south forereef site, and the western spur and groove site (NPS 2006c). Results for the south forereef of Buck Island are summarized in Figure 14.

Figure 14. Changes in Coral Cover in the South Forereef of Buck Island Reef National Monument Between February 2005 and March 2006



Source: NPS 2006c

From February 2005 to March 2006, 95.6 percent of coral present at these sites experienced bleaching (Clark et al. 2005; NPS 2006c). During this same period, a 42 percent reduction in live cover occurred, but this reduction was caused by coral mortality. The exact causal relationships between bleaching, disease (and other factors), and coral mortality are not known.

The National Oceanic and Atmospheric Administration (NOAA 2006d) published a separate report on coral bleaching in the park, based on data collected during October 16-30 and December 12-14, 2005. The study was conducted as part of the biannual NOAA/NPS fish and habitat survey for Buck Island. The survey identified the broad range of coral species affected by the bleaching event (NOAA 2006d). Recent coral death (i.e., overgrowth by Cyanobacteria or bluegreen algae) was observed in only a few species. Finger coral (*Porites porites*) and fire corals (*Millepora* spp.) had the highest occurrence of dead coral and may have been the species most affected by the bleaching event. Continued monitoring of Buck Island Reef National Monument and East End Marine Park corals was recommended to determine recovery and the overall impact of such extreme natural events on coral reef ecosystems (NOAA 2006d).

Diseases play a significant role in the losses of hard coral communities, and are identified as one of the most important factors in the deterioration of many Caribbean coral reefs (NOAA 2008). The number of described coral diseases has increased exponentially over the past three decades (Sutherland et al. 2004), and Buck Island Reef National Monument is no exception. NOAA (2005) reported that, "Between 1976 and 1989, white band disease, bleaching, and hurricanes reduced the cover of elkhorn coral by as much as 85 percent within the Virgin Islands National Park and Buck Island Reef National Monument" (Gladfelter, et al. 1977; Rogers, et al. 1982; Edmunds and Witman 1991; Bythell, et al. 1992; Rogers and Beets 2001). Furthermore, a white-plague disease outbreak, which followed the 2005 Caribbean coral bleaching event resulted in observed loss of up to 79 percent live tissue or percent coral cover on the massive coral-dominated south forereef area at the park (Miller, at al. 2009; Turgeon, et al. 2002).

White-Band Disease – Branching acroporid species, major reef-buiding corals, have been significantly impacted by white-band disease. At Buck Island Reef National Monument, elkhorn coral cover fell from 85 percent in 1976 to 5 percent in 1988, due to mortality from the combination of disease and tropical storms (Rogers, et al. 1982, Gladfelter 1991, *in* Turgeon, et al. 2002). White band typically starts at the base of the colony and moves towards the branch tips causing complete colony mortality. Shallow reef areas, once covered with elkhorn coral, are now graveyards with branches and fragments interspersed among algal-covered skeletons still upright in normal growth position. Although prevalence of white band has declined since the 1980s, this disease is still occasionally seen at the park and throughout the U.S. Virgin Islands.

White-Pox Disease – Elkhorn coral is the only species affected by white pox disease, which was first described in the 1990s. This disease is the primary cause of tissue loss on elkhorn colonies monitored monthly in Virgin Islands National Park (Miller, et al. 2005) and contributes to coral loss. Unlike white band disease, white pox does not typically kill entire colonies. Corals with white pox have the potential to heal disease-induced lesions as long as disease progression stops before complete colony mortality occurs.

Black-band Disease – This disease primarily infects major reef-building corals such as boulder star coral (*Montastraea annularis*) and brain coral (Edmunds 1991; Richardson, et al. 1997, *in* Turgeon, et al. 2002). In 1988, Edmunds (1991) found very low incidence of black-band disease (0.2%) on corals in seven sites in the U.S. and British Virgin Islands. Nemeth reported 1.2 percent on St. John and on St. Thomas or St. Croix (Nemeth ,et al. in press *in* Turgeon, et al. 2002). At the park, black-band disease is seen on Diploria spp. colonies but typically on fewer than 10 colonies a year (Hillis-Starr pers. comm., *in* Turgeon et al. 2002).

White-Plague Disease – Several months after the 2005 Caribbean coral-bleaching event, an outbreak of white-plague disease resulted in significant coral loss in St. John and Buck Island Reef National Monument (Miller, et al. 2009). Coral cover at the south forereef long term monitoring site in the park declined 79.3 percent within 1.5 years of the bleaching event. Average coral cover declined by more than 60 percent throughout St. John and Buck Island Reef National Monument, making this event the most widespread loss of coral cover ever documented within the Virgin Islands.

Other Diseases – Small U.S. Virgin Islands patch reefs of finger coral have died from an unknown disease and some of these reefs have been dead for over 12 years (Beets, et al. 1986; Rogers 1999; J. Miller pers. comm.; B. Kojis pers. comm., *all in* Turgeon, et al. 2002). Finger coral is not known to be susceptible to either white-band or black-band disease, but has been observed with white plague.

Sea fan disease, caused by the fungus *Aspergillis sydowii*, occurs in sea fans on St. John reefs (G. Smith pers. comm. *in* Turgeon, et al. 2002) as well as those in Buck Island Reef National Monument. The prevalence of this disease and its impact on the sea fan population of the U.S. Virgin Islands is presently unknown.

Invasive Lionfish: Lionfish (*Pterois volitans/miles*) are the first invasive marine fish to establish populations along the United State's Atlantic coast from Florida to Rhode Island (Lundgren and Starr

2009). Since 2000, Lionfish have expanded through the Caribbean including the Bahamas, Cayman Islands, Cuba, the Dominican Republic, Haiti, Jamaica, the Turks and Caicos, and have recently (2010) been identified at Buck Island Reef National Monument and Virgin Islands National Park(Hillis-Starr pers. comm., 2010; Lundgren and Starr 2009). Lionfish pose a significant threat to coral reef ecosystems due to few predators and negative effects on native species through competition and predation. Recent research in the Bahamas concluded that Lionfish caused an 80 percent reduction in coral reef fish recruitment (Lundgren and Starr 2009). Control of invasive Lionfish is currently taking place at Virgin Islands National Park, Virgin Islands Coral Reef National Monument and Buck Island Reef National Monument (Hillis-Starr per. comm., 2010).

Tropical Storms and Hurricanes: Tropical storms and hurricanes have major effects on coral reef communities in the Caribbean. Storms have the capacity to degrade reefs in several ways. They increase terrestrial runoff, sedimentation, and pollution affecting coral reefs, and cause extensive physical damage to the substratum (Waddell, et al. 2005).

Pollution: Sources of point- and non-point source pollution are addressed in the Water Resources subsection earlier in this chapter. The effects of nonpoint runoff from development can cause adverse effects on the structure and function of coral ecosystems through smothering of corals, reduction in coral photosynthesis, and interference with larval settling and growth (DPNR 2005b).

The principal concerns in the U.S. Virgin Islands are siltation, sedimentation, and smothering, following removal of upland vegetation, and nutrient enrichment, particularly in areas adjacent to inshore reefs (Goenaga and Boulon 1992 *in* DPNR 2005b). Turbidity associated with increased sediment load shades corals that require light for their algal symbionts (zooxanthellae), thus reducing productivity and growth. The energy expended by corals in clearing away sediment is also a factor influencing growth (Rogers 1990 *in* DPNR 2005b). Sediment loading may also influence the incidence of coral diseases (Peters 1984 *in* DPNR 2005b) and coral bleaching rates and it also reduces substrate availability for the settlement of coral and other larvae (Nemeth and Sladek-Nowlis 2001). Turbidity has clearly been shown to influence fish abundance and diversity (Amesbury 1981; Hubbard, et al. 1987; and Loya 1976a; *all in* DPNR 2005b).

Chronic sedimentation may reduce the abundance and diversity of corals and other reef organisms, increase coral stress and susceptibility to diseases, increase bleaching, and reduce the ability of corals and other reef organisms to recover and regenerate after natural disturbances such as hurricanes (Acevedo and Morelock 1988; Rogers 1990; Rice and Hunter 1992; and Nemeth and Sladek-Nowlis 2001 *all in* DPNR 2005b).

Land-use practices, such as upland clearing of vegetation, farming, urban development, fires, and animal grazing, increase the runoff of nutrients (fertilizers) and other contaminants (e.g., pesticides and metals). Nutrients enhance the growth of algae that compete with corals for space on the reef and influence coral larval recruitment (Birkeland 1977 in DPNR 2005b). Exposure of corals and associated biota to pesticides and other contaminants may result in toxic or sub lethal impacts depending on the concentrations and duration of exposure.

The impact of wastewater discharges on coral was reviewed by Pastorok and Bilyard (1985) and Marszalek (1987). Impacts include effects due to turbidity, sedimentation, enhancement of algal growth, increased risk of coral disease, and toxic effects. Marszalek (1987, *in* DPNR 2005b) concluded that the toxic effects of municipal wastewater were overshadowed by the indirect effects of nutrient loading. Eutrophication (nutrient enrichment) by sewage disposal or land drainage can stimulate algal blooms, which will outcompete or displace slower-growing organisms, such as corals. This can result in the proliferation of organisms that compete with, or damage corals (e.g., burrowing bivalves and boring algae and sponges).

Information on water quality in the park and vicinity is summarized in the *Water Resources* subsection of this chapter.

Vessels and Groundings: Vessels passing in or near the park have the potential to harm coral reefs by groundings, anchoring, oil or other discharges, spills, or pumping of bilge water (which may contain oil, grease, fuel, or other materials). Smaller vessels in the park can harm reefs and sea grass beds by inappropriate use of anchors, or by propeller or hull damage to shallow reefs. Over the last 20 years there have been several vessel groundings related to poor navigation, loss of engine power, and illegal smuggling. As of 2009, no oil spills have occurred in the park.

In addition, the presence of vessels in park waters has a potential to affect reef health through release or sloughing of toxic material contained in bottom paint. In 2007, the Danish Galathea Expedition conducted a study on organic pollutants and toxic metals in the marine environment. Tributyltin (TBT) and its metabolites dibutyltin (DBT) and monobutyltin (MBT) were detected at all the examined sites, including the park; however, only low levels of TBT were found in *Thais rustica* (neograstropod) samples in the park (Strand, *et al.* 2009).

Marine Debris: Marine debris includes remnants of fishing nets, floating manmade debris, plastics of all kinds, abandoned/lost fishing buoys, and abandoned fish traps. Fishing line and nets, rope, and other trash can wrap around animals and cause drowning, infection, or amputation, or can settle on hard bottom areas and kill coral colonies (Waddell, et al. 2005). The park has a fish trap removal program in place, and has made efforts to remove abandoned traps. Other debris found along the shoreline or on the reef is removed on a periodic and opportunistic basis.

FISH/AQUATIC LIFE

Buck Island Reef National Monument is a "no take" marine reserve. Like all marine reserves, the park provides beneficial effects on the marine resources in the reserve as well as a spill-over effect, potentially increasing fish abundance and fishery yield in nearby waters outside the park boundaries (Rogers and Beets 2001; NPS 2007a). There is convincing evidence that fully protected marine reserves, where no extraction is permitted, allow for the preservation of nature for recreation, research, inspiration; for rebuilding depleted fishing stocks; and for helping to restore productivity, sustainability, and resilience to the coastal ocean. In 76 studies of reserves around the world, densities of fishery species increased in 69 percent of reserves, the average body size of fish increased in 88 percent of reserves, and biomass was reported to increase in 92 percent of the reserves (NPS 2007a). Worm, et al. (2006) analyzed 44 fully protected marine reserves and reported that reserves and closures reversed the decline of marine biodiversity on local and regional scales.

Characteristics of fish assemblages in the park, the regulatory definition of "essential fish habitat" and how it applies to the park, and a discussion of spiny lobsters, conch, and the long-spined sea urchin are provided in this section.

Fish

Fish are associated with all marine habitat types in the park. Many fish depend exclusively on coral reefs for shelter, food, and spawning (Mac, et al. 1998). Certain other species, such as the bucktoothed parrotfish and fringed filefish, complete their entire life cycle in seagrass beds, and other species such as the French grunts (*Haemulon flavolineatum*) use the seagrasses as a nursery area. Snappers and grunts leave the reef at night and feed in seagrass beds (Mac, et al. 1998), while others, like the scrawled file fish (*Aluterus scriptus*), use hardbottom areas such as the mixed coral/gorgonian bank. The spotted snake eel (*Ophichtus ophis*) lives in the sand bottom community, and the chalk bass (*Serranus tortugarum*) depends primarily on algal plain habitats. Fish are therefore an integral part of the entire marine ecosystem in the park.

Numerous studies of the ecology of fish in the park have been completed. These include studies of community structure and dynamics (Gladfelter, et al. 1979; Gladfelter and Gladfelter 1980; and Simpson 1979b *in* Kendall 2004b), coral predation by parrotfish (Simpson, 1979a, in Kendall 2004b), population composition and abundance (Gladfelter et al. 1977; Tobias 1988), and qualitative observations of abundance and diversity (Bayer and Robins 1965).

The NPS and the National Oceanic and Atmospheric Administration Center for Coastal Monitoring and Assessment conducted a survey of reef fish in February 2001 in Virgin Islands National Park and Buck Island Reef National Monument (Kendall, et al. 2004b; Monaco, et al. 2003). The objective of this study was to provide a baseline assessment of fish communities within the parks that could be used for park planning. In February 2001, fish were monitored using visual counts along roughly 120 belt transects placed randomly in bottom habitats within and proximate to park boundaries that measured 25 by 4 meters. A detailed description of methods is provided in Kendall, et al. (2004b). Key results and conclusions of this study include:

> A total of 7,417 individual fish, including 35 families and 103 species, were observed. The most abundant fish observed at any single location included the bluehead wrasse (*Thalassoma bifasciatum*), slippery dick (*Haliocoeres bivittatus*), and blue tang (*Acanthurus coeruelus*). These fish had the highest abundance at hardbottom sites.
>
> The most frequently observed fish included slippery dick, bluehead wrasse, striped parrotfish, blue tang and ocean surgeonfish, bicolor damselfish (*Stegastes partitus*), and French grunt. Rare species included the tiger grouper (*Mycteropera tigris*), schoolmaster snapper (*Lutjanus apodus*), peacock flounder (*Bothus lunatus*) and Bermuda chub (*Kyphosus sectatrix*).
>
> A comparison of fish density, habitat type, and total number of fish in Buck Island Reef National Monument between 1975 and 2001 was provided in Kendall, et al. (2004b) (Table 12). Results show that expansion of the park increased the total number of fish that were protected from 2.6 million to over 24 million.

Table 12. Comparisons of Fish Densities and Estimates of Total Fish Protected by Buck Island Reef National Monument in 1975 and 2001

Habitat Type	Habitat Area (m^2)	Fish Density by Habitat (No. of Fish/m^2)	Total Number of Fish by Habitat	Total Estimated Fish Population – all Habitat Types
1975 Park Boundary				
Sand	293,000	0.20	58,600	
Seagrass	474,000	0.17	80,580	
Hard Bottom	1,963,000	1.26	2,473,380	
2001 Park Boundary			**Total**	**2,612,560**
Sand	2,696,000	0.20	539,200	
Seagrass	2,892,000	0.17	491,640	
Hard Bottom	18,297,000	1.26	23,054,220	
			Total	**24,085,060**

Source: Kendall et al. 2004b

The National Oceanic and Atmospheric Administration Center for Coastal Monitoring and Assessment conducted annual surveys of reef fish in Buck Island Reef National Monument's waters between 2001 and 2009 (NOAA 2001b; 2006b; 2006c). A review of the fish data (NOAA 2006b) shows that a total of 95,883 individual fish were counted in the six sampling events between 2001 and 2006. These data are summarized in Table 13. This included 55 families of fish, with over 43 percent from the wrasse family. Angelfish, surgeonfish and tangs, and parrotfish accounted for 14.7, 13.0 and 11.8 percent of the total, respectively. The remaining 51 families accounted for the rest of the fish observed. Menza et al. (2006) analyzed the results of this sampling program for the data from 2001 through 2005. Results were subdivided into hard and soft bottom habitat types as shown in Figure 15.

Table 13. Number of Fish of Each Family Observed at all Stations Between 2001 and 2006 During National Oceanic and Atmospheric Administration Surveys of Buck Island Reef National Monument

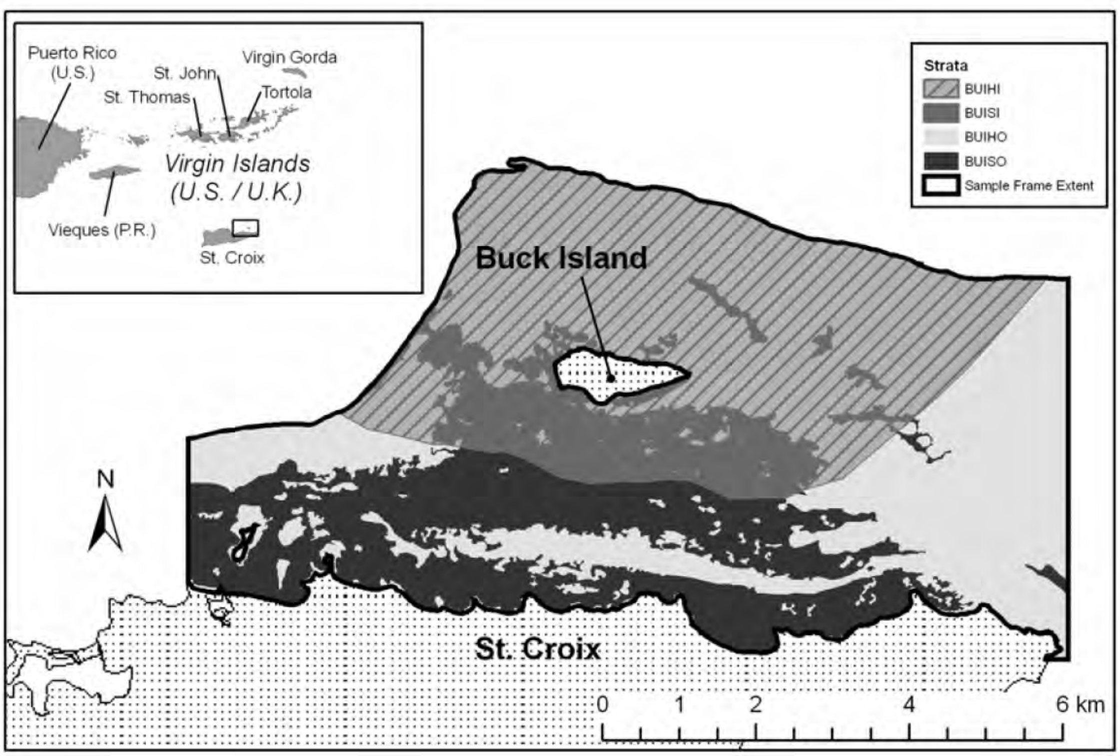
Common Family Name	Scientific Family Name	Number Observed	% of Total
Wrasses	Labridae	41,369	43.145%
Angelfishes	Pomacanthidae	14,066	14.670%
Surgeonfish and Tangs	Acanthuridae	12,507	13.044%
Parrotfishes	Scaridae	11,284	11.769%
Grunts	Haemulidae	4,291	4.475%
Jacks and Pompanos	Carangidae	2,235	2.331%
Gobies	Gobiidae	1,686	1.758%
Groupers and Sea Basses	Serranidae	1,645	1.716%
Conger and Garden Eels	Congridae	1,580	1.648%
Goat Fishes	Mullidae	775	0.808%
Squirrelfishes and Soldierfishes	Holocentridae	575	0.600%
Snappers	Lutjanidae	534	0.557%
Herrings, Shads, Sardines, Menhadens	Clupeidae	470	0.490%
Bonnetmouths	Inermiidae	385	0.402%
Barracudas	Sphyraenidae	343	0.358%
Butterflyfishes	Chaetodontidae	295	0.308%
Scaled Blennies	Labrisomidae	256	0.267%
Blennies, Combtooth Blennies, and Scaleless Blennies	Blenniidae	227	0.237%
Triggerfishes	Balistidae	185	0.193%
Pike-, Tube- and Flagblennies	Chaenopsidae	174	0.181%
Puffers	Tetraodontidae	153	0.160%
Mojarras	Gerreidae	133	0.139%
Tilefishes	Malacanthidae	116	0.121%
Basslets	Grammatidae	101	0.105%
Jawfishes	Opistognathidae	77	0.080%
Trumpetfishes	Aulostomidae	61	0.064%
Needlefishes	Belonidae	50	0.052%
Filefishes	Monacanthidae	40	0.042%
Boxfishes, Cofferfishes, Cowfishes, and Trunkfishes	Ostraciidae	39	0.041%
Lefteye Flounders	Bothidae	32	0.033%
Cardinalfishes	Apogonidae	31	0.032%
Stingrays	Dasyatidae	28	0.029%
Lizardfishes	Synodontidae	20	0.021%
Dragonets	Callionymidae	17	0.018%
Wormfishes	Microdesmidae	17	0.018%
Pilotfishes, Rudderfishes, and Sea Chubs	Kyphosidae	13	0.014%
Hawkfishes	Cirrhitidae	11	0.011%
Burrfishes and Porcupinefishes	Diodontidae	9	0.009%

Table 13. Number of Fish of Each Family Observed at all Stations Between 2001 and 2006 During National Oceanic and Atmospheric Administration Surveys of Buck Island Reef National Monument (Continued)

Common Family Name	Scientific Family Name	Number Observed	% of Total
Nurse sharks	Ginglymostomatidae	8	0.008%
Remoras	Echeneididae	7	0.007%
Mackerels, Tunas, Bonitos	Scombridae	7	0.007%
Pipefishes and seahorses	Syngnathidae	7	0.007%
Drums or croakers	Sciaenidae	5	0.005%
Moray eels	Muraenidae	4	0.004%
Flying Gurnards	Dactylopteridae	3	0.003%
Large-tooth Flounders	Paralichthyidae	3	0.003%
Firefishes, Goblinfishes, Rockfishes, and Ccorpionfishes and Scorporaenidae	Scorpaenidae	4	0.004%
Anchovies	Engraulididae	1	0.001%
Eagle and Manta Rays	Myliobatidae	1	0.001%
Batfishes	Ogcocephalidae	1	0.001%
Snake Eels	Ophichthidae	1	0.001%
Bigeyes and Catalufas	Priacanthidae	1	0.001%
	Total Observed	**95,883**	**100.0%**

Adapted from: NOAA 2006b

Figure 15. Areas Sampled for Fish Inside and Outside the Park (2001 to 2005) (Menza 2006).



The following is a summary of results of the study by Menza et al. (2006):

- The highest species richness (number of species) and assemblage densities of fish (total number of all fish per square meter) were typically found in linear reef, aggregated patch reef, and individual patch reef habitats, and the lowest species richness was found in sand, seagrass, and scattered coral/rock in sand habitats. The average number of species for all stations for the period 2001-2005 was 15.96 (standard error = 0.73 fish/100 m^2).
- Aggregated patch reefs, individual patch reefs, and colonized bedrock habitats also possessed high densities, but this pattern was not consistent for other groups of fish. The average density of all fish for all stations for the period 2001-2005 was 158.17 fish/100 m^2 (standard error = 23.88 fish/100 m^2).
- Species richness, mean density of the community (all species) and mean density of groupers were highest in mid-shelf reef sites, but snappers and piscivores (predatory fish) were conspicuously absent. Grouper, snapper, and piscivore density decreased steadily from 2002-2005.
- Significant differences in community biomass were observed with 2003 densities inside the park being greater than outside the park.

During this multi-year observation study, it was noted that fish that eat mobile invertebrates were the most commonly observed (49.6 percent of the total number of fish observed), and herbivorous (feeding mainly on plants) fish accounted for 37.1 percent of the total. Together, these two groups of fish accounted for 86.7 percent of all fish observed. The remaining fish included those that depend primarily on zooplankton, other fish, decaying plant material (detritovores), or combinations of the eating habits.

As part of the NPS National Vertebrate and Vascular Plant Inventory Program, Buck Island Reef National Monument conducted a cryptic fish inventory allowing the use of rotenone collection method. These additional fish surveys conducted with rotenone techniques show that a significant proportion of the park's reef fish assemblage has been underrepresented or missed when sampled using visual censuses only. Rotenone is a natural chemical produced by plants used as a tool for sampling reef and other shore species. Only 36 percent of the 228 species sampled with rotenone were visually detected, 70 percent of the 115 species visually detected were also collected with rotenone, and 31 percent of the 262 total species were common to both techniques (B. Smith-Vaniz 2006).

Fish and benthic habitats of the park were compared to the surrounding area (2003 to 2006) by Pittman and others (2008) using a wide range of comparative analyses of biotic components representing community, trophic, family and individual species level data incorporating measures of abundance, biomass and diversity. A summary of the findings is provided below (Pittman, et al. 2008).

Study results indicate that many of the coral reefs with the highest fish species richness were within 200 meters of seagrass beds. Other studies have also indicated links between fish distribution on coral reefs and proximity to seagrass beds, suggesting that many species may benefit from a mosaic of habitat types.

Increases in fish density in the park occurred in 2005 and 2006 that were significantly higher than 2003. It is not clear if this is the result of the park boundary being expanded, with enforcement of the no-take provision. Densities outside the park boundary were significantly lower in 2005 and 2006 compared to 2003.

Over the course of six years of monitoring (2001 to 2006) using 1,275 samples, only three Nassau grouper, three yellowfin grouper, and one tiger grouper were observed in the study region (both inside and outside the park), indicating that the grouper have been overfished.

Coney and red hind were more abundant around Buck Island between 2001 and 2006 compared to 1979.

Threespot damselfish (*S. planifrons*), a potential indicator of healthy reefs with high live coral cover, was more abundant around Buck Island in 1979 than in the 2001 to 2006 sampling period.

A total of 201 fish species/species groups were identified from 56 families. Nine of the 10 most frequently found species belonged to the wrasse, surgeonfish and parrotfish families.

The majority of the most abundant fish across the study region (inside and outside the park) were found in highest densities over hardbottom habitat types, and most also used multiple habitat types including seagrasses and sand.

Essential Fish Habitat

Essential fish habitat is defined under the reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (50 CFR 600.100). Section 302 of the Act established eight regional fishery management councils, including the Caribbean Fisheries Management Council, to develop Fishery Management Plans to regulate fisheries in an effort to prevent overfishing in each of the regions (CFMC 2004). The Magnuson-Stevens Act required fishery management councils to describe and identify essential fish habitat, identify adverse impacts from both fishing and non-fishing activities on essential fish habitat, and identify actions required to conserve and enhance essential fish habitat. An analysis of resources that would be considered ecologically critical areas, including essential fish habitat and habitat areas of particular concern as defined by the National Oceanic and Atmospheric Administration and mapped by the Council, is also required by the National Environmental Policy Act.

Essential fish habitat for reef fish, spiny lobster, queen conch, corals, and coral reefs in the park has been described by the Caribbean Fisheries Management Council (CFMC 2004). Because the life stages of these species (including pelagic stages) collectively occur in all habitats of the U.S. Caribbean, essential fish habitat under the Council's Generic Amendment included all waters and substrates (e.g., mud, sand, shell, rock, and associated biological communities), coral habitats (coral reefs, coral hard bottoms, and octocoral reefs), subtidal vegetation (seagrass and algae), adjacent intertidal vegetation (wetlands and mangroves), and pelagic waters. Therefore, essential fish habitat includes virtually all marine waters, substrates (mud, shell, rock, coral reefs), and associated biological communities in the areas between the coastline and 200 nautical miles into the sea (referred to as the exclusive economic zone by the Magnuson-Stevens Fishery Conservation and Management Act) including Buck Island Reef National Monument.

The Caribbean Fisheries Management Council identified coral reefs, hard and soft bottoms, sand/shell bottoms, benthic algae, and seagrass as essential fish habitat in the park (CFMC 2004). Since barrier reefs, deep reefs, patch reefs, extensive hard-bottom communities of gorgonid corals and sponges, unique elkhorn coral formations, and extensive seagrass beds occur in the park, Buck Island Reef National Monument is designated as habitat of particular concern for Caribbean coral species. The designation of habitat areas of particular concern is intended to identify those areas of essential fish habitat considered to be of the highest importance in the life cycles of managed species and most in need of protection. Buck Island meets habitat area of particular concern considerations for ecological importance and sensitivity to human-induced degradation (CFMC 2004).

Essential fish habitat provides forage and nesting areas for reef fish, spiny lobster, queen conch, and corals including now listed elkhorn and staghorn corals. Appendix C provides a comprehensive list of these species. Within the U.S. Virgin Islands, for each category of fishery, all waters, from mean high water to the outer boundary of the exclusive economic zone, are protected for eggs and/or larvae. For other life stages, the following essential fish habitats are defined (CFMC 2004):

Reef Fish — All substrates from mean high water to 100 fathoms depth.

Spiny Lobster — Seagrass, benthic algae, mangrove, coral, and live/hard bottom substrates from mean high water to 100 fathoms depth.

Queen Conch — Seagrass, benthic algae, coral, live/hard bottom and sand/shell substrates from mean high water to 100 fathoms depth.

Coral Fishery — Coral and hard bottom substrates from mean low water to 100 fathoms depth.

Other Marine Animals

Lobsters. Two species of lobsters occur in the park; the spiny lobster (*Panulirus argus*) and spotted lobster (*Panulirus guttatus*). The Environmental Impact Statement for Essential Fish Habitat in the Caribbean (CFMC 2004) concluded that the spiny lobster has a strong reliance on seagrass habitats. The following general information on lobsters is excerpted from Herrnkind (no date, *in* CFMC 2004; CFMC 1998):

> The lobster has six life history stages, and uses three distinct habitats: open ocean; the shallow, vegetated coastal zone; and coral reefs. The larvae spend several months as plankton, and may travel large distances. Postlarvae migrate to nearshore areas and settle to the bottom. Postlarvae molt to juveniles that live in algal beds or among mangrove roots, and subsequently move to crevices in shallow areas. Sub-adults and adults live on reefs.
>
> Most spiny lobster mate in spring and early summer along outer reefs near the shelf edge. Egg hatching occurs in deeper waters with strong water movements. The larval stage of spiny lobster is spent in the open ocean.
>
> Post larvae collect in shallow water areas, where they molt to an algal-phase that is dependent of shallow water habitats such as coral reefs, mangroves and seagrasses.
>
> The most important Caribbean habitats for juvenile lobster appear to be Thalassia beds and mangroves (CFMC 1998). Additional juvenile lobster habitat includes algal mats (plains) and rock crevices.
>
> Sub-adult lobster forage at night on benthic invertebrates and hide during the day around the bases of sea whips and large sponges, rock ledges, seagrass rhizome mats, or coral heads. In response to seasonal storms (especially during hurricane season), subadults mass-migrate in single-file queues from shallow banks to 10-20 m deep rock and coral shelters and disperse into sheltered waters.
>
> Adult lobster forage at night on seagrass beds, algal plains, and reefs.

In 1988, as part of the Virgin Islands Resource Management Cooperative, the first census work was conducted on spiny lobster in the park (Tobias, et al. 1988). Lobster populations were counted each month for six months at three study sites in the park. The average density of spiny lobster for the six-month study was 1.2 lobsters per 624 square meters, 1.5 lobsters per 165 square meters, and 1.3 lobsters per 1,500 square meters, respectively. It was noted that the abundance of lobster in the park is largely controlled by habitat availability, food supply, and seasonal migrations.

The Florida Fish and Wildlife Conservation Commission's Florida Marine Research Institute, in cooperation with the NPS, conducted a baseline study of the spiny lobster inside and adjacent to the park between April of 2004 and April of 2007 (Cox, et al. 2009). Five habitats comprising high quality lobster shelters were selected inside the park for monitoring (Deep Reef, Linear Reef, Back Reef, Patch Reefs and, Western Ledges). These areas were compared to areas outside the park. Two of the areas, colonized pavement and haystacks inside the park were eliminated from future sampling efforts because there was insufficient structure to support lobster.

Lobster size inside and outside of the park differed by habitat and distance from shore. Lobsters sampled close to the shore of St. Croix were primarily juveniles and increased in size at sites that were farther from the shore. The mean size of a lobster (measured as carapace length) on nearshore patch reefs, the habitat closest to St. Croix, was 51 mm. Back reef and base of linear reef outside of the park were also dominated by juvenile lobsters; mean sizes 54 mm and 61 mm, respectively. Lobsters on mid-channel patch reefs both inside and outside of the park varied widely in size. Adult lobsters are found in the remaining habitats, all within the park boundary. Lobsters on deep reef habitats and western ledges within the park were the largest (on average 106 mm). These habitats are the furthest from the shore of St. Croix. There were significantly more legal size lobsters on deep reef habitat inside the park than outside the park; and more legal lobster on mid-channel patches inside the park than those just outside the park (Cox, et al. 2009).

In general, the lobsters found outside the park at the deep reef and patch reef sites were smaller than those found inside the park. Cox, et al. (2009) reported that these differences were most likely due to the fact that the areas outside the park are fished. The higher abundance of larger lobsters inside the park compared to outside the park indicates that lobsters experience refuge from the fishery, and that fishers select out the largest animals. Overall, Cox, et al. (2009) concluded that the park has a positive effect on spiny lobster abundance and size.

Conch. Due to overfishing in many regions of the Caribbean and Florida, queen conch (*Strombus Gigas*) was listed in Annex II of the Cartagena Convention's Protocol Concerning Specially Protected Areas and Wildlife as a species that may be used on a rational and sustainable basis and that requires protective measures (Pittman, et al. 2008). The Unites States proposed and later adopted the queen conch for listing in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (referred to hereafter as the Convention) in 1992, making the queen conch the first large-scale fisheries product to be regulated by the Convention. The queen conch fishery is regulated under the auspices of the Caribbean Fishery Management Council (Pittman, et al. 2008).

Valle-Esquivel (2002) provides general information on the biology of the queen conch (*Strombus gigas*) in the Caribbean that is summarized in the paragraphs that follow. Conch generally occurs on shallow shelf areas in tropical or subtropical waters from a few inches in depth to a maximum of 250 feet in depth. Being benthic grazers, conch habitat and depth is limited to areas where clear water and sandy substrate support algae and seagrass production. Preferred habitats for conch are therefore shallower than 60 feet to 80 feet and include seagrass and sandy algal beds, gravel, coral rubble, smooth hard coral and beach rock bottoms (CFMC 1996 *in* Valle-Esquivel 2002).

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After a planktonic stage of life that lasts two or three weeks, conch settle in areas of soft sand and remain buried during the first year. Young juveniles emerge when their shells measure from 50 to 100 millimeters. They then transition to an epibenthic (on top of the benthic surface) existence in nearby seagrass beds (Appeldoorn and Ballantine 1983 *in* Valle-Esquivel 2002). Large conchs move more slowly than small conchs. They exhibit two types of migration: the first is an ontogenetic (developmental) migration, characterized by juveniles leaving the nursery areas to move gradually into deeper waters as they age. The second migration is seasonal and related to spawning. Adults move into shallower waters for reproduction during the summer months, and move back to deeper waters during the winter (Stoner, et al. 1988; Stoner and Waite 1990; CFMC/CFRAMP 1999 *all in* Valle-Esquivel 2002).

Surveys of conch conducted in the U.S. Virgin Islands in 1981, 1985, and 1990 showed declines in conch densities in St. Thomas and St. John (from 37 to 11 conch per hectare). Estimates for St. Croix were among the lowest (7.6 conch per hectare) in the Virgin Islands (Wood and Olsen 1983; Friedlander, et al. 1994; Friedlander 1997 *all in* Valle-Esquivel 2002). Tobias, et al. (1988) prepared a report on fish and shellfish populations within the park, including conch. Surveys were conducted along two, 332 meter long by 4 meter wide parallel elevated transects in a large seagrass bed within the park's boundary. Conch was associated with a dense bed of manatee and turtle grass. The mean density of conch along the two transects was one conch per 7 meters. This study indicated that the seagrass bed was being used as a nursery area (Tobias et al 1988).

Additional studies were conducted in St. Croix, both inside and outside the park from 2004 onward by NOAA and the NPS. Comparison of estimates of sighting frequency show that conch juveniles and adults were more common in northeastern St. Croix than for St. John or southwestern Puerto Rico (Pittman et al 2008), highlighting the importance of the large expanse of protected seagrasses between Buck Island and the St. Croix coastline as key resources supporting regional conch populations.

Long-spined Sea Urchins. A large-scale die-off of the long-spined sea urchin (*Diadema antillarum*) occurred in the Caribbean during 1983-1984, reducing its numbers by more than 97percent (Ogden, et al. 1973 *in* Miller, et al. 2005) and was not followed by rapid recovery. Because the sea urchin feeds on bottom dwelling algae on reefs, they affect the species composition and structure of the coral reefs in the park in a variety of different ways. Sea urchins clear the substrate of fast-growing algae, allowing coral larvae to settle and grow. Algal biomass within coral reefs increased following the urchin die-offs, thereby potentially reducing substrate for coral settlement (DPNR 2005b).

Intensive ecological studies of *Diadema* on St. Croix reefs in the 1970s showed that *Diadema* grazing caused the mysterious halos of bare sand found around Caribbean patch reefs (Ogden, et al. 1973 *in* Miller et al 2005). *Diadema* shapes the entire reef community (Miller, et al. 2005). Miller, et al. (2005) documented the possible beginnings of recovery of *Diadema* populations in St. Croix, comparing spatial patterns of recovery with that of the mass mortality. *Diadema* densities on St. Croix were reported to be far below pre-mortality numbers, but substantially higher than the near-zero densities that immediately followed the mass die-off. Rapid population growth (greater than 100 percent increase on back-reefs, and greater than 350 percent on patch reefs) is a sharp contrast to the very slow growth over the 17 years following the die-off. Size distribution reported in 2003 was reported to reflect successful recruitment, suggesting population recovery, returning *Diadema* to its critical role for the reef community (Miller, et al. 2005). Subsequent studies also report that although the long-spined urchin densities around Buck Island have not recovered since the mass mortality in 1983, some minor recovery may be occurring in the lagoonal and back reef areas along the sheltered coastline of northeastern St. Croix (Pittman, et al. 2008). Highest densities reported from surveys conducted inside and outside the Buck Island Reef National Monument between October 2005 and November 2006 were observed in the nearshore environments within the East End Marine Park on colonized bedrock, colonized pavement and macroalgal beds in close proximity to extensive seagrass beds (Pittman, et al. 2008).

SPECIES OF CONCERN

The NPS is required under the Endangered Species Act to ensure that federally listed species and their habitats are protected on all lands within the agency's jurisdiction. In addition, park policy and management actions include maintenance of territory program-listed species as part of the park's natural heritage.

The territorial lists of endangered and threatened animals and plants are maintained by the Division of Fish and Wildlife under the Virgin Islands Department of Planning and Natural Resources. The listings are supported by the U.S. Virgin Islands Indigenous and Endangered Species Act of 1990 (Act Number 5665, Section 104g) under Administrative Code title 12, Chapter 2. This Act gives the

Commissioner of the Department of Planning and Natural Resources the authority to promulgate territorial lists of endangered plants and animals. The list has not been updated since 1991, and there is a movement to revise the list through an Amendment to the Act. While the existing laws provide reasonable protection, enforcement is lax and ineffective (DPNR 2005b).

Table 14 provides a list of the species identified in the park and their status with respect to their federal or territorial designation for protection. The following paragraphs provide a summary of information presently available regarding the species of concern.

Table 14. Species of Concern on Buck Island Reef National Monument

Common Name	Scientific Name	Federal Status	Territory Status
Leatherback sea turtle	*Dermochelys coriacea*	Endangered	Endangered
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered	Endangered
St. Croix ground lizard	*Ameiva polops*	Endangered	Endangered
Green sea turtle	*Chelonia mydas*	Threatened	Threatened
Loggerhead sea turtle	*Caretta caretta*	Threatened	
Elkhorn coral	*Acropora palmata*	Threatened	
Staghorn coral	*Acropora cervicornis*	Threatened	
Lignum vitae	*Guaiacum officinale*		Endangered
Stinging bush	*Malpighia infestissima*		Endangered
Butterfly orchid	*Psychillis macconnelliae*		Endangered
Woolly nipple cactus	*Mammilaria nivosa*		Endangered
Spanish lady	*Opuntia triacantha*		Endangered
Brown pelican	*Pelecanus occidentalis*		Endangered
Least tern	*Sterna antillarum antillarum*		Threatened

Plants

Stinging bush ***(Malpighia infestissima Rich. Ex Nied; Malpighia pallens syn.)*** is endemic to St. Croix and Buck Island (Woodbury et al 1976). It has T-shaped hairs on the underside of the leaf surface which penetrate the skin on contact and cause an irritation or dermatitis. These stinging hairs may have led to its decline on St. Croix and extirpation on St. John. The stinging bush is found in coastal scrub and dry, deciduous forests. Threats and distribution are not well known and it was de-listed by the U.S. Fish and Wildlife Service in 1995 for those reasons.

Butterfly orchid ***(Psychillis macconnelliae)*** (also locally referred to as the Sandy Point orchid) was originally misidentified by Woodbury, et al. 1976 as *Epidendrum brittonianum*, by Gibney (1996) as *E. bifidum*, a species that only occurs in Haiti, and by Ray (2003) as *P. macconnelliae*. The butterfly orchid is an epiphyte on small trees and shrubs in a variety of habitats, usually near salt water. The flowers are showy and in various shades of red to lavender. Little is known about this orchid, including what pollinates it, or what its habitat requirements are, but as with most orchids, it is likely that it is threatened by habitat loss and illegal collecting.

Woolly nipple cactus ***(Mammilaria nivosa)*** is a small, colonial cactus with wooly white hairs at the base of each axil. The spines are yellow to brown, the flowers are yellow, and the fruits are red and succulent. The cactus is found on Puerto Rico, the Bahamas, and other West Indian Islands, but distribution is limited to a few colonies at each location. Threats to this species include loss of habitat, predation on fruits and seeds by introduced rodents, degradation of habitat due to exotic vegetation, and illegal collection. All *Mammilaria* species are popular with collectors and plant tradesmen.

Spanish lady ***(Opuntia triacantha)*** is a rare, medium-sized cactus of the dry, deciduous forest slopes and back beach areas in sandy, calcareous soils. It is found in small populations throughout the U.S.

Virgin Islands, Puerto Rico, and in the Florida Keys. It blooms year-round with yellow flowers, followed by succulent red fruits. Threats include loss of habitat, predation on fruits and seeds by introduced rodents, and predation by *Cactoblastis cactorum*, a non-native moth which preys on this and other *Opuntia* species.

Lignum vitae *(Guaiacum officinale)* is a large, slow-growing tree native to the Caribbean and was once found on nearly all the various islands. European settlers harvested the trees for use in the construction of boats, charcoal production, and for medicinal purposes. The wood had the unique quality of being self-lubricating and was valuable for use in bearings and bushing blocks for steamship propeller shafts (Woodbury, et al. 1976). The lignum vitae was extirpated from the park and has been nearly driven into extinction in other areas. Over the past 30 years the NPS successfully reintroduced lignum vitae to Buck Island.

Corals

On May 9, 2006 (Federal Register, Vol. 71, No. 89)(50 CFR Part 223), elkhorn coral and staghorn coral (*Acropora cervicornis*) were officially designated as threatened species by the National Oceanic and Atmospheric Administration/National Marine Fisheries Service. This listing was made on the basis of the following facts (Acropora Biological Review Team 2005):

Drastic and historic reductions (97%) in abundance of these species throughout their ranges, including the Florida Keys, Dry Tortugas, U.S. Virgin islands, and Jamaica.

Potential to restrict broad geographic ranges due to local extirpations.

Limited sexual recruitment in some areas and unknown in most areas, and unsuccessful settlement of larvae.

Decreases in fertilization success as densities of adults decline, and rapid mortality of new recruits at most locations.

Factors Affecting Health of Elkhorn and Staghorn Corals

The factors causing reductions in the abundance of these two species of coral throughout the Caribbean include hurricanes, disease, sedimentation, anthropomorphic abrasion and breakage, competition, predation, contaminants, loss of genetic diversity, African dust, elevated carbon dioxide levels, and sponge boring (Acropora Biological Review Team 2005). More recently, elevated water temperatures have shown to cause high mortalities (NPS 2006c). An overview of these factors is summarized in the description of coral communities in the “Marine and Coastal Resources” section of this chapter.

A more detailed summary of factors affecting the abundance of elkhorn and staghorn corals is provided by the Acropora Biological Review Team (2005), NPS (2003) and Rogers, et al. (2006). The Acropora Biological Review Team (2005) concluded that the combined effects of all known factors has led to the overall decline in elkhorn and staghorn corals in the Caribbean, with the resulting threat of extinction. It was estimated that elkhorn and staghorn corals would become extinct in approximately 30 years.

Biological Features of Elkhorn and Staghorn Corals

Elkhorn and staghorn coral are branching corals. They reproduce sexually by broadcast spawning and asexually by fragmentation (Acropora Biological Review Team 2005). They require clear, well-mixed water and rely almost exclusively on photosynthesis for sunlight. As a result, they depend on bright sunlight and are very sensitive to elevated turbidities caused by suspended matter in the water column. Due to their dependency on photosynthesis, they are also one of the most rapidly growing corals in the Caribbean, as opposed to corals that feed more on zooplankton. The optimal growth temperature range for elkhorn and staghorn corals is 25 to 29 degrees Celsius and they require near oceanic salinities between 34 to 37 parts per thousand (Acropora Biological Review Team 2005).

Historical Changes in Abundance of Elkhorn and Staghorn Corals in the Park

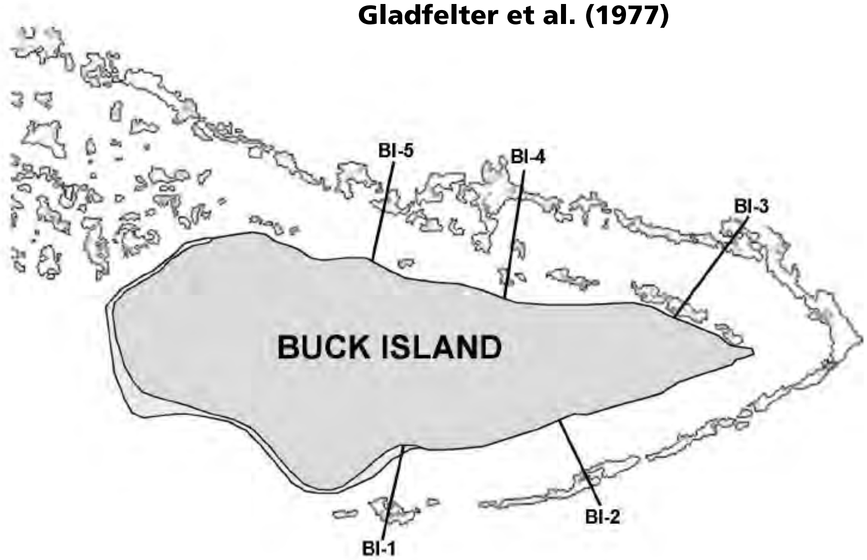
The spectacular elkhorn coral barrier reef was the primary reason for the establishment of the park. The park expansion included the elkhorn coral-dominated northern reef shelf, for a total of over 5,000 acres of critical habitat (Lundgren 2008). Because of this, additional details are provided in this *General Management Plan* on the historical trends of abundance and distribution of both elkhorn and staghorn corals in the park, and the factors thought to account for these changes. A detailed summary of the historical changes in the various other species of coral studied in the park is provided in the section of this plan entitled “Shallow Coral Reef Communities.”

The following is a discussion of historical trends in the abundance of elkhorn and staghorn corals arranged according to the time period in which the studies were conducted.

Early 1970s: The first signs of white band disease were noted by NPS staff (NPS reports, unpublished). Gladfelter, et al. (1977) determined prevalence levels at about 3 percent, where prevalence is defined as the number of cases of a disease in a population at a specific time.

1976-1988: Gladfelter, et al. (1977) established five transects in 1976 as shown in Figure 16. In 1976, elkhorn coral comprised over 50 percent of the south bank barrier reefs and the northern forereef (the area of the reef on the seaward side of the reef crest – see “Marine and Coastal Resources” section for further definition). Elkhorn coral "was the most abundant coral on the forereef slope down to . . . a depth of 10 to 15 meters in the north and east sections of the reef. In the south, this species was dominant to depths of 3 to 4 meters" (Rogers, et al. 2002).

Figure 16. Five Sampling Transects Established in the Park in 1976 by Gladfelter et al. (1977)



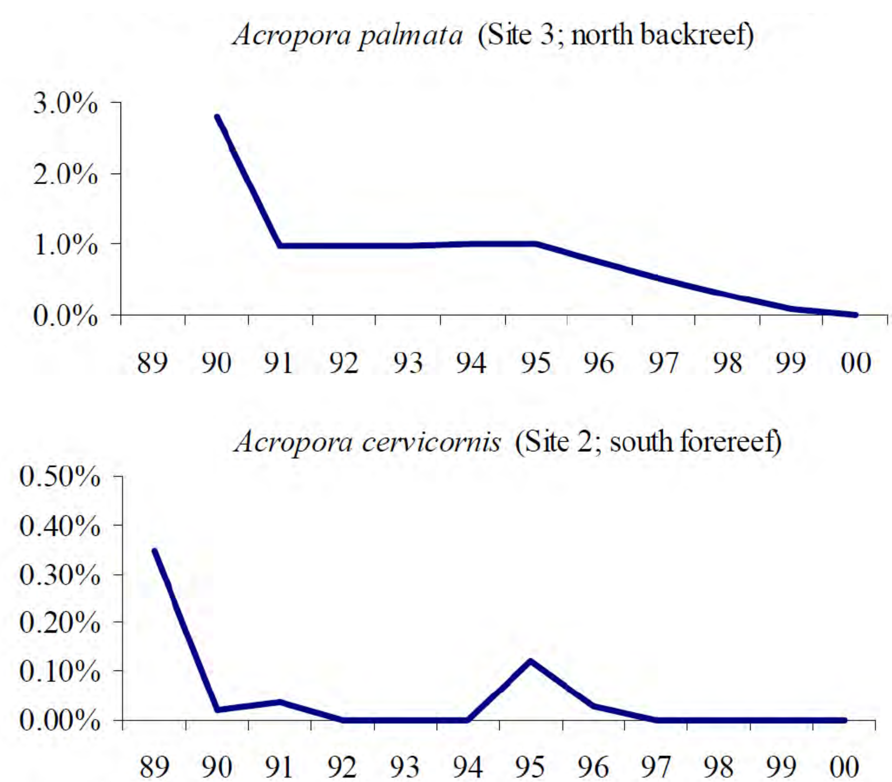
Additional declines in the elkhorn coral in the park were observed by 1988. Elkhorn coral cover on the forereef area in the vicinity of transects BI-3 and BI-4 (Figure 16) was 3 percent. However, along transect BI-5 (Figure 16) elkhorn coral comprised 72 percent of the total cover on the upper forereef, suggesting that this area was less affected by the mass mortality that devastated most of the reef. In 1988, elkhorn coral virtually disappeared on the north side of Buck Island (Bythell, et al. 1989 *in* Rogers, et al. 2002).

In 1988, additional permanent monitoring sites were established at Buck Island (Bythell, et al. 1992, 1993a *in* Rogers, et al. 2002). These studies concluded that elkhorn and staghorn corals were no longer a dominant part of the coral community and that further reductions in the previous 10 years occurred during a period of unusually intense hurricane activity (Bythell, et al. 2000a *in* Rogers, et al. 2002).

1989-2000: In 1989, Hurricane Hugo caused extensive destruction of the reefs in the park (Rogers, et al. 2002). The five reef transects established in 1976 by Bythell, et al. (1989) were re-surveyed. The shallow forereef on the south side of Buck Island was reported to have been reduced to pavement, and the coral rubble generated was moved up onto the reef crest, forming a raised berm 30 meters landward of the crest (Hubbard, et al. 1991). No elkhorn coral was recorded on the south reef in locations where it had previously been dominant. On the eastern shallow forereef, elkhorn coral cover fell from 5 percent to 0.8 percent in an area that had once supported 85 percent cover (Gladfelter et al. 1991). The north reef at Buck Island was less severely damaged by Hurricane Hugo, but elkhorn coral populations were still reduced from approximately 1.8 percent to 1.0 percent cover on the forereef of transect BI-3 (Gladfelter, et al. 1991). These surveys clearly showed the effects of the storm, even though most elkhorn coral mortality had already occurred.

In 1979, Hurricane David caused extensive physical damage to shallow elkhorn coral stands. Off the southeastern forereef, 66 percent of the elkhorn coral branches were still alive 11 months after the storm, with many beginning to heal and initiating new branches. However, elkhorn coral recovery was hindered by white band and live elkhorn coral coverage was reduced by over 90 percent, leaving vast areas of dead standing colonies (Anderson, et al. 1986; Bythell, et al. 1989; Rogers, et al. 2002). By 1984 elkhorn coral was dramatically reduced in the area of transects BI-3 and BI-2 (Figures 16 and 17). In the forereef area of transect BI-3, elkhorn coral was still dominant (greater than 10 percent cover). Patches of healthy elkhorn coral containing 80 percent live cover occurred in this area, but many stands on the forereef were almost completely dead (Anderson, et al. 1986).

Figure 17. Reductions in Cover of Elkhorn and Staghorn Coral at Transects BI-2 and BI-3 in Buck Island Reef National Monument



Source: Rogers et al. 2002

Beginning in 1993, elkhorn coral colonies were observed in the southeast forereef in the area scraped clean by Hurricane Hugo, although they were only a minor component (0.4%) of the coral community recruiting to the area (Bythell, et al. 1993a, 2000b). In 1995, after Hurricane Marilyn, some colonies were up to 1 to 2 meters across but exhibited physical damage from the storm.

2000-2008: Several different studies of elkhorn coral were initiated between 2000 and 2006. These are summarized in the order in which they began. In 2000, 25 individual colonies of elkhorn coral were tagged and monitored annually by the NPS. To document and monitor this re-growth, a pilot study was conducted in 2002 by Dr. Caroline Rogers of the U. S. Geological Survey Biological Resources Division (NPS 2003).

An additional study to document the re-growth of elkhorn coral was initiated in 2002 by the NPS (NPS 2003) to map the spatial distribution and colony size of elkhorn coral colonies along the south forereef. In 2003, a total of 2,150 colonies larger than 0.5 m were recorded within an area of approximately 10 acres. The areas surveyed during the 2002 pilot study experienced a 40 percent increase in medium size colonies (0.5 – 1 m), from 2002 to 2003 (NPS 2003).

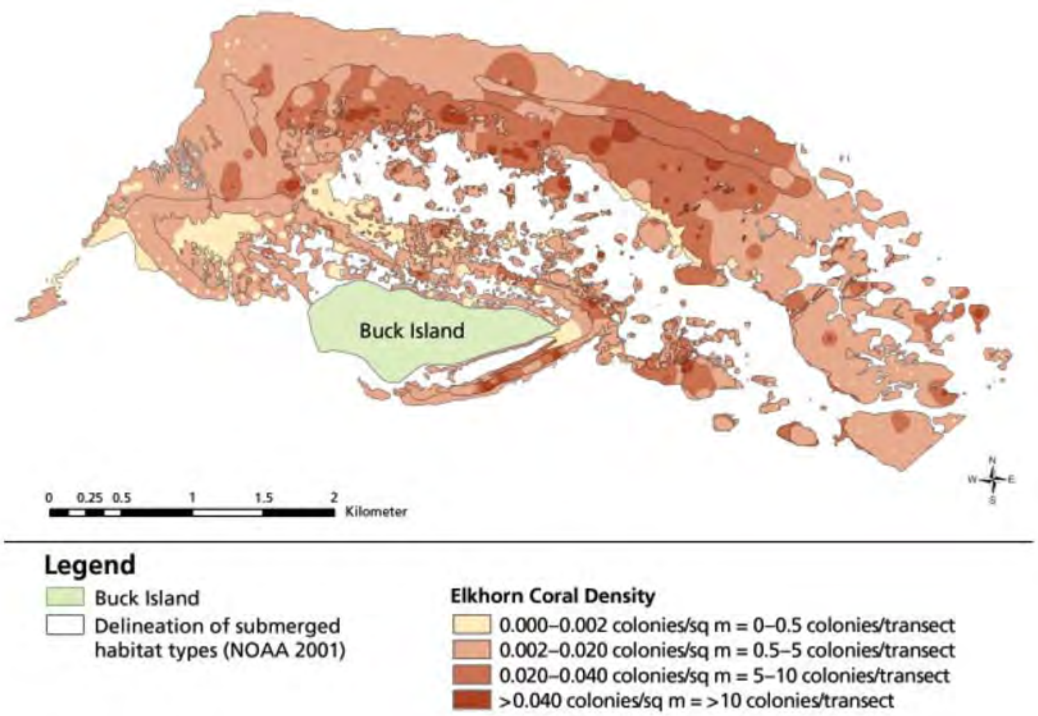
In 2002, Gladfelter surveyed selected reef zones around St. Croix that had been formerly dominated by elkhorn coral in order to measure percent cover and recruitment, and to compare current cover to that from the 1970s - 1990s (Rogers, et al. 2002). Included in this survey was a study area initiated in 1988, located on the eastern forereef of Buck Island (Gladfelter 1991). Size frequency distributions (made by measuring the maximum diameter of each colony) and colony density were also determined at some sites. Percent cover at the eastern forereef was reduced from 62 percent in 1976 to 0.5-1.0 percent in 2002, described in Rogers, et al. (2002) as a "catastrophic" reduction. However, by 2002, all the surveyed sites showed some live elkhorn coral, and some had evidence of at least two successful recruitment events in the past 10-15 years. The majority of the recovery, however, appeared to be from fragmentation, not sexual reproduction (Rogers, et al. 2002).

In 2004, park staff began mapping elkhorn coral distribution throughout the park. A pilot study was conducted in January 2004 and expanded to the rest of the park shelf area habitat by that summer. This program indicated that between 2002 and 2005, populations of elkhorn coral had made a comeback, in contrast to decreases in other parts of the Caribbean (Mayor 2006). However, monitoring of all coral species in the fall of 2005 revealed that the largest bleaching event in 20 years had occurred, having a significant impact on elkhorn coral recovery. At Buck Island, elkhorn coral experienced extensive bleaching in 2005. Water temperatures were higher than at any time since 1991 and exceeded the bleaching threshold by over 2 degrees Celsius, causing extensive coral bleaching. Forty-four elkhorn coral colonies were surveyed at three sites before, during, and after the thermal stress event. Elkhorn coral colonies in the backreef exhibited a different response to the thermal stress event than those located elsewhere in the park (forereef and north shelf) and bleached earlier and suffered greater live tissue loss (Lundgren 2008).

These results are discussed in more detail in the subsection entitled “Factors Affecting the Health of Coral Reefs and Marine Communities.” In the south forereef, over 99 percent of the elkhorn corals experienced bleaching, and 46 percent of the total coral populations had been killed, including elkhorn and staghorn corals (Lundgren 2008; NPS 2006c).

NPS data on densities of coral colonies from the most recent NPS surveys in 2006 are illustrated in Figure 18. Densities of elkhorn coral ranged from 0.002 to 0.020 colonies per square meter over the majority of the shallow water reefs in the park. Areas of intermediate densities (0.020 to 0.040 colonies per square meter) were observed over large areas of the reef shelf north of Buck Island and on the south forereef. The highest densities of elkhorn coral (greater than 0.040 colonies/m^2) were observed in shallow reefs scattered along the north side of Buck Island and the south forereef. The reefs will continue to be monitored to determine the effects of these bleaching and disease events on the abundance and diversity of elkhorn and staghorn coral, and other species. In 2010 NPS established 30 long-term elkhorn monitoring sites to track the species status in the park including recruitment, growth, and disease (Hillis-Starr, personal communication 2009). Data related to other coral species is included in the "Marine and Coastal Resources" section. Results of studies conducted to date for coral and other species are reported on the NPS, South Florida Caribbean Network website (http://science.nature.nps.gov/im/units/sfcn/Index.cfm), National Oceanic and Atmospheric Administration's website (http://www.noaa.gov/index.html) and the National Marine Fisheries Service website (http://www.nmfs.noaa.gov/).

Figure 18. Distribution and Density of Elkhorn Coral Colonies at Buck Island Reef National Monument in 2004



Source: Lundgren 2008

The St. Croix Ground Lizard

In 1977, the St. Croix ground lizard (*Ameiva polops)* was listed by the U.S. Fish and Wildlife Service as endangered. The St. Croix ground lizard's range was restricted to Green Cay, Protestant Cay near St. Croix, and the dredge spoil island off St. Croix's south shore, Ruth Cay. This lizard requires dry, rocky coastal areas with sandy soils and shrub-scrub or forested vegetation communities. The woody vegetation should be relatively open or intermediate in density to create dappled areas of sun and shade. The lizard requires bare, sandy, exposed ground with adjacent shaded areas with dense leaf litter. Burrows of crab species are also important in the preferred habitat (DPNR 2005b).

In the 1984 U.S. Fish and Wildlife Recovery Plan for the St. Croix Ground Lizard, Buck Island was identified as a relocation site pending successful removal of the non-native predators which would substantially increase the available habitat for the species and provide it a better chance of surviving catastrophic events like hurricanes. These non-native predators included mongooses and rats, which the NPS successfully eradicated in 2001 (Witmer, et al. 2007). This step made Buck Island a suitable site for re-introduction of the St. Croix ground lizard. In 2007, the NPS, in collaboration with the U.S. Fish and Wildlife Service, the Virgin Islands Division of Fish and Wildlife, and Texas A&M University initiated actions toward the translocation and introduction of the species. In 2008, the lizard was successfully translocated to Buck Island; 57 adults were released into enclosures and monitored from April to May 2008. By June, adults were exhibiting behaviors indicating a successful adaptation to their new environment, such as foraging, basking, courtship/copulation, and successful reproduction (a hatchling was observed on July 2008).

Sea Turtles

Four species of marine turtles nest seasonally on Buck Island. All four marine turtles are protected by the Endangered Species Act and international treaty. Buck Island is a significant breeding site for the Atlantic Hawksbill (*Eretmochelys imbricata*) whose nesting population has been the target of park management and conservation efforts resulting in a substantial increase in seasonal numbers of nesting females (40 to 80 per season) and success of hatched nests. Green sea turtles (*Chelonia mydas*) have benefited from these actions as well with seasonal nesting numbers between 12 to 20 females per season. Leatherback (*Dermochelys coriacea*) and loggerhead sea turtles (*Carretta carretta*) both nest on Buck Island but in smaller numbers (one to five per season). Both juvenile and adult hawksbill and green sea turtles are found in the coral reef and sea grass habitats surrounding the island year round. Hawksbills have demonstrated long-term residency in the developmental habitat around Buck Island (Riegl and Dodge 2008).

Sea turtles have been exploited for centuries by the indigenous people of the Caribbean for their meat and eggs. When Europeans settled in the Caribbean, the slaughter of sea turtles for food source increased, but sea turtles were also taken for oil, and hawksbill sea turtles were taken for their shells, which were used for curios and jewelry. In 1972, U.S. Virgin Islands laws made it illegal to harvest sea turtles on their nesting beaches and allowed harvest in the water only between the months of October and April. In 1973, leatherback and hawksbill sea turtles were protected under the Endangered Species Act. In 1978, the green sea turtle and loggerhead sea turtle were listed as threatened species; consequently, it is now illegal to harvest the sea turtles or eggs in U.S. waters. There is still a significant illegal trade in the hawksbill sea turtle shells, and some countries continue to allow the harvest of sea turtles (Mac, et al. 1998).

Current threats to sea turtles include nest poaching and illegal harvest of sea turtles as well as indirect impacts of humans. The introduction of animals such as hogs, mongooses, dogs, and goats destroy nests and eggs and harass nesting sea turtles. Development of coastal areas, recreational and commercial boating activity, incidental take from the fishery industries, ingestion of or entanglement in marine debris, and inadequate local protection and enforcement of laws are all modern day threats to sea turtles in the Caribbean (Mac, et al. 1998). Other human impacts on sea turtles include damage to coral reefs and seagrass beds by visitor use and boat-related damage, raw sewage discharges in Puerto Rico and the U.S. Virgin Islands, oil spills, and other forms of pollution in the marine environment (NOAA n.d.). Natural threats include beach erosion, hurricanes, and predation on hatchlings by natural predators such as birds, crabs, and large fish.

Between 40 and 80 hawksbill sea turtles seasonally nest on Buck Island, and the park is identified as an index beach for the hawksbill sea turtle recovery in the eastern Caribbean. Hence, the Buck Island Sea Turtle Research Program was started in 1988 and functions primarily to study the biology of the endangered hawksbill sea turtle, though information is also gathered on the leatherback, green, and loggerhead sea turtles. The program uses volunteers and trained scientists to monitor the sea turtles nesting activities all year, with intensified monitoring during July through October, which is the peak nesting season. Monitoring consists of patrolling the beaches at night and recording the nesting activity of the all sea turtle species encountered. Adult sea turtles are tagged after they nest, and each nesting sea turtle is evaluated for nesting behavior, fecundity, site selection and fidelity, remigration intervals, and, physical data such as size, weight, growth, and nesting and hatch success.

The hawksbill sea turtle utilizes different habitats at different stages of its life cycle. Post-hatchlings occupy the deep waters of the tropic ocean zones, and are often found riding in floating masses of sea plants that accumulate at convergent points. When they reach 20 to 25 centimeters in carapace length, they return to the coastal waters and frequent rocky areas, coral reefs, and lagoons. Adult hawksbill sea turtles rely on sponges as the main component in their diet, which explains their return to coastal areas and reefs that support sponge growth. Hawksbill sea turtles will nest on both low-and high energy beaches and, due to their small size and agility, they are able to maneuver over reefs to nest on beaches that would be inaccessible to other sea turtles (NOAA n.d.). The nesting habitat, which consists of 1,500 meters of Buck Island shoreline, is divided into four areas; North Shore, West Beach, South Shore, and Turtle Bay.

The leatherback sea turtle is federally-listed as an endangered species and is in a critical position world-wide, mainly due to loss of nesting and foraging habitat. The leatherback sea turtle is known to nest in relatively large numbers on Sandy Point National Wildlife Refuge, up to 200 nesting females per season, a beach on the southwest corner of St. Croix, and in much smaller numbers (one to five females per year) on Buck Island Reef National Monument. Leatherback sea turtles are unable to maneuver the coral reefs that surround the majority of Buck Island, while the beaches at Sandy Point are located near the shelf edge and are thus readily accessible. The leatherback sea turtles are likely limited to nesting on the southwest corner of Buck Island as a result.

The green sea turtle is federally-listed as a threatened species and is the subject of a federal recovery plan (DPNR 2005b). In the U.S. Virgin Islands, the green sea turtle is more susceptible to poaching than the other sea turtles because of their valuable meat, shell, and leather, and this species also appears to be more likely to become injured by boats and propellers (DPNR 2005b). Buck Island is not a significant green sea turtle nesting area, but the surrounding seagrass beds provide an excellent foraging area for adult and juvenile sea turtles. Between 12-20 green sea turtles currently nest on Buck Island per season. Green sea turtle nesting begins in May or June, peaks in August, and all eggs are hatched by October. The nesting activity is concentrated on either West Beach or Turtle Bay.

The loggerhead sea turtle is a federally-listed threatened species inhabiting continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters. Loggerhead sea turtles have a varied diet but feed mainly on mollusks, crustaceans, and horseshoe crabs (Dodd 1992). In the Atlantic, the range of the Loggerhead sea turtle extends from Newfoundland to as far south as Argentina. During the summer, nesting occurs in the lower latitudes. Mating takes place in late March to early June, and eggs are laid throughout the summer. The primary Atlantic nesting sites are along the east coast of Florida, with additional sites in Georgia, the Carolinas, and the Gulf Coast of Florida. The loggerhead sea turtle was listed as threatened throughout its range in 1978, with the most significant threats to the loggerhead sea turtle populations being coastal development, commercial fisheries, and pollution. Loggerhead sea turtles are the most abundant species in U.S. coastal waters, and are often captured incidentally by shrimp trawling (NMFS 2005d). Rare in the U.S. Virgin Islands, two loggerhead females have been nesting on Buck Island since the 2003 nesting season (Hillis-Starr 2006).

Birds

Two territory- listed avian species are known to nest in the park (NPS 2003b). The brown pelican and least tern have been identified by NPS staff as a high priority for conservation and management. There are currently at least three avian monitoring projects being conducted at the park:

- Brown pelican reproductive survey that includes counts of adults, nests, and fledglings
- Least tern adults, nests, and egg counts (seasonal)
- Christmas Bird Count that covers Buck Island

The **Caribbean brown pelican (*Pelecanus occidentalis occidentalis*)** was a federally-listed threatened species until November 2009 when it was de-listed by the U.S. Fish and Wildlife Service due to recovery. However, the brown pelican will remain protected under the provisions of the Migratory Bird Treaty Act, and it is anticipated that it will remain as a territory-listed species since the territory list has not been updated since 1991. The Caribbean brown pelican nests at four locations in the Virgin Islands. The two larger nesting sites are on St. Thomas and St. John, while the smaller sites are on Buck Island and Green Cay. Buck Island is the location of an important rookery for this species, with over 40 birds nesting there annually between September and February (NPS 2004). The breeding success of the Caribbean subspecies of the brown pelican is primarily limited by the availability of food. The timing and success of the breeding cycle and the pronounced seasonal fluctuations of pelican numbers in the region appear to be closely tied to the alternating and unpredictable periods of fish abundance. Other factors influencing the size of the population include poaching of eggs, hatchlings and adults; human disturbance of nesting colonies; non-native predators (rats, historically); mortalities resulting from the birds being caught on fish hooks and monofilament lines; and loss or degradation of mangrove forests (USFWS 1995).

Least tern *(Sterna antillarum antillarum)* is the smallest American tern and can be found on the east and west coast as well as in the interior of North America, throughout the Caribbean, and central and South America. Although the terns are widespread and even common in some localities, populations are declining due to the loss of nesting habitat. Terns nest on open sandy or gravelly beaches and river banks, and are therefore often subject to human disturbance. When terns leave their nests, the eggs may be subjected to extreme heat and potential predation. The least terns nesting in the Caribbean are declining due to the loss of habitat and the decline in fish populations due mainly to over fishing (Cornell Lab of Ornithology 2003). The tern is listed as a special concern species by the U.S. Virgin Islands Department of Planning and Natural Resources, Division of Fish and Wildlife (2005). Only the interior (50 miles from coast) population of the least tern is federally listed as endangered (*Sterna antillarum athalassos*) and does not occur at Buck Island Reef National Monument.

A colony of 20 to 80 least terns were known to nest on West Beach until 2006. The reason for the terns' absence from the park is unknown. The U.S. Fish and Wildlife Service found low breeding productivity over a four-year period of monitoring due to predation by dogs, cats, mongoose, and avian predators. On St. Croix, the majority of nests were laid on dried salt ponds, making them susceptible to inundation by flooding during heavy summer rain events (C. Lombard 2007). When terns nest at Buck Island, park staff mark the nesting area with signs and fencing. Although dogs are not allowed on Buck Island, there have been reports of dogs on the beach. Dogs are extremely dangerous to a nesting colony of terns as one dog can destroy a whole colony in a matter of minutes.

CULTURAL RESOURCES

Introduction

Cultural resource data were collected from Christiansted National Historic Site, Virgin Islands National Park, the Virgin Islands State Historic Preservation Office (VISHPO), pertinent literature, other available historic sources, and park visits. Data collection in the Virgin Islands occurred in August and September 2004. Additional records were researched through 2005. The park as a whole has not been subject to a systematic cultural resources survey, although numerous areas within Buck Island and the park have undergone investigation and archeological survey (Hardy 2006). As part of future surveys, shipwreck sites known to exist on the reef require mapping, testing, and evaluation.

The chronological scheme for the division of the prehistoric period (i.e., the time before Columbus) for the Lesser Antilles, including the U.S. Virgin Islands, is divided into five major stages: Casimiroid (or Lithic), 4000-2000 BC; Ortoiroid(or Archaic), ca. 2000-500 BC; Saladoid (Early Ceramic), ca. 500 BC-AD 500; Ostionoid (Late Ceramic), ca. AD 500-1492; and Taíno (European Contact), AD 1492-1550

(Rouse 1992; Hayward et al. 1997; Righter 1995; Vescelius 1952). Many of these stages are not represented on Buck Island. The following presents a brief overview of the prehistoric period for the region in general, followed by specific data regarding Buck Island.

Prehistory

Caribbean. Scholars (Rouse 1992; VISHPO 2002) have delineated two major prehistoric divisions within the Caribbean for the period prior to the development of ceramics. These divisions are the Casimiroid and Ortoiroid periods. The Casimiroid or Lithic period (approximately 4000-2000 BC) has been securely documented only in the Western Greater Antilles (Cuba, Haiti, Dominican Republic), but might extend into Puerto Rico and Jamaica. Central America appears to be a likely point of origin of the people associated with this period, although the northern coastal area of South America is also a possible candidate. No sites have been identified for this period within the Virgin Islands.

The Ortoiroid or Archaic period (2000-500 BC), as represented in the Virgin Islands, originated most likely from peoples migrating into the Antilles from Trinidad and the easternmost coast of Venezuela. Diagnostic material of the period includes hammerstones, edge grinders, shell picks, and chipped or partially ground stone celts. Simple shell and stone beads and pendants have also been recovered. Subsistence appears to have been based primarily on hunting, fishing, and gathering (e.g., shellfish, reef fish, birds, turtles, rodents). The diet appears to have consisted principally of shellfish obtained from shallow marine environments (beaches, river mouths, mangrove swamps), supplemented by other locally available foodstuffs. Sites consist mostly of shell middens and are located on or near the coasts. These sites were most likely occupied by small groups of people for short or recurrent periods (Righter 1995; Rouse 1992). Archaic period settlements have been identified at Krum Bay (St. Thomas) and Lameshur Bay (St. John).

The Saladoid period (ca. 500 BC-AD 500) marks the beginning of the Ceramic age in the Virgin Islands, the first appearance of settled village life, and a reliance on cultivated foodstuffs. Pre-ceramic groups may have begun experimenting with agricultural techniques (harvesting of certain crops, encouragement of others) in the preceding period. The peoples of this new cultural tradition, who perhaps rather rapidly displaced the Archaic populations, were again from mainland South America (Righter 1995; Rouse 1992). Subperiods within the Saladoid reflect changes in pottery style and decoration. Other material-cultural items typical of the early ceramic period include pottery griddles, coral hammerstones, chert tools, spindle whorls, mortars, manos, small zemis, stone axes, and various types of lapidary objects (beads, amulets). Lapidary objects are made largely from exotic and rare gemstones (e.g., amethyst, quartz crystal, greenstones, carnelian, lapis lazuli), indicating the existence of a Pan-Caribbean trade network involving the islands and mainland South America. The frequency of lapidary objects, and presumably the volume of trade in these particular items, declines from the early to the late Saladoid period.

Settlement patterns changed from the preceding Lithic and Archaic ages. The early ceramic period sites were located on coastal plains, near river mouths and the shoreline, and at the edge of the forests, presumably to take advantage of the available resources (shellfish, fish, birds, wood products, fruits). Nevertheless, the sites remain about the same size, and this territorial expansion continues into the Ostionoid period.

The Ostionoid period (AD 500-1492) in the Caribbean can be characterized by a continuation and intensification of previous trends toward increased sociopolitical organization and economic diversity, as well as the introduction of new trends, such as an increase in the regionalization of ceramic styles. During the Ostionoid period, three ceramic styles are represented in the Virgin Islands: Magens Bay/Salt River I and II, and III (Faber Morse 1995; Rouse 1992). In addition, petaloid celts are common, and ritual zemis (three-pointed objects) are manufactured out of local stone, shell, and clay.

Settlement-pattern data indicate an increase in the number of sites from the previous Saladoid period, with an emphasis on inland versus coastal site locations. Proximity to rivers still appears to have been a consistent factor in site location. Sites located on hilltops, ridges, or terraces suggest their location for protection from the natural elements or from other populations. Ostionoid peoples primarily relied on manioc, shellfish, fish, and birds for their subsistence. Resource exploitation became more specialized, with increased reliance on maritime and agricultural resources. Settlements on St. Croix during the early Ostionoid period appear to range from relatively small, possibly specialized procurement sites to the large village sites of Salt River and Aklis.

Differentiation and the ranking of sites are evident during the Ostionoid period. Site types include large and small coastal and inland villages, individual homesteads, specialized resource exploitation sites (forests, mangroves), specialized small or local ritual areas represented by cave or riverine rock art sites, and specialized regional ceremonial sites characterized by the presence of ball courts and plazas. An associated increase in sociopolitical organization is indicated as well. Increasing population and site density, the common occurrence of zemis and ball courts, the presence of regional ceremonial sites, and site differentiation all suggest a stratified social system (perhaps simply divided into upper and commoner classes) and a stratified political system, on the order of chiefdoms (Rouse 1992).

The indigenous peoples that Christopher Columbus encountered in Puerto Rico and Hispaniola have been termed the Taínos by present-day scholars (Rouse 1992). They were organized into hierarchical chiefdoms with a type of class system, and lived in permanent villages, the larger ones with populations ranging from 1,000 to 2,000 inhabitants. The Taínos played a ball game usually around a central plaza or ball court, rectangular in shape, referred to as a batey. The ball courts were used locally and games occurred between villages.

The Taíno religion focused on the worship of deities referred to as zemis (cemís). Two supreme zemis were recognized, one who reigned over the sea and cassava (manioc), and the other, his mother, who reigned over fresh water and human fertility. Lesser zemis representing spirits of ancestors and other spirits that lived in various places throughout the landscape have also been identified. Zemis were made of stone, wood, bone, shell, and pottery (Rouse 1992).

Buck Island. Scant information is available for Buck Island regarding the activities of peoples from prehistoric time to the early 1700s, but the island was probably used as a temporary camp to collect marine resources. The prehistoric Buck Island site (BUIS-2; 12VAm1-68) has produced Late Saladoid through Ostionoid period pottery, with decorative elements ranging from red painting on vessel rims to Chicoid and Elenoid-style incisions. Radiometric dates taken from charcoal and shell excavated from hearths at West Beach provided evidence for human occupation Cal AD 410-600 and Cal AD 510-700 (2 sigma) (Hardy 2006).

History

The Virgin Islands. Christopher Columbus encountered St. Croix and claimed it for Spain during his second voyage to the New World in 1493. When Columbus' fleet anchored off St. Croix on November 13, the Spaniards found it highly cultivated and "well populated" (Lewisohn 1970; VISHPO 2002). After a brief skirmish with the Amerindians at Salt River Bay, which was the first recorded instance of Amerindian-European conflict, the Spaniards sailed north to a cluster of small islands that were named *Once Mil Virgines*, then west to Puerto Rico; the Amerindians encountered at Salt River were likely Carib language speakers, who had recently taken over the island from the Taíno. Spain made no subsequent attempt to colonize St. Croix. Although subject to periodic Spanish raids, the Amerindians, who reportedly occupied 20 villages between 1509 and 1542, retained possession of St. Croix until the end of the sixteenth century, when they departed of their own accord, were driven away or annihilated (Figueredo 1978a; Hardy 2006).

At various times during the seventeenth century, the English, French, and Dutch attempted to settle St. Croix, but were driven off by either the Spanish or one of the other colonizers. In 1650, a brief contest for power erupted between the English, Spanish, Dutch, and French, from which the French emerged victorious. Philippe de Lonvilliers de Poincy, official of the Knights of Malta on St. Christopher, sent 160 men to St. Croix, eventually succeeding in getting the Spanish to abandon their holdings and return to Puerto Rico. Thereafter, the French managed to dominate St. Croix until abandoning it in 1696 (Boyer 1983; Caron and Highfield 1980; Figueredo 1978b; Lewisohn 1970; Tyson 1997; VISHPO 2002).

By 1653, Louis XIV, through de Poincy, deeded St. Croix to the Knights of Malta. Within ten years, the French Crown decided that expansion of their Caribbean holdings was necessary. In 1665, a new commercial company, the French West India Company, was created to govern the islands of St. Croix, St. Bartholomew, and the French halves of St. Christopher and St. Martin. Company rule of St. Croix was plagued with problems, and, in 1674, the Company's control over the island was dissolved by Louis XIV. The French Crown then directly ruled the islands. At its peak in the 1680s, the French colony numbered about 1,300 people (half were African slaves) who lived scattered throughout St. Croix. These colonists produced small quantities of sugar, cotton, tobacco, coffee, indigo, cocoa, and ginger, and engaged in illegal trade with the neighboring Danish colony of St. Thomas. However, because of the costs of handling illegal trade, war, privateering, and piracy, the Crown decided it was no longer feasible to maintain the colony. In 1696, the residents, including 147 white settlers and 623 African slaves, were removed to the more promising colony of St. Dominique. The French maintained weak title to St. Croix from 1696 to 1733, but made no effort to reoccupy it. During this period, St. Croix was visited periodically by parties of mariners and woodcutters. In the late 1720s into the 1730s, an unauthorized settlement of British planters (and their slaves) occupied the island (Boyer 1983; Caron 1982; Caron and Highfield 1980; Lewisohn 1970).

France sold St. Croix to Denmark in 1733. When the Danes arrived in 1735, they discovered 150 English settlers with 456 slaves already there. The Danes encouraged large-scale plantation agriculture (e.g., cotton and sugar), and the resulting plantation system dictated rural population and settlement patterns until the mid-twentieth century (Boyer 1983; VISHPO 2002). Before 1800, slaves accounted for over 90 percent of the total population, which rose to 28,803 in 1796. Danish colonial authorities encouraged other nationalities to bring their capital, slaves, expertise, and technology to the infant sugar colony. As a result, by the second half of the eighteenth century, Britons comprised some 40 percent of the plantation owners and most of the plantation supervisors. Controlled by foreign entrepreneurs, the plantation system on St. Croix spread rapidly at first. However, a process of consolidation after 1754 reduced the number of working plantations to 197 plantations by 1792. Of that number, 161 produced sugar, 27 cultivated cotton, and nine raised livestock and market provisions (Rigsarkivet 1792).

At the beginning of the nineteenth century, St. Croix, despite its relatively small size, had become the fourth largest sugar-producing colony in the Caribbean. In 1812, its peak year, St. Croix's 175 sugar plantations with 26,000 slaves produced 46,000,000 pounds of sugar and some 12,000,000 gallons of rum for export (Westergaard 1917). Slave emancipation in 1848 weakened the planter's control over rural workers. A stringent contract labor law was only partially successful in binding the field workers to the plantation (Green 1972). The restrictive laws were removed after a major labor insurrection in 1878. As the rural population declined and labor problems intensified, production costs rose, and Crucian sugar planters were increasingly uncompetitive with European beet sugar and other low-cost producers. As a result, the amount of land in cane production declined and the number of non-sugar plantations increased by the early 1910s. In 1917 the Danish Government sold St. Croix and Buck Island to the U.S. Government.

Despite these economic trends, Crucian sugar plantations retained their dominance over the economy and landscape until the middle of the twentieth century. Nearly two-thirds of all land on St. Croix was occupied by the sugar plantations in 1915 (Rigsarkivet 1742-1917). By 1930, their percentage of all land-holdings had dropped only slightly to 55 percent (Hardy 2006). Nevertheless, sugar production began falling after 1920, ceasing altogether in 1963. After 1960, the advent of a tourist and industrial economy began pushing residential, industrial and commercial development throughout St. Croix.

Buck Island. During the seventeenth and eighteenth centuries, what is now Buck Island received numerous names from various European mapmakers. Names given to the island included Isle Verte, Cabrit, Cabrite, Cabrito, Burre, Goat, Vert, Holm, Gedeoen Frederiksgave, Pockholz, Pocken Eyland, Bocken Island, and Diedrichs Plantage (Hardy 2006). The town clerk for Christiansted, Johann Diedrich, controlled Buck Island from 1754 to 1773 and reportedly erected a structure at the highest point on the island to observe the shipping lanes. It is unlikely that Diedrich actually lived on the island, but between six and 12 slaves did live there during this time. The slaves no doubt erected cisterns to collect rainwater and lived off the land; remains of cisterns have been identified on the island. Nicolay Salamon assumed control of Buck Island from Diedrich in 1773. From 1774 to 1780, Joseph Coakley managed the island for Salamon. From 1780 to 1797, John Heyliger Abrahamson was listed as island caretaker/taxpayer (he would serve in this position again in 1818 and from 1823 to 1826). John Benners served in this position from 1797 to 1802, when he was replaced by John de Graff Godette. It is not recorded if these men lived on the island, but between 1787 and 1789 only a single slave was recorded as living on the island (Hardy 2006). In 1789 a Royal Signal Station was erected by the Danes at the 329-foot elevation.

The Danish Government took control of Buck Island in 1822 under the policy of landskassen (land treasury), in which the government appropriated rural lands for its protection (Hardy 2006). The crown or its colonial designate would lease the island for “appropriate uses,” such as grazing of goats and sheep, fishing, or subsistence agriculture. A small number of individuals lived on the island throughout the remainder of the nineteenth century into the early twentieth century.

Not unexpected, shipwrecks occurred in the waters surrounding the island, including BUIS-3 (12VAm1-202) Buck Island Reef Wreck (or Coal Wreck). A U.S. Coast Guard signal beacon was constructed in the 1950s at the 329-foot elevation, near the ruins of the former signal station.

Under the Virgin Islands Organic Act of June 22, 1936, the Government of the Virgin Islands obtained direct control of Buck Island. However, submerged lands technically remained under control of the U.S. Government. In 1948, the Government of the Virgin Islands established Buck Island and its surrounding reefs as a territorial park (Hardy 2006). As previously mentioned, Buck Island Reef National Monument was established in 1961 by presidential proclamation as a unit of the national park system. In 1975, 30 acres of submerged lands were added to the park. The 2001 proclamation expanded the park’s size by 18,135 acres, establishing the 19,015-acre national park that exists today.

Previous Studies

This section describes the existing environment of the park and the surrounding region. A more detailed discussion of the cultural history of Buck Island can be found in *Archeological Overview and Assessment of Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands* (Hardy 2006). Further information on St. Croix and the Caribbean can be found in the *Archaeological Investigations at the Aklis Site Sandy Point National Wildlife Refuge St. Croix, U.S. Virgin Islands* (Hayward, et al. 1997), *The Taínos: Rise and Decline of the People who Greeted Columbus* (Rouse 1992), and *Statewide Comprehensive Historic Preservation Plan: Prehistoric Context* (Righter 1992).

A number of previous investigations and surveys provide data regarding Buck Island’s cultural and archeological resources. The majority of the reports seem to investigate the same three sites (the Buck Island site, the Signal Station site, and Buck Island Reef Wreck) in a cursory manner. Four of the studies are “trip reports” submitted by the Southeast Archeological Center (SEAC) of the NPS, and one of these investigations (Hardy 2004) is comprehensive. Although shipwrecks are known to have occurred in the waters surrounding the island and several have been identified, no systematic survey of shipwrecks has been conducted for the area surrounding Buck Island. The following section summarizes these studies (from earliest to latest).

In 1975, G.S. Vescelius and L.S. Robinson conducted archeological investigations at Buck Island for the Office of the Territorial Archeologist. Vescelius and Robinson identified the Buck Island site (BUIS-2; 12VAm1-68), which comprised a small surface scatter of Chicoid-style pottery and four conch/coral piles representing a prehistoric conch midden site. Their findings are cited in Prokopetz (1976c), but no formal report has been located.

A team of archeologists from the Southeast Archeological Center, directed by George Fischer, visited Buck Island in 1976 and conducted a reconnaissance survey. These investigations were documented in a trip report that dealt with the terrestrial and submerged cultural resources of the island (A. Wayne Prokopetz 1976a, 1976b, 1976c). The survey "examined three known cultural resources sites: 1) a historic homestead (BUIS-1, 12VA1-252), 2) an aboriginal site (BUIS-2, 12VA1-68), and 3) a historic period shipwreck (BUIS-3)" (Hardy 2004). These sites are itemized in the section that follows.

An inventory and assessment of the integrity of site 12VAm1-68 was conducted by Barbara Johnston and crew in 1982. At the time site 12VAm1-68 had been described as the West Beach site by Prokopetz (1976a), but was later included as part of the Buck Island site (Hardy 2006). No artifacts were collected, but pottery sherds from the Elenois/Chicoid period, were noted, along with bone, shell, and stone tools.

An anonymous 1984 source notes that a mammal bone was found around site BUIS-1; however, no report was prepared for this find. An investigation by Riddle, dated 1984, was cited in the literature, but no record of the work could be located.

In 1985, Elizabeth Righter conducted a cultural resources reconnaissance survey at Buck Island. This project included the systematic subsurface testing of the Buck Island site (BUIS-2). Intended to delineate the site boundaries, the testing recovered Ostionoid pottery, faunal food remains, a lithic tool, and a possible prehistoric shell midden.

Righter's survey also identified a stone masonry foundation near the western end of the island. Labeled the Foundation Site (BUIS-4), the find included historic ceramics and seemed to indicate a 1½ to 2-story structure that may have been a slave residence. In addition, a historic midden (BUIS-6) was discovered near BUIS-4 and BUIS-2. Afro-Cruzan vessel fragments ceramics (historic) found at BUIS – 6 were similar to those recovered at the Foundation site. Dates for the ceramics ranged from the end of eighteenth century through the nineteenth century. Righter's report recommended a full Phase I investigation for the entire island.

A 1985 trip report by Larry Murphy identified two shipwrecks, and described NPS assessment of the research potential of submerged cultural resources on the north side of Buck Island.

In the aftermath of Hurricane Lenny, Brenda Lazendorf and Richard Curry visited Buck Island to assess damage to the island's cultural resources. Their investigations, including a shipwreck previously identified by Prokopetz (later number 12VAm1-286), were described in a 2000 trip report.

In 2002, Meredith D. Hardy visited Buck Island to conduct archival research and to assess collections housed by Christiansted National Historic Site. Her trip report documented re-location of previously identified cultural resources, including the Signal Station site (BUIS-1; 12VAm1-252), the Buck Island prehistoric site (BUIS-2; 12Vam1-68), and the Buck Island Reef Wreck (BUIS-3). The remains of an above-ground cistern with nineteenth-century ceramics and glass were identified, and the site was designated as the West Beach Historic or Goby site (BUIS–5; 12VAm1-288). Surface collection between BUIS-1 and BUIS-5 identified ceramics and glass.

During the summer of 2003, Hardy and others from the Southeast Archeological Center conducted an archeological pedestrian survey and limited subsurface testing at Buck Island Reef National Monument. Sites visited and recorded via global positioning system included the Signal Station site (BUIS-1; 12VAm1-252) and the Foundation site (BUIS-4; 12VAm1-287). A second set of ruins was discovered nearby; this site (BUIS -6) had historic ceramics, glass, and pipe fragments. Late eighteenth- and nineteenth-century ceramics were collected at the West Beach Historic or Goby site (BUIS-5; 12VAm1-288). The Buck Island prehistoric site (BUIS-2; 12Vam1-68) was tested, a buried A-horizon was identified, and a hearth was excavated (Hardy 2004).

The archeological overview and assessment of cultural resources on Buck Island completed by Hardy in 2006 presents a summary of all archeological work on the island and assesses the status of museum collections.

Description of Known Archeological Resources

Since at least 1754, the African slaves of European colonists at St. Croix were sent to Buck Island to harvest lignum vitae trees; gather shellfish, lobsters, and crabs; and tend sheep and goats that were taken to the island to forage. A few Europeans lived on the higher ridges of the island (BUIS-1; 12VAm1-201).

BUIS-1 includes a privy foundation, an above-ground cellar foundation, stone wall remnants, and eighteenth through nineteenth century ceramic sherds, glass, and pipe fragments (Prokopetz 1976a; Hardy 2002). A National Register of Historic Places nomination form was prepared for the site, but was not submitted. A surface collection of ceramics and glass was made in the area between BUIS-1 and BUIS-5, and the site was recommended as potentially eligible for listing to the National Register of Historic Places (Hardy 2002; 2003).

The Buck Island Site (BUIS-2; 12VAm1-68) comprises a surface scatter of Late Saladoid through Ostionoid-style prehistoric pottery, and four conch/coral piles (Vescelius and Robinson 1975; Prokopetz 1976b; Johnston 1982; Righter 1985; Hardy 2002, 2003, 2004). Righter attempted to delineate boundaries of this site in 1985 through the systematic excavation of three units and 72 shovel tests. The site is recommended as potentially eligible for listing to the National Register of Historic Places.

The Buck Island Reef Wreck (BUIS-3; 12VAm1-202) was identified northwest of Buck Island in 1976. The ship's wood hull measured approximately 205 feet by 70 feet and was surrounded by copious amounts of coal (Prokopetz 1976b; Murphy 1985; Lazendorf 2000; Hardy 2002).

The Foundation Site (BUIS-4) consists of a stone masonry foundation whose dimensions are approximately 30-feet by 15-feet, without an eastern wall. A variety of historic ceramic sherds (dating from the end of the eighteenth century through the nineteenth century) were recovered (Righter 1985; Hardy 2003). A second foundation (a chimney), along with ceramics and glass fragments also was identified, and was recommended as potentially eligible for listing to the National Register of Historic Places.

The Goby Site (BUIS-5; 12-VAm1-203) comprises a cistern or well ruins and includes late eighteenth through nineteenth century ceramic sherds (Righter 1985; Hardy 2002, 2003, 2004). The site is recommended as potentially eligible for listing to the National Register of Historic Places.

Afro-Cruzan ceramic vessel sherds and ceramic sherds similar to those found at BUIS-4 were collected at the Historic Midden site (BUIS-6) (Righter 1985). This site is recommended as potentially eligible for listing to the National Register of Historic Places.

Ships occasionally wrecked on the coral reefs surrounding the island (see Table 15). Towle, et al. (1976) and Tyson (1983) identify shipwrecks in the vicinity of the Virgin Islands between 1523 and 1917. Two of these vessels were British slave ships, but most were smaller cargo ships or at least wrecked while carrying cargo. No systematic survey of maritime cultural resources has been conducted to date.

Table 15. Shipwrecks/Underwater Archeological Sites

Ship Type	Name /Location	Year (if known)	Source
Cargo ship	*Brothers* / St. Croix	1769	Towle et al. 1976
Cargo ship	*Lord Mount Cathell* / St. Croix	1773	Towle et al. 1976
Ship	Unknown Dutch ship / Buck Island	1781	Tyson 1983
Schooner/ cargo ship	*Nancy* / Buck Island	1793	Tyson 1983
Slave ship	*Mary* / Buck Island	1797	Towle et al. 1976
Slave ship from Africa (slave ship)	*General Abercrombie* / Buck Island	1803	Towel et al. 1976
Cargo ship	*Angelica* / Buck Island	1823	Towle et al. 1976
Cargo ship	Unknown	Between 1871-1917	Tyson 1983
Cargo ship	Unknown	Between 1871-1917	Tyson 1983
BUIS-3 / 12VAm1-202	Buck Island Reef Wreck Archeological site (historic/maritime)	Mid- 19^{th} to 20^{th} century	Prokopetz 1976b

Two shipwrecks have been identified north of Buck Island. The first is a circa 1850 shipwreck (Shipwreck 1), consisting of two anchors (Murphy 1985; Prokopetz 1976b; Lazendorf 2000). The second is a circa 1800 sailing ship wreck whose hull measures about 50 to 60-feet by 18- to 20-feet (Murphy 1985).

National Register of Historic Places. Although to date none of the previously identified archeological resources located on Buck Island are listed or have been determined eligible for listing on the National Register of Historic Places, five resources have been recommended as potentially eligible for listing (Table 16). These are the Signal Station site (12VAm1-252, BUIS-1); Buck Island Prehistoric Site (12Vam1-68, BUIS-2), Foundation site (12VAm1-287, BUIS-4); West Beach Historic or Goby site (12VAm1-288, BUIS -5); and the Bigeye/West End Historic Midden (12VAm1- 289, BUIS-6).

Thus the potential exists to encounter as yet unidentified resources associated with the prehistoric period, the colonial period, lives of slaves, the later historic period, and shipping. These sites could contribute useful information about the lifeways and subsistence activities of prehistoric peoples and African slaves, as well as shipping practices, fishing and subsistence activities, and related economic issues from colonial times to the present.

Table 16. Known Archeological Resources

Resource	Resource Type	Site Name/ Location	Date (if known)	Potentially National Register-Eligible
BUIS-1 / 12VAm1-201; 12VAm1-252	Archeological (historic)	Buck Island	Late 18th-19th century	x
BUIS-2 / 12VAm1-68	Archeological (prehistoric)	Buck Island	Ca AD 410-700	x
BUIS-4 / 12VAm1- 287	Archeological (historic)	Foundation and associated chimney	Late 18th-19th century	x
BUIS-5 / 12VAm1- 203	Archeological (historic)	Goby Historic Site	Late 18th-19th century	x
BUIS-6 / 12VAm1- 289	Archeological (historic)	Bigeye Historic Midden	Late 18th-19th century	x
	Archeological (historic/maritime)	Sail hull		

Threats to Archeological Resources. Current threats to archeological resources within the park boundaries include beach erosion, storm impact, non-native plants, bioturbation from plants and animals, vandalism and inappropriate visitor uses. As a result of climate change, areas of the park have experienced, or may in the future experience, higher sea levels, stronger wave effects, increased water temperatures and pH levels, acidification, and changed precipitation patterns. All of these factors could contribute to the loss of cultural resources.

SOUNDSCAPES

A soundscape refers to the total acoustic environment of an area. Both natural and human sounds may be desirable and appropriate in a soundscape, depending on the purposes and values of the park. Soundscapes often vary in their character from day to night and from season to season and can be affected by changes in the number of visitors who introduce human-caused sound into the environment.

The soundscape of the park includes existing and potential sources of natural sound and potential sources of interference (noise) to natural sounds in the park. The natural soundscape at the park is created by natural processes, including but not limited to, sound created by biological and physical components such as wind, wave action, birds, reptiles such as the woodslave or gekko, and insects. Natural ambient sound is the natural soundscape condition that exists in the park in the absence of noise made by humans. Noise is defined as undesirable human-caused sound. Sound can be perceived as noise because of loudness, frequencies, duration, occurrence at unwanted times or from an unwanted source, or because it interrupts or interferes with a desired activity. A sound that is considered neutral or desirable by one person (such as a radio or boat engine) may be considered unpleasant noise by another person because of a perception of inappropriateness or disturbance. Noise can adversely affect park resources or values, including the natural soundscape, wildlife, and visitor experience.

Buck Island Reef National Monument is a serene and quiet environment with a natural soundscape consisting predominantly of wind and wave sounds, and occasional birds. In high visitor use areas of the park, such as West Beach, motorized boating activity (speed boat engine noise) and human sounds can be heard during the day. These sounds include generators for lights, air conditioning, refrigeration, televisions, and sound speakers for loud music. Progressing inland from the shore, natural sounds dominate, and there is opportunity for ambient sounds to be appreciated without interruption. During periods of peak visitation, such as weekends, human-caused sound is of greater intensity than during weekdays when the natural soundscape prevails. This also varies by season. Sound levels have not been recorded at the park to date.

Some human-caused sound can be considered acceptable in that it is attendant to purposes and uses for which the park was created. NPS Director's Order 47 requires park units to determine the level of human-caused sound necessary for park purposes, and to achieve that level by reducing noise and restoring the natural soundscape to the greatest extent possible.

SCENIC RESOURCES

Scenic resources are a defining feature of Buck Island Reef National Monument as stated in the park's mission statement which is "…to protect, preserve, manage, and interpret the park's seascapes, scenic views, and unique natural and cultural resources unimpaired for the education, enjoyment and inspiration of present and future generations." Park visitors enjoy the views of sparkling blue water, white beaches, dry tropical forest vegetation, and sparse-to-no development (such as picnic tables, comfort stations). This unique combination of scenic resources is an asset to the national park system.

As visitors travel to the park from St. Croix, the view of Buck Island and the surrounding waters is virtually uninterrupted. There is relatively little infrastructure at Buck Island (no roads, utilities, etc.) with minimal facilities consisting of a pier, picnic shelter, observation platform, comfort station, and moorings at the underwater trail. Vessels anchored at West Beach are also visible upon the approach to Buck Island and may be viewed as an intrusion on the scenic landscape by some visitors, while others might perceive this as a common element of the picturesque, marine landscape. This same dual perception would also be applicable to moorings located near the underwater trail. The natural viewshed looking back toward St. Croix from Buck Island has been altered by private development and consists more of the built environment, including residential housing, roads, lights and commercial development.

VISITOR USE AND EXPERIENCE

Many different types of use and experiences occur at the park. This section provides a summary of the types and levels of visitor use and the types of access to park, recreational opportunities that occur, and the availability of information for visitors. Information contained within the following sections regarding general park use, recreation, and park polices has been obtained from park brochures, the Buck Island Reef National Monument website (http://www.nps.gov/buis), interviews with park staff conducted between 2004 and 2006, and review of visitor use surveys up to 2008.

Visitors Use and Access

Buck Island Reef National Monument fills an important role for the St. Croix community and visitor. It is the number one tourist destination for the island of St. Croix, with an annual visitation between 40,000 to 50,000 visitors each year, from 1995 to 2008. As a public use area, the park is exposed to a large and growing number of visitors for the underwater experience, sailing and boating, as well as hiking, picnicking, sunbathing, swimming, and snorkeling.

There are two ways to get to the park, either by private vessel or with park concession operators who charge a fee. Vessels for hire are not permitted within the park without authorization. An anchoring permit is required for all vessels, and anchoring is only allowed in a designated area near West Beach in deep sand. Anchoring permits are obtained from the Park Headquarters at Christiansted National Historic Site, Christiansted, St. Croix. Vessels cannot exceed 150 feet in length and vessels must be 42 feet in length or less to enter the lagoon.

Concession vessel sizes and passenger limits vary from one concessioner to another depending on the type of vessel and contract. Twelve authorized concessioners offer half and full day trips to the park, which include the trip to Buck Island, snorkeling at the underwater trail, and sometimes West Beach at Buck Island. The half day trip includes 45 minutes at the underwater trail and some include a trip to

West Beach; when the trip includes a beach visit, less time is spent at each location. A full day trip includes a trip to West Beach at Buck Island, 1 to 1.5 hours at the underwater trail, and another stop outside the park. Two vessels received storm damage in 2008 and have not been operating in the park since 2008.

Concessioners depart from the Christiansted Harbor or Green Cay Marina. Information regarding concessioner operations is also provided at Christiansted National Historic Site or the park website. A concrete pier, located on the south side of Buck Island mid-way between the two picnic areas, provides universal access.

Table 17 summarizes visitation counts from 1995 to 2008. The number of recreational visitors is calculated based on concessioner passenger logs and estimates of visitors arriving by private boat. Visitors arriving by private boat are estimated on a monthly basis, and range from 1,800 to 2,400 visitors per month (NPS 2002c). Park staff report that the majority of visitation, particularly from the local population, occurs on Sunday. In addition, visitation is typically greatest between the months of February and April with other increases in visitation for cold weather travelers. Under current management, there are no limits set on park visitation, and user capacity is limited by the number of visitors who can be transported via concessioner and by the number of anchoring permits issued.

Recreational Opportunities

Recreational activities at the park are both aquatic and land-based. Visitor activities include boating, swimming, sunbathing, snorkeling, SCUBA diving, guided interpretive tours, daily guided boat trips, picnicking, hiking, and nature observation. Recreational opportunities are typically availably year-around; however, portions of the park, particularly beach areas, may be closed at the park's discretion for resource protections, as during sea turtle and least tern nesting seasons. Beach closures may also occur for safety reasons.

Visitors may anchor by permit only in a designated area near West Beach, and shoreline bow and stern anchoring also occurs in this area. Moorings are also provided on the east side of Buck Island: up to ten at the underwater trail and two for SCUBA diving. Swimming, snorkeling, and boating are currently appropriate activities within all waters of the park; however, visitors must be aware of and avoid contact with sensitive resources (elkhorn coral) in order to maintain safe experiences in the park (see "Public Health and Safety" subsection) and to preserve and protect marine resources. Vessels in park waters cannot exceed 150 feet in length, and cannot exceed 42 feet in length in the lagoon.

Table 17. Annual Visitation Estimates for 1995 to 2008

Year	Annual Number of Visitors
1995	57,716
1996	45,618
1997	53,583
1998	46,455
1999	Data not available
2000	Data not available
2001	Data not available
2002	50,213
2003	46,274
2004	44,806
2005	47,883
2006	47,456
2007	46,303
2008	46,025

Source: NPS 2009

An underwater snorkeling trail is located off the east end of Buck Island. Visitors receive instruction from concessioner guides who lead visitors on the trail. Underwater signs are present along the underwater trail on the bottom, to aid and guide snorkelers and help interpret the various marine resources. SCUBA diving within the park is permitted at two designated SCUBA moorings on the northeast side of Buck Island. Dives are shallow (30 to 40 feet) and provide an opportunity to view elkhorn coral grottos and haystack formations. In addition, authorized concession operations provide marine life viewing and boating recreation for park visitors. Boat tours by catamaran, sailboats, and motor vessels are available. Fishing, fishing gear, and collecting activities are prohibited in the entire park.

The bulk of visitor activity on Buck Island occurs on West Beach and in the two picnic areas adjacent to the beach. Picnicking and barbeque grilling are favorite past-times for visitors. Frequently visitors plan family gatherings at the park and spend the entire day at the beach cooking lunch and dinner. All grilling must be conducted in grills provided by the park, and open fires are not permitted. In addition, motorized vehicles and pets are not permitted on the island. Special use permits can be obtained from park headquarters at Christiansted National Historic Site for weddings, sailing regattas, swim races, and other similar activities.

Hiking is also available at Buck Island on a marked overland hiking trail that extends from West Beach to the summit of Buck Island and then down to Diedrich's Point picnic area. From West Beach the trail goes through low-lying beach forest over gentle hillsides with turpentine and pigeon-berry trees to the island crest. A side trail to the north leads out to an observation point that affords views of the north shelf coral reef and drop-off into deeper waters farther out. The trail continues down the south side in small switchbacks through frangipani trees, organ pipe cactus, and bromeliads and ends at the Diedrich's Point picnic area. A shorter hike is also available by beginning at West Beach and exiting the main trail on a side trail that terminates on the beach. Visitors can then return to West Beach via the shoreline.

Camping and overnight stays are not permitted on Buck Island; however, overnight anchorage in the designated anchoring area is permitted. Lighting must be kept at a minimum during overnight stays since bright lights disorient sea turtles and disturb other wildlife and visitors.

Access to Orientation Information

Information regarding park resources and policies is disseminated to the public through a variety of sources. The primary visitor contact station is located at park headquarters in Christiansted National Historic Site on St. Croix. A visitor contact station is located in Fort Christiansvaern, where information is disseminated through park staff and through interpretive displays, and at the Eastern National Bookstore located in the Scale House. Anchoring permit applications and information regarding authorized park concessioners can also be obtained at park headquarters. At Buck Island, interpretation is provided by kiosks, one located at the West Beach picnic area and another at the Diedrich's Point picnic area shelter, located at the head of the hiking trail. Additional information is provided by underwater signs located throughout the underwater trail. In addition, park concessioners receive information from park staff and serve as liaisons for providing information to visitors regarding resource protection, park regulations and policies, and safety.

PARK OPERATIONS AND FACILITIES

Staffing

Park staff provide the full scope of functions and activities to accomplish management objectives and perform duties that include resource protection and management, visitor services, interpretation and education, law enforcement, emergency services, public health and safety, and maintenance. In 2008, there were 14 NPS staff shared between the three NPS units — Buck Island Reef National Monument, Christiansted National Historical Site, and Salt River Bay National Historical Park and Ecological Preserve. Some of the Resource Management staff are fully dedicated to Buck Island Reef National Monument, though the majority of the staff have duties at all three park units. For the purposes of this *General Management Plan*, it was estimated that if all positions serving the three NPS units were filled, it would translate to approximately 14 full time employees serving Buck Island Reef National Monument.

Park staff spend time partnering with a variety of federal, territorial, and other local agencies and organizations to aid the park in achieving its mission. The park actively coordinates with many other agencies, organizations and research/educational institutes including: the U.S. Geological Survey, Biological Resources Division; the National Oceanic and Atmospheric Association; and the many non-government organizations and universities. In addition, the park coordinates volunteers for its Youth Conservation Corps and the Buck Island Sea Turtle Research Program.

Park Infrastructure and Facilities

Park facilities are shown on Figure 4 in Chapter 2. The park has up to ten moorings installed near the underwater trail located at the east end of the island's coral barrier reef and two moorings in the north lagoon designated for SCUBA. Regulatory and boundary buoys are also located in the park. The underwater trail contains underwater interpretive signage and requires routine maintenance. A concrete pier is located midway between Diedrich's Point and West Beach.

At West Beach and Diedrich's Point there are picnic tables, charcoal grills, and comfort station / vault toilets. In addition, a small wooden shelter (16' x 24') is located at Diedrich's Point picnic area. This shelter provides for covered picnicking and has visitor educational displays and locked storage for park program use. The shelter is occasionally requested for use through special use permits for events such as family gatherings (NPS 2000b). There are no trash receptacles on Buck Island, and visitors must pack out all trash and wastes upon departing the island. In addition, there are no utilities or a potable water supply on Buck Island.

A marked terrestrial trail bisects the south side of Buck Island and leads up to an observation platform located on the north shore of the island. A U.S. Coast Guard navigational tower is also located on the island, but is closed to the public, and the trail leading to this tower is for administrative use only.

Commercial Services

Commercial services are a vital component of park operations since many of the park visitors access the park via authorized park concessioner boats. In 2010 there were 12 authorized concessioners providing charter services to Buck Island. In addition, Eastern National Parks & Monuments provides a bookstore/gift shop concession to the park under a national partnership agreement. It is located in the Scale House associated with the Christiansted National Historical Site. The need for a Commercial Services Plan for the park has been identified.

PUBLIC HEALTH AND SAFETY

The park is responsible for maintaining safe conditions that protect the health and safety of employees and the public. This not only applies to providing safe facilities and grounds within the park, but also includes NPS program and project operations. There are no recorded, comprehensive safety statistics available for the park. However, areas of concern related to health and safety identified during public and internal scoping for this *General Management Plan* include boating and beach safety, marine and reef hazards, terrestrial hazards, and law enforcement.

Boating and Beach Safety

Several issues regarding safe operation of vessels and beach access/safety were raised during public and internal scoping meetings. Disregard of the no-wake zone and operation of vessels at an unsafe speed near West Beach were identified as potential safety issues. These problems were noted to intensify during periods of high visitation, particularly on Sundays. The potential for vessel groundings is also a safety concern, since the shallow reef poses a navigational hazard.

Beach access was also noted as a potential safety concern. Currently, shoreline bow and stern anchoring is permitted on West Beach in the designated anchoring area, allowing a vessel to anchor directly on the beach. Many visitors have expressed a desire to maintain this policy, citing a concern for safety if vessels that do not have dinghies were forced to discharge passengers in open waters. This issue is compounded because there is no lifeguard on duty. Conversely, other visitors and park staff have noted that shoreline bow and stern anchoring poses a trip and fall hazard by allowing anchors and lines to extend onto the beach in the path of visitors. Additionally stern anchoring requires boats to motor stern to the beach, often with the propeller lifted up due to shallowness of the water, which exposes visitors to a spinning propeller in the shallow swimming area.

Boaters may use the pier for passenger and supply unloading, not for docking. The pier is used on a first come first serve basis, and is intended for short-term use only.

Marine and Terrestrial Biological Hazards

Shoreline shallows and near-shore reefs have many potential biological hazards such as Southern Atlantic stingrays, spiny sea urchins, fire coral, fire worms, barbed snails, and sharp corals. Cuts from marine organisms can quickly result in infection, and should be cleaned and medicated as soon as possible. To minimize contact with these organisms, it is recommended that visitors practice snorkeling in shallow water at the beach before going to the underwater trail and reef. During certain weather conditions, especially calm winds from the south, sea wasp and man-o-war jelly fish can be washed into the reef area and ashore. The NPS closes the beaches and anchoring area at Buck Island during certain storms, when stinging jellyfish are present, or during other hazardous conditions. Predator species such as barracuda and sharks are naturally occurring in park waters, and it is likely that these species will eventually become more numerous since the “no-take” policy will improve fishery resources.

Several forms of hazardous vegetation are present at Buck Island, making it important to stay on the beach or on designated trails while visiting the park. For example, contact with the leaves, bark, and fruit of the poisonous Manchineel tree causes a chemical burning and can cause blindness if contact is made with the eyes. Visitors should also avoid Christmas bush, which looks like holly, and stinging nettle, a small vine with heart shaped leaves with fine silver hairs. Various other trees, cacti, and plants bearing thorns or barbed hairs should be avoided. Centipedes, scorpions, biting spiders, and ants are also present in the park. In addition, island topography can also pose a hazard since slopes are steep (30-60 % grades) and soils are often unstable. The hot climate and lack of potable water on the island also results in the potential for dehydration.

Law Enforcement

The mission of park law enforcement includes ensuring resource protection as well as visitor safety. Park rangers are tasked with enforcement of the "no-take" policy, beach closings for sensitive species' nesting seasons, no wake zones, the "pack-it-in/pack-it-out" policy, anchoring and mooring area, and all other park rules and regulations. Park rangers also respond to swimmers, snorkelers, and boaters in distress and other safety-related incidents. In addition, illegal drug trafficking and illegal immigration is also a potential concern at Buck Island due to its offshore location.

The law enforcement division is shared between Buck Island Reef National Monument, Christiansted National Historical Site, and Salt River Bay National Historical Park and Ecological Preserve. Due to staffing limitations and funding constraints, law enforcement presence is not provided on a full time basis. The need for full staffing to meet the 16 hour /7 day per week schedule was an issue of concern expressed frequently during the scoping process.