The State of Coral Reef Ecosystems of the U.S. Virgin Islands

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INTRODUCTION AND SETTING

Coral reef ecosystems in the U.S. Virgin Islands (USVI) consist of a mosaic of habitats, namely coral and other hardbottom areas, seagrasses, and mangroves that house a large diversity of organisms. These biologically rich ecosystems provide important ecosystem services (e.g., shoreline protection) and support valuable socio-economic activities (e.g., fishing and tourism), but they are also affected directly and indirectly by these activities. This chapter presents an assessment of the current status of coral reef ecosystems in the USVI. It provides a comprehensive review of historic and current literature and long-term datasets that describe coral reef ecosystems of the territory. It also provides data synthesized from current monitoring programs conducted by Federal and territorial organizations.

The USVI comprises three large main islands and several smaller islands (Figure 4.1). St. Croix – the largest island – is 207 km^2 in size. St. Thomas is the second largest island at 83 km^2, and St. John is the third largest at 52 km^2. The geologically dissimilar islands lie between two major island archipelagos: the older Greater Antilles to the west and the younger Lesser Antilles to the east. St. Thomas and St. John are more similar to the Lesser Antilles than to Puerto Rico with which they share an extensive shallow water platform (Adey et al., 1977). St. Croix geologically belongs to the Greater Antilles but is isolated by the Virgin Islands Trough that is over 4,000 m deep (NOAA National Geophysical Data Center, http://www.ngdc.noaa.gov/mgg/gdas/gd_sys.html, accessed: 11/2/2004). Managed areas in coastal waters of the three main islands exist to protect, maintain, or restore natural and cultural resources (Figure 4.1).

Reefs in St. Thomas and St. John generally form fringing, patch, or spur and groove formations that are distributed patchily around the islands (see Figure 4.20). The eastern and southern shores of St. Croix are protected by well-developed barrier reef systems with near-emergent reef crests that separate lagoons from off-shore bank areas (Adey, 1975; Hubbard et al., 1993). Bank reefs and scattered patch reefs occur on geological features at greater depths offshore. Recently, the National Oceanic and Atmospheric Administration (NOAA) mapped 485 km^2 of benthic habitats in the USVI to a nominal depth of 30 m. Analyses of these maps revealed that coral reef and hard-bottom habitats comprise 300 km^2 (61%), submerged aquatic vegetation covers 161 km^2 (33%), and unconsolidated sediments comprise 24 km^2 (4%) of shallow water areas (Kendall et al., 2001; Monaco, 2001; http://biogeo.nos.noaa.gov, accessed 1/19/05).

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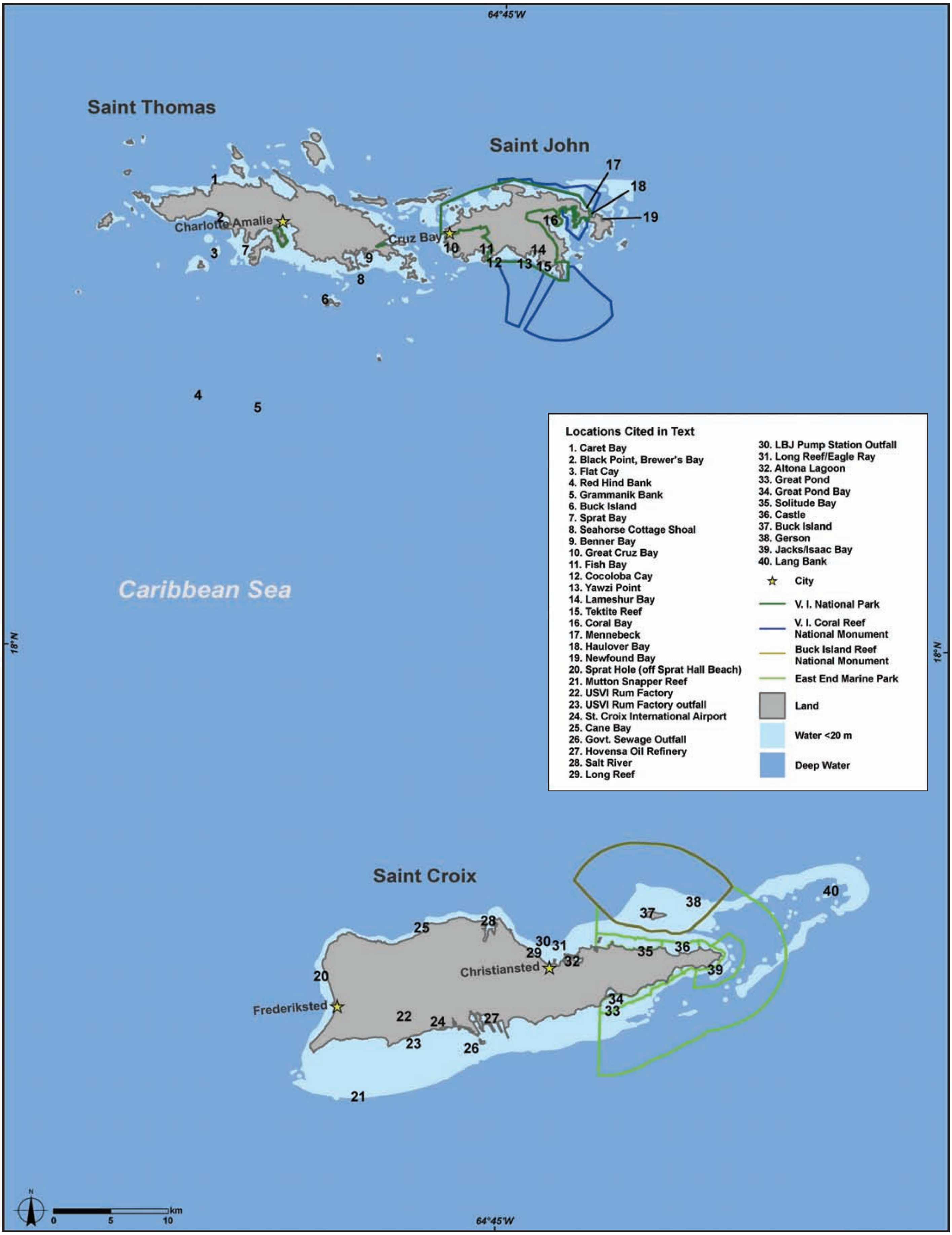

Figure 4.1. A map of the USVI showing managed areas, municipalities, and other locations mentioned in this chapter. Map: A. Shapiro.

ENVIRONMENTAL AND ANTHROPOGENIC STRESSORS

Coral reefs in the USVI face similar pressures as reefs elsewhere in the Caribbean (Rogers and Beets, 2001). Of the 13 major coral reef stressors identified by the U.S. Coral Reef Task Force, 10 have been identified as being problematic to reef ecosystems in the territory. These stressors include climate change; diseases; tropical storms; coastal development and runoff; coastal pollution; tourism and recreation; fishing; and ships, boats, and groundings. The impacts of these stressors on USVI coral reefs are summarized in this chapter. Other stressors such as alien species, security activities, and offshore oil activities are not relevant to the USVI. Stressors are described fully in Chapter 3 of this report.

Climate Change and Coral Bleaching

Climate change refers to the trend of increasing mean global air temperature and sea surface temperatures (SST) within the last century compared with previous estimates. This warming trend is generally attributed to the atmospheric accumulation of greenhouse gases. Bleaching in the USVI has been reported since 1987 (Figure 4.2). Bleaching was most severe and had the highest reported incidence of occurrence during the Caribbean-wide event of 1998-1999. According to the U.S. National Park Service (NPS), the 1998 bleaching event coincided with the highest recorded SSTs in the USVI. Bleaching was less severe in 1999 probably because water temperatures were slightly lower (28.8ºC) 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). For both years, bleaching was most severe in St. Croix, followed by St. John, and then St. Thomas (Figure 4.2).

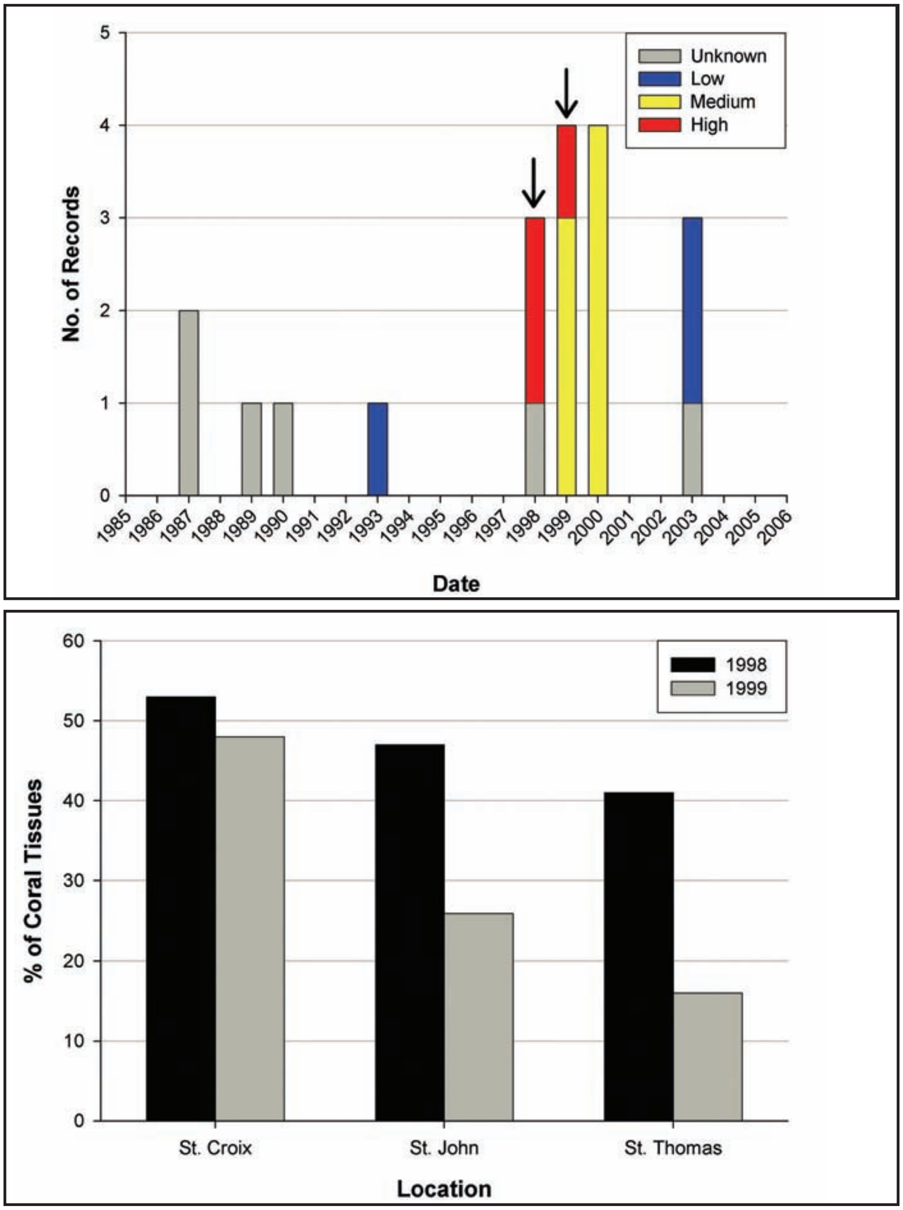

Figure 4.2. Annual trends in coral bleaching in the USVI. Upper panel shows the number of bleaching reports by year and severity. Arrows indicate the Caribbean-wide bleaching event of 1998-1999. Source: Reefbase 2003, http://www.reefbase.org, Accessed: 10/23/2003. Lower panel shows the estimated percent of coral tissues that bleached in 1998-1999. Bars represent the maximum percent of sampled coral colonies that bleached by island and year. Source: Rogers and Miller, 2001; Nemeth et al., 2003c.

Diseases

Several diseases have affected coral community structure and have degraded coral cover (Table 4.1). Between 1976 and 1989, white band disease (WBD), bleaching, and hurricanes reduced the cover of elkhorn coral (*Acropora palmata*) by as much as 85% within the Virgin Islands National Park (VINP) and the Buck Island Reef National Monument (BIRNM; Gladfelter et al., 1977; Rogers et al., 1982; Edmunds and Witman, 1991; Bythell et al., 1992; Rogers and Beets, 2001). Between December 1997 and May 2001, 14 species of

Table 4.1. Diseases affecting coral reef organisms in the U.S. Caribbean and Florida. Source: Bruckner, 2001.

DISEASE	DESCRIPTION	CAUSATIVE AGENT	NUMBER OF CORAL SPECIES AFFECTED	CORAL SPECIES AFFECTED	RATE OF INFECTION (MM PER DAY)
Aspergillosis	Irregular lesion(s) of various sizes distributed throughout the sea fan blade due to loss of tissue and skeleton. Tissue surrounding the lesion often becomes dark purple and may have nodules, both of which occur in response to a variety of stressors. Identification of this disease requires confirmation of the presence of white fungal filaments.	Fungus (*Aspergillus sydowii*)	10+ (Weil and Smith, 2003)	Common sea fan (*Gorgonia ventalina*), Venus sea fan (*G. flabellum*), and other branching gorgonians including *Pseudoterigorgia* spp.	Unknown
Black band	Crescent shaped or circular band of black filamentous material separating living, colored coral tissue from white exposed coral skeleton.	Cyanobacteria, Sulfide-oxidizing bacteria, Sulfate-reducing bacteria	20	Several soft corals and 20 hard corals including boulder star corals (*Montastraea annularis* complex) and symmetrical brain coral (*Diploria strigosa*)	1 - 20
Dark spots	Dark purple, gray, or brown circular or irregular patches of discolored tissue scattered on the surface of a colony or at the colony's margin. The discolored tissue increases in size and radiates outward as the area first affected dies. Darkened polyps often are depressed and appear smaller in size than normal polyps.	Unknown	3 or 4	Massive starlet coral (*Siderastrea siderea*), blushing star coral (*Stephanocoenia intersepta*), and *Montastraea annularis* complex	Unknown
Red band-I	Narrow band or mat of filamentous cyanobacteria that advances slowly across the surface of a coral and kills living tissue as it progresses. It is similar in appearance to black band disease, in that it forms a distinctive band that separates live coral tissue from bare white skeleton.	Cyanobacteria	14 or more	Lettuce corals (*Agaricia* spp.), boulder brain coral (*Colpophyllia natans*), cactus corals (*Mycetophyllia* spp.), blushing star coral, the common seafan (*Gorgonia ventalina*)	Unknown
Red band-II	During daylight, the filaments spread out like a net in a diffuse fashion over live tissue and bare skeleton; at night the band forms a compact balled-up mat at the interface between live tissue and exposed skeleton.	Cyanobacteria	6	*D. strigosa, C.natans, M. annularis, M. cavernosa, Porites astreoides,* and *Siderastrea radians*	Unknown
White band	Coral tissue peels or sloughs off from coral skeleton in a uniform band, from the base of the colony upwards. A second form (WBD-II) exhibits a transient zone between apparently healthy tissue and exposed skeleton that consists of bleached but intact tissue.	Unknown	3	Elkhorn and staghorn corals (*Acropora* spp.)	5
White plague complex (Types I, II, and III)	Similar to white band in that an abrupt line of exposed (white) coral skeleton separates living tissue from dead coral colonized by algae.	Plague type II is caused by a bacterium (*Aurantamonus coralicida*); the cause of Plague types I and III is still unknown	32 or more	At least 32 species including brain corals (*Diploria* spp. and *C. natans*), cactus corals (*Mycetophyllia* spp.), the elliptical star coral (*Dichocoenia stokesii*), star corals, and starlet coral (*Siderastrea siderea*)	3 - 200

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DISEASE	DESCRIPTION	CAUSATIVE AGENT	NUMBER OF CORAL SPECIES AFFECTED	CORAL SPECIES AFFECTED	RATE OF INFECTION (MM PER DAY)
White pox	White circular lesions on the surface of infected colonies.	*Serratia marcescens*	1	Elkhorn coral (*A. palmata)*	250 -1,050
Yellow blotch	Pale, circular blotches of translucent tissue or a narrow band of pale tissue at the colony margin surrounded by normal, fully pigmented tissue. Infected tissue dies, and exposed skeleton is colonized by algae.	Unknown	3	Boulder star corals (*Montastraea* spp.) and the brain coral (*Colpophyllia natans)*	< 1

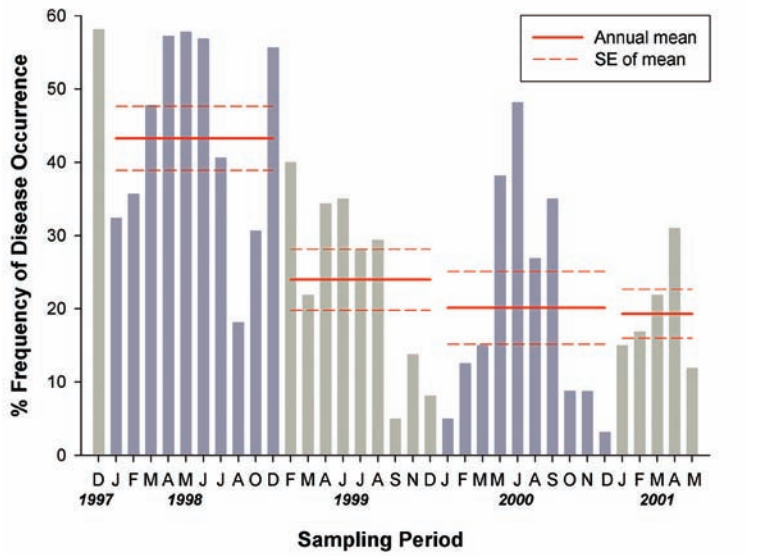

Figure 4.3. Mean monthly and annual frequency of disease occurrence on Tektite Reef, St. John, over 42 months. Source: Miller et al., 2003.

hard coral in the VINP were infected with the white plague type II, a newly identified disease (Miller et al., 2003; Weil and Smith, 2003). Miller et al. (2003) observed a new incidence of white plague type II every month, although the monthly frequency of infections decreased during the study (Figure 4.3). A disease-causing fungus, *Aspergillis sydowii*, has been isolated from air samples taken during African dust storms and has been infecting sea fans on reefs in the USVI (Garrison et al., 2003).

Tropical Storms

Tropical storms are a major force structuring 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. Several hurricanes have affected USVI reefs since 1979, but Hurricanes David (1979) and Hugo (1989) were the most severe and destructive (Figure 4.4). The eye of David – a category five hurricane - traveled about 160 km southwest of St. Croix; the eye of Hugo – a category four hurricane – passed directly over the island (Figure 4.4). Damage to reefs varied with storm path, strength and velocity, wave height and direction, the dominant coral species, and reef depth (Rogers et al., 1997; Bythell et al., 2000). The strongest evidence of storm damage to reefs was observed at Lameshur Bay, St. John, and Buck Island, St. Croix. Hurrincane David resulted in large stands of elkhorn coral on reef crests being replaced by mounds of dead elkhorn coral rubble at both Lameshur Bay and Buck Island (Rogers et al., 1982; Beets et al., 1986). In Lameshur Bay, Hurricane Hugo caused significant declines in total live coral cover, including star coral (*Montastrea annularis*), a dominant and slow growing coral species (Edmunds, 1991; Rogers et al., 1991). At Buck Island, Hurricane Hugo resulted in significant declines in cover of *M. annularis* and *Porites porites* at depths of 8–10 m, although *M. annularis* suffered greater mortality from predation and tissue necrosis over a two-year period than from physical damage from the hurricane (Bythell et al., 1993; Bythell et al., 2000). Hurricane Hugo also reduced areas on the south side of Buck Island to rubble pavement and moved the reef crest off the island's south side 30 m landward (Hubbard, 1991).

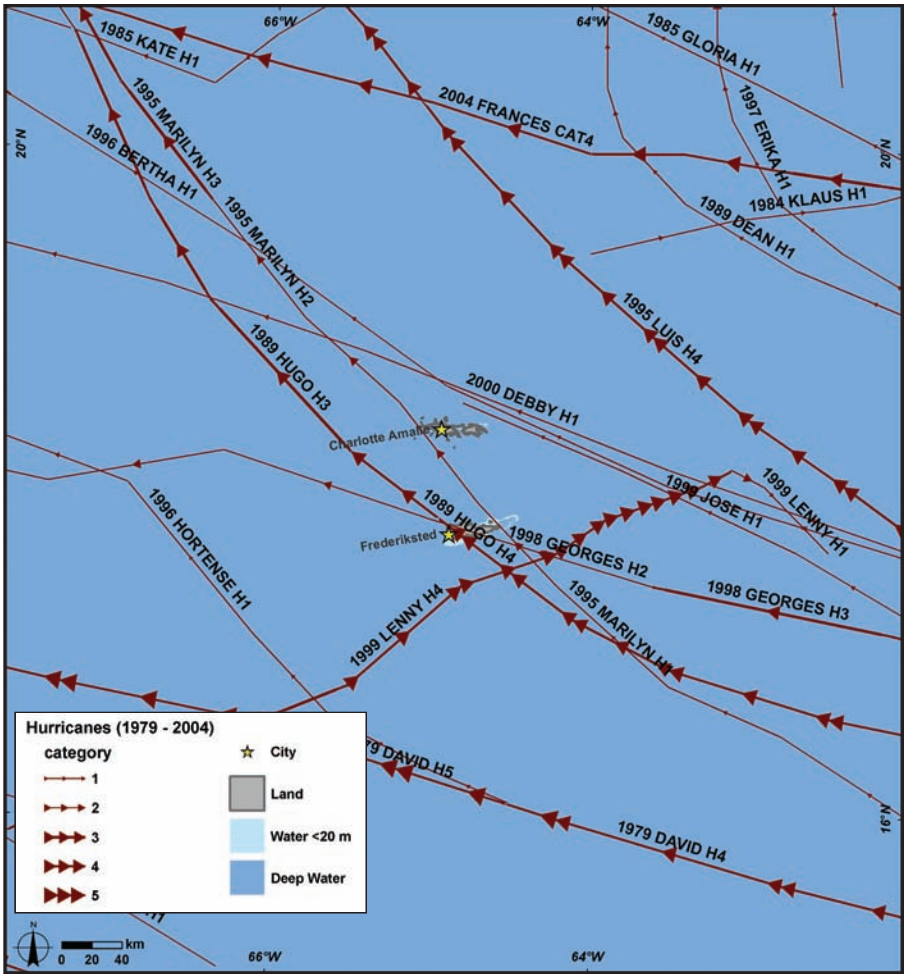

Figure 4.4. Hurrcanes that affected the coral reef ecosystems in the USVI between 1979 and 2001. Storm names are followed by year of occurrence and storm category on the Saffir-Simpson hurricane scale. H1 to H5 = Hurricane categories one through five. Arrows indicate the direction and path of the storms. Map: A. Shapiro. Source: NOAA Coastal Services Center.

Fifteen years after Hurricane Hugo, reefs in Lameshur Bay still have not shown significant increases in live coral cover (Rogers et al., 1997; C. Rogers, pers. obs.; J. Miller, pers. obs.). Exposure by Hugo of new substrates for colonization, coupled with a reduction in abundance of urchins and herbivorous fishes that consume macroalgae, may have facilitated extensive growth of macroalgae (Lessios et al., 1984; Levitan, 1988; Rogers et al., 1997). Macroalgae inhibit settlement and survival of coral recruits and growth by existing colonies, and mean benthic cover of macroalgae sometimes reaches over 30% in the affected areas (Lessios et al., 1984; Levitan, 1988; Rogers et al., 1997). At Buck Island, recovery of elkhorn coral damaged by Hurricane David was hindered by WBD and by Hurricane Marilyn in 1995 (Rogers et al., 1982; Rogers et al., 2002). Some recruitment of elkhorn coral has occurred since the 1995 hurricane (Bythell et al., 2000; Rogers et al., 2002).

Coastal Development and Runoff

Sedimentation associated with runoff from coastal development poses a serious threat to water quality in the USVI. In St. Thomas and St. John, the problem is worsened by the steep terrain of the islands (80% of the slopes exceed 30° in incline), and runoff from unpaved roads after intense rain showers is considered the largest contributor of eroded sediments to coastal waters (CH2M Hill Inc., 1979; Anderson and MacDonald, 1998; IRF, 1999). Although published data on the temporal increase and spatial extent of coastal development in the USVI are scarce, unplanned and poorly regulated development for a growing population, and a booming tourism industry may have taken a toll on coral reef ecosystems through the years (see Tourism and Recreation section). Nemeth and Sladek-Nowlis (2001) monitored the impacts of a hotel development on a nearby fringing coral reef at Caret Bay, St. Thomas (Figure 4.5) monthly for two years. The hotel construction site was on a steep hillside less than 50 m from the shoreline. The landward edge of the reef was 75-140 m from the shoreline. Rates of sedimentation, changes in water quality, and changes in the abundance and diversity of corals and other reef organisms were measured along five permanent transects from July 1997 to March 1999. Sediment loads and suspended solids were highest at ravine outlets and sheltered locations, increased during large rainfall events, and decreased after buildings and road pavements were completed. Live coral cover along the entire reef tract declined about 14% and was lowest at sites with the highest rates of sedimentation (Figure 4.6).

Severe rainfall events are problematic and can overwhelm existing sewer and stormwater systems. During November 2003, a low pressure system dropped 38 cm of rain in five days throughout the territory and contributed to the formation of large sediment plumes along developed areas of the coastline. Sediment plumes resulted in a decline in water quality, elevated turbidity on nearby reefs and seagrass beds, and forced the closure of swimming beaches. Additionally, wastewater disposal and sewage systems frequently malfunction and discharge raw sewage into nearshore areas. Despite the many environmental problems associated with coastal development, major development projects adjacent to environmentally sensitive habitats are being proposed and welcomed by government officials as boosters of the economy. Such projects may exacerbate existing problems of coastal pollution and runoff, and ultimately may harm the islands' economy that is at least partly dependent on the health of their natural resources.

Figure 4.5. A large mound of dirt was excavated from a construction site located less than 100 m from the shoreline at Solitude Bay, St. Croix. Photo: C. Jeffrey.

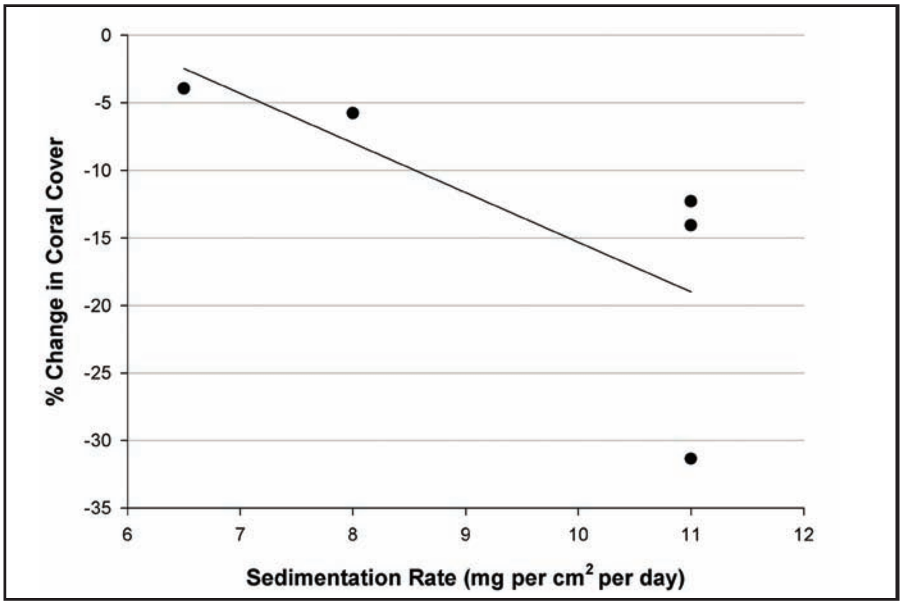

Figure 4.6. Percent change in live coral cover as a function of increasing rate of sedimentation at Caret Bay, St. Thomas. Data were collected from five permanent transects at Caret Bay Reef between July 1997 and March 1999 before, during, and after the construction of the Caret Bay Villas. The decline in live coral was significant ($p < 0.01$). Source: Nemeth and Sladek-Nowlis, 2001.

Coastal Pollution

Coastal pollution has led to several days of beach closings in the USVI. In 1999, the USVI was ranked third in the number of beach closings per year among U.S. States and Territories with 307 beach-closing days (National Resources Defense Council, http://www2.nrdc.org/water/oceans/ttw/sumvi.pdf, Accessed: 11/10/2004). Beach closings decreased to eight days in 2002, but increased tenfold to 80 days in 2003. The continued decline in coastal water quality has been linked to coastal development and runoff, as well as point and nonpoint source discharges (USVI DPNR, 2004). In St. Croix, the Virgin Islands rum manufacturing plant discharges a plume of wastewater that is visible from the discharge point to about 10 km westward along the shoreline. Biological pollution of coastal water results largely from a failing, overloaded municipal sewage system that frequently empties sewage directly into nearshore waters as well as the discharge of vessel wastes directly into the sea by boat owners. Coastal waters also become polluted when groundwater that has been contaminated by failing septic tanks, sewage infiltration, and petroleum is carried to the marine environment during flooding after intense rainfall (USVI DPNR, 2004). These pollution problems are worsened by a lack of public awareness about the importance of USVI waters, which further contributes to the degradation of marine water quality.

The USVI Department of Planning and Natural Resources (DPNR) conducts a Water Pollution Control Program to monitor all known point source discharges of pollution such as outfalls, harbors, marinas, and main recreational areas (USVI DPNR, 2004). The program also evaluates coastal water quality by monitoring nonpoint source discharges through a signed Memoranda of Agreement and Cooperation with several partner agencies, including the Virgin Islands Resource Conservation and Development Council, VI Conservation District, University of the Virgin Islands (UVI), U.S. Geological Survey (USGS), Island Resources Foundation, the NPS, and the St. Croix Environmental Association (SEA). Additionally, the NPS in St. John and UVI publish a local newsletter to inform and educate the public on nonpoint source pollution problems (USVI DPNR, 2004).

Tourism and Recreation

Historically dependent on agriculture and trade, the USVI has developed a robust tourism industry during the last 34 years, which has shifted the islands' economy to one that is mainly tourism-based. The number of tourist arrivals to St. Thomas and St. John has quadrupled between 1970 and 2000; tourist arrivals to St. Croix remained relatively unchanged during the same period (Figure 4.7). In 2000, 108,612 USVI residents were joined by 2.2 million visitors, but the annual number of tourists has remained fairly constant since then (U.S. Census Bureau, 2003, http://www.census.gov/prod/cen2000/island/VIprofile.pdf Accessed 3/1/05; USVI Bureau of Economic Research, http://www.usviber.org, Accessed 11/7/2004).

Tourism accounts for more than 70% of the gross domestic product of the territory, and as in other tourism-dependent countries, the environmental costs of tourism are evident. Visible impacts of increased visitation include physical damage to habitats, poor treatment and control of solid waste and sewage, increased eutrophication, groundwater depletion and contamination, increased sediment loads, and displacement of traditional resource use (IRF, 1996; Bryant et al., 1998; Burke and Maidens, 2004). Snorkeling and diving are major recreational activities that could cause physical damage to reefs. For exam-

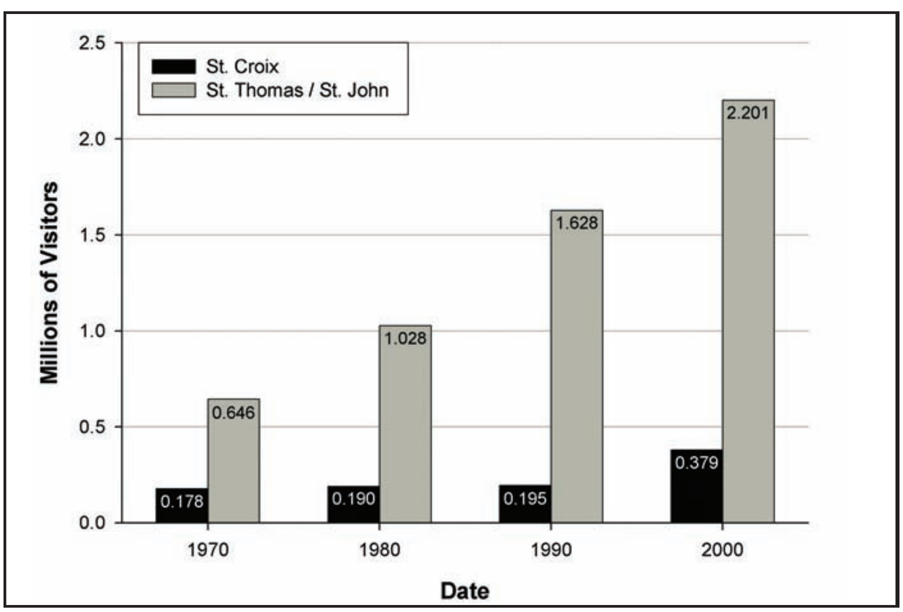

Figure 4.7. Number of visitors to St. Croix and St. Thomas/St. John between 1970 and 2000. Source: USVI Bureau of Economic Research, http://www.usviber.org, accessed 11/7/04.

ple, physical damage to corals has been observed at the BIRNM underwater snorkel trail, which attracts up to 200 visitors per day (Z. Hillis-Starr, pers. obs.). However, the more obvious impact of increased tourism has been the exacerbation of solid waste disposal problems caused by the high density of tourists and residents as well as an economy heavily dependent on high energy-consumption.

Tourists, residents, and poorly regulated development also contribute directly and indirectly to coastal pollution. For example, participation by residents and tourists in diverse marine recreational activities such as boating, fishing, diving, snorkeling, kayaking and beach camping negatively impact the marine environment in overpopulated areas. Most reported oil spills in the USVI stem from the refueling of yachts, ferries, and cruise ships (IRF, 1996). Poor lawn care practices on golf courses, in residential areas, and at tourist resorts are considered major sources of nitrate and phosphate contamination to nearshore areas through stormwater runoff (IRF, 1996). Finally, the development of major tourism facilities in coastal areas further threatens the coastal environment through increased sediment loads from the construction of buildings and roads, the operations of facilities, and stormwater runoff (IRF, 1996).

More thought and effort is now being given to promoting sustainable tourism. Dive and anchor buoys have been installed at popular dive sites to reduce the incidence of anchor damage. Environmental education and outreach is on the agenda of the national and local non-governmental organizations (NGOs), as well as territorial and Federal government agencies. For example, the NPS, UVI, SEA, and The Nature Conservancy are providing eco-hikes and other educational tours and programs for the public.

Fishing

Fishery resources have declined in the USVI since the 1960s (e.g., Appeldoorn et al., 1992). Although fishing is a visible and obvious impact to fisheries species in coral reef ecosystems, less tractable environmental threats such as habitat degradation or loss and marine pollution have also undoubtedly contributed to the decline in fisheries. Fishing has a long history in the USVI (Fiedler and Jarvis, 1932). Strongly integrated into the Virgin Islands culture, fishing provides subsistence, supplemental income, recreation, or full-time employment to the islanders. Residents and tourists consume a wide variety of marine species in relatively large quantities (i.e., about 15 kg/person/year; Swingle et al., 1979; Olsen et al., 1984). Resource managers divide the USVI fisheries into commercial and recreational fishing sectors. Presently, the bulk of information on USVI fisheries is derived from the commercial sector.

The USVI commercial fishery is artisanal in nature and consists of about 380 registered fishers – 240 on St. Croix and 140 on St. Thomas and St. John (Brownell, 1971; Brownell and Rainey, 1971; Tobias et al., 2000; CFMC, 2003; Gordon and Uwate, 2003; Kojis, 2004). Typically, fishers use small, open vessels (6 to 8 m in length) powered by outboard motors to fish with a variety of gear types and methods, although traps or fish pots are the most popular gear type (Sylvester and Dammann, 1972; Appeldoorn et al., 1992; Beets, 1997; Kojis, 2004). Scuba diving is also a common commercial method used to harvest reef fishes (by spear) and invertebrates (by hand or with snare; CFMC, 2003). In the past decade, gillnets and trammel nets used with the aid of scuba equipment have become common fishing gear on St. Croix, and annual landing from nets now exceed annual landings from traps on this island (Tobias and Toller, 2004). USVI commercial fishers must submit monthly catch records as a stipulation for permit renewal.

Recreational fishing is also very important to the USVI economy. Boat-based recreational fishing may have contributed as much as $5.9 million in fishing-related expenditures to the local economy in 2000 (UVI EEC, 2002), up from about $90,000 in 1986 (Jennings, 1992). Snappers were the most preferred species-group of fishers. Collectively, however, much of the reported fishing effort was directed towards pelagic fish species such as blue marlin, sailfish, dolphinfish, tuna, wahoo, and kingfish (UVI EEC, 2002). The recreational fishery for pelagics has been routinely monitored for over a decade but is not the subject of this review (see Adams, 1995; Mateo, 2000). Less data exist on the impact of recreational fishing to reef-associated species primarily because recreational fishers do not obtain fishing permits, and no records are kept on their population size or activity (Appeldoorn et al., 1992).

Reef Fish Fishery

Reef fish assemblages and the composition of reef fish landings have changed markedly in the USVI over the past 40 years (Appeldoorn et al., 1992; Rogers and Beets, 2001). Catanzaro et al. (2002) reviewed the lamentable collapse of the USVI fishery for Nassau groupers during the 1970s (Olsen and LaPlace, 1978) and red hind during the 1980s (Beets and Friedlander, 1992). Landings of larger individuals of snappers (Lutjanidae) and other groupers (e.g., the coney, *Epinephelus fulvus*) also declined in the 1980s (Appeldoorn et al., 1992). Although fishery-dependent monitoring data for the 1990s are still unavailable, a growing number of fishery-independent studies, primarily utilizing visual survey methods, indicate that populations of targeted grouper and snapper species have not recovered to date (Rogers and Beets, 2001; Beets and Friedlander, 2003; CCMA-BT, unpublished data; Nemeth et al., 2004). On average, fewer than eight groupers per year were observed during monitoring of reef fish assemblages at four reference sites within the VINP between 1989 and 2000 (Figure 4.8). Nassau grouper were observed in only 3% of 1,764 visual surveys conducted at the four reference sites during the entire study period (Beets and Friedlander, 2003). Of the 2,292 snappers and groupers observed during 756 visual fish surveys within the VINP and the BIRNM, less than 2% were greater than 35 cm in length (CCMA-BT, unpublished data). On nearshore reefs throughout the USVI, Nemeth et al. (2003c) also found a similar trend where snappers and groupers larger than 40 cm were mostly absent from the fish assemblage. Densities of snappers and groupers averaged five and three fish/100 m^2, respectively, with the most common size class of both families being 11-20 cm (Nemeth et al., 2003c). In contrast, the herbivorous fishes (e.g., Acanthuridae and Scaridae) dominated the fish assemblage with average densities between 10-20 fish/100 m^2.

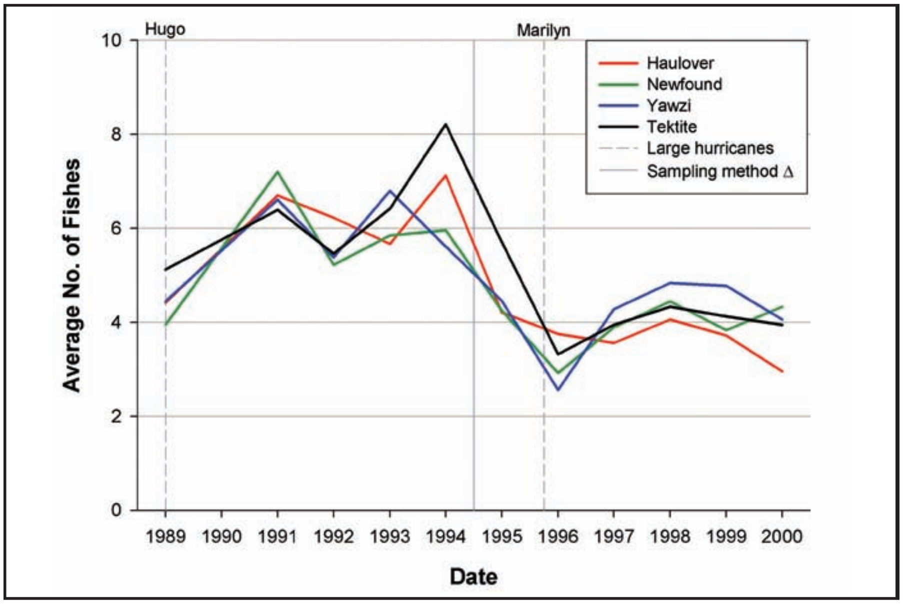

Figure 4.8. Abundance trends in groupers (Serranidae) among the four reference sites around St. John, U.S. Virgin Islands, from 1989-2000. Source: Beets and Friedlander, 2003.

Lobster Fishery

The Caribbean spiny lobster, *Panulirus argus*, is a species of tremendous commercial and recreational importance in the USVI. Spiny lobsters accounted for 6% of total reported landings in 1998-1999 (Tobias, 2000) and its commercial value probably exceeds that of any other single reef-associated species in the USVI. Although Bohnsack et al. (1991) concluded that USVI lobster populations appeared healthy, more recent studies found a 10% decrease in mean size between 1997 and 2000, which suggests that overfishing is occurring (Tobias, 2000; Mateo and Tobias, 2002). The Virgin Islands Division of Fish and Wildlife (DFW) routinely monitors commercial lobster landings (weight and carapace length) and has periodically monitored lobster recruitment around St. Thomas, where recruitment appears to be highly variable but generally low (Gordon and Vasques, in press). Limited field surveys around St. John also indicate that average lobster size and density have decreased since 1970 (Wolf, 1998).

Conch Fishery

The queen conch, *Strombus gigas*, forms an important fishery in the USVI. During the 1990s, conch accounted for about 2% of total USVI landings, with most conch landed on St. Croix (5% of total St. Croix landings) and less landed on St. Thomas and St. John (0.4% of total landings on St. Thomas and St. John; Valle-Esquivel, 2002). The value of reported USVI commercial conch landings in 1998-99 was about $340,000 (Tobias et al., 2000). In the USVI, commercial fishers harvest queen conch by hand, primarily by scuba diving, although some conch are also harvested by free diving (Rosario, 1995). Very little information exists presently on the recreational harvest of conch, but concerns about declining stocks have been voiced for over 20 years (Wood and Olsen, 1984; Valle-Esquivel, 2002). Although numerous territorial regulations were enacted in 1988 to protect conch stocks including a five-year closure of the fishery on St. Thomas and St. John, conch stocks have either not shown significant recovery or have continued to decline in the USVI (Friedlander, 1997; Gordon, 2002).

It is difficult to separate out the causal factors of fishery decline in the USVI. Overfishing, technological advances in fishery gear (larger boats, more powerful engines, and improved gear), and the deterioration of habitats may have contributed to significant changes in the community structure of reef fish assemblages and the observed decline in fishery yields. Several studies have documented the failure of existing regulations and a lack of enforcement in protecting reef fishes or reversing the declines in the abundance of preferred species such as the large groupers and snappers (Beets,1996; Wolff, 1996; Garrison et al., 1998; Rogers and Beets, 2001). Likewise, other studies have identified sedimentation and pollution as major factors in the decline of nearshore reef ecosystems, which may have contributed to the decline of fisheries species (deGraaf and Moore, 1987; Rogers and Beets, 2001).

On a more positive note, some USVI fisheries are beginning to show small signs of recovery. Since the closure of an important red hind spawning aggregation site south of St. Thomas in 1990, the average size of red hind from the St. Thomas fishery increased significantly from 26 cm to over 34 cm total length in 2003 (Nemeth, in review). Moreover, tag and release studies conducted by the UVI on a red hind spawning aggregation near a shelf-edge reef south of St. Thomas found that 78% of the fish were over 35 cm, 50% over 37.5 cm, and fish greater than 40 cm (Nemeth, unpublished data). In March 2004, scientists at UVI discovered the first evidence of a Nassau grouper spawning aggregation reestablishing itself south of St. Thomas. Underwater surveys estimated that up to 100 Nassau groupers have aggregated and showed signs of reproductive activity (Nemeth, in review). Unfortunately local fishers have targeted this unprotected reef for the past several years and fishing mortality may seriously threaten this Nassau spawning aggregation. In this same area, yellowfin grouper, tiger grouper, and cubera snapper have all been seen forming large spawning aggregations (Nemeth, in review).

Trade in Coral and Live Reef Species

The trade in coral and live species is a minor problem in the USVI and has not received as much attention as it has in other U.S. jurisdictions with coral reef ecosystems. The trade in live coral and fishes is prohibited by the USVI Endangered and Indigenous Species Act of 1990 (Title 12, Chapter 2), the purpose of which is "to protect, conserve, and manage indigenous fish, wildlife and plants, and endangered or threatened species for the ultimate benefit of all Virgin Islanders, now and in the future." Very few permits have been issued for the harvest or take of live coral and non-commercial or recreational fishes. Issued permits have been for research and education purposes only. Thus, there are very few exports of live coral (W. Coles, pers. obs.). Locally, U.S. Customs and Department of Agriculture officials have confiscated small amounts of live coral that had been recently collected by tourists departing from the territory. A much greater problem is the export of dead coral (some of which may have been collected alive) and other marine organisms. Considerable amounts of dead and dried coral, undersized conch, and shells have been confiscated at airports on the islands of St. Thomas and St. Croix and at the U.S. Postal Service inspection facility in Puerto Rico.

Ships, Boats, and Groundings

Data on the impacts of resource use within the territory are limited, and research on this topic is needed. A recent assessment of marine resource utilization identified boating as a major recreational activity in the USVI, and damage from small boats anchored in corals and seagrasses as a primary concern (Link, 1997). A total of 2,462 private and commercial boats were registered throughout the territory in 2000 (Uwate et al., 2001). To reduce anchor damage to reefs, the VINP has installed over 300 mooring and protection buoys around St. John and at the BIRNM. Another local program initiative called "Anchors Away" has recently installed 50 mooring buoys around the island of St. Croix. Additionally, funding from the NOAA Coral Reef Conservation Program has been approved for additional moorings within the East End Marine Park in St. Croix. Boat groundings are also of concern. In 1988, a cruise ship destroyed 283 m^2 of reef within the VINP, and coral recovery after 10 years has been minimal (Rogers and Garrison, 2001).

Marine Debris

Marine debris has become a problem in the USVI. Debris that washes out to sea via runoff (sewers, street litter) pollutes the water and shorelines and can be life-threatening to marine organisms and humans. 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. A major landfill that exists along the coast near Sandy Point, St. Croix receives most of the solid waste from the island. Debris from this landfill – consisting primarily of fishing lines, bottles, plastic bags and other street litter – is often washed out to sea where it becomes a health hazard to marine life. The same may be true for landfills on St. Thomas and St. John. The SEA has organized several beach cleanup campaigns to increase public awareness about marine debris and reduce the amount of debris that litters the nearshore environment, but this threat is an ongoing concern.

Aquatic Invasive Species

Aquatic invasive species are not recognized as a major threat in this jurisdiction.

Security Training Activities

No security training activities currently occur in this jurisdiction.

Offshore Oil and Gas Exploration

No offshore oil and gas exploration currently occurs in the USVI.

CORAL REEF ECOSYSTEMS—DATA-GATHERING ACTIVITIES AND RESOURCE CONDITION

This section focuses on resource monitoring activities, data collection and analyses, and summaries of published studies and data sets to provide an assessment of the current condition of resources in coral reef ecosystems of the USVI. Information is presented to describe three functional or structural components of coral reef ecosystems: marine water quality, benthic habitats, and coral reef-associated fauna (Table 4.2). A brief summary of ongoing research and monitoring programs, methods, results and discussion, and an assessment of overall condition are presented for each ecosystem component. Locations of monitoring and research efforts are shown in Figure 4.9.

Table 4.2. Data sets selected for the description of the current condition and status of coral reef ecosystems in the USVI.

ECOSYSTEM COMPONENT	DATA SET	SOURCE AGENCY/ORGANIZATION
Water quality	2000 Water Quality Assessment for the United States Virgin Islands. 305b Report to the Environmental Protection Agency.	Department of Planning and Natural Resources, Division of Environmental Protection (USVI DPNR-DEP)
	Water Quality Assessment for the Virgin Islands National Park, St. John, 1988 to 1998.	NPS and U.S. Geological Survey, Biological Resource Division (USGS-BRD)
	Coral Bay Sediment Deposition and Reef Assessment Study. Report to the USVI Department of Planning and Natural Resources, Division of Environmental Protection (USVI DPNR-DEP), Non-Point Source Pollution Grant Program MOA# NPS-01801 by the Center for Marine and Environmental Studies (Devine et al., 2003).	University of the Virgin Islands and USVI DPNR-DEP
Benthic habitats	Coral Monitoring Program for the Virgin Islands National Park (Miller et al., 2003).	NPS and USGS-BRD
	Elkhorn Coral Monitoring Project (C. Rogers, unpublished data).	NPS and USGS-BRD
	Video monitoring assessment of coral reefs in St. Croix, USVI. Year I and Year II reports to the USVI DPNR (Nemeth et al., 2002, 2003a).	UVI-CMES
	Atlantic and Gulf Rapid Reef Assessment Program. A rapid assessment of coral reefs in the Virgin Islands, Part 1: stony corals and algae (Nemeth et al., 2003b).	UVI-CMES
	Characterization of benthic habitats in the Virgin Islands National Park and the Buck Island Reef National Monument (NOAA, unpublished data).	NOAA CCMA-BT
Associated biological communities	Characterization of reef fish in the Virgin Islands National Park and the Buck Island Reef National Monument (Kendall et al., 2003, Monaco et al., in prep.).	NOAA CCMA-BT
	Quantitative estimates of species composition and abundance of fishes, and fish species/habitat associations in St. Croix, USVI. Year II report (Nemeth et al., 2003a).	USVI DPNR-DFWS
	Temporal Analysis of Monitoring Data on Reef Fish Assemblages inside Virgin Islands National Park and around St. John, US Virgin Islands, 1988-2000. Report to USGS/BRD (Beets and Friedlander, 2003).	NPS
	Atlantic and Gulf Rapid Reef Assessment Program. A rapid assessment of coral reefs in the Virgin Islands, Part 2: fishes (Nemeth et al., 2003b).	UVI-CMES

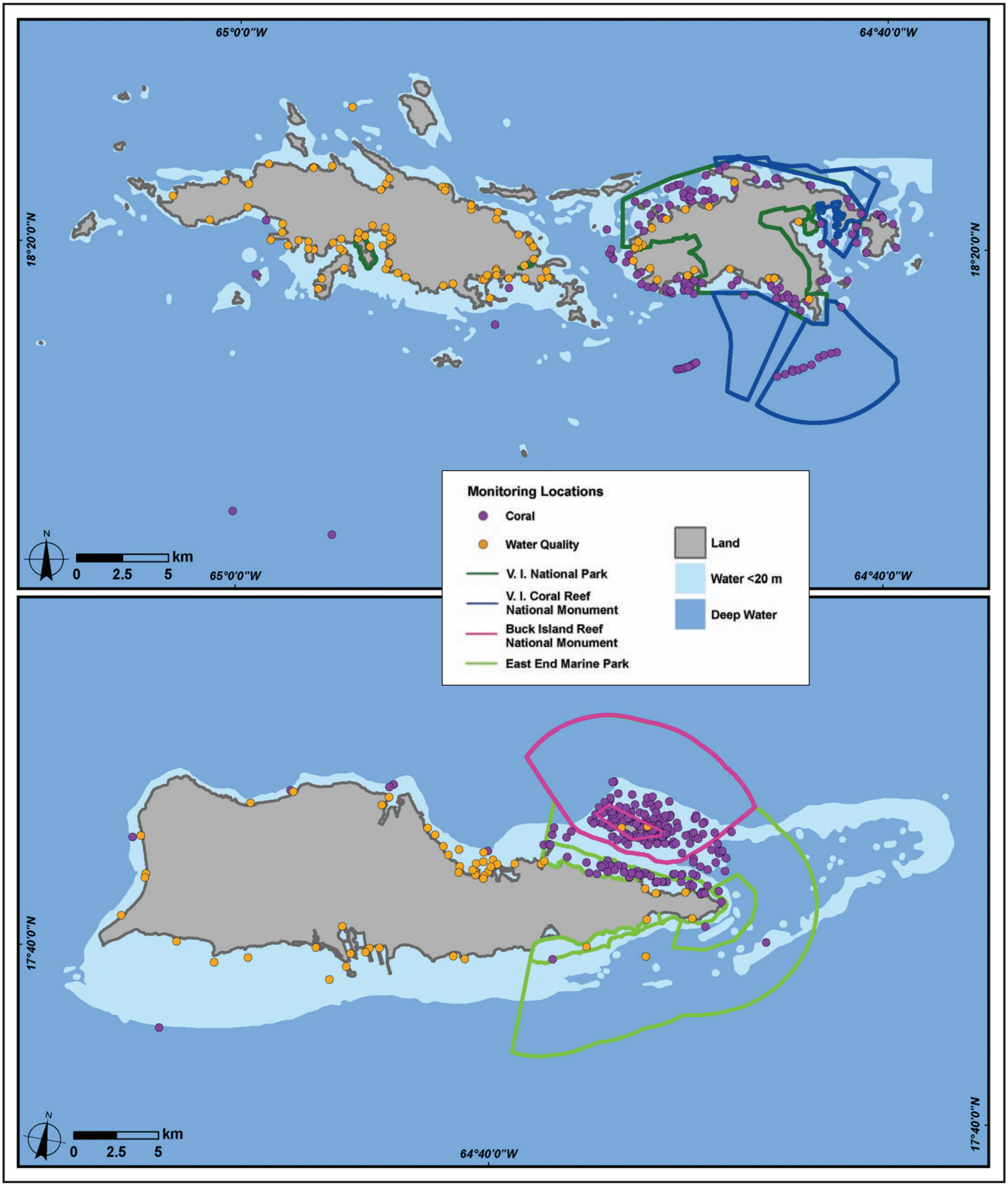

Figure 4.9. Locations of monitoring and research efforts in the USVI between 1988-2004. The boundary of the Buck Island Reef National Monument was expanded in 2001 from 880 acres to 19,015 acres. Both the original and expanded boundaries are shown. Water quality monitoring is conducted by the USVI DPNR. Coral monitoring is conducted by NOS, NPS, USGS, USVI DPNR, and UVI-CMES. Map: A. Shapiro.

WATER QUALITY

USVI DPNR/DEP Water Quality Monitoring

Methods

Water sampling in the USVI was initiated by the local health department in 1968. A network of fixed monitoring stations was selected within the bays and nearshore waters of the islands to target areas of particular concern, such as outfalls, harbors, marinas, and main recreational areas. The Division of Environmental Protection (DEP) within the USVI DPNR samples 135 sites quarterly each year (53 around St. Croix, 64 around St. Thomas, and 18 around St. John). At each monitoring site, water samples are collected at the surface to measure and record the chemical and physical parameters listed in Table 4.3. All data are uploaded into STORET, a national online database maintained by the U.S. Environmental Protection Agency (EPA, http://www.epa.gov/storet/dw_home.html, Accessed: 12/28/2004). Quarterly assessments are also complemented by periodic assessments of water quality during episodic events (e.g., a sewage bypass), when USVI DPNR-DEP collects daily samples until acceptable levels of water quality are reestablished.

Table 4.3. Water quality parameters measured by the USVI DPNR-DEP, NPS, and the U.S. Geological Survey.

PARAMETER	UNITS	COLLECTION METHOD
Temperature	˚C	*In situ* - YSI multi parameter meter: surface and near bottom
Dissolved oxygen	ml/L	*In situ* - YSI multi parameter meter: surface and near bottom
Salinity	Parts per thousand (ppt)	*In situ* - YSI multi parameter meter: surface and near bottom
pH	Scale of 1-14	*In situ* - YSI multi parameter meter: surface and near bottom
Turbidity	NTU	*In situ* - YSI multi parameter meter: surface and near bottom
Secchi disk depth	Meters (m)	*In situ* - Average depth of Secchi disk (disappearance/appearance)
Total suspended solids	mg/L	Grab near surface and send to a certified lab
Fecal Coliform / Enterococci	number of colonies/100 ml	Grab near surface and send to a certified lab
Nutrients	mg/L	Grab near surface and send to a certified lab

Results and Discussion

Data from the USVI DPNR-DEP water quality monitoring program indicate that water quality in the USVI is generally good but declining because of an increase in point and nonpoint source pollution (S. Caseau, pers. obs.). Almost all direct discharges in the USVI were traced to a failing and overloaded municipal sewage system. Moreover, sewage treatment plants malfunction as the result of human error, old equipment, or unusual conditions in the raw sewage.

Flooding is a major concern in the Virgin Islands. Watersheds have small areas, steep slopes, and increasing amounts of impervious surfaces, which in turn can result in high-volume runoff after short periods of intense rainfall. The territorial system consists of combined sewers, which are pipes designed to carry both raw sewage and stormwater. When the volume of rain becomes too great, the sewer system becomes overloaded, and untreated sewage discharge flows into nearby marine waters (Figure 4.10A). In non-urban and suburban areas, rainwater often flows directly over farms, golf courses, and lawns, washing pathogenic animal waste, fertilizers, and pesticides into the water. Failure to use effective silt-control devices during construction activities and improper discharge of waste by boat owners can result in pathogens that pollute beaches in less densely populated areas (Figures 4.10B, C).

The Virgin Islands rum manufacturing process generates wastewater that is discharged on the south coast of St. Croix. The effluent typically forms a plume visible from the discharge point to about 10 km westward along the shoreline. As a result, a strong turbidity and color gradient decreases light penetration, which could impede normal growth of submerged aquatic vegetation and corals. This effluent may be a reason for the absence of significant coral reefs within direct influence of the discharge.

Figure 4.10. Pollution of marine waters in the USVI. Left panel: Flooding of a sewer system in St. Croix after an intense rainfall. Center panel: Poor land management practices associated with accelerating coastal development in St. John. Right panel: Improper discharge of gasoline in marine waters from boating activities in St. Thomas. Source: V. Mayor, USVI DPNR-DEP.

NPS and USGS Water Quality Monitoring

Methods

The NPS and USGS conduct assessments of water quality within the VINP in St. John. Monitoring of water quality within and outside the park began in 1988. Thirty-one sites were originally identified for monitoring but were reduced to 15 in 1996. Samples are taken every three months at each site for the parameters listed in Table 4.3. Data through 2000 are available on-line at the EPA STORET website. Data from 2000 through the present are being processed and analyzed for uploading to STORET (http://www.epa.gov/storet/dw_home.html, Accessed: 12/28/2004). In June 2000, monthly sampling for *Enterococcus* spp. and fecal coliform began at three park swimming beaches.

Results and Discussion

Data collected by the NPS and USGS from 1988-1998 indicate that marine water quality in the VINP is excellent except at Cruz Bay. Horizontal visibility ranged from 10-20 m. Mean water temperature at 1m depth was 27.9°C with a range of 20.2-31.9°C. At a depth of 10 m, temperature varied from 24.5°C to 30.8°C. Average salinity was 35 parts per thousand and average conductivity was 54 siemens. Marine systems in the region experience little variation in these parameters. The extinction coefficient of photosynthetically active radiation (PAR) was approximately 0.18, which is extremely good. Dissolved oxygen over dense seagrass beds was 7-8 mg/L. Dissolved oxygen over barren, muddy substrates (e.g., Cruz Bay) averaged 6.0 mg/L and ranged between 5.0-7.1 mg/L.

Turbidity, a measure of particles in the water column, has been increasing. Additionally, turbidity was consistently higher outside the park than in waters inside the park, which may have resulted from sediment erosion caused by development of land outside the VINP. Total suspended solids (TSS) ranged from 1-15 mg/L adjacent to heavily disturbed watersheds after large rainfall events. Likewise, nutrient analyses resulted in detectable levels of micronutrients around mangroves, probably resulting from the natural production of organic nutrients and in bays adjacent to the most developed watersheds such as Coral Bay, Cruz Bay, and Great Cruz Bay. Clean, clear water is critical to maintaining healthy coral communities and seagrass beds.

UVI-CMES and USVI DPNR-DEP Coral Bay Study

Methods

The UVI Center for Marine and Environmental Studies (UVI-CMES) conducted a descriptive assessment of sediment deposition and marine water quality in Coral Bay, St. John. Nonpoint source pollution resulting from runoff contamination, sediment deposition, solid waste, and dumping of unregulated human waste is a common problem in the Virgin Islands, especially in Coral Bay.

Sediment coring and data on TSS were used to provide a rapid assessment of the state of Coral Bay. Sampling site locations were chosen based on: 1) proximity to expected inputs of terrigenous sediment and 2) achieving adequate spatial coverage throughout the bay. Sites were concentrated within Coral Harbor, the area most expected to be impacted by the recent increase in development. Sites outside of the harbor were chosen as control sites or sites at which to detect point sources of input from recent development. The assessment of water quality conditions in Coral Bay, Coral Harbor, and at other sites around St. John was based on a review of TSS data from the NPS water quality monitoring program at the VINP. Detailed descriptions of the sampling protocol are provided in Devine et al., 2003.

Results and Discussion

Devine et al. (2003) found poor water quality in Coral Bay. Vibracores and surface sediment samples indicated a seven-fold increase in the sedimentation rate and terrigenous input into Coral Bay as a direct result of development within the watershed during the last 100 years, and more probably over the past 40 years. Analyses of sediment samples also suggest that within the last 10-15 years, sedimentation rates in Coral Bay were 1) 10-20 times greater than the rate of natural sediment deposition averaged over the last 5,000 years and 2) the plantation era had a very small impact on sediment deposition. TSS was four times higher in Coral Harbor than the average for all other sampled locations in St. John. Mapping of sediment deposition and data on water chemistry indicate a growing problem within the harbor and the adjacent Coral Reef National Monument.

Coral Bay, an Area of Particular Concern (APC), is one of the largest watershed drainage areas within the territory at 1,215 ha (Hubbard et al., 1987; Devine et al., 2003). The area also has the highest recorded rate of population growth (79%) in the USVI between 1990 and 2000 (U.S. Census Bureau, 2001). The Coral Bay Watershed has steep slopes that average 18º (several greater than 35º), highly erodable soils, and very diverse land use along the shoreline (Devine et al., 2003).

Coral Bay has a protected inner harbor with critically valuable fringing mangroves and salt ponds. The area is also home to a cruising and live-aboard population of between 75-150 boats at any particular time. Many boats (i.e., 15-20) are permanently anchored to the small mangrove fringe. No pump-out facilities exist to handle vessel septic waste, no inspections are made of these vessels' holding tanks, and no regulations are enforced to protect marine resources. Along the inner harbor, commercial businesses and an undeveloped marina operate without containment for liquid spills or solid waste, paint, and dust. Residential roads, new homes, and failing septic systems contribute unmeasured amounts of pollutants to the harbor.

The tremendous growth and diverse uses of the landscape and marine resources in this watershed have visibly deteriorated marine water quality. Sedimentation and runoff are increasing in intensity and frequency, with routine sediment plumes inundating the area during the rainy season. Chronic pollution from point and nonpoint sources including the dumping of human and animal wastes, failing septic systems, and dumping of boat tank materials has resulted in high nutrient levels in Coral Bay.

BENTHIC HABITATS

NPS and USGS Coral Disease and Benthic Cover Abundance Monitoring

Methods

Long-term monitoring of coral diseases and abundance (percent cover) is conducted by the Inventory and Monitoring Program around St. John and Buck Island in St. Croix. Diseases of corals are specifically monitored using two different methods at two sites in VINP. The incidence and progression of the coral disease white plague type II in 28 tagged coral colonies is being monitoring approximately quarterly using still photography. Coral diseases are also monitored monthly with 1 m^2 quadrats along eight 10-m transects. Details of these monitoring projects, which began in 1997 and are still on-going, are given in Miller et al. (2003).

Benthic cover monitoring is conducted annually through the use of digital videography at four representative sites around St. John US Virgin Islands (three within VINP, one outside of the park); and at two sites within BIRNM in St. Croix. Monitoring of benthic cover began at two sites in 1999; four additional sites have been added since 2000 (J. Miller, pers. obs.). The benthic sampling protocol involves the selection of random (transect origin) sites, which is accomplished by using a SONAR-based mapping system (AquaMap®). Twenty 10-m transects are filmed using a digital video camera, and then the images are downloaded to a computer. Random dots are placed upon images captured from transects. The substrate underneath each dot is identified to the lowest taxonomic unit possible (e.g., coral to species, algae to genus) and entered into a database. Queries of the database produce values on the percent cover, diversity indices of species, and cover groups. Qualitative data on coral disease are also collected. A detailed description of the protocol is available online (http://science.nature.nps.gov/im/monitor/protocoldb.cfm, Accessed: 12/28/2004).

Results and Discussion

Live coral cover along disease monitoring transects decreased from 65.3% (± 7.41 standard deviation [SD]) to 43.4% (± 5.08 SD) between December 1997 and May 2001. The frequency of disease within transects ranged from 3% to 58%, and the area of disease patches ranged from 0.25 to 9,000 cm^2 within that same period. New incidences of disease were observed every month with associated loss of living coral. Increases in disease occurrence did not correlate with elevated water temperatures. The photos and observations revealed no recovery of diseased corals with all necrotic tissue being overgrown rapidly by turf algae, usually within less than one month. Most coral colonies suffered partial mortality and some colonies greater than 1.5 m in diameter were completely consumed in less than six months. Some limited recruitment (e.g., *Porites* spp., *Agaricia* spp., *Favia* spp., and sponges) has been noted on the diseased areas.

In general, reefs monitored by the NPS and USGS were dominated by dead coral with turf algae (Figure 4.11). Other benthic organisms such as gorgonians and sponges were not abundant and showed no significant temporal patterns in percent cover. In contrast, the estimates of the percent cover of macroalgae, turf algae, and abiotic substrates (sand, rubble, and pavement) varied substantially among sites and among sample periods. A total of 19 coral species were recorded throughout the study period; the number of species varied among sites and years. At Newfound Reef in St. John, the *Montastraea annularis* complex was the most abundant and most frequently observed coral, accounting for approximately 70% of live coral cover and was present in all 20 transects. The percent cover of live coral and algae was variable among sites, with Mennebeck Reef in St. John having the highest estimates of live coral cover (Figure 4.11). Mennebeck Reef and Western Spur and Groove Reef, St. Croix had more live coral than macroalgae, but live coral was twice as abundant on Mennebeck as on Western Spur and Groove (Figure 4.11). At Yawzi Reef, the opposite pattern occurred, with macroalgae being more abundant than live coral for all years (Figure 4.11). At South Fore Reef, St. Croix and Newfound Reef, mean estimates of live coral cover were similar to those for macroalgae (Figure 4.11).

Significant changes in live coral cover occurred only at Newfound Reef in St. John, where the mean percent live cover decreased by approximately 24% between 1999 and 2001 ($p<0.01$, Figure 4.11). *Porites porites* was the only coral species to increase in both mean live coral cover and frequency at Yawzi Reef. At both Yawzi and Mennebeck Reefs, *Porites* coral was consistently observed in more than 50% of belt-transects. Haulover Reef in St. John had a high abundance of live coral (22.1%) based on one year's worth of data (Figure 4.11). Fifteen species were recorded at Haulover. The *Montastraea annularis* complex comprised 84% of the live coral cover and occurred in all transects at Haulover Reef.

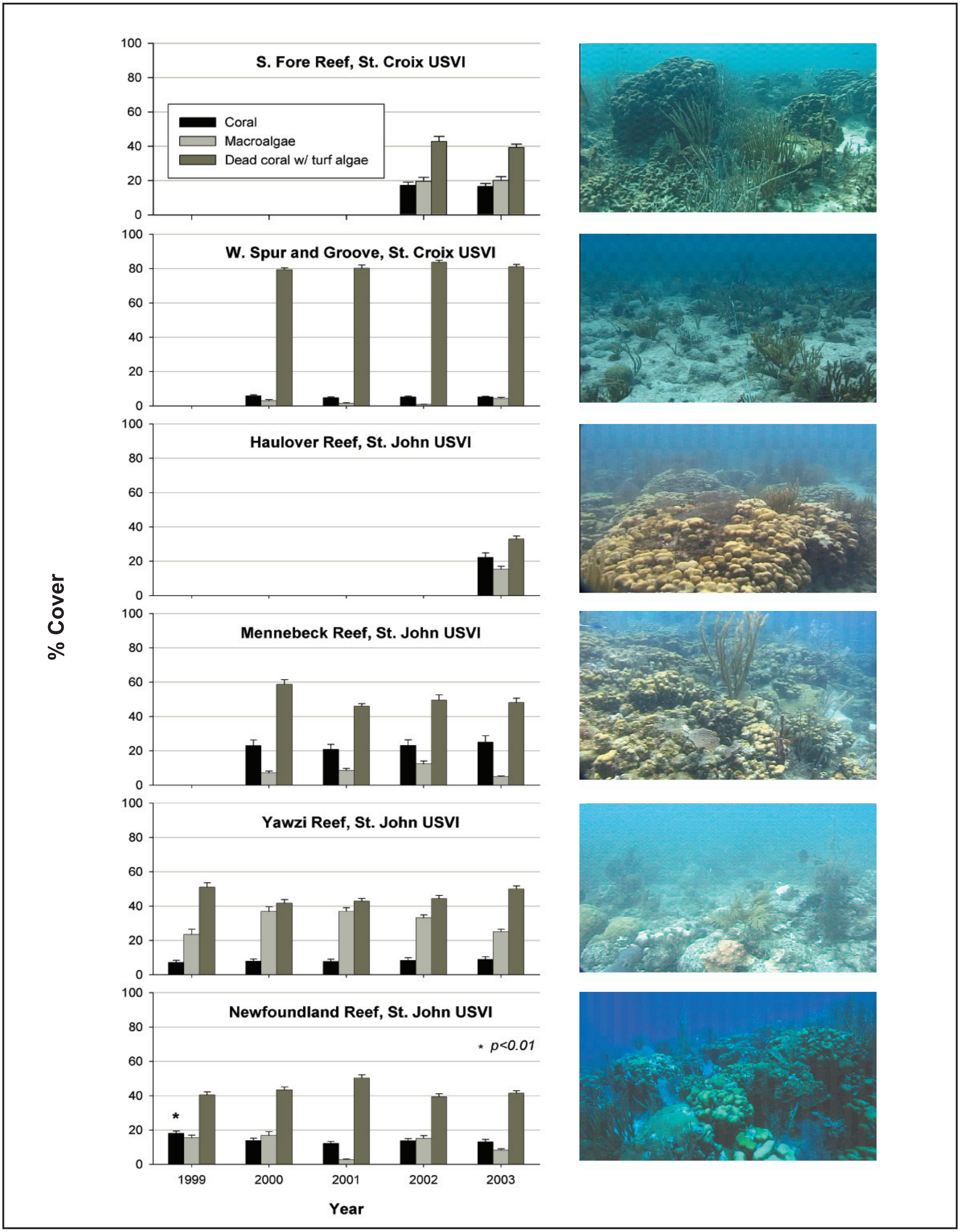

Figure 4.11. Mean percent cover (± SE) of coral, macroalgae, and dead coral with turf algae at six sites in the USVI. Data were collected according to video monitoring protocols developed by the USGS and NPS (http://science.nature.nps.gov/im/monitor/protocoldb.cfm). Specific sites or years without data were not sampled or the data are not yet analyzed. Source: J. Miller, unpublished data.

NPS, USGS, and UVI-CMES Elkhorn Coral *(Acropora palmata)* Monitoring

Methods

Researchers from the USGS, NPS, and UVI-CMES began an 18-month study of 66 tagged elkhorn coral colonies at Haulover Bay, St. John in January 2003. The geographic coordinates of the perimeter of each monitoring site and the locations of sampled elkhorn colonies are mapped onto geo-referenced aerial photographs. Data are recorded on the depth, three-dimensional size of colonies, type of substrate, percent cover of live and dead coral, presence/absence of specific diseases and lesions, and counts of damselfish territories and predators (snails – *Coralliophila abbreviata* and *C. caribaea*; and fireworms – *Hermodice* spp.).

Results and Discussion

Observations of 66 tagged corals over an 18-month period showed that 17% died, 74% had disease, and 30% suffered physical breakage, most likely from careless snorkelers (Table 4.4). Although 92% showed new growth throughout the study period, 15% of the new growth later lost 90-100% of their tissue. White pox disease was the most significant cause of coral mortality, however white pox lesions can heal. Forty-eight percent of the white pox lesions healed completely, mostly within three months. The onset of a severe disease outbreak coincided with increasing sea surface temperatures. Both the number of corals with white pox and the total number of disease lesions started to rise in September and continued increasing into November, tracking the trend in SST.

Table 4.4. The results of a study on the health and condition of *Acropora palmata* colonies (N=67). Data were collected through videography and *in situ* observation by the USGS Caribbean field station since February 2003 at Haulover Bay, St. John, USVI. Source: Rogers and Muller, unpublished data.

	NUMBER OF CORALS AFFECTED (N=67)		
	6 Months	18 Months	22 Months
New Growth	40	61	61
New White Pox	15	49	57
Healed White Pox	5	28	32
Snails Present	15	29	30
Physical Breakage	6	20	23
Complete Mortality	3	11	11
Unidentified Lesions	2	2	2
White Band	1	3	3
Bleached	0	1	1
Damselfish Territory	1	1	1

UVI-CMES Video Assessment of Benthic Substrates

Methods

UVI-CMES researchers used digital videography along belt-transects to characterize and monitor benthic cover at permanent and rapid assessment sites in St. Croix and St. Thomas. The maximum width and height and the percent of diseased coral cover were estimated from the videos for all coral colonies greater than 10 cm in diameter that were located directly under the transect lines. Data on diseases and bleaching were not collected at rapid assessment sites. In St. Croix, divers filmed three to six permanent 10-m transects at 10 long-term and two rapid assessment sites between April 2001 and March 2003. In St. Thomas, digital video transects were conducted at six coral reef sites between August 2002 and September 2003. The St. Thomas reefs were placed into three categories based upon their location along the insular platform: nearshore reefs (5-30 m deep, <2 km from the shoreline); mid-shelf reefs (5-30 m deep, 2-10 km offshore; and shelf-edge reefs (>30 m deep, 10-50 km offshore). Detailed video sampling methods are discussed in Nemeth et al. (2002). Results are reported separately here for St. Croix and St. Thomas.

Results and Discussion

St. Croix

The percent cover of living coral was variable among sites and ranged from 4.4% to 39.1%. Coral was the most abundant component at only one site. Turf algae covering dead coral comprised 50% or more of the substrata and was dominant at most sites (Figure 4.12A, B). Dead coral included both long dead and recently killed coral covered with a layer of turf algae. The percent cover of macroalgae ranged from 3.2% to 34.9% (Figure 4.12C). Percent cover of living coral was similar among years but a significant increase in turf algae and a corresponding decrease in macroalgae were observed at Buck Island between years (Figure 4.12 B, C). These trends were reversed at Sprat Hole, where an increase in macroalgae corresponded with a decrease in turf algae (Figure 4.12B, C). Significant increases in macroalgae also occurred at Long Reef (Figure 4.12C). It is unlikely that the significant changes observed in the abundance of macroalgae between years at Buck Island and Sprat Hole were caused by urchins (*D. antillarum*) because macroalgae were very rare at those sites. Sponges and gorgonians each comprised less than 10% of the benthic cover at all sites (Figure 4.13D, E). Sand was the only non-living substrate type found at the sites, ranging from 0.0% to 9.5% (Figure 4.13F). No significant changes occurred for sponges, gorgonians, or sand cover between years at any site.

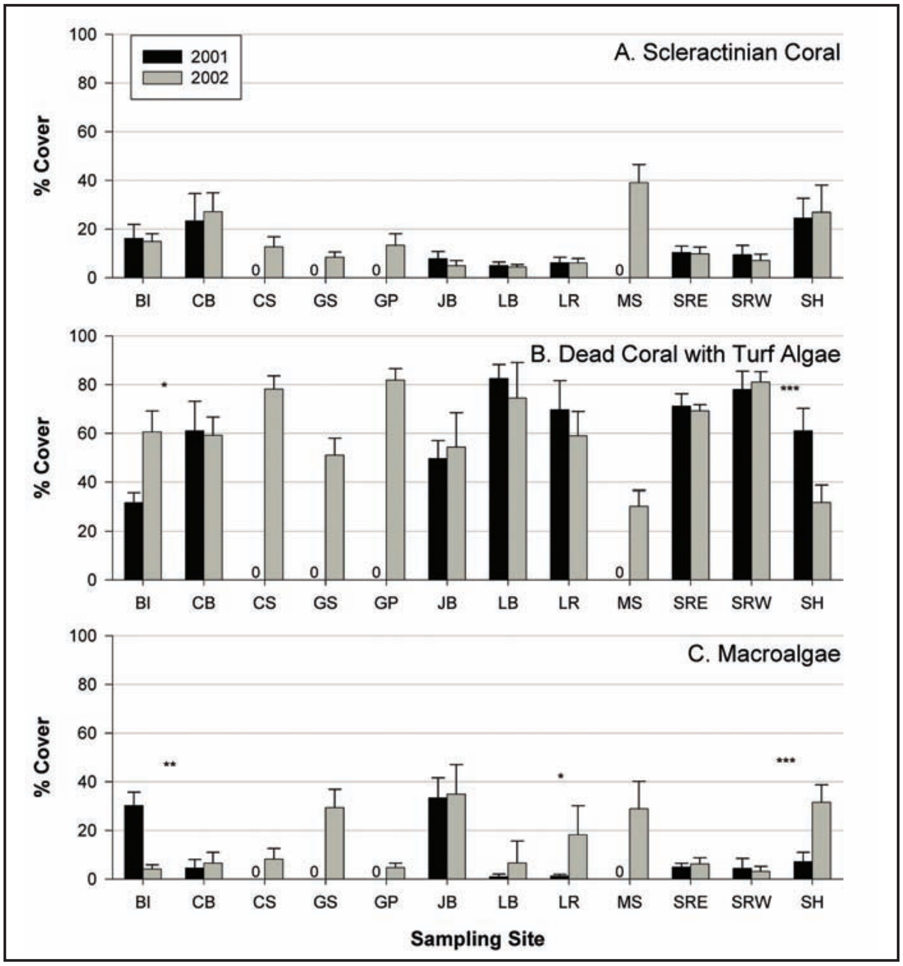

Figure 4.12. Annual mean percent of (A) scleractinian corals, (B) dead coral with turf algae, and (C) macroalgae for 12 sampling sites in St. Croix. Site codes are: BI=Buck Island, CB=Cane Bay, CS=Castle, GS=Gerson, GP=Great Pond, JB=Jacks Bay, LB=Lang Bank, LR=Long Reef/Eagle Ray, MS=Mutton Snapper, SRE=Salt River East Wall, SRW=Salt River West Wall, SH=Sprat Hole. Error bars represent standard deviation. Asterisks denote significant differences: *=p<0.05; **=p<0.01; ***=p<0.0001. Source: Nemeth et al., 2002, 2003a.

The composition of the coral community was similar among sites, with 10 species representing 95% of the coral community (Figure 4.14). *Montastraea* spp. were the most dominant corals except at Castle where *Porites porites* was most abundant, at Great Pond where *Porites astreoides* was most abundant, and at Gerson and Lang Bank where *Diploria strigosa* was most abundant. Coral diversity ranged from a Shannon-Weaver diversity index (H') of 1.50 at Great Pond to 2.40 at Salt River West Wall (Figure 4.15).

Coral condition varied greatly among sites. The incidence of coral disease and bleaching ranged from 0-17% at several sites and 0-22% at Lang Bank. Diseases and bleaching were observed among eight dominant coral species, with *Siderastrea siderea* having the highest incidence of disease (50% of colonies) and bleaching (80% of sampled colonies). Divers observed white plague, dark spots disease, yellow blotch/band disease, and white spots that were classified as disease, but were unidentifiable to a specific disease.

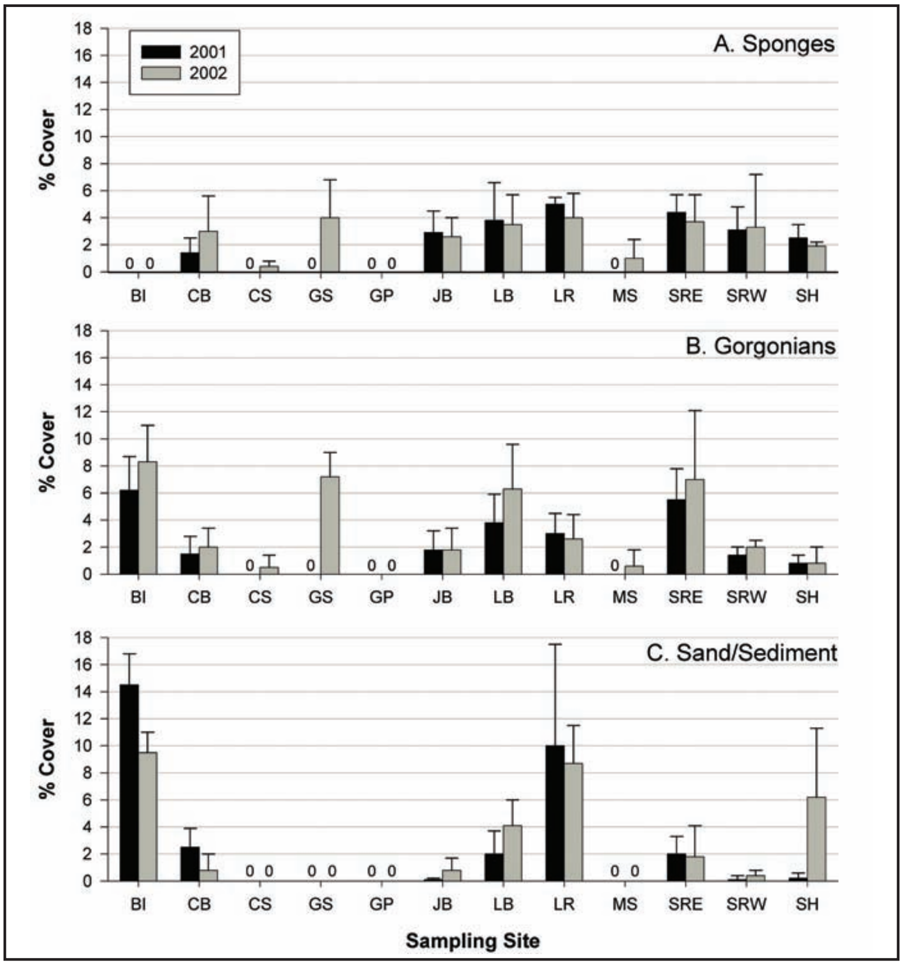

Figure 4.13. Annual mean percent of (A) sponges, (B) gorgonians, and (C) sand/sediment for 12 sampling sites in St. Croix. Site codes are: BI=Buck Island, CB=Cane Bay, CS=Castle, GS=Gerson, GP=Great Pond, JB=Jacks Bay, LB=Lang Bank, LR=Long Reef/Eagle Ray, MS=Mutton Snapper, SRE=Salt River East Wall, SRW=Salt River West Wall, SH=Sprat Hole. Error bars represent standard deviation. Asterisks denote significant differences: *=p<0.05; **=p<0.01; ***=p<0.0001. Source: Nemeth et al., 2002, 2003a.

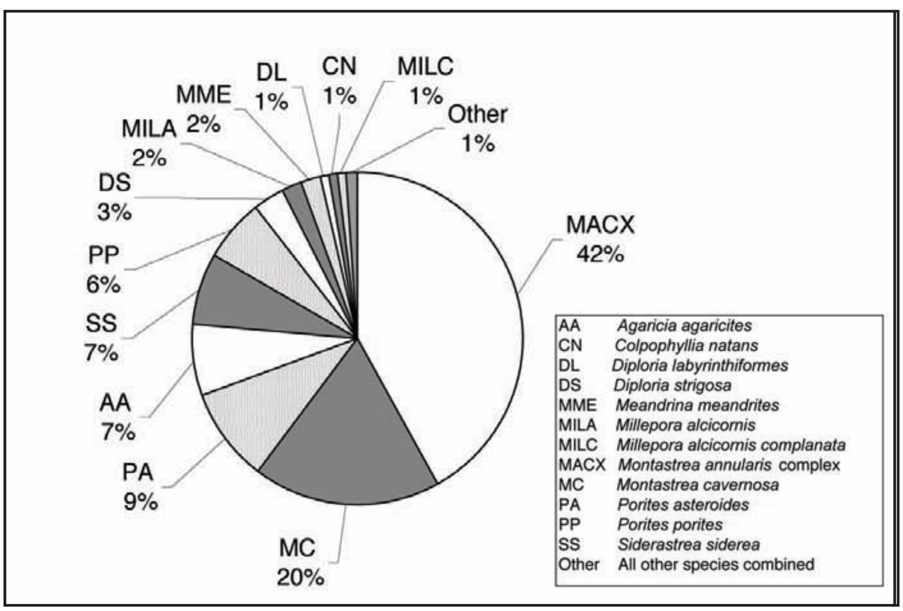

Figure 4.14. Percentage coral species composition at all sampled sites in St. Croix. 'Other' denotes percent of all other coral species combined: *Stephanocoenia michelinii, Eusmilia fastigiata, D. clivosa, Madracid decactis, M. mirabilis, Mussa angulosa, Mycetophyllia danaana, M. ferox, M. aliciae, Dichocoenia stokesii, Manicina areoloata*, and *P. divaricata.* Source: Nemeth et al., 2002, 2003a.

St. Thomas

The percent cover of living coral ranged from a low of 8.3% at Benner Bay to a high of 42% at Grammanik Bank (Figure 4.16A). The percent cover of dead coral covered with turf algae ranged from 15% at Seahorse Cottage Shoal to 45.6% at Benner Bay (Figure 4.16B). The percent cover of macroalgae ranged from 13.8% at Black Point to 42.7% at Seahorse Cottage Shoal (Figure 4.16C). Sponges and gorgonians each comprised less than 10% of the benthic cover at all sites (Figure 4.17D, E). No gorgonians were observed on the shelf-edge sites. The percent cover of sand/sediment ranged from 3% at the Grammanik Bank to 28% at Black Point (Figure 4.17F). Almost all of the substrate at Black Point was covered by sediment, whereas the substrates at other sites were predominantly sandy areas mixed with vertical reef structures.

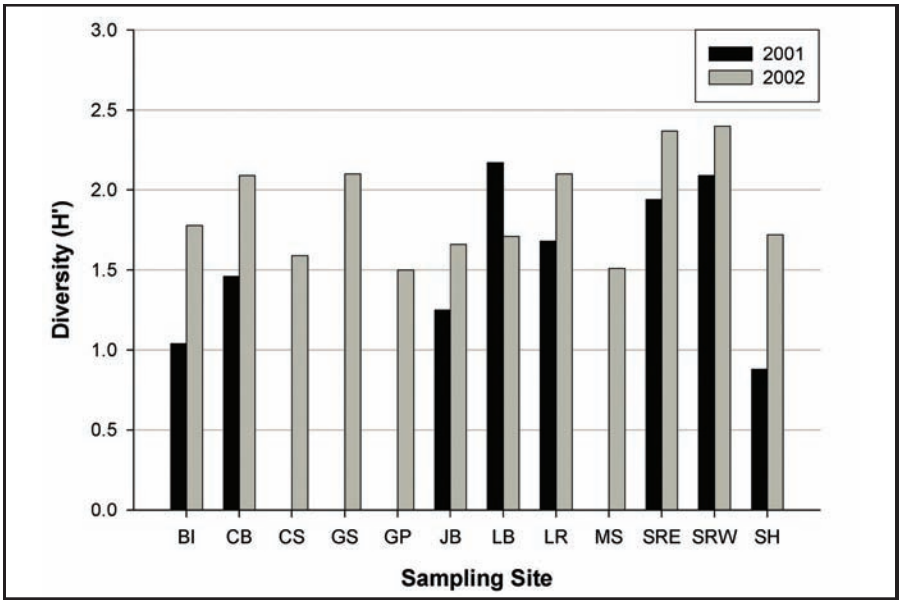

Figure 4.15. Annual diversity index (Shannon-Weaver H') for corals at 12 sites in St. Croix. BI=Buck Island, CB=Cane Bay, CS=Castle, GS=Gerson, GP=Great Pond, JB=Jacks Bay, LB=Lang Bank, LR=Long Reef/Eagle Ray, MS=Mutton Snapper, SRE=Salt River East Wall, SRW=Salt River West Wall, SH=Sprat Hole. Source: Nemeth et al., 2002, 2003a.

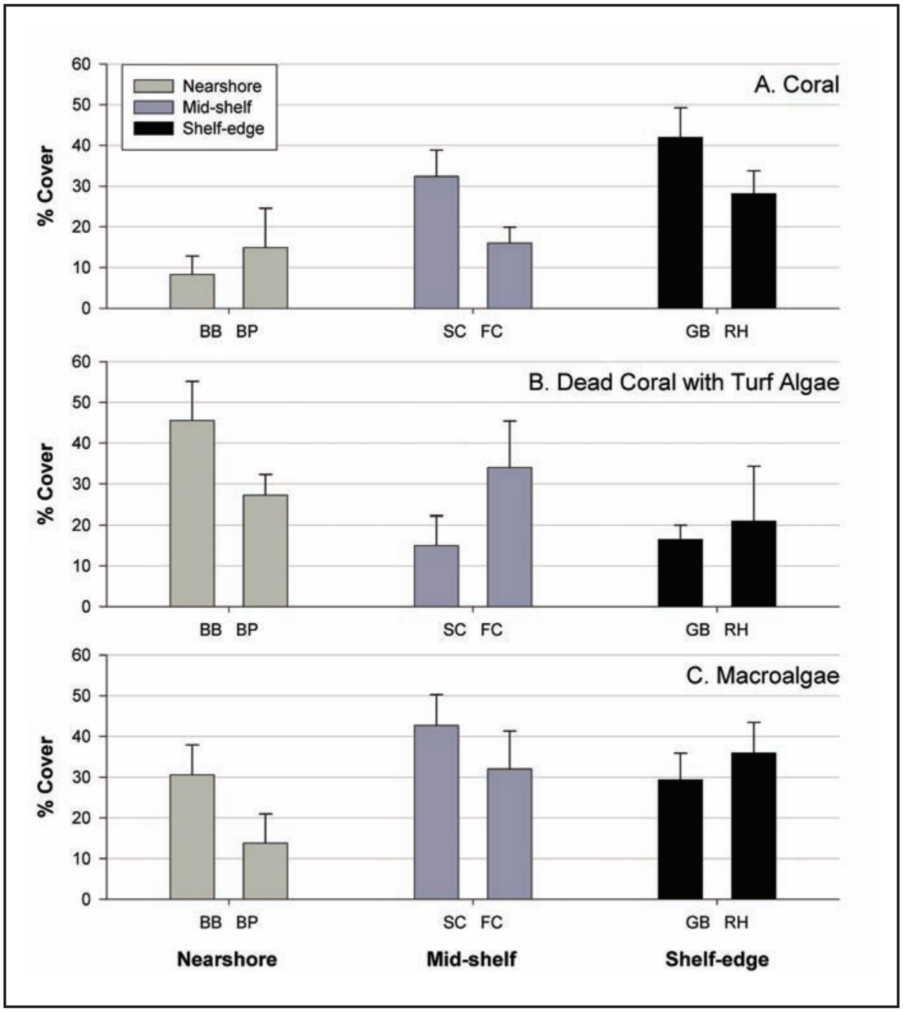

Figure 4.16. Mean percent cover of benthic organisms in St. Thomas at: BB=Benner Bay, BP=Black Point, SC=Seahorse Cottage Shoal, FC=Flat Cay, GB=Grammanik Bank, RH=Red Hind Bank. BB and BP are nearshore sites; SC and FC are mid-shelf sites; GB and RH are shelf-edge sites. n=6 transects for all sites. Error bars represent standard deviation. Source: S. Herzlieb, unpublished data.

Nearshore sites tended to have lower percent cover of living coral and higher percent cover of dead coral covered with turf algae than mid-shelf and shelf-edge sites (Figure 4.18). Also, nearshore sites tended to have lower percent composition of corals within the *M. annularis* complex and higher percent composition of the stress tolerant corals *P. astreoides* and *S. siderea* than mid-shelf and shelf-edge sites (Figure 4.18). The coral reefs of St. Thomas were generally dominated by coral species in the genus *Montastraea* (Figure 4.18). The Shannon-Weaver Diversity Index (H') for coral ranged from a high of 2.26 at Flat Cay to a low of 1.20 at Grammanik Bank. In general, deeper shelf-edge sites (Seahorse Cottage, Grammanik Bank, and Red Hind Bank) had lower diversity than the shallow sites (Figure 4.19).

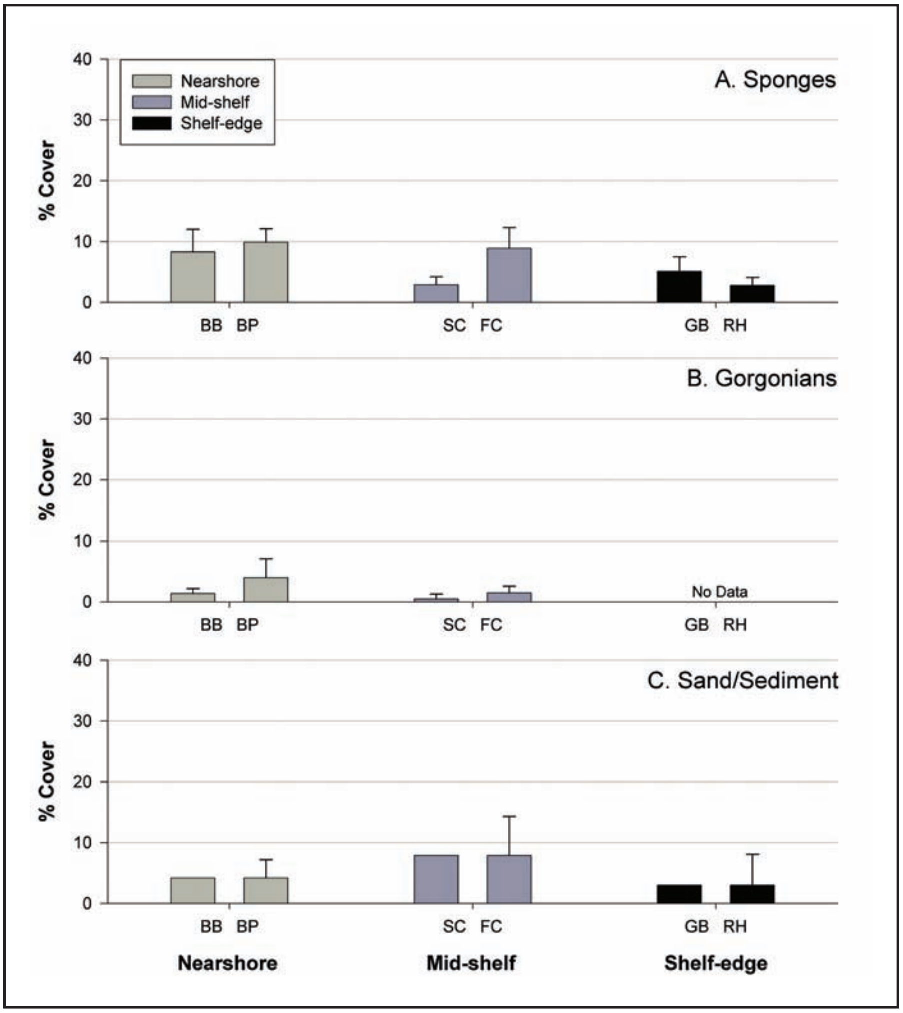

Figure 4.17. Mean percent cover of A. sponges, B. gorgonians, and C. sand/sediment in St. Thomas: BB=Benner Bay, BP=Black Point, SC=Seahorse Cottage Shoal, FC=Flat Cay, GB=Grammanik Bank, RH=Red Hind Bank. BB and BP are nearshore sites, SC and FC are mid-shelf sites, and GB and RH are shelf-edge sites. n=6 transects for all sites. Error bars represent standard deviation. Source: S. Herzlieb, unpublished data.

Since most research and monitoring in the Virgin Islands in have generally been concentrated on nearshore fringing reefs, mid-shelf and shelf-edge sites were chosen to fill gaps in the knowledge of other reef systems, as well as to establish an experimental design to test hypotheses involving differences between reefs located at different points along the insular platform off the coast of St. Thomas. The close proximity of nearshore fringing reefs to human populations and their relatively shallow depths, increases the susceptibility of these reefs to both harmful human activities (overfishing, sedimentation, nutrient enrichment, and physical damage) and the effects of natural disturbances (storm wave damage, high SSTs, and high irradiance).

Due to their similar depths but greater distance from shore, mid-shelf reefs are less susceptible to the human-induced stresses listed above, but are exposed to levels of natural impacts similar to nearshore reefs. Thus, the mid-shelf reefs provide an ideal control for measuring the effects of human-induced stresses on nearshore reefs. Deep reefs located along the edge of the insular platform are largely free from human induced stresses (excluding fishing and anchoring) and natural impacts because of their greater distance from human populations and their greater depths. The shelf-edge deep reefs are quite extensive, but largely unstudied. Monitoring of these systems will contribute greatly to an understanding of coral reef resources in the Virgin Islands. Cross-shelf patterns in benthic composition in St. Thomas warrant special attention because they suggest that overall reef quality is lower at nearshore sites compared with sites further offshore. However, only two reefs of each reef type were surveyed, thus robust comparisons between reef types are difficult. Future monitoring efforts involving a greater number of St. Thomas reefs will help to elucidate these and any further differences among the near-shore, mid-shelf, and shelf-edge reef systems.

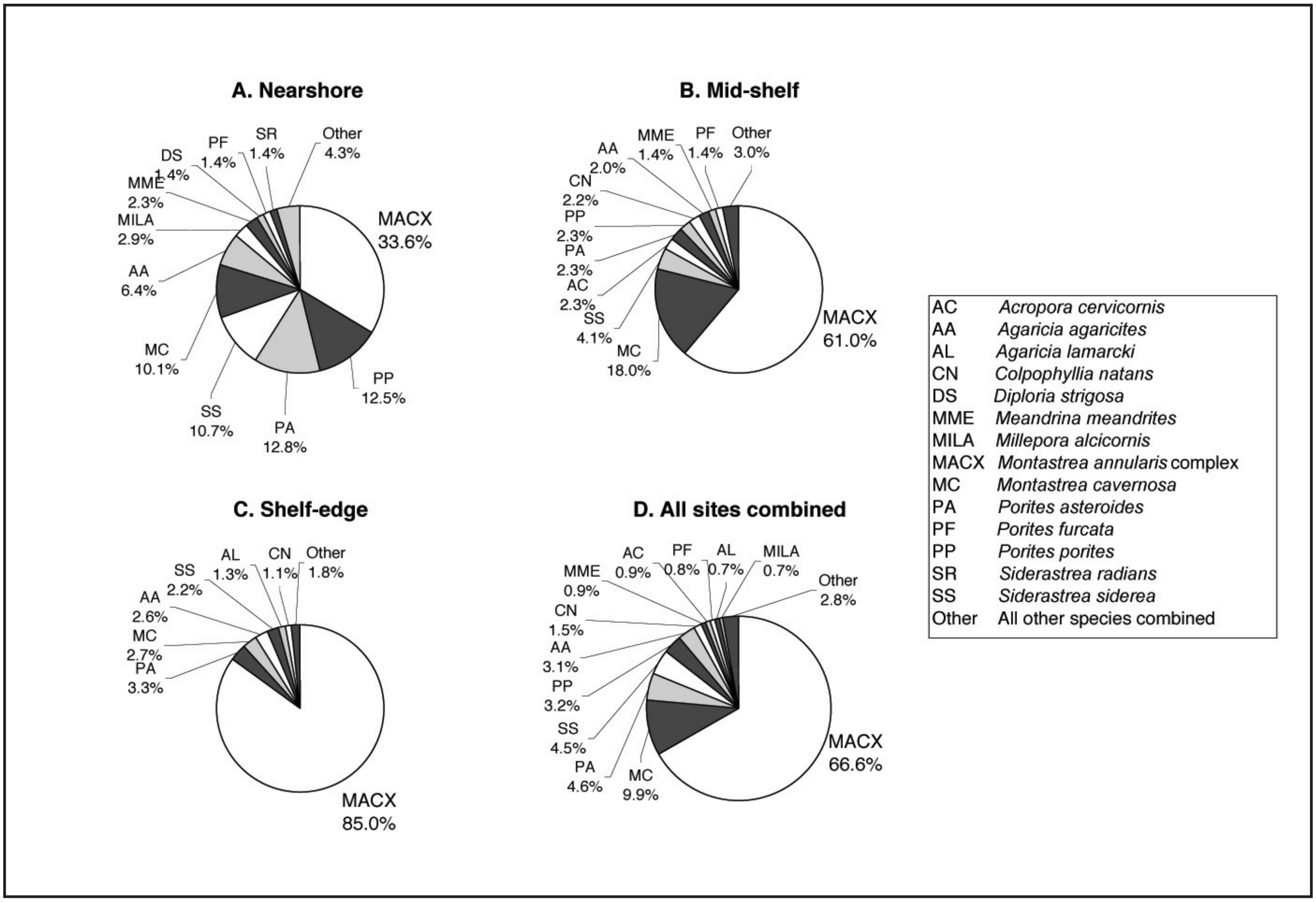

Figure 4.18. Percentage of coral species composition at nearshore sites, mid-shelf sites, shelf-edge sites and all sites combined for St. Thomas. 'Other' denotes percent of all other coral species combined and includes: *Agaricia grahamae, A. humilis, Dendrogyra cylindrus, Diploria clivosa, D. labyrinthiformis, Eusmilia fastigiata, Manicina areolata, Mycetophyllia aliciae, M. danaana, M. lamarckiana, P. divaricata, Solenastrea bournoni, S. hyades,* and *Stephanocoenia michelinii*. Source: S. Herzlieb, unpublished data.

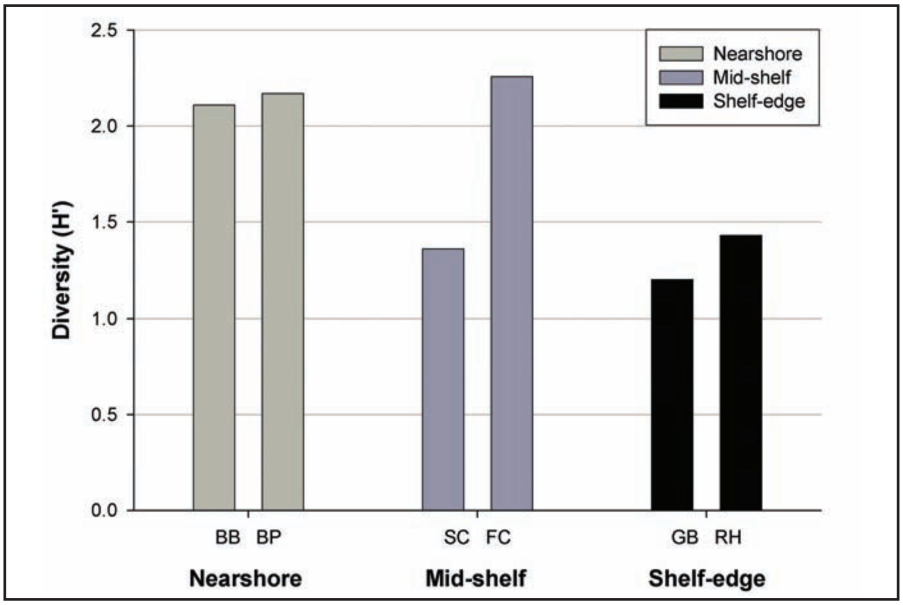

Figure 4.19. Shannon-Weaver Diversity Index (H') for corals at eight monitored sites in St. Thomas: BB=Benner Bay, BP=Black Point, SC=Seahorse Cottage Shoal, FC= Flat Cay, GB=Grammanik Bank, RH=Red Hind Bank. BB and BP are nearshore sites, SC and FC are mid-shelf sites, and GB and RH are shelf-edge sites. n=6 transects for all sites. Error bars represent standard deviation. Source: S. Herzlieb, unpublished data.

UVI-CMES AGRRA Assessments of Benthic Substrates

Methods

Between May 1998 and August 2000, 16 sites within the USVI were surveyed (Nemeth et al., 2003a) using the Atlantic and Gulf Rapid Reef Assessment protocol (AGRRA; Version 2.0). The AGRRA protocol focuses on three aspects of benthic reef communities: coral condition, algae abundance, and sea urchin density along a 10-m transect. To assess coral condition, the dimensions of 50-100 coral colonies, occurring directly beneath the transect line were measured. Coral colonies >25 cm in diameter were inspected for signs of disease, predation, and overgrowth. The percent of old or recent tissue mortality was also estimated for each coral colony from a planar view. Along these same transects, the point intercept method was used to estimate percent coral cover, and the number of *Diadema antillarium* sea urchins occurring within 1 m of each side of the transect line were counted. Finally at least 50 quadrats (0.25 m^2) were placed along the transect lines to estimate the percent cover and height of macroalgae, turf algae, and coralline algae, and to count the number of coral recruits <2 cm in diameter.

The assessment sites included eight reefs on St. John, five reefs on St. Thomas and three reefs on St. Croix. The data were summarized by depth (< 5.5 m and > 6 m) and geographic region (St. Thomas/St. John and St. Croix). St. Croix was considered a unique geographic region because of its isolation from the northern Virgin Island Archipelago, its unique geology (sedimentary/carbonate), and its location completely within the Caribbean Sea. St. Croix sites included Cane Bay, Salt River East Wall, and Long Reef. St. Thomas and St. John were grouped as the northern Virgin Islands because of their close proximity, similar geographic origins and topography (high volcanic islands), and exposure to both Atlantic waters from the north and Caribbean waters from the south. Reefs around St. Thomas included Brewer's Bay, Buck Island, Caret Bay, Flat Cay and Sprat Bay. Reefs around St. John included two sites in Great Lameshur Bay (Tektite, Yawzi Point) and two sites in Fish Bay (outer east and west). Shallow reefs <5.5 m on St. John included two sites in Great Lameshur Bay (Donkey Bight and VIERS) and two sites in Fish Bay (inner east and west). The AGRRA protocol is described in detail in Ginsburg et al. (1996).

Results and Discussion

The percent cover of living coral ranged from 10% to 35% in the Virgin Islands. Average cover of living coral on reefs deeper than 6 m was very similar between St. Thomas/St. John and St. Croix, but was significantly lower on the shallow reefs of St. John (Table 4.5; Nemeth et al., 2003a). Large stony corals that were individually surveyed were numerically dominated by the *Montastraea annularis* species complex in the shallow and deeper reefs around St. Thomas/St. John whereas similar reefs in St. Croix were dominated by *M. cavernosa*. The second most common taxon was *Siderastrea siderea*. The differences in the AGRRA data for St. Croix and the video assessment data presented above most likely resulted from differences in methods used (AGRRA only assessed colonies greater than 25 cm whereas the video method included colonies of all sizes). Moreover, the three sites surveyed for AGRRA were located on the north coast of St. Croix, whereas the larger number of sites (n=12) assessed for the video method were distributed around the entire island.

Table 4.5. Summary data for corals from AGRRA assessment of USVI reefs around St. John, St. Thomas, and St. Croix and the shallow reefs <5.5 m around St. John. Source: Nemeth et al., 2003b.

SITE NAME	DEPTH (m)	COLONIES (#)	CORAL COVER (%)	MORTALITY (%)			BLEACHED CORALS (%)	DISEASED CORALS (%)	CORALS W/ FISH BITES (%)
				New	Old	Total			
St. John (shallow)	4.5	407	12.4	3.4	43	46.4	28.5	4.5	17.3
St. John	9.5	419	22.4	0.8	27	27.8	21.6	8.3	2.8
St. Thomas	10.8	553	20.8	1.7	27.8	29.5	16.6	7.4	8.5
St. Croix	14.3	301	20.2	0.8	33.5	34.3	48.2	2	6.8

Between 1998 and 2000 the condition of coral colonies varied among island groups. Coral bleaching was recorded at all sites with the highest average values occurring on St. Croix, the lowest occurring around St. Thomas, and moderate levels around St. John (Table 4.6). Alternatively, incidence of disease was lowest on St. Croix and the shallow reefs of St. John but higher on the deeper reefs of the northern Virgin Islands. Divers were able to recognize four general disease types: black band, yellow blotch, white plague, and dark spots. The coral species most susceptible to disease included *M. faveolata, M. franksi, M. cavernosa, M. annularis, Colpophyllia natans,* and *Siderastrea siderea*. The high percentage of coral colonies with fish bites contributed to the elevated level of recent tissue mortality on shallow reefs of St. John. These shallow nearshore reefs were also affected by sedimentation especially those outside the boundaries of the VINP (i.e., Fish Bay) that had high levels of old tissue mortality.

Table 4.6. Summary data for algae (macro, turf, crustose coralline) and coral recruitment from AGRRA assessment of reefs around St. John, St. Thomas, and St. Croix and the shallow reefs <5.5 m around St. John. Source: Nemeth et al., 2003b.

SITE NAME	DEPTH (m)	QUADRATS (#)	MACRO ALGAL HEIGHT (cm)	ALGAE RELATIVE ABUNDANCE (%)			CORAL RECRUITS #/0.0625 m^2	DIADEMA #/100 m^2
				Macro	Turf	Crust		
St. John (shallow)	4.5	219	2.8	41.8	47	11.2	4.4	11.5
St. John	9.5	214	1.5	42.6	46.3	11.1	9.8	0.3
St. Thomas	10.8	232	2.5	50.9	31.4	17.7	8.2	1.8
St. Croix	14.3	170	1.2	16	74	10	10.3	1.3

Stony coral recruitment varied considerably from site to site, but on average, it was similar among reefs greater than 6 m depth (Table 4.6). Coral recruitment on the shallow reefs of St. John was about 50% of that on deeper reefs. With the exception of *S. siderea*, coral recruits were dominated by species that brood their larvae. The five most abundant taxa - *S. siderea* (23%), *Agaricia* spp. (17%), *Porites astreoides* (15%), *P. porites* (13%) and *S. radians* (6%) - comprised 70% to 80% of the recruits on all islands (Nemeth et al., 2003b). The relative abundance of macroalgae was significantly lower on St. Croix compared with the northern Virgin Island reefs and the shallow reefs of St. John, which had over two times the number of *Diadema* spp. urchins than deeper reefs (Table 4.6).

NOAA CCMA-BT Benthic Habitat Mapping

NOAA's Center for Coastal Monitoring and Assessment-Biogeography Team (CCMA-BT) completed a nearshore benthic habitat mapping project for the USVI in 2002. Aerial photographs were collected by a NOAA citation jet in 1999 and used to delineate habitat polygons in a geographic nformation system (GIS). The habitat polygons were defined and described according to a hierarchical habitat classification system consisting of 26 discrete habitat types. The project mapped approximately 490 km^2 of nearshore habitat in the islands including coral reefs, mangroves, seagrass beds, and other tropical marine bottom types. A series of 55 maps are now available via a CD-ROM, and on-line (http://biogeo.nos.noaa.gov/products/benthic. Accessed 1/19/05). Major habitat types are depicted in Figure 4.20.

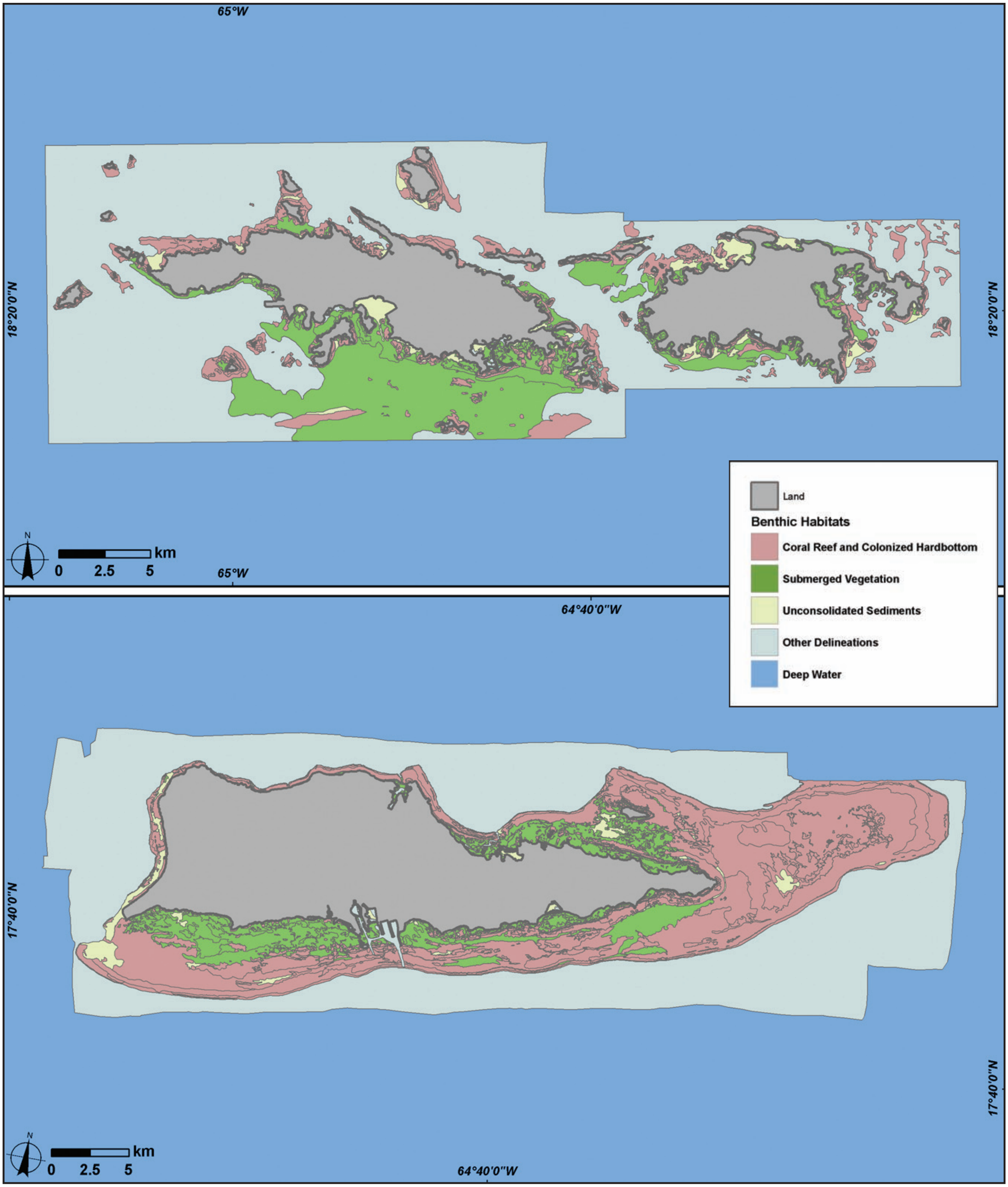

Figure 4.20. Nearshore benthic habitat maps were developed in 2001 by CCMA-BT based on visual interpretation of aerial photography and hyperspectral imagery. For more info, see: http://biogeo.nos.noaa.gov. Map: A. Shapiro.

ASSOCIATED BIOLOGICAL COMMUNITIES

Data from four monitoring and assessment programs were used to characterize community structure, biomass, trophic structure, and the size frequency distribution of fish assemblages in the USVI. Mean estimates of standard reef fish assemblage variables were determined from each data set. Species richness is the total number of species observed per sample. Abundance is the mean number of individuals per sample. Biomass is the estimated live wet weight of individuals per sample. Live wet weight (W) of each fish was estimated from the mean visually estimated fork-length (FL) with the equation: $W = a(FL)^b$, where a and b are known parameters of the length-weight relationship for each species (Randall et al., 1967; Froese and Pauly, 2000; http://fishbase.org., Accessed 12/28/2004). For species not in these databases, estimates from available literature on the species or congeners were used. The biomass of all fishes recorded in all censuses was obtained by multiplying the mean live wet weight for each size class for each species by the total number of individuals observed in that size class.

NPS Long-term Monitoring of Reef Fish Assemblages

Methods

Annual trends in total species richness, fish abundance, and biomass were analyzed and are presented separately for the NPS long-term reef fish monitoring dataset. NPS has been monitoring reef fish populations monthly at four reference sites in the VINP on St. John for 12 years (1988-2000). This data set represents one of the longest time series data sets on reef fishes for the territory. An investigation to study the monthly variation in reef fish assemblages was initiated in November 1988 and continued through May 1991 (Beets and Friedlander, 1990; Beets, 1993). The study was conducted at two sites (Yawzi Point Reef and Cocoloba Reef) using the stationary visual census technique developed by Bohnsack and Bannerot (1986). Following Hurricane Hugo in September 1989, NPS initiated reef fish sampling at several reef sites (n=18) around St. John in addition to the monthly sampling at the two sites in the southern portion of the VINP. The NPS used a modified visual census technique that was developed and used in the Dry Tortugas National Park in 1987 (Kimmel, 1992). Monitoring at the sites established in 1989 (originally 18 reef sites were selected with a few omitted and added among years) continued each June/July until 1994 using the modified method. In 1995, the standard stationary visual census technique (Bohnsack and Bannerot, 1986) was employed to continue long-term monitoring at four established reference sites, representing topographically complex, speciose sites including areas selected for monitoring other resources (coral, macroalgae, water quality). The goals of this monitoring project were to 1) establish a baseline of information on reef fish assemblages around St. John; 2) conduct sustained monitoring on representative high-diversity reefs; 3) collect data on reefs with known or potential environmental degradation; 4) compare fish assemblages among selected reefs; and 5) determine trends in reef fish assemblages over time. The four permanent reference sites (Yawzi Point Reef, Tektite Reef, Newfound Bay West Reef, and Haulover Bay West Reef) were monitored annually from 1989-2000 (except in 1990). Yawzi Point Reef was monitored monthly from 1988-1991.

Results and Discussion

In most tropical fisheries, many changes go relatively unnoticed and undocumented. Data acquisition and monitoring programs are frequently initiated following large resource changes. While this is true for the USVI, the area has fortunately received much scientific investigation at other times as well. A comparison of historical data (1958-1961) and more recent monitoring data (1989-2000) provides a view of changes in reef fish abundance over 60 years.

NPS reef fish monitoring data documented numerous significant declines in the abundance of several reef fish over a 12-year period (Beets and Friedlander, 2003; Figure 4.21). However, numerous species that were historically common in landings, such as the Nassau grouper, demonstrated no significant trend over the monitoring period (Figure 4.21). This may be because their abundance is presently too low to show significant trends, assuming that a decline in abundance has occurred. Furthermore, large declines in abundance for species, such as the Nassau grouper, may have occurred before monitoring projects were initiated.

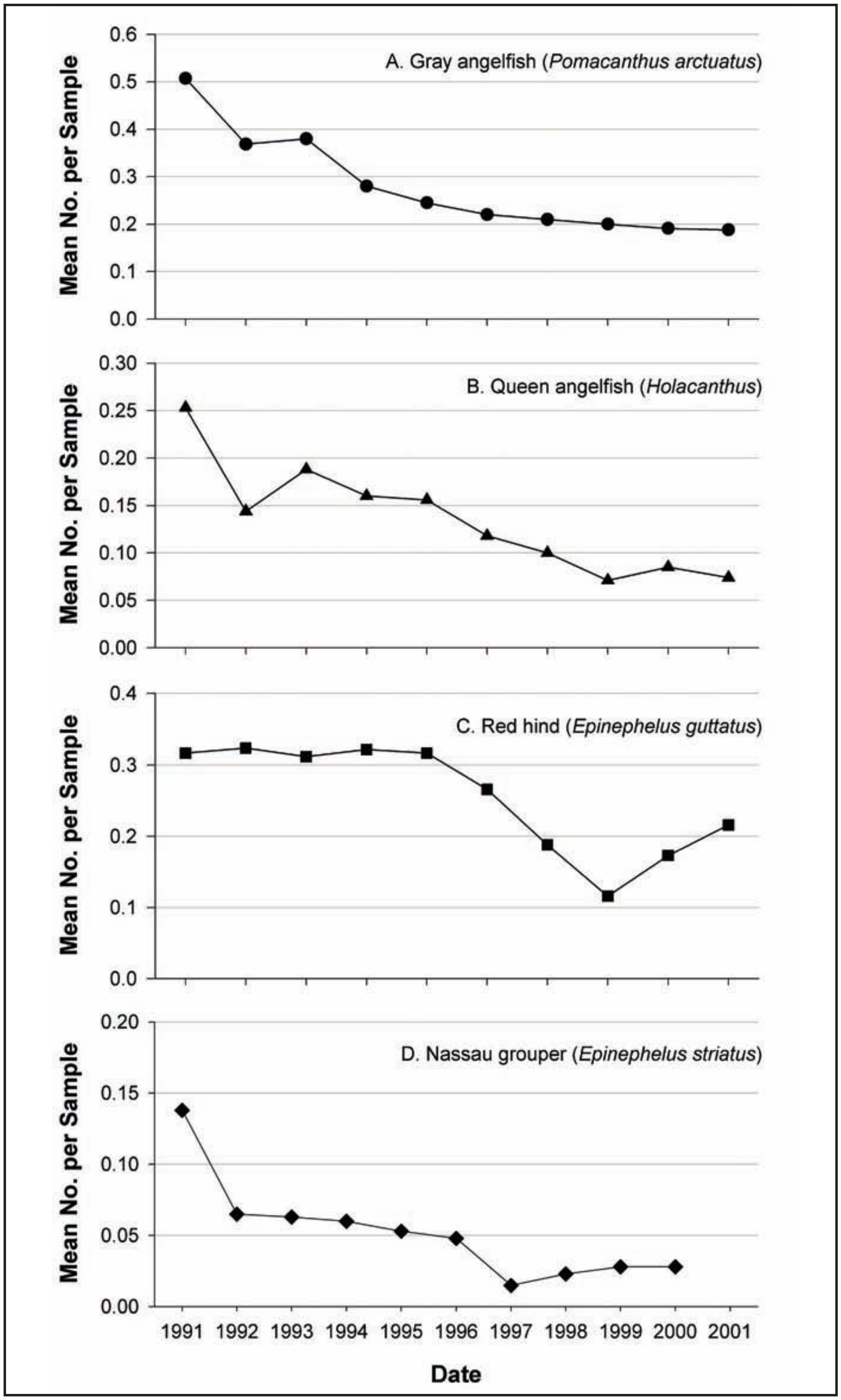

Figure 4.21. Significant (A-C) and non-significant (D) declines in abundance of four commercially-targeted species observed in visual monitoring data from four reefs around St. John, US Virgin Islands from 1991-2000. Source: Beets and Friedlander, 2003.

Historical data collected by previous investigators provide comparative information, although comparative abundance data frequently are not available. For example, Randall (1967) collected many species of fish for his landmark studies of Caribbean reef fishes around St. John from 1958-1961. Although few were quantitative, Randall's studies provided relative abundance and size structure of species. Large groupers frequently captured by Randall in 1958-61 were in very low relative abundance in the 1989-2000 monitoring data (Figure 4.22). The two smaller-sized groupers, red hind and coney, were much more common in the recent monitoring data. These long-term comparisons suggest that large changes have occurred in Virgin Islands fisheries, similar to patterns observed throughout the Caribbean. Over-exploitation by fisheries certainly has been a strong contributor to the observed declines.

The most apparent temporal signal in reef fish assemblage characteristics around St. John over the 12-year monitoring period resulted from the influence of large storm events (Beets and Friedlander, 2003). The Virgin Islands have been greatly influenced by numerous large storms since 1988. Data were separated into two periods (1989-1994 and 1996-2000) representing the post-storm recovery periods following the two major storms affecting St. John (Hurricane Hugo, Sept. 1989; Hurricane Marilyn, Sept. 1995). As data for 1995 were collected just prior to Hurricane Marilyn, those data were excluded from analysis. Assemblage characteristics (species richness, abundance, and biomass) showed statistically significant increases during the five-year period following Hurricane Hugo (1989, Figure 4.23). While species, number of individuals, and biomass all increased following Hurricane Marilyn (1995), none of these trends were significant for the

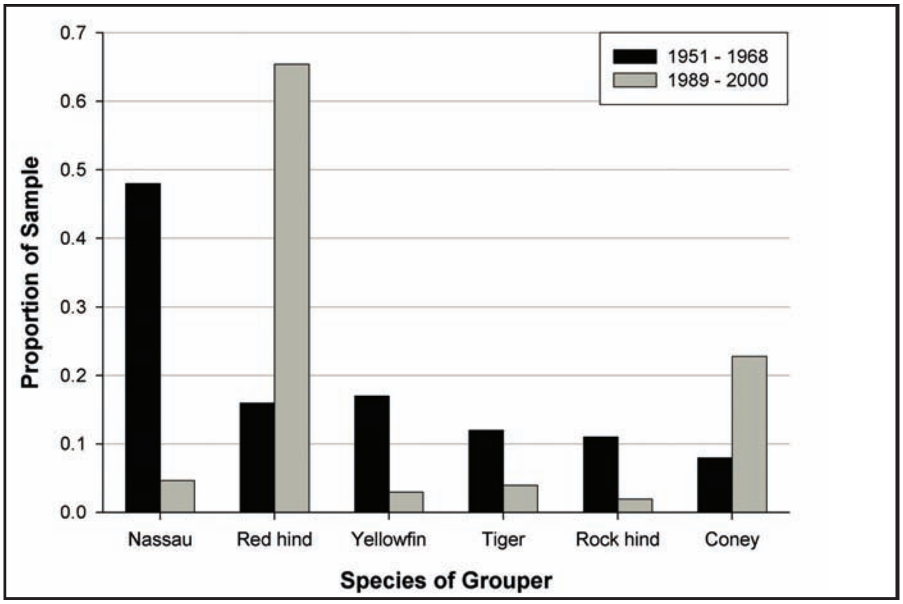

Figure 4.22. Comparison of the relative abundance of groupers collected by Randall from 1958-1961 and groupers sampled during 1989-2000 around St. John. Source: Beets and Friedlander, 2003.

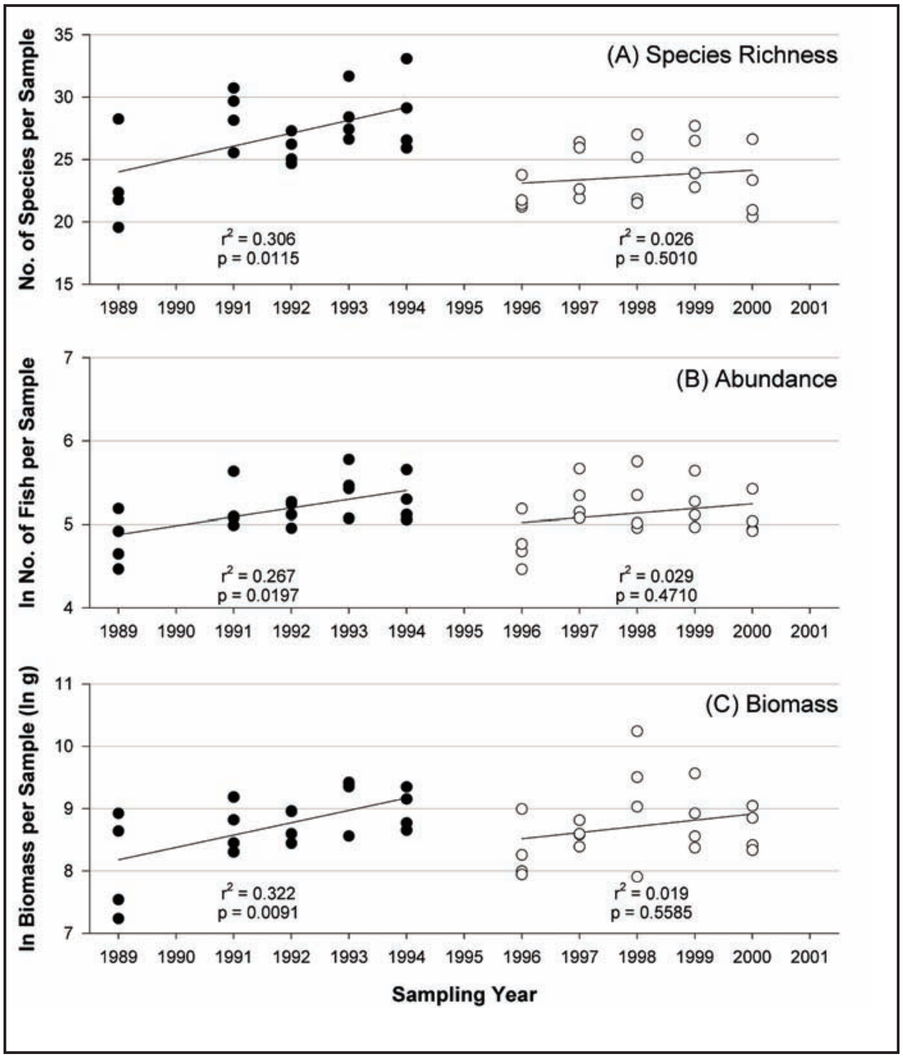

Figure 4.23. Trends in assemblage characteristics during the five years following two hurricanes which affected St. John (Hugo, Sept. 1989; Marilyn, Sept. 1995). Average values for each of the four reference sites are represented by circles for each year. Regression lines and coefficients were obtained from linear regression analysis. Data for 1995 were excluded from these analyses. Source: Beets and Friedlander, 2003.

five-year period following the storm (Figure 4.23). Large storms that passed near the USVI in 1998 and 1999 may have had a significant negative impact on reef fish assemblage recovery, as lower values in assemblage characteristics were noted for 2000. Without long-term consistent data, the ability to evaluate such events is limited.

Current Status of Reef Fish Assemblages in the USVI

Methods

The current status of reef fish assemblages in the USVI was determined from the CCMA-BT, DFW, and UVI-CMES reef fish monitoring programs. These programs present the most recent data on the status of reef fishes in the USVI. In 1998, UVI-CMES joined the Caribbean-wide effort to assess reef fish assemblages at 16 sites throughout the USVI. Since 2001, CCMA-BT has surveyed reef fishes semi-annually for three years at 309 and 128 hard bottom sites in St. Croix and St. John, respectively. Most recently, the DFW conducted 80 visual surveys and collected 120 trap samples at eight permanent hard bottom areas in St. Croix during spring and fall of 2002.

Table 4.8. Species of commercially important snappers (Lutjanidae) and groupers (Serranidae) for which estimates of mean biomass density (g/m^2) were calculated for the Virgin Islands National Park, St. John and the BIRNM, St. Croix. Source: Appeldoorn et al., 1992.

FAMILY	SPECIES	COMMON NAME
Lutjanidae (snapper)	*Lutjanus analis*	mutton snapper
	Lutjanus apodus	schoolmaster
	Lutjanus griseus	gray snapper
	Lutjanus jocu	dog snapper
	Lutjanus mahogoni	mahogany snapper
	Lutjanus synagris	lane snapper
	Ocyurus chrysurus	yellowtail snapper
Serranidae (grouper)	*Epinephelus cruentatus*	graysby
	Epinephelus fulvus	coney
	Epinephelus guttatus	red hind
	Epinephelus morio	red grouper
	Mycteroperca tigris	tiger grouper

Mean biomass density of 12 commercially important species of groupers and snappers (Table 4.8), the trophic biomass ratio of three broad feeding guilds (Table 4.9), and the size frequency distribution of selected species were calculated for each site. Biomass density is the live wet weight of groupers and snappers observed per area (m^2) sampled. Trophic biomass ratio is the proportion of live wet weight of fishes in one of three feeding guilds. Fishes were assigned to trophic guilds according to Randall (1996). However, Randall's trophic classification was reduced to three trophic groups to simplify the interpretation of the results. Randall's "mobile invertebrate feeders/piscivores" were integrated into the group "piscivores"; herbivores were not reclassified; all other trophic groups ("detritivores", "sessile invertebrate feeders", "zooplanktivores", and "omnivores") were combined into one category called 'generalized carnivores' (Table 4.9). Size class frequency is the proportion of individuals of a species belonging to one of eight size classes. Size classes were based on visual estimates of fork length (FL). Size class frequency was estimated for three commercially important species - red hind grouper (*Epinephelus guttatus*), coney (*E. fulvus*), and red band parrotfish (*Sparisoma aurofrenatum*) - and the bluehead wrasse (*Thalassoma bifasciatum*), a commonly occurring species with no commercial importance. These assemblage and species variables were chosen because they can provide a relative index of the condition of coral reef fish assemblages. Current estimates of these assemblage variables will be used as a baseline for comparison with estimates from future monitoring data to determine how reef fish assemblages are changing over time.

Table 4.9. Trophic guilds used to determine trophic biomass ratio of fishes in the USVI. Source: Randall, 1967.

TROPHIC GUILD	FOOD TYPE	EXAMPLE TAXA
Herbivores	Marine plants	Damselfishes, parrotfishes, surgeonfishes
Piscivores, mobile invertivores/piscivores	Other fish, crabs	Red hind, other groupers, snappers
Mobile invertivores, sessile invertivores, zooplanktivores, generalized carnivores	Crustaceans, corals, zooplankton, etc.	Spanish hogfish, wrasses, gobies, filefish, butterflyfish, blennies, cardinal fishes, angelfishes, squirrel fishes, goatfishes, scadblennies, cardinal fishes

NOAA CCMA-BT

Since August 2000, NOAA's CCMA-BT has led a collaborative effort to monitor coral reef ecosystems throughout the U.S. Caribbean, including the USVI. This regionally-integrated monitoring effort explicitly links observed fish distributions to shallow (<30 meters) benthic habitats recently mapped by CCMA-BT and its many partners (Kendall et al., 2001). Objectives of this work include: 1) developing spatially-articulated estimates of the distribution, abundance, community structure, and size of reef fishes, conch, and lobster; 2) relating this information to *in situ* data collected on associated habitat parameters; 3) using this information to establish the knowledge base necessary to implement and support "place-based" management strategies for coral reef ecosystems of the Caribbean; and 4) quantifying the efficacy of management actions.

This regional monitoring program has been conducted in partnership with the UVI, NPS, USGS, and DPNR, and provides standardized monitoring data for portions of the entire U.S. Caribbean. Since the inception of this effort, over 600 surveys of reef fish populations and associated benthic habitats have been conducted in southwestern USVI (see Figure 4.9). The foundation of this work is the nearshore benthic habitats maps created by CCMA-BT in 2001. Using ArcView© GIS software, the benthic habitat maps are stratified to select monitoring stations along a cross-shelf depth gradient. Because the program was designed to monitor the entire coral reef ecosystem, CCMA-BT and its partners survey seagrass meadows, mangroves, sand flats, as well as various coral reef formations. Survey sites are selected at random within each habitat stratum to ensure complete coverage of the study region. At each site, fish, conch, lobster, and benthic habitat information is collected using standard visual survey techniques (Christensen et al., 2003). Since 2003, CCMA-BT has also been collecting water quality and oceanographic characteristic data at each survey location. These water quality data are not yet available, but will be provided in a future report.

By correlating monitoring data to the habitat maps, CCMA-BT and its partners are able to map and model (predict) species and community level parameters throughout the seascape. Furthermore, by integrating this work with other studies being conducted concurrently by its partners on fish migration patterns, home range size, fish dispersal, and recruitment, CCMA-BT is in a unique position to answer questions about marine zoning strategies (e.g., placement of marine protected areas [MPAs]), and evaluate management efficacy through long-term monitoring.

USVI-DPNR-DFWS

Surveys of reef fishes were conducted by divers from the DFW. Surveys occurred during fall of 2003 at eight permanent long-term monitoring sites surveyed annually by researchers from UVI-CMES. The permanent sites were selected because they were considered representative of the reefs around St. Croix (Nemeth et al., 2002). Sites were hard-bottom, less than 15 m in depth, and considerably varied in the composition of benthic flora and fauna (Nemeth et al., 2002).

A 60 m^2 rectangular transect was used to assess reef fish assemblage structure (Nemeth et al., 2003c). Visual fish counts were conducted along 10 replicate transects at each site. During fish transects, transect width and fish lengths (measured in 5-cm increments up to 35 cm) were measured with a 1 m t-bar marked in 5 cm increments. Using transects as replicates, the average density (no./100m^2) and size (cm) of each species and family were calculated for each site.

The DFW also conducts independent fisheries monitoring of reef fishes with fish traps and hand-lines through the Southeast Area Monitoring and Assessment Program for the Caribbean (SEAMAP-C; Tobias et al., 2002). SEAMAP-C is a cooperative program among NOAA Fisheries, the Puerto Rico Department of Natural Resources, and DFW. SEAMAP-C was implemented to collect data needed to assess the status of marine resources of the U.S. Caribbean and to monitor any changes in status (Tobias et al., 2002). Briefly, 12 baited fish traps and three hand-lines (each with three hooks) were used to sample reef fishes in a 52 km^2 area northeast of St. Croix on 10 sampling missions between January 2001 and April 2002 (Figure 4.9). Traps were placed randomly at two depth strata (0-18 m and 19-36 m). Total trap soak time was 59 hours and total hand-line fishing time was also 59 hours. A detailed description of the SEAMAP-C sampling methods is provided in Tobias et al. (2002).

UVI-CMES

Between May 1998 and August 2000 16 sites within the USVI were surveyed (Nemeth et al., 2003b) with the AGRRA protocol (Version 2.0; Ginsburg et al., 1996). Visual fish counts along at least 10 60-m^2 transects were conducted at each site. On St. Croix, additional surveys were conducted at Cane Bay (n=3), Long Reef (n=5) and Salt River (n=6). Transect width and fish lengths (measured in 5-cm increments up to 35 cm) were estimated using a 1 m wide t-bar constructed of pvc. Using transects as replicates, the average density (no./100 m^2) and size (cm) of each species and family were calculated for each site and island group (see below). Parrotfish and grunts less than 5 cm were counted and identified to species when possible at all sites except St. Croix. Sites were identical to those listed in the UVI-CMES AGGRA Assessments of Benthic Substrates section of this chapter.

Results and Discussion

Despite the variation in sampling techniques, spatial extent, and temporal coverage, analysis reveals patterns in the abundance and assemblage structure of reef fishes that were consistent among the data sets. These patterns are described below.

The biomass of commercially important groupers and snappers was very low for all monitoring programs. Mean biomass density of groupers and snappers was 5.67 ± 0.55 g/m^2 (CCMA-BT) and 8.76 ± 1.17 g/m^2 (UVI-CMES). Furthermore, the NPS long-term reef fish data show clearly that the average number and frequency of occurrence of groupers decreased at reference sites during 12 years of sampling (Figure 4.22). Low estimates of biomass also reflect low abundance of groupers and snappers in USVI waters, and indicate a lack of recovery of local grouper populations to fishable levels. Intense fishing pressure, degradation of coral reef habitats, and tropical storm events have contributed to the demise of several large-sized grouper and snapper species such as the Nassau grouper, *Epinephelus striatus* and the dog snapper, *L. jocu* in the USVI (Olsen and LaPlace, 1978; Beets and Friedlander, 1992; Rogers and Beets, 2001). Now, the abundance of smaller-sized groupers (e.g., red hind, *E. gutatus*; coney, *E. fulvus*; graysby, *E. cruentatus*) that have replaced the decimated fisheries are so low that they too are rarely caught in recreational or commercial fisheries (W. Tobias, pers. comm.). Continued monitoring of grouper/snapper biomass density would provide an easy way to assess the future trends and health of USVI reef fish assemblages.

Overfished reef fish assemblages typically are characterized by a higher proportion of herbivores and fewer piscivores compared with unfished assemblages. Many large-bodied predatory species (e.g., groupers and snappers) usually are the primary targets of fishers, which results in the depletion of the largest and most valuable fishes from reef fisheries. As the abundance of these larger species decrease to unfishable levels, fishers are forced to switch to smaller and more undesirable fishes, a phenomenon known as "serial overfishing" (see Ault et al., 1998). Assuming a reduction in fishing pressure may result in an increase in the abundance of predators, monitoring temporal changes in the trophic structure could provide another way to determine the status of USVI reef fish assemblages. The three trophic categories were well represented among most of the data sets. Piscivores comprise 25% (CCMA-BT), 2% (DFW), and 6% (UVI-CMES) of fish biomass at sampled locations (Figure 4.24). Herbivores comprised 43% (CCMA-BT), 3% (DFW), and 18% (UVI/CMES) of

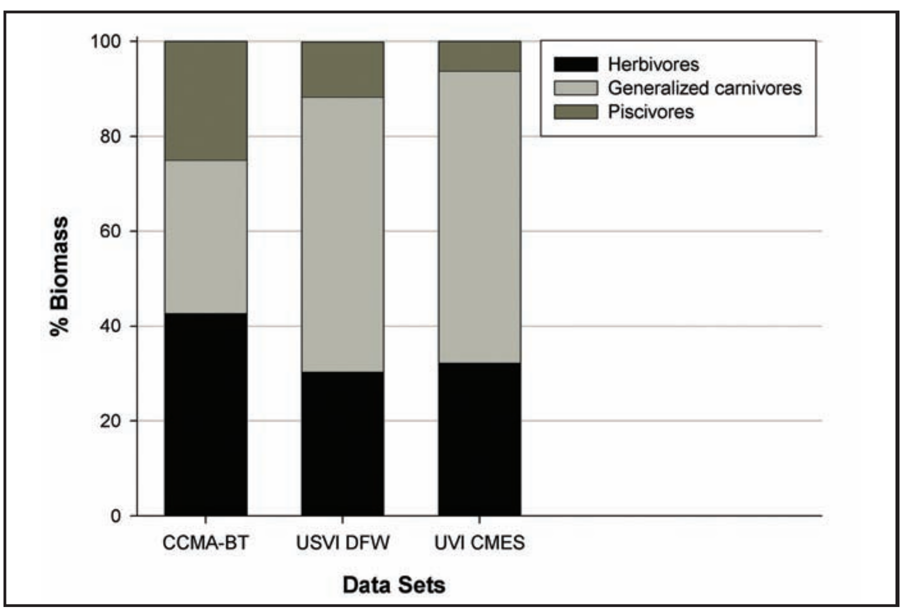

Figure 4.24. Percent biomass of piscivores, herbivores, and omnivores based on data collected by three monitoring and assessment programs: CCMA-BT, USVI DFW, and UVI CMES. Sources: Kendall et al., 2001; Nemeth et al., 2003a,c.

fish biomass. Other trophic guilds accounted for 38% (CCMA-BT), 67% (DFW), and 64% (UVI-CMES) of the observed biomass. Comparisons of current baseline data with future estimates of trophic biomass ratios could indicate whether fishing pressure on UVSI reef fish assemblages is increasing or decreasing.

The size frequency distributions of groupers suggest that grouper populations in the USVI consist predominantly of small-sized individuals. The average adult size of a red hind grouper ranges from 25-38 cm, with a maximum known length of 61 cm (Humann and Deloach, 2002). The coney is smaller with an average adult size ranging from 15-25 cm and a maximum length of 40 cm (Humann and Deloach, 2002). Eighty-three percent of the 909 red hind and coney groupers observed by CCMA-BT were smaller than 25 cm in size (Figure 4.25A). DFW caught 513 red hind and 46 coney groupers during trap and hand-line fishing in St. Croix. Of these, 89% were smaller than 25 cm in size (Figure 4.25B). UVI-CMES divers observed 30 red hind and 72 coney groupers, 94% of which were smaller than 30 cm in size (Figure 4.25C).

Most redband parrotfish observed in the USVI were smaller than the average size of an adult. The average adult-sizde redband parrotfish ranges from 15-25 cm (Humann and Deloach, 2002). A total of 3,043 redband parrotfish were observed during 373 CCMA-BT surveys (Figure 4.25D). Thirty-four percent (1,035 individuals) were 0-5 cm in length. The number of individuals decreased consistently as size-class increased, and only 21% were larger than 15 cm in length. DFW divers observed 590 red band parrotfish grouped into four size-classes, and 93% were less than 20 cm (Figure 4.25E). UVI-CMES reported 721 redband parrotfish grouped into five size-classes, with 82% being less than 20 cm in size (Figure 4.25F). The size frequency distribution

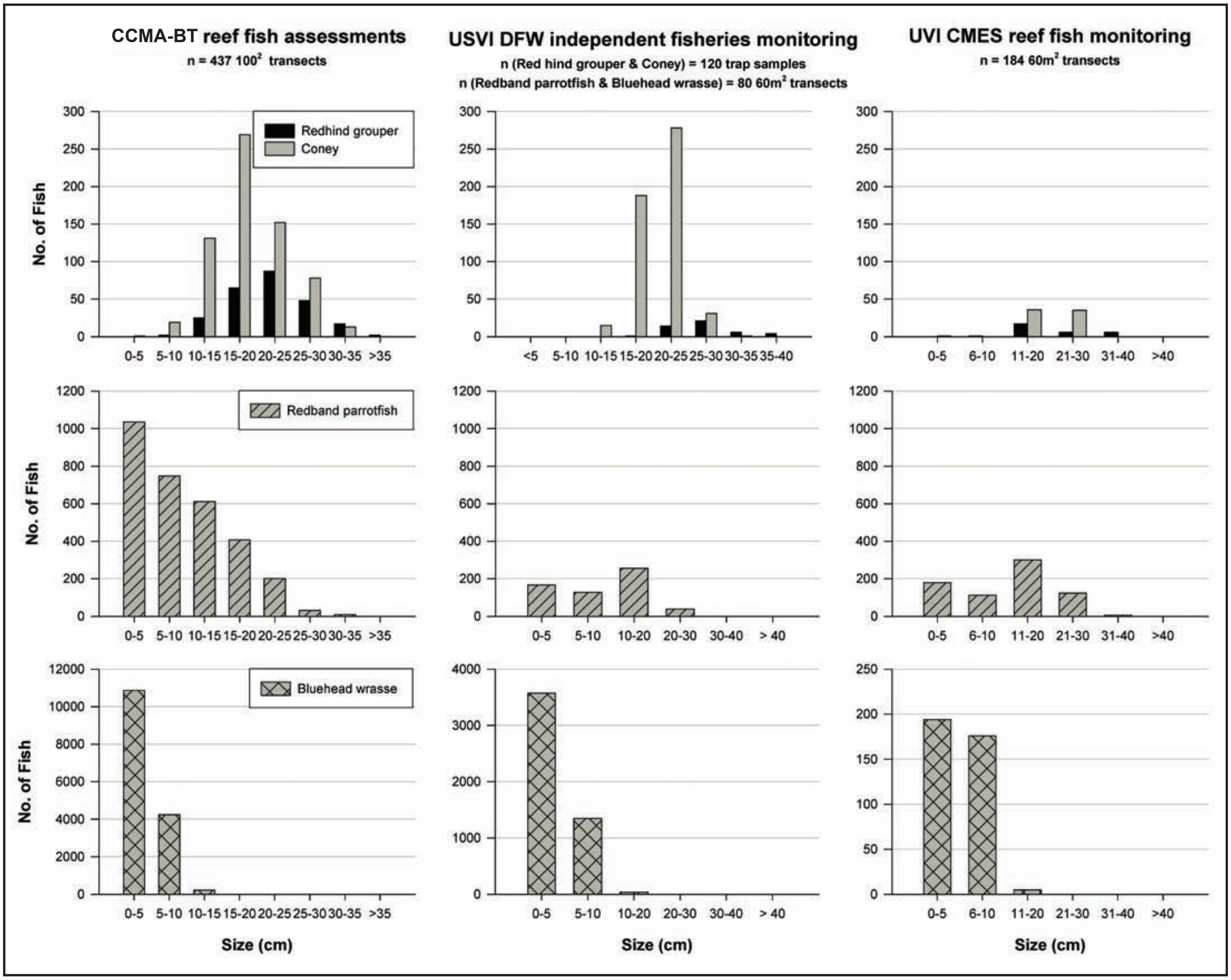

Figure 4.25. Size frequency histograms for four reef fishes based on data collected by three monitoring and assessment programs: CCMA-BT, USVI DFW, and UVI CMES. Sources: Kendall et al., 2003; Nemeth et al., 2003a,c.

indicates that redband parrotfish populations in the USVI generally consisted of immature individuals.

Bluehead wrasse populations in the USVI also consisted primarily of individuals smaller than the average adult size (10-13 cm; Humann and Deloach, 2002). CCMA-BT divers observed 15,337 bluehead wrasse on 398 of 437 surveys (Figure 4.25G). Most (98.5%) were less than 10 cm in length. DFW divers observed 4,959 bluehead wrasse in three size-classes and 99% were less than 10 cm in length (Figure 4.25H). UVI-CMES reported 375 bluehead wrasse grouped into three size-classes, and 98% were smaller than 10 cm in size (Figure 4.25I). The size frequency distribution of the bluehead wrasse indicates that the USVI populations consist primarily of juveniles and immature adults.

In summary, fish species composition on reefs and in fisheries catch has shifted to more herbivorous species since 1988. Additionally, there has been a decline in the number of grouper and snapper species as well as the average size of fishes observed on reefs during field surveys. Commercially important species such as large grouper and snapper species, that once abounded on USVI reefs during the 1950s and 1960s are currently of low abundance in fisheries landings. Continued monitoring of the status of reef populations and reef fisheries as well as commercially important macroinvertebrates (e.g., conch and lobster) is important.

CURRENT CONSERVATION MANAGEMENT ACTIVITIES

The U.S. Department of the Interior (DOI), U.S. Department of Commerce (DOC), and Virgin Islands Territorial Government all have jurisdiction in overlapping sections of submerged lands within the USVI (Table 4.10). These agencies have conducted several research and monitoring activities to aid in the management of USVI coral reef ecosystems. Both Federal and territorial agencies in the USVI use a variety of management tools to address issues such as fishing, recreational use, and land-based sources of pollution to protect the marine resources of the territory.

Table 4.10. Authorities with jurisdiction over waters and submerged lands with coral reefs in the USVI.

GOVERNMENT AGENCY	JURISDICTION
Department of Interior, Minerals Management Service	Leasing responsibility for Federal submerged lands within 200 nmi of shore.
NPS	Buck Island Reef National Monument, Salt River Bay National Historical Park and Ecological Preserve, Virgin Islands National Park, Virgin Islands Coral Reef National Monument
NOAA	3-200 nmi
Virgin Islands Territorial Government	All other waters and submerged lands from the shoreline to 3 nmi.

Mapping

In 2000, an extensive seafloor mapping project around the USVI was completed by NOAA, local partners, and the U.S. Coral Reef Task Force. For this project, much of the insular shelf of the USVI from the shoreline to a depth of approximately 20 m was mapped using visual interpretation of aerial photographs, a 26-category classification scheme, and a minimum mapping unit (MMU) of 1 acre (NOAA, 2001). Completed maps cover approximately 490 km^2 of benthic features including mangroves, seagrass, and coral reefs. These maps have been used for a wide variety of research and management applications, including stratification of sampling effort in reef fish monitoring projects, distribution and abundance surveys for elkhorn coral and lobster populations, and an inventory of cryptic fish. Mapping projects since 2000 have primarily covered smaller areas of particular interest in the USVI, focused on specific bottom types, and had smaller MMUs. Aerial photos have been used recently to map Buck Island and Salt River, St. Croix at a finer scale (100 m^2 MMU) than was done previously by CCMA-BT and NPS. These activities are focused on providing a more refined inventory of habitat types in the national parks located at those sites.

Automated computer analysis of historical and current aerial photos was recently completed to detect changes in seagrass beds northeast of St. Croix (Kendall et al., 2004). This information is currently being used to establish records of this critical habitat in a location where anchor damage has historically been a problem. Lidar has also been collected by USGS northeast of St. Croix and around St. John for fine-scale bathymetry and habitat mapping. Several groups at NOAA are using satellite data to map benthic cover and bathymetry. LandSat has been used to map bathymetry around the USVI (EarthSat), with cover mapping currently underway. IKONOS is being used by CCMA-BT to map bathymetry and bottom types around Buck Island, St. Croix.

Several sonar-based projects have also been completed or are underway in the region. These projects cover areas too deep or too turbid to map with either aerial or satellite-based sensors. Side scan sonar has been used by the Caribbean Fishery Management Council and DPNR to map the marine conservation district south of St. Thomas along with some nearby areas to aide fisheries management. An upcoming project by CCMA-BT and partners will use multi-beam sonar to map bottom features below 20 m around the BIRNM, St. Croix and along the mid-shelf reef south of St. John and St. Thomas. The cumulative result of these and future projects will be continuous map coverage of benthic cover and bathymetry from the shoreline to deep water areas beyond the insular shelf.

Marine Protected Areas

MPAs are used as management tools to protect, maintain, or restore natural and cultural resources in coastal and marine waters. They have been used effectively both nationally and internationally to conserve biodiversity, manage natural resources, protect endangered species, reduce user conflicts, provide educational and research opportunities, and enhance commercial and recreational activities (Salm et al., 2000).

Many different types of MPAs have been established throughout the USVI to provide different levels of protection for resources based on their size, management goals, and intended purpose (Table 4.11). Over the years, the number and size of these protected areas have grown steadily, thereby providing protection to a greater proportion of coral reef ecosystems. Recently, additional marine areas have been set aside for protection through Federal and local legislation.

The BIRNM is a large coral reef national park located off the island of St. Croix. The monument, originally established in 1962 by Presidential Proclamation, included a tropical dry forest island (0.7 km^2) and 2.9 km^2 of submerged land. Created to protect the island's elkhorn coral (*Acropora palmata*) barrier reef, the original park boundaries did not fully encompass all essential coral reef habitats or the unique "haystack" formations along the north side of the reef.

When the USVI was highlighted by the U.S. Coral Reef Task Force in 1999, the Secretary of the Interior actively sought to improve protection for coral reef areas under DOI jurisdiction. In 2001, this effort resulted in two Presidential Proclamations, one expanding BIRNM by adding over 75 km^2 acres of submerged lands, and another creating the Virgin Islands Coral Reef National Monument (VICRNM) on St. John. The VICRNM contains 48.9 km^2 of marine waters adjacent to the VINP, including bank shelf and spur-and-groove reef formations, mangrove shorelines, hardbottom habitat, and seagrass beds. VICRNM is almost entirely a no-take area (fishing for baitfish and blue runner in a specified zone is allowed) and anchoring is prohibited. The BIRNM expansion not only added many of the missing and essential coral reef habitats (seagrass, sand, shallow and deep shelf-edge reefs, and deep pelagic areas), but it also made the entire park a no-take area. Anchoring at BIRNM requires a permit.

BIRNM and VICRNM are two of the four units in the National Park System that contain fully-protected marine reserves. The parks were given two years to develop new general management plans and a vessel management plan, but the expansion of BIRNM and new regulations prohibiting all extractive uses were legally challenged by the USVI territorial government. To determine if the President had the right to expand BIRNM and create VICRNM, the Virgin Islands' delegate to Congress requested that the U.S. General Accounting Office review the Presidential Proclamations. The review, which took almost 18 months, found that the Proclamations were valid. The regulations for both monuments went into effect on May 5, 2003.

Table 4.11. USVI Marine Managed Areas (MMA) and their management agencies.

TYPE OF PROTECTION	ST. THOMAS	ST. JOHN	ST. CROIX	MANAGING JURISDICTION
MPAs, Reserves and No-Take	*Cas Cay/Mangrove Lagoon Reserve*	*Small Pond at Frank Bay Wildlife and Marine Sanctuary*	*St. Croix East End Marine Park* established 2003, in early stages of implementation	USVI Government
	St. James Reserve		*Salt River Bay National Historical Park and Ecological Preserve* established 1992, expanded 1975 and 2003 by Presidential Proclamations	NPS
	Compass Point Marine Reserve and Wildlife Sanctuary			
National Monuments		*Virgin Islands Coral Reef National Monument* established 2001 by Presidential Proclamations	*Buck Island Reef National Monument* established 1962, expanded 1975 and 2001 by Presidential Proclamations	NPS
National Parks		*Virgin Islands National Park* established 1956, expanded marine portions added in 1962	*Salt River Bay National Historical Park and Ecological Preserve* * established 1992, expanded 2002 * jointly with territorial government	NPS
Spawning Aggregations	*Red hind Closure* - closed year round		*Red hind Closure* - closed December 1 - February 28	USVI
			Mutton snapper Closure - closed March 1 - June 30	Joint Federal and Territorial Government
Restricted Areas			*Altona Lagoon and Great Pond* shrimp management area, restricted gear use	Territorial Government

The most recent addition to the existing network of protected areas is the St. Croix East End Marine Park, the first territorial park designated by the USVI Legislature in January 2003. With this designation, the USVI Legislature opened the way for the establishment of a territorial network of marine parks. The St. Croix East End Marine Park is not yet functional, but an advisory committee – comprised of stakeholders from the community – developed a management plan and will be involved in the implementation and management of the park.

By far, one of the most compelling reasons for the implementation of MPAs in the USVI has been their potential use as fisheries management tools. To this end, one permanent and two temporary closures exist to protect spawning aggregations of red hind grouper and mutton snapper in St. Thomas and St. Croix (Table 4.11). These closures were prompted by the drastic decline of grouper populations in the USVI primarily caused by heavy fishing pressure during spawning season, when the groupers and snappers form large aggregations. The Red Hind Bank Marine Conservation District south of St. Thomas, USVI was closed permanently in 1999 following nine years of seasonal protection covering the red hind spawning period. Recent data indicate that enforcement of these closures have been successful because the size and numbers of fish spawning within the aggregations have increased, as have the size of fish caught in the fishery (Nemeth, in review). The implementation of the MPA resulted in a reversal of the trend of declining red hind size (Figure 4.26) and a dramatic increase in the biomass of spawning individuals (Figure 4.27).

The NPS Sea Turtle Research Program is in its 18th year of operation (2005). This critical program provides for long-term monitoring, research, and conservation of nesting hawksbill (*Eretmochelys imbricata*), green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), and loggerhead (*Caretta caretta*) turtles at BIRNM.

In 2003, the Marine Managed Area (MMA) Inventory was completed for the territory through the collaborative efforts of the NOAA, DOI, and USVI Coastal Zone Management Program. The USVI inventory is part of a U.S.-wide MMA inventory. It is currently under review and will be accessible on-line at: http:/www.mpa.gov. The database contains detailed information on each MMA and can be queried for geographic location, management characteristics, resources, level of protection, and specific restrictions.

Other Management Tools
The DFW has deployed several fish aggregating devices (FADs) in territorial waters and the adjacent Exclusive Economic Zone in order to take fishing pressure off the reefs and promote a shift to pelagic fishes (Tobias, 2001). Six FADS are currently deployed around St. Croix and three around St. Thomas. Efforts are underway to increase these numbers during 2004.

Mooring buoys have been installed throughout the territory by Federal and territorial agencies as a management tool to decrease recreational impacts on coral reefs and related ecosystems. Mooring buoys are well used by dive operators, recreational fishers and boaters. Funding has been secured by the territorial government to increase the number of mooring buoys throughout the territory, especially within the St. Croix East End Marine Park.

Outside of managed areas, fishing is regulated under Federal and territorial rules and regulations. Size restrictions exist for whelks, conch, and lobster. The harvest of goliath grouper (*E. Itajara*) and Nassau grouper (*E. striatus*), as well as the commercial harvest of billfish is prohibited. Other restrictions are in place. The territorial fishing rules and regulations are currently under review and will be revised in the near future.

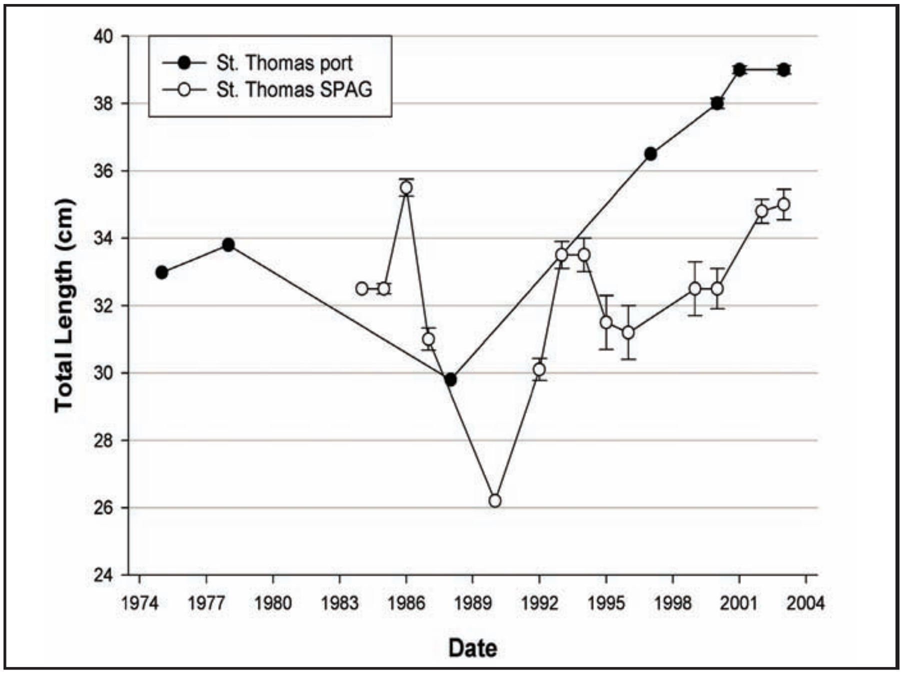

Figure 4.26. Length of red hind from fishery port surveys conducted over 30 years and from red hind spawning aggregation (SPAG). Modified from Nemeth (in review).

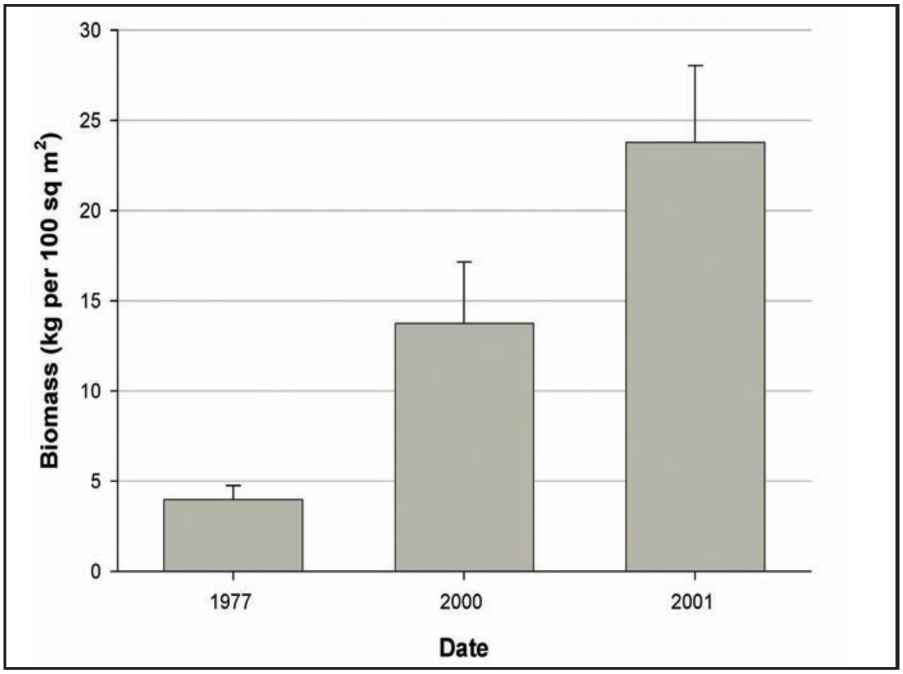

Figure 4.27. Biomass of spawning red hind at the Marine Conservation district south of St. Thomas USVI. Source: 1997 data: Beets and Friedlander (1999); 2000-2001: Nemeth (in review).

OVERALL CONCLUSIONS AND RECOMMENDATIONS
This report has identified several threats facing coral reef ecosystems in the USVI. Current assessments indicate that water quality is generally good, but it is declining because of an increase in point and nonpoint source discharges into the marine environment. Coral diseases remain abundant and epidemic, and the percent cover of coral remains low, while macroalgae abundance on reefs remains high. Dense stands of elkhorn coral that occurred on reefs during the 1960s and 1970s have not recovered to date. Likewise, populations of large-sized grouper and snapper species, which were abundant on reefs and were common in fisheries land-

ings 40 years ago, have not rebounded. Notwithstanding, the size and numbers of groupers and snappers spawning within some enforced MPAs may be increasing, which is very encouraging. Due to the existence of several MPAs, current coral reef ecosystem conditions could improve with: 1) a reduction in the number and intensity of the major threats affecting reefs; 2) enforcement of existing MPAs and laws governing resource use and extraction; and 3) increased environmental education and awareness among residents and visitors. Furthermore, coral reef ecosystems would benefit substantially from stronger coordination and collaboration among Federal and territorial agencies and NGOs that have an interest in marine conservation in the USVI.

Gaps, Problems, and Recommendations

Although the importance of MPAs has been recognized and much effort has been put into their establishment by government agencies and NGOs, a lack of enforcement of MPAs is a major problem. Minimal enforcement stems from a lack of management capacity caused by understaffed teams and limited project funding. The establishment of MPAs is meaningless unless rules and regulations governing those areas can be properly enforced. This is also true for territorial and Federal fishing regulations, which are not enforced because enforcement offices are understaffed. This issue must be addressed before additional or stricter regulations can be proposed and enacted.

Another problem caused by a lack of capacity is the absence of a flow of information between research and management programs within and among management agencies. For instance, monitoring programs have collected several years' worth of data, but analyses of these data have been delayed. Limited human resources caused by a lack of funding are a primary reason why the results and recommendations from data analyses sometimes are not available to local managers in a timely manner. Thus, management decisions concerning resource issues usually are not proactive. Additionally, research and management programs run by territorial agencies are supported mainly through funding from Federal agencies (EPA, NPS, NOAA and USGS) rather than through funding from the territorial government. Consequently, the direction and emphasis of research programs in the USVI are often directed by the programmatic mandates of non-territorial funding agencies rather than by specific resource issues that affect the territory.

The fact that several jurisdictions are involved in resource management has led to conflicts in the past. Approaches are very different among management agencies and jurisdictions, and conflicts have arisen where jurisdictions overlap. Whereas the territorial government tried to involve stakeholders and communities, the establishment of monuments and national parks has been a top-down approach. This approach has led to conflicts between managers of monuments and territorial management agencies, such as when objections were raised, and are still being raised to the 2001 presidential proclamation that expanded the BIRNM. The territory is also in need of management plans for all designated APC. As of now, these areas exist only on paper and are useful only for supporting permit decisions for coastal development. Along with efforts to address the issues here, the following actions would be very valuable in helping to manage and protect resources in the USVI. These actions include the following:

1. Establishing acceptable limits of change or carrying capacity for protected areas;
2. Training judges on adjudication of environmental issues and concerns;
3. Hiring trained environmental prosecutors (as environmental crimes are currently of low priority in the territory);
4. Shifting toward eco-tourism and increased support and promotion of sustainable and ecologically sound coastal development by the territorial government; and
5. Establishing pollution control criteria.

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