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Status of Coral Reefs in the US Caribbean and Gulf of Mexico: Florida, Texas, Puerto Rico, US Virgin Islands and Navassa

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14. STATUS OF CORAL REEFS IN THE US CARIBBEAN AND GULF OF MEXICO: FLORIDA, TEXAS, PUERTO RICO, U.S VIRGIN ISLANDS AND NAVASSA

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ABSTRACT

United States Federal funding for regional mapping, monitoring, and management of coral reef ecosystems of Florida, Texas, Puerto Rico, US Virgin Islands and Navassa increased significantly in 2000. The US Coral Reef Task Force outlined a National Action Plan, which the National Ocean Service (NOS) of NOAA (National Oceanic and Atmospheric Administration) funded some of the activities relevant to the US Caribbean and the Gulf of Mexico. Besides the NOS cooperative grants of over US\$0.6 million to assess and monitor coral reef ecosystems and to complete several projects outlined in the All Islands Initiative 'Green Book', NOS has spent several months mapping coral reefs off the US Virgin Islands and Puerto Rico. Additionally, NOS provided a further US\$1million of FY2000 funding cooperative grants for coral reef research and monitoring to the National Coral Reef Initiative (NCRI), and the Puerto Rico Department of Natural and Environmental Resources. NCRI grant projects include mapping, monitoring, and research conducted on Florida East Coast coral reef ecosystems. Puerto Rico will initiate assessments and set up at least 16 long-term monitoring sites at selected reefs around Puerto Rico, and a cooperative grant will result in a baseline characterisation of coral reef and seagrass communities off Vieques Island. The US Virgin Island grant will support a multi-agency effort among the Virgin Island Department of Planning and Natural Resources, the US Geological Survey, the University of the Virgin Islands, and the National Park Service to establish baseline conditions prior to the anticipated establishment of marine reserves so that their effectiveness in promoting recovery of fish assemblages and marine habitats can be evaluated.

The hope is that such heightened attention to coral reef issues in this region will continue into the near future, the following recommendations are proposed for regional scale action:

- Identify hydrological and ecological ecosystem linkages at regional scales;
- Establish procedures to reduce regional water quality stresses to coral reefs;
- Determine sources and sinks of marine resources on a regional scale;
- Use satellite resources to map and track watershed influences and aid in characterising the oceanographic patterns both upstream and downstream of coral reef areas;
- Establish cross-boundary and cross-jurisdictional agreements to manage reef areas using an ecosystem approach;

- Establish domestic and international agreements within a region to address coral reef issues, including protocols for marine resource management and protection;
- Establish and implement consistent research and monitoring procedures; and
- Share information that will facilitate cross-jurisdictional management of marine resources, such as when spawning aggregations of species within another jurisdiction feed larvae into the nursery areas elsewhere.

INTRODUCTION

The following report on the status of US Caribbean coral reef ecosystems has been summarised from more extensive reports submitted to the US Coral Reef Task Force (USCRTF) working group that implemented in 2000 'A National Program to Assess, Inventory, and Monitor US Coral Reef Ecosystems'. The more-lengthy reports are also the basis for the biennial-issued document, 'Status and Trends of US Coral Reef Ecosystems'. Each author is a recognised technical expert with responsibility for monitoring and/or managing aspects of their respective coral reef ecosystems.

Florida East Coast

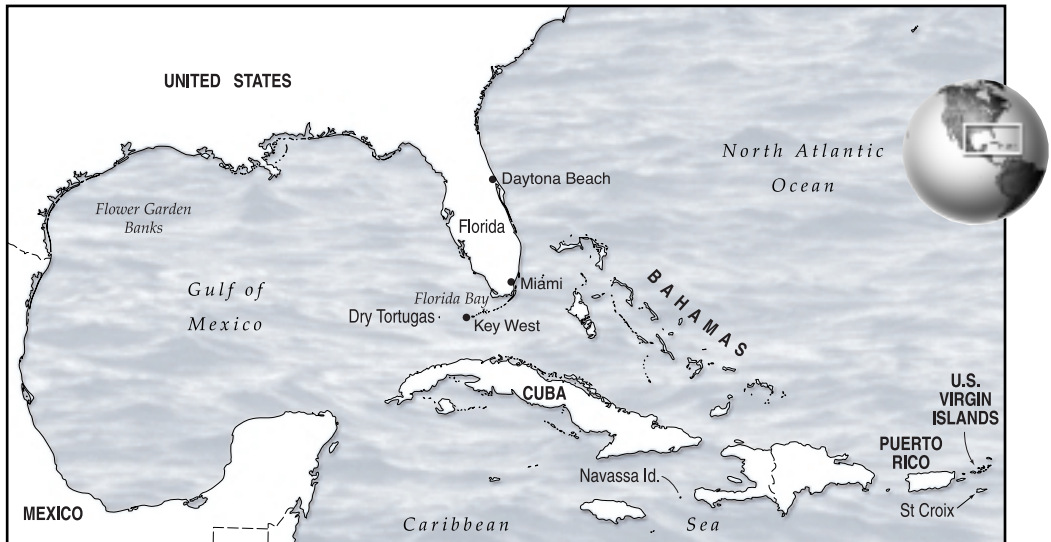
The reefs from northern Monroe County to Vero Beach are a series of 3 discontinuous reef lines parallel to the shore: First Reef to 3–5m of the surface with very low profile cover of algae and small octocorals; Second Reef 6–8m has more relief including dissecting channels and conspicuous octocorals often in high density; and Third Reef 15–22m has the most diversity and abundant stony corals including *Diploria clivosa*, *Dichocoenia stokesii*, *Montastraea cavernosa*, and *Solenastrea bourmoni*. There has been strong recruitment of *Acropora cervicornis* in the past 3 years and clusters of staghorn coral are common, especially in Broward County, along with large barrel sponges (*Xestospongia muta*). Stony corals are larger on the Third than the Second Reef and moderate sized colonies of *Montastraea annularis* complex are common. Active growth of *Acropora palmata* ceased more than 5,000 years ago on these reefs.

Most reefs have been mapped and coral cover estimated for the first two rows, but less so for the deeper Third Reef. These reefs are protected from some impacts by Florida State statutes and regulations e.g. fishing regulations, dredging permits, prohibition against harvest, sale, or destruction of corals etc., in addition, mooring buoys are being established.

Florida Keys

The Florida Keys coral reefs extend from just south of Miami to the Dry Tortugas and include the only emergent reefs off the continental United States. The Florida Keys National Marine Sanctuary was designated in 1990 to protect and conserve the nationally significant biological and cultural marine resources of the area, including critical coral reef habitats. The Sanctuary covers 9600km² with 325km² of coral reef (44% in Florida State territorial waters; 66% in Federal waters i.e. more than 3 nautical miles offshore). The reefs comprise a bank reef system of almost continuous reef communities in lines that run parallel to each another. There are several distinct habitats represented including offshore patch reefs, seagrass beds, back reefs and reef flats, bank or transitional reefs, intermediate reefs, deep reefs, outlier reefs, and sand and softbottom areas.

Texas Flower Garden Banks



These are two prominent geological features on the edge of the continental shelf in the northwest Gulf of Mexico, approximately 190km southeast of Galveston, Texas. The Banks are uplifted Jurassic salt domes, rising from 100m depth to within 17m of the surface and have about 1.4km² of luxurious bank reefs on the shallowest portions of the East and West Flower Garden Banks. These are the most northerly coral reefs on the continental shelf of North America (27°52' to 27°56' North) and also some of the most isolated reefs of the Caribbean, being over 690km from the nearest reefs of Campeche Bank off Yucatan, Mexico.

The East Flower Garden Bank (27°54'N; 93°36'W) has about 70% of the coral area, with the rest on West Flower Garden Bank (27°52'N; 93°49'W) about 22km away. These reefs have relatively low diversity of reef-building corals (21 species), probably because their isolation. The dominant coral species are *Montastrea annularis* complex, *Diploria strigosa*, *Montastrea cavernosa*, *Porites astreoides* and *Colpolphyllia natans*, but there are no branching *Acropora palmata* and *A. cervicornis*, and no sea whips or sea fans (gorgonians), which are common elsewhere in the Caribbean. Coral cover is high, ranging between 45 and 52% with crustose, coralline and calcareous green algae also common. The Flower Garden Banks are composed of large, closely spaced coral heads up to 3m in diameter and height, which are hollow in places due to bioerosion and separated by sand patches and channels. These corals grow from the top near 17m down to about 50 m.

The reefs were designated as the Flower Garden Banks National Marine Sanctuary (FGBNMS) in 1992, and Stetson Bank was added in 1996. The Sanctuary covers 143km² and includes all the coral reef areas. Regulations are designed to protect the corals with prohibitions on: oil and gas exploration; anchoring or mooring of vessels over 30m; anchoring of smaller vessels near mooring buoys; injuring or taking coral and other marine organism; use of fishing gear other than hook and line; discharging or depositing any substances or materials; altering the seabed; building or abandoning any structures; and using explosives or electrical charges.

Puerto Rico

Along with the main island, there are two inhabited small islands off the east coast (Culebra and Vieques), and three uninhabited islands (Mona, Monito, Desecheo) off the west coast. Most coral reefs occur in the east, south and west coasts, with fringing reefs being the most common type. The western two-thirds of the north coast consists of mainly hard ground and reef rock with low to very low coral cover and some small, sparse, low coral colonies. Coral reefs cover approximately 3,370km² within 3 nautical miles of the coasts, which are about 3% of the total coral reef area under US jurisdiction (Hawaiian Islands are first with 85%). The main islands of Puerto Rico, including Culebra and Vieques, are almost completely ringed by reefs, although coral reef abundance is highly variable and dependent of local conditions.

US Virgin Islands

Coral reefs occur around all the major islands; St. Croix, St. John, and St. Thomas, as well as the offshore cays. Fringing reefs, deep reefs (wall and shelf-edge), patch reefs, and spur and groove formations are present, although only St. Croix has barrier reefs. Bank reefs and scattered patch reefs with high coral diversity occur deeper offshore. The US Department of Interior, the US Department of Commerce, and the Virgin Islands Government have jurisdiction over submerged lands with coral reefs within the USVI.

Navassa

This tiny (5km²) uninhabited US protectorate, located between Jamaica and Haiti, is under the jurisdiction of the US Fish and Wildlife Service. Knowledge about the status of Navassa's reefs is extremely limited, being based primarily on several expeditions over the past 2 years sponsored by the Center for Marine Conservation.

STATUS OF THE CORAL REEFS

Florida East Coast

Reef Health

There have been no comprehensive surveys of the reefs in this area. Their general condition is similar to reefs in the Keys; relatively healthy coral populations with comparable bleaching. The only monitoring is on environmental impacts to specific sites (dredging, ship groundings, pipeline and cable deployments, and beach renourishment), and these have lasted a few years. Recent monitoring has expanded to include environmental conditions (physical and chemical oceanography), coral, sponge, and fish abundance and cover.

Florida Keys

Coral Health

Damage to reefs from human activities has been noticed for decades in the Florida Keys, including boat groundings, propeller scouring of seagrass, accumulation of debris, and improper anchoring practices, which have damaged large areas. In addition to these direct impacts, there are many indirect stresses that are affecting corals and other reef organisms. This is seen as a decrease in coral cover and species diversity and an alarming increase in coral diseases and coral bleaching along the Florida Keys. The Coral Reef/Hardbottom Monitoring Project (CRMP) is monitoring the status and trends of coral communities throughout the Florida Keys National Marine Sanctuary at 43 permanent sites. Since 1996, 73% of sites show losses in hard coral diversity with a maximum of 7 species lost, and most

sites have lost coral cover, with an overall loss of 16.4% at 9 sites. Coral diseases are becoming an increasing threat to the overall health of the reef system with over 10 coral diseases observed. Most of these are due to unknown causes, indicating an urgent research need. More and more sites contain diseased coral, and the number of species affected by disease is increasing. This increase in diseases may be directly linked to increases in seawater temperatures.

Coral Bleaching

There has been an increase in frequency and duration of coral bleaching events in the Florida Keys over the past 20 years. In June 1980, millions of reef fish died following 6 weeks of calm, hot weather, and soon after there was slight coral bleaching along the lower Keys reef tract. In June-July 1983, many corals were bleached severely from Big Pine Key to Key West during similar calm weather with warmer water temperatures. This coincided with the massive die-off of long-spined sea urchins. There were large outbreaks of black-band disease on corals in May-September 1986 throughout the Florida Keys, concentrated at the Looe Key National Marine Sanctuary, but coral bleaching was minor. Similar doldrum-like weather in June 1987 triggered severe coral bleaching which lasted 3 weeks. Slight bleaching was seen in 1989, before the advent of more calm weather in July 1990 provoked massive coral bleaching including coral communities in the near-shore waters for the first time. These corals were considered to be acclimatised to wide temperature variations, but the extremes of the summer of 1990 pushed them beyond their previous limits. Sanctuary biologists and managers documented 65% losses of *Millepora* corals at Looe Key Reef. Prior to this only a few percent of corals had died after bleaching episodes.

The next major coral bleaching was in 1997 during the same calm weather patterns with widespread bleaching of inshore coral communities. The following winter was mild and also the spring of 1998, so water temperatures remained high and bleaching virtually continued into the summer of 1998, when it was again severe. Then Hurricane Georges and Tropical Storm Mitch hit the Florida Keys while the corals were still stressed and large amounts of living coral cover was lost on some shallow reefs as a result of these combined impacts. These losses of corals have highlighted the importance of continued monitoring to improve management strategies to maintain coral health.

Research & Monitoring Programmes

The Sanctuary implemented a comprehensive monitoring programme in the Florida Keys reef. The largest component is the Water Quality Protection Program (WQPP) which began in 1994 with 3 components: water quality; corals and hardground communities; and seagrasses. The status of reef fishes, spiny lobster, queen conch, benthic cover, and algal blooms are also monitored at fixed stations. The Zone Monitoring Program monitors the effects of no-take management, which began in 1997 at 23 discrete marine reserves. The goal is to determine by 2002 whether the no-take zones are protecting marine biodiversity and enhancing human values related to the Sanctuary. Measures of effectiveness include the abundance and size of fish, invertebrates, and algae; and economic and aesthetic values of Sanctuary users and their compliance with regulations. This is a three-level program which includes monitoring changes in ecosystem structure (size and number of invertebrates, fish, corals, and other organisms) and function (such as coral recruitment, herbivory, predation). Human uses of zoned areas are also being tracked.

Water Quality

The Water Quality Protection Program of the Sanctuary has assessed the status and trends in a range of water quality parameters at 154 sites in the Florida Keys, Florida Bay, and western Florida shelf since 1995. These show higher nutrient concentrations in the Middle and Lower Keys than in the Upper Keys and Dry Tortugas regions, and declining trends inshore to offshore for nitrite, nitrate, and ammonium. There have also been significant increases in phosphorous.

Algae, Seagrasses, and Benthic Organisms

Rapid, large scale sampling of benthic communities along the Florida Keys National Marine Sanctuary began in 1998 at 80 sites, with 34 in no-take zones compared to others in fished reference areas. Algae were the dominant bottom cover at all sites (average cover above 75%) with fine and thick turf algae, brown fleshy algae and green calcareous algae dominating deep water sites, and calcareous algae such as *Halimeda* spp. dominant in shallower sites. Sponges and soft corals were abundant, but variable at all deep and shallow sites due to the impacts of Hurricanes Georges and Floyd in 1998 and Hurricane Irene in 1999. The cover and abundance of seagrasses has also been shown to vary.

Texas Flower Garden Banks

Reef Health

These are probably the least disturbed coral reefs in the Caribbean and western Atlantic i.e. in nearly pristine condition as they sit in clean oceanic waters with exceptional visibility of around 30m, and stable temperatures (minimums in February 19°-20°C; maximums in August 29°-30°C). Since the early 1970s, the coral communities have not changed and appear in excellent health. There is isolated damage from anchoring of vessels, laying of tow cables and seismic arrays and the impact of illegal fishing gear. Some of the targeted fish populations may have been reduced as anecdotal reports from the 1970s mention large populations of snapper, jewfish and other grouper. Like other reefs, these experienced significant increases in algal cover within 2 years of the die-off of the long-spined sea urchin (*Diadema antillarum*) in 1983, but unlike other reefs, the algal populations returned to earlier levels with apparent increases in other herbivores. There is periodic coral bleaching, but it is usually minor with little mortality. Bleaching during the summer of 1998 was slightly higher, but was still less than 5% of the entire reef, with mortality of less than 1%. Predation of living coral by parrotfish is commonly observed with no apparent long-term consequences.

In 1989, the National Oceanic and Atmospheric Administration (NOAA) and the Minerals Management Service (MMS) established long-term monitoring of coral cover, relative abundance, diversity, and coral growth rates and health. This enhanced another long-term study of the benthic community started in 1972 that assessed the potential impact of oil and gas development in the area. Other studies have included reef fish counts, coral spawning, recruitment and genetic observations. Coral health and cover has been stable since 1972 at an average of 47% with higher cover of 52% (54% on East Bank; 50% on West Bank) on the reef cap. Other components are bare rock (45%), algae (3%), sponges (2%) and sand (<0.1% -outside sand channel areas). *Montastrea annularis* is the dominant species (29%), followed by *Diploria strigosa* (9%), *Porites astreoides* (5%), and *Montastrea cavernosa* (4%). No bleaching was observed in 1996, and in 1997 less than 2% bleaching

was seen on both banks, and a very low incidence of coral disease. Bleaching in 1998 was less than 5% for both banks.

Puerto Rico

Coral Health

The dominant bottom cover of the shallow reefs (1-5m) was algae, ranging from 31.8% to 82.1% (mean 65%) and live corals varied from 48.9% to 3.7% (mean 15.5%). The dominant bottom cover at 6-12m was algae (28.2-98%) and live coral (0.6 - 49.1%). On deeper reefs (15-25m), coral cover varied from 0% to 44%. A total of 228 coral species, including 117 scleractinian (stony) corals, 99 soft corals and gorgonians, 13 corallimorphs, 3 fire corals, and 5 hydrocorals have been reported, such that the coral reefs of Puerto Rico are the best developed in the US. Caribbean. Generalisations about reef health are difficult because there are few long-term monitoring data, but it is obvious that reefs near the main island have been damaged because of their close proximity to coastal developments. Coral reef research at 52 reefs during the past 10 years has focused on community studies and monitoring programmes to select areas for marine reserves and long term data sets are available for only a few reefs from 1984 to 1999. Several monitoring programmes are underway to document changes in the community structure.

Coral Diseases

Mass mortalities of corals and other reef organisms have been seen in Puerto Rico e.g. white and black band disease destroyed large areas of corals in 1979 and mass mortalities of sea urchins in 1983, but the urchins have since reappeared. Whereas the brain corals were affected by an outbreak of the White Plague in 1996 less than a month after Hurricane Hortense.

Coral Bleaching

There was massive coral bleaching in the late 1980s with considerable mortality, and there was also major bleaching in 1998, followed by major recovery with very little mortality (see Chapter 1).

US Virgin Islands

Coral Health

An array of stresses has degraded the coral reefs and other marine ecosystems, as well as the fishery resources. Among the natural stresses are 8 hurricanes that caused conspicuous damage to USVI reefs in the last 20 years, and coral diseases that have caused coral losses on all 3 islands, especially in 1997 off St. John. Anchoring and ship groundings on coral reefs and seagrass beds are examples of acute stresses with immediate, and sometimes long-term effects. Dredging, sand extraction, groyne construction and sewage effluent have affected reefs, especially around St. Thomas and St. Croix. Throughout the islands, chronic stresses like over-fishing (commercial, hand-line, trap fishing, spear fishing, net, long-line, trolling, driftnet), point and non-point sources of pollution, and sedimentation from accelerated runoff after land clearing are harder to quantify and track, but may do the most damage. Moreover, many of these stresses can combine with natural disturbances to accelerate damage to reefs or slow their rate of recovery. Over-fishing has markedly reduced resources, including those within Virgin Islands National Park (VINP) and Buck Island Reef National Monument (BUI). Reports from 20 years ago suggested that fishing was already changing the reef fish populations, even before developments on land caused

extensive loss of habitat as well coral diseases, hurricanes, and other stresses. Fisheries are close to collapse, with even areas within the boundaries of 'marine protected areas' are deteriorating. Existing zoning, erosion control, and fishing regulations are not providing sufficient protection against this unprecedented combination of natural and human stresses.

Coral Diseases

These have caused extensive mortality on reefs around St. John and St. Croix. Corals around Buck Island experienced less disease than those around St. John, except for white band disease. Recent measures show the incidence of disease on corals to be 5.4% (St. Thomas), 5.6% (St. John) and 2.0% (St. Croix). The branching *Acropora palmata*, *A. cervicornis* are the most vulnerable to storm damage and are also susceptible to white band disease e.g. the impressive cover of *A. palmata* on Buck Island fell from 85% in 1976 to 5% in 1988. Only 6 living *A. palmata* colonies were found on Haulover Bay, St. John in 1999, where previously there had been impressive stands. Small patch reefs of *Porites porites* died in many bays, around St. John, St. Thomas, and St. Croix, possibly from an undetected disease, and some have been dead for over 12 years. Gorgonians have been killed by a fungal disease (*Aspergillus sydowii*), which coincided with strains of the fungus isolated from African dust carried over the Caribbean.

Coral Bleaching

There was extensive coral bleaching in 1998, but mortality was relatively minor. Bleaching on Newfoundland and Lameshur Reefs, St. John was 43% and 47%, and 41% on Caret Bay reef, St. Thomas during the hottest summer seawater temperatures on record. All corals that bleached at Buck Island recovered, but only 50% of bleached colonies of *Montastraea* on Saba Island, St. Thomas had fully recovered their pigmentation 6 months later. There was previous bleaching in 1987 and 1990 around St. John.

Navassa

Reef Health

The shallow reefs of Navassa have high live coral cover and a high degree of architectural complexity, which is particularly valuable as reef fish habitat. There is also a high abundance of small, newly recruiting corals and extremely low incidence of coral diseases, which suggests that the benthic reef communities are 'healthy'. At least 36 hard coral species are reported from 4 sites along the west (lee) coast. Octocorals were less varied with 12 species. Mean percent cover of live coral ranged from 20 to 26.1% for 4 sites along the west coast. Other major community components (in terms of space occupation) were sponges (7-27%), fleshy brown algae (10-24%), and crustose coralline algae (5-16%). Finally, the keystone grazing urchin, *Diadema antillarum*, was moderately abundant in all sites e.g. 2.9 urchins per 30 m² belt transect.

STATUS OF CORAL REEF FISHES AND INVERTEBRATES

Florida East Coast

Reef Fish

Recent observations indicate that some of these reefs are in relatively good condition based on corals and fish populations. The Florida Current (Gulf Stream) often influences these reefs (particularly the reefs off Palm Beach County). The current moderates winter

temperature and on occasion brings algal blooms over the reefs. During cold-water upwelling events there are also reef fish kills. In summary, these reefs are in similar condition as those in the Keys.

Florida Keys

Reef Fish

Over 500 fish species have been identified from the Florida Keys, with 180 being reef fish. Fish monitoring of 263 species began in 1979, and monitoring results indicate that over 59% of all fish come from 10 species. The bulk of the biomass was from a few species, namely bluehead wrasse, bicolor damselfish, tomtate, sergeant major, striped parrotfish, yellowtail snapper, bluestriped grunt, white grunt, masked goby, and French grunt. Other species of large fish seen are tarpon, barracuda, gray snapper, Bermuda chub, stoplight parrotfish, smallmouth grunt, and yellow goatfish. The most significant observations have been that there are relatively few individual fish of legal, harvestable size, confirming other data indicating that reef fish are over-exploited. Data show that 13 of 16 groupers, 7 of 13 snappers, one wrasse, and 2 of 5 grunts are over-fished in the Florida Keys and such non-sustainable fishing practices are changing fish trophic structures on the reefs and leading to reduced reproductive capacity.

But the news is not all bad. Fish numbers in the no-take areas are increasing and the numbers of target reef fish per are higher in no-take Sanctuary Preservation Areas than in fished reference sites. There has been an overall increase in abundance of 4 species of snapper (*Lutjanidae*) and hogfish (*Lachnolaimus maximus*) at 7 of 9 areas after the establishment of the no-take zones in 1997. Commercial fishing is one of the largest industries in the Florida Keys and is heavily regulated through annual catch quotas, closed seasons, gear restrictions, and guidelines which set minimum catch sizes. State and Federal fisheries management councils have developed laws and the State collects catch information on 400 species of fishes, invertebrates and plants in order to follow trends.

Invertebrates

Populations of spiny lobster (*Panulirus argus*) are now more abundant and larger in protected areas than in similar sites outside. However, queen conch populations (*Strombus gigas*) continue to decline in both no-take areas and reference sites despite a cessation of harvesting by commercial and recreational fishermen in the mid-1980s. Attempts are underway to supplement wild populations with laboratory-reared stock. Populations of the black-spined urchin (*Diadema antillarum*) have shown poor recovery since the die-off in 1983. So far 62 hard coral species and 90 species of algae have been identified in the Florida Keys, as well as 38 species of sponges, 33 species of polychaete worms, 82 species of echinoderms, two species of fire coral, and 42 species of octocoral.

Texas Flower Garden Banks

Fish Health

Fish diversity on the very isolated Flower Garden Banks is low compared to other Caribbean reefs (approximately 260 fish species), but abundances are high. The fish population includes both resident tropical species and migratory pelagic species. Some of the most abundant species at all three banks are butterflyfish (*Chaetodon sedentarius*), Spanish hogfish (*Bodianus rufus*), bluehead wrasse (*Thalassoma bifasciatum*), brown chromis

(*Chromis multilineata*), bicolor damselfish (*Stegastes partitus*), creolefish (*Paranthias furcifer*), and sharpnose puffer (*Canthigaster rostrata*). The banks are a year-round habitats for manta rays and whale sharks, and serve as a winter habitat for several species of sharks and juvenile loggerhead sea turtles. Anecdotal information suggests that populations of the major target fish (snapper and grouper) have declined.

Puerto Rico

Fish Health

There is no large-scale commercial fishing, but there are modest artisanal fisheries with clear evidence of over-fishing (reduced total landings, declining catch per unit effort, shifts in catch to smaller sized individuals and recruitment failures). Reef fisheries have plummeted with a reduction of 69% in fish landings from 1979 to 1990. The catch in 1996 was 1,640mt of fish and shellfish, valued at US\$7.06 million for the artisanal fisheries. There is an absence of large fish predators, and parrotfishes, which has stimulated a proliferation of damselfishes (e.g. *Stegastes planifrons*) which farm algae and inhibit coral growth. Persistent fishing pressure on spiny lobster has reduced their abundance, with a parallel increase in their favourite prey, coral eating molluscs, which are now affecting *Acropora palmata* populations in the southwest of Puerto Rico. There are approximately 800 species of coral reef fishes, but there are no endemic species.

US Virgin Islands

Fish Health

It is difficult to separate out the effects of mangrove, seagrass bed and reef loss from the effects of over-fishing. Degradation of these habitats has undoubtedly contributed to the significant changes in reef fish populations, but there is also clear evidence of heavy fishing pressure with reduced stocks even within the national parks. Existing regulations have failed to protect reef fishes or return populations of large groupers and snappers to natural levels. Enforcement is poor e.g. over 50% of traps did not have the mandated biodegradable panels to allow fish to escape if traps were lost. However, it is unlikely that full compliance with existing regulations will reverse these alarming trends. Queen conchs used to be very abundant around St. John, but populations are decreasing and density of conchs inside the Virgin Islands National Park are no higher than outside. Normally conchs live in seagrass beds, but this habitat has been reduced greatly as a result of hurricane and anchor damage. Similar estimates show decreases in the average size of lobsters since 1970.

Navassa

Fish Health

Despite its remoteness, an active artisanal fishery (primarily using traps and hook and line) by Haitians is the primary human stress to Navassa reefs. Subsistence fishing is allowed under Wildlife Refuge regulations, nevertheless, shallow reef fish communities have high density (range 97-140 fish/60m²) with healthy populations of large snapper, grouper, and herbivores, which are largely absent in nearby Caribbean locations with high fishing pressure.

ANTHROPOGENIC THREATS TO CORAL REEF BIODIVERSITY

Florida East Coast

There are varied and chronic stresses from this extremely urbanised coast. Dredging for beach renourishment, channel deepening and maintenance have significantly reduced water quality, smothering corals and other invertebrates and lowering productivity e.g. Boca Raton and Sunny Isles. Recreational usage can be extreme especially in warmer months, with clear evidence of fishing gear impact and anchor damage. Shipping from the large ports (Miami, Port Everglades, and Palm Beach) means that ships frequently run aground or anchor on reefs. Ocean outfalls pour large volumes of secondary treated sewage into the coastal waters.

Florida Keys

The major threats to the coral reefs stem from over 4 million annual visitors and 100,000 residents in the Florida Keys. The population of Monroe County has grown by 160% during the past 40 years, and this trend is expected to continue, with estimated increases of 65% over the next 20 years. Similarly, the number of registered private boats has increased over 6 times since 1965. Most visible damage in the last 20 years has been from direct human impacts such as grounding boats in coral, seagrasses, or hardbottom areas, breaking and damaging corals with ship anchors, destructive fishing methods, and divers and snorkelers standing on corals. Boat propellers have permanently damaged over 12,000ha of seagrasses, and over 500 small boat groundings are reported annually in the Florida Keys National Marine Sanctuary. Large ships have been responsible for damaging or destroying over 10ha of coral reef habitat.

Indirect human impacts are significantly affecting the coral reefs with eutrophication in nearshore waters a major documented problem. Wastewater and stormwater treatment, and solid waste disposal facilities are inadequate in the Keys. In Florida Bay, reduced freshwater flow has resulted in plankton bloom increases, sponge and seagrass die-offs, fish kills, and the loss of critical nursery and juvenile habitat for reef species, which affects populations on the offshore coral reefs. Other indirect pressures on reef resources include serial over-fishing that has dramatically altered fish and other animal populations. It is critical to reduce these impacts if the Florida Keys economy, largely based on the coral reefs, is to be sustained. Tourism is the number one industry, with commercial and recreational fishing also being important with annual contributions of US\$57 million and US\$500 million respectively.

Texas Flower Garden Banks

Physical damage from vessel anchoring, potential water quality degradation, impacts of fishing and fishing related activities, and impacts from oil and gas exploration and development are the primary anthropogenic threats to the coral reefs. Anchors from large ships have devastating local impacts with some clear examples, including foreign-flagged cargo vessels unaware of anchoring restrictions. This continues to be a problem, as the National Marine Sanctuary regulations are not included on foreign navigational charts. Potential pollution sources include coastal runoff, river discharges and effluent discharges from offshore activities such as oil and gas development and marine transportation. Oxygen-depleted or 'hypoxic' bottom waters occur in large areas of the northern Gulf (16,500km²) from the Mississippi delta to the Texas coast. Though not currently in proximity to the Flower Gardens, these could potentially influence resources on the Banks.

Puerto Rico

The present status of Puerto Rican coral reefs is amongst the most critical in the Caribbean, due to accelerated urban and industrial coastal development during the last 40 years combined with a lack of effective management of these resources. Massive clearing of mangroves, dredging of rivers for sand and harbours, runoff from large scale agricultural developments, deforestation in large watersheds, raw sewage disposal and power plants are all important factors stressing the coral reefs. Other major anthropogenic activities include oil spills, anchoring of large oil cargo vessels, over-fishing, uncontrolled recreational activities, eutrophication, and military bombing activities (at Vieques and Culebra Islands). The coastal waters are monitored and evaluated for direct human and indirect human health problems.

US Virgin Islands

Destruction from boat anchors and from boats running aground on reefs has been severe on St. John's reefs. The worst was the cruise ship *Windspirit*, which destroyed 283m² of reef in 1988, with no recovery 10 years later. Small boats frequently run aground on shallow reefs, destroying corals, particularly elkhorn coral making them more susceptible to storm damage and white band disease. Critical habitats have been damaged by anchoring gear, and deployment of fish traps on coral reef areas. Most coral breakage occurs during major hurricanes, however chronic coral damage occurs at areas of high recreational use by snorkelers and divers. On St. Croix, many popular snorkel and dive sites experience heavy visitor use (100-200 visitors/site) on days when cruise ships are in port e.g. Cane Bay, Davis Bay, Buck Island Reef NM, Carambola, Protestant Cay and Frederiksted beaches. The intensive use of the underwater trail at Buck Island Reef National Monument shows damage from snorkelers.

Navassa

Fishing is the only anthropogenic threat to Navassa reefs and this is unlikely to change.

CURRENT AND POTENTIAL CLIMATE CHANGE IMPACTS

Florida

The principal natural environmental controls in this area are hurricanes, severe storms, winter cold fronts, cold-water upwelling, and ground water effects. The assumed climate change scenario is for warmer waters, rising sea levels, more frequent and stronger hurricanes. This will probably cause significant changes to the reefs, including more bleaching. Rising sea levels will flood coastal areas and introduce water quality problems. Therefore, management strategies must focus on alleviating the controllable, anthropogenic impacts while working toward legislation and policy that will address global emissions in the long-term.

Texas Flower Garden Banks

There are no anticipated problems, as the location and depth of these reefs buffer them from the short-term effects of global warming and climate change. However, if summer water temperatures approach or exceed 30°C on a more consistent basis, the current minor incidences of bleaching will probably increase in severity.

Puerto Rico

Current levels of natural factors (hurricanes, coral bleaching, coral diseases) are resulting in considerable coral reef degradation which may mask any signals from climate change.

US Virgin Islands

Hurricanes David (1979) and Hugo (1989) caused severe destruction on the reefs in the USVI, and recovery has been very slow due to subsequent hurricanes in 1995, 1998 and in late 1999. Any increases in these hurricane events (as predicted by many climate models) will inhibit the recovery of elkhorn coral at some places around St. John, St. Thomas and, St. Croix.

Navassa

There is very little ecological information on Navassa reefs, and hence no basis for assessing trends in current and potential climate change impacts.

CURRENT MPAs AND MANAGEMENT CAPACITY

Florida East Coast

There are no MPAs in this area; however, the Biscayne National Park and the Florida Keys National Marine Sanctuary are immediately south. There is an *Oculina* MPA in the far north, established to protect the coral from dredging, trawling and long-line fishing gear damage. A suggested goal of the US Coral Reef Task Force is to declare 20% of all US coral reef ecosystems as MPAs as a wide swath from the intertidal to the state boundary, protecting all species from harvest.

Florida Keys

With the designation of the Florida Keys National Marine Sanctuary in 1990, the entire coral reef tract of the Florida Keys was afforded some level of protection, with oil exploration, mining, and large shipping traffic being excluded. Anchoring on or touching corals in shallow water is prohibited, as is collecting living or dead coral and harvesting 'live rock' for the aquarium trade. Potential pollution sources from outside the Sanctuary that have impacts within can be controlled. After 6 years, a management plan was implemented with strategies for conserving, protecting and managing the significant natural and cultural resources of the Florida Keys marine environment based on an overall ecosystem approach. There are several marine zones to protect specific reef areas more intensely e.g. 23 no-take zones, which cover less than 1% of the Sanctuary but protect 65% of shallow coral reef habitats and were implemented in 1997. Most of the smaller zones (Sanctuary Preservation Areas) are on the offshore reef tract in heavily used spur and groove coral formations. The 31km² Western Sambo Ecological Reserve protects offshore reefs and mangrove fringes, seagrasses, productive hardbottom communities and patch reefs. The Sanctuary is planning to create a new ecological reserve in the Tortugas (far west Florida Keys), which will increase the total protection of coral reefs within the Sanctuary to 10%.

Texas Flower Garden Banks

The Sanctuary protects the fragile ecosystem from threats posed by anchoring, oil and gas development and destructive fishing techniques. Sanctuary staff direct resource protection, education, research, and enforcement efforts. There is also an ongoing long-term

monitoring programme. Additional protection is provided by the Minerals Management Service through requirements imposed on industry operators such as the 'Topographic Features Stipulation' for the Flower Garden Banks.

Puerto Rico

The Department of Natural and Environmental Resources (DNER) has designated 8 Special Planning Areas (including all mangroves) and 23 coastal and marine natural reserves. Management plans for these have been developed to contribute to coral reef protection and management. Guidelines and funding under Section 6217 of the Coastal Zone Management Act will be provided in late 2000 to control non-point sources of pollution. A Natural Protected Areas Strategy has been prepared and includes a MPA Sub-system with guidelines for important coastal area and resources identification, management and protection. The new Action Plan maintains the original objective of addressing the lack of information and adequate management of coral reefs. Puerto Rico has completed coral reef assessments for Jobos Bay, Caja de Muerto, Guanica, Tourmaline, and Fajardo with 15 permanent monitoring transects established per site. A joint community and government initiative aims to undertake long-term monitoring of these sites. The Puerto Rico Coastal Zone Management Program has established an inter-agency Coral Reef Committee and it is compiling historic and new information on the coral reefs using a centralised data management system to facilitate the exchange of information. The first Natural Reserve in Culebra now incorporates 'No Take Zones'. A 'Marine Reserve' around Desecheo Island was added to the 23 existing Coastal Natural Reserves. New and revised laws and regulations for the protection of coral reefs, fisheries, and related habitats have been approved and the coral reefs in Puerto Rico are now being thoroughly mapped.

US Virgin Islands

- Hind Bank Marine Conservation District - a seasonal federal closure was enacted at the Red Hind spawning site off St. Thomas in 1990, and improvements in the fishery were documented. In November 1999, the closed area was designated a marine reserve with all fishing and anchoring prohibited;
- Buck Island Reef National Monument (BUIS) was designated in 1961 to protect 280ha around Buck Island, including the reef system. The eastern 66% is a no-take zone including most of the barrier reef, and limited fishing is allowed in the rest. No spearfishing is allowed anywhere in the Monument, but illegal trap fishing occurs throughout, and all types of fishing occur immediately outside the boundary of the Marine Garden. Due to inadequate enforcement and the lack of a buffer area, there has been no effective protection of fish populations;
- Virgin Islands National Park (VINP) occupies 56% of the 48km² island of St. John and 2,286ha of the surrounding waters. Traditional fishing with traps is allowed in the park, although illegal commercial fishing is occurring. No fishing, including spearfishing, is allowed in Trunk Bay, the site of an underwater trail;
- Salt River Bay National Historical Park and Ecological Preserve, this park and reserve has 160ha of land and 245ha of water to the 100m depth, including the marine resources of the Salt River Bay, Triton and Sugar Bays. (Omnibus Insular Areas Act of 1992. 16 USC 410tt).

THE TORTUGAS ECOLOGICAL RESERVE: PROTECTING OCEAN WILDERNESS

The Tortugas reefs boast the healthiest coral and highest water quality in the Florida Keys region. These reefs, which lie 120km west of Key West, also contain a diversity of fishes and other organisms that are not seen elsewhere in the Keys. Some populations may contribute a major source of fish and lobster larvae for the rest of the Florida Keys. The Florida Keys National Marine Sanctuary (FKNMS) is working with the State of Florida, the Gulf of Mexico Fishery Management Council, and the National Marine Fisheries Service to preserve the richness of species and health of fish stocks in the Tortugas. The threats to these resources include commercial and recreational fishing, anchoring by freighters, and high visitor levels. A 400km² 'no-take' ecological reserve was proposed for the remote western part of the sanctuary that would protect important spawning areas for snapper and grouper and deepwater habitat for other commercial species.

The Sanctuary convened a 25-member Working Group of commercial and recreational fishers, divers, conservationists, scientists, concerned citizens, and government agencies in 1998 to assist in designing the reserve. They used a series of public meetings and socioeconomic and resource evaluations to examine the whole ecosystem, and then recommended alternatives based on this information. In May 1999, the Working Group reached a consensus on proposed boundaries and regulations for the reserve. In June 1999, the Sanctuary Advisory Council unanimously approved their proposal. A Draft Supplemental Environmental Impact Statement (SEIS) for the proposed reserve was then released which detailed the alternatives considered. Over 4000 comments from locals, residents elsewhere in the USA and from around the world were received on the Draft SEIS, and the vast majority of strongly endorsed the concept of an ecological reserve in the Tortugas. This support was a good demonstration of value of having diverse stakeholder involvement in the planning process and the strong sense of ownership for the proposed plan. Currently, responses are being prepared to address public comments received on the Draft SEIS.

The USVI Government has also designated Marine Reserves and Wildlife Sanctuaries (Salt River, Cas Cay/Mangrove Lagoon and St. James) where fishing is allowed only with handlines or for baitfish with a permit (St. James).

Navassa

This island is part of the US Fish and Wildlife Service's Caribbean Islands National Wildlife Refuge.

GOVERNMENT POLICIES AND LEGISLATION

East Coast Florida

Policies on environmental impacts of dredging, fresh-water management, and nutrient input should receive attention. Vessel anchorages off Miami, Port Everglades and Palm Beach should be reviewed and changed to provide maximum protection for the reef system.

Texas Flower Garden Banks

Regulations governing the FGBNMS under the National Marine Sanctuaries Act, as amended, 16 U.S.C. 1431 are contained within the Code of Federal Regulations and can be viewed on the web at: <http://www.sanctuaries.nos.noaa.gov/oms/pdfs/FlowerGardensRegs.pdf>.

US Virgin Islands

The US Department of Interior, the US Department of Commerce (including NOAA and the Caribbean Fishery Management Council), and the USVI Government all have policies, laws and legislation relating to coral reefs in the USVI. The Code of Federal Regulations Title 36 and the enabling legislation for Virgin Islands National Park and Buck Island Reef National Monument relate to reefs in the national parks. The Caribbean Fishery Management Council has Reef Fish and Coral Reef Management Plans with regulations pertaining to federal waters. Title 12 of the Virgin Islands Code presents environmental laws and regulations of the Virgin Islands. Several specific Acts relate to regulations on corals, fishing, etc.

Navassa

A 12-mile fringe of marine habitat around Navassa (estimated at 134,000ha) is under US Fish and Wildlife management. Refuge policies allow subsistence fishing.

GAPS IN CURRENT MONITORING AND CONSERVATION CAPACITY

Florida East Coast

There is no comprehensive and systematic monitoring programme for these reefs, yet one is needed to provide a baseline assessment. Site selection should ensure that representative habitats and unique sites are mapped and monitored. This will require that a selection committee of academic, county, state, conservation and fishing groups be constituted, and decisions rapidly disseminated for public discussion.

Florida Keys

Current monitoring in the Sanctuary has focused largely on detecting changes in designated no-take zones and establishing the status and trends in corals, seagrasses, and water quality. Such monitoring must continue in the short-term until solid baseline data are obtained. This baseline will assist in detecting possible long-term changes in communities that may result from management practices (e.g. zoning) or from massive restoration efforts soon to be implemented in south Florida's Everglades.

Texas Flower Garden Banks

Recent observations of increased algal abundance highlight the need to improve water quality monitoring and assess currents and water circulation. The monitoring should include studies on algal populations, coral diseases, and extend to deeper coral reef communities. The great distance of the Sanctuary offshore makes surveillance and enforcement more difficult. Currently, the Sanctuary does not own a boat and relies on charter vessels to get to the area. Recent indications that the Banks may be important spawning areas for several grouper species highlight the need to create a marine reserve to protect the biodiversity of this area.

US Virgin Islands

Some of the longest data sets on coral reefs in the Caribbean come from a diverse array of ongoing monitoring activities. However, intensive, long-term monitoring has only been conducted at a few sites around St. Croix and St. John, with less information for St. Thomas. Coral reef monitoring needs to be extended to include a wider variety of coral habitats and more sites to provide managers with critical information to enable further protection and preservation of key reef areas. Very little is known of the deeper reefs around the USVI especially in the critical grouper and snapper spawning aggregation sites along the shelf edge. Some of these reefs have exceptionally high coral cover. Little is known about the interactions among reefs, mangroves and seagrass beds and how the deterioration of mangroves and seagrass beds contributes to the degradation of coral reefs. All agencies involved in coral reef monitoring suffer from a shortage of staff, and enforcement of regulations has been limited. The Code of Federal Regulations states that commercial fishing is prohibited 'except where specifically authorised by Federal Statutory law'. However, commercial fishing is occurring in the waters of Virgin Islands National Park and Buck Island Reef National Monument.

Navassa

There is no monitoring program ongoing nor even planned for Navassa reefs, nor the artisanal fisheries. This presents an important opportunity to assess the impacts of artisanal reef fisheries in the absence of other direct anthropogenic effects.

CONCLUSIONS

Florida East Coast and Keys

These coral reefs are in a rapid and unprecedented state of declining health, signalling that habitats in the ocean are responding to high human stresses over 4 decades. Corrective actions are required at all levels of national governments; this further emphasises the importance of the US Coral Reef Task Force. National and State leaders in the United States are paying closer attention to the problems confronting coral reefs, but it will take continued commitment and dedication for coral reefs to be protected and conserved for future generations. While there is a fine line between being an alarmist and a strong advocate for coral reef protection and conservation, decisions by people at the local level will have the greatest influence on the survival of coral reefs. It is not too late to take action and it is imperative that people continue to seek solutions to the problems which affect coral reefs. Coral colonies fragmented during Hurricane Georges in 1998 are re-establishing in the Florida Keys National Marine Sanctuary, indicating that the strong regeneration capacity of the reefs will result in recovery of these damaged reefs, provided that the major human stresses (pollution, sedimentation, over-fishing, and physical impact damage) are controlled. 2000 has been a good year for recruitment of staghorn coral (*Acropora cervicornis*), which indicates that management interventions can help coral reefs survive.

The following are recommendations for action in the Florida Keys that if implemented along with other local recommendations could have significant positive impacts on a regional scale:

- Map the benthic habitats of the coral reef community;
- Establish minimal water quality standards that exceed those of existing legislation;
- Eliminate sources of nutrients entering nearshore waters, and sources of heavy metal pollution near coral reefs;
- Protect and conserve all marine habitats;
- Establish 'no take' ecological reserves in strategically well-sited areas;
- Determine sources and sinks of marine larvae at local scales;
- Implement research and monitoring programmes to detect change and sources of change;
- Detect 'hot spot' areas of coral diseases at a local scale;
- Implement education and outreach programmes that focus on problems and solutions;
- Implement an enforcement program or determine alternative means of achieving compliance;
- Learn and monitor the socioeconomic aspects of the area and use these data to support management actions; and
- Form knowledgeable Advisory Groups of local resource users, conservation groups, scientists, and educators to provide information and personal experiences and observations to managers.

US Virgin Islands

There is compelling evidence that more marine protected areas need to be established in the USVI, specifically a 'marine reserve' that prohibits recreational and commercial uses that cause damage and restricts development of adjacent shorelines. This is essential to allow the recovery and replenishment of the fishery and benthic resources. There is irrefutable evidence that additional regulations and enhanced enforcement of existing regulations are necessary to reverse serious decline and degradation in the marine resources. Resource managers from the local government and National Park Service have expressed an interest in establishing marine reserves to protect functional reef ecosystems, to allow their recovery where damage has occurred; to allow recovery of fish assemblages.

- The USVI need management plans for all designated Areas of Particular Concern (APCs);
- There is an urgent need to designate 'no-take' areas (e.g. Lang Bank, Salt River, Buck Island ecosystem);
- The USVI Government needs to become more effective at enforcing existing environmental regulations;
- More stringent environmental regulations need to be created (e.g. no gill-netting, no spearfishing); and
- Environmental education for residents and visitors needs to be improved and extended.

In conclusion, we recommend the establishment of marine reserves in the USVI as soon as possible to reverse the alarming declines and degradation in fishery and benthic resources. Establishment of such recovery zones will be a start in implementing the National Action Plan to Conserve Coral Reefs that was officially adopted in March 2000.

Navassa

The presence of a relatively intact Caribbean reef could provide a unique opportunity for research on the ecological function of Caribbean reefs that could aid in understanding and effective management and restoration of such reefs in other areas of the Caribbean.

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THE US CORAL REEF TASK FORCE

US President Bill Clinton issued Executive Order 13089 in 1998 'to conserve and protect US coral reef ecosystems', along with a proposal to form the US Coral Reef Task Force (USCRTF) to implement the presidential edict. One of the first actions of the USCRTF was to form Working Groups to review the current position and propose activities within the themes of coastal uses, ecosystem science and conservation, mapping and information synthesis, water and air quality, international dimensions, and education and outreach. Working Group membership included representatives from Federal, State, Commonwealth, and Territorial agencies, non-governmental organisations, and the All Islands Coral Reef Initiative Committee. The USCRTF adopted the 1999 'US All Islands Coral Reef Initiative Strategy', which is the 'Green Book' for action. At the 4th meeting of the USCRTF, representatives from the US associated Pacific Island nations were invited to join the USCRTF. The Task Force issued a National Action Plan in mid 2000, which should generate considerable new coral reef work to start in 2000 and continue for the next few years.

The US Congress allocated US\$6 million for coral reef mapping and management activities to the National Oceanic and Atmospheric Administration's National Ocean Service (NOAA NOS), and to implement many of the critical activities identified in the National Plan. Among those actions, US\$1 million was devoted to mapping the coral reefs of the US Virgin Islands, Puerto Rico, and the Hawaiian Archipelago. Along with funds from the US Department of the Interior, another US\$1M was provided to support the All Island Green Book projects, and another US\$1M to help implement a multi-agency, comprehensive 'National Program to Assess, Inventory, and Monitor US Coral Reef Ecosystems'. Within this program, NOS gave support for 6 cooperative grants to start 3-year projects beginning in 2000 in Hawaii, Guam, Puerto Rico, American Samoa, and the Commonwealth of the Northern Mariana Islands. These projects will help build island capacity for assessing their coral reef resources, and filling gaps in monitoring coverage of US coral reef ecosystems.

The prognosis for further support for US States and Territories, and US affiliated Island coral reef ecosystems is reasonably good. Both the Departments of the Interior and Commerce have indications from congress of funding specified for US coral reef activities in FY2001. There are also several bills currently being debated on the floor of the US Senate and the House of Representatives to provide substantial funding for the mapping, monitoring, research, management, and restoration of US coral reefs. Information on the USCRTF can be obtained on <http://coralreef.gov/>

