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15. STATUS OF CORAL REEFS IN THE NORTHERN CARIBBEAN AND WESTERN ATLANTIC

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ABSTRACT

All countries have reported a deterioration of reef resources. The most widespread direct human impact is over-fishing, particularly acute in Jamaica, Haiti and the Dominican Republic, where narrow fringing reefs are easily accessible. Reef fish stocks dispersed over broad shelves are less depleted as in Cuba and, especially, in the Bahamas and the Turks and Caicos Islands. Higher standards of living in Bermuda and Cayman Islands have resulted in lower fishing pressures. Impacts from the mass mortality of the sea-urchin *Diadema antillarum* in 1983 are still apparent as excessive growth of macroalgae, at least where over-fishing had depleted herbivores. White-band disease in the *Acropora* spp. has led to catastrophic declines in coral cover, particularly in Jamaica (where there has been some recent recovery). In 1998, coral bleaching was severe in the Caymans and Cuba, but mortality appears to be low. Sediment runoff and nutrient pollution are especially prevalent in the three high islands. Careless coastal development for tourism has damaged reefs in most countries, while increasing pressures of diving tourism are apparent in the Cayman and Turks and Caicos Islands. There is increasing local awareness of the need for coastal conservation, and all countries have declared Marine Protected Areas, except Haiti. There is generally little enforcement of conservation laws and most agencies need more resources, trained personnel and political support.

INTRODUCTION

This report covers reefs from the Pedro Bank in the centre of the Caribbean Sea (17°N) to the Bermuda platform in the western Atlantic at 32°N. It includes: Cuba, Hispaniola (with Haiti and the Dominican Republic) and Jamaica of the Greater Antilles with their offshore banks and islands, and 3 clusters of smaller, low islands; the Cayman Islands, within the Caribbean Sea; the Bahamian Archipelago (shared between the Bahamas and the Turks and Caicos Islands) just north of the Caribbean; and Bermuda. Coral reefs are well developed everywhere, most obviously as fringing reefs, but also as patch and bank reefs, especially on broad shallow banks and island shelves. They are of great economic importance in all 8 countries for coastal protection, reef fisheries and, especially, tourism.

GEOGRAPHICAL REEF COVERAGE AND EXTENT

The major physical factors affecting the reef development include: freshwater runoff from the land, which is greater in the high islands; routine wave exposure, especially from the north-east and open to the Atlantic; and sea temperatures which may be modified by cool upwellings from adjacent deep water or by the warm Gulf Stream. Hurricanes are prevalent everywhere, but irregular in frequency. Hard coral diversity is high in most of the region, except for the northern Bahamas and, especially, Bermuda.

Bahamas

The islands lie on a limestone platform in several sections with carbonate banks. The largest is the Great Bahama Bank with Andros Island, while smaller ones form a chain extending from the Straits of Florida to the Caicos Islands. The total area of the banks is nearly 260,000km², much greater than the 1,300 islands (12,000km²). The islands are low-lying and mostly very porous limestone so there is no surface water. Therefore the corals can grow close to the shore. Coral reefs occur mostly fringing the bank margins, with some small patch reefs on the bank in areas with high tidal circulation, and a few bank-barrier reefs. The most important reef regions, with their approximate areas are, from the North: Little Bahama Bank (323km²), Bimini (90km²), Berry Islands/Andros (182km²), New Providence (30km²), Eleuthera/Cat islands (200km²), San Salvador/Rum Cay and Conception Islands (132km²), Exuma Cays/Ragged Islands (386km²) Samana Cays (50km²), Plana Cays (31km²), Mayaguana (72km²), the Inaguas (164km²), Hogsty Reef (23km²), Cay Sal Bank (153km²) and Crooked/Acklin Islands (151km²).

Bermuda

These are the most northerly coral reefs in the Atlantic and survive because of warm-water eddies from the nearby Gulf Stream. Cool winters are probably responsible for the low diversity of stony corals (only 20 species, with *Acropora* notably absent). Nonetheless, the reefs are well developed on the Bermuda platform in an atoll-like form (750km²), with patch reefs in the central lagoon.

Cayman Islands

The 3 low islands (Grand Cayman, Cayman Brac and Little Cayman, with a total land area of 259km²) have well-developed fringing reefs on narrow coastal shelves, with a total area of 241km².

Cuba

This is a large (110,000km²) high island, of which 98% of the 3,966km long shelf edge has coral reefs, and over 50% of these are separated from the mainland by cays or by broad shallow lagoons with many patch reefs. This separation has provided protection for the outer reefs from anthropogenic influences, except for fishing and, in some places, tourist diving. Important reef areas, clockwise from the north-west, include the Archipiélago de los Colorados, the Archipiélago de Sabana and the Archipiélago de Camaguey on the north coast; the Golfo de Guacanayabo, the Golfo de Ana Maria, the Archipiélago de los Jardines de la Reina, the Archipiélago de los Canarreos and the Isla de Juventad on the south.



Dominican Republic

The eastern part (48,500km²) of the high island of Hispaniola is mountainous, and large rivers drain extensive watersheds, limiting reef growth with freshwater and sediments. Only 27% of the 1,400km shore (average shelf width 8km) is fringed by mangroves and only 12% by coral reefs. Important reef areas on the north (Atlantic) coast include the Montecristi barrier reef in the north-west (where the shelf is widest), narrow high-energy reefs in the central region and the Bávaro-El Macao-Punta Cana barrier reef system at the eastern end. North of that, Samaná Bay receives many rivers and is the largest estuary of the insular Caribbean: reefs in the vicinity are poorly developed, but the Navidad Shoals and Silver Banks reef systems are about 100km to the north. To the south, on the Caribbean coast, are the well-studied reefs of Parque Nacional del Este and the adjacent Isla Saona. Westward past Isla Catalina to beyond Santo Domingo are uplifted carbonate terraces with reefs growing on narrow platforms e.g. Boca Chica and the Parque Nacional Submarino de Caleta. Conditions are not good for reefs in the south-west, except on the shallow sheltered shelf east of Cabo Beata at Parque Nacional Jaragua.

Haiti

This is the western part (27,600km²) of Hispaniola. Reefs occur: in the south, near Ile a Vache; all around Ile de la Gonave in the central bay of Port-au-Prince; on the Rochelois Bank and at Les Iles Cayemites, off the northern coast of the southern peninsula; and in the north, from the border with the Dominican Republic in the east to the Baie de l'Acul just west of Cap Haitien.

Jamaica

This high island (10,800km²) has major fringing reefs along the narrow submarine shelves of the north and east coasts while, on the south, where the shelf extends for up to 20km, shallow reef formations are patchy and interrupted by rivers and sediment slopes. Reefs also occur on 9 offshore banks including the Pedro Bank (two-thirds the size of the island of Jamaica) 70km south, and the Morant Bank, 50km south-west, both of which have coral cays.

Turks and Caicos Islands

There are 8 coral islands and 40 small cays, a total land area of about 425km² on two shallow banks. The four largest islands (Providenciales, North Caicos, Middle Caicos and East Caicos) have fringing reefs at about 1 to 2.5km offshore, along the entire northern coasts, generally with a wall drop off starting at 14-18m. Providenciales, West Caicos and Grand Turk have fringing reefs along their western coasts. Shallow patch reefs are common around all of the islands and cays.

BIODIVERSITY ON THE REEFS

The diversity of reef organisms in the Caribbean and Atlantic is much less than in the Indo-Pacific. There are about 65 species in 25 genera of reef-building stony corals in the Greater Antilles. The number of species is reduced by the cooler climate in the northern Bahamas, while there are about 20 species in Bermuda, which is highly seasonal. Fishes found in reefs and associated habitats show a similar pattern, with about 500 species in the Caribbean.

STATUS OF THE CORAL REEFS

Reef communities were seriously damaged over the last 20 years by a series of apparently natural disturbances. Mass mortality of the sea-urchin *Diadema antillarum* in 1983 resulted in macroalgal over-growth, at least where herbivorous fish had been depleted by fishing. White-band disease in the *Acropora* spp, led to major declines in coral cover, especially in Jamaica where T.F. Goreau had ranked the reefs among the best in the world 20 years earlier. Large-scale coral bleaching associated with unusually high sea-temperatures was unknown in this region before 1987, but has occurred many times since, including 1998 and 1999. Other diseases of stony corals and gorgonians have been reported with increasing frequency.

Continuing growth in human populations and economic development is increasing the stresses on coral reefs. Deforestation, especially on the mountainsides of the high islands is resulting in increased runoff of suspended sediment, which is damaging coral reefs near river mouths, most notably in Haiti, Cuba, Jamaica and the Dominican Republic. In the last

two countries, as well as in Cayman and the Bahamas, careless coastal tourism development has also caused sediment damage. Other forms of land-based pollution, from agriculture industry, tourism, and human waste disposal, are causing even more concern. Sewage pollution is particularly severe near large coastal cities such as Kingston, Havana, Port-au-Prince and Santo Domingo, but negative impacts are also detectable from smaller coastal communities. These problems, and those from over-fishing, are less severe in countries with relatively low population density.

The previous report in 1998 stressed the considerable reef degradation from the combined effects of over-fishing that removes important predators and herbivores, and the unrelated loss of the major grazing sea-urchin *Diadema antillarum* back in 1983. These initiated blooms of macroalgae that are still evident in many countries but not in Bermuda, Cayman or other places where herbivorous fish remain relatively abundant. Over-fishing has also been blamed for increased abundance of the coral-eating snail, *Coralliophila abbreviatum*, and of territorial damselfishes, *Stegastes* spp. that farm algal mats.

Bahamas

Coral reefs are in relatively good condition but are no longer pristine. *Acropora* and *Diadema* populations were decimated by disease. There was extensive bleaching in 1998 and some mortality in the Exuma Cays. CARICOMP monitoring at San Salvador (where coastal development is expanding) showed hard coral cover declined from 9.6% in 1994 to 6.1% in 1998, with algae rising from 17.5% to 39.3%. There have been extensive blooms of the green alga *Microdictyon marinum* on some islands. The best reefs are in remote locations like Cay Sal Bank. Hard coral cover was higher on Exuma patch reefs and highest nearshore where the reefs are especially vulnerable to changes in land use. Algal cover is higher on patch reefs in Montagu Bay. Comparison of aerial photographs of the north coast of New Providence island showed that 60% of the coral reef habitat has been lost from dredge and fill, construction of the cruise ship port, and sedimentation since 1943.

Bermuda

The reefs are generally in excellent condition, with an average coral cover of 30-35%; as high as 50% on the outer terrace, declining to about 9% inshore. Although coral bleaching occurred in 1998, there is no evidence of any significant mortality.

Cayman Islands

Coral reefs are in generally good condition, with an average coral cover of about 20%, ranging between 15% and 52%. *Acropora* species were severely impacted by white-band disease, although isolated healthy stands exist. Black band disease has been locally significant and most other coral diseases have been reported. Coral bleaching in 1998 was as severe as in 1995, when 10% mortality was measured in affected *Montastraea annularis* colonies. The sea-urchin *Diadema antillarum* is making a significant recovery from the mass mortality of 1983.

Cuba

Less than 3% of the shelf edge, including the vicinity of Havana, has been affected by severe pollution but extensive areas are affected by proliferation of macroalgae and blue green (cyanobacterial) mats, perhaps due to nutrification and the continuing low

populations of *Diadema*. Acroporid reefs are in decline, presumably because of white-band disease; other hard corals are affected by white plague and other diseases, and sea-fans by aspergillosis. Exceptionally intense coral bleaching occurred on both coasts in 1998, but there was widespread recovery. Low carnivorous and herbivorous fish populations and biomass occur in several reefs, which may partly explain the abundance of coral predators and scrapers, and macroalgae. Reefs at Herradura (31% coral cover), west of Havana, and in the Archipelago de los Canarreos are reported to be in good condition.

Dominican Republic

Numerous surveys since 1992 all document the progressive degradation of Dominican coral reefs and other coastal environments due to human and natural impacts. High coral cover is found only at some deep or offshore reefs e.g. hard coral cover can be as high as 50% (average 35%) on the outer part of the Montecristi barrier reef. At the Silver Banks, mean coral cover is 40%, with turf algae at 51%. On inaccessible steep slopes below high cliffs at Samaná, cover by corals is about 40%, and by tube sponges 28%. Leeward (west) of the Parque Nacional del Este and south of Isla Saona are spur and groove reefs, far from the coast, at the northern part of which coral cover reaches 34% (with 25 species) with algal cover at 35%. Coral cover is generally less than 10% on most fore-reef slopes, although a back-reef at 3m depth had 25% cover, with 14 species, dominated by *Porites furcata*. Other examples of high coral cover (33%) were found on deep spurs beyond the highly impacted reefs of the south coast, exceeding algal cover (26%).

Most nearshore reefs have been damaged by terrestrial runoff. Some watersheds have been deforested for centuries but sedimentation and other agricultural and industrial pollution continue today, especially from the many rivers. Shallow reefs near rivers on the central and south coast consist of mostly dead colonies, covered by turf algae, detritus and garbage. On deeper spurs at Boca Chica, coral cover is 20%, and that by algae 56%. At Parque Nacional Submarino La Caleta, the corresponding figures are 28% and 41%, while sponges and octocorals cover 13% each. On shallow, less disturbed coasts away from rivers, recent development for tourism has destroyed mangroves and wetlands, thus removing natural sediment traps and bringing nutrient pollution. Recent studies on shallow (3-10m) reefs of the north coast (Puerto Plata and Las Terrenas) show 80% coral mortality and 92% cover by algae.

The poor status of reefs is partly due to the diseases affecting *Acropora*, *Diadema* (the absence of which enhances the spread of algae) and *Gorgonia* in the last 20 years. Still erect stands of dead *A. palmata* were seen from Bávaro and Boca Chica, with signs of white band disease in *A. cervicornis* at Bahía de Las Aguilas in the south-west, but there are also some recent recruits and healthy stands of both species.

Haiti

While it is presumed that reefs have suffered from the recent Caribbean-wide mortalities in *Acropora* and *Diadema*, as well as the effects of extreme deforestation, over-fishing and local pollution, few data are available. Urban runoff from Port-au-Prince has caused obvious impacts.

Jamaica

There have been dramatic changes in Jamaican coral reefs in the last 20 years: once dominated by corals, they are now dominated by algae. Major causes have been white-

band disease in *Acropora* spp., hurricanes Allen (1980) and Gilbert (1988), and the loss of herbivores through extreme over-fishing and the mortality of *Diadema*. Sewage pollution has been implicated at many sites. The thickets of elkhorn and staghorn that dominated the north coast reefs are gone. On fringing reefs around the island, mean coral cover at 10m depth fell from 52% in the late 1970s to 3% in the early 1990s, while mean algal cover rose from 4% to 92%. Since then, studies at 27 sites along 10km of the north coast around Discovery Bay showed that coral cover has increased slightly. In 1997, at 5m it was 15% (algae 35%), at 10m it was 16% (algae 56%), and at 15m it was 11%, up from 2%, although algal cover was 63%. This increase was mainly due to recruitment by opportunistic species such as *Porites astreoides*, *P. porites* and *Agaricia agaricites*, rather than by the original frame-builders such as the *Acropora* spp. and massive corals. An AGRRA survey in August 2000 from the south-west, along the north coast to the east reported that 10 sites above 5m (mean depth 2m) had live coral cover of 5%, and at 47 sites below 5m (mean 9m) coral cover was 12%. Deeper reefs, especially on the southern shelf edge, are in relatively good condition with *Acropora palmata* and *A. cervicornis* growing actively near Port Royal and with no current signs of white-band disease, in contrast to most of the north coast. But, in the last 10 years, other coral diseases have appeared on Jamaican reefs, with black-band and yellow-band (first seen in *M. annularis* in 1996) being locally destructive. The most severe occurrence of mass coral bleaching was in 1995 and although there was bleaching again in 1998 and 1999 there was little mortality.

Turks and Caicos Islands

Reefs are generally in good condition, with some observed pollution damage along the north and east coasts of Providenciales and along the west coast of Grand Turk, some diver impact at heavily used sites, and much *Acropora palmata* apparently lost to disease. At 5 dive sites on Grand Turk in 1994, coral cover ranged from 26% to 42%, sponges from 0.1% to 16%, while macroalgal abundance was always low. The most frequently dived site showed signs of diver impacts. AGRRA surveys in 1999 at Grand Turk, Providenciales, West Caicos, South Caicos, Ambergris Cay and the Mouchoir Bank found that coral mortality was low (<1%), diversity was high (37 coral species), and coral cover as high as 30% at several locations. Almost no macroalgae were found except in the Mouchoir Bank, Ambergris Cay and in the shallow *Acropora palmata* zone. On the east-facing banks, dead *A. palmata* stands were more abundant than live ones and *A. cervicornis* was rare. The level of active coral diseases was low but many different diseases were seen, especially on the north side of Providenciales where tourism activities are intense, and at other heavily dived sites.

In 2000, the Coastal Resources Management Project (CRMP) assessed reefs around Providenciales and West Caicos. At Northwest Point and West Caicos, coral cover on the flat at the top of the wall was relatively low (<20%) and algae (*Dictyota* and *Lobophora* spp) were abundant. On the reef face at 15-25m hard coral cover ranged from 20-50%; generally with 30%-60% algal cover (*Lobophora*). Deeper on the reef wall there was higher hard coral cover of 30-60%, and lower *Lobophora* (20-50%). In the most popular near shore patch reef in Providenciales (1-3m depth on Bight Reef), there is repeated damage by snorkelers trampling and breaking coral, especially at low tide.

STATUS OF CORAL REEF FISH

Bahamas

Fisheries resources are abundant throughout the islands, because there are large areas of shallow banks compared to the land area with relatively few fishers. Groupers and snappers still dominate the catch but their abundance and size have diminished.

Bermuda

Towards the end of the 20th century, coral reef fishes were being over-exploited, but fish-traps were banned in 1990 and herbivorous fish numbers have increased, although large groupers remain rare.

Cayman Islands

The diversity and abundance of reef fish remains high, although larger individuals are becoming scarcer, presumably because of fishing.

Cuba

Reef fish populations are declining, due to habitat deterioration and over-exploitation.

Dominican Republic

Large reef fish are scarce or absent due to over-fishing, and conch and lobster populations are also threatened.

Haïti

There is evidence of severe over-fishing in reports from the Dominican Republic that people from Haiti poach anything edible from the D.R. National Parks of Montecmsti and Jagua, leaving empty reefs.

Jamaica

Coral reef fish communities have been greatly altered and reduced by relentless fishing pressure, especially on the very narrow and accessible shelf of the north coast. All large species and most predators are absent or very scarce and the main target species left are small parrotfish and surgeonfish. Fish stocks are a little better on the south coast shelf and offshore banks.

Turks and Caicos Islands

An AGRRA survey at 6 separated sites in 1999 found that fish diversity was high and groupers were abundant and relatively large.

STATUS OF CORAL REEF FISHERIES

Bahamas

There is a well-developed commercial and export fishery plus a recreational/local consumption fishery. Government policy reserves the commercial fishing industry for Bahamian Nationals, and all boats fishing within the EEZ must be 100% Bahamian owned. Total recorded landings for 1999 were 4,954 metric tons valued at US\$71.8 million, with half the weight and 85% of the value being spiny lobster tails. In addition, there were 866mt of snapper and 485mt of grouper mostly for export when the prices are sufficiently high. Recreational anglers come for pelagic gamefish, reef fish, and sportfish such as tarpon or bonefish that are caught and released. Widespread over-fishing is reported and awareness is growing about improved enforcement of existing regulations on fishing gear, closed seasons and size limits.

Bermuda

Commercial fish harvest is about 375mt per year, about 35% being reef species taken by hook and line. This is about 30% of the annual reef fish catch 40 years ago, prior to the banning of fish-traps. Recreational fisheries have much less impact, and there is no subsistence fishing. Dive tourism, for which reef fish are important, and other watersports, contribute significantly to the economy.

Cayman Islands

Coral reef fishing is limited to low volume recreational and subsistence fishing, which may have a relatively high impact, because of the limited habitat area. The increasing use of large, small-meshed fish-traps is causing local depletion and 4 spawning aggregations of Nassau Grouper (*Epinephelus striatus*) are intensively fished with hand lines, such that the average size and catch-per-unit-effort are declining. Fishing while using scuba gear is banned but 500 licensed local residents are permitted to use spearguns. Conch and lobster are also subject to intensive recreational and subsistence fisheries and are over-exploited, despite conservation regulations. The Department of the Environment and the Marine Conservation Board have recommended new measures to address all these issues but none has been implemented.

Cuba

Coral reef fishery resources are declining, due to habitat deterioration and over-exploitation in commercial and subsistence fisheries. They are still in better condition than those of Jamaica and other islands nearby. Annual exports of lobster are worth about \$100 million. There is a very small, supervised trade in aquarium fish. Some recovery of conch stocks has been documented.

Dominican Republic

There is an important artisanal fishery (13,000mt in 1998), mostly for finfish, but also conch, lobster, other molluscs and crustaceans. Fishing pressure on the reefs has apparently decreased, partly because men have taken better paid work in tourism and through the adoption of FADs (Fish Aggregating Devices) which help fishers to exploit pelagic fish. However, there has been an increase on the use of hookah diving equipment to take conch and large fish at greater depths. Harvesting of aquarium and souvenir specimens also goes on.

Haiti

Most fishing is artisanal but stocks are depleted because of inappropriate methods. Aquarium fish exporters have recently decreased from 5 to 2.

Jamaica

An artisanal fishery operates from over 200 fishing beaches around the island and the Kingston Fisheries Terminal. The larger catch is made from the south coast, which has access to a wide island shelf and to Pedro and other banks, whereas the north coast shelf is narrow (<1km). The principal fishing gear is the Antillean z-trap, generally made with 3cm wire-mesh, but nets, lines and spears are also used. Nation-wide fishery data, taken at irregular intervals, show a marked decline in catch-per-unit-effort since the early 1960s. The stocks have been over-fished and catch rates are very low, partly due to a policy of subsidising the fishery in the 1960s and 1970s. Nonetheless, the latest survey (1996) estimates total catch at 14,000 tonnes: twice that of 1981, a result which is under review. There is an important commercial fishery by teams of hookah divers for conch, on the Pedro Bank.

Turks and Caicos Islands

Lobster and conch fisheries generate the only national exports. There are 5 processing plants which handled the 646mt of conch (US\$1 million) and 314mt of lobster (US\$2 million) in 1998. Finfish landings are on a much smaller scale, primarily for local consumption.

ANTHROPOGENIC THREATS TO CORAL REEF BIODIVERSITY

Bahamas

The population is less than 350,000 people, mostly concentrated in Nassau, Marsh Harbor and Freeport. The proximity to the Miami-Fort Lauderdale area has supported a billion-dollar tourist industry that is the envy of the wider Caribbean. But there is rapid degradation of coastal water quality and local destruction of habitats near the growing towns. Mangroves are systematically cleared for waterfront access and to control mosquito populations. There is:

- too much over-exploitation of fishes, lobsters, conch and other marine life; all are markedly declining in abundance as fishing efficiency and effort increases;
- too much pollution of nearshore waters, even in relatively sparsely populated areas, due poor wastewater treatment, solid waste disposal or runoff control; and
- too much of the coastline is being altered for development without consideration for marine habitat loss, especially mangroves and nearshore hard bottom habitats.

Bermuda

The resident population of 65,000 plays host to 500,000 tourists each year. Potential anthropogenic threats include ship groundings, oil spills, persistent anti-fouling poisons, shore-side development, contaminated runoff, sewage and industrial outfalls. The most serious impacts have resulted from ship groundings and the construction of the airport (loss of approximately 4% of reef area), and siltation from dredging and cruise ships. Accidental, but relatively minor, recreational damage comes from anchors, propellers and divers.

Cayman Islands

There are about 40,000 locals, along with 1.4 million tourists per year, 40% of whom go diving. Current anthropogenic threats derive mostly from large recent increases in population and economic development in the absence of any growth management plans or coastal area management policies. They include: dredging and filling of wetlands; coastal engineering projects; anchoring of cruise ships; and over-use of dive sites, in many cases exceeding 15,000 dives per year.

Cuba

The population is about 11 million, which has led to extensive deforestation of watersheds since colonial times and land-based sedimentation which affects about 20% of the fringing reefs. Other continuing land-based sources of reef pollution include sugar mills, human settlements, cattle farms, yeast plants, and food and beverage processing factories. Commercial, subsistence and illegal fishing pressures continue. There is a small but growing tourist diving industry.

Dominican Republic

Increasing human population, now 8.7 million, and economic development underlie much of the stress on coastal ecosystems, through sedimentation, sewage and other terrestrial pollution from agriculture, mining, industry, shipping and tourism. Coastal habitats have been destroyed for tourism, not only in construction but misguided reconditioning of beaches causing more sediment damage. Over-fishing of reef resources is still a problem. New proposals for transshipment ports would require the destruction of reefs by dredging.

Haiti

There is little economic development for 7.5 million people but much artisanal activity. There are, however, increasing threats from near-shore road construction, sedimentation, pollution and over-fishing. There are no encouraging signs for the foreseeable future.

Jamaica

The population of 2.8 million is increasing, unemployment is high and the cost of living rising, therefore more people seek food and income by fishing, especially on the very accessible northern shelf. Rivers carry considerable runoff of suspended sediment, resulting from hillside clearance, and sewage pollution. Excess nitrogen is also channelled to the sea underground in the widespread limestone formations. The rapid growth of facilities for coastal tourism (about 1.5 million visitors per year) has also contributed to terrestrial runoff. There are proposals to site new industrial developments, including a transshipment port, in coastal areas.

Turks and Caicos Islands

There are 23,000 people with 73% on Providenciales (90km²). The major human threats to coral reefs include: nutrient discharge from marinas and coastal development, fish processing plants, conch aquaculture and hotel sewage; heavy metal contamination from anti-fouling paints; damage to corals caused by snorkelers and divers; anchoring on coral reefs and seagrass beds; boat groundings; construction of tourism infrastructure and private jetties in the nearshore environment; uncontrolled fishing in the marine parks; and increasing visitor use of selected marine areas.

POTENTIAL CLIMATE CHANGE IMPACTS AND RESPONSES

If sea temperatures continue to rise, we can expect more coral bleaching events and more coral mortality. If sea-level rises by as much as 0.5m (and it has been measured in Cuba at about 0.25cm per year) there could be several adverse consequences. If *Acropora palmata* populations remain low, important reef breakwaters will be unable to keep up and there will be additional erosion on some beaches and other sheltered habitats such as mangroves. Low-lying human settlements will be flooded in all countries, which will include the poorer sections of some cities. The GEF/OAS project Caribbean: Planning for Adaptation to Climate Change (CPACC), is addressing these and other concerns in the CARICOM countries.

MARINE PROTECTED AREAS (MPAs) AND MANAGEMENT CAPACITY

Bahamas

There are 12 National Parks totalling 1,300km² of both land and sea bottom; about 10% of the land area of the Bahamas but less than 1% of the coastal shelf area. The Bahamas National Trust (BNT) developed by-laws in 1986 to protect and conserve marine life in all the Land and Sea Parks in the Bahamas. These were originally designed for recreation but were re-designated as marine replenishment areas and nurseries and a moratorium was placed on all types of fishing within park boundaries:

- Inagua National Park, Great Inagua (744km²) - site of the world's largest breeding colony (60,000) of West Indian flamingos;
- Union Creek Reserve, Great Inagua (18km²) - a tidal creek, important for sea turtles, especially the green turtle;
- Exuma Cays Land & Sea Park, Exuma (456km²) - created in 1958, it later became the first marine fishery reserve in the Caribbean. It includes 10 large islands and numerous smaller cays in a 35.4km long section of the Exuma island chain;
- Pelican Cays Land & Sea Park, Great Abaco (8.5km²) - contains extensive coral reefs;
- Peterson Cay National Park, Grand Bahama (6ha) - one of Grand Bahama's most heavily used weekend getaway spots. Small patch reefs and hardbottom communities are protected here;
- Lucayan National Park, Grand Bahama (16 ha) - gives access to the longest known underwater cave system in the world, with 10km of caves and tunnels already charted, and every vegetative zone found in the Bahamas, including a large mangrove area, but there is no reef habitat;
- Conception Island National Park, Conception Island - an important sanctuary for migratory birds, sea birds, and green turtles. Large reefs around this island are protected but there are no staff on site; and
- Tilloo Cay, Abaco (8ha). A nesting site for tropic birds, among others. Although there are reef resources around the cay, they are not protected as part of the park. This park also has no staff.

EXUMA - AN EARLY MARINE PROTECTED AREA

The Exuma Cays Land and Sea Park (ECLSP) in the south central Bahamas, 80km south-east of Nassau, was established by the Government of the Bahamas in 1958, with by-laws allowing for a daily catch quota per boat. In the 1970s, commercial fishing escalated within the Exuma region, and many fishermen started using chlorine bleach to catch spiny lobsters. By the 1980s, fishing pressure had increased so dramatically that in 1986 the BNT declared the entire area a 'no-take zone', probably the first marine fisheries reserve in the tropical western Atlantic. The ECLSP is the only land and sea park in the Bahamas with a full-time staff: one warden, who is assisted by volunteers. The warden patrols the area in a boat each day to enforce the fishing regulations, assisted by an ECLSP Support Fleet of primarily visiting yachtsmen. Like the other marine parks, there were no management plan or clear objectives when it was granted protected status, apart from later no-take regulations. However, the ECLSP staff succeeded in developing many programmes and activities and, as these programmes grew and as the complexity of operating the ECLSP grew, it became increasingly apparent that the staff needed more management and funding support. The Park now needs additional living quarters for staff and Defence Force personnel, facilities to house researchers and volunteers and, most importantly, the capacity to generate a steady stream of income. The current concerns and issues of the ECLSP, typical of many marine parks, include: the lack of a long-term financial plan; conflicting perceptions of the mission of the Park (among Exuma residents, tourists, and the BNT); limited communication and outreach to local residents and businesses; and the incompatibility of recreational activities in the Park overwhelming the area's estimated carrying capacity.

Bermuda

There are 4 kinds of Marine Protected Area:

- Coral Reef Preserves, where it is illegal to remove any organism attached to the sea-floor, were established in 1966;
- Fishing is banned during the summer in Seasonally Protected Fisheries Areas, established in 1972 and most recently expanded in 1990, which cover about 20% of the reef platform;
- Similar legislation, starting in the mid-1980s, now bans fishing permanently at 29 popular dive sites; and
- the Walsingham Marine Park includes a marine area, with valuable seagrass beds and adjacent land (Bermuda National Parks Act, 1985).

The Department of Agriculture and Fisheries, which includes the Bermuda Aquarium, Museum and Zoo, has surveyed and mapped reefs through a Bermuda Biodiversity project, and is well equipped for reef monitoring. The Fisheries Division of the Department carries out reef fish censuses and the Bermuda Biological Station has maintained long-term reef monitoring of coral abundance, algal biomass, disease incidence, bleaching surveys and

reef fish censuses at fore-reef terrace, rim reef and patch reef sites since 1991. Annual CARICOMP surveys have been carried out at two reef and two seagrass sites since 1992.

Cayman Islands

A system of Marine Protected Areas was established in 1986 and covers 34% of the coastal waters of the 3 islands. There are 3 levels of protection:

- Marine Park Areas (15km²) where the taking of marine life, dead or alive, is prohibited, except for line-fishing from the shore;
- Replenishment Zone Areas (52km²) where all but line-fishing is prohibited; and
- one Environmental Zone in the North Sound of Grand Cayman (17km²), where all fishing, anchoring and in-water activities are prohibited.

The Department of the Environment is responsible for marine management and employs 5 Marine Park Enforcement Officers on Grand Cayman, one each on the sister islands, and 9 scientific staff running an extensive monitoring programme. Most notable is annual monitoring of 24 reef sites around the three islands since 1997, using photographic transects which are analysed digitally. CARICOMP also has surveys of Nassau Grouper aggregations and fisheries, conch and lobster and their recruitment, turtle nesting, and diver impacts. Water quality is monitored looking for evidence of pollution in and around Georgetown Harbour.

Cuba

The only legally protected reefs until recently were incidental to terrestrial Protected Areas. Now marine areas are receiving more attention and 20 MPAs are planned. The Ministry of Fishery Industry has declared 9 'no-take' areas, mostly on coral reefs. Cuba has the necessary professional and institutional capacity for coral reef research, monitoring and management, but has inadequate funding for implementation and enforcement. It has operated CARICOMP surveys at Cayo Coco since 1993 and, recently, surveys for AGRRA and Reef Check.

Dominican Republic

There are 6 MPAs, which cover the largest reef tracts and the most important nursery areas. Currently, they have no protection and no management, and there is intense fishing within them. Clockwise from the north-west they are:

- Parque Nacional Montecristi - the largest, least impacted coastal park, with diverse ecosystems;
- Humpback Whale Sanctuary - 38,000km², including the Silver and Navidad Banks;
- Parque Nacional Los Haitises - in Samaná Bay, dominated by mangroves and estuaries;
- Parque Nacional del Este - the most studied MPA, an important nursery for conch and lobster;
- Parque Nacional Submarino La Caleta - the oldest MPA, now an important dive site; and
- Parque Nacional Jaragua - another important nursery for lobster.

The reefs in most of these areas were recently assessed by the Centro de Investigaciones de

Biología Marina, Universidad Autónoma de Santo Domingo (which has maintained a CARICOMP monitoring site in Parque Nacional del Este since 1996), Fundación MAMMA, Inc. (a local NGO) and the National Aquarium.

The Dirección Nacional de Parques lacks qualified personnel to manage the MPAs and the Fisheries Department lacks enforcement officers and an effective extension programme. In addition, there are no appropriate penalties for violation of existing laws and confusion as to which institution should apply them. The development of tourism within the MPAs may help to bring better management of the marine resources.

Haiti

There are no MPAs and government currently has no capacity for management.

Jamaica

The management of National Parks is delegated to local NGOs. Marine Parks, Environmental Protection Areas with marine components, and Fish Sanctuaries are listed below, clockwise from the west:

- Negril Marine Park (1998) - managed by the Negril Coral Reef Preservation Society, within the Negril Environmental Protection Area;
- Montego Bay Marine Park (1989) - managed by the Montego Bay Marine Park Trust, includes the Bogue Island Fish Sanctuary;
- Ocho Rios Underwater Park (1966) - legally protected for 24 years, but still a 'paper park', the site of the classic T.F. Goreau study on the ecology of Jamaican coral reefs in 1959;
- Bowden Fish Sanctuary - associated with an oyster culture project;
- Palisadoes/Port Royal Protected Area (1998) - includes the Port Royal Cays; and
- Portland Bight Protected Area (1999) - managed by the Caribbean Coastal Area Management Foundation, includes 5% of Jamaica's land area and nearly half of the island shelf (1,350km²).

There are plans to establish a Marine Park at Ocho Rios and another at Port Antonio. A voluntary fish sanctuary has been managed by the Discovery Bay Fishermen's Association in association with the Fisheries Improvement Programme since 1996, based at the Discovery Bay Marine Laboratory. The Pedro and Morant Cays Act (1909) provides some protection for those offshore banks.

Park management organisations have to satisfy the Natural Resource Conservation Authority (NRCA) of their competence and sustainability before they are granted management authority. The organisations do their own coral reef monitoring, or accept help from outside agencies. The government (NRCA) has staff and equipment for monitoring, and is managing the country's participation in the Coral Reef Monitoring component of CPACC.

Turks and Caicos Islands

The National Parks Ordinance (1975) created 3 levels of protected area. Sanctuaries have the highest level of protection: human entry is regulated. Nature Reserves may be used for various activities, subject to ecological regulation. National Parks are open to the public for

recreational use and development which might 'facilitate enjoyment by the public of the natural setting of the area' (including marinas) is permitted. There are 4 Sanctuaries, 5 Nature Reserves and 10 National Parks, which are wholly or partly marine. From the West, they are:

West Caicos

West Caicos Marine National Park (4km²)

Providenciales

Princess Alexandra Land and Sea National Park (26km²)

Northwest Point Marine National Park (10km²)

Pigeon Pond and Frenchman's Creek Nature Reserve (24km²)

Chalk Sound National Park (15km²)

Fort George Land and Sea National Park (5km²)

North Caicos

East Bay Islands National Park (35km²)

Three Mary Cays Sanctuary (0.13km²)

Middle Caicos

North, Middle and East Caicos Nature Reserve (International Ramsar Site; 540 km²)

Vine Point (Man O' War Bush) and Ocean Hole Nature Reserve (8km²)

South Caicos

Admiral Cockburn Land and Sea National Park (5km²)

Admiral Cockburn Nature Reserve (4km²)

Bell Sound Nature Reserve (11km²)

French, Bush and Seal Cays Sanctuary (0.2km²)

Grand Turk

Columbus Landfall Marine National Park (5km²)

South Creek National Park (0.75km²)

Grand Turk Cays Land and Sea National Park (1.6km²)

Long Cay Sanctuary (0.8km²)

Big Sand Cay Sanctuary (1.5km²)

Management plans have been prepared for the 2 of the marine parks in Providenciales and that in West Caicos, by the Coastal Resources Management Project. This is expected to evolve into the National Parks Service in late 2000, and to assume responsibility for all protected areas, except for those leased to the National Trust. There is no active management of most of the protected areas outside of Providenciales.

GOVERNMENT LEGISLATION AND POLICY ON REEF CONSERVATION

Bahamas

There are 3 main government and non-government bodies responsible for coral reef resource protection and conservation in the Bahamas:

- The Bahamas Environment Science and Technology (BEST) Commission is responsible for the development of legislation to protect the environment and issue permits for development;
- The Department of Fisheries, within the Ministry of Commerce, Agriculture and Fisheries is aggressively taking responsibility not only for fisheries management, but also the establishment of marine fisheries reserves and coral reef monitoring programmes. It has a staff of 43, employing the greatest number of marine and fisheries scientists in the country, and participates in regional programmes such as CPACC; and
- The Bahamas National Trust, an NGO, was mandated, under the National Trust Act of 1959, with the responsibility and legal authority to manage the national parks of the country. The Government supports the park system through specific enforcement responsibilities carried out by the Bahamian Defense Force.

Bermuda

The management of marine resources is highly conservative and is mostly administered by the Ministry of the Environment through the Department of Agriculture and Fisheries. A comprehensive Green Paper on the Fishing Industry and Marine Environment in Bermuda in 2000 involved widespread public discussion and specialised working groups. The Marine Resources Board (a body advising the Minister on marine environmental matters) will recommend to the Minister revamped schemes for fishing licenses, more protection for corals, better management of sustainable resources, and improved concern for shoreline and coastal development, all with some strength in law. It is likely that the ensuing White Paper for proposed legislative initiatives (due in early 2001) will be a model for sustainable marine resource management for the region.

Cayman Islands

The Marine Conservation Law, passed in 1978, created the framework for marine conservation in Cayman.

Cuba

Since the Ministry of Science, Technology and Environment was created in 1994, environmental legislation has improved, including a Decree-law on Protected Areas (1999) facilitating the protection of coral reefs. There is collaboration between this Ministry, the Ministry of Fishery Industry, and the Ministry of Tourism in the development of protected areas, being a major step towards integrated coastal management.

Dominican Republic

An Environmental Law has only recently (August, 2000) been approved by Congress. Meanwhile, environmental legislation consists of over 300 environmental decrees, regulations and orders, administered by a large number of organisations. The newly formed

Subsecretaría de Gestión Ambiental and the Subsecretaría de Recursos Costero Marinos (both in the also newly formed Secretaría de Medio Ambiente y Recursos Naturales) face the task of managing this system, but there is considerable overlap of authority among institutions dealing with coastal issues and a lack of any central long-term vision on sustainable coastal area management.

Haiti

There are very detailed, though outdated, laws concerning coastal and marine resources. None is currently respected nor enforced. Both the Ministry of Environment and an NGO, the Fondation pour la Protection de la Biodiversité Marine, are working to raise awareness.

Jamaica

Until recently, the major law available for coral reef management was the Beach Control Act (1960). This was one of more than 50 environmental laws, administered by a multiplicity of ministries and other agencies. The enactment of the Natural Resources Conservation Authority Act (1991) started a process of rationalisation and, since it binds the Crown, obliged public sector entities to comply. That process continued in 2000 with the formation of the National Environmental Planning Agency (NEPA) by merger of the NRCA with the Town Planning Department and the Land Development Commission. In 1998, recognising the need for inter-sectoral collaboration in management of the Exclusive Economic Zone and coastal areas, government agreed to creation of the Council for Ocean and Coastal Zone Management. Its members are the heads of all relevant agencies and it reports, through the Ministry of Foreign Affairs, directly to cabinet.

Turks and Caicos Islands

There is no clearly defined national policy for conservation of marine resources, although some policy documents allude to conservation or sustainable development. The development trend in Providenciales, development proposals for West Caicos, current management of the national parks and the National Parks Regulation indicate that the maintenance of protected areas seem to favour recreational benefits for visitors and development opportunities for expatriates. These priorities, rather than broader conservation of coastal resources, have lead to the current type and intensity of uses within and adjacent to the parks. However, the recent UK White Paper on Progress Through Partnership proposes the following policy objectives for Overseas Territories:

- to promote sustainable use of the Overseas Territories natural and physical environment, for the benefit of local people;
- to protect fragile ecosystems such as coral reefs from further degradation and to conserve biodiversity in the Overseas Territories;
- to promote sustainable alternatives to scarce resources or species which are used for economic purposes; and
- to enhance participation in and implementation of international agreements by Overseas Territories.

The National Parks Ordinance (1975) and Regulations (1992) defined the protected areas and there are a number of other relevant Ordinances. There is no harmonisation among key pieces of legislation. The National Parks Ordinance needs revision, and will need more

when the National Parks Service is established, especially in terms of the administration of regulations and in zone designations.

GAPS IN CURRENT MONITORING AND CONSERVATION CAPACITY

Bahamas

The National Park System needs more funding, staff and equipment. There is only one 'no-take' area among the MPAs. More Protected Areas are needed and several have been planned.

Bermuda

A gap in the current MPA structure is the lack of protection of critical habitats for juvenile reef fishes. Other conservation priorities are environmental education at all levels; better enforcement of conservation laws; and the enactment of new legislation.

Cayman Islands

Current funding for marine monitoring is relatively good, but could be advanced with by additional technical staff and training for the Department of the Environment. There are more serious legislative deficiencies and an absence of conservation planning or political support. The Marine Conservation Law of 1978 is outdated; there is no enabling legislation for the Department of the Environment; there is aggressive development but no development plan; and conservation is perceived as incompatible with economic development.

Cuba

The greatest deficiency for monitoring and conservation is the lack of funds. Protected area staff are few and poorly trained but co-management with tourist enterprises may help with the funding of MPAs. More environmental education is needed at all levels to increase the awareness and involvement of stakeholders, communities and decision-makers in coral reef issues.

Dominican Republic

The immediate need is for effective management of the MPAs, which will require more funding to employ and train staff, combined with education programmes. There is also a need to resolve sanitary and solid waste pollution, at least at the major tourist centres.

Haiti

There are very few people with any training in marine sciences and no formal capacity for coastal management. The current political situation has renewed the 'brain drain'.

Jamaica

The government, burdened with debt repayments, lacks resources for adequate monitoring and enforcement of environmental laws. Environmental education has been included in formal education system but this should be expanded at all levels to encourage: responsible use of coastal resources; resolution of conflict between tourism and fishery interests; and more appreciation of the benefits of integrated coastal management.

Turks and Caicos Islands

All conservation agencies are under staffed, and few staff have the requisite training and experience. All agencies have insufficient equipment to carry out daily operations and in some cases out-dated or inappropriate equipment. Some conflicts among key agencies need to be resolved, and rights and responsibilities in management of the protected areas need to be clarified. There should be mechanisms for key stakeholders and users of reef resources to provide input to monitoring and conservation.

CONCLUSIONS

Bahamas

This region can be considered one of the least impacted in the tropical Americas but that situation is changing rapidly.

Bermuda

Coral reefs are in reasonably good condition and are well managed, although a higher level of enforcement to protect reef fish stocks is desirable.

Cayman Islands

Coral reefs and their resources are in relatively good condition but are increasingly threatened by rapid development, population growth and intensive tourism. Proper management is now crucial to their continued health but is hampered by the lack of political support.

Cuba

Offshore reefs are in relatively good condition. General coral reef decline in Cuba derives from regional and global stresses e.g. diseases and increased temperature, while the main anthropogenic stresses are sedimentation, organic pollution and over-fishing. Priority should be given to reforestation, to the reduction of nitrogen and phosphorus pollution by waste-water and to better controls on fishing. All options should be explored for sustainable funding of MPAs and environmental management. On the social side, there should be more environmental education, especially among local communities and decision-makers, and more cross-sectoral integration.

Dominican Republic

Most reefs are degraded from the overgrowth of algae due to the lack of grazing caused by over-fishing and, in some areas, nutrient pollution, even in the MPAs. Other reefs, especially near towns or tourism sites, are degraded from other causes. Government capacity to manage the coastal zone is seriously in need of improvement.

Haiti

Near-shore reefs are suffering from excessive algal growth and depleted fish stocks. Restoration of management capacity will require funds, training and a stable government.

Jamaica

Overgrowth by algae is occurring everywhere due to the lack of herbivores and also due to nutrient pollution in many places. There has been some regrowth of opportunistic corals, partly facilitated by the spread of sea-urchins. The reefs are now less able to provide important services to fisheries, tourism and coastal protection.

Turks and Caicos Islands

Most reefs are in good condition, but the pressures from tourism are increasing. Proper conservation and monitoring of coral reefs depends on the enhancement of human and material resources, probably by increased donor support.

GENERAL CONCLUSIONS

- Coral reefs are well developed throughout this region.
- The status of reef communities has declined in all 8 countries recently, most important has been the loss of reef building elkhorn and staghorn corals (*Acropora palmata* and *A. cervicornis*), apparently from white-band disease. Many reefs are overgrown by macroalgae released from herbivore control by over-fishing and the mass mortality of the grazing sea-urchin *Diadema*. Other diseases have become more common, where reefs are stressed by human activity, and some are causing serious mortality. Sediments, nutrients and other pollutants have impacted reefs near human population centres.
- Reef condition is relatively good in the small low islands and bad nearshore in the high islands. The worst may be in Jamaica (where there is a little recovery) and the Dominican Republic, but there is little information about Haiti. Some deep reefs are in better condition than shallow ones. The best reefs are far from human influence, on the outer shelves of Cuba, offshore banks, or the more remote islands of the small-island groups. Bermuda reefs, which had no *Acropora* to lose, have probably changed least.
- The diverse and formerly abundant coral reef fish resources have been depleted to some degree in all countries. The loss of predators and herbivores has impacted on benthic communities.
- The impact of reef fisheries (and other human factors) is modulated by geography, demography and economics. Over-fishing is particularly acute in Jamaica, Haiti and the Dominican Republic, where narrow fringing reefs are easily accessible to numerous low-income fishers. Reef fish stocks dispersed over broad shelves are less depleted, as in Cuba, the Bahamas and the Turks and Caicos Islands. Higher standards of living in the Cayman Islands and Bermuda result in reduced fishing pressures and reef fish stocks are relatively healthy. However, the more valuable resources such as queen conch and spiny lobster are also being exploited by larger commercial interests, and are at risk throughout the region.
- Increasing human population and careless economic development drive other major anthropogenic impacts; sediment pollution, nutrient pollution, and habitat destruction. These derive from agriculture, human habitation, industry and, increasing tourism sector, which is the largest earner of foreign exchange in the

region. There are examples from all countries of hasty development designed to facilitate enjoyment of the coastal environment that has degraded it.

- Bleaching in the ENSO year 1998-99 occurred throughout the region but was severe only in Cuba and Cayman. Consequent mortality was not measured but could have been as high as 10%.
- The best managed systems of Marine Protected Areas and coral reef monitoring are in Bermuda, Cayman and Jamaica. In the last, operation of the National Parks has been transferred to selected local NGOs. In the Bahamas, all national parks are managed by an NGO and some MPAs receive active protection. The Turks and Caicos Islands has an extensive, well-established system and a management programme is being developed. The Dominican Republic has 6 National Parks, which are not managed. Cuba is just beginning to establish MPAs. Haiti has none with no plans to establish any.
- Conservation for tourism is now the major force driving MPAs and some tourist dive operators are cooperating with management e.g. installing mooring buoys at popular dive sites to reduce anchor damage. The concept of carrying capacity at these popular sites is hard to apply and localised damage is occurring. Both tourists and fishermen want to see more fish and all kinds of MPA may enhance fisheries, but cooperation and joint planning by all stakeholders are required.
- All countries inherited uncoordinated sector-specific environmental laws and most have, to differing degrees, introduced better integrated conservation laws and administration. But further harmonisation is needed in most countries. Local government policy is supportive of marine conservation in the Bahamas, Bermuda, Cuba, Jamaica and the Turks and Caicos Islands.
- More trained marine conservation staff are required in the Bahamas, Cuba, Dominican Republic, Haiti, Jamaica and the Turks and Caicos Islands. More environmental education is needed at all levels in fisheries, tourism, administration and among politicians. There should be more horizontal and vertical integration of coastal management, to involve all stakeholders.

RECOMMENDATIONS TO IMPROVE CONSERVATION OF CORAL REEF RESOURCES

A. International actions:

- all governments, agencies and institutions should act on the Current Priorities of the 1998 ICRI Renewed Call to Action and implement the 1995 Call to Action and the Framework for Action;
- all governments should quickly implement measures to reduce 'greenhouse' gas emissions, to a minimum of the Kyoto Agreement; and
- developed country governments and international funding agencies could assist the environment by relieving debt and allocating these resources to conservation.

B. National actions of general application:

The following recommendations, which are also in the ICRI documents cited above, apply to most countries in the region. They will require local action for which external funding may be necessary for most countries.

Education

Promote environmental education on marine and coastal issues, widely spread at all levels of society.

Research and Monitoring

Complete the assessment of coral reef status and maintain monitoring at key sites; investigate the role of anthropogenic stress in promoting coral diseases that are having catastrophic impacts on Caribbean coral reefs.

Capacity-building

Employ more professional and technical staff in national conservation agencies and provide them with better training and equipment; and support the work of conservation staff by involving community members as environmental wardens, particularly for education and enforcement.

Management

- Apply the principles of Integrated Coastal Management, notably: cross-sectoral and vertical integration; and the involvement of all stakeholders in planning and management.
- Modernise and harmonise environmental legislation.
- Work to reduce direct human impacts on coral reefs by: promoting sustainable fishing; educating across all levels; limiting the effectiveness of fishing gear; creating replenishment reserves; and licensing fishers.
- Reduce sedimentation: by appropriate agricultural practices, e.g. terracing; reforestation near water-courses; protection of mangroves and coastal wetlands; and better planning and control of coastal construction.
- Reduce the discharge of polluting nitrogen and phosphorus to coastal waters by: better wastewater management, including: tertiary treatment; or the use of nutrients to enhance plant growth in agriculture or aquaculture.
- Reduce solid waste and industrial pollution.
- Reduce the environmental impacts of tourism by working with the Caribbean Tourist Organisation and other industry leaders.
- Enhance the effectiveness of Marine Protected Areas: by involving fishery, tourism and other local interests; by creating and implementing management plans; and by seeking sustainable funding.
- Build on MPAs as centres of inspiration for proper management of the entire landscape.
- The Cayman Islands Government should: accept Marine Conservation Board and Department of Environment recommendations to amend current legislation and enact environmental Legislation; establish a Conservation Trust Fund with monies currently being collected as Environmental Protection Fees; develop a comprehensive development plan incorporating Integrated Coastal Management; and also develop a tourism management plan that incorporates environmental issues (these issues were raised by the Cayman Islands but would apply to many other countries);

SUPPORTING DOCUMENTS

- P.M. Alcolado, R. Claro-Madruga, R. Estrada. Status of coral reefs of Cuba; T. Austin, G. Ebanks-Petrie. Status of coral reefs of the Cayman Islands; J. Barnes, Ann Glasspool, Brian Luckhurst, Robbie Smith, Jack Ward. Status of the coral reefs of Bermuda;
- F.X. Gerales, M.B. Vega. Status of the coral reefs of the Dominican Republic; F. Homer, D. Shim. Status of coral reefs in the Turks and Caicos Islands; ICRI Finance Survey, Bermuda Biodiversity Project; ICRI Finance Survey, Coastal Resource Management Project, Turks and Caicos Islands; K. Sullivan Sealey, E. Phillips. Status of coral reefs in the Bahamian Archipelago;
- J.D. Woodley. Status of the coral reefs of Jamaica; J. Wiener. GCRMN report for Haiti (all available from the authors below).

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