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STATUS OF CORAL REEFS IN THE SOUTH CENTRAL CARIBBEAN

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ABSTRACT

Caribbean corals have suffered from bleaching, diseases and *Diadema* die-off. Reefs on narrow shelves adjacent to high human population and many fishers (Colombia, Curaçao, Jamaica, Venezuela) suffer from imcreased terrestrial run-off and over-fishing, showing signs of degradation (fewer fish, more algae, less coral cover). Where shelves or banks are wide or far from human populations, reefs are less disturbed. Islands with fewer people and little fishing (Bonaire, Cayman) have good reef resources. Here, diving tourism is important, and there is more awareness of the need for reef conservation. Cayman has the best developed national coastal area management plan. Most of the other countries have Marine Protected Areas. These stimulate improved Coastal Area Management, aided by increasing numbers of Non-Governmental Organizations (NGOs).

INTRODUCTION

The status of Western Atlantic reefs and their management was reviewed by Wells (1988). The International Coral Reef Initiative (ICRI), responding to recent concern about their apparent deterioration, initiated reviews of the status of reefs throughout the world (Jameson et al. 1995) and of their management (for the Tropical Americas, see Woodley 1995). Here, we review those topics for the countries of the south central Caribbean: Aruba, Cayman, Colombia, Jamaica, the Netherlands Antilles islands of Bonaire and Curaçao, and Venezuela (Fig. 1).

ARUBA

Geographical setting

Aruba is a small arid island (30 x 8km) situated on the continental shelf 27km north of Paraguana, Venezuela. Like its neighbours, Bonaire and Curaçao (together, the ABC islands), it is elongated on a northwest/southeast axis, and its windward coasts are exposed to the persistent and consistently strong northeast tradewinds. Shallow-water coral communities and reefs are controlled by exposure, slope and sandy bottoms, and are best developed at the exposed eastern end (Bak 1975, 1977; summarised in Wells 1988). A fringing coral-algal reef extends alomg the southern leeward coast of Aruba for about 25km, separated from shore by a narrow, shallow lagoon. The western leeward coast is characterised by extensive sandy beaches and seagrass beds with some patch reefs; corals are mostly soft corals. The northern windward coast has a rocky shore; patch reefs and large fields of seafans occur here.

Human use of the coastal zone

Over the last decade, Aruba has been most successful in attracting tourism; having more than 600,000 stay-over visitors and in excess of 400,000 cruise arrivals in 1996. The population has risen over the same period from about 60,000 to 94,000; almost entirely due to immigration to service the booming tourism-based economy. The large oil refinery on the south-eastern end of the island, which closed down in 1985, was re-opened in 1992. Most development of human settlements (residential, commercial, touristic, service and other industrial) has taken place

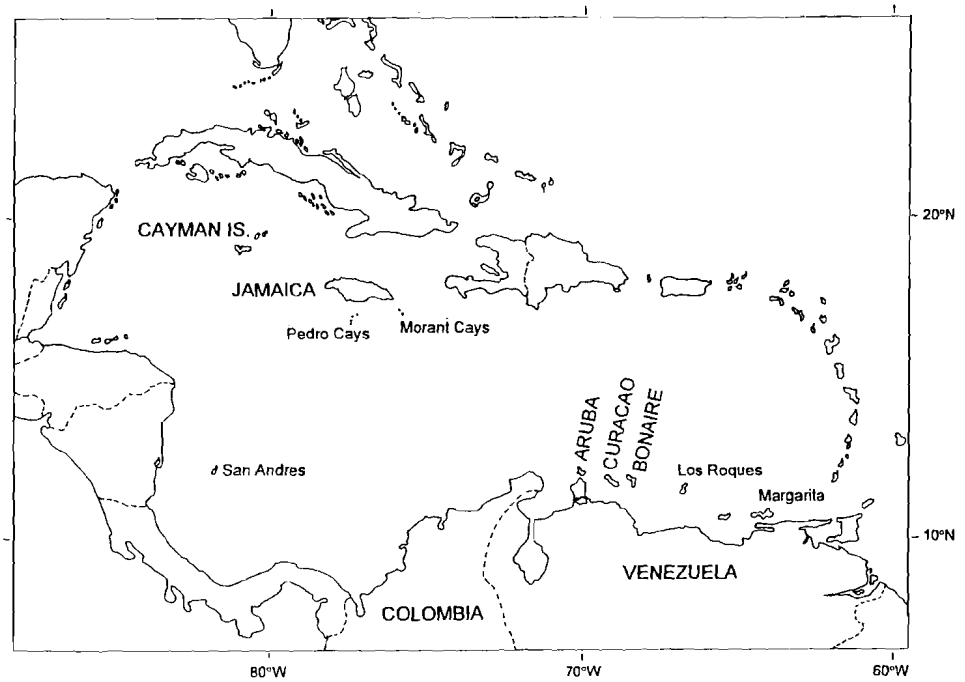

Fig.1 A map of the Caribbean Sea. Territories of the south central region, the subject of this paper, are named.

within the southern coastal zone, with land being "reclaimed" from the lagoon at several sites. It continues at an accelerated pace, although the development of appropriate infrastructure lags far behind. Consequent impacts result from accelerated and increased run-off, inappropriate sewage disposal, harbour activities and increased recreational use. Local fishing is mostly for pelagics, but there have been increasingly frequent incursions into coastal zone waters by Venezuelan and Far-Eastern fishing fleets.

Recent history, current status of reefs
Aruba lies at the edge of the hurricane belt, and impact from such storms is rare. In 1980-82, white-band disease killed over 90% of *Acropora cervicornis*, which occurs on the shallow terrace (Wells, 1988), and decreased that coral's ability to regenerate after physical damage (Bak and Criens 1981). As elswhere in the Caribbean, *Diadema antillarum* suffered mass mortality in 1983 (Bak et al. 1984). Eakin et al. (1994) documented localised impacts of the oil refinery on nearby coral communities. Resident divers report that reefs on the southern and western coasts have been severely degraded in the last decade, and that they are now in critical condition due to increased pollution and other pressures resulting from development. Reef areas on the northern coasts are still in good health.

Management regime
Corals, conch, turtles, reef fishes and other organisms have been legally protected since 1980, but more comprehensive conservation legislation was enacted in 1994. This makes it possible to establish legally protected areas, to install management authorities and to execute management plans. Government policy, and a plan for protection of the natural environment, are being prepared: the development of marine parks is considered a priority. Meanwhile, a private sector initiative, mainly by commercial watersports interests, established mooring buoys at major dive sites.

CAYMAN ISLANDS

Geographical setting
Grand Cayman, Little Cayman and Cayman Brac are small low islands (33 x 10, 14 x 3 and 17 x 3km, respectively) 300km west of the Sierra Maestre of Cuba. The submarine shelves of all three islands are narrow (0.5-2.0km) and bounded by steep walls dropping to great depths from 20-40m. Well-developed fringing reefs are located on the narrow shelves, on two successive terraces, and have been described by Roberts (1994) and Logan (1994).

Human use of the coastal zone
In the last 30 years, the Cayman Islands have shown phenomenal growth from an isolated, undeveloped country into a thriving financial centre and a popular destination for tourists. The resident population has grown from 8,500 to 30,000. Nearly 600,000 people visit on cruise ships each year, while there are over 280,000 longer stay visitors, many of whom are divers. Seafood is popular with visitors and, although there are no commercial fisheries, there has been considerable pressure on stocks of conch, lobster and, to a lesser extent, finfish.

Recent history, current status of reefs
There is frequent, though irregular, disturbance by hurricanes, the last major impact being that of Gilbert in 1988. As elsewhere in the Caribbean, *Diadema antillarum* suffered mass mortality in 1983. However, this did not result in a dramatic algal bloom, perhaps because reef-fish were still abundant. *Diadema* seems to be re-establishing itself in isolated areas on the west side of Grand Cayman. Large-scale bleaching of corals, observed in 1987, was much worse in 1995-96 (CARICOMP in press a). "White-band" disease has been observed, but the *Acropora* species are still quite common, although impacted by storms.

The deeper reefs off George Town have been destroyed by the continual anchoring of cruise ships, and nearby shallow reefs have suffered from consequent sedimentation. Another major source of stress on Cayman coral reefs is the impact of increasing numbers of divers.

The current condition of most Cayman reefs is relatively good, but veteran divers assert that they are deteriorating. Monitoring by the Dept. of the Environment at selected sites is just beginning. Reef fish are still abundant, although there is concern at the increasing use of large Antillean traps with small mesh wire. There is also concern about potential pollution of ground water (and coastal waters) consequent on the disposal of sewage by deep well injection.

Management regime
Under the Marine Conservation Law (1978), the taking of any marine life while on scuba is banned, the fishing of conch, lobster and turtle is controlled, and the discharge into the sea of harmful effluent and raw sewage is banned. The Marine Park Regulations (1986) established Marine Park Zones (no fishing, except with lines from the shore or beyond the drop-off, no anchoring), Replenishment Zones (no taking of conch or lobster, no spearfishing, no fishtraps) and (in part of the North Sound at Grand Cayman) an Environmental Zone (no hunting, fishing, swimming or anchoring). Between them, these zones include about 34% of coastal waters. In 1993, the Department of the Environment was created, and the monitoring and management of the coastal and marine environment is the reponsibilty of the Protection and Conservation Unit, which provides technical advice to the Central Planning Authority, and to the Executive Council. Four fulltime Marine Enforcement Officers are employed, and the maximum fine for breaching the Marine Conservation Law has been increased to CI$500,000 (=US$600,000).

COLOMBIA

Geographical setting
The Caribbean coast of continental Colombia, fringed by a shelf of 40 km maximum width, is strongly influenced by terrestrial runoff of fresh water and sediment. The central coast receives the Magdalena river, the largest river discharging directly into the Caribbean Sea. Hard bottoms are not common and the coastal zone is basically sedimentary. For these reasons, coral reefs are scarce on the mainland (present in less than 4% of the coast) but commoner and better developed on offshore islands. These include the Islas de San Bernardo and the Islas del Rosario on the continental shelf (20-30 km wide), and the more distant group of coral banks, atolls and islands in the Western Caribbean that constitute the oceanic Colombian archipelago of San Andrés and Providencia (Prahl, 1985; Wells, 1988; CORPES C.A., 1992).

Human use of the coastal zone
The continental Colombian coast supports a large human population (about 2 million people in 1985), concentrated at three port cities (CORPES C.A., 1992). Barranquilla, the largest and most industrialized, is located in the mouth of the Magdalena river. Cartagena and Santa Marta are mainly touristic (although the former also has important industry), and are located near coral reef areas. Significant human impacts in the coastal zone include sewage pollution, chemical pollution, coastal construction, overfishing, dynamite fishing, mangrove logging and tourism.

San Andres, the only densely populated island in the archipelago of San Andrés and Providencia (about 50,000 people in less than 30 km^2), is an active centre for commerce and tourism. Human impacts on the marine environment include sewage pollution, dredging, overfishing, coastal construction, tourism, oil pollution, and boat and anchor damage (Diaz et al. 1995).

Recent history, current status of reefs
Continental Colombia is outside the hurricane belt, but San Andrés and its neighbours suffer occasional impact (Geister 1992). Both areas have suffered from the mass mortality of *Diadema* in 1983 (Lessios et al. 1984, Geister, 1992), mass mortalities of *Gorgonia* spp. in the 1980's (Garzón-Ferreira

and Zea 1992, Diaz et al. 1995) and significant coral bleaching in the 1980's (Zea and Duque 1989, Williams and Bunkley-Williams 1990) and in 1995 (CARICOMP in press a).

Acosta (1994) compared reefs at Punta Betin and Isla Morro Grande, influenced by the Manzanares river and the harbour and city of Santa Marta, with reefs of the Tayrona National Park, where few people live. The former had fewer coral species (19-20 vs 24-26) and less coral cover (19-26% vs. 37-49%). Colonies of *Montastræa cavernosa*, showed smaller gonads and less fertility at the former, than at the latter sites. Moreover, surveys at Punta Betin in 1972 and 1975 had recorded more coral species, suggesting that subjective impressions of decline in diversity and abundance due to pollution in Santa Marta Bay were correct. But Garzón-Ferreira and Cano (1991) reported that, even at Tayrona, there had been extensive mortality of branching (*Acropora palmata, A. cervicornis, P. porites*) and foliose (*Agaricia tenuifolia*) corals at shallow waters and considerable mortality of massive corals (*Stephanocoenia intersepta, M. annularis* complex, *Colpophyllia natans, Diploria* spp.) at deeper reef slopes, in the previous decade.

Garzón-Ferreira and Kielman (1994) reviewed surveys since 1980 of coral reefs on islands near Cartagena: Islas de San Bernardo and Islas del Rosario. Extensive coral mortalities, especially in *Acropora* species, were reported from 1982 to 1989. *P. porites* and *A. tenuifolia* were severely affected, while massive corals also showed declines.

The reefs of San Andrés island were surveyed in 1968-73, and most coral communities seemed to be healthy (Geister 1975). They were surveyed again in 1992 and found to be in poor condition (Garzón-Ferreira and Kielman 1994; Diaz et al. 1995). The percentage of coral that had died so recently that it was still recognizable, not eroded or overgrown was estimated at 52%. The most affected coral species include *Acropora cervicornis* (which has almost disappeared from around San Andres), *A. palmata, Eusmilia fastigiata* and *C. natans*. Algae (mainly *Dictyota, Halimeda, Lobophora* and *Padina*) had proliferated.

During 1994-1995 observations were made for the first time on the structure and health of coral communities at three unpopulated atolls of the San Andrés and Providencia archipelago (Courtown, Serrana and Roncador). Estimates of recently dead coral at each atoll gave similar values to those found in San Andres island (43%-56%). Affected species included both branching (*Acropora* spp., *Porites porites*) and massive corals (*M. annularis* complex, *Siderastrea siderea, C. natans, Diploria* spp.). However, mortality levels of the two *Acropora* species, as well as that of *Gorgonia* spp., were clearly much lower at the atolls than in San Andrés (J. Garzón-Ferreira, unpublished data).

Management regime

Environmental management was boosted by creation of the Ministry of the Environment in 1993. National Parks and Reserves are administered now by the Ministry, and include those at Tayrona and Islas del Rosario. Both of these have some local staff with rangers to enforce regulations, but resources and infrastructure are still very scarce for an effective control. Management plans have been prepared for these and other proposed Protected Areas (including Islas del San Bernardo, San Andrés and Providencia), for which legislation is in preparation. Legislation and regulations are also being prepared for coastal area management, and for further protection of mangroves, seagrass beds and coral reefs.

JAMAICA

Geographical setting

The island of Jamaica (235 x 80km) is situated in the centre of the Caribbean Sea. NE Trade Winds prevail but Cuba, 150km north, limits their fetch and moderates wave exposure on the north coast. There, fringing reefs are well developed, close to shore on a very narrow submarine shelf. Reef formations on the south coast are punctuated by rivers, terrigenous sediment slopes, and by a shallow submarine shelf up to 20km wide. Reefs and coral communities occur on neighbouring banks, notably at the Pedro Cays, 70km south, and the Morant Cays, 50km south-west.

Human use of the coastal zone

Jamaica's human population, which has doubled in the last 30 years, is about 2.5 million. Coastal communities are numerous, and while industrial development has been concentrated at Kingston, there has been a great deal of recent development for tourism, mostly on the north coast.

Recent history, current status of reefs

In 1980, after 36 years free of major storm damage, Jamaican reefs were severely impacted by Hurricane Allen. Just a few weeks before, a white-band disease was observed in *Acropora cervicornis* (Knowlton et al. 1981), while three years later, the abundant sea-urchin *Diadema antillarun* suffered mass mortality (Hughes et al. 1985). These natural impacts marked the beginning of a major transition in Jamaican coral reef communities; one which might not have occurred, had it not been for insidious chronic disturbance caused by human activities, notably fishing and terrestrial run-off (Woodley 1992, Hughes 1994).

Over-fishing, especially on the narrow north coast shelf, was apparent in the 1960s, and documented in the 1970s (Munro 1983). At that time, the unusually high abundance of *Diadema* was attributed to removal of its fish predators and competitors, as were other possible changes in the benthic community (Woodley and Robinson 1977). Soil erosion has been recognised as a problem in Jamaica for at least 50 years, and local impacts of sediments on reefs have been seen near river mouths. As the human population has increased, nutrient pollution has become increasingly evident: in Kingston Harbour (Wade 1976) and at smaller coastal communities. Nitrate levels in ground water, percolating through porous limestone, are high (D'Elia et al. 1981).

For all these reasons, coral reef recovery from natural disturbances in the early 1980s took place under circumstances greatly altered from those in which the reefs had developed. In the absence of fish competitors, *Diadema* had become the most important herbivore on Jamaican reefs, and a major control on macrophytes. After its mass mortality there was a great increase in the biomass of benthic algae (Liddell and Ohlhorst 1986, Hughes et al. 1987), which tended to overgrow coral colonies and inhibit successful recruitment of juveniles. Reduced herbivory, allowing algal growth, also made reefs more sensitive to nutrient pollution, which may play a role all around the island. Coral mortality is evident westward of Kingston Harbour, downstream in the Caribbean Current, consistent with the impact of a pollution plume (Woodley 1989). In addition, Jamaican corals suffered mass bleaching in the winters of 1987, 1989 and 1990, followed by considerable mortality.

Resurveys in the early 1990s of nine reefs (mostly on the north coast) previously surveyed in the late 1970s, revealed an average decline in coral cover from 52% to 3% at 10m depth, and an increase in cover by fleshy macroalgae from 4% to 92% (Hughes 1994). Even in the Mixed Zone, dominated by massive corals at Discovery Bay, coral cover is only 10% (CARICOMP in press b), while the highest coral cover recorded in a rapid assessment of the Montego Bay Marine Park was 14% (Sullivan and Chiappone 1994). Some coral assemblages on reefs at the Port Royal Cays are in surprisingly good health, with cover reaching 20% (Mendes 1992) and even *Acropora cervicornis* is locally abundant.

Management regime

For many years, the principal law controlling development of the coastal zone was the Beach Control Act (1960), which required the licencing of construction or drainage works within a mile of the shore, and of any interference with the sea-bed. It was administered by a small, underfunded department, and was often ignored. Environmental management has been greatly strengthened by the Natural Resources Conservation Act (1994) and by the creation of the Natural Resources Conservation Authority, with more staff and funding than its predecessor, within a Ministry of Environ-

ment and Housing. Marine Parks created in 1967 (Ocho Rios) and 1974 (Montego Bay) were classic "paper parks", without staff or funding, until 1989, when the Montego Bay Marine Park was revitalised with USAID funding.

Government efforts in conservation and protected area management have been increasingly supplemented by NGO activities. Local groups have formed, all around the country, several of which are doing valuable work in the coastal zone: notably the Negril Coral Reef Preservation Society, the Portland Environmental Protection Association, the South Coast Conservation Foundation, and the St. Ann Environmental Protection Association. The Fisheries Improvement Programme, based at the Discovery Bay Marine Laboratory, is helping artisanal fishermen to better manage fishery resources (Woodley 1994).

NETHERLANDS ANTILLES (NETHERLANDS)

Geographical setting

Bonaire and Curaçao are small oceanic islands (38 x 10 and 61 x 14km, respectively) situated about 70km north of Venezuela, but surrounded by deep water. Each is elongated northwest/southeast, and their eastern coasts are exposed to the persistent tradewinds. The submarine shelves are very narrow; about 100m wide to a depth of 8-12m, beyond which they slope steeply, often to a second, sandy terrace at 50-60m, dropping off again at 80m. On the leeward coasts, coral communities and reefs are well developed on the shallow terrace and slope. On the windward coasts, the shallow terraces are dominated by crustose algae and *Sargassum*, and coral communities are displaced deeper (Bak 1975, 1977; summarised in Wells 1988).

Human use of the coastal zone

The most important industry in Bonaire is tourism, increasing at 10% per year for the last ten years, currently about 60,000 per year, of whom 26,000 are divers. The resident population (c. 11,000) is growing, partly due to the tax benefits of retirement to the island. In consequence, there is a building boom, especially in the coastal zone, already the site of much tourist and private housing. Terrestrial runoff occurs from land clearance and construction, and there is no central sewage treatment plant. Most fishing is for pelagics; little occurs among the reefs.

The total population of Curacao (c. 160.000) has decreased somewhat during the last few years, due to increased emigration, but the pressure on the natural environment has increased dramatically. The economy is quite diverse, based on an oil refinery, other industrial activities, tourism and off-shore banking. Massive coastal development forms the biggest threat to the marine environment. Raw sewage discharge, harbor related pollution, and sedimentation due to deforestation are the main impacts on the reef. Most fish caught are pelagics: reef fish catch is estimated at 90-180 tonnes/year (LVV 1988).

Recent history, current status of reefs

Bonaire and Curaçao lie at the margin of the hurricane belt and tropical storms are rare; so when they do impact, their effects are marked. As at Aruba, white-band disease decimated *Acropora cervicornis* in 1980-81. As elsewhere in the Caribbean, *Diadema antillarum* suffered mass mortality in 1983 (Bak et al. 1984) leading to an increase in fleshy algae (Ruyter van Steveninck and Bak 1986). Mass bleaching of corals occurred in 1987 (Williams & Bunkley-Williams, 1990), 1990 (Meesters & Bak, 1993) and 1995 (CARICOMP in press a, Nagelkerken et al. in preparation).

Bak and Nieuwland (1994) reported on a 20-year study of $3m^2$ quadrats at four depths (10, 20, 30 and 40m) at four sites: three near to CARMABI in Curaçao, and one in Bonaire. Between 1973 and 1992, coral cover decreased at the two shallower depths from 50-55% to 25-30%; at 30m it stayed about the same (on average), while at 40m it increased from 25 to 30%, largely as *Agaricia lamarcki*. In trying to explain the decline, the authors ruled out most natural causes and were left with increased benthic algae, increase in the abundance of *Trididemnum solidum* (possibly related to eutrophication), and changes in water quality due to coastal development and artificial beach construction.

The general condition of reefs at Bonaire is very good, with only localised impacts of anchoring and sewage pollution. Also, the abundance and biomass of reef fishes is high (Roberts and Hawkins 1994).

By far the healthiest reefs in Curaçao are those east of the population centre. These reefs, upstream of urban and industrial development, have been spared the longterm polluting impacts of coastal development and industry. Due to rougher waters and more limited public access, fishing and diving pressures are also limited. Elsewhere, reef condition and reef fish populations have degraded.

Management regime

In the 1970s, the Bonaire Island Government passed several ordinances on marine resource management, which banned spearfishing and coral collection. The Bonaire Marine Park, which extends all around the coast of Bonaire and Klein Bonaire was created in 1979. Like other parks in the Netherlands Antilles, it is administered by the private foundation STINAPA Netherlands Antilles. There is a zonation and management plan, a visitor centre, and permanent moorings have been established. The park is completely self-financed, based on diver admission fees (US$10 per year), grants and donations.

In Curacao, the Reef Management Ordinance of 1976 prohibits spearfishing and coral collection and is still the only relevant legislation. The Curacao Underwater Park, opened in 1983, extends 20km from Oostpunt (eastern tip of the island) to Willemstad (capital city). To date the park has no legal status and has never been really effective due to the absence of sufficient financial means (only some government subsidies are available). A management plan was recently produced (Van't Hof et al. 1995), and the legal department of the island is now designing upgraded legislation. Implementation of the proposed management regime is planned for early 1997.

VENEZUELA

Geographical setting

The coastal waters of continental Venezuela are strongly influenced by freshwater and sedimentation from terrestrial runoff, and by cool upwellings, which limit the occurrence of corals. Nearshore coral reefs are scarce, but notable examples occur at Moroccoy and Mochima. Better developed reefs occur around offshore oceanic islands, which include the Archipiélago Los Roques.

Human use of the coastal zone

There has been much industrial, urban and touristic development of the coast in recent years, with consequent pollution by sedimentation and human and industrial wastes. The fringing continental reefs are used intensively for fishing, as are those at Los Roques (lobster, conch and finfish). Heavy tourism is also a common factor in these reefs whilst the island reefs are less exploited and less controlled.

Recent history, current status of reefs

The influence of hurricanes is relatively rare. As elsewhere in the Caribbean, mass mortality of *Diadema* was reported in 1983 (Lessios et al. 1984). Large-scale bleaching of corals, observed in 1987, was much worse in 1995-96 (CARICOMP in press a). Some reefs are currently affected by terrestrial runoff. The reefs of the Morrocoy National Park were recently affected by a mass mortality of marine organisms which led to nearly total elimination of all massive coral species in the park.

Management regime

Natural resource conservation is the responsibility of the Ministerio del Ambiente y de los Recursos Naturales y Renovables (MARNR). Many laws and regulations apply, including a total and absolute ban on felling, burning, dredging and dumping in mangrove communities (1974), and

declaration as a Protected Area of the coastal strip for 80m inshore of the highwater mark (1990). Protected Areas, managed by INPARQUES, include National Parks at Los Roques (1972), Mochima (1973) and Moroccoy (1974). INPARQUES has insufficient boats, trained personnel, and financial support. Many oceanic island are controlled by the Navy, so access is restricted and no tourism or fishing occurs. There are management plans for all the protected areas but in the present conditions they are not fully implemented.

Some NGOs are currently supporting research programs in the reefs. ECONATURA assigns grants for small projects in protected areas and trains personnel to monitor physico-chemical variables in marine parks. FUDENA maintains a conservation programme of the marine turtles.

DISCUSSION

There are reports of coral reef degradation, to differing degrees, from all six countries reviewed here. The reefs reported in best condition are at Bonaire and Cayman, while those which have shown the greatest decline are on the north coast of Jamaica and at Moroccoy, Venezuela. In all countries, both natural and human causes are implicated, often compounding one another.

Diseases are important among the natural factors; it is not known if they are advanced by human disturbance. *Acropora* species, dominant frame-building corals in many Caribbean reefs, are known to have suffered mortality from "white-band" diseases, which often escape notice and are usually unquantified (Aronson and Precht, in prep.). Populations of the herbivorous sea-urchin *Diadema antillarum* have not recovered from mass mortality in 1983 which, in many countries, resulted in increased biomass of benthic algae.

Hurricanes are the most conspicuous of the natural impacts on coral reefs and have affected most countries recently, as they have done for thousands of years. But they may now act as triggers for major community changes, since chronic human perturbations have altered the conditions under which recovery should occur (Hughes 1994).

Those human perturbations, greatly increased as populations expanded and developed in the late 20th century, are mostly in the form of terrestrial runoff (of sediments and nutrients) and fishing. The greater impacts have been seen where there are more people, as in the pollution from coastal cities and towns. Reefs on narrow offshore shelves of well populated countries (like the north coast of Jamaica) suffer relatively high impact both from terrestrial runoff and fishing. But where shelf and reef areas are large relative to fishing population, as on the south coast of Jamaica, and Cayman, reef fish are larger and more abundant, and play more of a role in benthic reef ecology.

Two significant trends in resource management can be recognised in countries of the region. First, there is a progression from legal protection of species, to protection of a habitat area, to protection of the wider ecosystem and, ultimately, nation-wide environmental management. None of the countries under consideration has reached that goal. However, most of them have established Marine Protected Areas (MPAs), mostly as National Parks. Even where they have too little funding to be fully effective, they can play a valuable role in drawing public and government attention to the importance of natural resources. They act as local stimuli for Integrated Coastal Area Management (ICAM) initiatives, and become valuable centres for learning, and for developing appropriate measures, although initially on a small scale. The development of ICAM is usually hampered by the multiplicity of agencies involved. More unified structures for environmental decision-making have been created by restructuring departments and by the creation of consultative committees, as in Cayman.

The small island states, Bonaire and Cayman, where dependence on marine resources is more obvious, have apparently established more effective conservation regimes than their larger sister territories of Curaçao and Jamaica, in which there are many more competing interests. Cayman recently declared a (temporary) moratorium on development, but Bonaire, like many another "island paradise" has yet to establish limits.

The enforcement of environmental laws requires political will, trained staff and money. As the awareness of environmental issues spreads among voters, political will increases. But most natural resource agencies in the region are understaffed, and law enforcement officers are often unaware of, or unconcerned by, environmental laws. Levels of penalties are generally low relative to the importance of the breach of law, and fines have been reduced to paltry levels by inflation. Now these anomalies are being addressed in several countries, as illustrated by the example from Cayman.

However, environmental management through only the imposition of laws and regulations by central government is expensive and inefficient: people are much more likely to change their behaviour if they are informed and involved. Relevant to this is the second observed trend: a move from "top-down" control by central authority to incorporate "bottom-up" participation by local resource users in a co-management framework. In the last ten years, environmental managers and funding agencies have realised the necessity of involving all "stakeholders" in environmental planning and regulation. There has been much talk, and some action, in this area throughout the region, and the participation of NGOs in coastal area management has increased.

There is no doubt that governments, institutions and some communities throughout the region have been made aware of the importance of maintaining coastal resources by ICAM, and that more effective management policies are slowly being introduced. How long it will be before these policies succeed in reversing apparent trends of anthropogenic degradation of coral reefs is another question. A recent remark about one country in the region applies to them all: "To reverse this trend in Jamaica will require a revolution in the way we exploit and live with the limited resources of this island. That is the real challenge of sustainable development" (Woodley 1992).

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