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, Curacao, Jamaica, Venezuela) suffer from increased 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 Curacao, and Venezuela (Fig. 1).
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. Concomitant impacts result from accelerated run-off, inappropriate sewage disposal, harbour activities and increased recreational use. Local fishing is mostly for pelagic, but there have been increasingly frequent incursions into coastal zone waters by Venezuelan and Far-Eastern fishing fleets.

Recent history, current status of reefs

Antilles, 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. Under this policy, and as a result 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 no-fishing buoys at major dive sites.

Management regime

Coral reefs are very sensitive to environmental changes. Overfishing, catastrophic storms, anchor damage, and sewage pollution are all threats to the health of coral reefs. In addition, coral reefs are vulnerable to the impact of human activities such as tourism, construction, and pollution.

Human use of the coastal zone

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. Diadema seems to be re-establishing itself in isolated areas on the west side of Grand Cayman. Diadema seems to be re-establishing itself in isolated areas on the west side of Grand Cayman. Diadema seems to be re-establishing itself in isolated areas on the west side of Grand Cayman.

Human impacts in the coastal zone

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 continental shelf (20-30 km wide), and the more distant group of coral banks, atolls and islands in the archipelago of San Andrés and Providencia (Prachi, 1985). Islands include the Isla de San Andrés, the Isla de Providencia, the Isla de Barú, and the Isla de Santa Marta. These islands are mainly tropical and are located near the coast of Venezuela. The Magdalena river. Cartagena and Santa Marta are mainly tropical (although the former also has important industrial activities), and are located near the 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 Andrés, the only densely populated island in the archipelago of San Andrés and Providencia (about 50,000 people in less than 30 km²), 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.

Recent history, current status of reefs

Colombian waters are relatively good, but minor divers observe 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 size. 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 a vessel 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, mooring 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 responsibility of the Marine Division of the Ministry of Environment. Four full-time Marine Enforcement Officers are employed, and the maximum fine for breaches of the Marine Conservation Law has been increased to COP250,000 (about US$65,000).

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 (except in limited areas of the coast) but commoner and better developed on offshore islands. These include the Islas de San Andrés, the Islas de Providencia, the Islas de Barú, and the Islas de Santa Marta. These islands are mainly tropical and are located near the coast of Venezuela. The Magdalena river. Cartagena and Santa Marta are mainly tropical (although the former also has important industrial activities), and are located near the coral reef areas. Significant human impacts in the coastal zone include sewage pollution, chemical pollution, coastal construction, overfishing, dynamite fishing, mangrove logging and tourism.

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Recent history, current status of reefs

The current condition of most Cayman reefs is relatively good, but minor divers report 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 size. There is also concern about potential pollution of ground water (and coastal waters) consequent on the disposal of sewage by deep well injection.
Reefs in the South Central Caribbean


Acosta (1994) compared reefs at Punta Metín and Isla Morro Grande, influenced by the Mananare river and the harbour and city of Santa Marta, with reefs of the Tayrona National Park, which few people live in. The latter had fewer coral species (19-20 vs 24-26) and less coral cover (19-26% vs. 37-45%). Colonies of Montastrea cavernosa, showed smaller gonads and less fertility at the former, than at the latter sites. Moreover, surveys at Punta Metín in 1972 and 1976 and 1995 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-Peréz and Kielman (1994) reviewed surveys since 1980 of coral reefs on islands near Cartagena: Isla de San Andrés and Isla del Rosario. Extensive coral mortalities, especially in Acropora species, were reported from 1982 to 1989. P. porites and A. tenuifolia were severely affected. Typhus annularis, was seen in ever decreasing numbers. Isla de San Andrés island were surveyed in 1968-73, and most coral communities seemed to be healthy (Kilester 1975). They were surveyed again in 1992 and found to be in much worse condition (Garzón-Peréz et al. 1994; Dias 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 died out in the last decade, Euphyllia paradivisa 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 (Courton, Barrera and Roncador). Estimates of recent dead coral at each atoll gave similar values to those found in San Andrés island (43-54%). Affected species included both branching (Acropora spp., Porites porites) and massive corals (M. annularis and Euphyllia divisa, 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-Peréz, unpublished data).

Management regime

Effective coral reef 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 Isla del Rosario. But these areas 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 Isla 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 mangrove, 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 in 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, notatly at the Pedro Cays, 70km south west, and the Morro 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 (Hughes et al. 1981) while three years later, the abundant sea-urchin Diadema antillarum suffered mass mortality (Hughes et al. 1981). These natural impacts marked the beginning of a major transition in Jamaican coral reef communities: one which might not have occurred naturally, and which was exacerbated by pruning of local populations, sometimes for human activities, notably fishing and terrestrial run-off (Woodley 1997, Hughes 1994).

Over-fishing, especially on the narrow north coastal 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 away from the southernmost coral benthic community (Woodley and Robinson 1977). Scleractinian corals have been recognized 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 with 4 million in 1980, and 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 has become the most important herbivore on Jamaican reefs, and a major control on macrophytes. After its massive mortality there was a great increase in the biomass of benthic algae (Liddell and Orchard 1986, Hughes et al. 1981), 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 the around the island. Coral mortality is evident near west 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 52% (Hughes 1994). Even in the Mixed Zone, dominated by massive corals, recovery of 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% (Bullivant and Chisgome 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 near-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 (1991) and by the creation of the Natural Resources Conservation Authority, with more staff and funding than its predecessor, with 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 action. Small groups of NGOs are active 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 Curacao are small oceanic islands (38 x 10 and 61 x 14 km), respectively situated about 70 km north and 150 km west of Venezuela, but surrounded by deep water. Each is elongated northwest/southeast, and their eastern coasts are exposed to hurricanes and tropical storms. The western 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 Zargassum, and coral communities are displaced deeper (Bak 1975, 1977; summarised in Meina 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 50,000 tourists per year. Local groups are forever all around the island, 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. Most fish caught are pelagics: reef fish catch is about 10% of total landings, and is still the only relevant legislation. The Curacao Underwater Park, opened in 1984, 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 upwellings, which limit the occurrence of corals. Nearshore coral reefs are scarcer, but notable examples occur at Morrocoy and Mochima. Better developed reefs occur off uninhabited oceanic islands, which include the Archipiélago Los Roques.

Human use of the coastal zone

There has been much industrial, urban and tourist 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 snapper). 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

Bonaire and Curacao lie at the margin of the hurricane belt and tropical storms, and some reefs are subject to hurricanes. The major effects are marked. As at Aruba, white-band disease (dechlorization) is widespread. At elsewhere in the Caribbean, diatoms antillarum suffered mass mortality in 1983 (Bak et al. 1984) leading to an increase in fleshy algae (Rugger van Steveninck and Bak 1986). Mass bleaching of corals occurred in 1987 (Williams & Bunker-Williams, 1990), 1990 (Meesters & Bak, 1993) and 1995 (CARCOMP in press a, Nagelkerken et al. in preparation).

Bak and Nieuwland (1994) reported on a 20-year study of 3m2 quadrats at four depths (20, 30 and 40m) at four sites: three near CURAÇAO and one in Bonaire. Between 1973 and 1992, coral cover decreased at the two shallower depths from 50-55% to 25-30%; largely as Agaricia lanterna. 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 limited 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 Curacao are those east of the population centre. These reefs, upwelling 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 status and management plan, a visitor centre, and permanent monitoring stations 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 1984, 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.

Recent history, current status of reefs

The influence of hurricanes is relatively rare. As elsewhere in the Caribbean, mass mortality of Diadema has been reported in 1983 (Lessios et al. 1984). Large-scale bleaching of corals, observed in 1987, was much worse in 1995-96 (CARCOMP 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 various organisms which led to serious localised impact of anchoring and sewage pollution at some reefs.
declaration as a Protected Area of the coastal strip for 5m inside of the highwater mark (1990). Protected Areas, managed by INPARQUES, include National Parks at Los Roques (1972), Mochima (1973) and Morrocoy (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 no marine reserves or other protected areas in the present conditions they are not fully implemented.

Some NGOs are currently supporting research programs in the reefs. ECOAFRICA assigns grants for small projects in protected areas and trains personnel to monitor physico-chemical variables in marine parks. FUDENA maintains a conservation program 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 Morrocoy, Venezuela. In all countries, both natural and human causes are implicated, oftencompounding 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 being lost, to have suffered "white-band" diseases, which often escape notice and are usually unquantified (Aronson and Precht, in prep.). Populations of the urchin Diadema antillarum in Andrew’s Reef, where they 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; they have affected all marine protected areas by, 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 impacts both terrestrial runoff and fishing. But where shelf and reef areas are large relative to fishing populations, as on the south coast of Jamaica, and Cayman, reef fish are larger more abundant, and play more of a role in benthic reef ecology.

Two significant trends in resource management can be recognized 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, to overall, to-atmosphere environment 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 can 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 Curacao 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, training of and support for all involved, but the present conditions limits to power levels by inflation. How 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 ineffecient: 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 two 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 communities throughout the region have seen 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. The recent report of Dougs management policies 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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