# STATUS AND PROSPECTIVE OF CORAL REEF MANAGEMENT IN CUBA

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ABSTRACT. Main human induced impacts on Cuban coral reefs are pollution, sedimentation and over-fishing of fin-fish and invertebrate predators and herbivores, which enhance algal proliferation and coral damage and disease. Regional/global impacts include: dye-off of the sea urchin *Diadema antillarum*, coral bleaching, coral pathogenic diseases, cyclones, and probably regional oceanic water nutrification. The term "coral reef" begins to appear explicitly in a currently improving environmental legislation since 1997. A recently approved Decree-Law on Protected Areas paves the way to the protection of several coral reefs. Agreement between fishery, conservation and tourism stakeholders is converting diving sites in "no take areas" but illegal fishery still poorly controlled in some of them. A great effort is being devoted to organic pollution control after increasing awareness of its importance for coral reef health and for tourism. Enhancing public education, awareness and involvement has to be a next high priority action.

## 1. INTRODUCTION

Cuban coral reefs can be found along virtually the entire border of the Cuban shelf and extend inshore across broad areas of the shelf. The shelf edge extends along 3966 km: 2150 km on the north coast and 1816 km on the south coast (Núñez-Jiménez, 1984a). The entire Cuban shelf edge is almost continuously fringed by fore reefs (>98%). In many places these reefs bear reef crests at their shallowest zone. Reef crests in Cuba tend to be more abundant at the edge of the four broad sections of the Cuban shelf: the Gulf of Guanahacabibes (Northwest Cuba), Sabana-Camagüey Archipelago (central north), Gulf of Ana María-Guacanayabo (Southeast) and Gulf of Batabanó (Southwest). However, in the narrow shelf of Northeast reef crests are also widespread and quite long.

Inshore patch reefs are found dispersed on the north-western (Gulf of Guanahacabibes), south-western (Gulf of Batabanó) and south-eastern (Gulf of Ana María-Guacanayabo) sections of the shelf of Cuba. Zlatarsky and Martínez-Estalella (1980, 1982) discovered unique reefs on muddy substrates in the Gulf of Guacanayabo.

Highly prized coral reef fishes provide about 40% of commercial catch. Lobster export provides more than 100 millions USD annually to the country. Coral reef diving tourism is being developed in Cuba. Furthermore, some coral reef protected areas and fishery reserves ("no-take areas") are being planed and implemented. Because of a greater awareness about the value, vulnerability, and current coral reef decline and threats, there is an increasing government will to protect, assess and monitor coral reefs in spite of current economic constraints.

This paper provides a brief panorama about the status, and current and prospective approaches for management in Cuban coral reefs.

## 2. STATUS OF CORAL REEF BENTHOS AND FISHES

Organic and chemical pollution have been observed to affect the coral reefs off Havana City (Fig. 1) due to the highly polluted waters of Havana Bay and the Almendares and Quibú rivers, as well as the underwater sewage out-fall point located east of Havana Bay entrance (Playa El Chivo). That nutrient enrichment produces a great proliferation of fleshy and filamentous algae in the reefs located near Havana Bay, Río Quibú, Playa El Chivo (Havana City) and near the entrance of Mariel Bay (at the north-western end of Havana Province).

On the reefs close to Havana Bay, diversity of scleractinians, sponges and gorgonians have dropped to very low values and their communities are dominated by the scleractinian *Siderastraea radians*, the sponges *Clathria venosa*

and *Iotrochota birotulata f. musciformis*, and the gorgonian *Plexaura kuekenthali, Eunicea flexuosa or Pseudoplexaura spp*. The dominance of these species, only when it is accompanied with low species diversity is considered to be an indicator of organic pollution (Alcolado *et al.* 1994). The population density of stony corals and gorgonians is very low, and is variable for sponges (Alcolado *et al*. 1994). As a consequence of the degradation of these reefs, shelter capacity and available food considerably decreased, thus leading to a dramatic decrease in fish diversity and abundance. This situation is reinforced by a high pressure or subsistence and recreational fishing. A slight recovery has been observed in part due to the economic depression.

Great proliferation of fleshy macroalgae have been observed also in the Sabana-Camagüey Archipelago (central north of Cuba), Cayo Largo and Cayo Juan Garcia (south-west of Cuba), and North of Pinar del Río Province (north-west of Cuba). This is very probably due to a synergy of the massive mortality of the black sea urchin *Diadema antillarum* (whose populations are showing a low degree of recovery in a few places) and the observed relatively high nutrient concentrations (dissolved phosphate concentrations higher than Lapointe's *et al.* (1992) threshold for enhancement of algal proliferation). During a coral reef assessment in may 1999 in the Sabana-Camagüey Archipelago an algal cover of 60-80% ( from the shallow reefs down to 25 m in depth) was observed in the same stations where ten years ago they were very scarce. A great amount of dead scleractinian corals and gorgonians, already covered by the algae, was observed in most of the stations. Remaining living corals were scarce but healthy. Very few corals have been seen with bleaching or other diseases. That great coral cover decline could be the consequence of the very strong ENSO events of 1998. Fish density and particularly fish biomass decreased drastically, and changes in fish community structure were evident (Claro et al., in preparation). In these cases there was a scarcity of herbivore fishes, mainly of great sizes. The abundance of medium and great size predators also decreased.

Extensive purple to black coloured cyanobacterial mats have been observed in spring months at the coral reefs of Cayo Largo in 1998 and 1999 (Alcolado et al. 1999) and Punta Francés in 2000 (E. de la Guardia, pers. com.), both located in the south-west of Cuba. Those mats covered the algae, corals and sponges.

Thermal pollution caused by the cooling system of a power plant located east of Mariel Bay has killed a shallow reef area, producing extensive coral bleaching. Mechanical pollution by fibre wastes from a henequen (an agave plant used to produce ropes) fibre processing factory was observed at a shallow reef near Mosquito River (east of Mariel Bay), causing abrasion of stony corals, sponges and gorgonians (Alcolado *et al.,* 1994). The observed increase of ciguatoxic fishes could be a consequence of this general coral reef deterioration.

Some degree of pollution may be affecting the reefs near the entrance of Cienfuegos (south central region), Santiago de Cuba (south-eastern Cuba), Nuevitas, Nipe (north-eastern Cuba), and Matanzas (north-western Cuba) bays, as well as near Baracoa City (north-eastern Cuba), and some other locations, although it has not been assessed yet. An environmental assessment recently conducted by Bustamante *et al.* (in press) in the reefs near Guantánamo Bay revealed the absence of significant pollution. We roughly estimate that less than 3% of the shelf border is affected by a high degree of organic pollution, but quite extensive areas are being affected by some degree of nutrification enhancing algal growth in detriment of corals.

Generally, *Diadema antillarum* populations are still very depressed. Coral reef decline is becoming common in Cuban coral reefs. In that sense, apart from the mentioned algal proliferation, the extensive death of *Acropora palmata* and *A. cervicornis*, presumably produced by the "white band" disease, is an outstanding issue. Another significant pathogenic disease affecting gorgonians in Cuban coral reefs is "aspergillosis". To a less extend, massive stony corals are affected by "white plague", "yellow band", "black band", and "dark spot". "White pox" has been recorded and photographed with other coral diseases by Quirolo (1998).

Coral bleaching events usually take place during ENSO, mostly along the north coast (Carrodeguas *et al.*, 1996). However, an intense coral bleaching extended along both the north and south coasts of Cuba mainly during late summer 1998 coinciding with high water temperatures during one of the two strongest ENSOs of the recorded meteorological history.

Decline in carnivore and herbivore fish and invertebrates (finfish, lobster, octopus, etc.) due to commercial, subsistence and furtive over-fishing is also a common issue as discussed below. Big sizes are getting quite scarce. Because of this lack of big predators, it is not rare to find over-populations of the coral predator gastropod *Coralliophylla abbreviata* (e.g. Punta Francés in the south-west of Cuba, and Cayo Levisa and Cayo Paraiso in the north-west), the gorgonian predator gastropod *Cyphoma gibbosum* (Punta Francés), and damselfish *Stegastes spp.* (e.g. María la Gorda in the west end of Cuba).

## 3. STATUS OF CORAL REEF FISHERIES

After a period of great increase in fish catches from 1960 to 1975, some commercial coral reef dwelling species became over-fished. Examples are the lane snapper (*Lutjanus synagris*) in the Gulf of Batabanó, the Nassau grouper (*Epinephelus striatus*) in virtually the entire Cuban shelf (Claro *et al*., 1994), and the queen conch (*Strombus gigas*).

After the first collapse of conch stocks in 1978, following an authorised capture of 2578 Tons in 1977, the Ministry of Fishery Industry (MIP) established a permanent closed season throughout the entire Cuban shelf from 1978 to 1981. Since 1990, a closed reproductive season in north and south-western Cuba (April-September), prohibition of catching juveniles, and smaller local fishing quotas were also established. This stock reduction was produced mainly by the over-fishing due to the illegal harvesting of meat for bait (with a rough estimate of more than 1500 Tons of complete animal wet weight per year), or for selling the shells as souvenirs.

Two stock assessments carried out in 1984 (all around Cuba) and 1987 (north central Cuba) and a qualitative survey in 1991 (north central Cuba) showed that these measures did not stop the decline in conch populations in those years, at least on the north coast. Two stock assessments suggested a slight recovery in the south of Cuba, one in Cabo Cruz (Southeast Cuba) in 1990, and another in the south of the Gulf of Batabanó (Southwest Cuba) in 1991. Very rarely, did the percentage of juveniles in the assessed populations exceed 20%. A drop in larvae recruitment coming from upstream is suspected (Ferrer and Alcolado, 1994).

The Queen Conch fisheries were again opened for domestic consumption in the central south of Cuba after some fishery data analysis as well as in the Northeast after fishermen reported some population increase in 1998. For accomplishing CITES regulations, assessments of conch populations in 1999 and 2000 revealed increased densities ($> 0.3$ ind./$m^2$) in the Northeast (north of Camagüey Province) and Southeast (Cayos Doce Leguas) of Cuba (M. Formoso, pers. com.). Now, local fishing quotas require a license from the Environmental Agency of the Ministry of Science, Technology and Environment (CITMA).

Spiny lobster *Panulirus argus* is an important resource closely linked to coral reefs. This marine resource is considered to be the best regulated and the most sustainable in Cuba. Since 1978, catches have varied between 11000 and 13000 metric tons per year and were mainly based upon lobsters inhabiting the seagrass beds of the Cuban shelf, and not just upon those dwelling in the reefs, where an important reproductive potential remains. In the last years total catch varied between 9000 and 10000 metric tons due to some decrease in recruitment since 1989 (R. Cruz, in preparation). Baisre (In press) also documents this decline. Private lobster fishing is not allowed, but some poaching for the black market takes place.

Variable catches of turtles on the order of 500 to 1300 Tons per year were obtained from 1968 to 1992, with values higher than 1000 Tons only before 1975. Since this year catches began to diminish down to 44 Tons in 1997. The National Program for the Conservation of Turtles gradually diminished the legal harvesting of turtles since 1992, in accordance with the Convention for the International Trade of Endangered Species of Flora and Fauna. Measures included the prohibition of the private catching of turtles and the egg collection, as well as their transportation and consumption. Among other measures, the program establishes the protection of beaches where turtles nest. Since 1997, a total quota of 45 Tons was established for two places (Nuevitas in the north-east of Cuba, and Cocodrilo in the south-west). There is some poaching for local consumption through the black market. Research to test the hypothesis that Cuba has a resident hawksbill turtle (*Eretmochelys imbricata*) population is being conducted. Research on the artificial rearing of the hawksbill, green, and loggerhead turtles has been carried out for the establishment of turtle farms. Financial constraints have limited the possibility of implementation of the two existing turtle farm programs of Cayos Doce Leguas and Cocodrilo (formerly Jacksonville).

In the 80's and the first years of the 90's, some harvesting of the gorgonian *Plexaura homomalla* has taken place along two reefs at the south-east of Isle of Youth (Southwest Cuba) to obtain prostaglandin. This collection was done in a sustainable way by pruning 50% of the "mature" (>30 cm tall) colonies and a subsequent "resting" of the harvested areas.

Recently, craftsmen and some local state mini-enterprises have illegally collected several species of gorgonians for the manufacturing of jewellery and handicrafts, and also to imitate black coral (by some individual sellers). This has led to the devastation of gorgonian gardens in the shallow reef zones of Havana City and Varadero Beach (as far as we know).

Since the 70's, the black coral (*Anthiphates caribbeana*) began to be collected in an unregulated manner. The official exploitation of black coral (mainly directed to *Anthiphates caribbeana*) began in the second half of the 80's.

The harvesting of this resource was regulated in 1990 but continued in an ineffectively co-ordinated and poorly controlled way by a few state enterprises. Very recently, there has been a significant improvement in control by means of permanent harvest inspection on-board of fishing boats. Illegal harvesting has occurred since the 70's. As a consequence, adult black coral stocks have been depleted in many locations (at the shallower depth ranges of black coral) around Cuba. In 1998, there was an official estimate that 1468.6 kg of black coral had been extracted at depths of 20-55 m by four enterprises.

The regulated minimum size for black coral collected in Cuba is 1.20 m tall and 2.5 cm in diameter. Due to the lack of knowledge on the abundance, biology, ecology and distribution of black coral, a research project partially supported by the UNDP was conducted in order to investigate black coral ecology and assess its populations.

As a result of shifts in target coral reef fish (mutton snappers, groupers, etc.), the partial replacement of these species led to increases in the catches of other species such as rays (*Dasyatis* sp.), gray snappers (*L. griseus*), jacks (Carangidae), and grunts (Haemulidae), among others. Bathoid fishing yields dropped afterwards. Shark fishing yields also decreased in recent years due to a long period of sustained low profile over-fishing (Claro *et al*. 1994, Alcolado *et al*., 1997). A very small scale of aquarium fish trade takes place under official supervision.

Cuban coral reef ichtyofauna, as revealed by its higher biomass, species richness and average size, is in better condition than those from other Caribbean islands such as Martinique, Guadeloupe and Jamaica (Claro *et al.,* 1998). Most of the damage to the finfish fisheries was caused by the use of massive and low-selective fishing gear (e. g. set nets), and by heavy fishing on spawners during reproductive periods. In this regard, the most significant event was the over-fishing of the lane snapper (*Lutjanus synagris*) in the Gulf of Batabanó, which activity induced great changes in the structure of reef fish communities. The lane snapper population was replaced by grunts (Haemulidae), which are species of lower quality and commercial value. The proliferation of grunts prevented the recovery of the lane snapper stocks in the Gulf, despite the enforcement of drastic fisheries management regulations. Now, after more than 20 years, the Lane Snapper stocks in the Gulf of Batabanó, showed a moderate recovery under a relatively moderate fishing pressure. In Caibarién region, the captures dropped to less than half after the construction of a crossway to join the mainland with Cayo Santa María. Evidently this crossway have interrupted the migration of early stages from Bahía Buenavista to Bahía San Juan de los Remedios (Claro et al., in preparation).

Nassau grouper (*Epinephelus striatus*) was an important target reef fish species in Cuba, as well as in all the Caribbean. Commercial catches declined throughout their range over the last 20-30 years, in some cases severely, as in Cuba. Much of the annual commercial landings came from spawning aggregations, which seems to be the major factor conducting to the depletion of their stocks. On the other hand, the increase of urban, industrial and tourist developments have reduced the availability of suitable juvenile and adult habitat, including the coral reefs habitat. Seawater temperature increase due to global warming, could affect reproduction, since it appears to be temperature specific (25-26ºC) (Sadovy and Eklund, 1999).

## 4. ANTHROPOGENIC THREATS TO CORAL REEF BIODIVERSITY

Main human induced impacts and threats on Cuban coral reefs are land based organic pollution and sedimentation, as well as reduction of stocks (due to both commercial, subsistence and illegal fishing, and probably regional scale mismanagement) of some predators and herbivore fishes, which enhance algal proliferation and coral damage and disease. These factors act in synergy with regional/global factors as the *Diadema* sea urchin pandemic dye-off since 1983, coral bleaching due to increased temperatures during ENSO events, several pathogenic coral diseases, and a probable nutrification of oceanic waters in the Caribbean and the Gulf of Mexico. These regional/global factors seem to be the main causes of coral reef decline in Cuba.

About half of the Cuban shelf edge (54 %) is separated from the mainland by broad shallow-water bodies and groups of keys that prevent anthropogenic influences from reaching the reefs. Great extensions of the mainland coasts are only slightly urbanised or industrialised. However, watersheds have been extensively deforested since remote times enhancing sediment runoff to the sea. For these reasons, extreme pollution affects coral reefs only at a few localised places, while some degree of sedimentation (including that of natural origin) seems to be more common (Alcolado *et al.* 1994).

Main pollution sources are sugar mills and human settlements, but also agriculture, cattle raising farms, "Torula" yeast plants, and food and beverage processing plants, make significant contribution. Tourism derived pollution is not significant yet but can become a serious threat if appropriate wastewater management schemes are not applied at

least in places near coral reefs. Environmental licences for resort construction demand the inclusion wastewater treatment plants in the projects.

Land based sedimentation due to deforestation seems to take place at approximately 20% of the reefs that fringe the Cuban Archipelago, where the marine shelf is narrow and mountains are associated with the adjoining watersheds. We have observed great sediment plumes during strong rains at the hilly coasts of the east of Havana City and of the coast east of Cienfuegos Bay.

Over-fishing is still a threat for the trophic balance of coral reefs. The Ministry of Fishery Industry and the Ministry of Science, Technology and Environment are aware of that and planing and implementing relevant actions. Such actions include better regulations, environmental impact assessments for granting fishing licences, fishery reserves, marine protected areas, patrolling of governmental Fishery Inspection Body, etc. Small amount of eventual coral extraction under pertinent supervision is devoted to production of hidroxiapatite for artificial bone implants.

Diving tourism in Cuba, in spite of its high potential, is still poorly developed and thus has apparently had limited impact on coral reefs. Up to the present, existing regulations on protection of coral reefs from tourist visitation are not yet fully enforced. More than 35 diving centres are implemented and proposed, with more than 400 diving sites. Measures are being tailored and applied by the relevant institution to minimise additional damage. For that reason, mechanical damage and extraction of stony corals and other organisms are degrading reef in some sites where tourists engage in diving and boating activities. Two examples of this situation are the once beautiful scenic reefs of Rincón de Guanabo, Puerto Escondido (north-east of Havana Province) and the one at Km 14 of Varadero (east of Matanzas Bay). Anchoring on coral outcrops has been and continues to be a practice in fishery and nautical activities. At present, mooring buoys are used at some reef dive sites of Cuba. There are other reef diving sites, near human settlements where mooring buoy deployment were stopped because buoys were frequently stolen. There is an increasing awareness about the need of deploying more mooring buoys and the number of diving sites with such buoys is increasing.

Trash, illegal coral collection, illegal and authorised spear-gun fishing, and entangling of fishing lines are factors that impact coral reefs near human settlements.

In spite of the efforts made by the Centre of Information, Management and Education (CIGEA of CITMA), the National Aquarium, the Institute of Oceanology, the Coastal Ecosystem Research Centre, the Provincial Units of Environment of CITMA, the National Centre of Protected Areas (CITMA), the National Enterprise for the Protection of Flora and Fauna, and the ONG “Sibarimar”, among others, the lack of enough public awareness about coral reef issues is still a real threat.

## 5. CURRENT AND POTENTIAL CLIMATE CHANGE IMPACTS

An increase of 0.2 – 0.29 cm/year of sea level rise around Cuba has been estimated (Hernández *et a*l. 1998). This can involve an increase in coastal erosion rates and consequently more sedimentation stress on coral reefs.

An average temperature rise of 0.13ºC per decade in the south west of Cuba (at Cayo Largo) was estimated in Alcolado *et al*. (1999). Repeated coral bleaching events in Cuba have been associated to several ENSOs by C. Carrodeguas *et al.* (In press) and us. For that reason, an increase in frequency and intensity of seawater warming associated to ENSO has to be a matter of great concern for local scale coral reef survival.

## 6. CURRENT MPAS AND MONITORING AND CONSERVATION MANAGEMENT CAPACITY

Design and implementation of MPAs in Cuba only recently became to be approached deeply and integrally. Before 1998 virtually all protected coral reef were those that were incidentally included in Terrestrial Protected Areas (e.g. Punta Francés, María la Gorda, etc.). Only 4 reef areas have a significant but yet insufficient level of management. Now those reefs are becoming an important component in the management plans of those protected areas, and 20 properly Protected Areas with marine component are being planed and proposed for approval. The Ministry of Fishery Industry has declared 9 “no-take” areas. Most of them include extensive coral reef habitats and virtually function as MPAs. They can serve as a starting point for incorporating them in the National System of Protected Areas as Fauna Refuges, National Parks and Ecological Reserves.

Cuba has the necessary professional capability and the institutional capacity for the research, monitoring and management of its coral reef areas. However, Cuba’s present economic difficulties seriously limit the financial

resources available to implement and enforce conservation actions, and coral reef research and monitoring are still very fragmentary. The research project *General Assessment of the Ecological Status of Cuban Coral Reefs and Monitoring of the Cuban Regional CARICOMP Station*, which finishes at the end of 2000, has been being conducted by the Institute of Oceanology (IDO) with many constraints. It is aimed at the assessment of the status of coral reefs throughout Cuba and at identifying the natural and anthropogenic stressors involved, as well as at giving relevant management recommendations to the Environmental Agency and other institutions. It is also engaged in the monitoring of the coral reef station of the Cuban CARICOMP site in Cayo Coco (northern Cuba). The CARICOMP project will be continued by the Coastal Ecosystem Research Centre (CIEC, that also belongs to the Environment Agency of CITMA) located at Cayo Coco, north of Cuba.

Our country also has also joined the Atlantic and Gulf Rapid Coral Reef Assessment Initiative (AGRRA), and has assessed the coral reef of María la Gorda using its protocol and is planning to continue extensively in other areas. The ONG "Sibarimar" which takes care of the coral reef of Rincón de Guanabo (east of Havana City) is working with Reef Check.

Other institutions involved in coral reef research are the Centre of Marine Research (CIM) of the University of Havana, the CIEC, and GEOCUBA enterprise. A system of four local monitoring laboratories added to CIEC, is being gradually implemented in the 465 km long Archipelago Sabana-Camagüey (north of Cuba) within the framework of the UNDP/GEF project CUB/98/G32, named "Priority Actions for Consolidating Biodiversity Protection in the Sabana-Camagüey Ecosystem". This initiative is thought to be gradually extended through the country in the framework of the emerging National Monitoring System of CITMA.

## 7. GOVERNMENT POLICIES, LAWS AND LEGISLATION

Since the 1970's more attention began to be paid to Cuban coral reefs research. However, real possibilities for a differentiated, comprehensive, holistic and legally supported reef management did not exist up to recent times. Rather, management was fragmentary and regulatory measures poorly enforced. A certain degree of protection and sustainability was then achieved through:

- Some fishery regulations
- Existing legislation on the protection of natural resources, flora and fauna, on the prevention of pollution, on marine collecting, and on environmental impact assessment In that legislation, the term coral reef was not expressed, but included within the generic concept of fragile ecosystems.
- Regulatory measures for tourism development in natural areas, required for the acquisition of environmental licenses
- Commitments with international treaties such as Agenda 21, MARPOL, SPAW and CITES.

In 1994 a process of institutional improvement took place in which the Ministry of Science, Technology and Environment (CITMA) and its subordinate Environment Agency (AMA) were created. Since 1996 the legislation relevant to protection and rational use of fragile ecosystems improves year after year (*Resolution 111/96 Rules about Biological Diversity, 1996; Resolution 168 Rule of Environmental Impact Assessment and for obtaining Environmental Licences,* 1996; *Law 81 of Environment*, 1997; *National Environmental Strategy*, 1997; the *National Strategy for the Conservation and Sustainable Use of Biological Diversity,* 1999 and others). CITMA, AMA and MIP are more aware and conscious of the urgent need for action for the conservation and sustainable use of coral reefs and are formulating plans, regulations and a new legislation for the achievement of these goals. AMA and MIP are discussing specific regulations for coral reef use and protection. In 1996 appear the first explicit regulations for coral reefs (*Decree-law 164 Rules of Fishery,* 1996; *Resolution 33 on Black Coral*, 1996; *Joint Resolution MIP-MCTMA No. 1/97* of the Ministry of Fishery Industry and CITMA; and the draft bill of the *Decree-Law of Biological Diversity*). Among these regulations are the prohibition of collecting, anchoring, dredging, pouring sediments, pollutants and solid wastes, and using explosives in coral reefs and their vicinities. Fines are to be imposed for violations of those regulations according to the *Decree-law of Contravention System on Environmental Issues*, 1999 (Alcolado *et al.,* in press). A recently approved *Decree-law on Protected Areas* (1999) paves the way to the urgent protection of several coral reefs in Cuba.

A greater effort is being devoted to organic pollution control after increased awareness. For that reason, enhancing public awareness, with emphasis on decision-makers, is a task being considered of high priority in the Environmental Agency (including its provincial delegations), the Centre of Information, Management and

Environmental Education (CIGEA, belonging to the former) the National Aquarium, the Institute of Oceanology, the Coastal Ecosystem Research Centre, the Marine Research Centre (University of Havana), the National Center of Protected Areas (CNAP), the National Enterprise for the Protection of Flora and Fauna (ENPFF), GEOCUBA and the NGO "Sibarimar", among others. CIGEA is the official responsible of leading the environmental awareness in Cuba. The widely participatory UNDP/GEF National Project "Priority actions for Consolidating Biodiversity Protection in the Sabana-Camagüey Ecosystem" is also involved both in coral reef research and public awareness.

In spite of being essential, a sound legal framework is only part of the solution to the problems impacting coral reefs. The above-mentioned *National Environmental Strategy* shows the path to achieve the protection and sustainable use of natural resources.

Advancing toward an Integrated Coastal Zone Management, a complex and difficult but vital issue for coral reef conservation, is a current target of CITMA. A relevant example is the joint agreement of MIP, CITMA and the Ministry of Tourism (MINTUR) for the establishment of several already existing "no take" areas (named as "Zones with Special Regime of Use and Protection") in coral reefs (e.g. Cayo Largo, Cayos Doce Leguas, Punta Francés, María la Gorda, among others). Other areas are proposed for implementation. MIP stops commercial fishing in these areas with the aim of improving fisheries in the remaining areas, CITMA increases the protected areas, and MINTUR benefits from diving tourism. In other grounds several experiences of Integrated Management have been developed.

## 8. GAPS IN CURRENT MONITORING AND CONSERVATION CAPACITY

Lack of financial resources can be considered the main constraint for effectively monitor and preserve coral reefs in Cuba. The enforcement capability is also constrained for that reason. Co-management with tourism enterprises is being considered as a possible partial solution to lack of funds for MPAs. Protected area staffs are limited in number and still are poorly trained. Knowledge and sensitivity are important drivers of man action and will. For that reason, more effort is needed to increase education and awareness of the communities, decision-makers and stakeholders on coral reef issues. A greater community involvement in monitoring and conservation activities is required too.

## 9. CONCLUSIONS AND RECOMMENDATIONS FOR CORAL REEF CONSERVATION

Our main conclusions are:

1. Coral reef decline in Cuba is mostly based on regional/global scale stressors (*Diadema* mortality, coral diseases, probable nutrification of oceanic water of the Caribbean and Gulf of Mexico, temperature increases associated to the joint effect of ENSO events and gradual global warming).
2. Sedimentation, organic pollution, and over-fishing are the main anthropogenic stressors.
3. Lack of financial resources can be considered the main constraint for effectively monitor and conserve coral reefs in Cuba. It also reduces the enforcement capability.
4. Lack of MPAs is a fully recognised issue that is being driven to solution by the relevant instituions
5. Cuba is gradually advancing toward integrated coastal management and better institutional, legal and scientific research frameworks.
6. A greater community education, awareness and involvement in coral reef issues is required.

A long list of recommendations would be needed for being exhaustive. The followings are considered of higher priority:

1. Accelerate the world-wide implementation of measures for diminishing "green house" gasses to stop global warming.
2. Keep and accelerate the current reforestation programs, giving high priority to riparian reforestation.
3. Implement appropriate wastewater management schemes that avoid additional pouring of nitrogen and phosphorus to the sea. Wastewater out-falls must be a matter of concern because they increase the nitrogen and phosphorus load in oceanic water. As there are not effluent wastewater treatments currently available that reduce nitrogen and phosphorus to the required new UNESCO standards for the Caribbean, water recycling schemes have to be kept in mind as the solution (Neis and Blume, 1998).

4. Keep the relevant actions to get financial support from international collaboration sources, and search for other sustainable options for financing MPAs and for increasing the National Fund for Environment (taxes, fines, entrance payment in Protected Areas, co-management etc.).
5. Increase cross-sectoral integration in coral reef management as exemplified by the Ministry of Science, Technology and Environment, the Ministry of Fishery Industry and the Ministry of Tourism in the implementation of "no take" areas devoted to diving tourism and protection.
6. Increase community education, awareness and involvement in coral reef issues is required.
7. Better enforce the already existing legislation and regulations.
8. Search for better institutional and legal ways by means of which sectoral interests of eventual decision–makers and other subjective factors, cannot prevail over the need for a sound integrated management.

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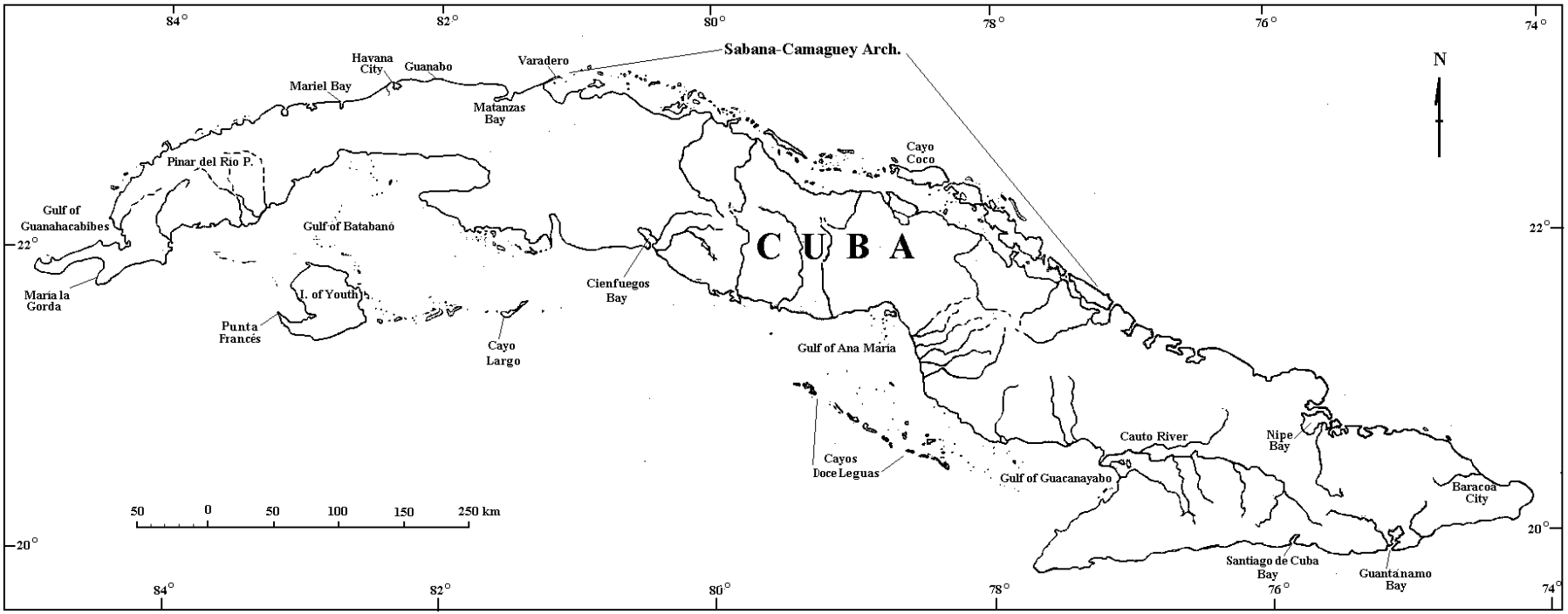


Figure 1. Cuban Archipelago.