Coral Reef Monitoring For Management of Marine Parks: Cases From The Insular Caribbean.

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Background and rationale.

Management of coral reefs, and indeed any other natural resource, most often implies amelioration or minimization of man's impacts. Of the range of impacts associated with reef degradation, those most relevant to the insular Caribbean are:

- overfishing;
- use of destructive fishing methods;
- eutrophication by nutrients from sewage, waste water and fertilizers;
- sedimentation;
- physical damage from recreational and commercial use, including damage by anchors and divers.

The results of a survey of 25 islands (Rogers, 1985) suggested that during the decade 1975 to 1985 there had been significant degradation of coral reefs in the Western Atlantic. While part of this degradation can be attributed to human impacts, a variety of natural events were also implicated, including physical destruction by hurricanes, diseases that affected certain hard coral species, and the mass mortality of the herbivorous urchin that resulted in a proliferation of algae on many reefs. During the same period there was also a decline in reef fisheries that was probably the result of overfishing and loss of habitat.

There is a wide range of management tools available in the region, for marine resources in general and more specifically for protected areas. Despite this, of the 135 legally established marine and coastal protected areas in the wider Caribbean, including US territories, (OAS/NPS, 1988), only 29% claim to be fully protected. Excluding US territories, the figure is only 16%. In a survey of 54 marine protected areas in the region (Van't Hof, 1985), only 24% of the respondents claimed to have effective day-to-day-management.

Against this background, the following points constitute a rationale for the development of coral reef monitoring programmes in the insular Caribbean:

* governments are evidently committed to the management of reefs, and it is therefore desirable to improve the present very low level of active management in the region;

* realistic management is only effective when sufficient information is available, firstly to direct management activities, and secondly to assess the effects of management interventions. This information can only be obtained by precisely directed monitoring;

* however, while management is scarce, monitoring of Caribbean reef communities, and the environmental variables that affect them, is almost non-existent. Given the evident commitment to their protection, and the availability of published information on monitoring methodology, the reason for this lack of monitoring activities deserves particular attention;

* there is a world-wide trend towards the promotion of nature tourism, often referred to as ecotourism, and this is now becoming evident in our region. However, while this is usually viewed as a novel development, reefs have for many years been the basis of almost all of the Caribbean's nature tourism. The information that is available shows a rapid increase of diving tourism, with a resulting increase in the economic importance of this segment of the tourism industry. However, it is strongly suspected that an increase in recreational diving is correlated with an increase in physical damage to reefs, and information from monitoring is needed to provide guidelines for estimating some indicator of sustainable levels of use and guiding the future development of that sector.

Statement of objectives.

The objective of the activities described in this study is to develop and test approaches to reef monitoring that meet the following criteria:

- relevance to the needs of local resource management and development planning;

- use of the expertise that is locally available, particularly the community of dive operators, and the use of methods appropriate to that expertise;

- facilitation of dive operators' contribution to, and responsibility for, monitoring and management programmes for reefs;

- accessibility and cost-effectiveness.

Case histories.

Three cases are presented, describing different situations and outcomes in a proposed national park in St. Lucia, and in established marine parks in Bonaire and Saba, in the Netherlands Antilles (Figure 1).

Case A. Soufriere, St. Lucia.

Background.

Soufriere is situated in an area of great natural beauty, both terrestrial and marine. The mountainous landscape is dominated by the two Pitons, remnant volcanic cones that form part of the coastline immediately south of the town of Soufriere. The underwater topography is equally steep and rapidly becomes too deep for coral growth. Reef development is, therefore, limited to a narrow inshore band that includes some dramatic and almost vertical slopes. The combination of natural, historical and cultural features and resources makes Soufriere a unique part of the country with great potential for further development and contribution to the island's tourism industry.

The principal marine resources in the Soufriere area are fisheries, the coral reefs as a tourism attraction, and to a smaller extent the scenic anchorages for visiting yachtsmen. Access to these resources has traditionally been open. The Department of Fisheries, through the Fisheries Act, has responsibility for management of fisheries and protection of living marine resources. Fisheries regulations impose certain seasonal, technological and catch limits on the reef fishery. In 1986, many of the major reefs in St. Lucia were declared Marine Reserve Areas (MRAs). This included most of the reefs at Soufriere, which is where reef development is most spectacular. Legislation provided for complete protection of the reef community within the MRAs. However, although the MRAs were named, the boundaries were not defined at that time, making effective management impossible. Fishing, therefore, continues on all MRAs, involving spearfishing, potfishing, gill-netting and seining.

There is little information on fishing effort or landings for the reef fishery at Soufriere. Based on observations of a large number of fish pots *in situ*, the level of fish landings is probably sustainable, with a relatively small impact on the populations of reef fish. However, some of the methods that are used are destructive, such as placing pots directly on the corals, and chasing schooling fish into nets by throwing large numbers of rocks into the water above the reef. In general, the involvement of the fishing community in management planning has been minimal, and fishermen have had little opportunity to participate in the planning of developments and the decisions that directly affect them.

The use of reefs for diving has also been open-access, with no restriction of activities other than those concerning fishing that would be governed by the Fisheries regulations. The management of recreational use of the reefs has been almost exclusively the responsibility of the dive leaders, through control of the activities of divers. Although informal, this has been effective as the level of awareness and standard of briefing of divers is high in most diving operations on the island.

The level of recreational diving in the Soufriere area has more than doubled over the last three years (Smith, 1991), despite a relatively low level of promotion of St. Lucia as a diving destination. Further, a promotion programme is presently being considered which would greatly increase the number of diving visitors. However, the dive operators and

others have suggested that such an approach may not be advisable, firstly because there is a clientele that appreciates smaller dive groups and less crowded reefs, and secondly because St. Lucia's most important reefs are all within a relatively small area and their carrying capacity has yet to be determined.

With a relatively limited resource base, there is always a potential for conflicts among the various groups of resource users. The fact that fishing continues in all Marine Reserve Areas has led to conflicts with the diving community. The dive operators have attempted to establish a dialogue in order to achieve an understanding on day-today practical matters, but an official policy of community participation is needed.

Case history.

In 1987, the Government of St. Lucia requested the assistance of the Organisation of American States (OAS) in the preparation of a proposal for the development of a national park. The Soufriere National Park was to include both terrestrial and marine components, specifically the best reefs along the coast to the north and south of Soufriere. Development of the proposal (OAS, 1989) began with a study to determine suitable zoning of Marine Protected Areas and Fishing Priority Areas, followed by a study to devise management strategies for the MRAs and to recommend and initiate monitoring activities (Smith, 1988).

Monitoring activities were planned in collaboration with local and regional institutions, and with the dive operators. The intention was to monitor the levels of some of the factors known or suspected of causing reef degradation (such as diving activity and fishing), and environmental variables (such as water quality and rate of sedimentation), and to monitor certain indicators of change in reef structure (such as percent live coral cover and species diversity).

Following the establishment of a mechanism for monitoring, the fieldwork was continued, with contributions by the dive operators, by the Caribbean Natural Resources Institute (CANARI), a regional non-governmental organisation which focuses on the involvement of communities in the management of the resources that they use. By the end of 1988 the following monitoring activities had begun:

1: the names of the dive sites had been standardized and dive operators submitted figures for the distribution of dives and total number of dives at each site per month.

2: the rate of sedimentation on various reefs was monitored continuously by means of sediment traps, and dive operators assisted in installing and retrieving these.

3. permanent photo-quadrats were established and were photographed every two to three months for later determination of changes in reef structure, such as live coral cover, mortality, species diversity, and the effects of bleaching events. The methods developed for these activities were relatively simple, firstly so that they could be carried out without specialized training, and secondly so that they would not be so

time-consuming as to discourage resource users from continuing to participate. The photographic system is easily operated by one diver, and each station can be photographed in under five minutes. A four-year time series of images is now available. These are digitized using readily-available hardware and software, and the data are analyzed using standard statistical methods.

Since 1988 CANARI has continued to involve the dive operators in the Soufriere area in the development and testing of these monitoring methods, as a contribution to the Soufriere Heritage Programme. This programme is part of the broader Caribbean Heritage Programme, implemented by the Caribbean Conservation Association (CCA), CANARI, and governments and NGOs of participating countries. The reef monitoring programme fulfils a number of functions that will be carried out by a park management authority, which would be needed once a park is established. It is also intended to contribute in two ways to various (national) environmental monitoring programmes that are planned by national and regional governmental agencies. The first is the provision of data on certain impacts and their effect on reef health. The second contribution is the testing and demonstration of how such agencies and relevant NGOs can involve resource users in their programmes, and to develop the instruments that would best favour such involvement.

There is no institution whose sole responsibility is the management of activities on the Soufriere reefs and the programme is carried out on a pilot basis by the dive operators and CANARI. At the same time, there is a continued emphasis on a centralized approach to marine resource management by the government, and a failure, or reluctance, to involve resource users in the monitoring and management process. The diving community is presently planning to re-activate the St. Lucia Dive Operators Association, which was formed in 1989 for the purpose of promoting awareness of the importance of the resource, and to agree on standards for briefing and monitoring of divers.

Case B. Bonaire.

Background

Bonaire, one of the Netherlands Antilles, is located 87km off the coast of Venezuela, and has long been well known among the diving community for its stable physical conditions, clear water, diverse coral reef biota and unspoiled reefs. Impacts on the coral reef system were limited to incidental anchor damage and occasional dragging of moorings. In the early eighties the resource seemed to be in excellent conditions, but there had been little research to substantiate this.

The diving industry in Bonaire began to develop rapidly in the mid-seventies. In 1990, 16,000 SCUBA divers visited Bonaire and the island became the sixth most popular Caribbean dive destination for North American divers (Skin Diver Magazine, 1991).

Prior to the development of the diving industry, artisanal fishing was essentially the only use of the coral reef system. The pressure on the resource was probably low because of the island's rather low and stable population density. Nevertheless, in 1971 the Bonaire Government banned spearfishing, which was not a traditional fishing method.

In 1979 the Bonaire Marine Park was established, encompassing all waters and the seabed from the high water mark down to the 60 m depth contour. The Park is zoned to a limited extent, and it includes two small scientific reserves, where access is restricted to through-passage of boats and where trap fishing is not permitted. Specific regulations were drawn up for Lac, a shallow lagoon with seagrass beds and mangrove forests. Anchoring is prohibited throughout the Park, with the exception of one anchorage in front of the town.

Prior to the establishment of the Park dive operators had already taken the initiative to install permanent moorings to prevent anchor damage to reef invertebrates. Following the ban on anchoring the Park expanded the mooring buoy system to allow diving from boats. Dive operators were involved in the selection of mooring sites and provided voluntary labour and services during the installation of moorings.

The establishment of the Park and the associated regulations for the use of the resource have their basis in the Marine Environment Ordinance. This is an Island Ordinance, adopted by the Island Council, which is the legislative body at the level of the Island Government. Although violations of the ordinance have been successfully tried in court, some lawyers contend that jurisdiction of the sea is the domain of the Central Government. Management of the Park was delegated by the Island Government to the private Bonaire National Parks Foundation (STINAPA-BONAIRE).

Case history

The need for monitoring in support of management was recognized early on in the process of establishing the Bonaire Marine Park and two kinds of monitoring were initiated in the early eighties:

1. The dive operators cooperated in submitting dive statistics on a monthly basis, including the total number of divers and the number of dives for each dive site.

2. A number of quadrats were marked for long-term photographic monitoring of changes in sessile components of the coral reef community. One set of quadrats served to monitor recovery following anchor damage, while another series of quadrats was designed to detect the possible impact of recreational diving by monitoring changes in heavily used and unused areas.

Unfortunately the photographic monitoring was discontinued after a few years due to serious financial problems and the resulting lack of staff and equipment. The dive operators continued to submit monthly statistics on the total number of divers, but information on the distribution of dives is no longer available. During the years that the Park had no staff nor operating funds the dive operators continued to contribute to management by maintaining the mooring buoy system, by briefing their divers on the existence of the Park and its regulations and by reporting violations of the park regulations to the authorities.

In 1991 funding became available for an extensive revitalisation of the Bonaire Marine Park. STINAPA has formed a new park management committee, in which the dive operators are represented and by the end of 1991 the park will have a staff of four. In the revitalisation process the different functions of park management, including monitoring, are being restored. Although some of the original photographic monitoring may be continued, it was decided to concentrate on two aspects:

1. Improving the collection of visitor statistics. SCUBA diving has increased at a steady 10% per annum in recent years, larger dive boats are being used, and it is important for the park management authority to have accurate data on the recreational pressure on individual dive sites. The collection of dive statistics requires the involvement and full cooperation of the dive operators. In addition to diving, yachting has also increased significantly and yachting statistics will be collected in collaboration with the Customs Department.

2. Estimating the carrying capacity of the coral reef system in relation to recreational SCUBA diving. In view of the increasing number of SCUBA divers visiting Bonaire it has become necessary to determine carrying capacity rather than monitoring diver impact *per se*. Such a study would be based on the assumption that interactions of SCUBA divers with the sessile components of the reef community can lead to permanent change. The questions that need to be answered are:

- what permanent change as a result of diver interactions is acceptable?

- at what diver densities is the acceptable permanent change exceeded?

The programme would include the following components:

a. Documenting diver interactions.

b. Establishing a relationship between diver density and distance from the mooring buoy or entry point.

c. Selecting diver interactions to be monitored over time at various diver densities (i.e. different distances from the mooring or entry point) to determine the occurrence and nature of any permanent change to the reef.

Analysis of results would include:

a. Relating permanent changes caused by divers to distance from the mooring and to diver density.

b. Assessing the importance of other stress factors on the outcome of diver interactions.

c. Developing criteria for acceptable levels of permanent change.

d. Establishing diver densities liable to result in unacceptable permanent change to the reef.

e. Establishing minimum distances between moorings.

Although it is not envisaged that the dive operators will play a direct role in the implementation of the study, observing and recording diver interactions certainly requires their understanding and cooperation.

Case C. Saba.

Background

Saba, with a surface area of 12 km^2, is the smallest island of the Netherlands Antilles. It has long been isolated because of its rudimentary airstrip and lack of a harbour. The population has declined since the beginning of this century and is now stable around 1,000 inhabitants. Consequently, development pressure has been low and so has pressure on the nearshore marine resources, even though fishing has traditionally been open-access.

SCUBA was introduced to the island in the late seventies, but in 1984 the number of visiting divers was estimated at merely 500 per year. However, in view of the exceptional quality of the marine resources, promotion of SCUBA diving was considered to be a promising means of strengthening tourism development and hence the economy of the island.

At the same time the Island Government, though eager to promote diving tourism, showed genuine concern about preserving and managing the nearshore environment and solicited the help of the Netherlands Antilles National Parks Foundation (STINAPA). This course resulted in the establishment of a zoned marine park around the entire island in 1987, based on comprehensive marine environmental legislation. The legislation also made provisions for a permitting system for dive operators, and introduced a visitor fee system. The latter had been a condition of the Dutch Government for granting money to establish the park, clearly inspired by the desire to avoid the financial problems experienced by the marine parks in Bonaire and Curaçao.

As in Bonaire, the question of jurisdiction of Central versus Island Government remains unresolved, although jurisdiction by the Island Territory through the Marine Environment Ordinance Saba has not yet been appealed by the higher authority of Central Government. The Island Government has delegated management of the Marine Park to the private Saba Conservation Foundation, which employs a park staff of two.

Case history

Prior to the establishment of the Marine Park, the dive operators demonstrated an environmentally conscious attitude by installing permanent moorings. They also made informal agreements with the local fishermen not to fish at the most popular dive sites. These agreements were formalized and expanded through the zoning system of the Park.

Although the direct involvement of the dive operators in managing the marine resources diminished with the establishment of the Marine Park, they continued to contribute to management in a number of ways through the requirements of their permits. They provide the park manager with monthly visitor statistics, including total number of SCUBA divers and snorkellers, total number of dives, and distribution of dives. They also collect the visitor fees from the divers and snorkellers and transfer the funds to the park manager, and they are required to ensure that park regulations are adhered to.

The park manager compiles the visitor statistics and makes them available to the diving industry. Furthermore the park manager is responsible for conducting biannual reef fish census for comparison of the reef fish populations in fishing and no-fishing zones, as well as for conducting a diver impact study. The latter is designed to establish a correlation between selected diver-induced damage and distance from the mooring (assuming decreasing diver density with increasing distance from the mooring), if there is a detectable diver impact. Considering the small park staff both types of monitoring could benefit greatly from voluntary assistance from the diver community.

Case D. Regional.

The diving community has demonstrated a willingness and ability to assist in the protection and management of reefs in a number of islands, and the case of Bonaire is a good example of this. By 1991, various institutions had expressed an interest in starting practicable monitoring programmes. Accordingly, a network of monitoring centres is being established to promote and assist in the implementation of these programmes. The network will facilitate the exchange of information on methodology, experiences and continuing developments, among correspondents. It will also ensure that many of the monitoring methods will be standardized, thereby allowing a comparison of results from a range of locations in the region. To further these ends, the first activity of the network will be a training workshop for park personnel and dive operators, carried out at the St. Lucia site.

Lessons learned.

1. Management planning should begin with an assessment of existing practices of resource use, and use these as a basis for the development of management strategies wherever possible.

An assessment of resource use will ensure that all groups of resource users are identified early in the planning stage so that their interests and needs can be addressed. In cases where community management of the resources already exists, these management practices should be supported and incorporated into management plans wherever possible. An example is the responsibility for protection of reefs and control of diver impact that has been demonstrated by the diving community in some islands.

2. Effective planning must be based on a clear understanding and recognition of the role that various institutions and groups of resource users can play in contributing to a cohesive plan for resource management.

The monitoring and management of coral reefs requires the collaboration of a number of governmental and non-governmental institutions and communities. For a given country this could include the fisheries department, port authority, coast guard, tourist board, national trust, environmental NGOs, research institutions, fishermen's cooperatives, and dive operators' associations. Each of these groups has particular capabilities that should be considered at the planning stage, to determine the type of information that each is best equipped to provide, and the activities that each is most competent to perform.

3. Resource users can best represent their interests, and collaborate in management, when they are organized into some form of association or cooperative.

A user group that is not cohesive, and which is unable to express its needs and concerns, is most likely to remain marginalized, especially as centralized governments have had little incentive to encourage the participation even of well established cooperatives. In the case of fishermen and dive operators in a number if islands in the region, including St. Lucia, their lack of organization has limited their opportunities for consultation and has led to conflicts, both with government and between each other. Conflicts are obviously not unique to this situation, but the lack of group organization also makes them more difficult to resolve.

4. It is necessary to ensure that all groups are formally assigned the management roles that were identified in the planning stage.

An institutional structure for management involving NGOs and other groups is much simpler than one which involves one or several government agencies, as is the case in most of the Caribbean territories. NGOs can play an important role as facilitators of management in the coastal zone. This approach has been successful in Saba, where government determines policy issues and regulations, and delegates management responsibility to a local NGO which implements management with the involvement of the private sector. This sharing of responsibility could no doubt be applied successfully elsewhere in the region.

5. The lack of continuity is the greatest threat to effective monitoring programmes, and to management as a whole. Mechanisms are therefore required to ensure the sustainability of such programmes.

Most monitoring programmes have been based on external funding and expertise, and have, therefore, been vulnerable to the uncertainty of project approval, with no guarantee of continued support. The involvement of NGOs is therefore important, but their success as facilitators of management also depends to a large extent on the funding made available to them or their ability to raise funding for management. In this respect the role of communities of resource users in carrying out certain activities remains essential.

6. Most monitoring programmes have been started by external or regional scientific institutions, using methods that require scientific expertise in both the collection and processing of data, despite the fact that few islands have the resources to continue such programmes.

Research institutions have been responsible for most of the monitoring programmes that have been attempted, and they have usually imposed monitoring protocols that can only be carried out with specialist training and resources. Because of this, their activities have seldom enhanced local capacity to continue with the work, which is an essential consideration in any monitoring programme. Much of the methodology is inappropriate to the situation in most Caribbean islands, where even the best equipped Fisheries departments cannot allocate the manpower and time to carry out the necessary fieldwork and interpretation of data. Further, the monitoring protocols have stressed the surveys of reef structure and paid little attention to monitoring the factors that are suspected of affecting it.

7. There has been little appreciation of how the needs of monitoring differ from those of descriptive surveys of reef communities.

The rationale for monitoring is the recognition of the potential for change in what is being monitored (Hellawell, 1991). Admittedly, a study of the population dynamics of a species, or of community structure dynamics is, by definition, based on change. However, while these are approached objectively, and often autecologically (i.e. considering a species in isolation), monitoring in the present sense must be more subjective, based on an awareness of the most likely agents of change, and in this case directed towards the assessment of man's impact on the reef community, both destructive and constructive. In the case of destructive impacts, the intention is be able to detect early indications of such change and to address the causes that are implicated. In the case of constructive impacts, the intention is to assess the beneficial effects of intervention through management.

It has been argued that monitoring and surveys may not be different, and that monitoring is simply a series of surveys carried out over time. The difference lies firstly in the methods that are used. Surveys require more input than can be justified (or is possible) if the surveys are to be repeated often enough to permit a correlation of changes with perturbations (Roberts, 1991). Secondly, survey methods do not normally address the question of monitoring environmental variables. In the majority of cases in the insular Caribbean, reef monitoring programmes have ignored environmental variables, and such factors as seasonal variability of various impacts have been treated as parameters of the study sites.

The approach that has been imposed on local agencies has been to follow methods that were designed to provide community descriptors for species interactions, succession, diversity, population dynamics and productivity. This approach will provide more information than is needed to detect changes that require management intervention. Kingston & Riddle (1989) have addressed this issue in the context of monitoring impacts of oil extraction in the North Sea. Having applied the sampling strategies widely used for such monitoring that were originally developed for descriptive ecological studies of the marine benthos, they demonstrate that a greatly reduced sample size, obtained at much lower cost, provided a statistically valid indication of adverse impact. Further, it can be argued (Hellawell, 1991) that it is pointless to monitor situations over which one has no control or for which no response would be required.

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