Chapter 1

Integrated Coastal Zone Management in the Tropical Americas and the Role of Decision Support Models

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Coral reef ecosystems are under increasing pressure, the threats being primarily from human activities. In some cases, natural disturbances further compound the effects of anthropogenic stress. The declining state of coral reef ecosystems has sparked concern by scientists, managers and government officials. The 1991 National Science Foundation, Environmental Protection Agency and National Oceanic and Atmospheric Administration sponsored workshop on coral bleaching, coral reef ecosystems and global climate change (D'Elia *et al*. 1991), the Seventh International Coral Reef Symposium in 1992 (Richmond 1993), and the meeting of experts on "Global Aspects of Coral Reefs: Health, Hazards and History" held at the Rosentiel School of Marine and Atmospheric Science in Miami (Ginsburg 1994) all stressed these concerns. The IUCN (1993) estimated that about 10% of tropical coral reefs have already been degraded beyond recovery and another 30% are likely to decline significantly within the next 20 years. An International Coral Reef Initiative report (Jameson *et al*. 1995) stressed that unless effective integrated coastal zone management is implemented, more than two-thirds of the world's coral reefs may become seriously depleted of corals and associated biota within two generations.

The coral reef ecosystems at greatest risk are in South and Southeast Asia, East Africa, and the Caribbean; however, people have damaged or destroyed reefs in more than 93 countries (Jameson *et al*. 1995). Rapid population growth and migration to coastal areas, where coral reef ecosystems occur, exacerbate the problem. The resulting coastal congestion leads to increased coastal pollution and problems related to coastal construction. Increasing competition for limited marine resources results in the adoption of destructive fishing methods. Technologies allow humans to exploit the reef with mechanical dredges, hydraulic suction, dynamiting, and poisoning. Some of the major causes of localized coral reef ecosystem decline include:

- The overexploitation of reef resources (fish stocks have declined significantly in many reef areas, especially near centers of human population);
- Excessive domestic and agricultural pollution; and,
- Poor land use practices that increase the amount of sediment entering the coastal environment.

Results of the 1997 and 1998 Global Coral Reef Monitoring Network/Reef Check surveys showed that most of the world's reef-building "corals" are in good to excellent condition, because they are either remote from human populations, or they are under good management, such as the Great Barrier Reef (Wilkenson 1998). Reef Check 1997 surveys, from over 300 reefs in 31 countries, found that the mean percentage of living coral cover on reefs was 31% world-wide; the Caribbean had the lowest percentage at 22%, "possibly reflecting losses due to bleaching and disease" (Reef Check 1997). However, 1997 Reef Check surveys indicated that few "coral reefs" were unaffected by human activities, even in very remote sites, because overfishing has reduced high-value indicator organisms such as lobster, sharks and grouper to low levels at most reefs, including some with marine protected areas (Hodgson 1998). Surveys also showed that management in most marine parks is failing to stop the loss of high-value, edible species, and that greater attention is needed to improve management. The ecological balance in many of the world's best reefs has been altered by the removal of high-value organisms (Wilkenson 1998). In 1998, over 40 countries participated in the second annual Reef Check survey, and results showed that extensive bleaching and mortality of corals has occurred in parallel with the massive 1997/1998 El Niño event. Mortality on a scale never previously reported is occurring, including some corals that have previously survived for centuries (Hodgson 1998).

A recent estimate by the World Resources Institute, using map-based indicators, suggested that as many as 58% of the world's reefs are threatened by human activity (Bryant *et al.* 1998). Approximately 10% of the world's reefs have been severely damaged or destroyed by being mined for sand and rock, reclaimed for development (particularly for airports), or buried under sediment washing into the sea from inappropriate land use (Wilkenson 1998).

Based on current global climate change and population trends, Kleypas *et al.* (1999) and Buddemeier (1999) predict that, on a large scale within the next few decades, coral reefs will continue to die because of rising human population levels, rising temperatures, rising atmospheric/surface ocean CO_2 levels, and other local aspects of global climate change.

Benefits of Coral Reefs

Millions of people depend on reefs for a source of food and livelihood. Reefs also create sheltered lagoons and protect coastlines and mangroves against wave damage. Mangroves in turn protect reefs from sedimentation and eutrophication. Mangroves and seagrasses also play an important role in coastal protection and provide spawning and nursery areas for reef and offshore fishes. The economies of many atoll nations are primarily based on marine resources. In the Pacific, over 2.5 million people live on islands built by, or surrounded by, coral reef ecosystems. In Hawaii, coral reefs are central to a US$700 million marine recreation industry. Reef fish, lobsters, and bottom fish generate approximately US$20 million in landings annually and are an important source of food for local people and for restaurant consumption (Grigg 1997). Diving brings US$148.6 million annually to Guam (Birkeland 1997). Over 300,000 people live on coral islands in the Indian Ocean and many more in the Caribbean. Coral reefs provide 10% to 12% of the harvest of finfish and shellfish in tropical countries and 20% to 25% of the fish catch of developing countries. As much as 90% of the animal protein consumed on many Pacific islands comes from marine sources (IUCN 1993).

The potential sustainable yield of fishes, crustaceans and molluscs from coral reefs could be some 9,000,000t (12% of the world fisheries catch; IUCN 1993). At the present time, only a fraction of this potential yield is realized. More important than the actual monetary values associated with the fisheries, people more widely benefit from reef use as a major source of income and employment in regions where often few employment alternatives exist. Tourism and the recreational use of reefs on a large-scale are recent developments.

Numerous figures are available describing tourist revenue derived from coral reefs, but few are clearly defined or comparable. The coral reefs of Florida alone have been estimated to generate US$1.6 billion annually from recreation uses (USDOC 1994). Figures for developing countries are better expressed in other ways. For many Caribbean countries, tourism is now the key economic sector, often providing over 50% of GNP, and growing quickly (Jameson *et al.* 1995). In 1990, Caribbean tourism earned US$8.9 billion and employed over 350,000 people (Holder 1991). Divers and other special interest tourists may account for one-fifth or more of this total. A 1981 Island Resources Foundation cost-benefit study of the Virgin Islands National Park found that the benefits associated with reef use (US$23.3 million, of which US$20.0 million was indirect) were more than ten times larger than the costs (US$2.1 million), clearly showing the economic benefits of a marine protected area (Dixon 1993). In Thailand, some 5,000 small boat and dive shop operations are dependent on reef tourism (Spencer Davies and Brown 1992).

Collecting aquarium fishes and live corals for European and North American markets has developed into another lucrative, but sometimes destructive, industry. Harvesting methods often kill organisms not intended for collection and many of the fish collected may die before reaching markets. Tourism can be an environmentally friendly way of generating income from coral reef ecosystems, but only when resort development and operations are carefully controlled. Unlimited collecting, sport fishing, and accidental damage by waders, swimmers and boat anchors can all degrade the reefs that earn tourist dollars. Allowing sewage and other wastes from tourist facilities to pollute reefs, or siting resorts such that beach erosion increases, can be even more degrading to the health of the reefs than the direct damage caused by individuals. Degradation of coral reef ecosystems would have significant negative impacts on world food sources, long-term negative economic impacts on fishery and tourist industries, and devastating social and economic impacts on millions of people around the world for whom coral reefs represent the primary source of livelihood.

The North Coast of Jamaica Perspective

In the most frequently cited work on the status of Jamaica north coast coral reefs, Hughes (1994) attributes the decline in coral cover (from more than 50% in the late 1970s to less than 5% in 1993) and the increase in macroalgal cover (representing a "phase shift" in the community) to the combined effects of overfishing, hurricane damage, and disease. He further states that "there is no evidence that the nation-wide algal bloom in Jamaica was caused by increased nutrients, because it occurred throughout the Caribbean immediately following *Diadema antillarum* [sea urchin] die-off, usually far from sources of pollution", and that there is "an urgent need to control overfishing" (Hughes 1994). However, there is considerable evidence that eutrophication, by itself, can lead to a reduction in reef fish populations (Johannes 1975). Thus, it is unlikely that simply controlling fishing practices will restore Jamaica's reefs, or other coral reefs being impacted by severe eutrophication. More importantly, the reality of large-scale coastal eutrophication needs to be vigorously confronted by scientists and managers alike, both in Jamaica and world-wide.

Discovery Bay

LaPointe *et al*. (1997), using 1987 data (i.e., nutrient enrichment bioassays, alkaline phosphatase assays, water-column nutrient determinations, indicator species, biotic cover and tissue nitrogen levels) from when reef communities were undergoing a phase shift from coral to macroalgal dominance, challenged Hughes' (1994) assumptions concerning the role of nutrient enrichment by showing that it was, in fact, an important synergistic factor responsible for the increased growth rates and standing crop of macroalgae on reefs at Discovery Bay. This finding offers an additional dimension of complexity and robustness towards fully understanding the phase shift.

LaPointe *et al*. (1997) affirms the need to adopt broad theoretical approaches to testing management related hypotheses regarding the degradation of coral reefs. He warns that scientists should guard against preconceived concepts, research designed to verify rather than falsify hypotheses, and narrow approaches that do not test multiple hypotheses, which can all lead to the acceptance of oversimplified hypotheses. While this is unhealthy for science in general, it can be especially devastating for coral reef conservation, especially in light of bureaucrats and resource managers often looking for a politically expedient "quick fix". Hughes' (1994) conclusion that a ban on fish traps is needed to save Jamaican reefs is extremely important, but unfortunately implies to managers that the effects of eutrophication are relatively minor.

Other points made by LaPointe *et al*. (1997) that have important management implications for other reef locations on the north coast of Jamaica, and throughout the world, include the following:

- The dissolved inorganic nitrogen (DIN) and soluble reactive phosphorus (SRP) concentrations at Discovery Bay measured during this study rank among the highest concentrations reported for coral reefs anywhere in the world and explain why such impressive macroalgal biomass now dominates this eutrophic reef system.
- The potential eutrophication at Discovery Bay was documented by widespread groundwater inputs of nitrate (NO_3^-) in conjunction with predictions of increased SRP enrichment associated with exponential human population growth and sewage pollution.
- NO_3^- and SRP concentrations reported by D'Elia *et al*. (1981) for back-reef habitats already exceeded critical nutrient thresholds for eutrophication, explaining why macroalgal blooms began expanding in the early 1980s throughout back-reef communities prior to the die-off of *Diadema antillarum* in 1983.
- Near-shore groundwater data from Lapointe *et al*. (1997) and D'Elia *et al*. (1981) suggest that nutrient concentrations increased in the back-reef during the 1980s and spatially spread offshore, elevating DIN and SRP levels on the fore-reef above critical thresholds.
- The significant NO_3^- levels and concomitant salinity stratification throughout the study area at Discovery Bay shows that nutrients derived from submarine groundwater discharges and springs along the shore are transported offshore as buoyant plumes.
- In addition to offshore nitrogen dispersion via buoyant surface plumes, low salinity, high NO_3^- pore waters have been found (Pigott and Land 1986) in fore-reef sediments at Discovery Bay, suggesting that NO_3^--rich groundwater is seeping through the fore-reef itself and clearly showing that extensive areas of the Discovery Bay fringing reefs to depths of at least 24m are being affected by groundwater DIN enrichment.
- DIN and SRP concentrations throughout the back-reef had been above critical thresholds for over a decade before Hurricane Allen struck in 1980, causing severe damage to the reef and the luxuriant stands of elkhorn coral. The reduction of upright corals to rubble, at a time when nutrient concentrations were above critical thresholds, allowed the faster developing macroalgae to physically out-compete the corals and turf algae. Eutrophication not only increases the biomass of macroalgae, but also reduces the reproductive capacity of hermatypic reef corals and inhibits coral larval settlement and survival.

All of these factors, driven by eutrophication processes, provide a more robust explanation for the replacement of corals by macroalgae on reefs at Discovery Bay.

- Other evidence moderating the "top-down" interpretation of Hughes (1994) includes the fact that fish populations on the deep fore-reef (below 15m) were overfished through intensive use of fish traps in the 1960s (Munro 1983), long before the widespread and massive blooms of *Sargassum polyceratium* developed on the reefs in the late 1980s. Furthermore, the mass mortality of *Diadema antillarum* occurred in 1983, years prior to the expansion of *Chaetomorphia linum* and *Sargassum polyceratium* from restricted areas around grottos in the back-reef onto the fore-reef. Hence, there is inconsistency in the timeline between reduced herbivory from overfishing and massive macroalgal overgrowth in both shallow and deep habitats. These observations further reinforce the conclusion that reduced herbivory could not have been the only factor causing the massive macroalgal blooms that developed on reefs at Discovery Bay.
- The locations of most of the macroalgal dominated habitats cited by Hughes (1994) suggest large-scale non-point-source nutrient loading associated with deforestation, sewage, and agricultural and industrial development. All of these sources increased in prominence along Jamaica's coast over the past decades and, hypothetically, contributed to nutrient over-enrichment, giving rise to the macroalgal blooms that now dominate these degraded coral reefs.

Montego Bay

Sullivan and Chiappone (1994), in their rapid ecological assessment of Montego Bay, consider nutrient loading and eutrophication, water quality and circulation changes, and mechanical damage as the three most serious threats to the coral reef ecosystem within the Montego Bay Marine Park. Jameson (1997), Hitchman (1997) and USAID (1996) also show nutrient levels above threshold values for coral reef ecosystems. Box 1.1 describes an environmental monitoring program conducted for Montego Bay that was funded by the patron of the new sewage treatment plant.

Williams and Polunin (1999) discovered that Jamaica (Montego Bay and Negril sites) had the lowest abundance of herbivorous fishes, the highest coverage of macroalgae (70.5% for Montego Bay and 66.15% for Negril) and the lowest coverage of grazed substratum (turf, bare and crustose coralline surfaces) of 19 reefs surveyed throughout the Caribbean. Except for Jamaica, the abundance of herbivorous fishes was broadly similar on most of the other 19 reefs. There was a six-fold difference (2.7g/m^2 vs. 17.1g/m^2) in the concentration of herbivorous fishes between Jamaica and Barbados (the highest abundance in the study). Pooled data from all sites sampled in Montego Bay by Sullivan and Chiappone (1994) and Williams and Polunin (1999) shows that, from 1992 to 1997, algae cover (all types) increased from 36% to 84%.

The big challenge for Montego Bay Marine Park will be to reverse the aforementioned phase shift. Effectively dealing with the nutrient rich secondary treated effluent that will be discharged into the Park by the new sewage treatment plant is top priority (unfortunately, only human health concerns, not coral reef health, were considered when the new facility was designed). A deep ocean outfall taking the effluent nutrients away from the coral reefs or artificial wetlands that remove the nutrients before discharge into the bay are viable options. Identifying and mitigating other land-based sources of pollution will also be of the utmost importance. Restoring the herbivorous fish population and the critically important macroalgae grazing sea urchin population (Woodley 1999; Woodley et al. 1999) will also be a vital part of the restoration process required to bring this valuable ecosystem back into balance (see Chapter 2).

Negril

Recent water quality research off Negril (LaPointe 1999), using radioisotope techniques, shows that the reefs are, on average, above the nitrogen threshold for macroalgal blooms. The nitrogen was high year round on both deep and shallow reefs, whereas phosphorus concentrations significantly increased in rivers, streams and groundwaters within the watershed and throughout the entire Negril Marine Park. The nitrogen concentration is always high in the Park because it is consistently being transported and discharged through groundwater into the marine environment. Salinity data from Sands Club showed that fresh water from groundwater discharges is affecting reefs several kilometres from shore. Video surveys show that macroalgal blooms on deep and shallow reefs had distinct compositions. *Halimeda*, a calcareous algae, dominated deep reefs off Green Island and Little Bay, compared to shallow reefs that were dominated by fleshy macroalgae, such as *Sargassum, Dictyota, Cladophora,* and *Chaetomorphia*. Rainfall and nutrient data indicated that the massive blooms of *Chaetomorpha* on the shallow reefs of Orange Bay were initiated by phosphorus enrichment, apparently linked to "soak aways" (cesspits) on the adjacent watershed, as well as possibly other sources such as fertilizers. The radioisotope monitoring data revealed that the nitrogen ratio in macroalgae at Davis Cove, North Negril, Long Bay and Little Bay were linked to sugarcane fertilizers, in comparison to macroalgae in South Negril and to a lesser extent Ironshore, where they were found to be associated with sewage nitrogen. The watershed monitoring data illustrated how different land uses enrich the rivers and streams in the area. In the low salinity areas where there are fresh water inputs, there were higher levels of nitrogen and phosphorus. All data consistently showed that salinity was inversely correlated with nitrogen and phosphorus, showing the importance of enrichment to nutrient delivery on downstream reefs. Both phosphorus and nitrogen concentrations on the Davis Cove sub-watershed were significantly higher around canefields, showing the nutrient enrichment associated with fertilizers on canefields in the Davis River that flows out to the reef. In the South Negril River sub-watershed, the high phosphorus concentrations in the estuarine portion of this study area are linked to the considerable sewage inputs from "soak away" pits, squatter communities without sanitary conveniences, inadequately treated sewage outfalls, and livestock on the river bank.

The Monitoring of Coral Reefs

Information for accurately evaluating the condition of the world's reefs is critical for effective management. In many cases, however, this knowledge is lacking. Many countries with coral reef ecosystems need training and capacity building to apply scientific management principles. Non-governmental organizations (NGOs) have played and will continue to play a significant role in coral reef ecosystem conservation. As most countries have not incorporated integrated coastal zone management (ICZM), economic and environmental decision-making has not been fully integrated for the protection and sustainable use of coral reef ecosystems. However, global and regional coral reef programs have developed (Table 1.1).

A project which is specifically designed to provide centralized access to information from these and other coral reef programs is ReefBase: the International Database on Coral Reefs (McManus and Ablan 1997). This project of the International Center for Living Aquatic Resources Management (ICLARM) seeks to gather a broad range of information about the status of the world's reefs from papers, reports and inputs from monitoring projects. The project includes an activity of the World Conservation Monitoring Center (WCMC) to digitize maps of coral reefs and to make them available through the database. The ReefBase project serves as a medium of information exchange for scientists, particularly those in developing countries with limited library facilities, and as a conduit of useful information to coastal planners and managers.

The Land-Ocean Interactions in the Coastal Zone (LOICZ) project of the International Geosphere-Biosphere Programme (IGBP) is looking at the role of coastal processes in global climate change. The crucial role of CO_2 and other gases in the calcification process of reef-building corals is of critical importance with the increasing CO_2 levels associated with global warming. They stress the need to better understand coral reef systems, with various scales and perspectives, especially with respect to survival, adaptation and acclimatization (Buddemeier 1999). They also stress the need to better understand human impacts on reef functions, the responses of reefs to changes in sea level, and the interactions between coral reefs and other ecosystems. In particular, more needs to be known about interactions with adjacent land masses, such as through the hydrological cycle. LOICZ is also concerned that rising sea levels would have very serious consequences for many nations situated on low coral reef archipelagos, such as the Republic of the Maldives.

Table 1.1. Relevant partnerships involved with global or regional coral reef programs (source: derived from a database maintained by Anthony J. Hooten of the World Bank)

Partnership or activity	*Region or country*	*Specific activities*	*Resources (million US$)*	*Status*
Coral Bleaching and Mortality in the Central and Western Indian Ocean	India, Kenya, Madagascar, Maldives, Mozambique, Seychelles, Sri Lanka, and Tanzania	Program will focus on the ecological and socio-economic effects of coral mortality in coastal areas of eight participating countries	1.1 over three years (Sida/ SAREC)	Approved (first meeting January 1999)
Coral Bleaching and Mortality in the Central and Western Indian Ocean	Same as above	Same as above	0.35 (World Bank/ Netherlands)	Approved (first meeting January 1999)

Table 1.1 continued overleaf

Table 1.1. continued

Partnership or activity	*Region or country*	*Specific activities*	*Resources (million US$)*	*Status*
World Bank/ GEF Indian Ocean Commission/ France - WIO Coral Reef Monitoring	Comoros, Madagascar, Mauritius, Reunion, and Seychelles	Establishment of a long-term coral reef monitoring program for the IOC countries	1.0 for medium-sized GEF project	Under preparation (endorsement letter from all countries)
Meso-American Barrier Reef Initiative (MBRI)	Belize, Guatemala, Honduras, and Mexico	Regional program to jointly manage and protect the world's second largest barrier reef	16.25	Under preparation (began 1998)
International Coral Reef Initiative (ICRI)/ Global Coral Reef Monitoring Network (GCRMN)	World-wide, based upon six regional nodes and the ICRI Secretariat	A global effort to increase capacity of regions and countries to monitor and manage coral reefs and associated ecosystems through ICZM and other vehicles, with over 80 participating countries	Unknown (some support from US State Department, Australia, and France)	Secretariat transferred to France for 1998 to 2000; five of six regional nodes identified for the GCRMN
International Coral Reef Action Network (ICRAN)	World-wide (total of eight regions)	A global effort to reverse the trend of coral reef degradation by initiating priority protective action in constituent countries, including model protected areas and coral reef management systems	1.15 start-up (United Nations Fund; four year action phase TBD)	Anticipated early 1999, pending proposal acceptance before the United Nations Fund
COREMAP Indonesia (supported by the World Bank, ADB, and USAID)	Indonesia	Establishment of management structures in Indonesia, including improved monitoring efforts	33.1 phase one; total of 263.1 over 15 years	Supported by the World Bank, ADB, USAID, and Indonesia
Information related to the Caribbean Program for Adaptation to Climate Change (CPACC) - World Bank/ OAS	Caribbean basin (three pilot countries - Bahamas, Belize, and Jamaica)	Pilot to establish a Caribbean monitoring program to measure effects of climate change and anthropogenic impacts	0.406	Underway (workshop held in 1998; monitoring to be established in 1999)
Reefs At Risk - World Resources Institute (in collaboration with ICLARM, WCMC, and UNEP)	World-wide	Map-based indicator of threats to the world's coral reefs	Unknown (supported by WRI and ICLARM)	Global phase completed; beginning regional assessments, starting with the Philippines
ReefBase	World-wide	Serves as a global database for coral reef related information, including the GCRMN	Unknown (supported by ICLARM)	Active
Edited Monograph on Coral Reef Economics	World-wide	Text of coral reef economics with global case histories	Unknown (supported by Sida/ SAREC)	Under development (estimated completion late 1999)

Diagnostic Biological Monitoring— Essential to Manage Coral Reef Ecosystems

Coral reef monitoring programs have become ubiquitous over the course of the past two decades (Eakin *et al*. 1997; Risk 1992), ranging from monitoring by individual research scientists to that conducted by large institutions like the Australian Institute of Marine Science, the CARICOMP (Caribbean Coastal Marine Productivity) network or world-wide efforts such as the Global Coral Reef Monitoring Network. The scope of reef monitoring has recently expanded even further with the introduction of monitoring programs specifically designed for volunteer sport divers, such as the ReefBase Aquanaut and Reef Check programs (Hodgson 1997; McManus *et al*. 1997). While these "state of the art" efforts have been very successful at what they were designed to do (i.e., document change in coral reef ecosystems), they are, for the most part, not capable of predicting what is causing the changes.

Because of the non-diagnostic nature of most coral reef monitoring programs, policy-makers and government officials are not well equipped to communicate to the public or politicians the causes of coral reef resource decline or the appropriate solution for remediation. To protect coral reef resources, we should track the biological condition of these ecosystems in a manner similar to the way we track local and national economies or diagnose personal health—using calibrated indicators. Indicators that integrate the influence of all forms of degradation caused by human actions can thus guide diagnostic, curative, restorative and preventive management actions.

Importance of Bioindicators in Coral Reef Ecosystem Assessment

Indicator organisms have a long history of use for detecting qualities about an environment that are otherwise difficult to perceive, from the well-known "canary in the coal mine" to the highly successful "Musselwatch" program in North American bays (Soule 1988). Freshwater and marine organisms have been used extensively as bioindicators since the 1970s (Phillips 1980).

The use of bioindicators has been justified in marine pollution monitoring programs for at least three reasons (Maher and Norris 1990):

1. They assess only those pollutants which are bioavailable, ostensibly those which are most important;
2. They can reveal biological effects at contaminant levels below current chemical analytical detection limits (either due to chronic, low level pollution or short-term pulses); and,
3. They can help assess synergistic or additive antagonistic relationships among pollutants, an important consideration given the typical multiple pollution impacts impinging on most reefs in the developing world (Ginsburg 1994).

The aim of any coral reef ecosystem assessment program is to distinguish relevant biological signals from noise caused by natural spatial and temporal variations. In choosing biological indicators, one should focus on attributes that are sensitive to the underlying condition of interest (e.g., human influences) but insensitive to extraneous conditions. Faced with the dizzying number of variables, disturbances, endpoints, and processes, marine managers and researchers have periodically failed to choose those attributes that give the clearest signals of human impact. The world's coral reef ecosystems have declined as a result.

Status of Coral Reef Ecosystem Bioindicators

Jameson *et al*. (1998) review the status of coral reef ecosystem bioindicators. With few notable exceptions, the majority of these bioassays have not yet been fully developed into usable monitoring protocols. In these respects, coral reef bioindicators lag far behind freshwater and temperate marine biomonitoring programs, many of which have undergone extensive calibration and have been developed into multi-metric indices of "biotic integrity" with well-defined interpretative frameworks (e.g., Davis and Simon 1995; Karr 1991; Karr and Chu 1999; Karr *et al*. 1986; Kerans and Karr 1994; Lang *et al*. 1989; Lenat 1988; Rosenberg and Resh 1993; Wilson and Jeffrey 1994). Many of these indices result in the calculation of a simple numerical "score" for a particular site, which can then be compared over time or with other sites. Such rankings have an intuitive appeal to resource managers and users, and can be an effective means of galvanizing political willpower towards pollution prevention and conservation activities.

Developing Biological Criteria for Coral Reef Ecosystem Assessment

Biological criteria are narrative expressions or numerical values that describe the "biological integrity" of aquatic communities inhabitating waters of a given designated aquatic life use (USEPA 1990a). Biological integrity is the condition of the aquatic community inhabiting unimpaired or minimally impaired water bodies of a specified habitat as measured by community structure and function (USEPA 1990b).

The first step towards effective biological monitoring and assessment is to realize that the goal is to measure and evaluate the consequences of human actions on biological systems. The relevant measurement endpoint for biological monitoring is biological condition. Detecting change in that endpoint, comparing the change with a minimally disturbed baseline condition, identifying the causes of the change, and communicating these findings to policymakers and citizens are the tasks of biological monitoring programs. Understanding and communicating those consequences to all members of the human community is perhaps the greatest challenge of modern ecology (Karr and Chu 1999).

The use of multiple measures, or metrics, to develop biocriteria is a systematic process involving discrete steps (Jameson *et al*. 1998). The United States Environmental Protection Agency recognizes the need and benefits of a biological criteria program for coral reef ecosystem assessment and is in the process of exploring the feasibility of developing a program for coral reef ecosystems under United States jurisdiction (Jameson *et al*. 1998, 1999).

The Need for Integrated Coastal Zone Management

As stated in the introduction to this chapter, many marine ecosystems in the tropics are deteriorating under heavy pressure from human and economic activities. About 10% of the world's reefs have already been degraded beyond recognition, while another 60% are likely to disappear in the next 10 to 40 years; the 30% that do not appear to be undergoing negative effects are those in remote areas, essentially removed from the influences of man. Lack of harmonized legislation between the tropical islands (such as regional sand mining legislation), lack of appropriate policies (such as existing subsidies for gasoline to artisanal fishers), lack of adequate protection mechanisms (such as designated marine protected areas), lack of appropriate zoning (such as designated fishery priority areas), and lack of infrastructure to support tourism (such as sewage and solid waste management) have all caused marine resource deterioration, threatening the natural and cultural fabric of these vulnerable small island developing states.

International tourism has been an important economic element in the post-war period to the Caribbean. These countries primarily draw on outstanding marine ecosystems attracting the "sun-sea-sand" clientele and the ecotourist, who is also attracted by cultural/ethno-historical phenomena such as pre-Colombian archaeological sites, colonial architecture, and contemporary handicraft industries. Both types of tourists require distinct packages and infrastructure, and both types have led to resource and cultural deterioration, coining the phrase "tourism destroys tourism".

Rehabilitation and management of conservation areas, revitalization of the tourism industry, and empowerment of local governments and communities to manage and benefit from the sustainable use of natural resources, are now high priorities for the Caribbean countries as demonstrated by important policy and institutional reforms already completed or underway. Montego Bay, Jamaica, provides an excellent example. Responsibility for management of the marine park has recently been transferred from the Jamaican government to an NGO—the Montego Bay Marine Park Trust (the Trust). The Trust has an explicit policy of promoting community participation in management and the sharing of the benefits.

Over a period of several years, the people of Montego Bay have felt the repercussions of poor planning:

- Serious resource depletion problems increasing pollution of the inshore, coastal and ocean environment;
- Loss or damage to productive coastal ecosystems, increasing losses of life and property from coastal hazards and disasters; and,
- Conflicts of interests among user groups.

They began to share a common vision, including a desire to increase the economic benefits flowing from the use of coastal zone resources and the exploration of economic opportunities associated with new forms of development in the coastal zone. Solutions included implementing a more participatory approach to planning involving NGOs and community-based groups, developing institutional mechanisms for cross-sectoral cooperation, and the enforcement of and compliance with integrated policies, including the use of positive reinforcement and incentives (see Chapters 2 and 11). There are examples to which the Trust can turn that demonstrate the elements of a successful ICZM strategy. Box 1.2 describes a case study that provided rapid results in the United States.

The World Bank and Integrated Coastal Zone Management

There is a growing interest, particularly among private sector hotel associations and environmental NGOs, in adopting ICZM as a means of maintaining a balance between economic growth and the protection of valuable ecosystems. ICZM guides jointly the activities of two or more sectors in the planning, development and implementation of projects, instead of treating individual sectors separately (e.g., sewage pollution and industrial waste management). The World Bank has recently issued guidelines for the use of ICZM (World Bank 1993a, 1996; guidelines have also been developed for integrated water resources management for the environmental impact assessment of projects that might affect coastal ecosystems).

The definition of the coastal zone used for small islands usually includes the island as a whole—that is, including all watersheds that drain into the coastal zone. Also, from an ecological perspective, the zone in which freshwater and saltwater mix (i.e., estuaries, mangroves or lagoons) is usually very valuable. These gradient zones often have a very high level of biodiversity and productivity. There are also many physical linkages between coastal and freshwater resources:

- Watershed management influences run-off and erosion, which affects water quality in the coastal zone (e.g., non-point source pollution);
- Groundwater exploitation in alluvial coastal plains that lowers the groundwater table often increases saline seepage and infiltration;
- Wastewater management (e.g., treatment plants, ocean outfalls) directly influences water quality in the coastal zone;
- Coastal wetlands, such as mangroves and lagoons, are dependant on both the water resources and coastal zone management; and,
- For coastal tourism, the management of the coastal zone and the water resources are often intricately linked.

Immediate government priority must be placed on the development and implementation of ICZM strategies to effectively manage the coral reef ecosystems of the world. These strategies should address human activities in the coastal watershed and marine environment and involve combinations of:

- Public education (including education in the use of traditional forms of reef tenure and management, education on sustainable use practices, and education to stabilize population growth);
- Community development;
- Economic incentives;
- Legal and institutional restructuring;
- Well managed marine protected areas;
- Regulation and enforcement of reef resource exploitation;
- Management of tourism and recreational activities (e.g., education programs, installation of mooring buoys);
- Management of land-based activities and coastal development (e.g., using environmental impact assessments, wise siting of facilities); and,
- Coral reef ecosystem monitoring, mapping, and database creation and restoration.

Combining these management techniques is critical for success. If used alone, these techniques tend to be ineffective over the long-term. They must be strongly supported at scales ranging from the village to the nation, and often at the regional scale as well. They must be oriented towards the long-term sustainability of reef resources, and designed to be adaptive to different cultures and governments, as well as changing situations, without compromising effectiveness.

A world-wide system of marine protected areas should be established to encompass at least 20% of all reefs (Jameson *et al*. 1995; PDT 1990). This should include widely dispersed small reserves involving up to a few tens of square kilometres, and several strategically located large reserves at the scale of hundreds or thousands of square kilometres. Ideally, these protected areas should form part of wider coastal zone planning initiatives encompassing the reef systems of entire countries and integrating the needs of local peoples, commercial fisheries, tourism, terrestrial construction and agriculture development, and nature conservation.

Capacity Building

A concerted effort must be made to enhance the capacities of countries, particularly developing countries with coral reefs, to conduct scientific research and to design and implement informed, effective integrated management systems. This implies not only the transfer of information, but more importantly, the exchange of experiential learning among developing countries.

Improved Scientific Understanding of Coral Reef Ecosystems

Efforts must be enhanced to survey the coral reefs of the world to provide information on their ecological and management status. Scientific management information is needed for:

- Understanding the relationship of natural to anthropogenic impacts;
- Conducting damage assessments;
- Understanding coral recruitment, and the maintenance and renewal of reefs;
- Understanding current patterns to determine the distribution of reefs and the fate of pollutants; and,
- Developing an improved scientific concept of what constitutes a healthy reef so it will be possible to gage changes on impacted ecosystems.

So that the health of coral reef ecosystems can be monitored in a systematic manner, the Intergovernmental Oceanographic Commission (IOC) Global Coral Reef Monitoring Network, which will provide valuable data to the larger Global Ocean Observing System, should be maintained and improved (Jameson *et al*. 1995). In addition, new efforts to develop diagnostic coral reef monitoring techniques (Jameson *et al*. 1998, 1999) should be supported. This information will not only help local authorities monitor the health of their coral reef ecosystems and improve management capabilities, it will also provide a perspective on the conditions of coral reef ecosystems and the effects of climate change world-wide.

The coral reef ecosystems of the world represent an important resource, both in terms of global biological diversity and with respect to the well-being of the people who live near and depend upon them. Many coral reefs are at risk and better management is required. The future actions of managers, scientists, national bodies, local communities and international programs will be critical in determining whether or not these natural treasures are saved.

The Role of Decision Support Models

The Need For Modeling—Integrated Coastal Zone Management Decision Support

Throughout the world, both in developed and developing nations, we face complex coastal zone management challenges associated with our attempt to achieve economic growth without destroying the ecological systems that support human existence. As previously outlined, coral reef ecosystems are valuable for many reasons. They provide thousands of people with food, tourism revenue, coastal protection, and potential new medications for the treatment of diseases—despite being among the least monitored and protected natural habitats in the world.

Coastal zone management decisions often require the integration of numerous parameters, frequently more than the human mind can handle effectively. In the management of tropical coral reef ecosystems, some of these parameters include the location of industrial and tourist facilities, water quality issues such as nutrient concentrations and sedimentation, fishing pressure, and socio-economic concerns.

To assist the three small island developing states of the Maldives, Curaçao and Jamaica (i.e., Montego Bay) in effective coral reef management, the World Bank recently created models using multivariate statistical procedures that show the result of ICZM decisions when a variety of parameters interact together (see subsequent chapters). Costs are incorporated into the models to help decision-makers choose least-cost solutions, without making costly mistakes that are, in many cases, irrevocable.

Capacity Building with the Models—Helping Stakeholders

The integrated socio-economic and ecological model, framed with a user-friendly computer interface will benefit stakeholders by:

- Assisting the communication between the various stakeholder groups;
- Facilitating the planning process required for successful ICZM;
- Providing a powerful tool to managers and stakeholders for demonstrating the need for coastal zone management and the impacts of status quo management on valuable coral reef resources and the local economy; and,
- Identifying appropriate policy and institutional reforms for improving the capture of resource values associated with coral reefs in developing countries, and clarifying the potential operational role of the World Bank and other development assistance agencies in helping to effect these reforms.

The Dissemination Strategy

The dissemination strategy for this work focuses on in-country workshops and seminars for user groups and stakeholders, government agencies, and private and non-governmental organizations involved in ICZM. In addition, it includes activities to foster cooperation among countries on coordinated environmental policies, strategies, and action plans in the coastal zone, and provides a consultation mechanism for formulating, strengthening, harmonizing, and enforcing environmental laws and regulations.

Ten Commandments for ICZM

In order to further guide the effective and successful implementation of an ICZM strategy, the following "ten commandments" are suggested:

1. *Identify problems and causes*. It is tempting to blame what is visible for all the problems (e.g., garbage and eroded beaches) and difficult to identify the actual causes of serious problems, which are usually multiple in number and difficult to uncover. The identification of the root causes of problems and solutions is required to ultimately prevent or reduce problems. A cleanup alone is not sufficient to prevent re-occurrence. Controlling problems at the source is the most efficient and effective means to reduce cost and improve quality (Scanlan 1988).

2. *Strive for continuous improvement*. However, know that the environmental quality improvement journey is not without setbacks. Stay focused on the goal with continuous effort and eliminate the sources of the problems that affect the reaching of your goal. A fast repair strategy is required to achieve minimum performance standards, and a root cause prevention strategy is required to achieve excellence. Continuous improvement requires continuous discovery, continuous development, and continuous maintenance. Measures of results (samples) are required to provide data for control and improvement. Invent awards with criteria that can be used to check progress, provide feedback for improvement, and recognize excellence (Scanlan 1988).
3. *Gradualism and realism*. National or regional policies can be implemented gradually by pilot projects or experimental programs. The establishment of plausible and enforceable norms, standards, and guidelines is an important starting point. Start modest. Do not try to implement policies and instruments beyond the institutional means available.
4. *Institutional integration*. Intragovernmental and intergovernmental integration must be pursued to overcome barriers and to merge institutional strengths. Government economic agencies must be included, as well as parliamentary representation.
5. *Leadership*. The environmental management sector must lead the decision-making process by identifying stakeholders, barriers, and channels to consensus building.
6. *Participation*. Public participation is a key issue. Participation by stakeholders must be planned and based on information building and sharing. Avoid stalemate issues that might paralyze the process. Equity issues must be properly identified, evaluated and addressed.
7. *Market reliance*. The growing reliance on markets must be incorporated into environmental policy and incentive structures to influence behavioral changes. Avoid high transaction and collection costs. Do not outpace implementation and acceptance of market adjustments.
8. *Seek out business partners and recognize them*. Work with the decision-makers first as those controlling the resources must be informed and supportive of ICZM efforts. Tackle the more simple jobs first—a visible improvement will build constituencies.
9. *Recognize, motivate, and promote excellence and good behavior*. This is more effective than handing out fines, and more constructive. More people working on a solution results in more solutions (Scanlan 1988).
10. *Minimize government, and maximize voluntary management and partnerships*. Governments rely too heavily on laws, regulations and punishment. Citizens must be involved to help set goals for excellence for our society. They are the customers for government services. The governance process, as well as key operational processes, in business or government, has to be continuously improved to meet changing marketplace situations and new stakeholder requirements. Government does not regulate itself well and is often the worst offender. Government should not require subsidies for things citizens do not want and should fund things that support our objectives (Scanlan 1988).

Box 1.1. Environmental monitoring data as a basis for management decisions: The Montego Bay case study.

Bernward Hay

Louis Berger International Inc., Needham, MA, USA

Among the goals of any integrated coastal zone management program is to protect coastal resources, or improve them if degraded, while at the same time balance the various uses of the stakeholders of the coastal zone. A key element towards achieving this goal is a solid understanding of the environmental conditions of the coastal resources within the management district and factors that affect the state of these resources now and in the future. Some of the most significant resources are the biological ecosystem and water quality. Factors that affect the state of these resources include contaminated water sources entering the coastal zone (i.e., rivers, stormwater, sewage pipes and outfalls, groundwater seepage), circulation patterns, land use, urban growth, and many others.

The specific biological resources and the factors influencing their state vary for each coastal management district. Prior to the development of every integrated management plan, existing environmental information needs to be collected and synthesized. Data gaps should be identified and an approach should be developed to fill these gaps. In many cases, the appropriate approach may consist of an environmental monitoring plan. Monitoring essentially provides for the collection of data at regular time intervals, but should also allow for the collection of data during extreme events. Regular data collection intervals are important as coastal systems may vary daily, monthly, seasonally, or annually. Extreme events such as hurricanes, major rainstorms, or drought periods may be crucial as well, as certain coastal resources are only impacted during such events.

The Montego Bay Environmental Monitoring Program (USAID 1996) is an example of an environmental baseline study that has already benefited coastal zone management decision-making. At the same time, lessons learned in Montego Bay apply to many other places in the developing tropics.

Overview of the Montego Bay Coastal Environment

Montego Bay is the second largest city of Jamaica and the largest port city for cruise ships in Jamaica (Figure 1.1). Tourism is a vital industry for the economy of the country (see Chapter 5). The city has grown rapidly in the last 30 years when much of the now developed urban areas still consisted of sugarcane fields (Figure 1.2). In addition, a large part of the valuable mangrove forest has since been filled and converted to mainly industrial and commercial property.

The coastal environment of Montego Bay includes two main waterbodies—Montego Bay, which consists of a deep natural harbor and engineered port basin, and the Bogue Lagoon, a shallow lagoon with a fringing coral reef and mangrove forest. Both waterbodies are part of the Montego Bay Marine Park.

The major river entering into Montego Bay is the Montego River, draining a comparatively large watershed. Land use in the watershed consists of urban and rural developments, agriculture (mainly sugarcane and plantations), and woodlands. The discharge in the river varies greatly between dry and rainstorm conditions, an important factor to be considered for monitoring and the development of management plans. For example, the suspended sediment load in the bay three days after hurricane Gilbert in 1989 (Figure 1.3) was significantly larger than the load from runoff after a regular rainfall (Figure 1.1). River runoff affecting coastal resources in the bay consists largely of eroded soil from the watershed and stormwater runoff from urban areas. Some of the suspended sediment is deposited on the reefs along the outer fringes of the bay, resulting in the smothering of reef organisms. In addition, release of nutrients during decomposition of organic matter contained in the sediment may be utilized by macroalgae, resulting in overgrown reefs.

In addition to the river, the bay receives domestic wastewater effluent from an old treatment plant, as well as from non-point source discharges into gullies and small channels that drain into the bay. These discharges have been a large source of bacteria and nutrients entering into the bay.

In contrast, discharges to Bogue Lagoon consist only of stormwater runoff from the immediate area of the lagoon and inflow from a groundwater spring.

Project Components

Currently, the wastewater treatment system of the city is being greatly expanded to meet the needs of the growing population and tourism industry. The main components of the new system are nine waste stabilization ponds constructed adjacent to the upland side of the mangrove forest surrounding Bogue Lagoon (Figure 1.4). As part of the final design phase for the new treatment system, Louis Berger International Inc. was hired by the U.S. Agency for International Development (USAID) to monitor the existing conditions in the coastal zone and to assess the impacts of the new treatment system on the coastal environment.

The five-year program included regular water quality sampling of coastal waters, rivers and gullies, and groundwater (Figure 1.4), biological surveys of the mangrove system, waste source determinations, and hydrodynamic surveys. Present and future water quality conditions and contaminant loads were modeled. In addition, a circulation model was developed to simulate the movement of contaminants in the coastal zone. The monitoring program was part of a larger infrastructure improvement program in Jamaica (Northern Jamaica Development Project), carried out for the Planning Institute of Jamaica and the National Water Commission (USAID 1996).

Bogue Lagoon

In the original design, the wastewater effluent from the new treatment system was to be discharged into Bogue Lagoon. However, the monitoring results clearly demonstrated that the lagoon is already experiencing some environmental stress at the present time due to slow circulation and, thus, a slow water exchange rate with the ocean. Slow circulation is caused by the shallow reef that spans the entire entrance to the lagoon. The lagoon is nutrient enriched, in part because nutrients in the sediment are recycled back into the water column several times before they are transported out to sea. On the other hand, the concentrations of fecal bacteria in the lagoon waters are very low, making the lagoon suitable for water contact recreation.

Discharging effluent from the new wastewater treatment ponds into the lagoon would have increased the nutrient concentrations in the lagoon by 200% to 1,300% by the year 2015, greatly reducing the diversity and abundance of aquatic species. Possible adverse effects could also have been floating macroalgal mats, occasional fish kills, and odor development. Further, increased bacteria loading from the effluent would have rendered the lagoon unsuitable for water contact recreation. Aside from serious ecological impacts, the tourism industry would have suffered.

Montego Bay

In the bay of Montego Bay, the water exchange rate with the open ocean is roughly an order of magnitude more rapid than in Bogue Lagoon. Thus, nutrients and bacteria from land sources are transported comparatively rapidly to the open ocean rather than staying in the bay. Further, the main coastal resources are limited to the outer bay, including fringing reefs and three beaches on the northern side.

Environmental monitoring and modeling indicated that the nutrient loads in the bay would increase from the new wastewater treatment system by only 5% to 15% by the year 2015. Bacteria concentrations would sharply decrease, possibly to levels that would allow contact recreation in the outer bay during dry weather. However, the data also showed that during rainstorms, the runoff from the Montego River watershed would continue to discharge elevated concentrations of bacteria and nutrients into the bay. Management of the coastal resources in Montego Bay needs to take source reduction in this watershed into consideration for future management activities.

Main Project Recommendations

Given the existing conditions in the coastal zone of Montego Bay, our monitoring team recommended changing the targeted effluent receiving body from the lagoon to the bay. In addition, we recommended lining the wastewater treatment ponds with an impermeable layer to prevent seepage of nutrient-rich wastewater through the ground into the lagoon. These recommendations prevented serious environmental problems for the coastal waters in Bogue Lagoon, and averted negative economic consequences for the tourism industry. For example, a multi-million dollar condominium development along a small part of the lagoon is currently under construction. The lagoon has further potential for ecotourism activities, thus providing income for sustaining local businesses and potentially for financing the marine park. Also, the cruise ship port is immediately adjacent to the lagoon. Property values would have been considerably lower, ecotourism would not be possible, and the first impression of Jamaica by tourists arriving in the cruise ship port would have suffered if the lagoon was overgrown with algal mats and experiencing occasional massive fish kills and odors.

At the same time, the impacts to Montego Bay are considered minor given the limited natural resources in the bay, the circulation pattern in the bay which tends to transport land runoff straight out to sea, and the fact that there are other, in part natural, factors that will limit the development of pristine coral reefs within the bay proper, such as large stormwater discharge events that carry large amounts of silt, nutrients and bacteria from the Montego River watershed.

The recommendations from our study were adopted by the National Water Commission of Jamaica prior to construction of the new wastewater treatment system. Construction is expected to be completed by the summer of 1999.

Long-Term Benefits

Long-term, the extensive environmental database generated for the coastal waters in the area will serve as the basis for other coastal zone management decisions in the future. Such decisions will include, for example, issues related to the rapid growth of the city, the expansion of the industrial zone and associated handling of discharges, stormwater management, coastal zoning for appropriate uses, and the management of the marine park.

The project in Montego Bay demonstrated that understanding of the environment and its response to human induced changes of influencing factors should be one of the first steps in the process towards balanced coastal zone management decisions. Such understanding is frequently also important for the "ground-truthing" of economic benefit models and necessary in the development of integrated ecological economic models.

Figure 1.1. Photograph of the coastal zone of Montego Bay, looking to the northeast. Bogue Lagoon is in the foreground. Montego Bay (the waterbody) is in the centre of the photograph. The waste stabilization pond system is currently under construction to the right of Bogue Lagoon adjacent to the mangrove forest. The straight brown plume entering Montego Bay via Montego River consists of suspended sediment derived from soil erosion after earlier rainfall. The City of Montego Bay is in the background. The peninsula in the middle of the photograph is Montego Freeport (photograph taken by J.S. Tyndale-Biscoe on September 9, 1990).

Figure 1.2. Bogue Lagoon 35 years ago, looking to the west. Montego Freeport at that time consisted of several mangrove islands that were later filled and connected. Most of the land use in the area was sugarcane cultivation. The mouth of Montego River was located in the southern corner of Montego Bay. The mouth was later moved east during straightening of the river (photograph taken by J.S. Tyndale-Biscoe on October 24, 1960).

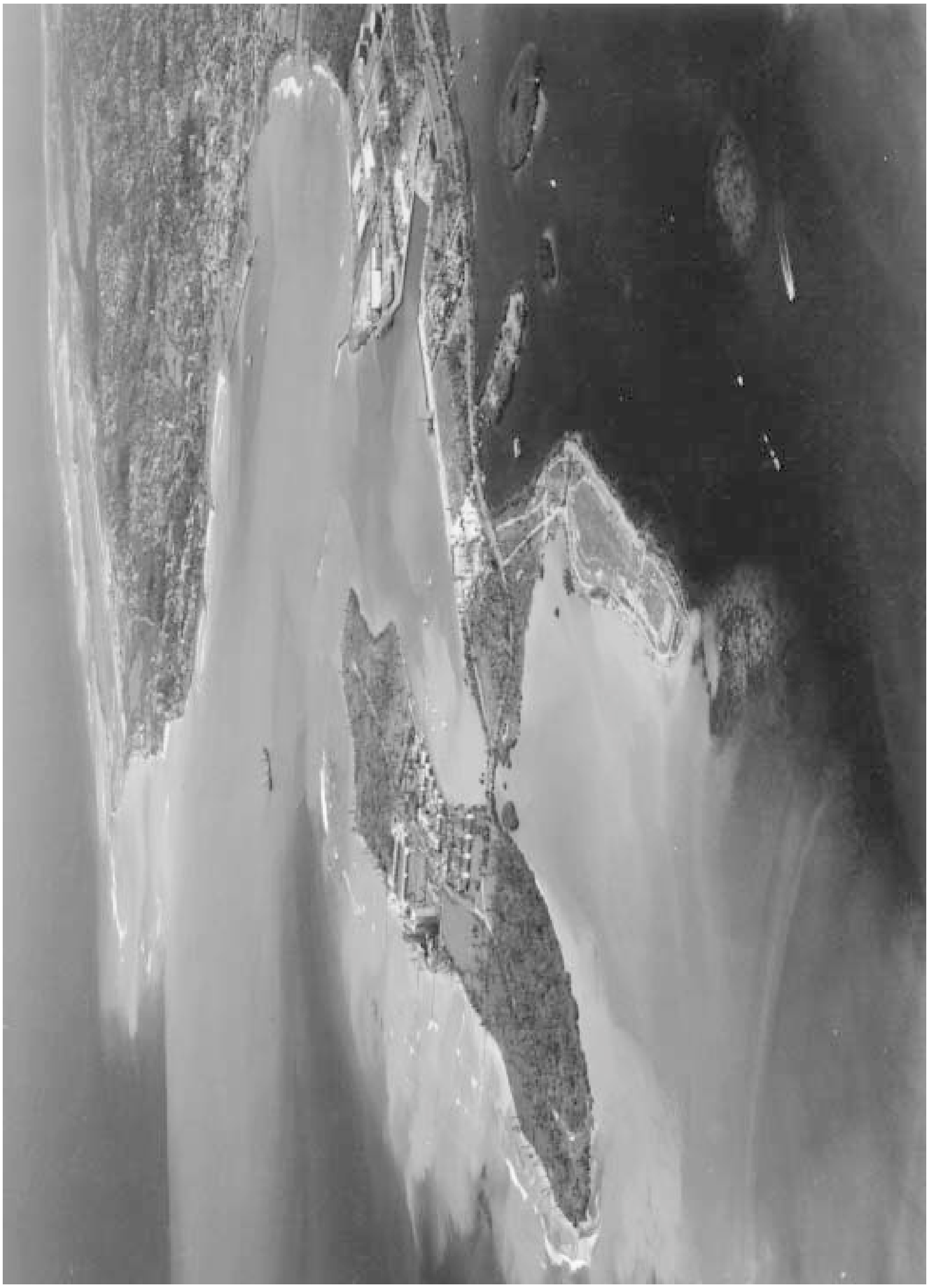

Figure 1.3. Project area three days after hurricane Gilbert, looking to the northeast. The hurricane resulted in a large inflow of suspended sediments into Montego Bay. The basin of the port does not appear to be affected strongly by the Montego River plume. Sediment was also resuspended from Montego Freeport and the outer Bogue Lagoon. The inner lagoon showed little effects (photograph taken by J.S. Tyndale-Biscoe on September 15, 1988).

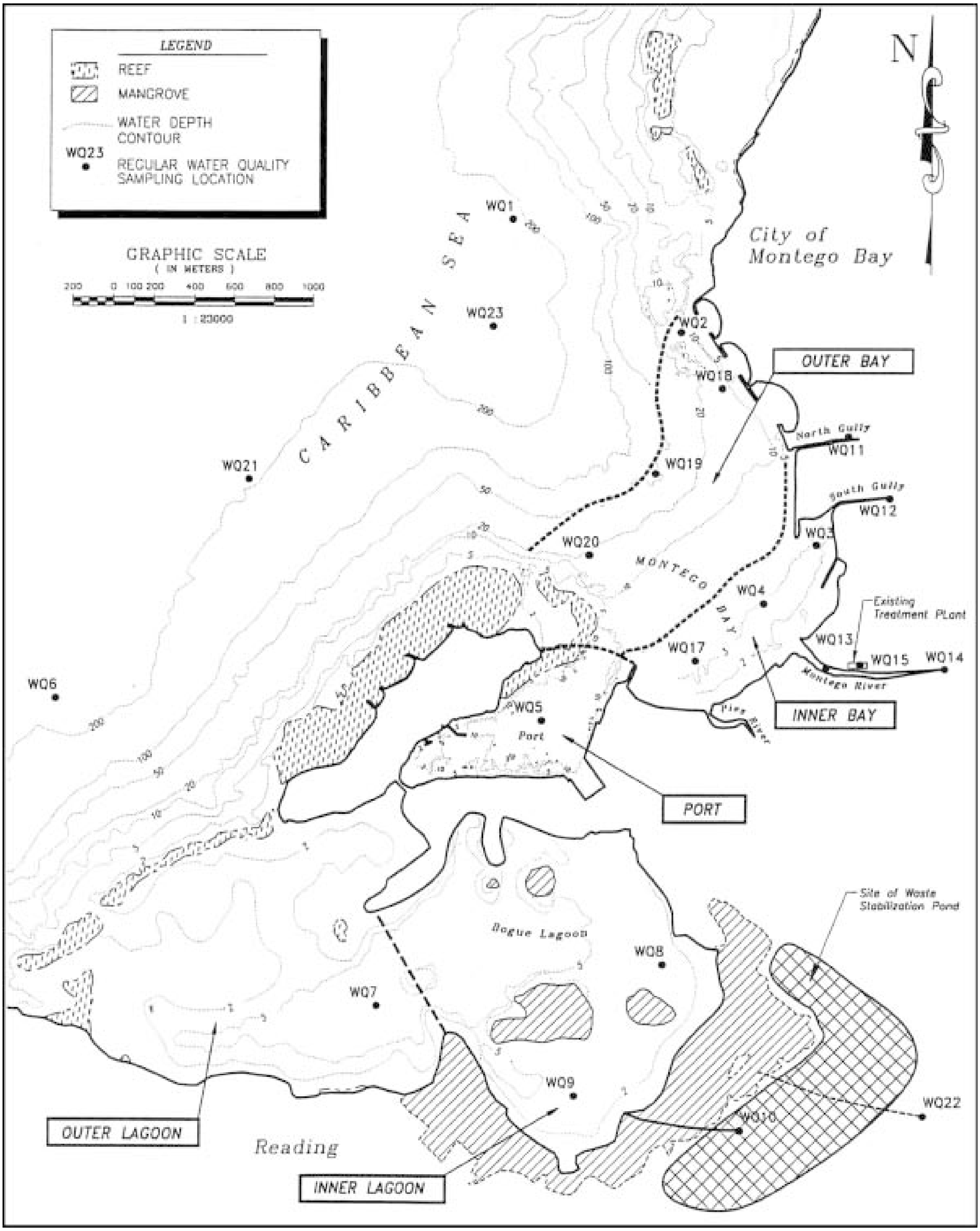

Figure 1.4. Bathymetry of the coastal zone and overview map of the station locations of the environmental monitoring program (USAID 1996). Shown also is the location of the new waste stabilization pond system adjacent to the mangrove forest of Bogue Lagoon. The thicker dashed lines within Montego Bay and Bogue Lagoon represent the boundaries of subareas in these waterbodies that were used for water quality modeling (i.e., inner bay, outer bay, port, inner lagoon, and outer lagoon).

Box 1.2. A successful ICZM case study achieving rapid results.

The Dolphins Are Back: A Successful Quality Model for Healing the Environment (Scanlan 1988)

By the end of the 1980s, the once beautiful and treasured New Jersey shoreline had become one of the most polluted coasts in the United States. Communities felt the frustration of a record high number of beach closures and disappearing wildlife. In one dramatic example, over 1,000 bottlenose dolphins washed ashore along the Atlantic coast from Florida to New Jersey. As the situation worsened, the challenging job of finding a solution was eventually taken up by an innovative partnership representing business, government and private citizens.

At the direction of Phillip Scanlan, who brought along his talent and Baldrige Award-winning experience as quality vice-president at AT&T, the group borrowed a successful tactic businesses had been using for years—they applied a total quality approach to clean up the shore and achieved a culture of continuous improvement.

Scanlan (1988) outlines two compelling stories simultaneously—his experience implementing the industry-renowned quality methodology at AT&T, as well as the struggles and ultimate success of applying this same quality approach to cleaning up the New Jersey shore. The book highlights the importance of recognizing the potential strength in relationships among business, government, and citizens. In a quality environment, these partnerships have the ability to tackle any seemingly complex and impossible task.