Rapid Ecological Assessment of the Montego Bay Marine Park, Jamaica: Evaluation of Marine Parks as Marine Fisheries Reserves

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ABSTRACT

A rapid ecological assessment of the Montego Bay Marine Park, Jamaica, was carried out in three phases; 1.) preliminary mapping of marine benthic communities from 1:12,000 natural-color aerial photographs, 2.) field surveys designed to ground-truth imagery and identify gradients of anthropogenic disturbance from known point-sources of pollution and 3.) construction of a final marine benthic community map with assessment and ranking of communities.

Field survey methodologies included the characterization and assessment of marine benthos and adjacent mangrove communities. The benthic community map and community descriptions are important in the development of a park management plan and the evaluation of an area as a fisheries reserve.

Recommendations on the improvement of benthic community health as well as the enhancement of fish communities in the park include: 1.) restoration of circulation within the bay, 2.) improvement in the run-off quality from rivers and stormwater, and 3.) improvement in the patterns of resource utilization through education, installation of mooring buoys and restricting extraction of resources in zones within the park.

INTRODUCTION

The number and scope of marine parks or protected areas are growing throughout the Caribbean area. The designation of parks is a response to a recognized need to formulate strategies for marine conservation to protect both tourism and fisheries interests.

Anecdotal information and quantitative data indicate that there has been widespread degradation of shallow-water benthic communities with a concurrent decline in neritic fish production. The causal agents are likely to be complex and many in number, but overfishing coupled with low-level chronic stresses have exacerbated the collapse of coastal ecosystems (See Knowlton *et al.*,1981, 1990; Tunnicliffe, 1981; Woodley *et al.*, 1981). Designation of areas as parks or fisheries preserves is not sufficient to protect marine resources. Restoration and protection of shallow-water benthic community diversity is key to healthy production in coastal fisheries. An ecological assessment for the characterization, assessment, and eventual monitoring of the benthic communities can be an important tool in both the management of fisheries and protected areas.

The Montego Bay Marine Park (MBMP) is located on the northwest coast of Jamaica. MBMP encompasses an area offshore of the city of Montego Bay from the Donald Sangster International Airport to the eastern point of the Great River (about 15 km^2). The Park extends from the shoreline (mean high tide mark) to the 100 m depth contour. This area has traditionally been used by fishermen, watersports operators, hoteliers, and settlements living along the shoreline of the bay. The major impacts to the Montego Bay area include: 1.) dredge and fill development of the fringing mangrove forests and mangrove islands of Bogue Sound, 2.) change in freshwater flow, sedimentation and nutrient loading in the Montego River, 3.) alteration of the natural coastline and coastal communities, including adjacent freshwater wetlands and mangrove forests, and 4.) high utilization of the area by fishermen and tourists.

Montego Bay has a long history of anthropogenic disturbance; the coastal areas adjacent to the park are dramatically altered from human development and run-off patterns. Beginning in the 1960s, the coastline of Montego Bay was altered with the dredge and fill construction of Seawind Island and the Montego Freeport. This construction project, along with the growing population of the town, drastically altered the run-off and circulation patterns in the bay. The

Montego Freeport was created by dredging and filling 690 hectares of mangrove and associated fish habitat in the Bogue Island Lagoon. This development effectively destroyed these areas and associated reef communities. The construction of Seawind resorts on a fill island further contributed to the degradation of adjacent seagrass beds and reefs. The upland border of the mangrove community has been slowly eroded by the development of sugarcane fields, fishing camps, illegal dumps, and wood gathering.

The rapid ecological assessment (REA) methodologies were developed to combine existing oceanographic, geological and biological information with focused field surveys (Abate, 1992).

The REA can proceed or often direct lengthier scientific inventories, and are intended to provide the critical mass of information needed to catalyze management action. The objectives of this assessment in Montego Bay were two-fold: 1.) to prepare a map of the MBMP with the associated benthic community descriptions that provide an assessment of the health of, and conservation concerns in, each community class and 2.) to study inshore-to-offshore patterns of communities, including mangroves, within the park to describe trends associated with point- and non-point sources of nutrient loading and pollutants. The assessment produced specific recommendations to improve the condition of nearshore marine communities. The increase in diversity and health of benthic communities is inevitably tied to fish communities and fisheries interests. A vital part in restoring ecosystem function and community diversity is the recovery of fish populations in the bay.

This paper will report on the specific field methodologies used and the interpretation of results for benthic community class designations and assessment. The distribution of marine benthic communities in the bay, the relative health of reef and seagrass bed communities throughout the park, and documented trends or patterns of disturbance are critical in evaluating the effectiveness of a marine fisheries reserve in the bay.

METHODS AND MATERIALS

Aerial Imagery Analysis

Low altitude natural-color aerial photography of the Montego Bay area was examined to determine the occurrence of shallow-water marine communities and to select specific survey sites. The photographs were used to generate 1: 12,000 scale maps of marine communities using a stereoscope (Ciciarelli, 1991). Sites were selected to attempt to quantify both inshore to offshore gradients in diversity and species composition across the Bay. After the photo-interpretation of the community polygons, the color imagery was used to guide field surveys. A hierarchical classification of the marine benthic communities of the western tropical Atlantic was modified for community classes present in Montego Bay (Table 1). The definitions used were modified from Dethier (1992). Benthic

Table 1. Classes of marine benthic communities mapped in the Montego Bay Marine Park from 1:12,000 natural color aerial photographs. Mangrove communities are not included in this list.

SOFT SEDIMENT / Unconsolidated Bottom

- 1A. Sand-Mud / Bare Bottom
  - Calcareous muds
    - Anchialine ponds / saline land-locked ponds
    - Mangrove channels / lagoons
  - Terrigenous muds
    - Anchialine ponds / saline land-locked ponds
    - Mangrove channels / lagoons
- 1B. Sand-Mud / Seagrasses
  - Sparse seagrass (<30% coverage)
  - Moderate to dense seagrass communities
  - Seagrass patches on a matrix of soft bottom
- 2A. Sand / Bare Bottom
  - Sand beaches (intertidal)
    - Calcareous sand beaches
    - Terrigenous sand beaches
  - Sand shoals and sand bars
- 2B. Sand / Seagrasses / Algal Turf
  - Sparse seagrass (<30% coverage)
  - Sandy algal turf
  - Mixed algal turf / sparse seagrass
  - Bioturbation zone
- 3. Rubble / Loosely Consolidated Hard Bottom
  - Reef rubble communities

HARD SUBSTRATUM / Consolidated Bottom Communities

- 4A. Hard Bottom / Algal Turf / Sponges / Coral
  - Sparse hardbottom communities
  - Dense hardbottom communities
- 4B. Hard Bottom / Seagrass / Algal Turf Matrix
  - Hard bottom matrix with patches of seagrass
- 4C. Hard Bottom / Coral Reef Communities
  - Patch reefs
  - Reef crests
  - Spur and groove system / buttress zone / intermediate reefs
  - Fore reef slope and vertical walls

communities were a division within marine and estuarine systems. "Class" level designations of communities were based on substratum and lifeform. Substrate is defined as sand-mud, sand, rubble and hardbottom. Lifeform was described by algae, seagrasses, sponges, octocorals or stony corals. Communities at this level are image-definable in the tropical western Atlantic. "Type" level designations of communities required descriptions to the species-level for dominant benthos as identified by: density, area coverage, area per individual or colony and maximum size.

Field Surveys

Two days reconnaissance visits and five days of sampling by two teams of six scientists allowed the assessment and characterization of 30 different communities within the park including the mangrove communities in Bogue Sound (Table 2). MBMP was arbitrarily divided into five areas based on geography and usage patterns in the bay: 1.) North Airport (northeastern boundary of park), 2.) Core Reefs and Beaches (west of the airport), 3.) Seawind Island 4.) Bogue Sound and mangrove communities and 5.) Western Shore and Reefs (Figure 1). The central part of Montego Bay has been dredged to accommodate shipping channels and no longer represents a natural community; this area was not included in the survey.

The benthos is the primary focus of initial community characterization. Benthic diversity in the community can indicate the three-dimensional complexity of a habitat and can be indicative of the diversity of associated fishes and invertebrate epifauna (Sullivan and Chiappone, 1992). A global positioning system receiver (GPS-Trimble Transpak II) was used for recording locations and testing the accuracy of base maps.

Three survey methods were used: 1.) Substratum / lifeform characterization to determine "Class" level designation of benthic communities. 50-m transect lines were placed across each survey site each year to capture maximum variability (heterogeneity) as judged from aerial imagery. Transect lines were oriented in different locations on each site based on the heterogeneity observed within the interpreted polygon of the image. The appropriate length of the transect lines was determined using species-area curves for sponges and stony corals combined (Gleason, 1922; Loya, 1972). Transect lines were used as a guide for the placement of 1 m^2 quadrats placed each meter along the line. For initial characterization, each quadrat was scored for percent area coverage of both substratum and lifeform categories (See Sullivan and Chiappone, in press). Substrate categories included: sand-mud, sand, rubble and hard bottom. Lifeform categories included: benthic macro-algae, seagrass, sponges, octocorals, and stony corals. 2.) Species presence / absence inventories for characterization of benthic communities. Previous studies at Discovery Bay Marine Laboratory and the north coast of Jamaica were utilized to develop

Table 2. Survey sites and data collected for marine benthic communities in the Montego Bay Marine Park during 6-11 July, 1992. Three survey methodologies were used: 1) substrata and lifeform characterization; 2) species inventories of benthic macroalgae, sponges, stony corals and octocorals; and 3) belt quadrat sampling.

Area	Community Class	Number of Survey Sites	Substrata / Lifeform Characterization	Species Inventories	Belt Quadrats
AREA 1					
North Airport	Moderate to dense seagrass	2	*	*	
	Sand / Mixed algal turf	1	*	*	
	Reef rubble zone	2	*	*	
	Patch reefs	1	*	*	*
	Spur and groove reefs	1	*	*	
AREA 2					
Core Reefs	Moderate to dense seagrass	1	*	*	
and Beaches	Hard bottom matrix	1	*	*	
	Patch reefs	2	*	*	
	Reef crests	1	*	*	
	Spur and groove reefs	3	*	*	*
AREA 3					
Seawind Island	Moderate to dense seagrass	2	*	*	
	Reef crests	2	*	*	
AREA 4					
Bogue Sound	Mangrove Forests	11	*	*	*
AREA 5					
Western Shore	Moderate to dense seagrass	2	*	*	
	Reef rubble zone	1	*	*	
	Dense hard bottom	1	*	*	
	Reef crests	2	*	*	*
	Spur and groove reefs	2	*	*	*

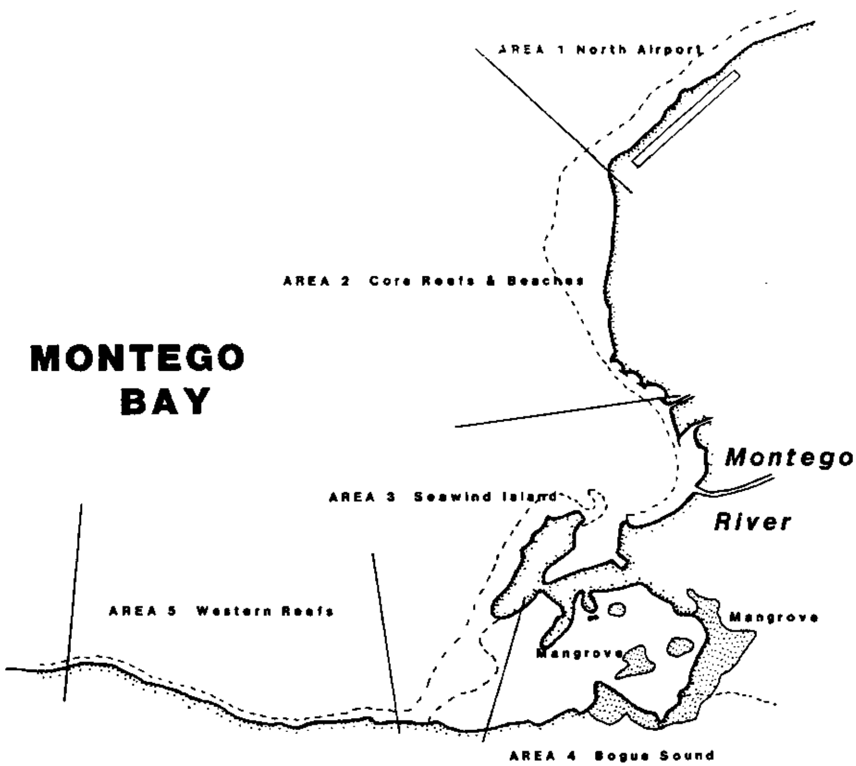


Figure 1. Map of Montego Bay, Jamaica. The Rapid Ecological Assessment of the Park divided the bay into five areas: 1) North Airport, 2) Core Reefs and Beaches, 3.) Seawind Island, 4) Bogue Sound and 5) Western Reefs.

species checklists for the major taxa observed at the survey sites (Goreau and Goreau, 1973; Goreau, 1959; Woodley and Robinson, 1977). Checklists and identification keys were developed for conspicuous sponges, octocorals (Bayer, 1961), stony corals (Goreau and Wells, 1967; Wells, 1973; Kinzie, 1973) and benthic macroalgae (Taylor, 1960; Earle, 1969; Littler *et al.*, 1989). For benthic macroalgae, only conspicuous species that could be identified to genus or species in the field were included. 3.) Belt Quadrats for assessment of benthic communities. Belt quadrat sampling of hard bottom communities is described in Sullivan and Chiappone (1992) allows for the collection of detailed information on the spatial patterning of benthos. Benthos were identified to both the taxa level [sponges, octocorals, stony corals, algae or seagrass] and to species. Plot methods allowed for the direct measurement of colony sizes and density. From each quadrat, the numbers of colonies or individuals were counted and sizes (planar areas for corals and sponges or heights for octocorals) of colonies or individuals measured for taxa groups.

Data Analyses

Substratum and lifeform characterization data were converted to area coverage classes, with mean and standard deviation values calculated for each category. This was accomplished by taking the mid-point of each percentage coverage class and converting percentage values to cm^2 of coverage in each quadrat. Histograms were constructed to provide a graphical picture of the community structure based on overall substratum and lifeform features.

For belt-quadrat data, analyses were divided into taxa-level and species-level quantitative descriptors for sponges or corals. For taxa-level analyses, information for a taxa group was pooled for all species. All quantitative data was standardized to 1 m^2. Parameters were broadly grouped into "density" and "area" measurements.

RESULTS

Shallow-water Marine Benthic Communities of Montego Bay

A list of the classes of natural marine communities interpreted from the aerial imagery is given in Table 1. Twenty-five classes of communities were mapped in each of the five subdivisions of the bay. Approximately 1000 hectares of shallow-water and intertidal bottom was image-definable to the class level of community classification. Field survey sites represented most community classes and were distributed throughout the five areas (Table 2). The patterns of communities from inshore to offshore differed markedly between the eastern and western areas of the bay seagrass beds. Eastern areas (1 & 2) had a wider shallow-shelf area, and had a greater diversity of benthic community classes. The western areas (3,4 & 5) included Bogue Sound (4) but had a relatively narrow shelf, and fewer community classes (Table 3).

Table 3. Area of each benthic community class (in hectares) from five areas within Montego Bay Marine Park, Jamaica.

Community Class	Area 1 North	Area 2 Core Reefs	Area 3 Seawind	Area 4 Bogue Sound	Area 5 West Shore
A. SAND-MUD / BARE BOTTOM					
Saline Lakes	0	0	0	4	0
Calcareous Muds	1	0	0	0	0
Terrigenous Muds	0	29	30	86	9
B. SAND-MUD / SEAGRASSES					
Sparse Seagrass					
Nearshore *Thalassia*	4	7	33	56	12
Offshore *Syringodium*	7	37	5	0	0
Dense Seagrass					
Nearshore *Thalassia*	2	13	32	34	19
Offshore *Syringodium*	31	43	0	0	4
2A. SAND / BARE BOTTOM					
Sand Beaches	1	2	4	1	1
Sand Shoals and Sand Bars	0	0	1	0	0
2B. SAND / ALGAL TURF					
Sandy Mixed Algal Turf	16	19	41	23	19
Bioturbation Zone	0	0	0	0	0
3. RUBBLE					
Back Reef Rubble Zone	2	12	9	0	4
4A. HARD BOTTOM / ALGAL TURF / SPONGE / CORAL					
Sparse Hard Bottom / Algal-Dominated	0	0	5	0	0
Dense Hard Bottom / Algal-Dominated	19	12	0	0	0
4B. HARD BOTTOM / SEAGRASS MATRIX					
Hard Bottom Matrix with Dense Seagrass Patches		0	15	0	0

Table 3. (Continued) Area of each benthic community class (in hectares) from five areas within Montego Bay Marine Park, Jamaica.

Community Class	Area 1 North	Area 2 Core Reefs	Area 3 Seawind	Area 4 Bogue Sound	Area 5 West Shore
4C. HARD BOTTOM / CORAL REEF COMMUNITIES					
Patch Reefs	0	15	13	0	0
Reef Crests-*A. palmata* Framework	17	21	26	0	18
Spur and Groove Reefs-*A. cervicornis/M. annularis*	27	40	36	0	24
Fore Reef Slope and Vertical Walls	4	7	5	0	6
ADJACENT MANGROVES	(0)	(0)	(0)	(74)	(0)
TOTAL AREA (MARINE)	131	272	240	204	122

Table 4. Belt quadrat taxa-level summary for two spur and groove reef communities in the Montego Bay Marine Park, Jamaica. Belt quadrat information has been pooled for all species within each taxa group. The density of species for each taxa group is based on the mean number of species per 1 m^2 quadrat. The density of sponge individuals and coral colonies is based on the mean number of individuals or colonies per m^2. Area coverage for sponges and stony corals is expressed as the mean coverage (cm^2) per m^2. Individual and colony sizes for sponges and stony corals are expressed in cm^2. Colony sizes for octocorals are based on colony heights (cm). Values are based on twenty-five 1m^2 sampled quadrats. Values in parentheses represent 1 standard deviation.

Mooring Buoy #10 - North Airport

Taxa	No. Species per m^2 (cm^2)	Individual or colony density	Area Coverage cm^2m^{-2}	Individual or Colony Sizes
Sponges	2.6(1.9)	2.89(2.78)	192.4(262.3)	68.2(111.8)
Stony Corals	3.2(1.5)	7.73(4.37)	1413.9(1443.2)	183.9(577.1)
Octocorals	0.3(0.5)	0.37(0.91)	26.4(19.5)	

Mooring Buoy #22 - Western Shore

Taxa	No. Species per m^2 (cm^2)	Individual or colony density	Area Coverage cm^2m^{-2}	Individual or Colony Sizes
Sponges	0.7(0.8)	1.15(1.95)	172.3(406.5)	149.8(368.1)
Stony Corals	4.8(1.8)	15.25(8.31)	1421.2(1561.7)	93.2(226.0)
Octocorals	0.8(0.6)	2.00(2.08)	11.4(7.7)	

In all areas of the bay 15 species of octocorals, 38 species of stony corals, 64 species of sponges and 87 species of benthic macro-algae were recorded from prepared checklists. Overall, nearshore areas in the western area of the bay showed the lowest diversity and highest level of disturbance based on substrate lifeform characterizations and belt quadrat assessments. Deep reefs along the entire bay showed a high degree of similarity, but reef crests and hardbottom communities nearer to shore differed markedly between areas. On spur and groove reefs in the core reef area (1), sponges were more diverse and occurred in higher densities and were on the average larger than sponges recorded from the western reefs. In contrast, stony corals were more diverse, occurred at higher densities on western reefs. Total area coverage of live coral and octocoral diversity was similar throughout the park, but small colonies dominated the western reef sites (Table 4).

Area 1 - North Airport

The North Airport area had the smallest image-definable area (131 hectares) but a diverse assemblage of communities. The entire shoreline along the northern airport boundary is a bulkhead and is filled with culverts allowing drainage of a small brackish swamp area. Away from the culverts, the typical pattern of benthic communities from inshore to offshore is presented in Figure 2. Moderate to dense seagrass (*Thalassia testudinum*) dominated nearshore. The rubble in this area was mostly dead *Porites* spp. The community class changed moving offshore to an algal-dominated hardbottom community with less coral rubble and the appearance of live coral colonies.

The reef crests offshore showed the highest number of coral species compared to reef crests in other areas (four octocoral and twenty stony coral species). Area coverage of the reef crest was dominated by benthic macroalgae (mean coverage 52%) with 30 species recorded. Spur and groove/ buttress zone reefs showed visible signs of anchor damage on the tops of the spurs.

Offshore spur & groove and patch reef communities are dominated in area coverage by benthic macroalgae, particularly *Halimeda* spp. The density of stony corals was 2.24 ± 3.11; the most important species in terms of colony density were *P. porites, Montastrea annularis, Agaricia agaricites* and *Millepora complanata*. Area coverage was dominated by *M. annularis* in terms of both total coverage and mean colony size. Coral coverage was highest on patch reefs located in the broad lagoon inside the reef crest.

Area 2 - Core Reefs and Beaches

This area represented the largest and most diverse area in terms of communities present in the bay. Nearshore areas were dominated by soft sediment communities and beaches. The broad, shallow shelf supported hard bottom/seagrass/algal turf matrices, patch reef and coral rubble communities. Transects from nearshore to offshore revealed mixed algal turf/seagrass beds with a notable epifauna diversity to moderate to dense seagrass to algal dominated hardbottom and hard-bottom/ seagrass matrix communities. The diversity of communities was greatest in this area of the bay.

Area 3 - Seawind Island

The nearshore areas to the eastern end of Seawind Island were evaluated as communities closest to dredging activity in the port of Montego Bay and discharge from the Montego River. Nearshore communities off the beaches appeared in the aerial imagery to be dense seagrass, but ground-truthing revealed sparse seagrass patches in an area dominated by sand/mud mixed algal turf. The area appeared to have recently experienced a die-off based on seagrass accumulated on the beach and presence of rhizomes in the substrata. This seagrass community historically may have been characterized by *Porites* spp.

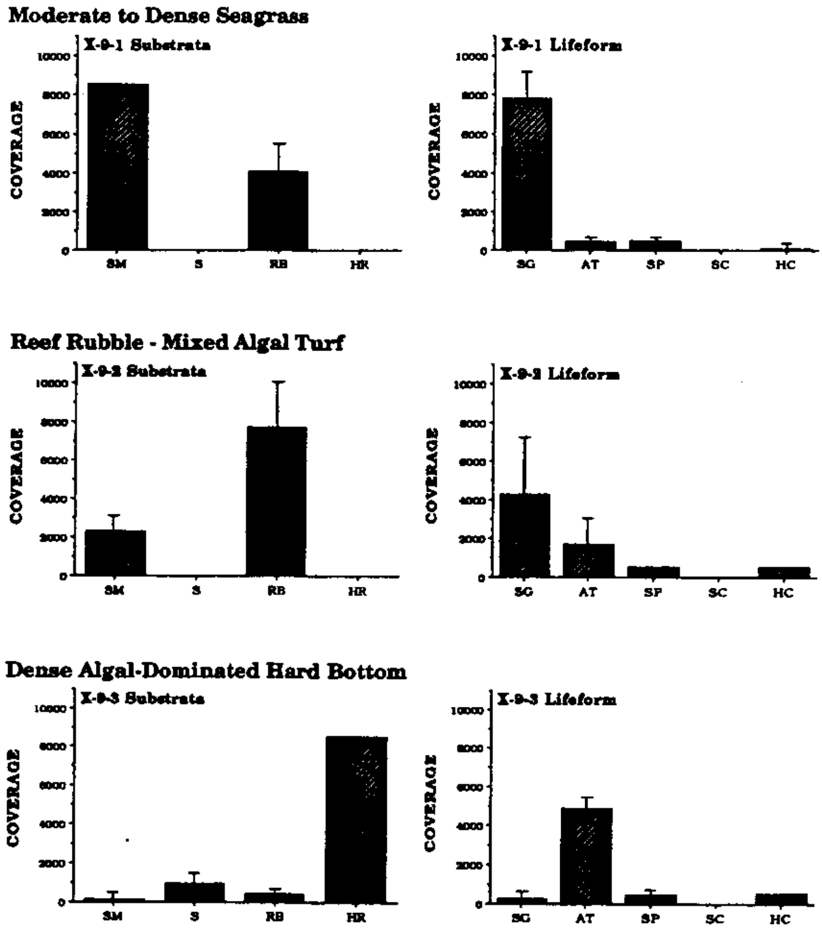


Figure 2. Substrata/ lifeform histograms for onshore to offshore transects of eastern Montego Bay (Area 1 North Airport). Histograms represent mean and standard deviation for area coverage estimates made from 25 grids in each polygon. Class level community designations are given.

colonies. Some colonies of coral were seen and accumulation of coral rubble was noted.

Reef ridges seaward from the seagrass and soft sediment communities were algal dominated with low area coverage and low diversity of sponges and stony coral species. Many hard bottom communities at the eastern end of Seawind Island had sand-mud accumulation, and indication of sedimentation events (either chronic or episodic).

Area 4 - Bogue Sound

Bogue Sound (Area 4) was exclusively soft sediment communities, most of the area was mixed muds/bare bottom, mixed algal turf and sparse seagrass communities. Anchialine or saline lakes that occurred in the interior of the mangrove islands were a unique community class to the area. Community classification in this area focused on the assessment of adjacent mangrove forests. Eleven survey sites within the mangrove forests described density, strata and height of trees in a *Rhizophora mangle*-dominated fringing forest.

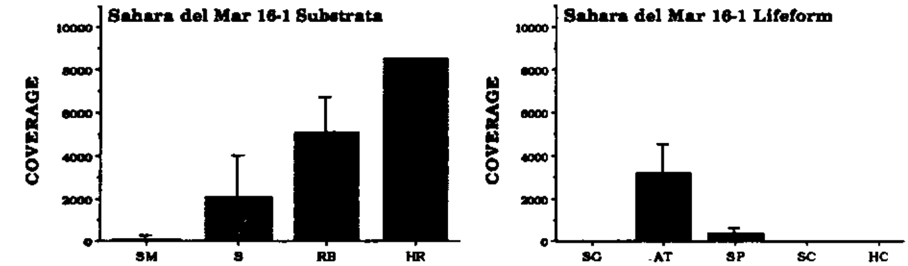
Most of the mangrove area in or adjacent to Bogue Sound was *Rhizophora mangle* overwash islands or fringing forest. Moving inland the zonation of *Rhizophora* to *Avicennia germinans* and *Laguncularia racemosa* was visible, but compressed into a narrow band parallel to the shoreline. Areas of both *Rhizophora* and *Laguncularia* were over 60% dead trees from consumptive use of the wood and clearing for fill and development. The landward extent of the mangrove forest was marked by *Conocarpus erectus*. Assessments showed less than 70 hectares of undisturbed mangroves with most of the forest experiencing consumptive use or fill. The mangrove forests represented the most severely impacted community class visited within the park.

Area 5 - Western Shore

The Western Reefs (Area 5) represented the narrowest shelf area of the park with the smallest proportion of soft sediment communities. (Table 3). Area 5 reef crests characteristically had few, if any, coral and sponge species, and were dominated by frondose brown algae. Nearshore communities were highly disturbed with signs of coastal erosion and bulkheading of beaches and rocky shore areas (Figure 3).

Overall in the park there was an unusually low diversity and small size range of fishes associated with both the reefs and nearshore communities. There is a lack of large coral colonies on the reefs, and a surprisingly low diversity of larger reef sponges on spur and groove as well as deeper intermediate reef communities. Although there is still the remarkable diversity of coral species, particularly on reefs in the northeastern part of the park, there are very few large colonies alive. The reef has an unexpectedly low diversity of massive vase or tube sponges, but evidence of many boring sponges.

Nearshore Rubble - Fill Area



Moderate to Dense Seagrass

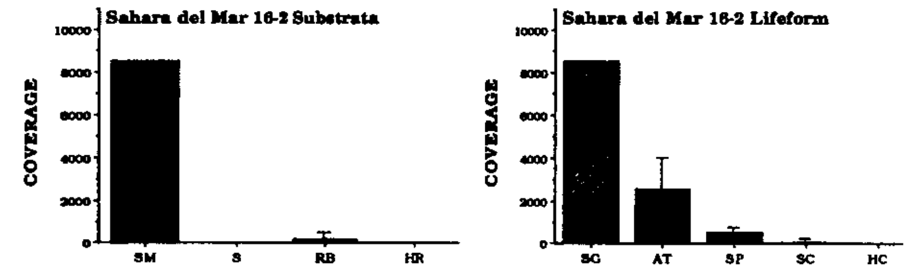


Figure 3. Substrata/ lifeform histograms for onshore to offshore transects of western Montego Bay (Area 5 Western Shore and reefs). Histograms represent mean and standard deviation for area coverage estimates made from at least 25 grids in each polygon. Class level community designations are given.

Based on similarity indices, northern reefs in the park (Areas 1 & 2) appear slightly more robust and speciose in contrast to the reefs along the western shore of the park (Areas 3 & 5). However, all reefs showed low coverage of constructional components (stony corals and sclerosponges; Lang *et al.*, 1975) and a high incidence of erosional components (boring sponges) (Pang, 1973). Reef crests near shore have the lowest coral diversity and cover, and are dominated by frondose brown macroalgae.

DISCUSSION

Symptoms of Low-level Chronic Stress

The symptoms of community or ecosystem stress have been recently reviewed (Rappaport *et al.*, 1985). Tropical reef ecosystems adjacent to cities and coastal development are affected by nutrient loading, increased sedimentation, degradation in water quality and mechanical damage (Banner, 1974; Marszalek, 1987; Pastorak and Bilyard, 1985). A central challenge to managing marine parks is the segregation of change caused by low-level chronic stressor (anthropogenic) from the natural dynamics of communities. Historically, the reefs along the north coast of Jamaica have been described as diverse, coral dominated reefs subjected to natural catastrophic events (*i.e.* . hurricanes) that can alter the species order but not eliminate species from a reef area (Liddell and Ohlhorst, 1981, 1987; Wilkerson and Cheshire, 1988; Reiswig, 1973). Anthropogenic impacts may often mimic natural disturbances, but there are differences between natural variability and unnatural rates of change (Brown and Howard, 1985). The symptoms of community degradation on tropical shallow-water benthic communities over a short-term (years) period include: 1.) the rapid loss of species 2.) loss of large coral colonies or sponge individuals 3.) limited or no evidence of recruitment inferred from the lack of small coral colonies or sponges and 4.) acute change in the size-frequency distribution of benthic organisms that is not associated with a catastrophic event. Many of these symptoms can be documented throughout Montego Bay through anecdotal reports, underwater photographs and published reports.

Management Implications

Scientists and managers of marine parks and protected areas are reaching a consensus on the role of marine fisheries reserves in conservation of tropical coastal ecosystems. Although difficult to legislate and enforce, fisheries scientists have recommended that a minimum of 30% of the coast be designated as "fisheries reserves" or areas free from extraction (Craik, 1992; PDT, 1991) as a long-term goal.

The purpose of the park is foremost to protect and conserve the natural resources of Montego Bay. The park can serve to coordinate, under a central park management, the activities necessary to restore and preserve the natural resources. Marine fisheries reserves (MFR's) require the protection of high quality coastal areas for fish population replenishment. As a greater percentage of coastal areas are developed, there will be less high quality benthic communities, and thus functioning coastal ecosystems to designate as MFR's. These reserves might be best co-located with parks to combine resources for coastal zone management and habitat restoration. The analysis of the survey information will help identify trends in community degradation, and highlight the most important actions to be taken in the park management plan.

Improvements of the benthic communities within the park for both tourism and fisheries can be grouped into three categories: 1.) restoration of natural water flow and circulation, 2.) restoration of water quality, and 3.) minimizing consumptive or utilization damage to resources. The damage done to the marine communities at Montego Bay was not accomplished overnight, nor will the recovery be quick. Circulation within the bay combined with run-off quality would appear to be the most encompassing factors to be addressed. The circulation patterns, quantity and quality of water entering the bay are of far more importance and exacerbate the impacts of overfishing and mechanical damage to the shallow- water marine communities.

Sediment load from adjacent rivers and dredging is perhaps the largest scale problem based on the accumulation of sand-mud in benthic communities close to Seawind Island and the Montego River. The problem of coordinating the many activities that influence soil erosion and increased sediment loading in the watersheds and river is difficult to address. The coastline of the park has been drastically altered by development and lack of education. Mangroves have been removed for security and aesthetic reasons. A campaign to re-plant mangroves along exposed shorelines could add to the overall improvement of water quality. Further efforts to clean the Montego River will help not only the environment but also improve public health.

The long term success of both marine parks and marine fisheries reserves will be the integrated management of both marine resources and coastal zone development patterns. Rapid Ecological Assessments of proposed parks and reserves can provide a tool for directing management action on a broad scale as well as focusing research for specific restorative projects. The success of Montego Bay Marine Park will be measured ultimately on the ability of many government and non-government agencies to work in an integrated fashion on a multi-faceted restoration plan.

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