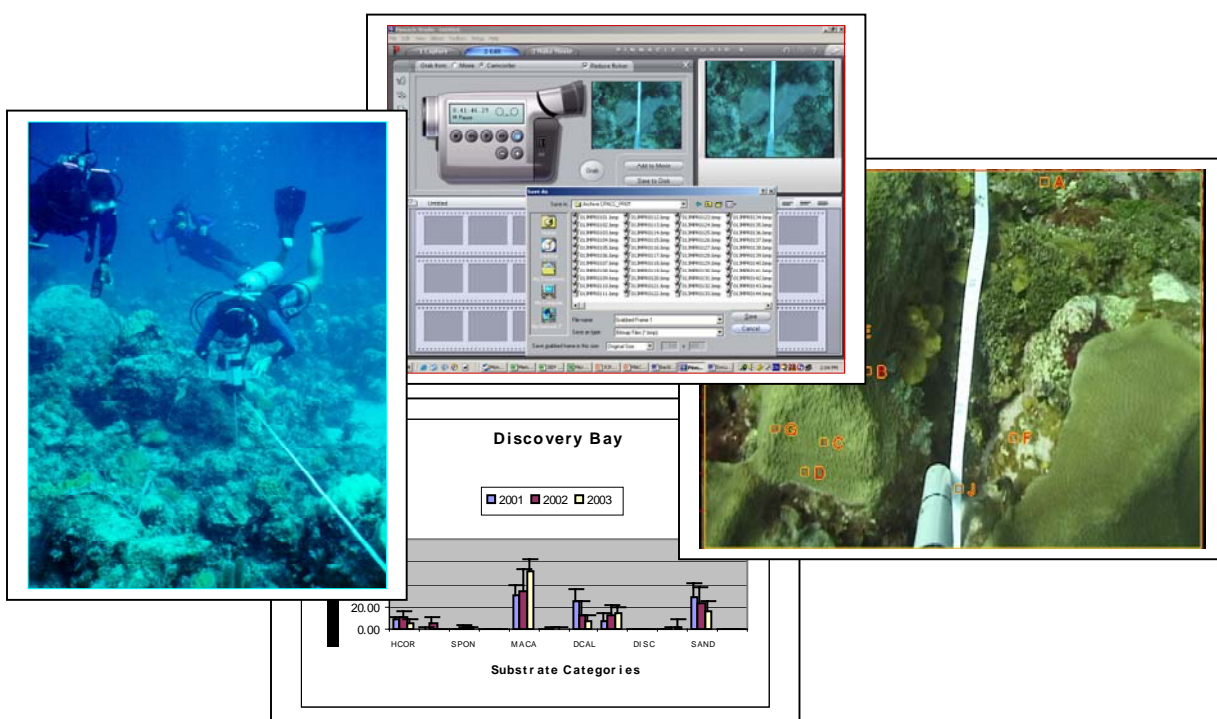




Mainstreaming Adaptation to Climate Change (MACC) Project
Strengthening of the Climate and Coral Reef Monitoring Network

**Coral Reef Monitoring for Climate Change Impacts
Jamaica 2001-2003**



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List of Acronyms

ACCC	Adaptation to Climate Change in the Caribbean
CARICOM	Caribbean Common Market
CARICOMP	Caribbean Coastal Marine Productivity Programme
CCDC	Caribbean Coastal Data Centre
CMS	Centre for Marine Sciences
CPACC	Caribbean: Planning for Adaptation to Global Climate Change
DLS	Department of Life Sciences
GCC	Global Climate Change
GHGs	Greenhouse Gases
MACC	Mainstreaming Adaptation to Climate Change
MOU	Memorandum of Understanding
UWI	University of the West Indies
NRCA	Natural Resources Conservation Authority
NEPA	National Environment and Planning Agency

Acknowledgment

The Centre for Marine Sciences would like to acknowledge the contributions to the study of Peter Wilson-Kelly, Sean Green and Jerome Smith of NEPA who conducted the video monitoring and Loureene Jones (CMS) and Ivana Kenny(DLS) who assisted with the data processing and analysis. Funding for the preparation of this report was provided by the MACC project.

Executive Summary

Introduction

The Mainstreaming Adaptation to Climate Change (MACC) project was initiated in January 2003 to facilitate the creation of an enabling environment for climate change adaptation in CARICOM Small Island developing and low-lying states. Under a Memorandum of Understanding (MOU) with the CARICOM Secretariat, the executing agency for the MACC project, the Centre for Marine Sciences (CMS) agreed to undertake the processing, analysis and reporting on the data backlog for Jamaica for the period 2001 – 2003. This report presents the results of the coral reef monitoring conducted in Jamaica.

Background

The Caribbean Planning for Adaptation to Global Climate Change (CPACC) project was established in 1998 by CARICOM countries in response to the growing concerns regarding the impact of global climate change in the region. Component 5 of the CPACC project, **Coral Reef Monitoring for Climate Change Impacts**, was designed to establish a long term monitoring programme in the region. Under CPACC, the CMS provided technical assistance in the execution of the coral reef monitoring programme in three pilot countries (The Bahamas, Belize and Jamaica). Reports on the first year of monitoring were prepared and submitted by Jamaica (Chevannes Creary, 2001) and Belize (Bood, 2001). An evaluation of Component 5 was undertaken during a “Planning and Technical Review Workshop” held in 2001 in Jamaica (Lawrence & Edwards, 2001). Due to financial constraints the plan to extend the coral reef monitoring programme to the remaining eight CPACC countries¹ was never executed and the CPACC project came to a close in December 2001.

Methodology

The National Environment and Planning Agency, NEPA (formally the Natural Resources Conservation Authority, NRCA) conducted the field monitoring for the period 2001 – 2003 as part of their regular work programme. Staffing and computer software constraints prevented the processing and analysis of the data in-house. The Caribbean Coastal Data Centre (CCDC) of the CMS, under the MOU with the MACC project carried out the data processing, analysis and archiving. The three Operational Areas that were selected for monitoring were Eastern Portland (minimally impacted), Discovery Bay in St Ann (mildly impacted) and Port Royal Cays in Kingston (severely impacted). The target habitat selected was the mixed zone on the windward slopes, consisting mainly of spur and groove formations, dominated by *Montastrea annularis* within a depth range of 7-13 m. Twenty transects, each 20 m in length were located randomly within the target habitat, parallel to the depth contour, and monitored using the CPACC Video Monitoring Protocol.

¹ The eight countries that were expected to be involved in the second phase of the monitoring programme were, Antigua and Barbuda, Barbados, Dominica, Grenada, St. Kitts and Nevis, St. Lucia, St. Vincent, and Trinidad and Tobago.

Results

MACROALGAE, DEAD CORAL WITH ALGAE and CORALLINE ALGAE dominated the benthic substrate at all locations. At Monkey Island, Portland MACROALGAE and DEAD CORAL WITH ALGAE dominated the benthic community representing a combined percentage cover of approximately 60% for all three years. CORALLINE ALGAE was the next highest contributor to the benthic substrate cover representing 13.47% in 2001, 23.66% in 2002 and 5.15% in 2003. The HARD CORAL cover fluctuated between 11.24% in 2001, down to 6.23% in 2002 and up again to 11.80% in 2003.

MACROALGAE and DEAD CORAL WITH ALGAE also dominated the benthic substrate of “Gorgo” City near Discovery Bay, St Ann, but to a lesser extent than observed in Portland. Their combined percentage cover was 54.97% in 2001, 45.80% in 2002 and 59.85% in 2003. CORALLINE ALGAE formed the next largest component of the benthic substrate accounting for 6.72%, 12.21% and 13.52% for 2001, 2002 and 2003 respectively. HARD CORAL cover was variable ranging from 8.08% in 2001 to 11.13% in 2002 and 5.91% in 2003.

Algae in the form of MACROALGAE, DEAD CORAL WITH ALGAE and CORALLINE ALGAE dominated Southeast Cay, Port Royal Cays, Kingston. These three categories combined made up between 85% and 95% of the benthic substrate cover. The HARD CORAL cover at Southeast Cay was very low accounting for 1.25% in 2001, 2.14% in 2002 and 2.24% in 2003.

During the period 2001 to 2003 14 coral species were identified from both Monkey Island and Southeast Cay respectively while 18 species were identified at “Gorgo City”. The most commonly occurring species for all three locations and on all sampling occasions were *Agaricia agaricites*, *Montastrea annularis*, and *Porites astreoides*. Other commonly occurring species were *Acropora cervicornis*, *Montastrea faveolata*, *Porites porites*, *Diploria strigosa* and *Siderastrea siderea*.

Discussion

The data presented in this reports represents the continuation of the CPACC monitoring programme that was started in 2000, the designated baseline year, using percentage benthic substrate cover as the indicator of coral reef health. The great variability in the quality of the underwater videography made analysis difficult in some instances.

The results of the monitoring programme for the three-year period 2001 to 2003 were similar to those obtained in the study carried out in 2000. HARD CORAL cover in Port Royal remained characteristically low ranging from 1.25% (in 2001) to 2.24% (in 2003). This compares to HARD CORAL cover of 2.1% obtained in 2000. HARD CORAL cover for both Monkey Island and Discovery Bay fluctuated during the period but did not rise above 12% at either location. From the results (Tables 1, 3 and 5) it can be seen that there is not a great deal of difference between hard coral cover at these two locations, which is in keeping with the results obtain in 2000. A total of 20 species were identified for all three locations over the three-year period compared to 13 observed in 2000. The dot method of assessing coral cover can fail to detect less common species and coral

recruits, as was evident at Monkey Island in Portland, where five additional species were identified. A more comprehensive species list could be achieved by independently reviewing the images. However, the benthic substrate continued to be dominated by the algal species found commonly on reefs. These included *Sargassum*, *Dictyota*, *Halimeda* and *Lobophora*.

Jamaica is the only pilot country that has been able to continue monitoring beyond the baseline year. The CMS and NEPA, in association with the MACC project, need to work in partnership in order to ensure the long-term sustainability of this monitoring programme.

Recommendations

Site Selection

- Consideration should be given to selecting a site that represents a healthier coral cover than is presently obtained for Monkey Island in Portland.
- Attempts should also be made to monitor the reef flats and deeper reefs within each Operational Area.
- Detailed site descriptions and detailed maps are still outstanding.

Monitoring

- Consideration should be given to the establishment of permanent transects.
- Physical parameter such as temperature, salinity, dissolved oxygen, turbidity and pH need to be incorporated into the monitoring programme.
- An annual evaluation of the execution of the monitoring protocol is required in order to ensure quality control/quality assurance.

Data Processing and Analysis

- The divers and data analysts should review the videotapes together in order to ensure consistency in the identification of substrate categories and coral species.
- Consideration should be given to investigating the use of the Coral Point Count Methodology for the analysis of captured images.
- Statistical analysis needs to be incorporated into the data analysis protocol.

1 Introduction

The Mainstreaming Adaptation to Climate Change (MACC) project was initiated in January 2003 to facilitate the creation of an enabling environment for climate change adaptation in CARICOM small island developing and low-lying states, building upon and consolidating research undertaken under the Caribbean: Planning for Adaptation to Global Climate Change (CPACC) and Adaptation to Climate Change in the Caribbean (ACCC) projects.

Under the Memorandum of Understanding (MOU) between the CARICOM Secretariat, the executing agency for the MACC project, and the Centre for Marine Sciences (CMS), UWI Mona, the agreement was made to collaborate in the area of strengthening the coral reef monitoring network in the region. Under Article 1 Section 1.2(i) of the MOU the CMS agreed to undertake “Maintaining the central data management and quality control of the coral reef monitoring for GCC (Global Climate Change) network established under the CPACC project”. As part of this agreement the CMS has undertaken the task of processing, analyzing and preparing the report on the backlog of data collected during the monitoring programme carried out in Jamaica for the period 2001 –2003. This report presents the results of the coral reef monitoring conducted in Jamaica for the period 2001 – 2003.

2 Background

The Caribbean: Planning for Adaptation to Global climate Change (CPACC) project was established in 1998 by CARICOM countries in response to the growing concerns regarding the impact of global climate change in the region. The CPACC project consisted of nine components, one of which, **Component 5 - Coral Reef Monitoring for Climate Change Impacts**, was designed to establish a long term monitoring programme in the region. Monitoring under Component 5 was intended to show the effects of global warming factors (temperatures stress, sea level rise and severe weather events) on coral reefs. Component 5 was also designed to document, where possible, the extent and sources of existing coral reef degradation in the region.

Under CPACC, the CMS provided technical assistance in the execution of the coral reef monitoring programme for three pilot countries (The Bahamas, Belize and Jamaica). Reports on the first year of monitoring (2000) were prepared and submitted to CPACC by Jamaica (Chevannes Creary, 2001) and Belize (Bood, 2001). Due to logistical difficulties experienced with respect to implementing the prescribed CPACC Video Monitoring Protocol, The Bahamas was unable to complete their monitoring. They were, however, able to submit a report on their progress, which also highlighted their constraints to implementation (Phillips, 2001).

An evaluation of Component 5 was undertaken during a “Planning and Technical Review Workshop” held in 2001 in Jamaica (Lawrence & Edwards, 2001). During that workshop the challenges faced and the potential solutions were discussed. There was the expectation that the pilot countries would institutionalize the monitoring programme and establish coral reef monitoring utilizing the CPACC Video Monitoring Protocol as part of their regular workplan. Jamaica was able to do this for three additional years.

Preliminary plans for the expansion of the coral reef monitoring programme to the Eastern Caribbean were also developed. However, due to financial constraints this plan to extend the coral reef monitoring programme to the remaining eight CPACC countries² was never executed and the CPACC project came to a close in December 2001.

3 Methodology

3.1 Monitoring Protocol

The National Environment and Planning Agency, NEPA (formally the Natural Resources Conservation Authority, NRCA) conducted the field monitoring for the period 2001 – 2003 as part of their regular work programme. Staffing and computer software constraints prevented the processing and analysis of these data in-house. The Caribbean Coastal Data Centre (CCDC) of the CMS, under the MOU with the MACC project carried out the data processing, analysis and archiving. Coral reef monitoring by NEPA was not carried out in 2004 or 2005 due to in house capacity constraints (staffing, funding and equipment).

Three Operational Areas were selected for monitoring following the guidelines established in the Draft Site Selection Protocol (Woodley, 1999) prepared under the CPACC project; these were Eastern Portland (minimally impacted), Discovery Bay in St Ann (mildly impacted) and Port Royal Cays in Kingston (severely impacted). For this monitoring programme “impact” is defined as land-based, anthropogenic stress, transported to reefs by fluvial inputs or actual physical impacts on reefs caused by activities within the marine environment. The target habitat selected in each Operational Area was the mixed zone on the windward slopes, consisting mainly of spur and groove formations, dominated by *Montastrea annularis* within a depth range of 7-13 m. Twenty transects, each 20 m in length were located randomly within the target habitat, parallel to the depth contour, and monitored using CPACC Video Monitoring Protocol. The resultant videotapes were catalogued (Appendix 1 & 2). Using a computer and specialized software (Pinnacle Studio 9TM), adjacent non-overlapping images were captured, dotted and stored as image files. The benthic components under the random dots were identified based on specified benthic category codes (Appendix 3 & 4) and the resultant data points were summarized and stored in spreadsheets.

A more detailed description of the methodology employed can be found in the **Jamaica 2000** report (Chevannes Creary (2001). The methodology was reviewed extensively during the Technical Review Workshop held in 2001 and is documented in detail in the proceedings (Lawrence & Edwards, 2001). The video monitoring technique is adopted from the methods used by Miller (2000).

3.2 Description of the Operational Areas

The island of Jamaica (10,800 km²) is situated in the northern Caribbean (18°N, 77°W). Cuba, 150 km to the north, moderates the effects of the northeast trade winds on the well-developed fringing reefs of the north coast, which have developed on a very narrow shelf.

² The eight countries that were expected to be involved in the second phase of the monitoring programme were, Antigua and Barbuda, Barbados, Dominica, Grenada, St. Kitts and Nevis, St. Lucia, St. Vincent, and Trinidad and Tobago.

Patchy reef formations on the south coast grow on a shallow shelf up to 20 km wide, but are punctuated by rivers and sediment slopes. Coral reefs also grow on the neighbouring banks of the Pedro Cays, 70 km south, and the Morant Cays, 50 km southwest. The map of Jamaica (Figure 1) highlights the location of the three Operational Areas as selected under the CPACC project.

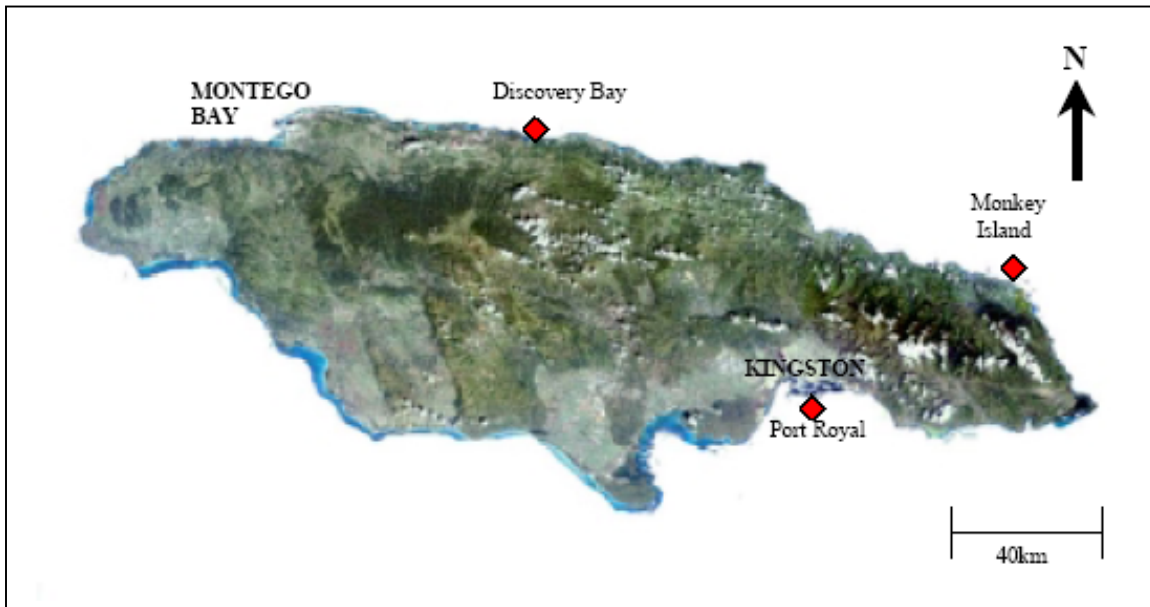


Figure 1 Map of Jamaica showing the location of the minimally impacted (Monkey Island, Portland) mildly impacted (Discovery Bay, St Ann) and severely impacted (Port Royal Cays, Kingston) Operational Areas selected for long term monitoring.

3.2.1 Monkey Island, Portland

Portland is located along the northeast coast of Jamaica in a part of the island that records the highest annual rainfall. The area consists predominantly of mountainous terrain covered with deciduous forests and is dissected by numerous small to medium sized rivers. The main economic activities carried out in this sparsely populated parish are agriculture, fishing and tourism. Eco-tourism has become increasingly popular because of the relatively undisturbed nature of the environment. There are no major industrial activities but the port facilities at Port Antonio, the parish capital, facilitative cruise ships and banana exporting vessels.

Monkey Island in Portland was selected because it was considered to be minimally affected by anthropogenic factors. The monitoring site is located approximately 10km east of Port Antonio, away from major land-based influences, and extends from due north of Monkey Island eastwards to the Blue Hole area following the 7 – 13 m depth contour (Figure 2). This fringing reef is parallel to the shoreline, separated from the mainland by a shallow, sandy bottom lagoon. The spur and groove formation is very pronounced with steep sided sand channels giving rise to heterogeneous stony coral buttresses. Figure 3 below gives a visual representation of the reef structure in this area.



Figure 2. Aerial photograph showing the location of the monitoring site at Monkey Island, Portland, representing reef conditions considered to be minimally impacted by anthropogenic factors.

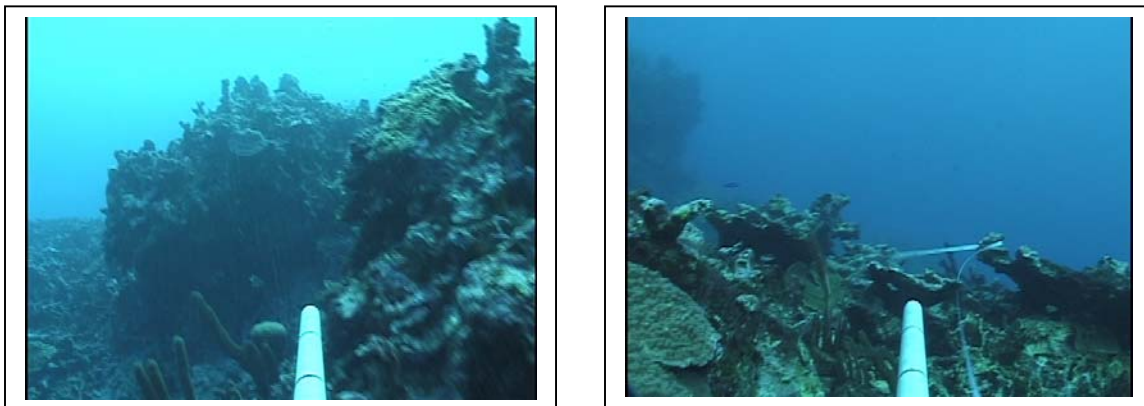


Figure 3. Selected images representing the general appearance of the coral reef ecosystem at Monkey Island in Portland.

3.2.2 “Gorgo City” near Discovery Bay, St Ann

Discovery Bay is located along the central portion of the north coast of Jamaica. The town extends to the south and east of the bay and to the southeast is the loading facility of a major bauxite company. Bauxite export along with fishing, tourism and research are the primary activities in this area. The bay has no permanent rivers; instead ground water enters through deep crack in the basement limestone, which impacts the temperature and salinity in the back reef. Discovery Bay has experienced severe hurricanes (Hurricane Allen – 1980; Hurricane Gilbert - 1988), which have resulted in a high-level of

destruction of corals. This along the with impacts of over-fishing have been cited as being responsible for the “phase shift” from a coral dominated reef to a low diversity algae dominated reef (Hughes, 1994).

The monitoring site, located to the west of Discovery Bay at “Gorgo City” (Figure 4), was regarded as mildly impacted. The monitoring site had a gentle profile with continuous fringing reefs developed in a spur and groove formation. The reef has developed on the narrow submarine shelf typical of the north coast. Figure 5 contains images of the typical appearance of the reefs at “Gorgo City”.



Figure 4. Aerial photograph showing the location of the monitoring site at “Gorgo City” near Discovery Bay, St Ann, representing reef conditions considered to be mildly impacted by anthropogenic factors.

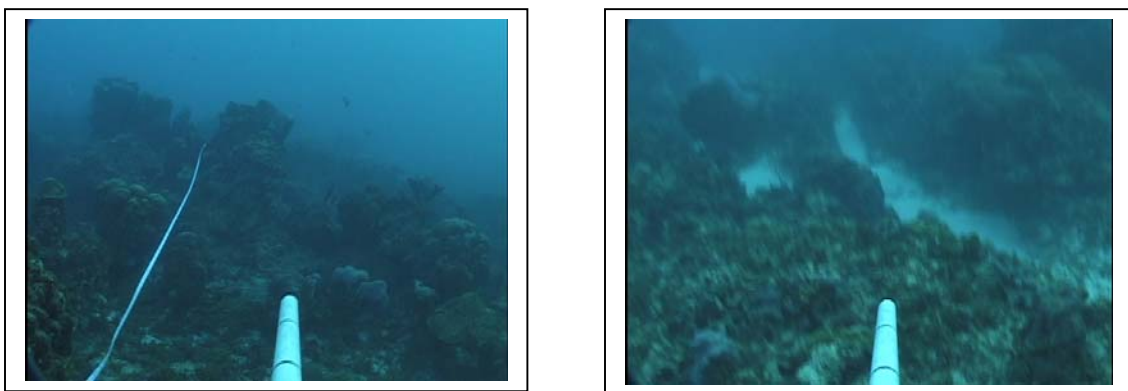


Figure 5. Images representing the general appearance of the coral reef at “Gorgo City” near Discovery Bay. St Ann.

3.2.3 Southeast Cay, Port Royal Cays, Kingston

The Port Royal Cays are located off the southeast coast of the island, outside of Kingston Harbour and are affected by the direct influence of its highly eutrophic waters (Morrison & Greenaway, 1989). The major contributor to the pollution of the harbour, and by extension the cays, is domestic sewage effluent from the city of Kingston. The Port Royal Cays are comprised of a number of coral islets situated on the island shelf, which is considered to be a drowned eroded landscape consisting of limestone and sand (Goreau & Burke, 1996). This shelf serves as a protective barrier for the Palisadoes tombola and the town of Port Royal. The cays are important to the nearshore artisanal fishing industry as well as for recreation (Mendes, 1992). The monitoring site at Southeast Cay, which is somewhat removed from the direct southern outflows of the harbour, has a gentle profile between the depths of 7-13 meters (Figure 6) and is comprised primarily of coral rubble dominated by a variety of algal species. Visibility in this area is generally poor as can be seen in the images presented below (Figure 7).

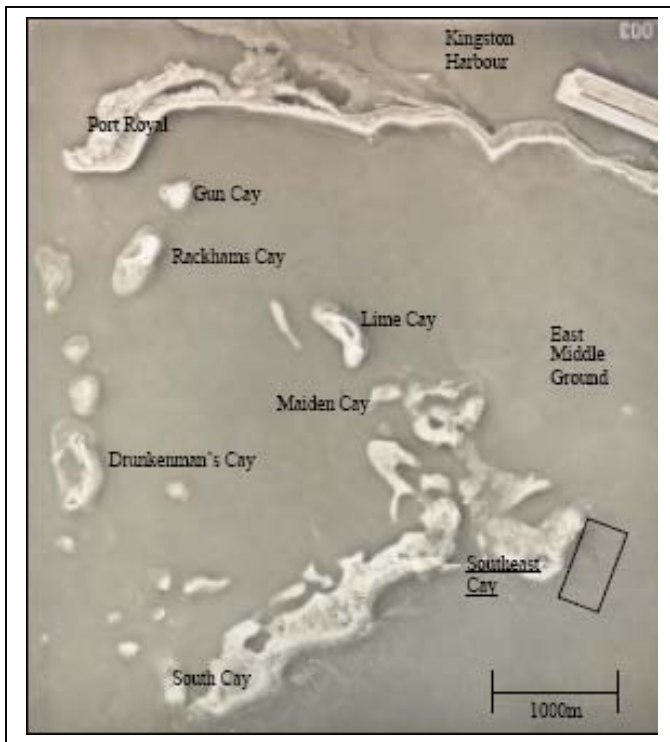
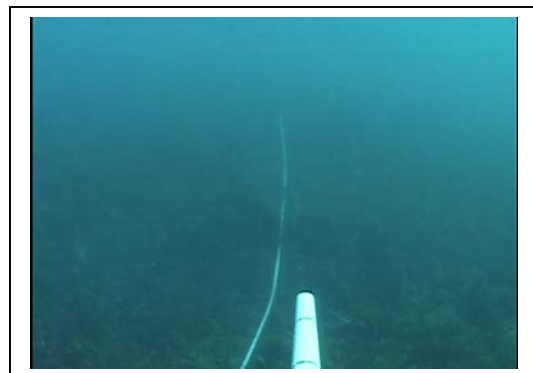
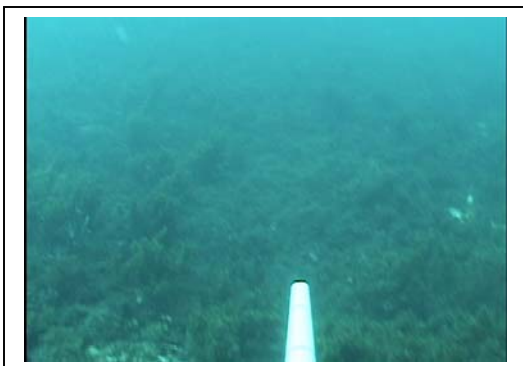


Figure 6. (Left) Aerial photograph of the Port Royal Cays, Kingston showing the location of the monitoring site at Southeast Cay. This site is representative of moderately to severely impacted reef conditions.

Figure 7. (Below) The images presented here highlight the poor visibility and high algal cover found at Southeast Cay, Port Royal Cays, Kingston.



4 Results

The results are presented for the period 2001 to 2003 for each of the three Operational Areas established in Jamaica, Monkey Island in Portland, “Gorgo City” near Discovery Bay, St Ann and Southeast Cay in Port Royal Cays, Kingston.

4.1 Monkey Island, Portland

4.1.1 Benthic Substrate

The HARD CORAL cover varied from between 11.24% in 2001 down to 6.23% in 2002 and up again to 11.80% in 2003. HARD CORAL cover for this location was 7.1% in 2000 (Appendix 5). As was the case in 2000 the MACROALGAE and DEAD CORAL WITH ALGAE dominated the benthic community representing a combined percentages cover of approximately 60% for all three years. In 2000 the combined percentages for MACROALGAE and DEAD CORAL WITH ALGAE was 69%. The CORALLINE ALGAE was the next highest contributor to the benthic substrate cover representing 13.47% in 2001, 23.66% in 2002 and 5.14% in 2003. GORGONIANS, SPONGES and ZOOANTHIDS each contributed less than 2% of the benthic cover for each of the years monitored. The percentage cover represented by DISEASED and RECENTLY DEAD CORAL was negligible, each accounting for less than 1% over the three year period. SAND, RUBBLE, ROCK AND BOULDER, found primarily in the sand channels, made up 10.26% of the substrate in 2001, 7.53% in 2002 and 17.70% in 2003. The data for Monkey Island, Portland for the period 2001 to 2003 is presented in Table 1 and graphically illustrated in Figure 8 below.

Table 1 Summary of mean percentage cover for the substrate categories found at Monkey Island, Portland for the period 2001 to 2003.

Substrate Category	2001		2002		2003	
	Mean	Stdev	Mean	Stdev	Mean	Stdev
HARD CORAL	11.24	4.86	6.23	3.67	11.80	8.03
GORGONIANS	1.41	1.52	0.13	0.19	0.19	0.33
SPONGES	1.46	1.55	0.23	0.32	0.13	0.27
ZOANTHIDS	0.00	0.00	0.00	0.00	0.01	0.06
MACROALGAE	26.92	18.52	55.02	10.34	55.85	17.93
OTHER, LIVE	0.74	0.89	1.36	0.51	1.38	0.66
DEAD CORAL WITH ALGAE	33.95	18.36	3.94	5.43	5.29	4.29
CORALLINE ALGAE	13.47	8.08	23.66	9.46	5.14	5.77
DISEASED CORALS	0.14	0.25	0.00	0.00	0.00	0.00
RECENTLY DEAD CORALS	0.38	0.61	0.04	0.10	0.04	0.14
SAND, RUBBLE, ROCK, BOULDER	10.26	4.44	7.53	4.70	17.70	10.05
UNKNOWN	0.03	0.11	1.86	1.62	2.46	1.63

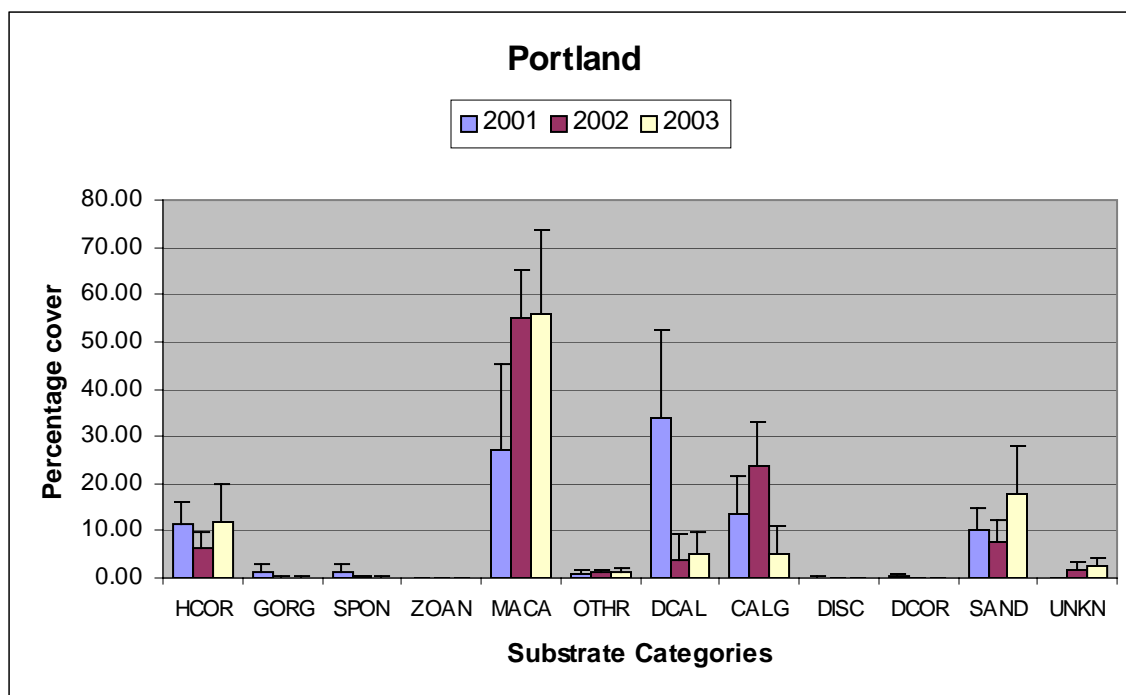


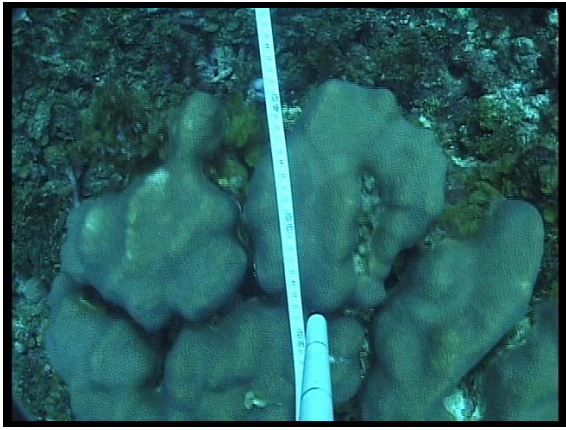
Figure 8. Graph illustrating the mean percentage cover of the different substrate categories found at Monkey Island, Portland for the period 2001 to 2003. Error bars represent Standard Deviation (Stdev). (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; SPON - Sponge; ZOAN - Zooanthids; MACA - Macroalgae; OTHR - Other, live; DCAL - Dead coral with algae; CALG - Coralline algae; DISC - Diseased coral; DCOR - Recently dead coral; SAND - Sand, rubble, rock and boulder; UNKN - Unknown.)

4.1.2 Coral Species

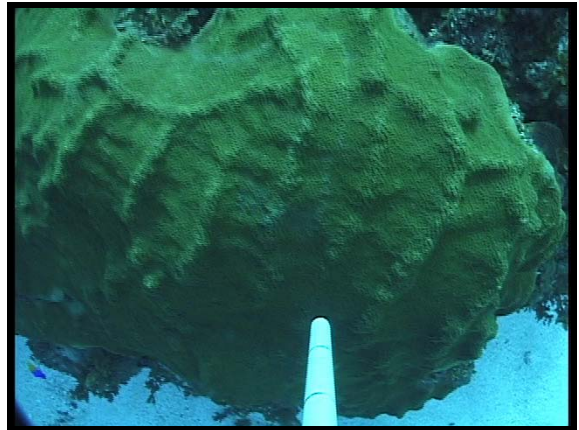
During the period 2001 to 2003 a total of 14 coral species were recorded from Monkey Island; 11 during 2001, 10 during 2002 and 9 during 2003. Eight species consistently occurred over the three-year period. The most commonly occurring species were *Agaricia agaricites*, *Montastrea annularis*, *Montastrea faveolata*, *Porites astreoides* and *Porites porites*. Three species (*Diploria strigosa*, *Madracis mirabilis*, and *Siderastrea siderea*) were identified in each of the three years but exhibited very low percentage cover values. Six species were recorded only once during the three-year period, these were *Acropora cervicornis*, *Diploria labyrinthiformis*, *Millipora alvicornis*, *Porites furcata*, *Scolymia sp* and *Siderastrea radians*. A number of other species were observed and identified but not captured during the data processing and analysis exercise and were included under the CORAL OF UNKNOWN SPECIES category. These were *Mycetophyllia forex*, *Colpophyllia natans*, *Diploria stokesii*, *Madracis asperula* and *Eusmilia fastigata*. Table 2 provides a summary of the percentage cover for each of the coral species identified during the period 2001 to 2003. Images of some of the species occurring at Monkey Island, Portland are presented in Figure 9.

Table 2. Coral species recorded at Monkey Island, Portland during the period 2001 to 2003.

Coral Species	2001	2002	2003
Acropora cervicornis (ACER)	0.00	0.01	0.00
Agaricia agaricites (AAGA)	1.36	0.52	1.50
Diploria labyrinthiformis (DLAB)	0.00	0.00	0.04
Diplora strigosa (DSTR)	0.01	0.06	0.07
Madracis mirabilis (MMIR)	0.07	0.05	0.04
Millipora alcicornis (MALC)	0.18	0.00	0.00
Montastrea annularis (MANN)	1.44	0.52	1.07
Montastrea faveolata (MFAV)	0.81	0.78	1.10
Porites astreoides (PAST)	4.70	2.41	3.18
Porites furcata (PFUR)	0.29	0.00	0.00
Porites porites (PPOR)	1.66	0.94	2.42
Scolymia sp (SCOL)	0.01	0.00	0.00
Siderastrea radians (SRAD)	0.00	0.11	0.00
Siderastrea siderea (SSID)	0.32	0.04	0.07
Coral of Unknown Species	0.38	0.80	2.31
Total % Coral Cover	11.24	6.23	11.80
Number of known species	11	10	9



a) *Montastrea annularis*



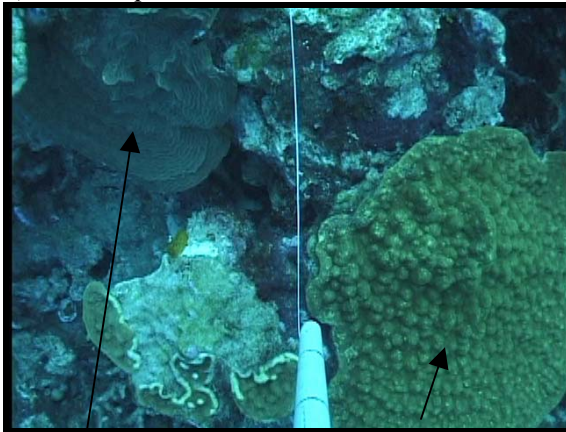
b) *Montastrea faveolata*



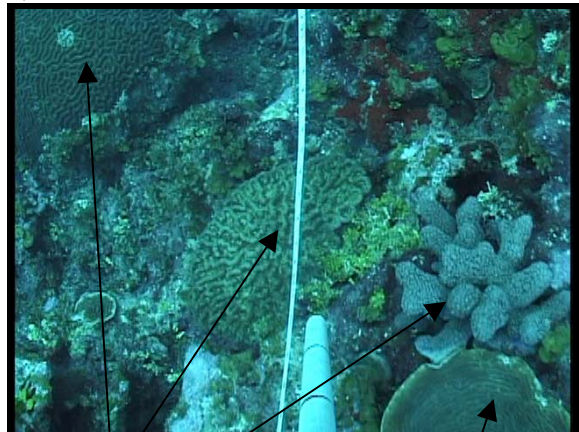
c) *Porites porites*



d) *Porites astreoides*



e) *Agaricia agaricites* and *Porites astreoides*



f) *Diplora strigosa*, *Agaricia agaricites* and *Porites porites*

Figure 9. Selected images of the commonly occurring hard coral species found at Monkey Island, Portland during the period 2001 to 2003. [a) *Montastrea annularis*, b) *Montastrea faveolata*, c) *Porites porites*, d) *Porites astreoides*, e) *Agaricia agaricites* and *Porites astreoides*, f) *Diplora strigosa*, *Porites porites*, and *Agaricia agaricites*].

4.2 Discovery Bay, St Ann

4.2.1 Benthic Substrate

HARD CORAL cover was variable ranging from 8.08% in 2001, 11.13% in 2002 and 5.91% in 2003. This compares to 6.7% observed in 2000 (Appendix 5). MACROALGAE and DEAD CORAL WITH ALGAE also dominated the benthic substrate but to a lesser extent than observed in Portland. Their combined percentage cover was 54.97% in 2001, 45.80% in 2002 and 59.85% in 2003, which compared to 65.1% in 2000. CORALLINE ALGAE formed the next largest component of the benthic substrate accounting for 6.72%, 12.21% and 13.52% for 2001, 2002 and 2003 respectively. GORGONIANS were uncharacteristically high in 2002 when compared to the other two years. In 2002 GORGONIANS represented 5.03% of the benthic substrate cover while in 2001 and 2003 the percentage cover was determine to be 0.37% and 0.28% respectively. Low percentage cover values were obtained for both SPONGES and ZOOANTHIDS. OTHER LIVE unidentified organisms made up less than one percent of the benthic substrate. No DISEASED CORALS were observed in 2001 and very low levels detected in 2002 (0.11%) and 2003 (0.05%). RECENTLY DEAD CORALS were also at a low level accounting for 0.28% in 2001, 0.81% in 2002 and 2.01% in 2003. SAND, RUBBLE, ROCK AND BOULDER, found in patches throughout the reef, accounted for 28.88% of the substrate cover in 2001, 22.25% in 2002 and 16.82% in 2003. Table 3 and Figure 10 provide the summaries of the results from Discovery Bay for the period 2001-2003.

Table 3. Summary of mean percentage cover for the substrate categories found at “Gorgo City”, near Discovery Bay, St Ann for the period 2001 to 2003.

Substrate Category	2001		2002		2003	
	Mean	Stdev	Mean	Stdev	Mean	Stdev
HARD CORAL	8.08	3.38	11.13	5.44	5.91	3.73
GORGONIANS	0.37	0.53	5.03	4.77	0.28	0.29
SPONGES	0.25	0.34	2.04	1.84	1.12	0.77
ZOANTHIDS	0.03	0.14	0.00	0.00	0.00	0.00
MACROALGAE	30.37	8.03	33.59	20.21	52.08	9.73
OTHER, LIVE	0.17	0.22	0.61	0.64	0.44	0.46
DEAD CORAL WITH ALGAE	24.60	11.62	12.21	11.90	7.77	5.25
CORALLINE ALGAE	6.72	7.06	12.21	9.11	13.52	5.94
DISEASED CORALS	0.00	0.00	0.11	0.20	0.05	0.10
RECENTLY DEAD CORALS	0.28	0.39	0.81	0.99	2.01	6.11
SAND, RUBBLE, ROCK, BOULDER	28.88	12.72	22.25	15.42	16.82	8.24
UNKNOWN	0.26	0.41	0.02	0.06	0.00	0.00

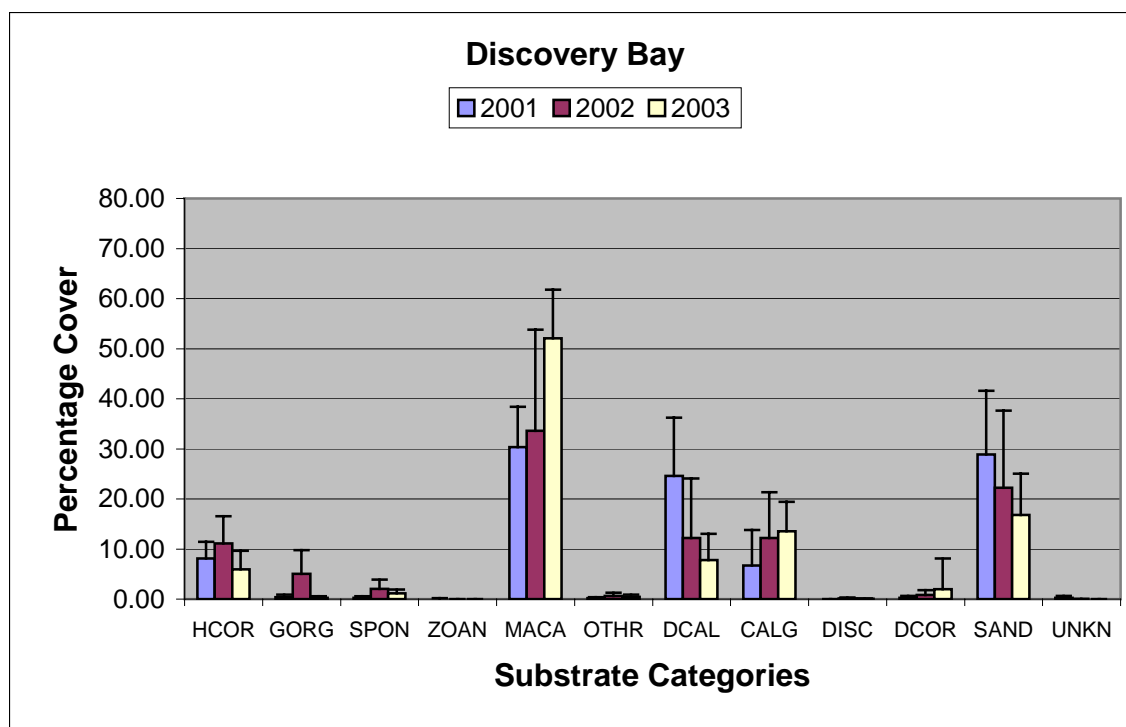


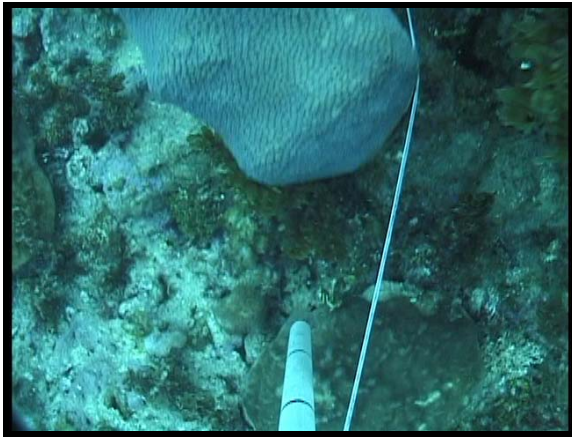
Figure10. Graph illustrating the mean percentage cover of the different substrate categories found at “Gorgo City”, Discovery Bay, for the period 2001 to 2003. Error bars represent Standard Deviation (Stdev). (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; SPON - Sponge; ZOAN - Zooanthids; MACA - Macroalgae; OTHR - Other, live; DCAL - Dead coral with algae; CALG - Coralline algae; DISC - Diseased coral; DCOR - Recently dead coral; SAND - Sand, rubble, rock and boulder; UNKN - Unknown.)

4.2.2 Coral Species

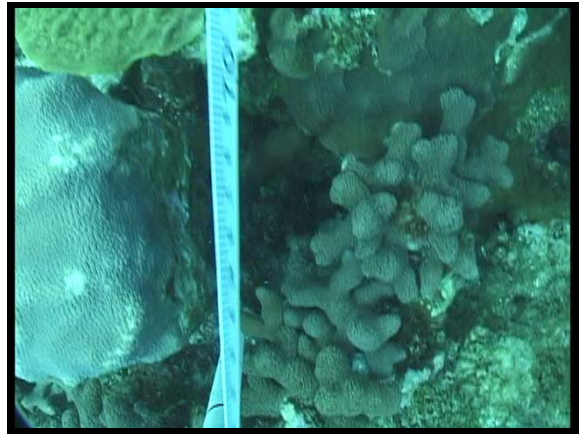
A total of 18 coral species were identified from “Gorgo City” near Discovery Bay, St Ann, 10 were identified in 2001, 17 in 2002 and 8 in 2003. Six species were found on all sampling occasions, these were *Agaricia agaricites*, *Diploria strigosa*, *Montastrea annularis*, *Porites astreoides*, *Porites porites* and *Siderastrea siderea*. Seven species were recorded only once during the three year period. *Siderastrea radians* was recorded only once in 2001 while *Acropora palmata*, *Agaricia grahamae*, *Agaricia humilis*, *Agaricia larmarcki*, *Madracis mirabilis*, *Millipora complanata* were recorded once in 2002. Other species identified at the Discovery Bay monitoring site were *Acropora cervicornis*, *Diploria labyrinthiformis*, *Millipora alcicornis*, *Montastrea cavernosa* and *Montastrea faveolata*. A summary of the coral species and their respective percentage cover for the period 2001 to 2003 is presented in Table 4. Images of some of these species can be found in Figure 11.

Table 4. Coral species recorded at “Gorgo City”, Discovery Bay during the period 2001 to 2003.

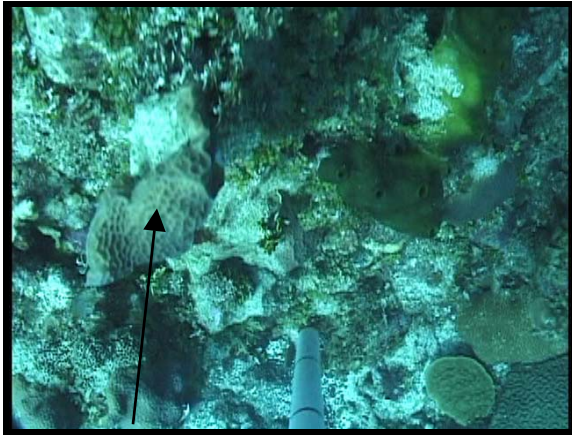
Coral Species	2001	2002	2003
Acropora cervicornis (ACER)	0.05	0.20	0.00
Acropora palmata (APAL)	0.00	0.15	0.00
Agaricia agaricites (AAGA)	0.50	0.47	0.34
Agaricia grahamae (AGRA)	0.00	0.02	0.00
Agaricia humilis (AHUM)	0.00	0.03	0.00
Agaricia lamarcki (ALAM)	0.00	0.07	0.00
Diploria labyrinthiformis (DLAB)	0.05	0.04	0.00
Diploria strigosa (DSTR)	0.12	0.08	0.02
Madracis mirabilis (MMIR)	0.00	0.01	0.00
Millipora alcicornis (MALC)	0.00	0.10	0.16
Millipora complanata (MCOM)	0.00	0.04	0.00
Montastrea annularis (MANN)	1.47	2.56	1.48
Montastrea cavernosa (MCAV)	0.37	0.11	0.00
Montastrea faveolata (MFAV)	0.00	0.22	0.48
Porites astreoides (PAST)	3.31	4.80	1.99
Porites porites (PPOR)	0.33	0.96	0.47
Siderastrea radians (SRAD)	0.03	0.00	0.00
Siderastrea siderea (SSID)	1.45	0.89	0.80
Coral of Unknown Species	0.39	0.40	0.17
Total % Coral Cover	8.08	11.13	5.91
Number of Species (identified)	10	17	8



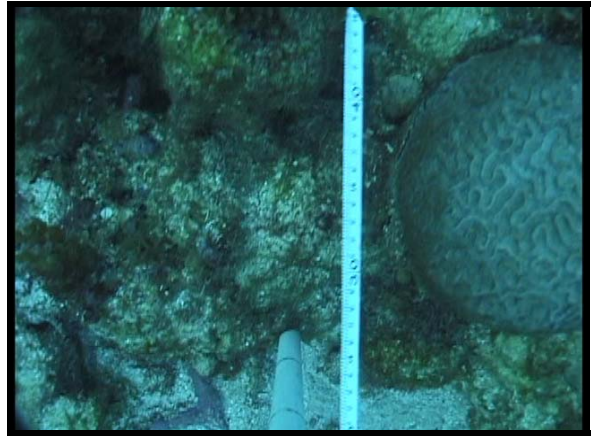
a) *Montastrea annularis*



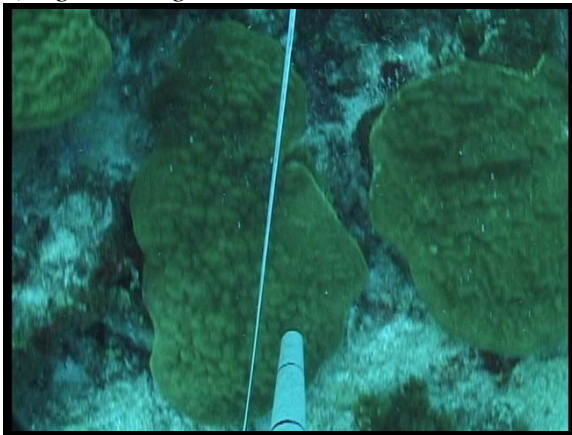
b) *Montastrea annularis*, *Porites porites*, *Porites astreoides*



c) *Agaricia agaricites*



d) *Diploria strigosa*



e) *Porites astreoides*



f) *Siderastrea siderea*

Figure 11. Selected images of the commonly occurring hard coral species found at “Gorgo City” near Discovery Bay, St Ann during the period 2001 to 2003. [a) *Montastrea annularis*, b) *Montastrea annularis*, *Porites porites*, *Porites astreoides* c) *Agaricia agaricites*, d) *Diploria strigosa*, e) *Porites astreoides* f) *Siderastrea siderea*].

4.3 Port Royal Cays, Kingston

4.3.1 Benthic Substrate

The HARD CORAL cover at Southeast Cay was very low accounting for 1.25% in 2001, 2.14% in 2002 and 2.24% in 2003. Mean percentage cover of HARD CORAL in 2000 was 2.1% (Appendix 5). Algae in the form of MACROALGAE, DEAD CORAL WITH ALGAE and CORALLINE ALGAE dominated the area. These three categories combined made up between 85% and 95% of the benthic substrate cover. MACROALGAE cover was greater than 50% on all sampling occasions (55.74% in 2001, 58.47% in 2002 and 53.59% in 2003) while DEAD CORAL WITH ALGAE varied widely (33.46% in 2001, 5.96% in 2002 and 9.53% in 2003) over the three-year period. CORALLINE ALGAE increased from 6.55% in 2001 to 19.77% in 2002 and 22.24% in 2003. SAND, ROCK, RUBBLE AND BOULDER made up 2.26% of the substrate in 2001, 11.38% in 2002 and 9.68% in 2003. All other substrate categories each contributed less than 2% to the benthic cover. The summary data for Southeast Cay for the period 2001 to 2003 is presented in Table 5 and illustrated in Figure 12.

Table 5. Summary of mean percentage cover for the substrate categories found at Southeast Cay, Port Royal cays, Kingston for the period 2001 to 2003.

Substrate Category	2001		2002		2003	
	Mean	Stdev	Mean	Stdev	Mean	Stdev
HARD CORAL	1.25	1.29	2.14	2.53	2.24	1.77
GORGONIANS	0.27	0.65	0.05	0.12	0.32	0.78
SPONGES	0.14	0.28	0.33	0.67	0.10	0.22
ZOANTHIDS	0.03	0.10	0.02	0.10	0.00	0.00
MACROALGAE	55.74	17.00	58.47	13.73	53.59	10.12
OTHER, LIVE	0.03	0.14	1.43	0.64	1.23	0.44
DEAD CORAL WITH ALGAE	33.46	17.73	5.96	6.51	9.53	3.31
CORALLINE ALGAE	6.55	7.99	19.77	8.80	22.24	5.59
DISEASED CORALS	0.02	0.09	0.00	0.00	0.00	0.00
RECENTLY DEAD CORALS	0.11	0.20	0.01	0.05	0.00	0.00
SAND, RUBBLE, ROCK, BOULDER	2.26	2.74	11.38	10.90	9.68	6.02
UNKNOWN	0.15	0.19	0.43	0.32	1.06	0.61

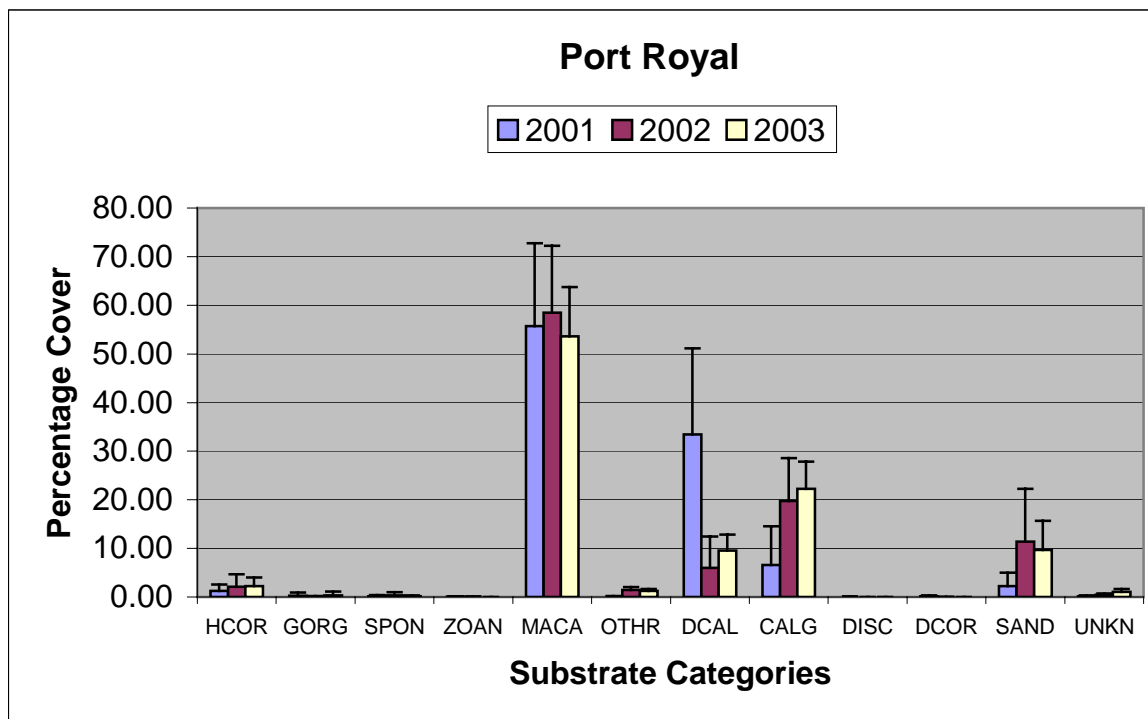


Figure 12. Graph illustrating the mean percentage cover of the different substrate categories found at Southeast Cay, Port Royal Cay, Kingston, for the period 2001 to 2003. Error bars represent Standard Deviation (Stdev). (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; SPON - Sponge; ZOAN - Zooanthids; MACA- Macroalgae; OTHR - Other, live; DCAL - Dead coral with algae; CALG - Coralline algae; DISC - Diseased coral; DCOR - Recently dead coral; SAND - Sand, rubble, rock and boulder; UNKN - Unknown.)

4.3.2 Coral Species

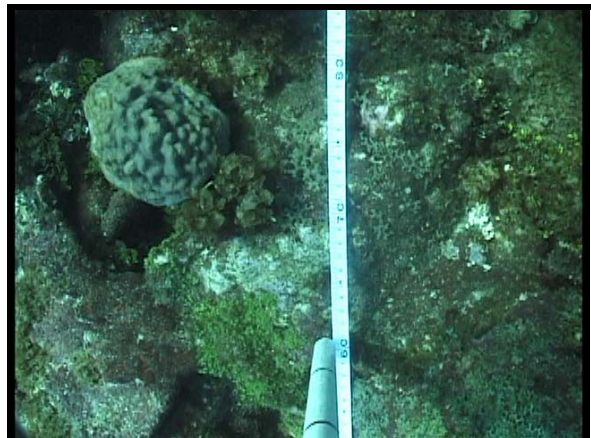
Despite the fact that coral cover was relatively low at Southeast Cay, the number and species composition was comparable to those found in Monkey Island and Discovery Bay. In 2001 there were 12 species identified, in 2002 nine species were identified and in 2003, eight species were identified. Those species that occurred on all three sampling occasions were *Acropora cervicornis*, *Agaricia agaricites*, *Diploria strigosa*, *Montastrea annularis* and *Porites astreoides*. *Diploria labyrinthiformis*, *Madracis mirabilis*, *Millipora complanata* and *Montastrea cavernosa* were only identified during one sampling occasion. Other species occurring at this site were *Acropora palmata*, *Montastrea faveolata*, *Porites porites*, *Siderastrea radians* and *Siderastrea siderea*. Table 6 provides a summary of the percentage cover for each of the coral species identified at Southeast Cay, during the period 2001 to 2003. Some of these species are illustrated in Figure 13.

Table 6. Coral species recorded at Southeast Cay, Port Royal Cays, Kingston during the period 2001 to 2003.

Coral Species	2001	2002	2003
Acropora cervicornis (ACER)	0.02	0.01	0.36
Acropora palmata (APAL)	0.15	0.00	0.19
Agaricia agaricites (AAGA)	0.03	0.16	0.19
Diploria labyrinthiformis (DLAB)	0.07	0.00	0.00
Diploria strigosa (DSTR)	0.18	0.08	0.11
Madracis mirabilis (MMIR)	0.00	0.00	0.02
Millipora complanata (MCOM)	0.01	0.00	0.00
Montastrea annularis (MANN)	0.23	0.20	0.11
Montastrea cavernosa (MCAV)	0.04	0.00	0.00
Montastrea faveolata (MFAV)	0.01	0.53	0.00
Porites astreoides (PAST)	0.22	0.83	0.84
Porites porites (PPOR)	0.02	0.02	0.00
Siderastrea radians (SRAD)	0.00	0.01	0.02
Siderastrea siderea (SSID)	0.03	0.01	0.00
Coral of Unknown Species	0.23	0.29	0.39
Total % Coral Cover	1.25	2.14	2.24
Number of Species (identified)	12	9	8



a) *Diploria strigosa*



b) *Porites astreoides*



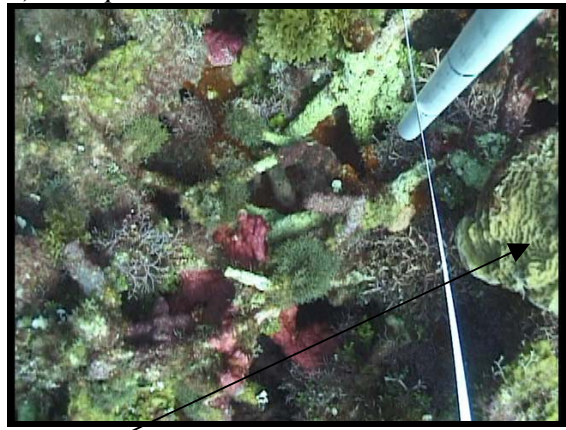
c) *Montastrea annularis*



d) *Acropora cervicornis*



e) *Porites astreoides*



f) *Agaricia agaricites*

Figure 13. Selected images of the commonly occurring hard coral species found at Southeast Cay, Port Royal Cays, Kingston, during the period 2001 to 2003. [a) *Diploria strigosa* b) *Porites astreoides* c) *Montastrea annularis*, d) *Acropora cervicornis*, e) *Porites astreoides*, f) *Agaricia agaricites*].

5 Discussion

The establishment of a long-term coral reef monitoring programme in Jamaica is critical to the understanding of the changes taking place in the reef ecosystem, with or without climate change. Long-term scientific data is required to guide management efforts and evaluate their effectiveness. The data presented in this reports represents the continuation of the CPACC monitoring programme that started in 2000 (Chevannes Creary, 2001). The year 2000 was established as the baseline year and it was the intention of the monitoring programme that annual coral reef health assessments would be conducted using percentage benthic substrate cover as the indicator of coral reef health.

The CPACC Video Monitoring Protocol employed has many advantages, particularly the ability to provide a visual representation of the status of the reef habitat. However, there is the need to maintain consistency in the quality of the video images obtained for the full benefits of this methodology to be realized. There was some amount of variability in the quality of the videotaping (i.e. filming carried out too quickly) resulting in some of the captured images lacking the desired sharpness. This impacted on the results obtained from the data analysis process because in some instance it was more difficult to accurately identify the species from the images. In a number of cases the broader substrate category code (e.g. identifying substrate as massive coral instead of *Diploria strigosa*) had to be used where specific species could not be identified.

The results of the monitoring programme for the three-year period 2001 to 2003 were similar to those obtained in the study carried out in 2000. The reefs continue to be dominated by algae (MACROALGAE, DEAD CORAL WITH ALGAE and CORALLINE ALGAE), ranging from 58% (Discovery Bay in 2002) to 95% (Port Royal in 2001) of the benthic substrate. HARD CORAL cover in Port Royal remained characteristically low ranging from 1.25% (in 2001) to 2.24% (in 2003). This compares to HARD CORAL cover of 2.1% obtained in 2000. HARD CORAL cover for both Portland and Discovery Bay fluctuated during the period but did not rise above 12% at either location. From the results (Tables 1, 3 and 5) it can be seen that was little difference between HARD CORAL cover at these two locations, which supports the results obtain in 2000 (Appendix 5).

A total of 20 species were identified from all three locations over the three-year period compared to 13 observed in 2000. (Chevannes Creary 2001). What was evident, particularly when looking at the Monkey Island species list (where five additional species were observed but not captured in the analysis) is that poor image quality combined with the dot method of assessing coral cover can result in failure to detect less common species and coral recruits. A more comprehensive species list could be achieved by independently reviewing the images. The more commonly occurring coral species were similar to those identified in 2000, namely *Montastrea annularis*, *Porites porites*, *Porites astreoides* and *Siderastrea siderea*. However the benthic substrate continued to be dominated by the algal species found commonly on reefs particularly *Sargassum*, *Dictyota*, *Halimeda* and *Lobophora*.

The results are in keeping with the trends documented in the **Status of Coral Reefs of World: 2002** publication (Wilkinson, 2004) in which it was reported that the shallow reefs along the north coast showed a dominance of macroalgae with low levels of hard coral (2 – 20%). For Discovery Bay there were indications of recovery verified by the presence of coral recruits on the shallow reefs. Coral cover reported for Southeast Cay was 7.3%, with an average of 15% for the entire Port Royal Cays. Since 2002 several monitoring sites were established around the island using the Reef Check Methodology. On the north coast coral cover as high as 34% at 3m and 42% at 10m (Boscobel, St Mary) were observed while on the south coast (Portland Bight and Port Royal Cays) coral cover ranged from 5 – 46% (Wilkinson, 2004).

In addition to the existing threats to coral reefs such as coastal development, sedimentation and pollution from inland sources, marine based threats, and over-fishing there is the emerging threat of climate change and coral reef diseases (Burke and Maidens, 2004). With the build up of greenhouses gases (GHGs) in the atmosphere average Earths temperature has increase by 0.6 – 0.8 °C and sea level has risen approximately 18cm over the last 100 years. Increased incidence of bleaching, due in part to increases in sea surface temperature has been the most direct impact of climate change on corals. Other factors such as the increased incidence of hurricanes and severe weather events, sea-level rise and reductions in calcification potential places coral reefs under further stress. In addition to the potential impacts of climate change, there has been an increase in the array of new diseases severely affecting the corals and other reef organisms such as the long-spined black urchin (*Diadema antillarum*). Very little is know about the reasons behind the sudden emergences and rapid spread of these diseases throughout the Caribbean

Jamaica is the only CPACC pilot country (the others countries being The Bahamas and Belize) that has been able to continue monitoring beyond the baseline year. NEPA was not able to monitor during 2004 and 2005 because of the lack of funds to maintain and upgrade the video equipment. They also lacked the advance software required to carry out the image capture and subsequent analysis in-house. The major constraints to full implementation and sustainability of the CPACC monitoring programme continue to be the lack of both financial resources and overburdened professionals. However, with the threats to the viability of the coral reefs increasing due to the emergence of climate change factors and diseases, it is imperative that the monitoring programmes be reestablished and fully implemented. The CMS and NEPA along with the MACC project need to revisit the monitoring programme, particularly in light of the proposed expansion of the programme to the Eastern Caribbean, in order to devise strategies for its long-term sustainability.

6 Recommendations

The recommendations made here are based on the results of this study and well as suggestions previously made in the Jamaica 2000 (Chevannes Creary, 2001) report.

6.1 Site Selection

- Consideration should be given to selecting a site that represents a healthier coral cover than is presently obtained for Monkey Island in Portland. The conditions at “Gorgo” City and Monkey Island are similar and both sites could be considered to be sites that are moderately impacted by anthropogenic factors. This new site could either be added to the present complement or used to replace the Monkey Island site in Portland.
- Attempts should also be made to monitor the reef flats and deeper reefs within each Operational Area. Monitoring in these habitats need not be conducted annually but possible every 3 to 5 years. The data obtained could be valuable in assessing the changes occurring in the reef ecosystem with respect to sea level rise, climate change and coral reef diseases.
- Detailed site descriptions and detailed maps are still outstanding for each of the Operational Areas

6.2 Monitoring

- Consideration should be give to the establishment of permanent transects and also to reducing the number of transects based on the recommendation made in previous reports (Chevannes Creary, 2001; Lawrence and Edwards, 2001).
- Physical parameter such as temperature, salinity, dissolved oxygen, turbidity and pH need to be incorporated into the monitoring programme.
- An annual evaluation of the monitoring protocol is required in order ensure quality control/quality assurance. Videotapes should be review by both divers and data analysts in order to improve the execution of the CPACC Video Monitoring Protocol. The data is only as good as the quality of the videotaping.

6.3 Data Processing and Analysis

- The divers and data analysts should review the videotapes in order to ensure consistency in the identification of substrate categories and coral species. A species list should then be developed which is all-inclusive (i.e. include rare coral species and coral recruits).
- Consideration should be given to investigating the use of the Coral Point Count Methodology for the analysis of captured images. The software can be obtained from the Internet free of cost and may be simpler to use than the CPACC methodology.
- Statistical analysis needs to be incorporated into the data analysis protocol.

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Appendices

- Appendix 1.** Catalogue of videotapes for the period 2001 to 2003. (Tape # JM31 could not be located therefore transects data from this tape could not be included in this report).
- Appendix 2.** Example of an individual Tape Log. Tape # JM27, Transects 1-10, from Southeast Cay, Port Royal Cays, Kingston.
- Appendix 3.** Coral Reef Substratum Category Codes
- Appendix 4.** List of species and corresponding species/category codes
- Appendix 5.** Results from monitoring exercise carried out in 2000 in Jamaica.
- Appendix 6.** Summary of recommendations from previous reports.

Appendix 1. Tape Log for Videotapes (Tape # JM 31 could not be located therefore transects data from this tape could not be included in this report).

Tape #	Date	Site	Transect #s
JM 13	21-Nov-01	Port Royal - Southeast Cay	Transects 1-7
JM 14	21-Nov-01	Port Royal - Southeast Cay	Transects 8-14
JM 15	23-Nov-01	Port Royal - Southeast Cay	Transects 15-20
JM 16	28-Nov-01	Discovery Bay - West Fore Reef	Transects 1-15
JM 17	28-Nov-01	Discovery Bay - West Fore Reef	Transects 16-50
JM 18	5-Dec-01	Portland - Monkey Island	Transect 1-13
JM 19	6-Dec-01	Portland - Monkey Island	Transect 14-20
JM 20	5-Sep-02	Port Royal - Southeast Cay	Transects 1- 10
JM 21	5-Sep-02	Port Royal - Southeast Cay	Transects 11- 20
JM 22	2-Oct-02	Discovery Bay - West Fore Reef	Transects 1 - 7
JM 23	2-Nov-02	Discovery Bay - West Fore Reef	Transects 8 - 14
JM 24	2-Nov-02	Discovery Bay - West Fore Reef	Transects 15 - 20
JM 25	10-Oct-02	Portland - Monkey Island	Transects 1 - 11
JM 26	10-Oct-02	Portland - Monkey Island	Transects 12 - 20
JM 27	4-Aug-03	Port Royal - Southeast Cay	Transects 1- 10
JM 28	5-Sep-03	Port Royal - Southeast Cay	Transects 11- 20
JM 29	17-Sep-03	Portland - Monkey Island	Transects 1 - 6
JM 30	18-Sep-03	Portland - Monkey Island	Transects 7 - 20
JM 31		Discovery Bay - West Fore Reef	Transects 1- 10
JM 32	25-Sep-03	Discovery Bay - West Fore Reef	Transects 11 - 20

Appendix 2. Example of a Tape Log. Tape # JM27, Transects 1-10, from Southeast Cay, Port Royal

Location	Tape number	Tape counter	Depth (ft)	Comments
Transect 1 Intro	JM27	00:00 - 01:35	43 ft	
Transect 1		01:36 - 06:33		
Transect 1 Swim back		06:40 - 07:05		
Transect 2 Intro		07:06 - 07:54	40 ft	
Transect 2		07:55 - 13:15		
Transect 2 Swim back		13:30 - 13:59		
Transect 3 Intro		14:00 - 14:31	40 ft	
Transect 3		14:32 - 19:18		
Transect 3 Swim back		19:30 - 20:00		
Transect 4 Intro		20:01 - 20:39	41 ft	
Transect 4		20:40 - 25:02		
Transect 4 Swim back		25:16 - 25:47		
Transect 5 Intro		25:48 - 26:19	40 ft	
Transect 5		26:20 - 30:52		
Transect 5 Swim back		31:07 - 31:20		
Transect 6 Intro		31:21 - 31:57	43 ft	
Transect 6		31:58 - 35:35		
Transect 6 Swim back		35:45 - 36:12		
Transect 7 Intro		36:13 - 36:47	40 ft	
Transect 7		36:48 - 40:48		
Transect 7 Swim back		41:03 - 41:16		
Transect 8 Intro		41:17 - 41:57	41 ft	
Transect 8		41:58 - 45:58		
Transect 8 Swim back		46:05 - 46:25		
Transect 9 Intro		46:26 - 46:59	44 ft	
Transect 9		47:00 - 51:33		
Transect 9 Swim back		51:50 - 51:59		
Transect 10 Intro		52:00 - 52:41	42 ft	
Transect 10		52:42 - 57:09		
Transect 10 Swim back		57:28 - 57:56		

Appendix 3. Coral Reef Substratum Category Codes

Category		Code	Description	Example
ALGAE	Turf Algae	TALG	May look fleshy and/or filamentous but do not rise more than 1 cm above the substrate.	
	Fleshy Algae	FALG	Includes macroalgae that are not hard to the touch and whose fronds are projected more than 1 cm above the substratum.	<i>Laurencia</i> , <i>Caulerpa</i> , <i>Sargassum</i> , <i>Dictyota</i>
	Calcareous Algae	CALG	Covers a wide range of species that are usually hard to the touch or pinch.	<i>Halimeda</i>
	Encrusting Calcareous Algae	EALG	Occur on hard, smooth pavement on the substratum, covering small or large area. Usually the colour varies from dark pink to purple, and sometimes may show a grayish hue.	<i>Porolithon</i> , <i>Peyssonellia</i>
HARD CORAL	Branching Coral	BRAN	Erect roughly cylindrical colony that has produced lateral extensions or branches.	<i>Acropora</i> , <i>Porities porites</i>
	Massive Corals	MASS	A coral colony that has developed a third dimension such that it extends the colony out from the substratum in a mound or domal shape but is unbranched.	<i>Favia fragum</i> <i>Montastrea</i> , <i>Diploria</i> <i>Dendrogyra</i> <i>Siderastrea</i>
	Encrusting Corals	ENCO	Coral colonies that grow laterally and remain relatively planar in form and conform to the substratum.	<i>Montastrea</i> <i>Mycetophyllia</i> <i>Agaricia</i>
	Foliaceous Corals	FOLI	Coral colonies that are plate-like or leaf-like and extend off the substratum, projecting into the water	<i>Agaricia tenuifolia</i> <i>Agaricia sp</i> <i>Montastraea</i> <i>Leptoseris</i>
	Milleporines	MILL	All growth forms of the fire corals.	<i>Millipora. sp</i>
	Juvenile Corals	CORJ	Juvenile corals of all species	

SOFT CORALS	Anemones	ANEM	Members of the Class Anthozoa, Order Actiniaria. They often look like a mass of tentacles projecting from crevices and flowing to and fro with the currents.	
	Gorgonians	GORG	Soft corals which are magnificently colored and typically are identified by the holdfast and branches	
	Encrusting Gorgonians	ENGR	Because of their distinctive growth forms these two encrusting gorgonians are classified separately.	<i>Bariareum</i> <i>Erythropodium</i>
	Zoanthids	ZOAN	Order Zoanthidia – colonial Anemone. Usually form mats of interconnecting polyps. Oral disks crowded together, each fringed with a ring of tiny tentacles.	
	Corallimorpharians	CMOR	False corals: Order Corallioimorpharia. May be solitary or colonial. Oral disk covered with button-like or wart-like tentacles or clumps of short hair like tentacles. One of several mouths may project upward on short conical papillae from oral disc.	
SPONGES	Erect Sponges	ERSP	Those whose colony project above the surface or hang from it.	Tube or vase sponges
	Encrusting Sponges	ENSP	All sponges able to produce a layer over the substrate. Many of these sponges are borers.	

NON LIVING SUBSTRATA	Bare Boulder	BOUL	Large blocks of dislodged dead coral heads or terrigenous material, between 0.3 to 1.0 m diameter, that are aggregated and distinct from rubble deposits.	
	Bare Sediment	SAND	Sand (Including coarse sand) and mud. Particle have a mean diameter of less than 4.0 mm	
	Bare Rubble	RUBB	Sedimentary material composed of particle or pieces whose average diameter if 4.0 mm to 30 cm.	
	Bare Rock	ROCK	Exposed calcareous substratum or hard ground without layer of sand or apparent algal growth. Also referred to as pavement.	
	Holes, Gaps, Overhangs	GAPS	Spaces and voids where it is impractical to determine any attributes. Overhang refer to the inner space below a projected surface and (shadow)	
	Recently Dead Coral	DCOR	Recently dead coral, devoid of algal growth with indentations for polyps still visible.	
	Dead Coral with Algae	DCAL	Dead coral overgrown with thin layer of filamentous or some other type of unidentifiable algae.	
MISC.	Other Organisms	OTHR	Other living organism and other items found on the reef not grouped into a specific category.	Sea urchin, fish, sampling equipment etc. This should be indicated in the notes.
	Unknown	UNKN	Used when unable to make a confident identification.	
	Tape	TAPE	Measuring tape used to measure transect.	
	Wand	WAND	40 cm wand used to keep the camera a fixed distance from the substrate.	
NOTES	Bleached Coral	BL	Included in the notes column to differentiate recently dead coral from bleached corals.	
	Diseased Coral	DS	Included in the notes column to indicate diseased corals.	

[This Coral Reef Substratum Category Codes was adapted for CPACC from the formats used by CARICOMP and Jeff Miller, USG.]

Appendix 4. List of species and corresponding species/category codes

Species	Code
Acropora cervicornis	ACER
Acropora palmata	APAL
Agaricia agaricites	AAGA
Agaricia grahamae	AGRA
Agaricia humilis	AHUM
Agaricia lamarcki	ALAM
Diploria labyrinthiformis	DLAB
Diploria strigosa	DSTR
Madracis mirabilis	MMIR
Millipora alcicornis	MALC
Millipora complanata	MCOM
Montastrea annularis	MANN
Montastrea cavernosa	MCAV
Montastrea faveolata	MFAV
Porites astreoides	PAST
Porites furcata	PFUR
Porites porites	PPOR
Scolymia sp	SCOL
Siderastrea radians	SRAD
Siderastrea siderea	SSID
Branching corals	BRAN
Massive corals	MASS
Encrusting corals	ENCO
Foliaceous corals	FOLI
Milleporines	MILL
Coral juvenile	CORJ

Appendix 5. Results from monitoring exercise carried out in 2000 in Jamaica³.

Table 1 Summary of the mean percentage cover for the substrate categories found at Monkey Island, Portland; “Gorgo City”, Discovery Bay; and Southeast Cay, Port Royal.

SUBSTRATE CATEGORY	Portland		Discovery Bay		Port Royal	
	Mean	Stdev	Mean	Stdev	Mean	Stdev
HARD CORAL	7.1	3.9	6.7	3.3	2.1	1.4
SOFT CORALS	0.3	0.4	0.1	0.3	0.1	0.3
SPONGES	0.1	0.2	0.6	0.9	0.6	1.1
RECENTLY DEAD CORAL	2.0	2.0	4.0	3.8	0.2	0.4
FLESHY ALGAE	52.3	11.6	49.5	9.4	43.0	8.6
OTHER, LIVE	0.0	0.1	0.3	0.5	0.0	0.0
DEAD CORAL WITH ALGAE	17.0	11.3	15.6	9.5	22.0	11.0
CALCAREOUS ALGAE	14.3	10.3	9.9	5.8	26.9	11.2
SAND, PAV, RUB	6.6	4.9	12.7	6.8	4.6	7.8
UNKNOWN	0.3	0.3	0.5	0.5	0.4	0.8

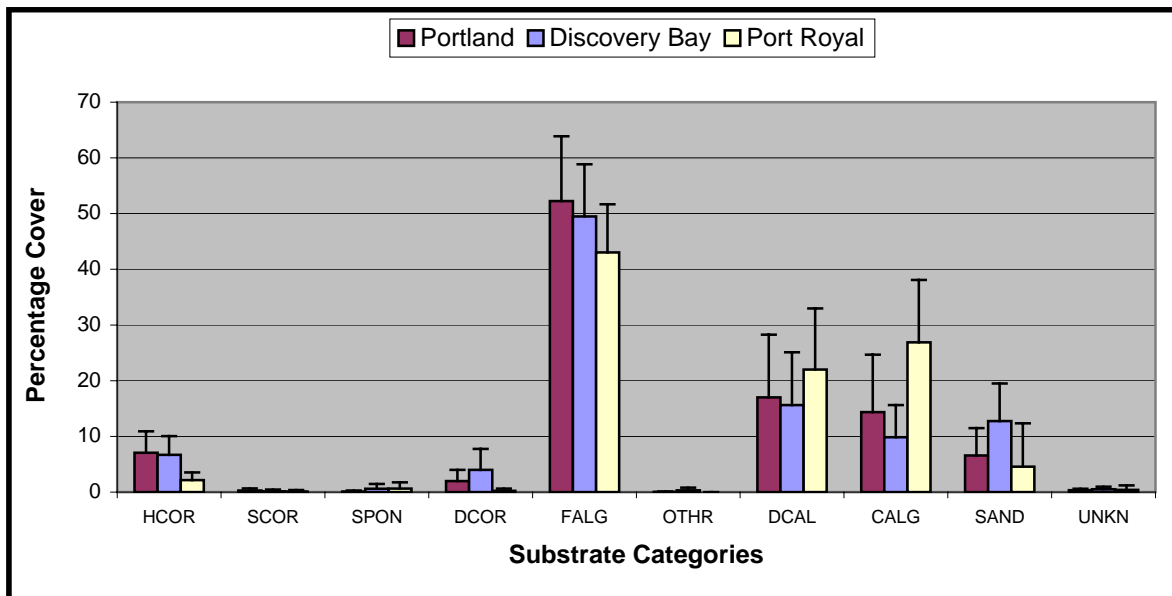


Figure 5 Graph illustrating the mean percentage cover of the different substrate categories found at Portland, Discovery Bay and Port Royal. Error bars represent Standard Deviation (SD). (Substrate categories: HCOR - Hard coral; SCOR - Soft coral; SPON - Sponge; DCOR - Recently dead coral; FALG – Fleshy algae; OTHR – Other; DCAL - Dead coral with algae; CALG – Calcareous algae; SAND – Sand, rubble etc; UNKN – Unknown.)

³ “Component 5: Coral Reef Monitoring for Climate Change Impacts. Jamaica 2000” report. (Chevannes Creary, 2001)

Appendix 6. Summary of recommendations from previous reports.

The following recommendations are based on some of the findings of this study as well as recommendations proposed during the Component 5 Technical Workshop for the Implementation held in Belize in March 1998 (Walling, 1998) and the Planning and Technical Review Meeting held in Jamaica in May 2001 (Lawrence & Edwards, 2001).

6.1 Site Selection

- A review of other potential operational area should be conducted with a view to identifying a remote operational area that is unaffected by anthropogenic influences, in addition to or to replace the Portland area. This should involve re-evaluating the issues associated with the establishment on a site offshore at Pedro Cays (70 km to the south) or the Formigas Bank (50 km to the east northeast).
- Attempts should be made to include the assessment of the reef flats which are the active breaker zones and reef builders. Erosion of these barriers will be important with respect to sea level rise associated with global climate change. There should be the assessment of the deeper reefs, which are thought to still be in good conditions as well as the sheltered reef communities.
- The detailed sites descriptions, including an account of the adjacent land use patterns and the environmental history (e.g. storm events), along with appropriate maps should be prepared for inclusion in subsequent reports.
- The monitoring sites should be geo-referenced for inclusion in a GIS database such as the CRIS.

6.2 Monitoring

- Fixed transects should be randomly and independently established within the target habitats which will be located at specified depths to ensure that the same community is being sampled by all transects, a reduction in introduced variation and to allow for direct comparison over time. In addition, permanent photo quadrats and the identification of monument corals should be incorporated into the monitoring programme.
- The video monitoring exercise should include the filming of additional footage on the reefs and other relevant subject matter of importance and interest to be used to illustrate the reports and document required for the monitoring programme.
- Attempts should be made to incorporate fish counts (species, number and size) into the monitoring exercise. Additional fish data could also be obtained from the Fisheries Division to give an indication of the species caught and their distribution.
- Bio-indicator parameters such as turf algae, sponges, *Diadema*, and Chlorophyll 'a' could be used to establish pollution gradients within the operational areas.
- Consideration should be given to adding coral growth (particularly as it related to the increase in CaCO_3 in the water) and coral recruitment to the parameters to be monitored for climate change impacts.
- Physical parameters such as temperature, salinity, dissolved oxygen, turbidity and pH should be monitored to effectively assess the impacts attributable to climate change factors. Additional parameters such as chlorophyll, BOD, COD, nitrate, phosphates and sedimentation should also be considered.

- Hydrometeorological data (rainfall, cloud cover, hours of sunshine, wind speed and maximum & minimum temperatures) should be obtained from the National Meteorological Services to complement the physical data collected.
- It is suggested that a roving team of experts be established to assist with monitoring in the countries with limited manpower capacity. Volunteers and dive shops should also be considered for assistance with assessing bleaching episodes.

6.3 Data Analysis and Processing

- During the data analysis the preparation of an all-inclusive species list should be carried out as an additional exercise to ensure that the rare coral species and coral recruits are recorded.
- The CARICOMP species list, which includes all the Caribbean species of hard coral, soft coral and algae, should be adopted and incorporated into the final data entry spreadsheet.
- The present data entry sheet should be updated and standardized for distribution to CPACC member countries.
- The Benthic Features Manual should be upgraded and training in the identification of video images should be conducted especially in light of the difficulty of differentiating between turf algae and other algae as well as between boring sponges and non-boring sponges.

6.4 Statistical Analysis

- The Standard Error Test (Bros & Cowell, 1987) should be carried out at a wider number of locations before the 20-transects/20m protocol can be modified. The figure for the number of transects and the length of transects would have to be standardized for all participating countries to facilitate spatial and temporal comparisons.
- Statistical analyses (such as Box and Whiskers graphs, ANOVA or any other appropriated analyses) should be incorporated into the monitoring and data analysis protocol.
- A statistician should be assigned to the project to ensure that the statistical analyses are homogeneous for all monitoring sites and countries.

6.5 Project Coordination and Management

- A comprehensive Monitoring Manual needs to be produced which includes the site selection protocol, video monitoring protocol, benthic substrate identification manual, the quality control/quality assurance manual, CARICOMP species list and category codes and the statistical analysis protocol. The manual should allow for modifications to be made to suit each country with information on the data entry mechanism, manpower and logistics requirements and communication procedures. A mechanism for ensuring the integrity of data (including off-site storage of duplicate data sets) and the sharing of experience from personnel should also be included. The manual should be updated periodically when decisions are taken or adjustments are made to the methodology.
- The monitoring programme requires more involvement of the interests groups and non-governmental organizations indicated in section 3.1 in the site selection and data

collection processes. Analyzed data would then be conveyed to these organizations for use as a project management tools.