CARIBBEAN COMMUNITY CLIMATE CHANGE CENTRE (CCCCC)

MAINSTREAMING ADAPTATION TO CLIMATE CHANGE

Coral Reef Monitoring for the Organization of Eastern Caribbean States and Tobago

Status of the Coral Reefs

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CENTRE FOR MARINE SCIENCES
THE UNIVERSITY OF THE WEST INDIES
AT MONA, JAMAICA

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Coral Reef Monitoring for the Organization of Eastern Caribbean States and Tobago

STATUS OF THE CORAL REEFS

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Table of Contents

List of Figures iv
List of Tables vii
List of Appendices viii
Acknowledgements ix
Acronyms and Abbreviations xii
Acronyms and Abbreviations xii
Executive Summary xiii

Chapter 1: Coral Reef Monitoring for the OECS and Tobago 1
1.1 Introduction 1
1.2 Background 1
1.2.1 Caribbean: Planning for Adaptation to Global Climate Change Project 1
1.2.2 Caribbean Community Climate Change Centre 2
1.2.3 Mainstreaming Adaptation to Climate Change Project 2
1.2.4 Centre for Marine Sciences, University of the West Indies 3
1.3 Training and Coral Reef Monitoring in the OECS and Tobago 3
1.3.1 The Regional Training Workshop 3
1.3.2 Monitoring in the Participating Countries 4
1.3.2.1 Site Selection and Video Monitoring 4
1.3.2.2 Data Processing, Analysis 5
1.3.2.3 Report Preparation 5

Chapter 2: Antigua and Barbuda 6
2.1 Antigua and Barbuda Country Profile 6
2.2. Coral Reef and Marine Resources of Antigua 7
2.3 Overview of Coral Reef Monitoring in Antigua 8
2.4 MACC Coral Reef Monitoring in Antigua 8
2.4.1 Methodology 8
2.4.1.1 Site Selection and Description 9
2.4.1.2 Video Monitoring 10
2.4.1.3 Data Processing and Analysis 10
2.4.2 Results 11
2.4.2.1 Benthic Substrate 11
2.4.2.2 Hard Coral Species 14
2.5 Discussion 16

Chapter 3: Dominica 17
3.1 Dominica Country Profile 17
3.2 Coral Reef and Marine Resources of Dominica 18
3.3 Overview of Coral Reef Monitoring in Dominica 19

3.4 MACC Coral Reef Monitoring in Dominica 20
3.4.1 Methodology 20
3.4.1.1 Site Selection and Description 20
3.4.1.2 Video Monitoring 21
3.4.1.3 Data Processing and Analysis 21
3.4.2 Results 21
3.4.2.1 Benthic Substrate 21
3.4.2.2 Hard Coral Species 24
3.5 Discussion 25

Chapter 4: Grenada 26
4.1 Grenada Country Profile 26
4.2 Coral Reef and Marine Resources of Grenada 27
4.3 Overview of Coral Reef Monitoring in Grenada 28
4.4 MACC Coral Reef Monitoring in Grenada 28
4.4.1 Methodology 28
4.4.1.1 Site Selection and Description 28
4.4.1.2 Video Monitoring 29
4.4.1.3 Data Processing and Analysis 29
4.4.2 Results 29
4.4.2.1 Benthic Substrate 29
4.4.2.2 Hard Coral Species 31
4.5 Discussion 32

Chapter 5 33
St Kitts and Nevis 33
5.1 St Kitts and Nevis Country Profile 33
5.2 Coral Reef and Marine Resources of St Kitts and Nevis 34
5.3 Overview of Coral Reef Monitoring in St Kitts and Nevis 35
5.4 MACC Coral Reef Monitoring in St Kitts and Nevis 35
5.4.1 Methodology 35
5.4.1.1 Site Selection and Description 35
5.4.1.2 Video Monitoring 36
5.4.1.3 Data Processing and Analysis 36
5.4.2 Results 36
5.4.2.1 Benthic Substrate 36
5.4.2.2 Hard Coral Species 38
5.5 Discussion 39

Chapter 6: Saint Lucia 40
6.1 Saint Lucia Country Profile 40
6.2 Coral Reef and Marine Resources of Saint Lucia 41
6.3 Overview of Coral Reef Monitoring in Saint Lucia 41
6.4 MACC Coral Reef Monitoring in Saint Lucia 42
6.4.1 Methodology 42

6.4.1.1 Site Selection and Description 42
6.4.1.2 Video Monitoring 43
6.4.1.3 Data Processing and Analysis 44
6.4.2 Results 44
6.4.2.1 Benthic Substrate 44
6.4.2.2 Hard Coral Species 46
6.5 Discussion 47

Chapter 7: St Vincent and the Grenadines 48
7.1 St Vincent and the Grenadines Country Profile 48
7.2 Coral Reef and Marine Resources of St Vincent and the Grenadines 49
7.3 Overview of Coral Reef Monitoring in St Vincent and the Grenadines 50
7.4 MACC Coral Reef Monitoring in St Vincent and the Grenadines 50
7.4.1 Methodology 50
7.4.1.1 Site Selection and Description 50
7.4.1.2 Video Monitoring 51
7.4.1.3 Data Processing and Analysis 52
7.4.2 Results 52
7.4.2.1 Benthic Substrate 52
7.4.2.2. Hard Coral Species 54
7.5 Discussion 56

Chapter 8: Trinidad and Tobago 57
8.1 Trinidad and Tobago Country Profile 57
8.2 Coral Reef and Marine Resources of Trinidad and Tobago 59
8.3 Overview of Coral Reef Monitoring in Trinidad and Tobago 61
8.4 MACC Coral Reef Monitoring in Tobago 61
8.4.1 Methodology 61
8.4.1.1 Site Selection and Description 61
8.4.1.2 Video Monitoring 62
8.4.1.3 Data Processing and Analysis 63
8.4.2 Results 63
8.4.2.1 Benthic Substrate Cover 63
8.4.2.2 Coral Species 65
8.5 Discussion 67

Chapter 9: Summary of Coral Reef Monitoring Results 69

Chapter 10: Recommendations 73

References 76

Appendices 78

LIST OF FIGURES

Figure 2.1: Map of Antigua and Barbuda i

Figure 2.2: Outline map of Antigua showing the location of coral reefs. The Operational Area at Little Bird Island is highlighted. 8

Figure 2.3: Satellite photograph showing the location of the monitoring site at Little Bird Island, Antigua. 9

Figure 2.4: Graphs illustrating the mean percentage cover of the different substrate categories found at Little Bird Island, Antigua, October 2007 and April 2008. Error bars represent Standard Deviation (STD. DEV.). (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; SPON – Sponge; ZOAN – Zoanthids; MACA– Macroalgae; OTHR – Other, live; DCAL - Dead coral with algae; CALG – Coralline algae; DCOR– Diseased coral; SAND – Sand, rubble, rock and boulder; UNKN – Unknown.) 13

Figure 2.5: Images showing the general appearance of the coral reefs at Little Bird Island. The benthic substrate was dominated by dead *Acropora palmata* overgrown with macroalgae and large sand patches. 14

Figure 2.6: Images of hard coral species observed during monitoring at Little Bird Island in Antigua, October 2007 and April 2008; *Porites astreoides, Montastraea cavernosa and Acropora cervicornis.* 15

Figure 3.1: Map of Dominica. 17

Figure 3.2: Outline map of Dominica showing the existing and proposed marine park boundaries. The Operational Area located at the Soufriere/Scott's Head Marine Reserve is highlighted. 19

Figure 3.3: Satellite photograph showing the location of the monitoring sites within the Soufriere/Scott's Head Marine Reserve 20

Figure 3.4: Divers participating in the coral reef monitoring exercise in Dominica. 21

Figure 3.5: Graph illustrating the mean percentage cover of the different substrate categories found in the Soufriere/Scott's Head Marine Reserve, Dominica, November 2007. Error bars represent Standard Deviation (STD. DEV.). (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; SPON – Sponge; ZOAN – Zoanthids; MACA– Macroalgae; OTHR – Other, live; DCAL - Dead coral with algae; CALG – Coralline algae; DCOR– Diseased coral; SAND – Sand, rubble, rock and boulder; UNKN – Unknown.) 23

Figure 3.6: Images showing the reef formations at the Danglebens monitoring site located in the Soufriere/Scott's Head Marine Reserve, Dominica 23

Figure 3.7: Images of the more commonly occurring hard coral species observed during monitoring at four sites within the Soufriere/Scott's Head Marine Reserve, Dominica, November 2007; *Meandrina meandrites, Porites astreoides, Siderastrea siderea* and *Porites porites.* 25

Figure 4.1: Map of Grenada 26

Figure 4.2: Outline map of Grenada showing the location of the coral reefs. The Operational Area within the Grand Anse reef system is highlighted. 27

Figure 4.3: Map showing the location of the monitoring sites in the Grand Anse reef system, Grenada. 28

Figure 4.4: Graph illustrating the mean percentage cover of the different substrate categories found in the Grand Anse reef system, Grenada, October/November 2007. Error bars represent Standard Deviation (STD. DEV.). (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; SPON – Sponge; ZOAN – Zoanthids; MACA– Macroalgae; OTHR – Other, live; DCAL - Dead coral with algae; CALG – Coralline algae; DCOR– Diseased coral; SAND – Sand, rubble, rock and boulder; UNKN – Unknown.)....30
Figure 4.5: Images of hard coral species observed during monitoring in the Grand Anse reef system, Grenada, October/November 2007; *Porites porites, Porites astreoides and Montastraea cavernosa.* 32
Figure 5.1: Map of St Kitts and Nevis 33
Figure 5.2: Outline map of St Kitts and Nevis showing the location of the coral reefs. The Operational Area at Sandy Point is highlighted....34
Figure 5.3: Satellite photograph showing the location of Paradise Reef at Sandy Point along the northwest coast of St Kitts. 35
Figure 5.4: Member of monitoring team reeling in the transect tape at the end of the video monitoring exercise at the Paradise Reef monitoring site at Sandy Point, St Kitts....36
Figure 5.5: Graph illustrating the mean percentage cover of the different substrate categories found at Paradise Reef, Sandy Point in St Kitts, November 2007. Error bars represent Standard Deviation (STD. DEV.). (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; SPON – Sponge; ZOAN – Zoanthids; MACA– Macroalgae; OTHR – Other, live; DCAL - Dead coral with algae; CALG – Coralline algae; DCOR– Diseased coral; SAND – Sand, rubble, rock and boulder; UNKN – Unknown.)....37
Figure 5.6: Images of the Paradise Reef at Sandy Point, St Kitts, highlighting the spur and groove formation typical of this area. 38
Figure 5.7: Images of the more commonly occurring coral species found at Paradise Reef, Sandy Point, St Kitts, November 2007; *Porites astreoides, Montastraea annularis, Montastraea faveolata* and *Siderastrea siderea*. 39
Figure 6.1: Map of Saint Lucia i
Figure 6.2: Outline map of Saint Lucia showing the location of the coral reefs. The Operational Area at the Soufriere Marine Management Area is highlighted. 42
Figure 6.3: Satellite photograph showing the location of the monitoring sites within the Soufriere Marine Management Area, Saint Lucia. 43
Figure 6.4: Team members conducting video monitoring at the Grand Caille monitoring site located in the Soufriere Marine Management Area, Saint Lucia. 44
Figure 6.5: Graph illustrating the mean percentage cover of the different substrate categories found within the Soufriere Marine Management Area, Saint Lucia in September 2007. Error bars represent Standard Deviation (STD. DEV.). (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; SPON – Sponge; ZOAN – Zoanthids; MACA– Macroalgae; OTHR – Other, live; DCAL - Dead coral with algae; CALG – Coralline algae; DCOR– Diseased coral; SAND – Sand, rubble, rock and boulder; UNKN – Unknown.) 45
Figure 6.6: Images of the Grand Caille (left) and Turtle Reefs (right) showing the sloping nature of the reef formation.... 46
Figure 6.7: Images of some of the commonly occurring hard coral species found in the Soufriere Marine Management Area; *Diploria strigosa, Madracis mirablis, Porites astreoides* and *Porites porites*....47

Figure 7.1: Map of St Vincent and the Grenadines..... 48
Figure 7.2: Outline map of St Vincent and the Grenadines showing the location of the coral reefs. The Operational Area at Castle Bay, Kingstown is highlighted. 50
Figure 7.3: Map showing the location of Castle Bay in Kingstown, St Vincent.....51
Figure 7.4: Members of the team conducting the video monitoring at sites in Castle Bay, Kingstown. 52
Figure 7.5: Graph illustrating the mean percentage cover of the different substrate categories found at Castle Bay, Kingstown, St Vincent in October 2007. Error bars represent Standard Deviation (STD. DEV.). (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; Dead coral with algae; CALG – Coralline algae; DCOR– Diseased coral; SAND – Sand, rubble, rock and boulder; UNKN – Unknown.).....53
Figure 7.6: Images of the coral reef at the Castle Bay monitoring site in Kingstown, St Vincent illustrating the high percentage of coral cover observed there. 54
Figure 7.7: Images of the most commonly occurring coral species at Castle Bay in Kingstown, St Vincent; *Porites astreoides, Siderastrea siderea, Montastraea annularis* and *Diploria strigosa.* 56
Figure 8.1: Map of Trinidad and Tobago showing the location of Tobago relative to the island of Trinidad. 57
Figure 8.2: Map of Tobago. 58
Figure 8.3: Outline map of Tobago showing the location of the coral reefs. The Operational Area at Speyside is highlighted. (Map provided by the IMA).....59
Figure 8:4: Map of the reefs of Speyside, Tobago showing the location of Japanese Garden and Angel Reef. (Map provided by the IMA) 60
Figure 8.5: Members of the team conducting video monitoring at the Japanese Garden and Angel Reef sites in Speyside, Tobago.....63
Figure 8.6: Graph illustrating the mean percentage cover of the different substrate categories found at Japanese Garden and Angel Reef at Speyside in Tobago during October 2007. Error bars represent Standard Deviation (STD. DEV.). (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; SPON – Sponge; ZOAN – Zoanthids; MACA– Macroalgae; OTHR – Other, live; DCAL - Dead coral with algae; CALG – Coralline algae; DCOR– Diseased coral; SAND – Sand, rubble, rock and boulder; UNKN – Unknown.) 64
Figure 8.7: Images of the coral reefs assemblage at the Japanese Garden and Angel Reef monitoring sites at Speyside, Tobago.....65
Figure 8.8: Images of some of the coral species observed at Japanese Garden and Angel Reef in Tobago; *Diploria strigosa, Madracis mirabilis, Montastraea faveolata and Siderastrea siderea*.....67
Figure 9.1: Graph illustrating the mean percentage cover for the different substrate categories found at the coral reefs sites in Antigua, Dominica, Grenada, St Kitts, Saint Lucia, St Vincent and Tobago monitored during the period September 2007 to April 2008. (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; SPON – Sponge; ZOAN – Zoanthids; MACA– Macroalgae; OTHR – Other, live; DCAL - Dead coral with algae; CALG – Coralline algae; DCOR– Diseased coral; SAND – Sand, rubble, rock and boulder; UNKN – Unknown.) 70
Figure 9.2: Graph summarising the hard coral composition (percentage cover and number of species) at the monitoring sites in Antigua, Dominica, Grenada, St Kitts, Saint Lucia, St Vincent and Tobago monitored during the period September 2007 to April 2008.....72

LIST OF TABLES

Table 2.1: Summary of the mean percentage cover for the benthic substrate categories at Little Bird Island, Antigua collected in October 2007..... 11

Table 2.2: Summary of the mean percentage cover of the benthic substrate categories at Little Bird Island, Antigua collected in April 2008.....12

Table 2.3: Hard coral species identified at Little Bird Island, Antigua in October 2007..... 14

Table 2.4: Hard coral species identified at Little Bird Island, Antigua in April 2008.....15

Table 3.1: Summary of mean percentage cover for the substrate categories at Soufriere/Scott's Head Marine Reserve, Dominica, November, 2007.....22

Table 3.2: Hard coral species identified at four monitoring sites within the Soufriere/Scott's Head Marine Reserve, Dominica during November 2007. 24

Table 4.1: Summary of the mean percentage cover for the substrate categories at Grand Anse reef system, Grenada in October/November, 2007 30

Table 4.2: Hard coral species identified at Grand Anse reef system, Grenada, October/ November 2007.31

Table 5.1: Summary of mean percentage cover for the substrate categories at Paradise Reef, Sandy Point in St Kitts during November 2007 37

Table 5.2: Coral species identified at Paradise Reef, Sandy Point in St Kitts, November 2007. 38

Table 6.1: Summary of mean percentage cover for the substrate categories for the Soufriere Marine Management Area, Saint Lucia.....45

Table 6.2: Hard coral species identified in the Soufriere Marine Management Area, Saint Lucia during September 2007. 46

Table 7.1: Summary of mean percentage cover for the substrate categories found at Castle Bay, Kingstown. 53

Table 7.2: Coral species identified at Castle Bay in Kingstown, St Vincent. 55

Table 8.1: Summary of mean percentage cover for the substrate categories at Japanese Garden and Angel Reef at Speyside in Tobago, October 2007..... 64

Table 8.2: Hard Coral species identified at Japanese Garden and Angel Reef, Tobago (Octacorals not included) 66

Table 9.1: Combined summary of the mean percentage cover for the substrate categories at the coral reef sites in Antigua, Dominica, Grenada, St Kitts, Saint Lucia, St Vincent and Tobago monitored during the period September 2007 to April 2008. 70

Table 9.2: Hard Coral species identified at the coral reef sites in Antigua, Dominica, Grenada, St Kitts, Saint Lucia, St Vincent and Tobago monitored during the period September 2007 to April 2008. 71

LIST OF APPENDICES

Appendix 1: Regional Training Workshop.....78

Appendix 2: Monitoring Schedule and Sites.....82

Appendix 3: Catalogue of Video Tapes..... 84

Appendix 4: Image Capture Log 85

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ACRONYMS AND ABBREVIATIONS

ANBAGLO	Saint Lucia's Dive Association
AGRRA	Atlantic and Gulf Rapid Reef Assessment
BPOA	Barbados Plan of Action
CARICOMP	Caribbean Marine Productivity Programme
CERMES	Centre for Resources Management and Environmental Studies
CCCCC	Caribbean Community Climate Change Centre
CCDC	Caribbean Coastal Data Centre
CMS	Centre for Marine Sciences
CMRC	Caribbean Marine Research Centre
CPACC	Caribbean Planning For Adaptation to Global Climate Change
CPCe	Coral Point Count with Excel Extension
CREWS	Coral Reef Early Warning System
GCRMN	Global Coral Reef Monitoring Network
ECS	Eastern Caribbean States
GEF	Global Environmental Facility
GPS	Global Positioning System
IMA	Institute of Marine Affairs
IPCC	Inter-Governmental Panel on Climate Change
JCRMN	Jamaica Coral Reef Monitoring Network
MACC	Mainstreaming Adaptation to Climate Change
MOA	Memorandum of Agreement
MPA	Marine Protected Area
NEPA	National Environment and Planning Agency
NGOs	Non-Governmental Organization
NOAA	National Oceanic and Atmospheric Administration
NRCA	Natural Resources Conservation Authority
OECS	Organization of Eastern Caribbean States
OPAAL	OECS Protected Area and Associated Livelihood Project
PIMS	Perry Institute for Marine Sciences
RTLs	Roving Team Leaders
SGU	St George's University
SIDS	Small Island Developing States
SMMA	Soufriere Marine Management Area
SSMR	Soufriere/Scott's Head Marine Reserve
SUSGREN	Sustainable Grenadines Project
TNC	The Nature Conservancy
USGS	United States Geological Survey
UNFCCC	United Nations Framework Convention on Climate Change
UWI	University of the West Indies
WB	World Bank

EXECUTIVE SUMMARY

Coral Reef Monitoring in the OECS and Tobago

Introduction

The objective of the Coral Reef Monitoring for the Organization of Eastern Caribbean States (OECS) and Tobago project was to strengthen the coral reef monitoring network in the region and to conduct an assessment of the coral reefs in these participating countries. In 2007 an agreement was made to collaborate in the area of strengthening the coral reef monitoring network in the region between the CCCCC, the executing agency for the MACC project, and the CMS. This report presents the results of the monitoring programme conducted in the OECS and Tobago in 2007/2008.

Background

Component 5 - *Coral Reef Monitoring for Climate Change Impacts* represented one of the nine components of the CPACC project that was established in 1998. The overall objective of the CPACC project was to create a long term monitoring programme to show the effects of global warming factors on coral reefs. Monitoring was conducted in 2000 by the pilot countries The Bahamas, Belize and Jamaica and the data was collected using underwater digital videography to permanently record the status of the reefs. Coming out of the Technical Review Workshop held in 2001 was the recommendation to implement coral reef monitoring in the seven remaining CARICOM countries. Through the CCCCC, established by regional governments in 2002, the MACC project, with funding from the World Bank facilitated the expansion of the coral reef monitoring network as proposed under CPACC.

Training and Coral Reef Monitoring in the OECS and Tobago

A Regional Training Workshop was held in Saint Lucia during September 10-13, 2007 in association with the Sustainable Development & Environment Section (Ministry of Economic Affairs, Economic Planning & National Development), the Department of Fisheries (Ministry of Agriculture, Forestry & Fisheries) Saint Lucian Fisheries Department and the SMMA. Participants were trained in site selection, video monitoring, data processing & analysis and report preparation, based on the CPACC video monitoring protocol and the lessons learnt from monitoring carried out in the pilot countries. A core group of resource persons was established to provide technical support to the participating countries and monitoring was conducted over the period September 2007 to April 2008. Each country selected sites for monitoring based on the guidelines presented in the training workshop. The video monitoring protocol adapted for CPACC was employed and the resultant video tapes were processed and analysed at the CMS who prepared this report prepared in collaboration with the participating countries.

Antigua and Barbuda

Antigua and Barbuda are coral limestone islands with varied coastlines consisting of extensive shallow fringing reefs systems. Historically, coral reef monitoring was carried out mainly by the Fisheries Division in collaboration with the Coast Guard. Little Bird Island was selected as the Operational Area because this area had been previously studied and falls within the North East Marine Management Area. Video monitoring was started in October 2007 but because of technical difficulties and poor weather conditions the exercise was repeated in April 2008.

The results of the monitoring showed that in October 2007 the area was dominated by dead coral with algae (28.47%) and macroalgae (27.75%). Hard coral made up only 3.98% of the total benthic substrate cover while gorgonians accounted for 2.30%. The remaining live components of the benthic substrate were sponges (0.20%), zoanthids (0.22%) and coralline algae (0.23%). Of note was that diseased coral (0.12%) was also observed during this assessment. The assessment for April showed macroalgae (33.76%) dominating and to a lesser extent dead coral with algae (11.11%). Sand, pavement and rubble accounted for almost half (47.75%) of the benthic substrate cover. Hard coral only accounted for 3.80%, while gorgonians made up 2.43% of the benthic substrate cover. Sponges (0.95%) and zoanthids (0.03%) made up the remaining live component of the benthic substrate. Nine hard coral species were observed in October 2007 and 13 species in April 2008. *Acropora cervicornis* (1.57%), *Porites astreoides* (0.67%) and *Montastraea cavernosa* (0.53%) recorded the highest percentage cover for hard corals in October 2007. *Porites astreoides (1.47%)* was the most commonly occurring species in April 2008.

Although *Acropora palmata* beds were previously reported to be extensive in this area no colonies were observed during this monitoring exercise. A review of the video footage and an examination of the data revealed that the area had experienced significant disturbance which supports the observations of Bouchon *et al* (2004) particularly with respect to the low coral (approximately 4%) and high algal (macroalgae and dead coral with algae) cover.

Monitoring in Antigua suffered a number of setbacks which resulted in two sets of monitoring being conducted. Poor weather conditions and other logistical constraints resulted in significant delays, to the extent that the establishment of new transects and monitoring had to be repeated (April 2008). The Antiguan team felt that a follow up workshop in which the application of the initial training could be evaluated would be useful.

Dominica

Dominica is an island of volcanic origin with steep topography and productive coral reefs close to shore. Four dive sites within the Soufriere/Scott's Head Marine Reserve (SSMR) were selected for monitoring. The

staff of SSMR and the Fisheries Division play an active role in coral reef conservation. Video monitoring was carried out during the period November 13-15, 2007.

The four sites selected were dominated by dead coral and algae (54.91%). Hard coral made up 11.40% of the benthic substrate cover while macroalgae accounted for 11.64%. Gorgonians (0.97%), sponges (3.68%), zoanthids (0.04%), coralline algae (0.09%) other live unidentified organisms ((0.71%) made up the remaining living components of the benthic substrate. Sand, pavement and rubble accounted for 16.27% of the benthic substrate. Diseased corals (0.04%) were also observed at this location. There were 21 identified hard coral species at the four monitoring sites. The most commonly occurring species were *Porites astreoides* (3.04%), *Siderastrea siderea* (1.80%), *Meandrina meandrites* (1.41%) and *Porites porites* (1.41%). The remaining 17 species each accounted for less than 1% of the substrate cover.

The 11.64% coral cover and 21 hard coral species identified were not indicative of the full coral biodiversity within the SSMR. Bouchon *et al* (2004) describes the reefs in Dominica as having "high hard and soft coral abundance, very low algal cover, no observable disease, no bleaching". The results of this study did not reflect the condition of the typical Dominican reefs; therefore a decision will have to be made as to whether to retain these sites or to select sites that are more representative. The Fisheries Department was also of the view that other staff members would benefit from training in this CPACC video monitoring protocol. They also felt that the data processing and analysis portion of the training should be allotted more time as this was not sufficiently addressed during the training exercise in Saint Lucia.

Grenada

The island is a volcanic mountainous island with some fringing and patch reefs around the entire coast. Most of the conservation work is done by private dive operations, with some involvement of the St Georges University in association with the Fisheries Division. The Operational Area selected was located on the western side of the island in the Grand Anse reef system because of its accessibility and the existence of previously collected data. Video monitoring was carried out during the period November 13-15, 2007.

The Grand Anse reef system was dominated by dead coral and algae (42.46%) and macroalgae (41.78%). Hard coral cover represented 10.09% of the benthic substrate while gorgonians, sponges, zoanthids, coralline algae and other unidentified living organisms represented 1.13%, 0.17%, 0.15%, 0.01% and 0.14% respectively. Sand, pavement and rubble accounted for only 4.04% of the benthic substrate cover and there were no diseased corals observed. A total of 15 hard coral species were identified; *Porites porites* and *Porites astreoides* were the most commonly occurring species accounting for 5.17% and 2.59% respectively of this benthic substrate cover. Other coral species frequently observed included *Montastraea annularis* (0.77%) and *Montastraea cavernosa* (0.59%) *Siderastrea siderea* (0.32%) and *Diploria strigosa* (0.28%).

Tourism is very well developed on the southeast coast of Grenada, particularly at Grande Anse Bay, an area that is very important for recreational diving. The Fisheries Department has proposed a system of marine protected areas for Grenada (Burke & Maidens, 2004) and it is expected that the results from this monitoring exercise will be used in conjunction with previous data to form part of a proposal to be submitted for the Grand Anse reef system to be designated a protected area.

St Kitts and Nevis

St Kitts and Nevis are islands of volcanic origin and mountainous with fringing reefs along most of its coastline. Coral reef monitoring is presently carried out by the Dept of Sustainable Development along with assistance from the Coast Guard. Paradise Reef located offshore from Sandy Point was selected as the Operational Area primarily due to its accessibility for monitoring. Video monitoring was carried out during the period November 5-7, 2007.

The substrate at Paradise Reef was dominated by macroalgae (73.77%). Hard coral cover accounted for 10.25% of the benthic substrate, while sponges made up 7.49% of the total. Gorgonians, zoanthids, coralline algae and other unidentified living organisms represented 1.02%, 0.09%, 0.05% and 0.13% respectively of the benthic substrate. There were 21 hard coral species identified, the most commonly occurring species was *Porites astreoides* (5.81%) and to a much lesser extent *Montastraea faveolata* (1.15%), *Montastraea annularis* (0.91%) and *Siderastrea siderea* (0.72%).

Paradise Reefs is located within the designated National Marine Park at Sandy Point[1] and features giant basket sponges as part of the coral assemblage. This area is well used by divers but its designation as a protected area prevents boats from anchoring and damaging the reefs. Despite the challenges related to the institutional arrangements for coral monitoring there is good cooperation between the relevant agencies, and this facilitated the seamless implementation of this monitoring programme.

Saint Lucia

Saint Lucia is also a volcanic island surrounded by coral reefs that forms a thin veneer over the underlying the volcanic substrate. The Operations Area was established in the Soufriere Marine Management Area (SMMA) which is managed by a non profit association. This area was selected because it has a well established monitoring programme for a variety of parameters and could provide logistical support to the Fisheries Department to carry out the video monitoring. Monitoring was carried out during the period September 12-14, 2007 immediately following the regional training workshop.

[1] Source: www.stkittstourism.kn

Results showed that the area was dominated by macroalgae (44.11%). The hard coral cover was determined to be 9.53% while gorgonians made up 1.35% of the cover and sponges made up 7.07%. Other categories which included coralline algae (0.90%), other unidentified living organisms (0.97%) and dead coral with algae (0.25%) were also observed. Sand, pavement and rubble made up 33.26% of the benthic substrate and 2.56% was unidentified (unknown). No zoanthids or diseased corals were observed. Twenty species of hard corals were identified; the more commonly occurring species included *Porites astreoides* (1.97%), *Porites porites* (1.87%), *Diploria strigosa* (1.13%) and *Madracis mirablis* (0.80%).

The fringing reef communities along parts of the west coast are of great importance to fisheries industry and as popular diving destinations. Because Saint Lucia is ranked highly as one of the best diving destinations in the world[2] reefs are under pressure from tourism, coastal development and the subsequent increases in population (Burke & Maidens, 2004). The SMMA has a comprehensive monitoring programme but still faces challenges with respect to adequate resources for processing and analyzing the data collected. It is hoped that collaboration with the MACC and the CMS may help to alleviate these problems.

St Vincent and the Grenadines

St Vincent is volcanic and mountainous with reefs systems that are not extensive. Castle Bay, which is located close to the capital Kingstown, was selected as the Operational Area and video monitoring was carried out during the period October 20 -24, 2007.

Hard coral (29.18%) and macroalge (36.51%) dominated the benthic substrate. There were also a high proportion of sponges (12.07%) and gorgonians (3.56%) were present to a lesser extent. There were limited amounts of dead coral and algae (3.06%) and a small proportion of diseased corals (0.13%) detected. Sand pavement and rubble (14.34%) made up the non-living portion of the benthic substrate. No zoanthids or coralline algae were observed. There were 29 hard coral species observed during the monitoring exercise, the most commonly occurring species was *Porites astreoides* (8.07%), *Siderastrea siderea* (6.57%) and *Montastraea annularis* (5.55%) and to a much lesser extent *Diploria strigosa* (1.79%), *Meandrina meandrites* (1.56%) and *Montastraea cavernosa* (1.29%).

The site selected at Castle Bay had the highest coral cover and number of coral species when compare to the other sites monitored during this study. Despite its close proximity to the capital, Kingstown, and the

[2] Presentation by Mr. John Calixe, Deputy Permanent secretary, Ministry of Economic Affairs, Economics Planning, National Development and Public Service, Saint Lucia. Regional Training Workshop September 10-13, 2007. (Creary, 2007)

impact by runoff and discharges from the rivers, particularly during the rainy season the reefs were is relatively good condition. Previous monitoring has been carried out in this area, which is also a popular dive site, and the results of this monitoring exercise will serve to add to the already existing body of knowledge.

Tobago

Tobago is located approximately 26 km to the northeast of Trinidad and supports a well developed sloping reef supplied with nutrient rich waters from the Orinoco River in Guyana. Speyside was selected as the Operational Area and represents an area in which the IMA has recently started to conduct coral reef monitoring. Video monitoring was carried out during the period October 16-17, 2007. Two video tapes were submitted to the CMS along with the field report and metadata. A total of 1362 non-overlapping images were captured using Pinnacle Studio™ software and analyzed using CPCe. Data was automatically stored in Microsoft Excel worksheets.

The sites monitored at Speyside, Tobago were dominated by macroalgae (25.44%), sponges (21.15%), gorgonians (16.80%) and hard coral (15.88%) which together accounted for approximately 80% of the benthic cover. The remaining living components of the benthic cover were comprised of coralline algae (2.13%), zoanthids (0.93%) and other unidentified living organisms (0.01%). Sand, pavement and rubble (13.57%) made up the remainder of the benthic cover. There were 19 hard coral species observed during the monitoring exercise; the most commonly occurring species was *Madracis mirabilis* (9.54%) and to a much lesser extent *Montastraea faveolata* (1.61%). The remaining 17 species individually represented less than 1% of the coral cover.

In photo-quadrat surveys conducted by Laydoo (1985) on the reef crest and upper forereef (0-9 m; 0-30 feet) at Goat Island, 13 hard coral species were reported. Species recorded by Laydoo (1985) but not observed in this survey were *Diploria labyrinthformis*, *Madracis decastis*, *Eusmilia fastigiata* and *Mussa angulosa*. Species recorded in this survey but not by Laydoo (1985) were *Porites furcata*, *Mycetophyllia aliciae*, *Agaricia undata*, *Favia fragum*, *Leptoseris cucullata*, *Madracis mirabilis*, *Millipora complanata*, *Montastraea cavernosa*, *Monastraea faveolata* and *Solenastrea hyades*. A more detailed evaluation of the two studies needs to be carried out before a conclusion can be drawn about these results.

Summary of Coral Reef Monitoring Results

The data collected and reported on in this document represents the first in the series of monitoring exercise forming the long term coral reef monitoring programme for the OECS and Tobago. The programme will document change on the coral reefs over time using coral cover as an indicator of coral reef health.

The results shows that the monitoring sites selected in each country had varying levels of coral cover ranging from 3.80% in Antigua (2008) to 29.18% in St Vincent. Dominica, Grenada, St Kitts and Saint Lucia had coral cover at about 10% while Tobago had 15.88%. Gorgonians were not very abundant in all the islands ranging from 0.97% 3.56% with the exception of Tobago which had 16.80% mean percentage cover. Sponges were also found in the highest abundance in Tobago with 21.15%, St Vincent had a little over half that amount with 12.07%, while St Kitts and Saint Lucia had 7.49% and 7.07% respectively. The other three countries had less than 4% sponges. The zoanthids represented a very small proportion of the benthic cover in all the countries ranging from 0.00% to 0.93%. Also, not well represented are the coralline algae which ranged from 0.00% to 0.90% for all countries except Tobago which had a higher cover of 2.13%. Disease corals were observed in limited amounts in Antigua (2007), Dominica, St Kitts and St Vincent.

Of significance for all the countries was the high level of macroalgae combined with dead coral and algae found on the reefs with Antigua (2007) having a combined value of 56.22%, Dominica having 66.55%, Grenada with the highest at 84.24% and St Kitts at 76.02%. Tobago (25.92%) and St Vincent (39.57%) exhibited the lowest levels of macroalgae combine with dead coral and algae, while Antigua – 2008 (44.87%) and Saint Lucia (44.36%) had intermediate levels.

A total of 41 coral species were observed in addition to other unidentified coral species and coral juveniles. The most widely distributed species were *Diploria strigosa*, *Montastraea annularis, Montastraea cavernosa, Porites astreoides* and *Siderastrea siderea,* which were found in all countries and *Agaricia agaricites, Meandrina meandrites, Millipora complanata* and *Porites porites* which occurred in six of the seven countries. Just under half (18) of the species identified were found in only one or two countries, with remaining 15 species occurring in 3-5 countries.

Recommendations

The following recommendations coming out of this monitoring exercise should be considered for incorporation in any future monitoring programme.

- ***Monitoring Review Workshop*** – with participating institutions to review the monitoring protocol and the data collected.
- ***Training*** – review of training with participants and provide training to additional persons in countries that request it.
- ***Site Selection*** – sites selected should be reviewed to ensure they are suitable for long term monitoring.
- ***Monitoring*** – persons should endeavour to adhere to the established protocol, video monitoring equipments should be thoroughly checked before going out into the field, field reports and metadata should always accompany tapes and HoboTemp loggers should be deployed.

- ***Data Processing and Analysis*** - increased focus on in-country coral species identification and data analysis.
- ***Supplementary Studies*** - provisions should be made to monitoring coral bleaching, coral diseases and other indicators of coral reef health and efforts should be made to gather all other relevant data related to the site selected.
- ***Video versus still photography*** - a brief desktop assessment indicates that the high-resolution video technology which is now available is adequate for monitoring benthic cover on coral reefs and is cost effective when compared to other monitoring methods.

CHAPTER 1

CORAL REEF MONITORING FOR THE OECS AND TOBAGO

1.1 INTRODUCTION

The objective of the Coral Reef Monitoring for the Organization of Eastern Caribbean States (OECS) and Tobago project was to strengthen the coral reef monitoring network in the region and to conduct an assessment of the coral reefs in these participating countries. The project was implemented by providing technical support in the areas of training, monitoring, data analysis and report preparation.

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 Agreement (MOA) between the Caribbean Community Climate Change Centre (CCCCC), the executing agency for the MACC project, and the Centre for Marine Sciences (CMS), University of the West Indies (UWI), Mona, collaboration in the area of strengthening the coral reef monitoring network in the region was undertaken. This report presents the results of the monitoring programme conducted in the OECS and Tobago during the period September 2007 and April 2008.

1.2 BACKGROUND

1.2.1 CARIBBEAN: PLANNING FOR ADAPTATION TO GLOBAL CLIMATE CHANGE PROJECT

Component 5 - *Coral Reef Monitoring for Climate Change Impacts* represented one of the nine components of the Caribbean: Planning for Adaptation to Global Climate Change (CPACC) project that was established in 1998. The overall objective was to establish a long term monitoring programme, which over time would be expected to show the effects of global warming factors (temperature stress, sea level rise and hurricanes) on coral reefs. The monitoring was also designed to increase the knowledge on the extent and sources of coral reefs degradation within the Caribbean region.

A sub-regional forum of specialist from governments, NGO's and CARICOM institutions, as well as experts from the scientific community, consulted and formulated the methodology employed in this monitoring programme. Three monitoring sites were selected in each of three pilot countries (The Bahamas, Belize and

Jamaica) to represent mildly impacted, moderately impacted and severely impacted coral reefs. The data was collected using underwater digital videography to permanently record the status of the reefs and the resultant videotapes were processed and analyzed using specially developed software.

Monitoring was conducted in 2000 and reports on the results of the monitoring exercise have been prepared for The Bahamas (Phillips, 2001) and Belize (Bood, 2001). Copies of the Belize summary data were sent to the Caribbean Coastal Data Centre (CCDC) of the CMS for archiving. Processing, analysis and archiving of the Jamaican data was carried out directly at the CCDC (Chevannes Creary, 2001). Monitoring continued in Jamaica beyond the pilot phase for the period and the report for the period 2001-2003 has been prepared (Centre for Marine Sciences, 2006). The archived data includes videotapes, captured images and data in the form of spreadsheets and summary reports.

In May 2001, a regional planning and technical review workshop was held in Jamaica to review the monitoring methods and data as well as to plan the future expansion of the monitoring programme to other countries of the region. This technical review meeting included participants involved in the monitoring from the pilot countries as well as coral reef scientists, coastal zone managers and government officials from the region. Coming out of the workshop was the recommendation to move towards the implementation of coral reef monitoring in the seven remaining CARICOM countries (Lawrence & Edwards, 2001). Unfortunately, the CPACC project ended before the implementation of these recommendations.

1.2.2 CARIBBEAN COMMUNITY CLIMATE CHANGE CENTRE

Regional governments established the Caribbean Community Climate Change Centre (CCCCC) in order to coordinate the regional response to climate change. It is the key node for information on climate change issues and the Caribbean's efforts to manage and adapt to climate change. The establishment of the CCCCC, which is based in Belize, was endorsed by the CARICOM Heads of Government in 2002. An Executive Director was first appointed in December 2003.

Through its role as a Centre of Excellence, the CCCCC has supported the people of the Caribbean as they address the impacts of climate variability and change on all aspects of economic development through the provision of timely forecasts and analyses of potential hazardous impacts of both natural and man-induced climatic changes on the environment, and the development of special programmes which create opportunities for sustainable development.

1.2.3 MAINSTREAMING ADAPTATION TO CLIMATE CHANGE PROJECT

The CCCCC is executing the Mainstreaming Adaptation to Climate Change (MACC) project, which started in 2003, with funding from the Global Environmental Facility (GEF) through the World Bank. The primary

objective of the MACC project is to mainstream adaptation to climate change into national development planning through technical support and capacity building. Under its Component 1 – the MACC project aims to build capacity to assess vulnerability and risks associated with climate change and climate variability. Part of this capacity building would involve the strengthening of the climate change and coral reef monitoring network in the region. To this end the MACC project supported the expansion of the coral reef monitoring network as proposed under CPACC.

1.2.4 Centre for Marine Sciences, University of the West Indies

The CMS, under a MOA with the CCCCC for the MACC project led and coordinated the expansion of the coral reef monitoring programme to the OECS and Tobago and provided technical support training, monitoring, data analysis and report preparation. The CMS has had a long and distinguished tradition of research in the coastal zone of Jamaica. This research has been conducted mainly through the Discovery Bay and the Port Royal Marine Laboratories. Through regional and international collaboration with other marine research institutions and universities the CMS has also established a strong regional and international presence.

CMS is a founding member of the Caribbean Coastal Marine Productivity Programme (CARICOMP), a regional scientific network, which collects baseline data on three important marine ecosystems – coral reefs, seagrass beds and mangrove forests. In addition to being the repository for the CARICOMP database the CMS has and continue to expand its role as a regional data archiving and management centre to include data from other regional and global environment programmes such CPACC, the Global Coral Reef Monitoring Network (GCRMN) and Reef Check.

1.3 Training and Coral Reef Monitoring in the OECS and Tobago

The objective of the Coral Reef Monitoring for the OECS and Tobago project implemented by the CMS was to strengthen the coral reef monitoring network in the region and to conduct an assessment of the coral reefs in these participating countries. The project was implemented by providing technical support in the areas of training, monitoring, data analysis and report preparation. Following the monitoring programme the participating countries would be expected to review strategies for mainstreaming coral reef monitoring into the national decision making process.

1.3.1 The Regional Training Workshop

The objective of the workshop was to train participants from the Eastern Caribbean and Tobago in the video monitoring protocol developed under CPACC with a view to establishing a long-term monitoring programme, which would over time be expected to show the effects of global warming factors on coral reefs. The training was conducted over the period September 10-13, 2007 in Saint Lucia in collaboration with the Sustainable Development & Environment Section (Ministry of Economic Affairs, Economic Planning & National Development), Department of Fisheries (Ministry of Agriculture, Forestry & Fisheries) and the

Soufriere Marine Management Association (SMMA). There were a total of 16 trainees from the seven Eastern Caribbean countries[3] in addition to other local participants, presenters and trainers (Appendix 1). During the training workshop the participants were brought up to date with the achievements of CPACC, the development of MACC and the CCCCC as well as the vision for addressing the climate change issues of the region. Participants were trained in site selection (Woodley, 1999), video monitoring (Miller & Roger, 2002), benthic substrate identification, data processing, data analysis and report preparation. Strategies for participating countries to mainstream coral reef data into the national decision making process were discussed and a core group of resource persons to support the implementation of the monitoring programme in the participating countries was established.

1.3.2 MONITORING IN THE PARTICIPATING COUNTRIES

Monitoring took place under the supervision of the Roving Team Leaders (RTLs) from the CMS in collaboration with the local trainees who had participated in the Regional Training Workshop, local resources persons and volunteers. Each RTL was assigned responsibility for two countries. Monitoring in Saint Lucia took place immediately following the workshop in September while monitoring took take place in the other countries during the period September to November 2007. The only exception was Antigua, who due to unavoidable circumstances was not able to complete their monitoring until April, 2008. The monitoring schedule and sites are presented in Appendix 2.

1.3.2.1 SITE SELECTION AND VIDEO MONITORING

Each country selected coral reef areas (Operational Areas) for monitoring based on the guidelines outlined in the site selection protocol (Woodley, 1999) taking into consideration the use to which the data would be put, the peculiarities of the area and any constraints that might be encountered during monitoring. Each country was requested to installed 20 permanent transects, each 20m long, at the selected sites prior to the arrival of the RTL.

Given the constraints of scuba diving, photography provides the most practical and economical means of sampling large areas underwater. The video protocol is based on the Aronson method that was adapted for the CPACC coral monitoring programme carried out in the pilot countries (Miller, 2000). This method utilizes a high resolution video camera to video tape the substrate. There are a number of advantages of this method over the traditional underwater data collection methodologies. These include the provision of permanent photographic records that can be re-assessed, reduced time spent in the water by divers and a monitoring protocol that can be carried out by persons who are not coral experts. These factors combined make this monitoring method the most cost effective.

[3] Antigua & Barbuda, Dominica, Grenada, St Kitts & Nevis, Saint Lucia, St Vincent & the Grenadines and Trinidad & Tobago.

The general procedure followed by the monitoring team is outlined below. Prior to filming, a slate containing information about the transect (site name, date depth, transect number and videographer) was recorded. Divers then videotaped while swimming slowly along the transect holding the camera perpendicular to the substratum at a height of 40 cm (guided by a 40cm wand attached to the camera housing) in order to provide a belt transect that was approximately 40 cm wide (Miller, 2000). At the end of filming each transect recording was continued in a more horizontal view, making a 360° rotation of the transect area and then a "swim back" along the transect tape at about 1-2 m above the bottom. The "swim back" was used to record a wider reef area in order to provide a qualitative view of the reef and to put the contents of the transect into context. The resultant videotapes were reviewed to ensure that clarity and resolution were satisfactory and then labeled and sent to the CMS for processing and analysis.

1.3.2.2 Data Processing, Analysis

At the CMS the tapes were numbered, catalogued, the content of each tape logged and the tape quality assessed. With the Sony™ Mini DV player connect to the computer and utilizing the Pinnacle Studio™ software discrete non-overlapping adjacent images were captured from each transect and saved in an image directory. The random point count method was used to estimate the benthic cover from images grabbed from video footage. Coral Point Count with Excel extensions (CPCe Ver 3.5) was selected because it is a standalone Visual Basic program which automates the random point count method for the statistical analysis of marine benthic communities and is freely downloadable (Kohler & Gill, 2006). The results are comparable to those obtained using the previous CPACC software set up. The CPCe programme was used to randomly overlay 10 points on each image from which the benthic species or substrate category lying under each point was identified to the highest functional taxonomic group. The standard coral/substrate code that came with CPCe was replaced by those codes used in the previous method developed under CPACC (Miller, 2000; Chevannes Creary, 2001). Once identified the codes were entered directly into an associate Microsoft Excel Spreadsheet which had the ability to automatically generate statistical parameter for each species/substrate category (relative abundance, mean, standard deviation, standard error) and the calculation of the Shannon–Weaver diversity index for each species.

1.3.2.3 Report Preparation

The report was prepared by the CMS in collaboration with the RTLs and persons from each of the participating countries. The report contains a separate chapter for each country, with each chapter containing background information on the particular country, an overview of the marine resources and previous monitoring activities, the site selection and the monitoring procedures and the results of the monitoring. In addition, suitable images were selected to illustrate various aspects of the monitoring exercise.

CHAPTER 2

ANTIGUA AND BARBUDA

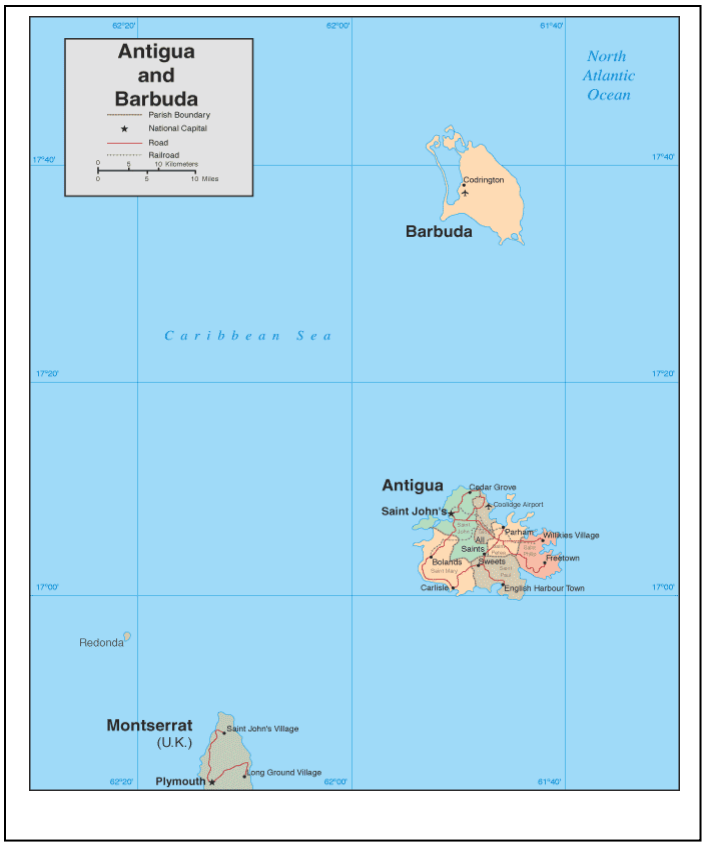

Figure 2.1: Map of Antigua and Barbuda

2.1 ANTIGUA AND BARBUDA COUNTRY PROFILE[4]

Antigua and Barbuda are coral limestone islands located on an emergent 3,400 km² sub-marine platform, one of the largest in the Eastern Caribbean (Figure 2.1). The depth of water between the two islands is about 27-33 m. The precise geographical coordinates of Antigua are: 17°10' latitude and 61°55' longitude. The island of Barbuda is 28 mi (45 km) north of Antigua, located at latitude 17°35', longitude 61°48'. Antigua is roughly round and has an area of 280 km² (108 mi²) and Barbuda 160 km² (62 mi²). Both islands have numerous white sand beaches. Antigua and Barbuda has an exclusive economic zone of 370 km (200 nautical miles) and a coastline of about 153 km (95 mi).

[4] Source: CIA The 2008 World FactBook. (www.cia.gov/library/publications/the-world-factbook); The Columbia Encyclopedia 6th Edition. 2007. Columbia University Press (ww.bartleby.com)

There are several tiny uninhabited islands surrounding Antigua. Redonda (0.6 mi^2 or 1.6 km^2) is the largest. The coastline of Antigua is indented with numerous islands, creeks, inlets, associated sand bars and wet lands. A large portion of the east, north and south coasts are protected by fringing reefs. On the west coast, there are large areas of sandy bottom in shallow water, with sandy bottom between fringing reefs and the shore. The coastline of Barbuda is less varied but has extensive reef systems especially off the east coast.

Antigua can be described as undulating with most slopes being less than 30° and its highest point Boggy Peak rising to 402 m (1,319 ft) in the southwest of the island. Barbuda being relatively flat with its highest point just less than 40m (125 ft) is dominated by coralline limestone rocks. On the western side of the island is the Codrington Lagoon averaging about one and a half miles in width and separated from the sea by a narrow spit of sand. The lagoon is bordered by mangroves and sand ridges. This area is of importance to the fisheries and wildlife of Barbuda.

The economy is primarily service-based with tourism being the principle earner of foreign exchange. Government services represent the key sources of employment and income for the estimated population of 69,842 (2008). Presently, there are coordinated efforts to diversify the economy by encouraging growth in sectors such as transportation, communications and financial services.

2.2. CORAL REEF AND MARINE RESOURCES OF ANTIGUA

There are extensive shallow-reef systems on Antigua with some areas remote from the land between Long Island and Bird Island, where navigation is particularly difficult. Barbuda has extensive fringing reefs, particularly along its eastern coastline, topped by a well-developed algal ridge (Figure 2.2). The reefs, particularly in nearshore areas, are reported to have been degraded in recent years, possibly due to increasing sedimentation and nutrient enrichment associated with coastal development. Offshore reefs and those to the north of Barbuda generally have higher coral cover and species richness (Spalding, 2001). There are extensive *Acropora palmata* beds on top of most reef crests but in recent years, hurricanes have detached many *Acropora palmata* colonies from the shallow areas and deposited some in the deeper areas where species such as *Diploria sp, Siderastrea siderea, Montastraea annularis, Porites astreoides* predominate. Macro-algal cover is relatively high, and is thought to be linked to a lack of adult algal grazers (Bouchon *et al*, 2004).

Before 2005 there were no marine protected areas (MPAs) and because of this there were limited management mechanisms in place to conserve the coral reef resources, especially the fisheries. However, the partnership between Dive Antigua, Fisheries Division and the Coast Guard has been effective in establishing some enforcement and management (Bouchon *et al*, 2004).

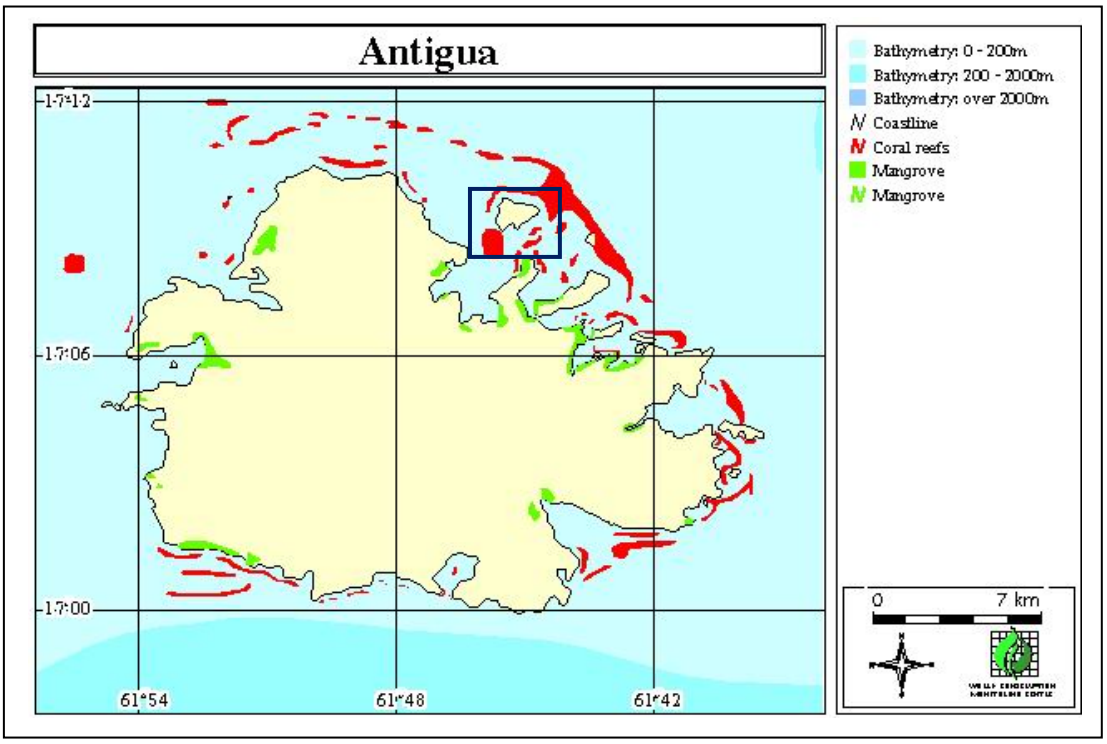

Figure 2.2: Outline map of Antigua showing the location of coral reefs. The Operational Area at Little Bird Island is highlighted.

2.3 Overview of Coral Reef Monitoring in Antigua

Coral reef monitoring is carried out primarily by the Fisheries Division in collaboration with supporting entities such as the Reef Check team from Barbados, scuba diving entities and the Coast Guard (Bouchon *et al*, 2004). The earliest work on the reefs commenced after Hurricane Hugo and was conducted by a British team. More recently, the Fisheries Division acquired a boat under the OPAAL project. The methods they employed provided some information but there were weaknesses in the methodology. They presently have two active divers and have access to equipment through assistance from local dive operators and could replicate monitoring on the existing Reef Check/Reef Keeper sites. The Department also has video footage of the reef following Hurricane Dean. (Creary, 2007)

2.4 MACC Coral Reef Monitoring in Antigua

2.4.1 Methodology

2.4.1.1 SITE SELECTION AND DESCRIPTION

Little Bird Island was selected as the Operational Area (Figure 2.2) in which to establish transects for video monitoring. Little Bird Island is located approximately 6 km (4 miles) to the north east of the Vere Bird International Airport near to the capital city of St. Johns and west of North Bird Island in the North East Marine Management Area which was declared a marine protected area in December 2005. The area is used for tourism, fishing and recreational activities. There are several offshore islands, both habited and uninhabited, comprised of a vast coral reef system ranging from shallow reef flats to a back reef area down to 12 m (40 ft).

Within the Operational Area the site selected for monitoring consisted of shallow reefs (10m and less) comprised primarily of the *Acropora palmata* framework. Observation of the area in October revealed that the *Acropora* framework was largely devoid of live tissue and had been severely impacted by the passage of several hurricanes including Hurricane Dean in 2007. Horizontal visibility was generally less than 20m for the duration of the survey.

The Little Bird Island (Figure 2.3) site was selected because the area had been one of several Antiguan coral reef sites studied under a pilot project for Promoting a *Regional Approach to the Assessment and Selection of Coral Reef Marine Protected Area Sites in the Eastern Caribbean States.* Thus, information on the composition and status of the area exists. The area is of significance for tourism and recreation and there is also the presence of a wide variety of coral species. The monitoring site was close to the Fisheries Department office, the location at which the Departments' research boat was stored and the hotel from which diving gear was obtained for the monitoring. However, access to the monitoring site was limited to those knowledgeable of the reef system.

Figure 2.3: Satellite photograph showing the location of the monitoring site at Little Bird Island, Antigua.

2.4.1.2 VIDEO MONITORING

Field works was started in October 2007 but was not completed due to several delays resulting from technical difficulties and poor weather conditions. Because of the long delay in completing the monitoring the entire exercise was repeated in April 2008.

Initially, video monitoring was conducted over the period October 16-17, 2007 and generally followed the procedure outlined in section 1.3.2.1. The monitoring team was comprised of personnel from the CMS, Fisheries Department, Antigua and Barbuda Coast Guard and Dive Antigua. The dives were conducted from a tethered surface float marking the coordinates to establish the locations of the starts and ends of the monitoring transects. Randomly generated bearings and distances were used for the identification of the starting points, which were marked with submerged floats attached to 5 kg lead weights. The end points for each transect were measured 20 meters from each start point swimming in a westerly direction. Thus, all transects were aligned West to East. The transects were not permanently marked prior to the execution of monitoring, thus it was decided that temporary markers would be established, with the Department of Fisheries staff replacing these with permanent markers once the monitoring was completed. Actual video monitoring of 5 of the 10 marked transects was carried out on October 16 and it was decided that the Antiguan Fisheries Department and the Coast Guard personnel would complete the remaining transect deployment and videotaping. However, due to logistical difficulties and poor weather conditions monitoring was not completed in October 2007.

Because of the time lag after the monitoring started in October it was decided to repeat the entire monitoring exercise. This was carried during the period April 9-11, 2008 within the same Operational Area. During this exercise the permanent transects were established at sites previously monitored in 2002 using the line and point intercept method. These sites were located using GPS coordinates and the transects laid out in a specific pattern, which was repeated for the layout of all the 20 transects. To re-locate the transects for future monitoring the starting point has to be found, then the layout pattern followed.

2.4.1.3 DATA PROCESSING AND ANALYSIS

A total of three (3) videotapes were submitted to the CMS along with the metadata and field reports. One tape contained five (5) transects recorded in October 2007and the other two tapes contained 20 transects recorded in April 2008. Transect #6 from April 2008 was discarded as it was incomplete. A total of 231 discrete non-overlapping images were captured from the October 2007 transects and 908 images from the April 2008 transects, giving a total of 1089 images. Processing of the tapes and the analysis of the images generally followed the procedure outlined in section 1.3.2.2. The tape catalogue and image capture logs are presented in Appendix 3 & 4.

2.4.2 RESULTS

2.4.2.1 BENTHIC SUBSTRATE

The result presented here represents data obtained from five transects collected in October 2007 (Table 2.1) and 20 transects collected in April 2008 (Table 2.2) at Little Bird Island in Antigua.

The results for October 2007 (Table 2.1) showed that the area studied was dominated by dead coral with algae (28.47%) and macroalgae (27.75%). The area was also comprised of a large proportion of sand, pavement and rubble (36.29%). Hard coral made up only 3.98% of the total benthic substrate cover while gorgonians accounted for 2.30%. The remaining live components of the benthic substrate cover were sponges (0.20%), zoanthids (0.22%) and coralline algae (0.23%). Of note is that diseased coral (0.12%) was also observed during this assessment. These results are illustrated in Figure 2.4.

Table 2.2 contains the results of the monitoring carried in April 2008 in which all twenty transects were videotaped. The assessment shows that the area was dominated by macroalgae (33.76%) and to a lesser extent dead coral with algae (11.11%). Sand, pavement and rubble accounted for almost half (47.75%) of the benthic substrate cover. Hard coral only accounted for 3.80%, while gorgonians made up 2.43% of the benthic substrate cover. Sponges (0.95%) and zoanthids (0.03%) made up the remaining live component of the benthic substrate. No coralline algae or diseased corals were identified during this assessment. These results are illustrated in Figure 2.4.

Table 2.1: Summary of the mean percentage cover for the benthic substrate categories at Little Bird Island, Antigua collected in October 2007.

MAJOR CATEGORY (% of transect)	MEAN	STD. DEV.	STD. ERROR
HARD CORAL	3.98	1.87	0.83
GORGONIANS	2.30	1.37	0.61
SPONGES	0.20	0.29	0.13
ZOANTHIDS	0.22	0.22	0.10
MACROALGAE	27.75	7.65	3.42
OTHER LIVE	0.00	0.00	0.00
DEAD CORAL WITH ALGAE	28.47	21.29	9.52
CORALLINE ALGAE	0.23	0.51	0.23
DISEASED CORALS	0.12	0.28	0.12
SAND, PAVEMENT, RUBBLE	36.29	21.49	9.61
UNKNOWNS	0.43	0.26	0.12
Sum (excluding tape+shadow+wand)	100.00		

Table 2.2: Summary of the mean percentage cover of the benthic substrate categories at Little Bird Island, Antigua collected in April 2008.

MAJOR CATEGORY (% of transect)	MEAN	STD. DEV.	STD. ERROR
HARD CORAL	3.80	2.04	0.47
GORGONIANS	2.43	2.16	0.49
SPONGES	0.95	0.79	0.18
ZOANTHIDS	0.03	0.13	0.03
MACROALGAE	33.76	11.29	2.59
OTHER LIVE	0.00	0.00	0.00
DEAD CORAL WITH ALGAE	11.11	7.33	1.68
CORALLINE ALGAE	0.00	0.00	0.00
DISEASED CORALS	0.00	0.00	0.00
SAND, PAVEMENT, RUBBLE	47.75	13.42	3.08
UNKNOWNS	0.16	0.31	0.07
Sum (excluding tape+shadow+wand)	100.00		

A comparison of the results for both October 2007 and April 2008 showed similarities in the benthic substrate cover for most of the substrate category assessed at Little Bird Island. Live hard coral cover was low in October 2007 (3.98%) and April 2008 (3.80%) while macroalgae was high (27.75% and 33.76% respectively) for the corresponding periods. In October 2007 there was more dead coral with algae recorded (28.47%) than in April 2008 (11.11%) while a higher level of sand, pavement and rubble was recorded at the monitoring site in April 2008 (47.75%) than in October 2007 (36.29%). The other live components of the benthic substrate (gorgonians, sponges, zoanthids and coralline algae) all showed similar levels of abundance on both monitoring occasions. Diseased corals were only observed in October 2007. Figure 2.5 shows images of the general appearance of the coral reefs system at Little Bird Island.

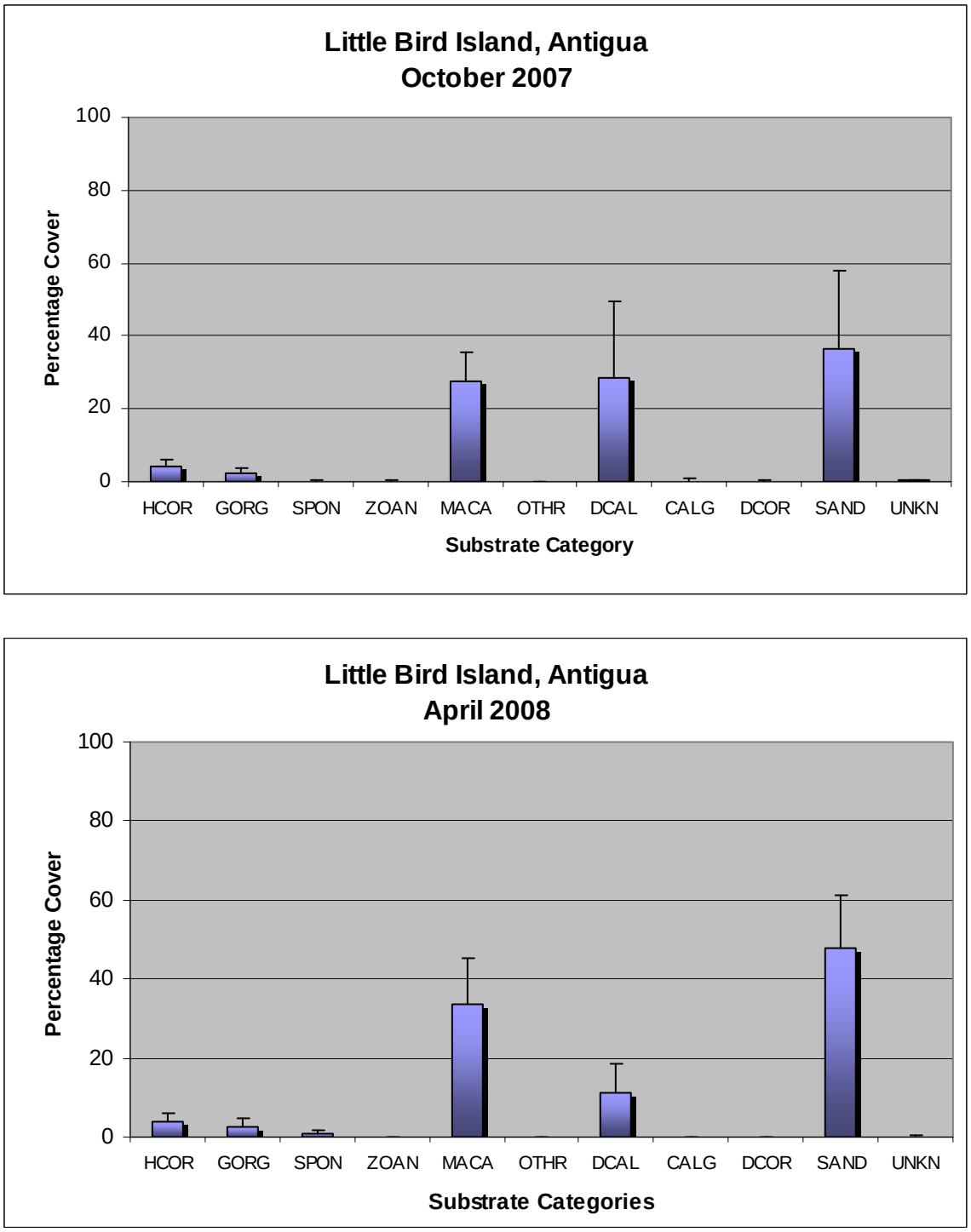

Figure 2.4: Graphs illustrating the mean percentage cover of the different substrate categories found at Little Bird Island, Antigua, October 2007 and April 2008. Error bars represent Standard Deviation (STD. DEV.). (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; SPON – Sponge; ZOAN – Zoanthids; MACA– Macroalgae; OTHR – Other, live; DCAL - Dead coral with algae; CALG – Coralline algae; DCOR– Diseased coral; SAND – Sand, rubble, rock and boulder; UNKN – Unknown.)

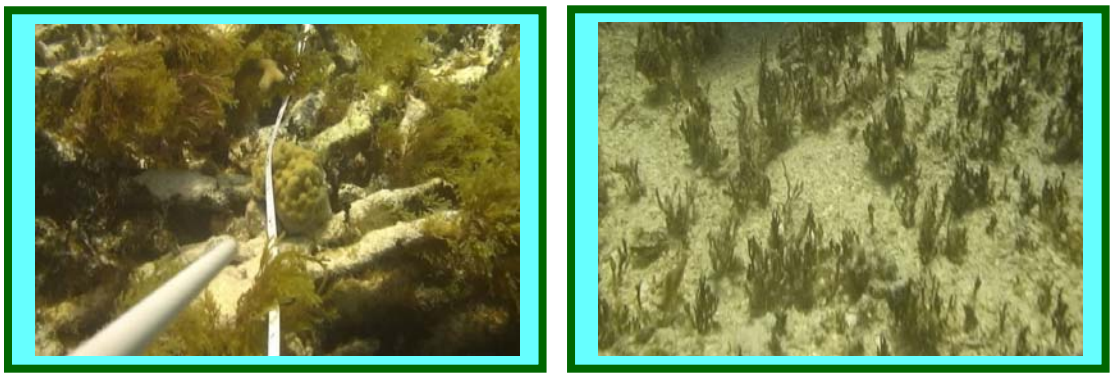

Figure 2.5: Images showing the general appearance of the coral reefs at Little Bird Island. The benthic substrate was dominated by dead *Acropora palmata* overgrown with macroalgae and large sand patches.

2.4.2.2 HARD CORAL SPECIES

Nine (9) hard coral species were observed at Little Bird Island in October 2007 and 13 species in April 2008. *Acropora cervicornis* (1.57%), *Porites astreoides* (0.67%) and *Montastraea cavernosa* (0.53%) recorded the highest percentage cover for hard corals in October 2007 (Table 2.3). *Porites astreoides (1.47%)* was the most commonly occurring species in April 2008. Other species of note included *Diploria labyrinthiformis* (0.27%), *Diploria strigosa* (0.39%), *Montastraea cavernosa* (0.36%), *Porites porites* (0.37%) and *Siderastrea siderea* (0.40%) also contributed to the coral cover (Table 2.4). Unidentified massive coral and coral juveniles were also observed. Images of some of the coral species observed in both October 2007 and April 2008 are presented in Figure 2.6.

Table 2.3: Hard coral species identified at Little Bird Island, Antigua in October 2007.

HARD CORAL SPECIES	MEAN	STD. DEV.	STD. ERROR
Acropora cervicornis	1.57	2.23	1.00
Agaricia agaricites	0.04	0.09	0.04
Diploria labyrinthiformis	0.04	0.09	0.04
Diploria strigosa	0.08	0.19	0.08
Massive corals	0.50	0.47	0.21
Montastraea annularis	0.17	0.17	0.07
Montastraea cavernosa	0.53	0.57	0.26
Porites astreoides	0.67	0.70	0.31
Porites porites	0.13	0.21	0.09
Siderastrea radians	0.24	0.27	0.12
Total % Coral Cover	3.98		
Number of Known Species	9		

Table 2.4: Hard coral species identified at Little Bird Island, Antigua in April 2008.

HARD CORAL SPECIES	MEAN	STD. DEV.	STD. ERROR
Acropora cervicornis	0.06	0.19	0.04
Agaricia agaricites	0.06	0.26	0.06
Colpophyllia breviserialis	0.01	0.07	0.01
Coral juvenile	0.01	0.05	0.01
Diploria labyrinthiformis	0.27	0.40	0.09
Diploria strigosa	0.39	0.61	0.14
Massive corals	0.18	0.28	0.06
Montastraea cavernosa	0.36	0.63	0.14
Montastraea faveolata	0.01	0.06	0.01
Mycetophyllia aliciae	0.03	0.08	0.02
Porites astreoides	1.47	1.06	0.24
Porites furcata	0.03	0.14	0.03
Porites porites	0.37	0.37	0.09
Siderastrea radians	0.14	0.15	0.03
Siderastrea siderea	0.40	0.85	0.20
Total % Coral Cover	3.80		
Number of Known Species	13		

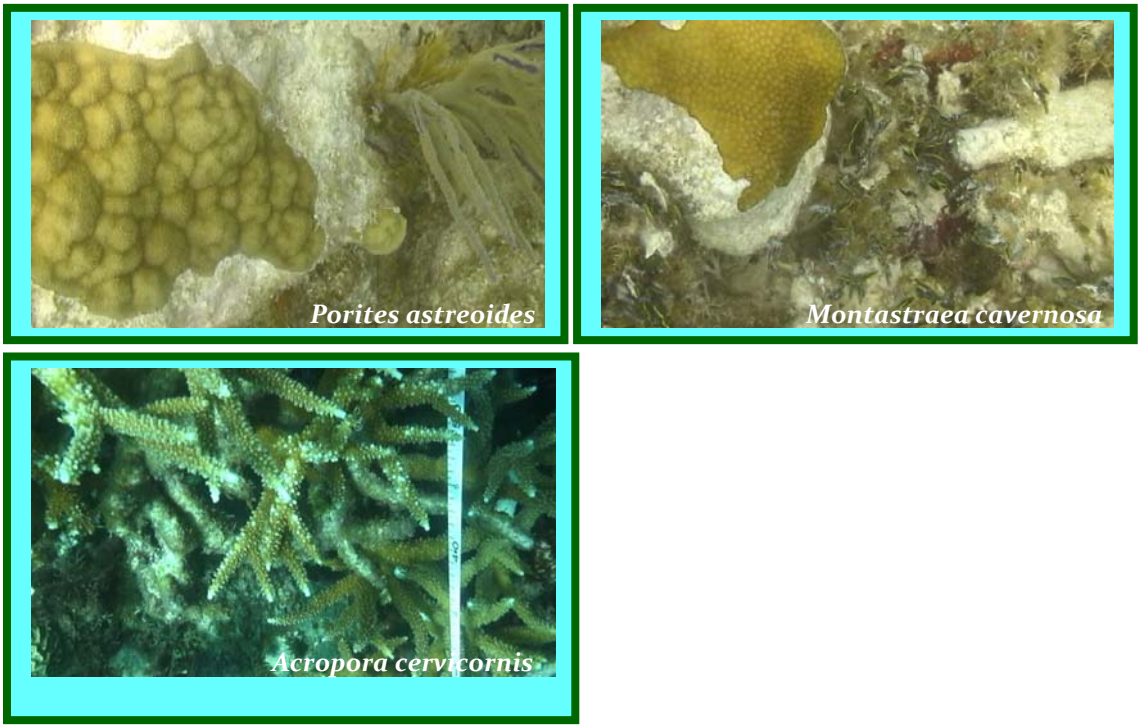

Figure 2.6: Images of hard coral species observed during monitoring at Little Bird Island in Antigua, October 2007 and April 2008; *Porites astreoides, Montastraea cavernosa and Acropora cervicornis.*

2.5 DISCUSSION

The hard coral cover observed during both monitoring occasions were similar in value even though different numbers of transects were videotaped. Although *Acropora palmata* beds were previously reported to be extensive in this area no colonies were observed during this monitoring exercise. This similarity was also observed with the other benthic substrate categories. A review of the video footage and an examination of the data revealed that the area had experienced significant disturbance which supports the observations of Bouchon *et al* (2004) particularly with respect to the low coral (approximately 4%) and high algal (macroalgae and dead coral with algae) cover.

Monitoring in Antigua suffered a number of setbacks which resulted in two sets of monitoring being conducted. During the first monitoring exercise (October 2007) time was spent establishing the transects which left limited time to conduct the actual monitoring. Poor weather conditions and other logistical constraints resulted in significant delays, to the extent that the establishment of new transects and monitoring had to be repeated (April 2008). The April 2008 transects were established at the site of a 2002 study which was conducted using line and point intercept methods. These were in a different location from those established in October 2007.

It was felt by the Antiguan team that the lessons learnt in the training workshop in St. Lucia were invaluable, and could be enhanced by a follow up workshop in which the application of the initial training could be evaluated, compared to field experience and fine-tuned. The efforts of the Fisheries Division were greatly facilitated by Dive Antigua, a local dive shop. This type of cooperation between public and private stakeholders greatly enhances conservation activities.

CHAPTER 3

DOMINICA

Figure 3.1: Map of Dominica.

3.1 DOMINICA COUNTRY PROFILE[5]

Dominica officially called the Commonwealth of Dominica (290 mi^2/750 km^2), is an island of volcanic origin with very steep topography (Figure 3.1). It is mountainous and forested, with a wide variety of flora and fauna and an extensive national park system. The population is estimated at 75,514 (2008) and is primarily

[5] Source: CIA The 2008 World FactBook. (www.cia.gov/library/publications/the-world-factbook); The Columbia Encyclopedia 6th Edition. 2007. Columbia University Press (ww.bartleby.com)

involved in the cultivation of bananas for export along with citrus, coconuts, and the production of coconut oil. Mangoes and root crops are also grown. Industry is generally limited to food processing and the manufacture of soap and other coconut-based products. Tourism is now becoming an important foreign exchange earner.

3.2 CORAL REEF AND MARINE RESOURCES OF DOMINICA

The small population and minimal coastal development means that the corals have not been severely impacted by human activities. There are few well-defined offshore bank reefs, as the shelf can drop steeply within 30 m of the shore. The most productive coral reefs are within 250 m of the shore (Bouchon *et al*, 2004). Typically these reefs have high hard and soft coral abundance, very low algal cover, no observable diseases, no bleaching, and no anchor damage. Sediments from heavy rains have smothered some reefs on the southern coast nears Scott's Head. The low algal cover is probably linked to high populations of *Diadema* and parrotfish/doctorfish (algal grazers) and there are some large groupers, which is rare for the Caribbean. (Bouchon *et al*, 2004)

Dominica has an impressive record in coral reef conservation for the region, the existing and proposed marine park boundaries are illustrated in Figure 3.2. Staff of the Soufriere/Scott's Head Marine Reserve (SSMR) and the Fisheries Division has been particularly active in conserving the reefs and have the cooperation of commercial diver operators. Water temperature monitoring is carried out and the Fisheries Division conducts diver surveys as part of their monitoring process. Photographic quadrat monitoring was carried out during the period 1994-1996. (Hoetjes, 2002).

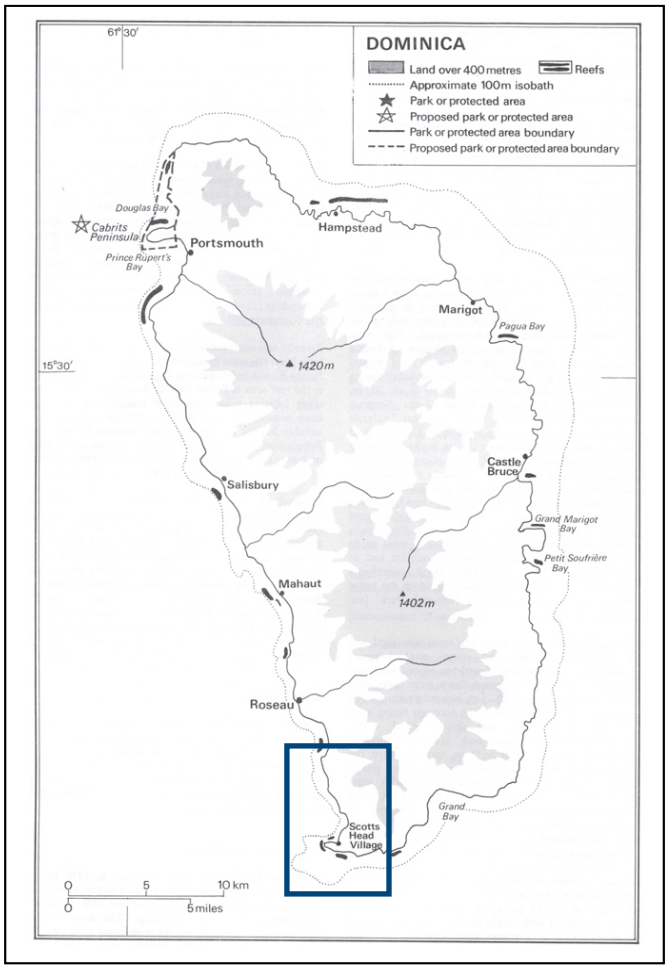

Figure 3.2: Outline map of Dominica showing the existing and proposed marine park boundaries. The Operational Area located at the Soufriere/Scott's Head Marine Reserve is highlighted.

3.3 Overview of Coral Reef Monitoring in Dominica

The Fisheries Department presently have four divers available to participate in the monitoring to take place at four sites within the SSMR located in the southwest of the island. Assessments of seagrass and fish abundance as well as visual surveys of the reef priorities areas within the SSMR have been carried out and raw data exists which have not been processed nor analyzed (Creary, 2007).

3.4 MACC CORAL REEF MONITORING IN DOMINICA

3.4.1 METHODOLOGY

3.4.1.1 SITE SELECTION AND DESCRIPTION

The Soufriere/Scott's Head Marine Reserve which is located at the south western coast of Dominica was selected as the Operational Area (Figure 3.2). Four monitoring sites were selected within this Operational Area which consisted of large volcanic rock and boulders. These were Soufriere Pinnacle which consisted of pinnacles rising up from the coast shelf, Danglebens reef formed from granite extrusion and consisting of a main ridge interwoven with pinnacles and valleys, Point Guignard a gradually sloping reef with wave cut channels and Champagne named because of the presence of hot springs which release hot water that bubbles resembling that of champagne (Figure 3.3). Currents were minimal and visibility was generally good (15 to 25m).

These four sites were selected for a number of logistical and practical reasons. They were in close proximity to dive shop base of operations and all sites were already in use as tourist dive spots and as such had permanent moorings in place. Although the impacts from tourism and possibly from nearby quarry could potentially adversely impact these sites the normal weather conditions tended to divert impacts away from these areas. The impact of quarry on marine environment was, however, being investigated at the time of monitoring by another project.

Figure 3.3: Satellite photograph showing the location of the monitoring sites within the Soufriere/Scott's Head Marine Reserve

3.4.1.2 VIDEO MONITORING

Video monitoring was conducted over the period November 13-15, 2007 and generally followed the procedure outlined in section 1.3.2.1. The monitoring team was comprised of personnel from the CMS, the Fisheries Division and the SSMR. As transects were not established prior the start of the monitoring exercise temporary transects had to be put in place and their positions marked with a combination of iron stakes and flagging tape. Sketches of the orientation of transects at each site were prepared to assist in the relocation of their positions for future monitoring. The transects were oriented generally parallel to the shoreline, except in two sites where some transects had to be oriented perpendicular to the shore to fit on the narrow shelf. Transect 1-7 were videotaped at Soufriere Pinnacle, transects 8-14 at Danglebens, transects 15-20 at Point Guignard and transect 21-22 at Champagne. The two additional transects were videotaped due to the uncertainty of the quality of some of the video footage. Figure 3.4 shows divers participating in the monitoring exercise.

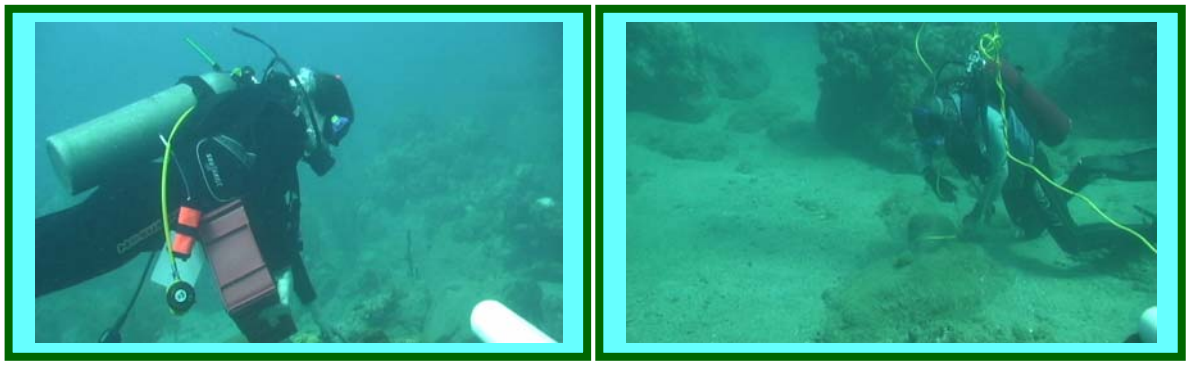

Figure 3.4: Divers participating in the coral reef monitoring exercise in Dominica.

3.4.1.3 DATA PROCESSING AND ANALYSIS

At total of four (4) videotapes were submitted to the CMS along with the metadata and field reports. The tapes contained footage of 22 transects recorded over the period November 13-16, 2007. One transect was discarded because of poor video quality. A total of 1,265 discrete non-overlapping images were captured. Processing of the tapes and the analysis of the images generally followed the procedure outlined in section 1.3.2.2. The tape catalogue and image capture logs are presented in Appendix 3 & 4.

3.4.2 RESULTS

3.4.2.1 BENTHIC SUBSTRATE

The results (Table 3.1, Figure 3.5) of this assessment conducted in November 2007 showed that the four sites selected were dominated by dead coral and algae (54.91%). Hard coral made up 11.40% of the benthic substrate cover while macroalge accounted for 11.64%. Gorgonians (0.97%), sponges (3.68%), zoanthids

(0.04%), coralline algae (0.09%) other live unidentified organisms ((0.71%) made up the remaining living components of the benthic substrate. Sand, pavement and rubble accounted for 16.27% of the benthic substrate. Diseased corals (0.04%) were also observed at this location. The reef formation at Danglebens is shown in Figure 3.6.

Table 3.1: Summary of mean percentage cover for the substrate categories at Soufriere/Scott's Head Marine Reserve, Dominica, November, 2007.

MAJOR CATEGORY (% of transect)	MEAN	STD. DEV.	STD. ERROR
HARD CORAL	11.40	4.44	0.97
GORGONIANS	0.97	1.21	0.26
SPONGES	3.68	3.62	0.79
ZOANTHIDS	0.04	0.18	0.04
MACROALGAE	11.64	12.18	2.66
OTHER LIVE	0.71	0.88	0.19
DEAD CORAL WITH ALGAE	54.91	12.84	2.80
CORALLINE ALGAE	0.09	0.20	0.04
DISEASED CORALS	0.04	0.10	0.02
SAND, PAVEMENT, RUBBLE	16.27	7.63	1.66
UNKNOWNS	0.25	0.42	0.09
Sum (excluding tape+shadow+wand)	100.00		

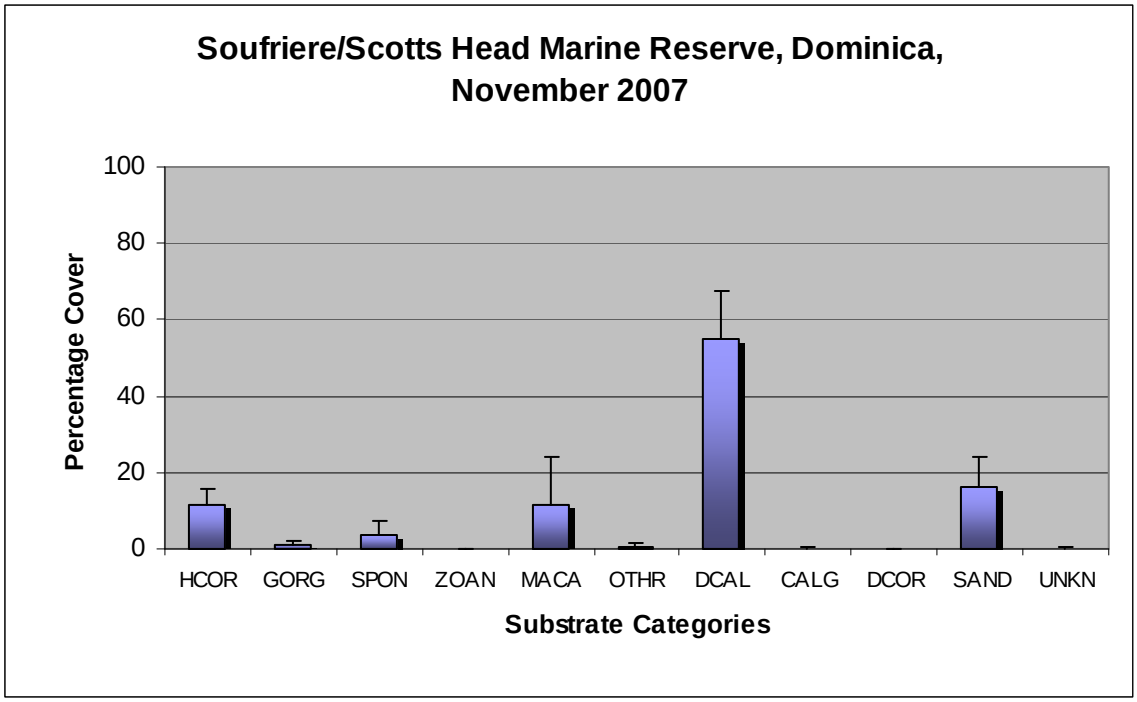

Figure 3.5: Graph illustrating the mean percentage cover of the different substrate categories found in the Soufriere/Scott's Head Marine Reserve, Dominica, November 2007. Error bars represent Standard Deviation (STD. DEV.). (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; SPON – Sponge; ZOAN – Zoanthids; MACA– Macroalgae; OTHR – Other, live; DCAL - Dead coral with algae; CALG – Coralline algae; DCOR– Diseased coral; SAND – Sand, rubble, rock and boulder; UNKN – Unknown.)

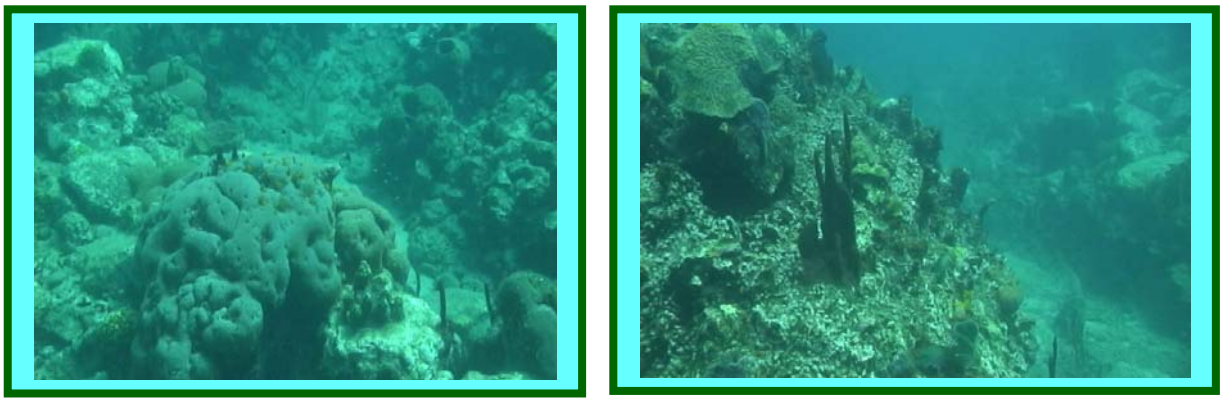

Figure 3.6: Images showing the reef formations at the Danglebens monitoring site located in the Soufriere/Scott's Head Marine Reserve, Dominica.

3.4.2.2 HARD CORAL SPECIES

Twenty-one (21) hard coral species were identified from the four monitoring sites studied in the SSMR which accounted for 11.40% of the benthic substrate cover. The most commonly occurring species were *Porites astreoides* (3.04%), *Siderastrea siderea* (1.80%), *Meandrina meandrites* (1.41%) and *Porites porites* (1.41%). The remaining 17 species each accounted for less than 1% of the substrate cover. Table 3.2 below provides a summary of the percentage cover of the hard coral species observed. Images of some of the more commonly occurring hard coral species observed at the four monitoring sites are shown in Figure 3.7.

Table 3.2: Hard coral species identified at four monitoring sites within the Soufriere/Scott's Head Marine Reserve, Dominica during November 2007.

HARD CORAL SPECIES	MEAN	STD. DEV.	STD. ERROR
Agaricia agaricites	0.12	0.26	0.06
Agaricia fragilis	0.02	0.08	0.02
Agaricia grahamae	0.11	0.27	0.06
Colpophyllia natans	0.09	0.41	0.09
Diploria clivosa	0.02	0.06	0.01
Diploria strigosa	0.31	0.79	0.17
Favia fragum	0.03	0.09	0.02
Manicina areolata	0.07	0.22	0.05
Massive corals	0.01	0.06	0.01
Meandrina meandrites	1.41	1.20	0.26
Millipora complanata	0.15	0.48	0.10
Montastraea annularis	0.61	0.92	0.20
Montastraea cavernosa	0.87	1.47	0.32
Mussa angulosa	0.06	0.28	0.06
Mycetophyllia ferox	0.02	0.05	0.01
Porites astreoides	3.04	2.13	0.46
Porites porites	1.41	2.82	0.62
Scolymia lacera	0.04	0.17	0.04
Siderastrea radians	0.38	0.69	0.15
Siderastrea siderea	1.80	2.30	0.50
Solenastrea bournoni	0.05	0.24	0.05
Solenastrea hyades	0.78	2.63	0.57
Total % Coral Cover	11.40		
Number of Known Species	21		

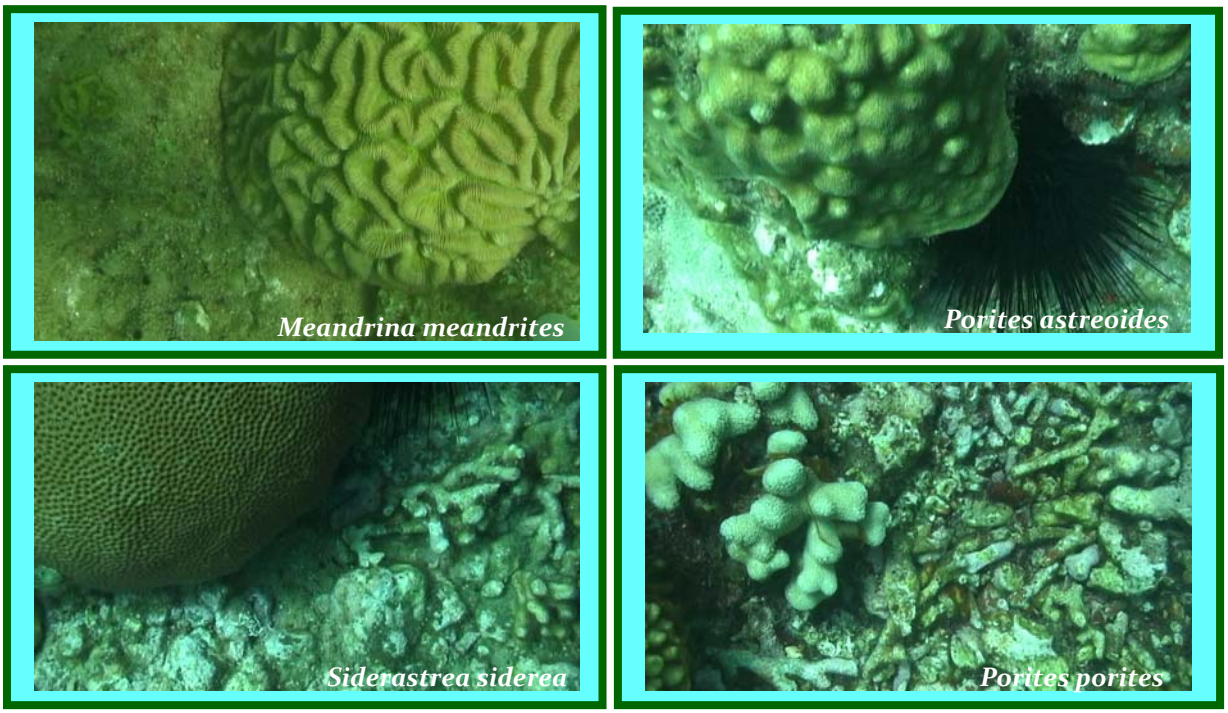

Figure 3.7: Images of the more commonly occurring hard coral species observed during monitoring at four sites within the Soufriere/Scott's Head Marine Reserve, Dominica, November 2007; *Meandrina meandrites, Porites astreoides, Siderastrea siderea* and *Porites porites.*

3.5 DISCUSSION

The sites selected for monitoring fell within the boundaries of SSMR and were located at sites frequently used by dive tourists. The 11.64% coral cover and 21 hard coral species identified were not indicative of the full coral biodiversity within the SSMR (per com Fisheries Department Representative). Bouchon *et al* (2004) describes the typical reefs in Dominica as having "high hard and soft coral abundance, very low algal cover, no observable disease, no bleaching". He also indicated the "sediment from heavy rains have smothered some reefs in the southern coast near Scott's Head". The results of this study did not reflect the condition of the typical Dominican reefs; therefore a decision will have to be made as to whether to retain these sites or to select sites that are more representative.

The Fisheries Department was also of the view that other staff members would benefit from training in this CPACC video monitoring protocol. They also felt that the data processing and analysis portion of the training should be allotted more time as this was not sufficiently addressed during the training exercise in Saint Lucia.

CHAPTER 4

GRENADA

Figure 4.1: Map of Grenada

4.1 GRENADA COUNTRY PROFILE[6]

The island state of Grenada (133 mi² /344 km²), includes the island of Grenada (120 mi²/311 km²) and the southern half of the archipelago known as the Grenadines, a group of largely uninhabitable small islands and islets north of Grenada (Figure 4.1). The island of Grenada is a volcanic, mountainous island with crater lakes. The estimated population is 90,343 (2008) and they are involved primarily in agricultural

[6] Source: CIA The 2008 World FactBook. (www.cia.gov/library/publications/the-world-factbook); The Columbia Encyclopedia 6th Edition. 2007. Columbia University Press (ww.bartleby.com)

directed towards the export of bananas, cocoa, nutmeg, fruits and vegetables and mace. Textiles and clothing are manufactured, and tourism is a developing economic activity.

4.2 CORAL REEF AND MARINE RESOURCES OF GRENADA

There are some fringing and patch reefs around the entire coast of Grenada itself, although the total area of reef is not great. Off the eastern coasts of Carriacou and Petit Martinique relatively large bank barrier reefs have been formed (Spalding, 2001). Grenada has extensive shallow banks that are covered with large robust corals *(Siderastrea, Montastraea)*. The deeper, low profile reefs are, however, quite healthy; algal cover appears to be very seasonal and not strongly linked to eutrophication as considerable growth of macro-algae was observed off uninhabited islands. Parrotfish abundance is quite healthy, however, most fish are small, and *Diadema* are predominantly found in deeper areas. (Bouchon et al, 2004).

There is evidence of significant damage from Hurricane Lenny (and damage from Hurricane Ivan is suspected) at many shallow offshore bank and patch reefs, where large stands of *Acropora palmata* have fallen and have broken up. This damage was also evident on the north of the island. Carriacou and Sandy Island have lost a very high percentage of branching corals in last 5-7 years due to storms. The best reefs in Grenada are off the north coast with some healthy, large, dense stands of *Acropora palmata*; however these may not have survived Hurricane Ivan (Bouchon et al, 2004). Most of the conservation work is done by private dive operations, with some involvement of St Georges University in association with the Fisheries Division. The outline map of Grenada in Figure 4.2 shows the location of the coral reefs.

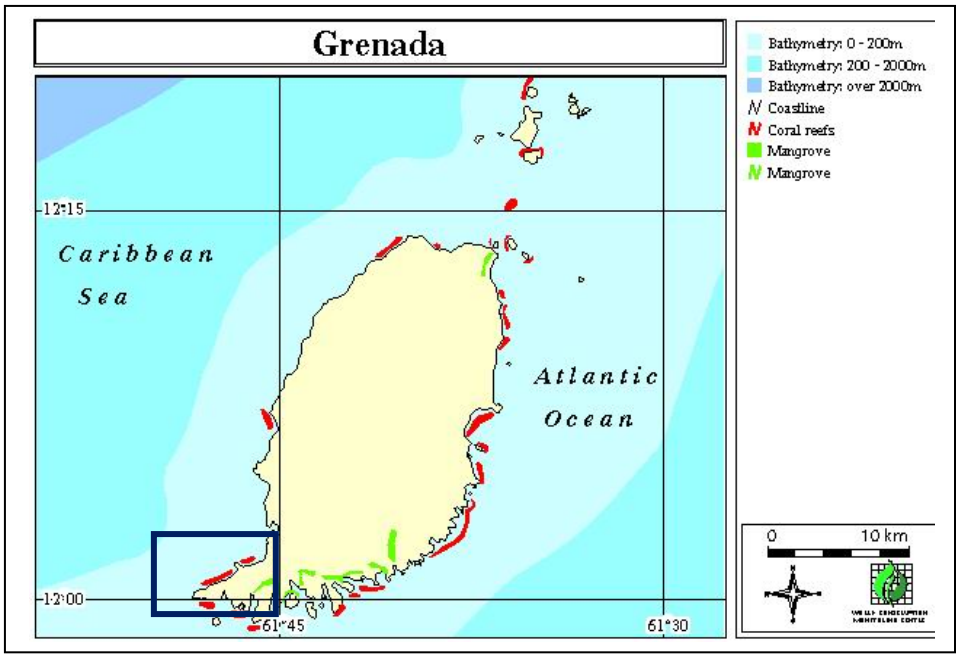

Figure 4.2: Outline map of Grenada showing the location of the coral reefs. The Operational Area within the Grand Anse reef system is highlighted.

4.3 Overview of Coral Reef Monitoring in Grenada

In 2002 Grenada (along with Antigua) participated in a coral reef and coastal zone monitoring programme organized through the NOAA/PIMS/CMRC project that utilized the ECS protocol, one that was similar to that used by AGRRA. These surveys were conducted mainly at the proposed Sandy Island Marine Protected Area. Data was collected quarterly or when time permitted. The ECS method used a volunteer team of 15 persons made up mainly St Georges University (SGU) students and dive operators. Also, mangrove monitoring was conducted by TNC along with SGU, at a total of 29 sites. Reports and data are available for these. Coastal monitoring also included water quality at four established sites where pH, salinity, dissolved oxygen, turbidity, temperature and feacal coliform levels were measured. Other coastal monitoring studies included current pattern surveys, which were carried out on an as needed basis (Creary, 2007).

4.4 MACC Coral Reef Monitoring in Grenada

4.4.1 Methodology

4.4.1.1 Site Selection and Description

The Operational Area selected in located in the south western side of the island of Grenada in the Grand Anse reef system (Figure 4.2). Boss Reef, Middle Boss Reef, Bottom Boss Reef and Northern Exposure were selected as the monitoring sites within the Operational Area (Figure 4.3). The reef system is extensive consisting of gently sloping spur and groove formations supporting various coral reef assemblages. Selection of monitoring sites was based on a number of factors such as their proximity to the dive shop base of operations and the fact they were used as tourist dive spots. These sites however, did not have any permanent moorings. In addition, the Fisheries Department already has data previously collected from this area. There is however existing impacts from fishing activities and nutrient loading from the St Johns River and storm drains from the capital city, St Georges.

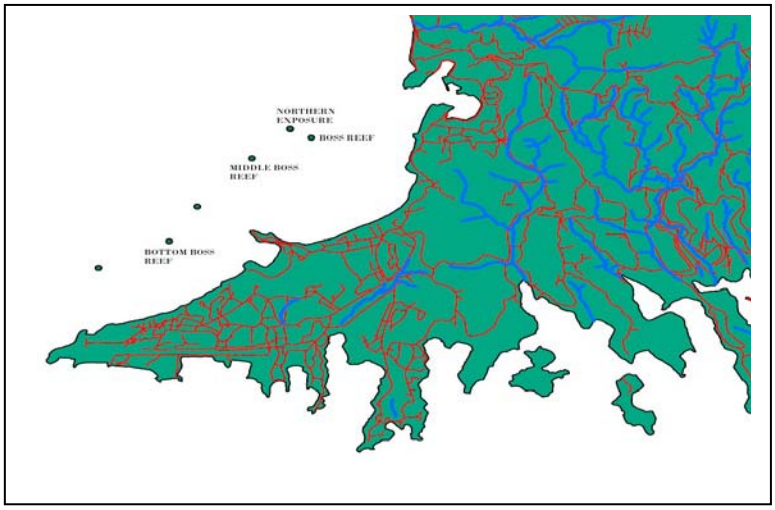

Figure 4.3: Map showing the location of the monitoring sites in the Grand Anse reef system, Grenada.

4.4.1.2 VIDEO MONITORING

Video monitoring was conducted over the period October 31 – November 2, 2007 and generally followed the procedure outlined in section 1.3.2.1. The monitoring team experienced technical problems with the Sony DC1- HC69 camera and the Ikelite underwater housing and had to rent a replacement camera from the dive operators. The monitoring team was comprised of personnel from the CMS, the Fisheries Division and Native Spirit Dive Shop. Monitoring was carried out at the following locations; Boss Reef, Middle Boss Reef, Bottom Boss Reef, and Northern Exposure. As transects were not established prior the start of the monitoring exercise temporary transects had to be put in place and their positions marked with a combination of iron stakes and flagging tape. The transects were oriented generally parallel to the shoreline. Sketches of the orientation of transects at each site were prepared and these along with GPS coordinates will be used to assist in the relocation of their positions for future monitoring. Transect 1-7 were videotaped at Boss Reef, transects 8-11 at Middle Boss Reef, transects 12-15 at Bottom Boss Reef and transect 16-20 videotaped at Northern Exposure..

4.4.1.3 DATA PROCESSING AND ANALYSIS

Footage from the videotaped transects were downloaded from the rented camera to a laptop and copied to CDs. At total of twelve (12) CDs containing the footage from the 20 transects that were recorded over the period October 31 -November 2, 2007 were submitted to the CMS along with the metadata and field reports. Processing of the tapes and the analysis of the images generally followed the procedure outlined in section 1.3.2.2. The tape catalogue and image capture logs are presented in Appendix 3 & 4.

4.4.2 RESULTS

4.4.2.1 BENTHIC SUBSTRATE

The assessment of the benthic substrate cover in the Grand Anse reef system of Grenada showed that the area was dominated by dead coral and algae (42.46%) and macroalgae (41.78%). Hard coral cover represented 10.09% of the benthic substrate while gorgonians, sponges, zoanthids, coralline algae and other unidentified living organisms represented 1.13%, 0.17%, 0.15%, 0.01% and 0.14% respectively. Sand, pavement and rubble accounted for only 4.04% of the benthic substrate cover and there were no diseased corals observed. These data are presented in Table 4.1 and represented graphically in Figure 4.4.

Table 4.1: Summary of the mean percentage cover for the substrate categories at Grand Anse reef system, Grenada in October/November, 2007

MAJOR CATEGORY (% of transect)	MEAN	STD. DEV.	STD. ERROR
HARD CORAL	10.09	4.58	1.02
GORGONIANS	1.13	1.61	0.36
SPONGES	0.17	0.25	0.05
ZOANTHIDS	0.15	0.38	0.08
MACROALGAE	41.78	12.90	2.88
OTHER LIVE	0.14	0.25	0.06
DEAD CORAL WITH ALGAE	42.46	11.11	2.48
CORALLINE ALGAE	0.01	0.03	0.01
DISEASED CORALS	0.00	0.00	0.00
SAND, PAVEMENT, RUBBLE	4.04	2.98	0.67
UNKNOWNS	0.02	0.07	0.02
Sum (excluding tape+shadow+wand)	100.00		

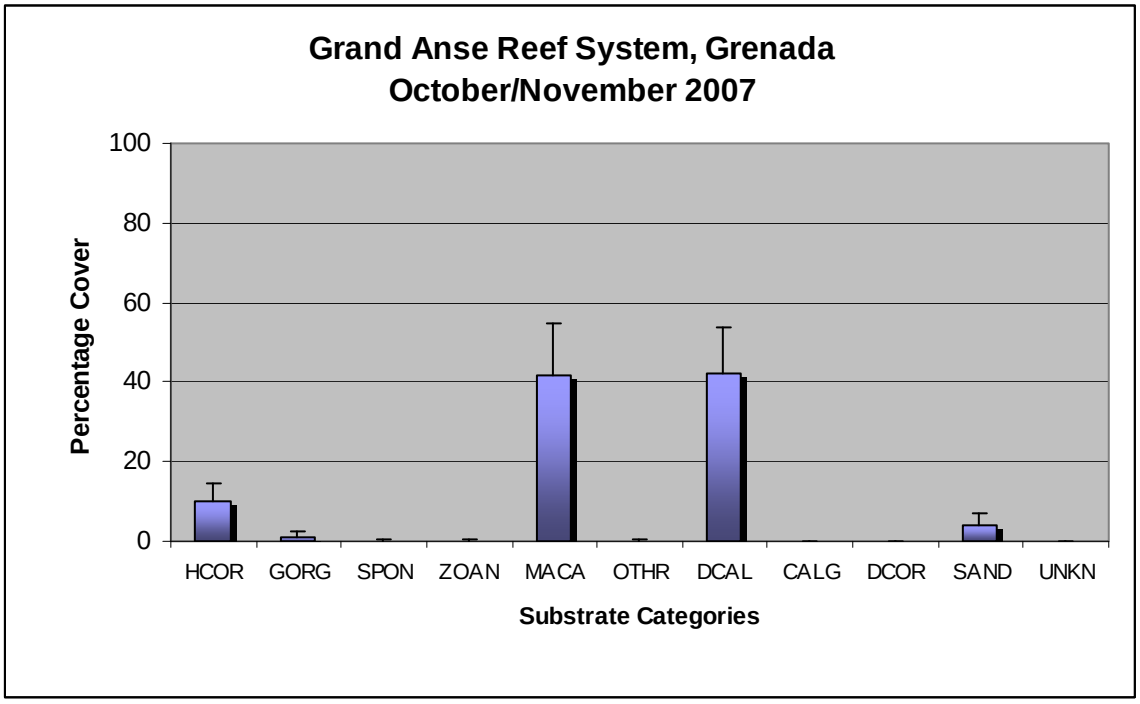

Figure 4.4: Graph illustrating the mean percentage cover of the different substrate categories found in the Grand Anse reef system, Grenada, October/November 2007. Error bars represent Standard Deviation (STD. DEV.). (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; SPON – Sponge; ZOAN – Zoanthids; MACA– Macroalgae; OTHR – Other, live; DCAL - Dead coral with algae; CALG – Coralline algae; DCOR– Diseased coral; SAND – Sand, rubble, rock and boulder; UNKN – Unknown.)

4.4.2.2 HARD CORAL SPECIES

A total of fifteen (15) hard coral species were identified during the video monitoring assessment of the Grand Anse reef system which accounted for 10.09% of the benthic substrate cover. *Porites porites* and *Porites astreoides* were the most commonly occurring species accounting for 5.17% and 2.59% respectively of this benthic substrate cover. Other coral species frequently observed included *Montastraea annularis* (0.77%) and *Montastraea cavernosa* (0.59%) *Siderastrea siderea* (0.32%) and *Diploria strigosa* (0.28%). Table 4.2 provides a summary of the percentage cover of the coral species occurring at Gande Anse, some of these coral species are illustrated in Figure 4.5.

Table 4.2: Hard coral species identified at Grand Anse reef system, Grenada, October/ November 2007.

HARD CORAL SPECIES	MEAN	STD. DEV.	STD. ERROR
Diploria clivosa	0.03	0.12	0.03
Diploria labyrinthiformis	0.03	0.10	0.02
Diploria strigosa	0.28	0.44	0.10
Meandrina meandrites	0.03	0.09	0.02
Millipora alcicornis	0.04	0.10	0.02
Millipora complanata	0.12	0.30	0.07
Montastraea annularis	0.77	1.22	0.27
Montastraea cavernosa	0.59	0.81	0.18
Mycetophyllia aliciae	0.01	0.03	0.01
Mycetophyllia ferox	0.01	0.04	0.01
Porites astreoides	2.59	1.36	0.30
Porites furcata	0.01	0.05	0.01
Porites porites	5.17	3.62	0.81
Siderastrea radians	0.09	0.29	0.07
Siderastrea siderea	0.32	0.42	0.09
Total % Coral Cover	10.09		
Number of Known Species	15		

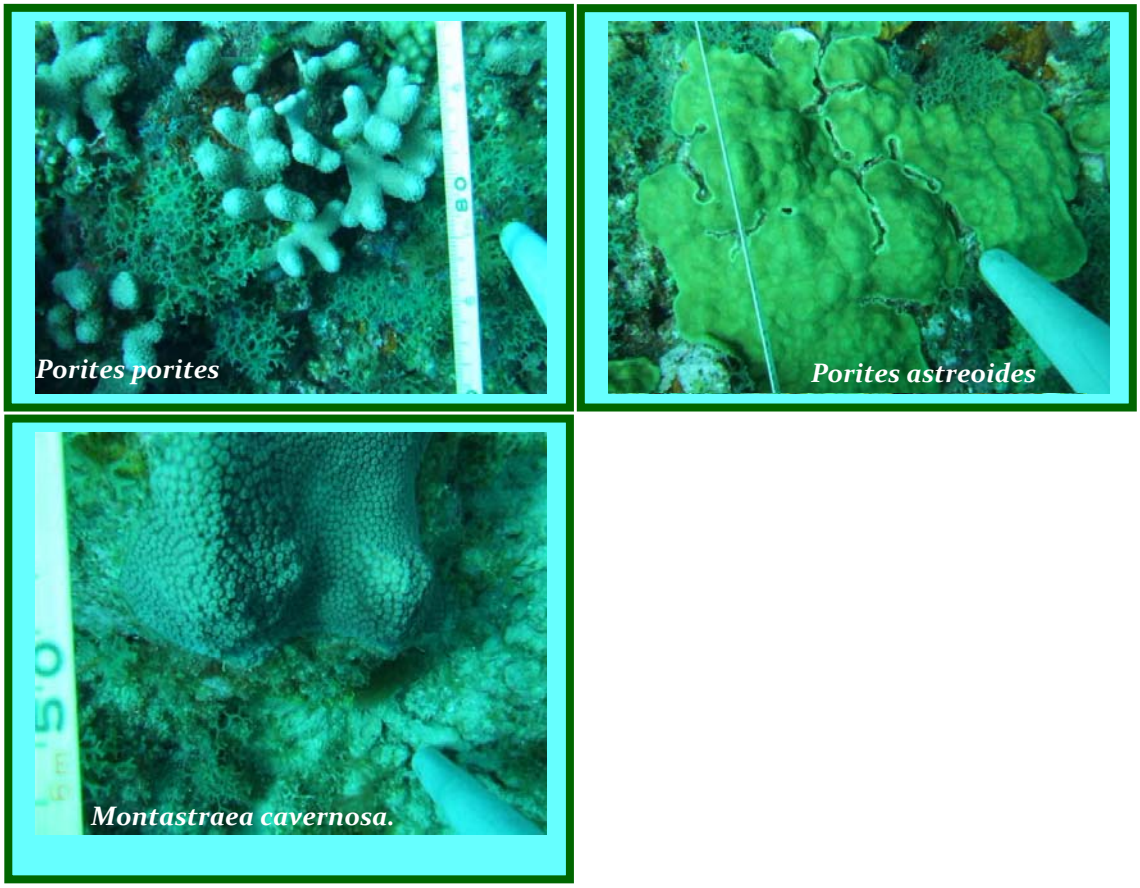

Figure 4.5: Images of hard coral species observed during monitoring in the Grand Anse reef system, Grenada, October/November 2007; *Porites porites, Porites astreoides and Montastraea cavernosa.*

4.5 Discussion

Tourism is very well developed on the southeast coast of Grenada, particularly at Grande Anse Bay, an area that is very important for recreational diving. The Fisheries Department has proposed a system of marine protected areas for Grenada (Burke & Maidens, 2004) and it is expected that the results from this monitoring exercise will be used in conjunction with previous data to form part of a proposal to be submitted for the Grand Anse reef system to be designated a protected area.

With regards to the monitoring there were some technical and logistical challenges faced by the monitoring team. The transects were not set up prior to monitoring and one set up was not permanently marked but GPS coordinates and transect alignment sketches were prepare to aid in relocating the transect positions for future monitoring. There were problems associated with camera and housing provided by MACC and a replacement digital camera was rented to conduct the monitoring. The video footage was therefore downloaded directly to DVDs hence no video tapes are available for archiving.

CHAPTER 5

ST KITTS AND NEVIS

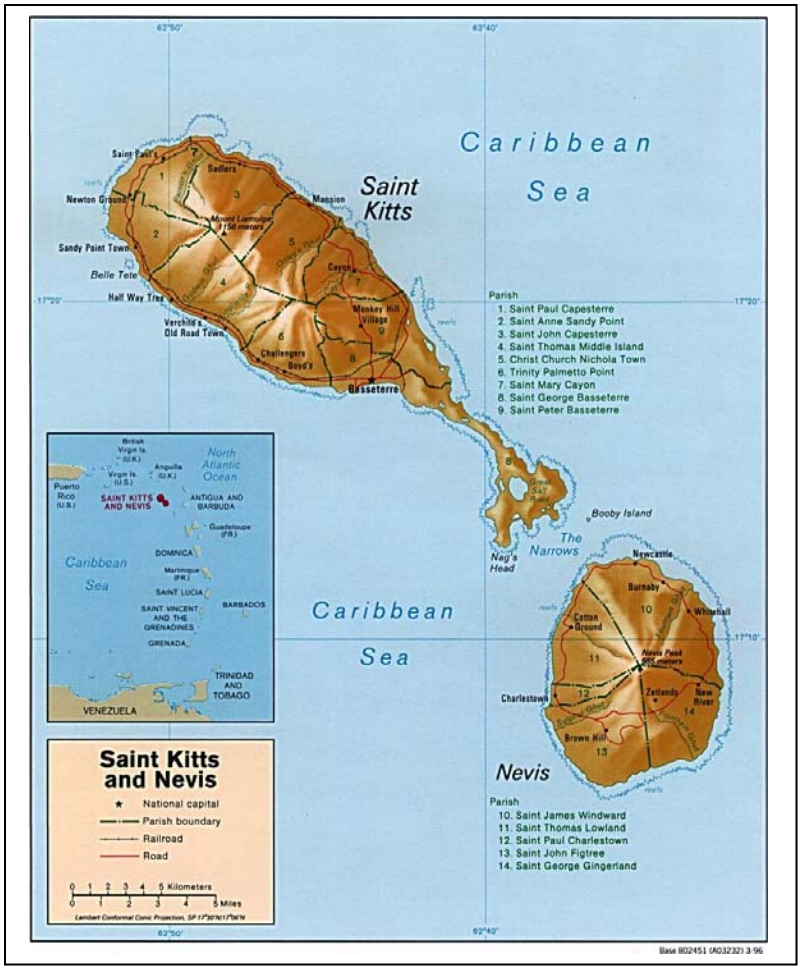

Figure 5.1: Map of St Kitts and Nevis

5.1 ST KITTS AND NEVIS COUNTRY PROFILE[7]

Saint Kitts and Nevis (120 mi² /311 km²), consists of the islands of Saint Kitts, also called Saint Christopher (68 mi²/176 km²), Nevis (50 mi²/130 km²), and Sombrero (2 mi²/5.2 km²) (Figure 5.1). A narrow strait separates the two larger islands, which are volcanic in origin, mountainous, and renowned

[7] Source: CIA The 2008 World FactBook. (www.cia.gov/library/publications/the-world-factbook); The Columbia Encyclopedia 6th Edition. 2007. Columbia University Press (ww.bartleby.com)

for their scenery. The population is estimated at 39,619 (2008) and is largely involved in tourism, manufacturing, and a growing offshore financial industry. Machinery, food, electronics, beverages, and tobacco are exported. Sugar and molasses were also historically important exports, but financial losses led the government to end sugar production and processing in 2005.

5.2 Coral Reef and Marine Resources of St Kitts and Nevis

St Kitts has fringing reefs along much of the coastline (Figure 5.2), offshore bank reefs, such as Ponds Bar, and near vertical walls. Monitoring was restricted to the leeward side of island, where fish populations of both predatory and grazing species were relatively high, however, *Diadema* populations were relatively low. The Kenneth Dive Centre has maintained observations of fish abundance for 30 years and reports a significant decline, although the numbers are comparable with other Caribbean islands. (Bouchon *et al*, 2004).

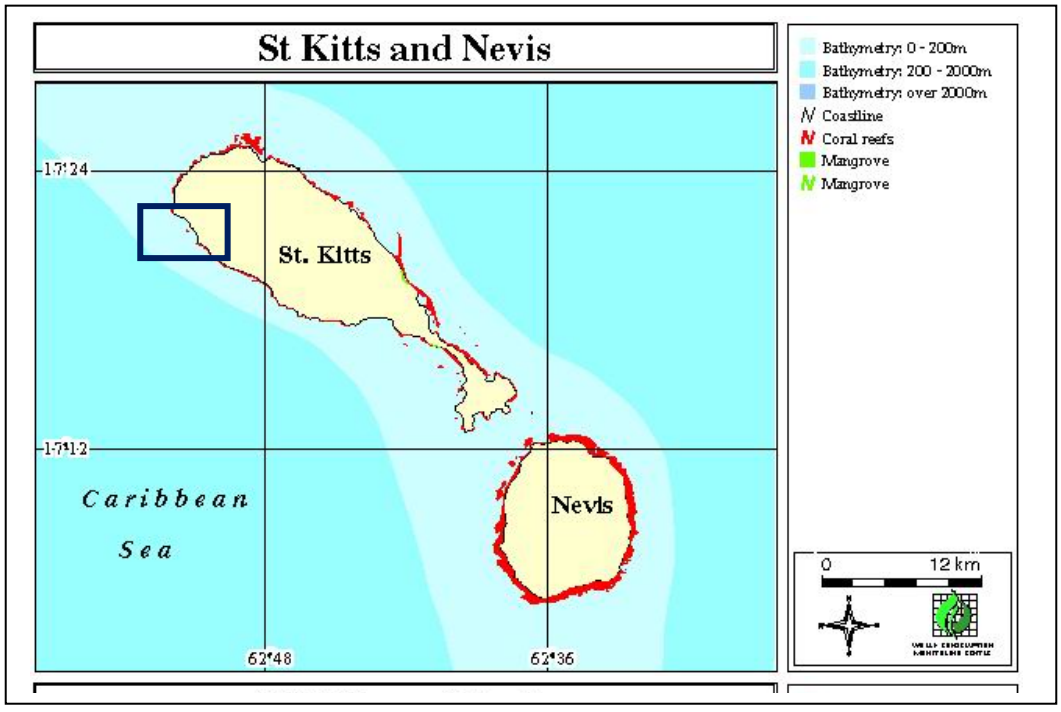

Figure 5.2: Outline map of St Kitts and Nevis showing the location of the coral reefs. The Operational Area at Sandy Point is highlighted.

5.3 Overview of Coral Reef Monitoring in St Kitts and Nevis

The monitoring of coral reef in St. Kitts started in the early 90's. From 1992 the Fisheries Department was responsible for coral reef monitoring in St. Kitts, until 1996, when the government created the Department of Environment which should have assumed the responsibility for coral reef monitoring. However, because of a misunderstanding regarding the role and responsibilities of the two departments the monitoring programme came to a halt. With the creation of the Department of Environment, the Fisheries Department stopped monitoring. However, the new Department of Environment was not adequately staffed to take on monitoring responsibilities and they assumed that the Fisheries Department would continue doing the monitoring. In 2005 the government of St. Kitts merged the Department of Physical Planning and Environment to create the Department of Sustainable Development. At present the Department of Sustainable Development along with assistance from the St. Kitts Nevis Defence Force Coast Guard has resumed the coral reef monitoring. The Coastal Zone Management Unit will assume the responsibility for coral reef monitoring once it is established. The Department of Fisheries has several trained scuba divers and one dive master and the Sustainable Development Unit have one trained scuba diver.

5.4 MACC Coral Reef Monitoring in St Kitts and Nevis

5.4.1 Methodology

5.4.1.1 Site Selection and Description

Sandy Point is located approximately 13 km to the north west of the capital of Basseterre. Paradise Reef, located offshore of Sandy Point is an isolated reef with spur and groove formations surrounded by sand, 50 m wide and approximately 250 m long (Figure 5.3). The reef was located in moderately deep water, ranging from 20 m depth in its south-eastern section to 15 m in its north-western section. Horizontal visibility was generally greater than 20 m for the duration of the survey. The Paradise Reef system at Sandy Point site was selected primarily due to its accessibility for monitoring.

Figure 5.3: Satellite photograph showing the location of Paradise Reef at Sandy Point along the northwest coast of St Kitts.

5.4.1.2 VIDEO MONITORING

Video monitoring was conducted over the period November 5-7, 2007 and generally followed the procedure outlined in section 1.3.2.1. The monitoring team was comprised of personnel from the CMS, The St Kitts Coast Guard and the Planning Department. The monitoring team journeyed by boat from the St. Kitts Coast Guard base in Basseterre picking up additional team members from shore at Sandy Point. The St. Kitts team had managed to deploy most of the 20 permanent transects prior to the conducting of video monitoring. The PVC pipes on the rebars used to define the transects were clearly visible from the surface and the lobate shape of the reef made it easy to define the general location of the start points of the exercise. Transects were generally numbered extending from the deepest location at the site to the shallowest site, with the transects being oriented along the long axis of the reef (i.e., southeast to northwest). Figure 5.4 shows a member of the monitoring team participating in the monitoring exercise.

Figure 5.4: Member of monitoring team reeling in the transect tape at the end of the video monitoring exercise at the Paradise Reef monitoring site at Sandy Point, St Kitts.

5.4.1.3 DATA PROCESSING AND ANALYSIS

Three videotapes containing 19 video transects were submitted to the CMS along with the metadata and field report. A total of 1331 discrete non-overlapping images were captured from the video transects. Processing of the tapes and the analysis of the images generally followed the procedure outlined in section 1.3.2.2. The tape catalogue and image capture logs are presented in Appendix 3 & 4.

5.4.2 RESULTS

5.4.2.1 BENTHIC SUBSTRATE

Paradise Reef at Sandy Point in St Kitts was assessed during November 2007 and was found to be dominated by macroalgae (73.77%). Hard coral cover accounted for 10.25% of the benthic substrate, while sponges made up 7.49% of the total. Gorgonians, zoanthids, coralline algae and other unidentified living organisms represented 1.02%, 0.09%, 0.05% and 0.13% respectively of the benthic substrate. A summary of this data is found in Table 5.1 and illustrated in Figure 5.5. Images of Paradise Reef shown in Figure 5.6 below illustrates the spur and groove formation typical of this area.

Table 5.1: Summary of mean percentage cover for the substrate categories at Paradise Reef, Sandy Point in St Kitts during November 2007

MAJOR CATEGORY (% of transect)	MEAN	STD. DEV.	STD. ERROR
HARD CORAL	10.25	4.31	1.01
GORGONIANS	1.02	1.25	0.29
SPONGES	7.49	2.97	0.70
ZOANTHIDS	0.09	0.16	0.04
MACROALGAE	73.77	6.50	1.53
OTHER LIVE	0.13	0.12	0.03
DEAD CORAL WITH ALGAE	2.25	1.99	0.47
CORALLINE ALGAE	0.05	0.10	0.02
DISEASED CORALS	0.04	0.08	0.02
SAND, PAVEMENT, RUBBLE	4.86	5.18	1.22
UNKNOWNS	0.06	0.14	0.03
TAPE, WAND, SHADOW	2.90	1.25	0.29
Sum (excluding tape+shadow+wand)	100.00		

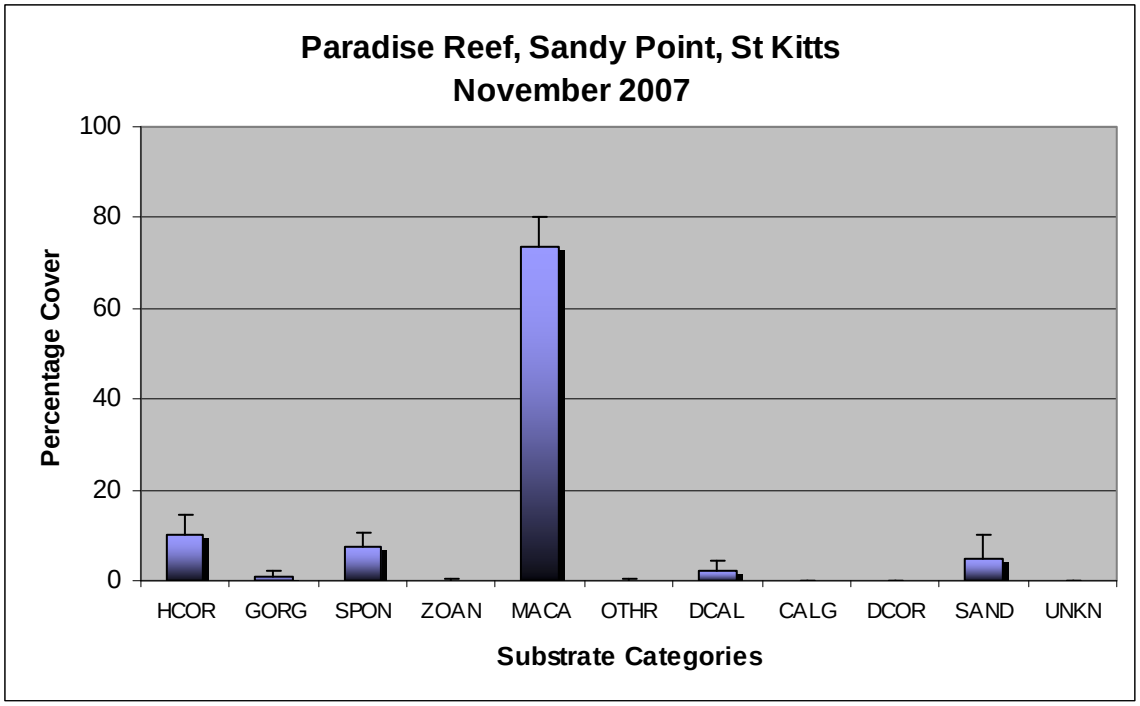

Figure 5.5: Graph illustrating the mean percentage cover of the different substrate categories found at Paradise Reef, Sandy Point in St Kitts, November 2007. Error bars represent Standard Deviation (STD. DEV.). (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; SPON – Sponge; ZOAN – Zoanthids; MACA– Macroalgae; OTHR – Other, live; DCAL - Dead coral with algae; CALG – Coralline algae; DCOR– Diseased coral; SAND – Sand, rubble, rock and boulder; UNKN – Unknown.)

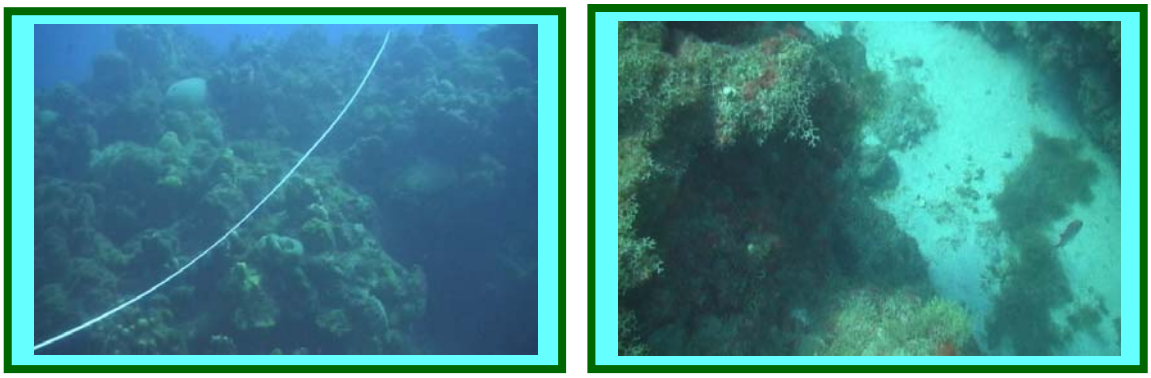

Figure 5.6: Images of the Paradise Reef at Sandy Point, St Kitts, highlighting the spur and groove formation typical of this area.

5.4.2.2 HARD CORAL SPECIES

There were twenty-two (21) hard coral species identified during the monitoring exercise, which made up 10.25% of the total benthic substrate cover. The most commonly occurring species was *Porites astreoides* (5.81%) and to a much lesser extent *Montastraea faveolata* (1.15%), *Montastraea annularis* (0.91%) and *Siderastrea siderea* (0.72%). Table 5.2 provides as summary of the percentage cover of the hard coral species occurring at Paradise Reef. Images of some of these species are presented in Figure 5.7.

Table 5.2: Coral species identified at Paradise Reef, Sandy Point in St Kitts, November 2007.

HARD CORAL SPECIES	MEAN	STD. DEV.	STD. ERROR
Agaricia agaricites	0.04	0.13	0.03
Colpophyllia natans	0.12	0.29	0.07
Dichocoenia stokesi	0.02	0.07	0.02
Diploria labyrinthiformis	0.23	0.42	0.10
Diploria strigosa	0.06	0.17	0.04
Eusmilia fastigiata	0.10	0.19	0.04
Favia fragum	0.01	0.03	0.01
Madracis mirabilis	0.16	0.56	0.13
Massive corals	0.02	0.07	0.02
Meandrina meandrites	0.30	0.39	0.09
Millipora complanata	0.01	0.02	0.01
Millipora squarrosa	0.02	0.07	0.02
Montastraea annularis	0.91	1.02	0.24
Montastraea cavernosa	0.38	0.47	0.11
Montastraea faveolata	1.15	2.23	0.53
Mycetophyllia lamarckiana	0.07	0.13	0.03
Porites astreoides	5.81	2.24	0.53
Porites furcata	0.04	0.12	0.03
Porites porites	0.05	0.14	0.03
Siderastrea radians	0.01	0.03	0.01
Siderastrea sidereal	0.72	0.89	0.21
Solenastrea bournoni	0.03	0.11	0.03
Total % Coral Cover	10.25		
Number of known species	21		

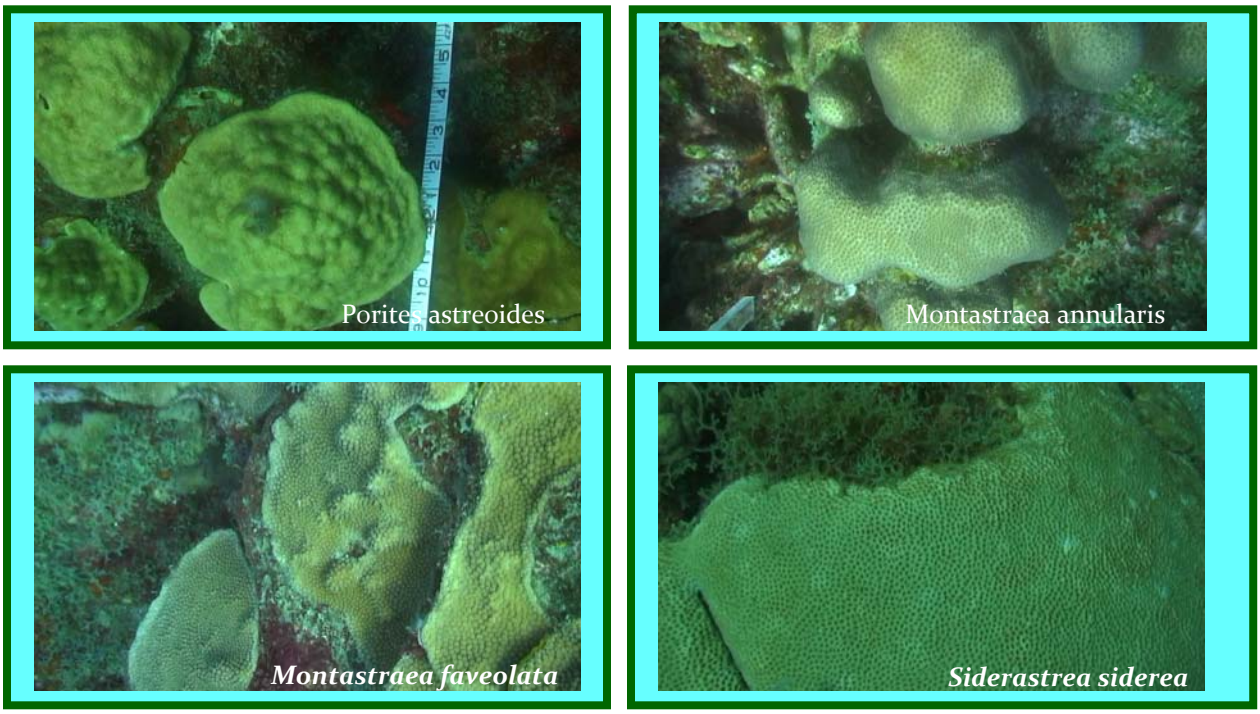

Figure 5.7: Images of the more commonly occurring coral species found at Paradise Reef, Sandy Point, St Kitts, November 2007; *Porites astreoides, Montastraea annularis, Montastraea faveolata* and *Siderastrea siderea*.

5.5 Discussion

Paradise Reefs is located within the designated National Marine Park at Sandy Point and features giant basket sponges as part of the coral assemblage. This area is well used by divers but its designation as a protected area prevents boats from anchoring and damaging the reefs[8].

Despite the challenges related to the institutional arrangements for coral monitoring there is good cooperation between the relevant agencies, and this facilitated the seamless implementation of this monitoring programme.

[8] Source: www.stkittstourism.kn

CHAPTER 6

SAINT LUCIA

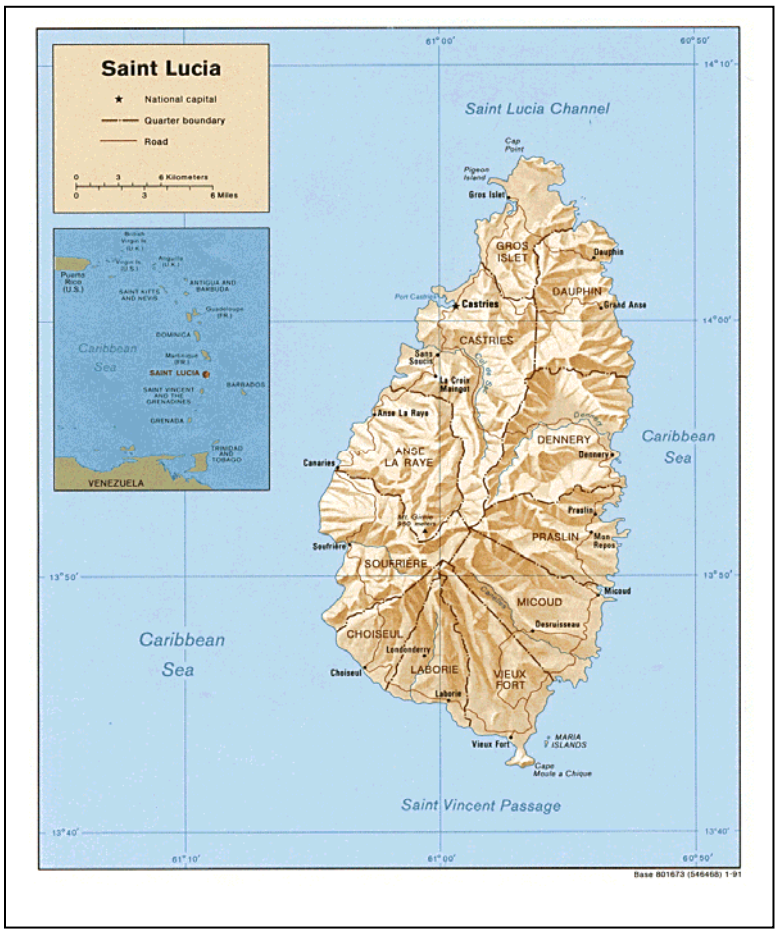

Figure 6.1: Map of Saint Lucia

6.1 SAINT LUCIA COUNTRY PROFILE[9]

Saint Lucia (238 mi² /616 km²) is a volcanic island (Figure 6.1). The highest point on Saint Lucia, Mount Gimie (3,145 ft/959 m) and the twin pyramidal cones known as the Pitons, which are within the Piton Management Area, a World Heritage Site (2004), are the most imposing landmarks. Saint Lucia has an

[9] Source: CIA The 2008 World FactBook. (www.cia.gov/library/publications/the-world-factbook); The Columbia Encyclopedia 6th Edition. 2007. Columbia University Press (ww.bartleby.com)

estimate population of 172,884 (2008) and has an economy based largely on tourism and agriculture (bananas, cocoa, and other tropical products are exported). The island is also involved in the offshore banking industry, and has diversified its industrial base to include light manufacturing: the assembly of electronic components, and oil refining and transhipment.

6.2 Coral Reef and Marine Resources of Saint Lucia

Coral reefs are generally poorly developed, often only forming a thin veneer over the underlying volcanic substrates. The best-developed reefs are in the south and east, although the best studied and most heavily utilized coral communities occur along the west coast (Spalding, 2001) (Figure 6.2). Reef Check surveys in Saint. Lucia (Maria Island Wildlife Nature Reserve, Anse Chastanet, Coral Gardens, Malgretoute and Turtle Reef) in 2001 showed that the shallow reefs (3 m) continued to be under stress with further declines since the 1999 surveys. The shallow sites were dominated by standing dead *Acropora palmata*, which contributed to more than 50% of the total benthic cover. Live coral cover averaged 6.9%, ranging from 2-10.6% and fleshy algal cover averaged 15.8%, ranging from 12-19.4%. The deeper reefs (10 m) appeared healthier than the shallow reefs with 17% cover, although this was still a decline from 1999. Algal cover averaged 22.2% (Hoetjes, 2002).

The Soufriere Marine Management Area (SMMA) extends along the southwest coast of Saint Lucia. The Soufriere Marine Management Association, a non-profit stakeholder company, manages the site. The establishment of the SMMA has contributed to an increase in scientific study, improved the status of coral reefs and fish stocks in the marine reserves, and increased fishers' catches. The SMMA's mission is *'to contribute to national and local development, particularly in the fisheries and tourism sectors, through the management of the Soufriere coastal zone, based on the principles of sustainable use, cooperation among resource users, institutional collaboration, active and enlightened local participation, and equitable sharing of benefits and responsibilities among stakeholders'*. User fees have made the reserve effectively self-financing but in addition, the government of Saint Lucia and donor organisations assist with infrastructure development, training and public education (Bouchon et al, 2004).

6.3 Overview of Coral Reef Monitoring in Saint Lucia

The SMMA was started in 1995 and has a comprehensive monitoring system in place. This system provided a framework that gave priority to research and monitoring utilizing established protocols. Weekly monitoring of salinity, turbidity and sedimentation were performed, while Reef Check monitoring was carried out twice per year. Beach and water quality monitoring were carried out in conjunction with the Department of Fisheries. The SMMA has also been a part of a regional exercise involving nutrient monitoring in conjunction with Bonaire, Curacao and Florida. Temperature loggers are in place at the five permanent Reef Check transect locations. There are Reef Check, water quality monitoring and nutrient monitoring sites throughout the island but data analysis is considered a major constraint with regards to getting the information to decision makers (Creary, 2007).

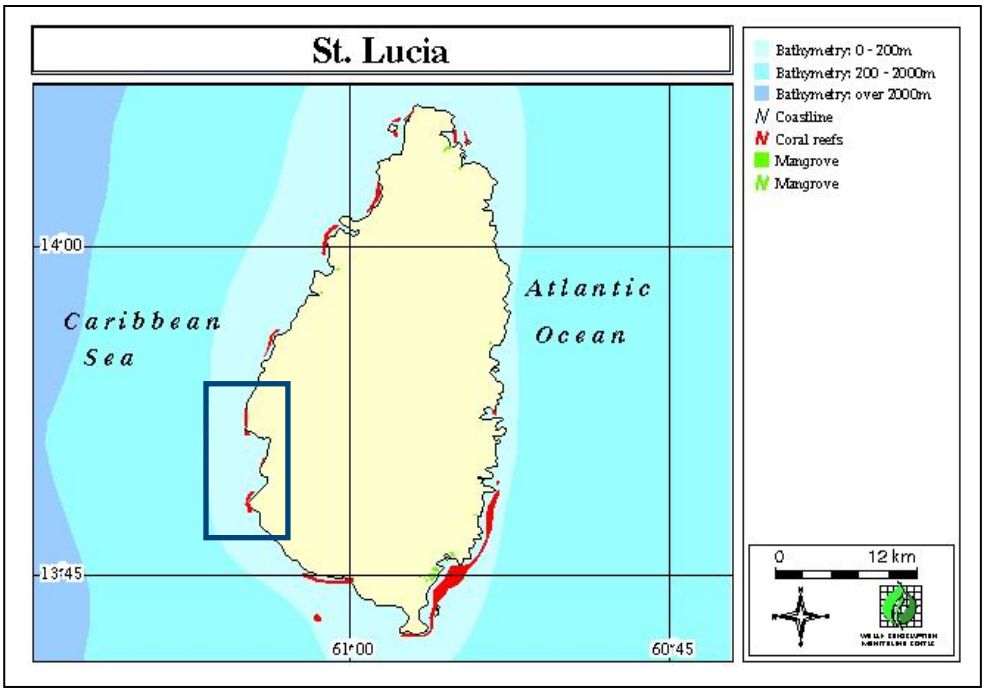

Figure 6.2: Outline map of Saint Lucia showing the location of the coral reefs. The Operational Area at the Soufriere Marine Management Area is highlighted.

6.4 MACC Coral Reef Monitoring in Saint Lucia

6.4.1 Methodology

6.4.1.1 Site Selection and Description

Saint Lucia was the location for the regional training workshop that saw 16 participants from seven countries trained in the CPACC Video Monitoring Protocol. Members of the Fisheries Department were requested to select a site suitable for training as well as long term monitoring. The SMMA was selected as the Operational Area for this project because of its status as a protected area and that it already had a comprehensive monitoring programme in place (Figure 6.2). The SMMA also had a number of dive sites with permanent moorings. Turtle Reef, Anse Chastnanet Reef, Grand Caille, Coral Gardens and Malgretoute were selected for video monitoring as they best met the site selection criteria outlined in the protocol (Figure 6.3). Some transects were marked prior to the monitoring and the remainder done during the training and monitoring exercise.

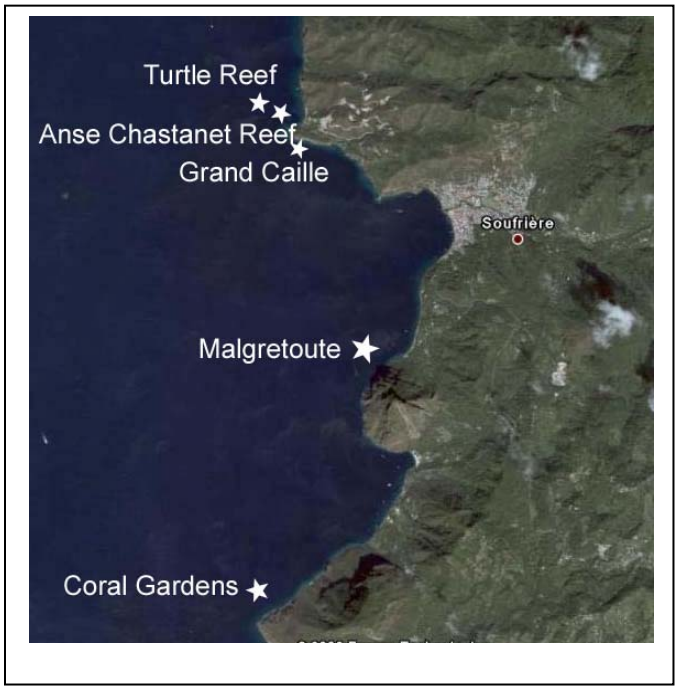

Figure 6.3: Satellite photograph showing the location of the monitoring sites within the Soufriere Marine Management Area, Saint Lucia.

6.4.1.2 VIDEO MONITORING

Monitoring in the SMMA was carried out over the period September 12-14, 2007 immediately following the regional training workshop and generally followed the procedure outlined in section 1.3.2.1. Monitoring was carried out by two teams of divers comprised of personnel from the CMS, SMMA and the Fisheries Department. Logistical support for the monitoring was provided by the staff of the Fisheries Department and the SMMA, which included the provision of boats and dive equipment (Figure 6.4). One team used a Sony DC1- HC69 camera fitted with an Ikelite underwater housing, while the second team used the camera and housing belonging to the SSMA. The first team conducted video monitoring at Turtle Reef (Transects 6-9) and Grand Caille (Transects 1-4) while the second team carried out video monitoring at Anse Chantanet (Transects 10-13), Coral Gardens & Malgretoute (Transect 14-21). Transects 5 was omitted and replaced with transect 21.

Figure 6.4: Team members conducting video monitoring at the Grand Caille monitoring site located in the Soufriere Marine Management Area, Saint Lucia.

6.4.1.3 Data Processing and Analysis

Four (4) videotapes containing 20 video transects were submitted to the CMS along with the metadata and field report. A total of 1,089 discrete non-overlapping images were captured from the video transects. Processing of the tapes and the analysis of the images generally followed the procedure outlined in section 1.3.2.2. The tape catalogue and image capture logs are presented in Appendix 3 & 4.

6.4.2 Results

6.4.2.1 Benthic Substrate

The assessment of the coral reefs within the SMMA was carried out in September 2007. Analysis of the data showed that the area was dominated by macroalgae (44.11%). The hard coral cover was determined to be 9.53% while gorgonians made up 1.35% of the cover and sponges made up 7.07%. Other categories which included coralline algae (0.90%), other unidentified living organisms (0.97%) and dead coral with algae (0.25%) were also observed. Sand, pavement and rubble made up 33.26% of the benthic substrate and 2.56% was unidentified (unknowns). No zoanthids or diseased corals were observed. These results are tabulated in Table 6.1 and illustrated in Figure 6.5. The general appearance of two sites (Grand Caille and Turtle Reef) showing the sloping nature of the reef formation is shown in Figure 6.6.

Table 6.1: Summary of mean percentage cover for the substrate categories for the Soufriere Marine Management Area, Saint Lucia

MAJOR CATEGORY (% of transect)	MEAN	STD. DEV.	STD. ERROR
HARD CORAL	9.53	6.19	1.38
GORGONIANS	1.35	3.23	0.72
SPONGES	7.07	3.83	0.86
ZOANTHIDS	0.00	0.00	0.00
MACROALGAE	44.11	15.37	3.44
OTHER LIVE	0.97	0.75	0.17
DEAD CORAL WITH ALGAE	0.25	0.32	0.07
CORALLINE ALGAE	0.90	1.24	0.28
DISEASED CORALS	0.00	0.00	0.00
SAND, PAVEMENT, RUBBLE	33.26	14.84	3.32
UNKNOWNS	2.56	1.50	0.33
Sum (excluding tape+shadow+wand)	100.00		

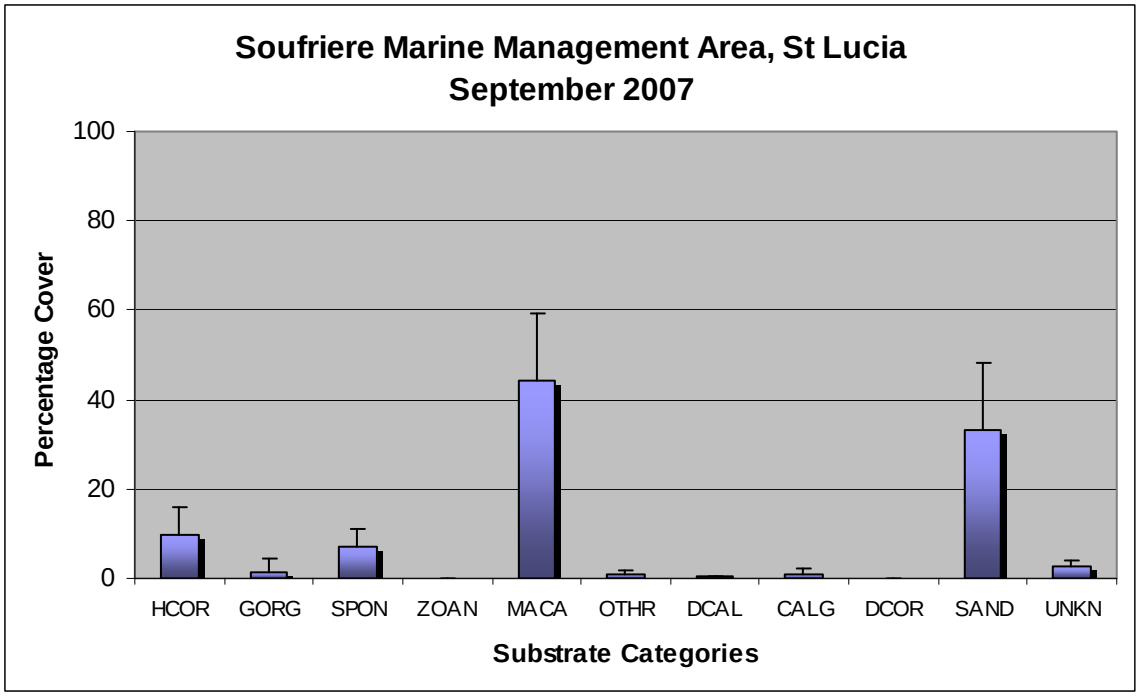

Figure 6.5: Graph illustrating the mean percentage cover of the different substrate categories found within the Soufriere Marine Management Area, Saint Lucia in September 2007. Error bars represent Standard Deviation (STD. DEV.). (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; SPON – Sponge; ZOAN – Zoanthids; MACA– Macroalgae; OTHR – Other, live; DCAL - Dead coral with algae; CALG – Coralline algae; DCOR– Diseased coral; SAND – Sand, rubble, rock and boulder; UNKN – Unknown.)

Figure 6.6: Images of the Grand Caille (left) and Turtle Reefs (right) showing the sloping nature of the reef formation.

6.4.2.2 HARD CORAL SPECIES

During monitoring in the SMMA twenty (20) species of hard corals were identified which accounted for 9.53% of the total benthic substrate cover. The more commonly occurring species included *Porites astreoides* (1.97%), *Porites porites* (1.87%), *Diploria strigosa* (1.13%) and *Madracis mirablis* (0.80%). Table 6.2 provide a list of the coral species observed and the more commonly occurring species are illustrated in Figure 6.7

Table 6.2: Hard coral species identified in the Soufriere Marine Management Area, Saint Lucia during September 2007.

HARD CORAL SPECIES	MEAN	STD. DEV.	STD. ERROR
Acropora palmata	0.02	0.06	0.01
Colpophyllia natans	0.52	0.90	0.20
Coral (general)	0.42	0.32	0.07
Dichocoenia stokesi	0.01	0.06	0.01
Diploria labyrinthiformis	0.06	0.15	0.03
Diploria strigosa	1.13	2.19	0.49
Eusmilia fastigiata	0.08	0.20	0.05
Madracis decactis	0.02	0.07	0.02
Madracis mirabilis	0.80	1.38	0.31
Meandrina meandrites	0.63	0.82	0.18
Millipora alcicornis	0.04	0.19	0.04
Millipora complanata	0.26	0.61	0.14
Montastraea annularis	0.32	0.53	0.12
Montastraea cavernosa	0.17	0.27	0.06
Montastraea faveolata	0.41	0.70	0.16
Montastraea franksi	0.05	0.19	0.04
Mycetophyllia aliciae	0.03	0.09	0.02
Porites astreoides	1.97	1.39	0.31
Porites furcata	0.01	0.07	0.01
Porites porites	1.87	3.10	0.69
Siderastrea siderea	0.70	0.81	0.18
Total % Coral Cover	9.53		
Number of Known Species	20		

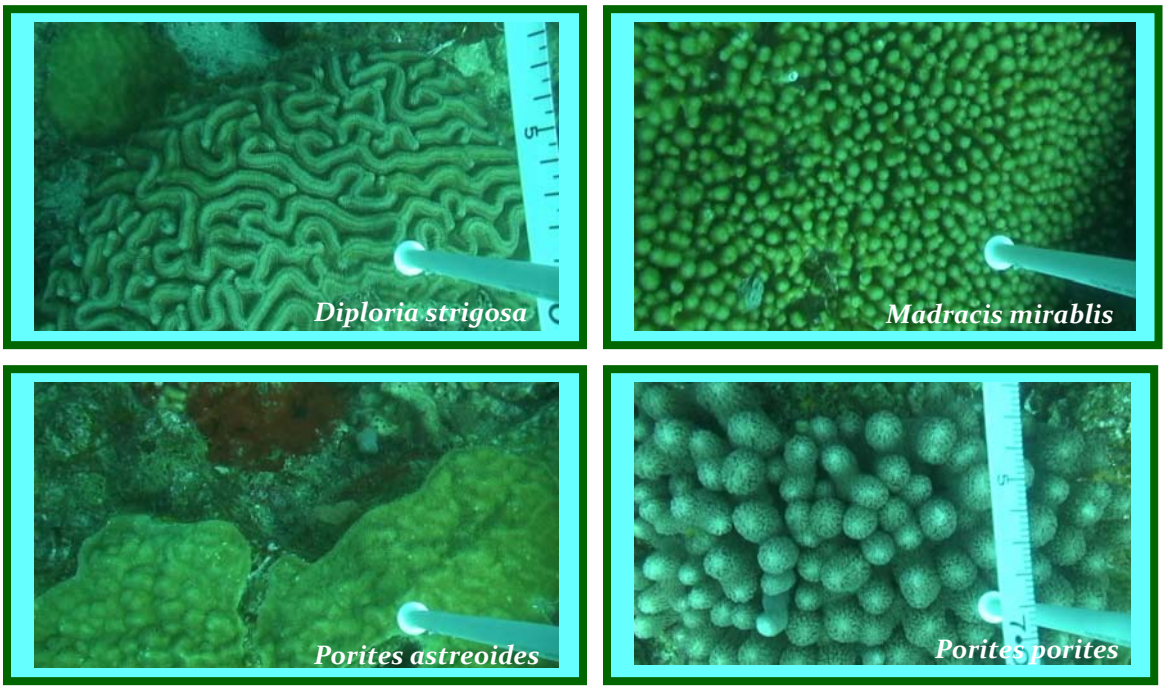

Figure 6.7: Images of some of the commonly occurring hard coral species found in the Soufriere Marine Management Area; *Diploria strigosa, Madracis mirablis, Porites astreoides* and *Porites porites*.

6.5 Discussion

The fringing reef communities along parts of the west coast are of great importance to fisheries as well as becoming increasingly popular as a diving destination. Because Saint Lucia is ranked highly as one of the best diving destinations in the world[10], reefs are under pressure from tourism and coastal development with increasing populations along the coast (Burke & Maidens, 2004). The SMMA has a comprehensive monitoring programme but still faces challenges with respect to adequate resources for processing and analyzing the data collected. It is hoped that collaboration with the MACC and the CMS may help to alleviate these problems.

[10] Presentation by Mr. John Calixe, Deputy Permanent Secretary, Ministry of Economic Affairs, Economics Planning, National Development and Public Service, St Lucia. Regional Training Workshop September 10-13, 2007. (Creary, 2007)

CHAPTER 7

ST VINCENT AND THE GRENADINES

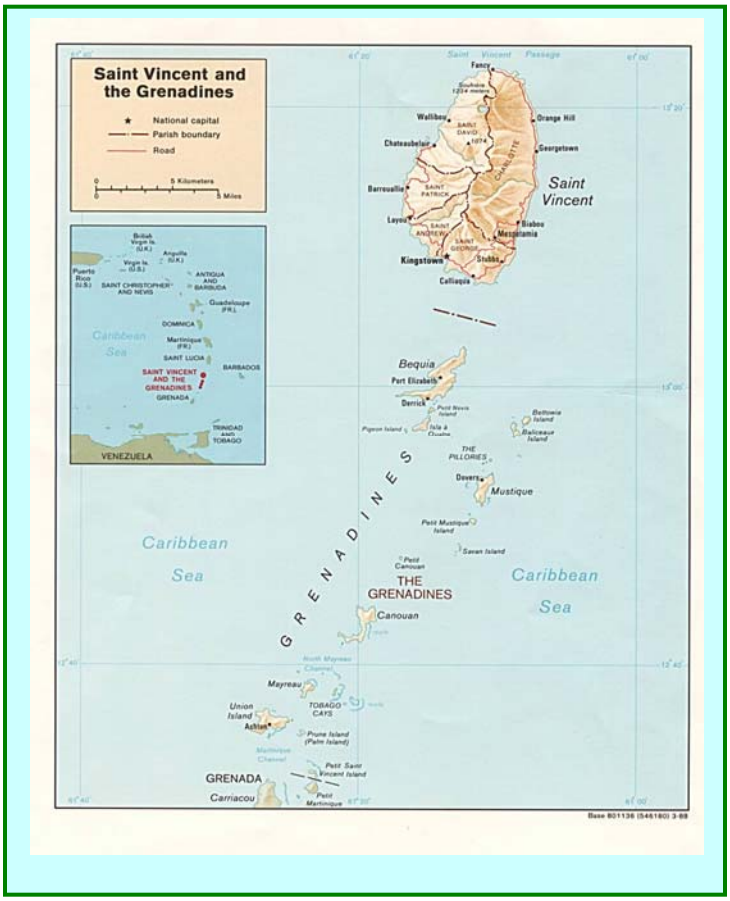

Figure 7.1: Map of St Vincent and the Grenadines.

7.1 ST VINCENT AND THE GRENADINES COUNTRY PROFILE[11]

St Vincent and the Grenadines is an island nation, which covers approximately 388 km² (50 mi²) and makes up part of the Windward Islands (Figure 7.1). It comprises the island of St Vincent (140 mi²/363 km²) and about two thirds of the small Grenadine islands to the south. The island of St Vincent is mountainous,

[11] Source: CIA The 2008 World FactBook. (www.cia.gov/library/publications/the-world-factbook); The Columbia Encyclopedia 6th Edition. 2007. Columbia University Press (ww.bartleby.com)

rising to a maximum elevation of 1,234 m (4,048 ft) at the Soufriere volcano. The population is estimated at 118,432 (2008) and agriculture forms an important part of St Vincent's economy with bananas, dasheen and arrowroot being the primary agricultural export products. Other economic activities include light industry, offshore banking and tourism.

7.2 Coral Reef and Marine Resources of St Vincent and the Grenadines

The relatively young coastline, together with new volcanic sediments, has prevented the development of extensive reefs (Figure 7.2). There are no reef developments around the north and east coasts, and only a few coral communities are found on rocky headlands along the west coast. Small areas of fringing reefs occur on the south and southeast coasts. Running south from the main island is the chain of the Grenadines, where there are considerable areas of reef. Large bank barrier reef complexes have developed on the windward side of some islands. Among the best-developed reefs are those around the small islands of the Tobago Cays. Each island has a fringing reef; the larger Horseshoe Reef encircles them to the east, while beyond this there is the larger World's End Reef. The reefs of St. Vincent and particularly the Grenadines are important for fishing and tourism, while large numbers of yachts visit these waters. The Tobago Cays are particularly important, but their condition has deteriorated recently because of storm damage, white band disease, physical damage from fishing gear and boat anchors, and pollution from visiting yachts (Spalding, 2001).

Sites have been assessed within 8 km of the capital which have been reported by locals to be indicative of the other reefs. There was relatively high coral abundance, which ended at the sharp drop-off. There are large areas (100's of metres) dominated by the branching *Madracis mirabilis*. The high abundance of *Diadema* and parrotfish probably accounts for the low algal cover and high coral abundance at some sites. The west coast has numerous bays with extensive coral growth on the headlands. Coral diseases were minimal and restricted to black spot disease, and bleaching was absent at all sites monitored (Bouchon, *et al*, 2004).

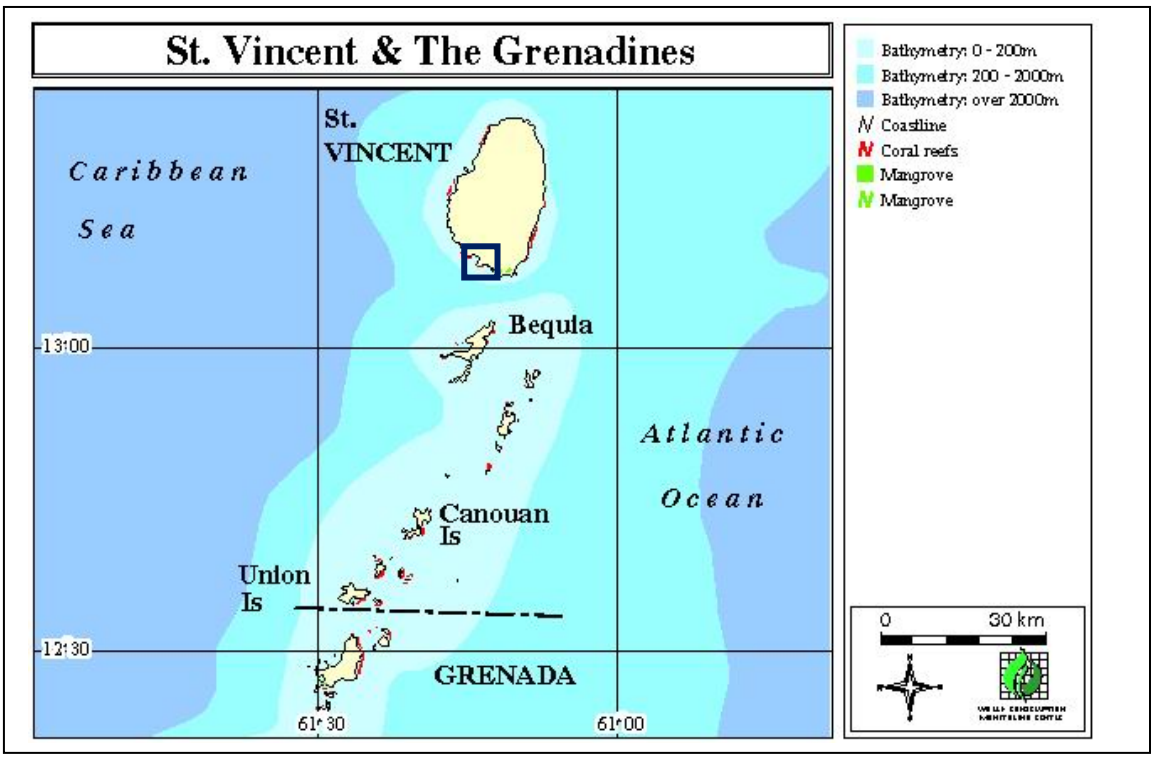

Figure 7.2: Outline map of St Vincent and the Grenadines showing the location of the coral reefs. The Operational Area at Castle Bay, Kingstown is highlighted.

7.3 Overview of Coral Reef Monitoring in St Vincent and the Grenadines

The Fisheries Division has experience in using the Reef Check, AGRRA, CARICOMP and CPACC coral reef monitoring methodologies. Coral reef monitoring was conducted at 8 sites, 1-2 times per year. Fish and water quality monitoring was also carried out. Monitoring was conducted under the SUSGREN/CERMES Project. Neither mangrove nor seagrass monitoring were carried out. St Vincent has seven sites that could be monitored using the CPACC video-monitoring protocol (Creary, 2007).

7.4 MACC Coral Reef Monitoring in St Vincent and the Grenadines

7.4.1 Methodology

7.4.1.1 Site Selection and Description

Castle Bay, which was selected as the Operational Area, is located on the fringes of Kingstown Bay. There is a historical significance of this area in that Fort Charlotte built by the British in

1763, sits on top of the bay. It is not uncommon to find glass bottles dating back to the 16th century at this site. As a result of the close proximity to the capital city of Kingstown the site is influenced by runoff and discharge from the river during rainy periods. Site selection and monitoring was conducted over the 4 days during the period, October 20 - 24, 2007. Selection of the location and the establishment of the transects was carried out over a two and a half days during which time a total of 19 potential sites were inspected along the leeward coast of the island and eventually two sites in Castle Bay were chosen (Figure 7.3). Both were shallow reef systems with a gentle slope down to 18 m (60 feet). Ten transects were established at each site and the HoboTemp data logger was deployed at the first site. Video monitoring has never been conducted in this area; however local dive operators often visit it.

Figure 7.3: Map showing the location of Castle Bay in Kingstown, St Vincent.

7.4.1.2 VIDEO MONITORING

Monitoring was conducted over the period October 20-24, 2007 and generally followed the procedure outlined in section 1.3.2.1. The monitoring team was comprised of personnel from the CMS, Department of Fisheries and Indigo Dive Academy. The first attempt at videotaping the transects had to be aborted due to severe fogging of the camera's housing. The problem was resolved and videotaping was completed on the final two days of monitoring. Figure 7.4 shows members of the team conducting monitoring at the sites in Castle Bay.

Figure 7.4: Members of the team conducting the video monitoring at sites in Castle Bay, Kingstown.

7.4.1.3 Data Processing and Analysis

A total of three (3) videotapes containing 20 video transects were submitted to the CMS along with the metadata and field report. Transects 19 and 20 could not be used because of the excessive fogging of the camera lens. A total of 1,472 discrete non-overlapping images were captured from the video transects. Processing of the tapes and the analysis of the images generally followed the procedure outlined in section 1.3.2.2. The tape catalogue and image capture logs are presented in Appendix 3 & 4.

7.4.2 Results

7.4.2.1 Benthic Substrate

A summary of the mean percentage cover for the various substrate categories is presented in Table 7.1. Hard coral (29.18%) and macroalge (36.51%) dominated the benthic substrate. There was also a high proportion of sponges (12.07%) and gorgonians (3.56%) were present to a lesser extent. There were limited amounts of dead coral and algae (3.06%) and a small proportion of diseased corals (0.13%) detected. Sand pavement and rubble (14.34%) made up the non-living portion of the benthic substrate. No zoanthids or coralline algae were observed. These results are illustrated in Figure 7.5. The high percentage coral cover observed at this location is illustrated in selected images found in Figure 7.6.

Table 7.1: Summary of mean percentage cover for the substrate categories found at Castle Bay, Kingstown.

MAJOR CATEGORY (% of transect)	MEAN	**STD. DEV.**	STD. ERROR
HARD CORAL	29.18	15.74	3.71
GORGONIANS	3.56	4.44	1.05
SPONGES	12.07	6.33	1.49
ZOANTHIDS	0.00	0.00	0.00
MACROALGAE	36.51	9.30	2.19
OTHER LIVE	0.99	0.59	0.14
DEAD CORAL WITH ALGAE	3.06	1.55	0.37
CORALLINE ALGAE	0.00	0.00	0.00
DISEASED CORALS	0.13	0.21	0.05
SAND, PAVEMENT, RUBBLE	14.34	9.02	2.13
UNKNOWNS	0.15	0.38	0.09
Sum (excluding tape+shadow+wand)	100.00		

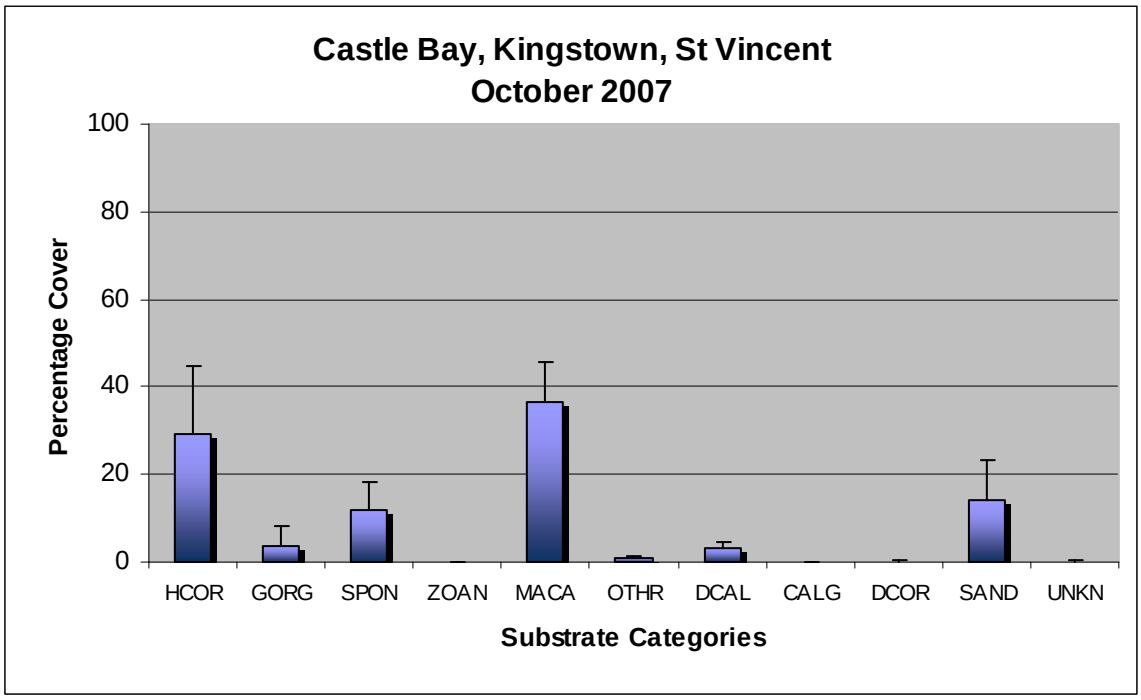

Figure 7.5: Graph illustrating the mean percentage cover of the different substrate categories found at Castle Bay, Kingstown, St Vincent in October 2007. Error bars represent Standard Deviation (STD. DEV.). (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; SPON – Sponge; ZOAN – Zoanthids; MACA– Macroalgae; OTHR – Other, live; DCAL - Dead coral with algae; CALG – Coralline algae; DCOR– Diseased coral; SAND – Sand, rubble, rock and boulder; UNKN – Unknown.)

Figure 7.6: Images of the coral reef at the Castle Bay monitoring site in Kingstown, St Vincent illustrating the high percentage of coral cover observed there.

7.4.2.2. HARD CORAL SPECIES

There were twenty-nine (29) hard coral species observed during the monitoring exercise, which made up 29.18% of the total benthic substrate cover. The most commonly occurring species was *Porites astreoides* (8.07%), *Siderastrea siderea* (6.57%) and *Montastraea annularis* (5.55%) and to a much lesser extent *Diploria strigosa* (1.79%), *Meandrina meandrites* (1.56%) and *Montastraea cavernosa* (1.29%). Table 7.2 provides as summary of the percentage cover of the coral species occurring at Castle Bay. Images of some of these species are presented in Figure 7.7.

Table 7.2: Coral species identified at Castle Bay in Kingstown, St Vincent.

CORAL SPECIES	MEAN	STD. DEV.	STD. ERROR
Acropora cervicornis	0.04	0.12	0.03
Agaricia agaricites	0.86	0.57	0.14
Colpophyllia breviserialis	0.01	0.03	0.01
Colpophyllia natans	0.38	0.87	0.20
Coral juvenile	0.01	0.03	0.01
Dendrogyra cylindrus	0.17	0.65	0.15
Dichocoenia stokesi	0.37	0.44	0.10
Diploria clivosa	0.14	0.23	0.06
Diploria labyrinthiformis	0.02	0.08	0.02
Diploria strigosa	1.79	1.37	0.32
Eusmilia fastigiata	0.16	0.35	0.08
Favia fragum	0.10	0.25	0.06
Isophyllia sinuosa	0.01	0.03	0.01
Madracis mirabilis	0.76	1.30	0.31
Manicina areolata	0.02	0.10	0.02
Massive corals	0.04	0.08	0.02
Meandrina meandrites	1.56	1.11	0.26
Millipora alcicornis	0.07	0.18	0.04
Millipora complanata	0.01	0.03	0.01
Millipora squarrosa	0.39	0.43	0.10
Montastraea annularis	5.55	8.50	2.00
Montastraea cavernosa	1.29	1.51	0.36
Montastraea faveolata	0.03	0.07	0.02
Mycetophyllia lamarckiana	0.03	0.09	0.02
Porites astreoides	8.07	4.51	1.06
Porites divaricata	0.01	0.03	0.01
Porites furcata	0.26	0.47	0.11
Porites porites	0.35	0.67	0.16
Siderastrea radians	0.02	0.07	0.02
Siderastrea siderea	6.57	4.77	1.13
Solenastrea bournoni	0.12	0.19	0.04
Total % Coral Cover	29.18		
Number of Known Species	29		

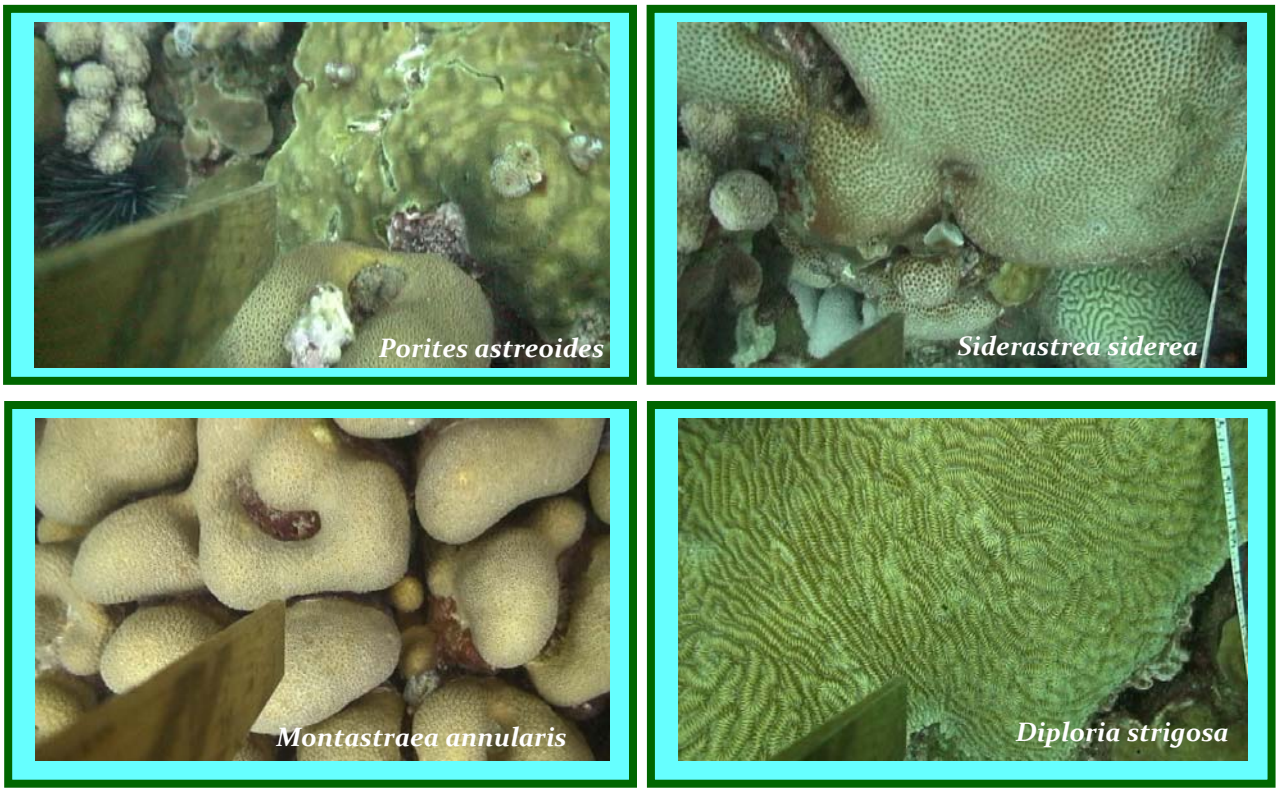

Figure 7.7: Images of the most commonly occurring coral species at Castle Bay in Kingstown, St Vincent; *Porites astreoides, Siderastrea siderea, Montastraea annularis* and *Diploria strigosa.*

7.5 DISCUSSION

The site selected at Castle Bay had the highest coral cover and number of coral species when compare to the other sites monitored during this study. Despite its close proximity to the capital, Kingstown, and the impact by runoff and discharges from the rivers, particularly during the rainy season the reefs are is relatively good condition. Previous monitoring has been carried out in this area, which is also a popular dive site, and the results of this monitoring exercise will serve to add to the already existing body of knowledge.

During the field exercise the there was severe fogging and some flooding of the camera and housing. This caused some delays in the monitoring and rendered some of the transects unusable.

CHAPTER 8

TRINIDAD AND TOBAGO

Figure 8.1: Map of Trinidad and Tobago showing the location of Tobago relative to the island of Trinidad.

8.1 TRINIDAD AND TOBAGO COUNTRY PROFILE[12]

Trinidad and Tobago lies in the Caribbean Sea off the northeast coast of Venezuela north of the Orinoco River Delta (Figure 8.1). Trinidad (1,864 mi^2/4,828 km^2) is largely flat or undulating with a range of low

[12] Source: CIA The 2008 World FactBook. (www.cia.gov/library/publications/the-world-factbook); The Columbia Encyclopedia 6th Edition. 2007. Columbia University Press (ww.bartleby.com)

mountains in the north, central and South. The highest peak is Mount Cerro del Aripo in the Northern Range that reaches a height of 940 m (3,085 ft). Tobago (116 mi^2/300 km^2) is located to the northeast of Trinidad and is the exposed top of a mountain ridge and is densely forested with hardwood trees. The Pitch Lake located in the southwest of Trinidad, is the largest (114 acres/46 hectares) basin of natural asphalt in the world. Trinidad and Tobago has a population of 1,047,366 (2008 estimate). The most important exports are natural gas, petroleum and petroleum products, chemicals, steel products, and fertilizer. Trinidad possesses sizable oil and gas reserves, and its prosperity is linked directly to the production of petroleum and petrochemicals. The islands also have a significant tourist industry. Agriculture employs a smaller proportion of the population than industry and services; agricultural products include cocoa, rice, coffee, citrus fruit, and flowers.

Tobago lies approximately 33 km (21 mi) northeast of Trinidad and is 26 km (16 mi) long and 11 km (7 mi) wide (Figure 8.2). Tobago has the oldest protected rainforest in the northern hemisphere with an estimated 210 bird species, 123 butterfly species, 16 types of lizards, 14 different frogs, 17 bats and 24 non-poisonous snakes as well as number of mammals[13]. Tobago's coast supports well-developed sloping reefs and the waters are nutrient rich, primarily as a result of the Orinoco River (Guyana) discharge. In addition, Tobago lies just south of the hurricane belt.

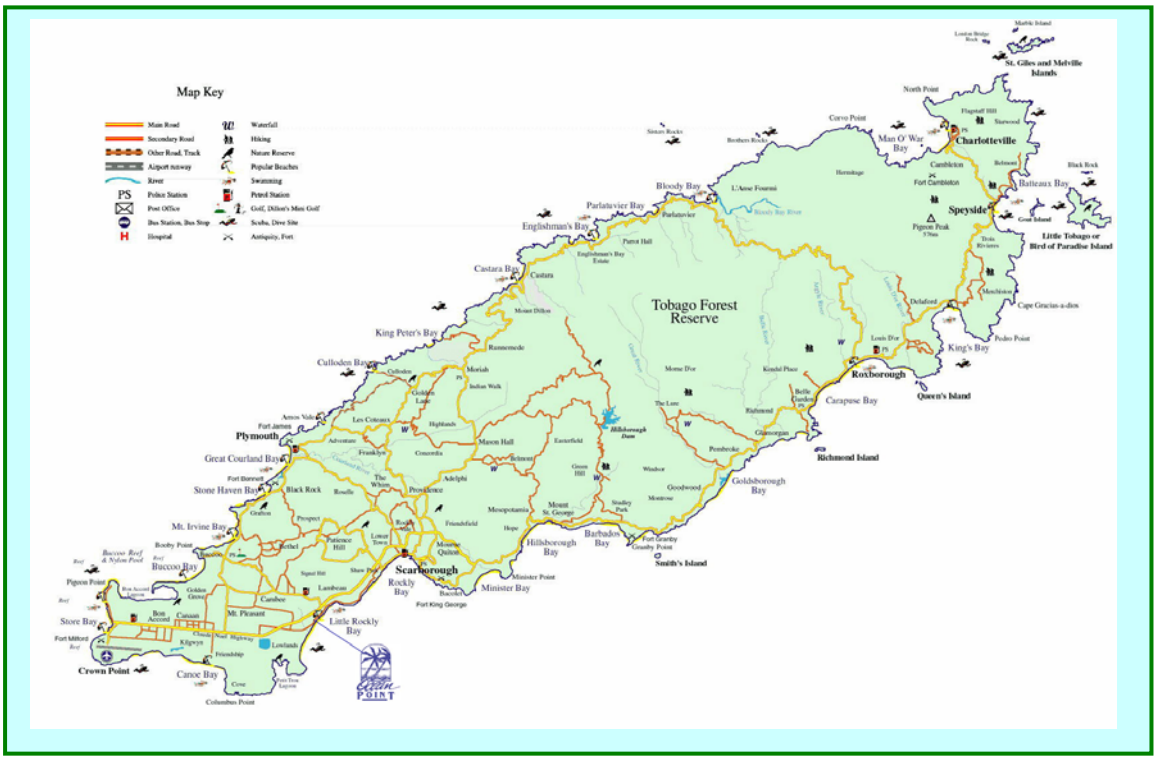

Figure 8.2: Map of Tobago.

[13] Environment Tobago (www.environmenttobago.net)

8.2 CORAL REEF AND MARINE RESOURCES OF TRINIDAD AND TOBAGO

Trinidad and Tobago are on the edge of the South American continental shelf, and under the direct influence of the Orinoco River. Thus, there are comparatively fewer coral reefs in Trinidad than Tobago There is a single fringing reef on the northeast coast of Trinidad, and many patch reefs near the offshore islands (Hoetjes, 2002). There are many well developed fringing reefs around Tobago (Figure 8.3) (Laydoo, 1985). CARICOMP data for Eastern Reef, Tobago shows virtually unchanged cover of hard and soft corals, or algae over 5 years. There are occasional elevated values of ammonia, nitrates and petroleum hydrocarbons on some of the reefs with discharges from land being the likely cause. The most common problems are coral bleaching and diseases, but these have been much less than elsewhere in the Caribbean. There was a major fish kill around Trinidad and Tobago's reefs in 1999 that correlated with flooding of the major South American rivers (Hoetjes, 2002).

Buccoo Reef was declared a protected area in 1973 under the Marine Areas (Preservation and Enhancement) Act, and remains the only marine park in Trinidad and Tobago. Management plans were formulated for Buccoo Reef Marine Park in 1995, and Speyside Marine Area Draft Plan in 2000, but the Tobago House of Assembly has not yet implemented them. Pot and spear fishing are not encouraged on the reefs, but there has been no attempt to reduce these activities (Hoetjes, 2002). The only reef monitoring that is carried out is through the Institute of Marine Affairs applying the CARICOMP methodology annually on the Buccoo Reef Complex. An NGO, the Buccoo Reef Trust plans to build the Tobago Marine Research Centre as an international institution for research and education on tropical reef ecosystems and sustainable aquaculture. Funding is being sought from many sectors. There are major gaps in capacity and funding for effective ecological and socio-economic monitoring (Hoetjes, 2002).

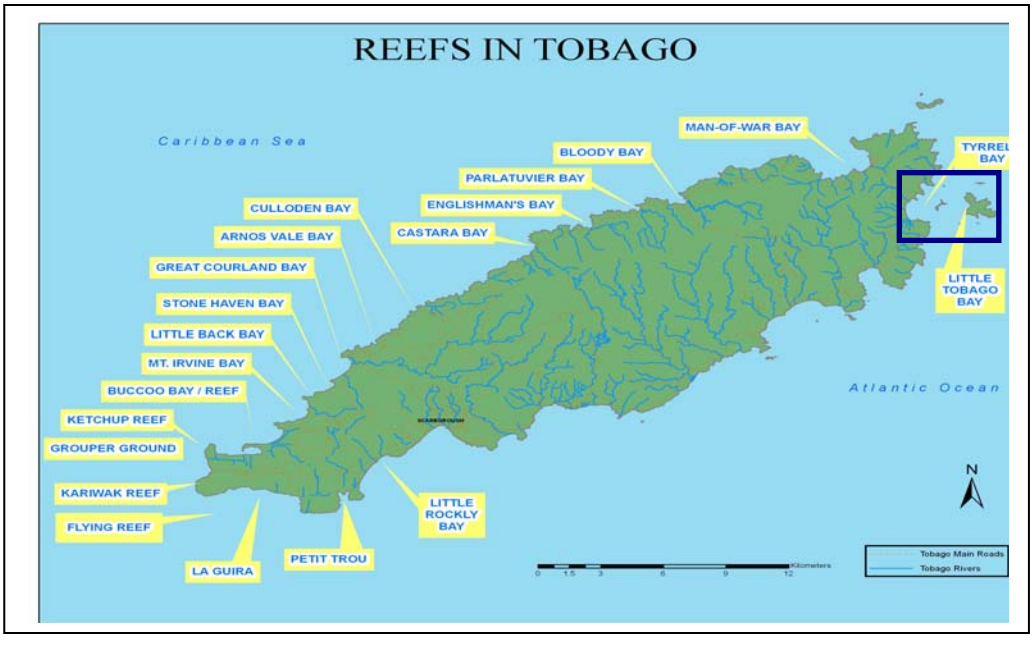

Figure 8.3: Outline map of Tobago showing the location of the coral reefs. The Operational Area at Speyside is highlighted. (Map provided by the IMA)

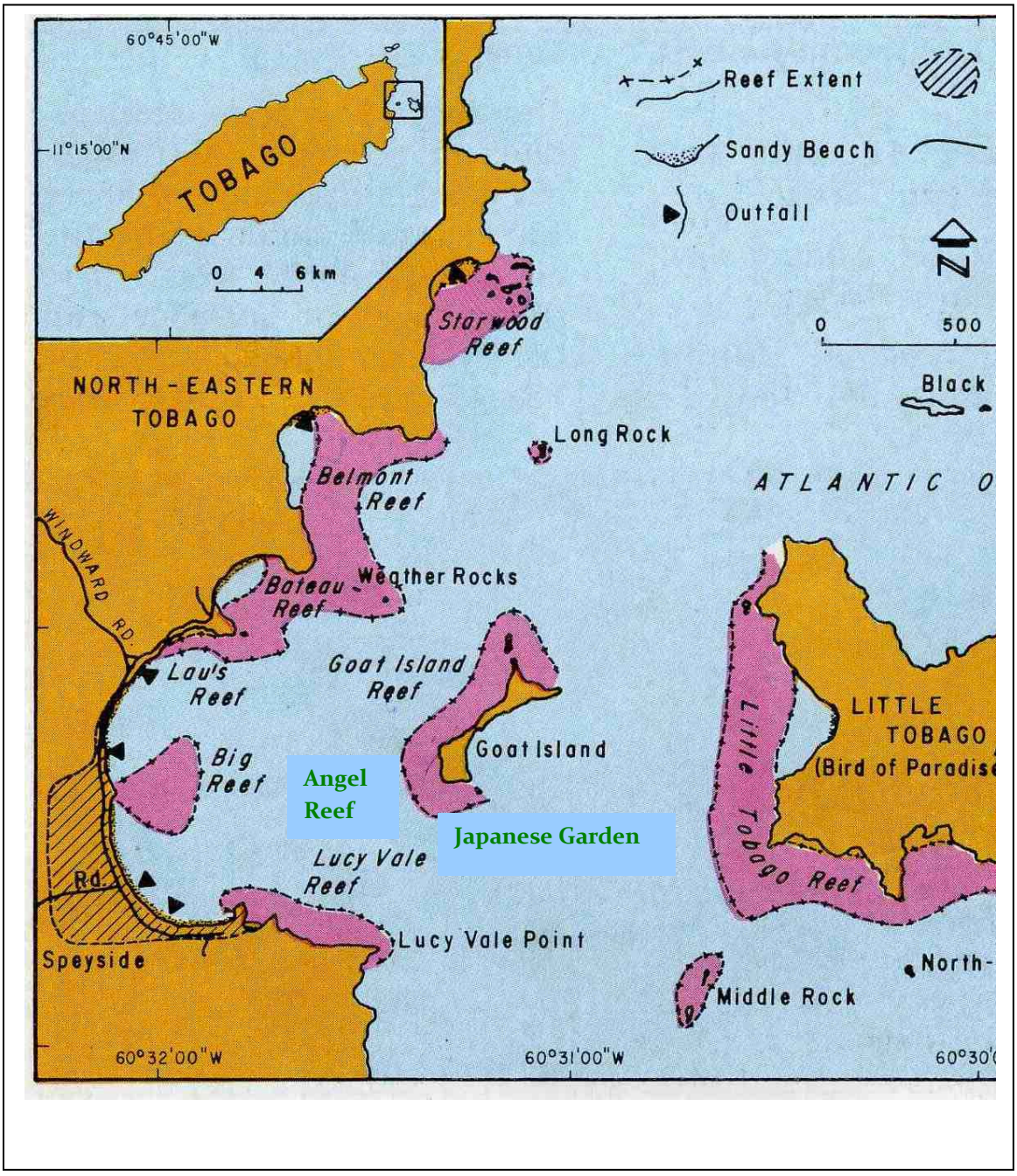

Figure 8:4: Map of the reefs of Speyside, Tobago showing the location of Japanese Garden and Angel Reef. (Map provided by the IMA)

8.3 Overview of Coral Reef Monitoring in Trinidad and Tobago

The Institute of Marine Affairs (IMA) is a government funded research institution responsible for conducting coral reef monitoring in Trinidad and Tobago. The IMA became part of the CARICOMP network in 1991 and began monitoring the Buccoo Reef/Bon Accord Lagoon Complex in Tobago. The Buccoo Reef/Bon Accord Lagoon was chosen as Trinidad and Tobago's CARICOMP site as it was the best example of contiguous coral reef, mangrove swamp and seagrass beds. Sampling was conducted once a year in September with the exception of 2000 where sampling took place in January. Besides the CARICOMP monitoring, photo quadrat surveys have been used on other reefs in Tobago such as Speyside. Other monitoring projects undertaken by the IMA include seagrass monitoring at 9 sites using the CARICOMP methodology since 2002 and beach profile monitoring, conducted since the 1980's (Creary, 2007).

8.4 MACC Coral Reef Monitoring in Tobago

8.4.1 Methodology

8.4.1.1 Site Selection and Description

Coral reef monitoring by the IMA is relatively new at the Speyside sites. Photo transects were recorded in May 2007 at the Japanese Garden site and a light intensity data logger was previously deployed at the site but was lost. There is however, some video monitoring conducted by UWI/Bucco Reef Trust on some reefs in Speyside and at other key dive sites around the island. Speyside, in the northeast tip of the island, was selected as the Operational Areas. It faces the Atlantic Ocean and contained two small offshore islands, namely Goat Island and Little Tobago.

The monitoring sites selected were located in the lee of Goat Island on Goat Island Reef. The two sites selected were Japanese Garden on the southern side of Goat Island and Angel Reef on the western. Japanese Garden get its name from the sea whip corals, which resemble bonsai trees. This site was comprised of a shallow sloping reef, which began at 30 ft and descended gently to 100 feet[14]. Large barrel sponges dominated this site as well as gorgonian and small sized corals such as *Porites astreoides*, *Porites porites* and *Siderastrea siderea*. The Angel Reef was located adjacent to the Japanese Garden site and was fairly flat, descending to depths of 50-60 feet. Massive corals such as *Montastraea annularis*, *Diploria Strigosa* and *Montastraea cavernosa* dominated this reef.

The currents in the area are generally in a northerly direction year round with current velocity at the surface varying between 7.7-34.5 cm s^{-1} and sub- surface velocity varying between 5.1-

[14] Source: Tobago Dive Experience (www.tobagpdiveexperience.com)

111.6 cm s^{-1} (Laydoo, 1985). Surface currents are slightly deflected north-west by prevailing winds, which generates eddies in deeper waters and choppy seas often with strong current in shallower areas (Laydoo, 1985) tend to flow inshore. There is however a strong influence from the Orinoco in the rainy season. When this occurs the water is generally turbid at the surface then becomes clear at greater depths[15]. The monitoring sites in Speyside are very popular for recreational diving and there were few small-scale hotels in the coastal catchment area. The deployment of the permanent transects was carried out following the procedures outlined in the CPACC Video Monitoring protocol (Creary, 2007).

8.4.1.2 VIDEO MONITORING

Video monitoring was conducted over the period October 16-17, 2007 and generally followed the procedure outlined in section 1.3.2.1. The monitoring team was comprised of personnel from the CMS, IMA and Tobago Department of Marine Resources and Fisheries (Figure 8.5). On Day 1 of monitoring 4 transects were completed at the Japanese Garden site at 9 m (30 feet). There was a strong current at the site and the first two transects were recorded while swimming with the current while transects 3 & 4 were recorded while swimming against the current. The data collection was subsequently discarded as a result of the fogging observed in the camera's housing. Adjustments were made to the camera and housing for data collection on Day 2. This included applying silica gel to the inside of the housing to reducing the incidence of fogging. Also the white balance was adjusted for a more vivid picture quality and to eliminate the use of the red filter.

All the transects at the Japanese Garden site were completed on Day 2 as the camera problems were resolved**.** The weather and currents was excellent and the 6 remaining transects 4 at 12 m (40 feet) and 2 at 15 m (50 feet)) were completed in approximately 40 minutes. There was an hour and a half surface interval, during which time the battery and tapes were changed in the camera for data collection at Angel Reef. There were no problems with the camera and videotaping at Angel Reef so the 10 transects (4 transects at 9 m (30 feet) and 6 transects 6 m (at 20 feet)) was completed in approximately 85 minutes. A temperature logger was placed on site October 15, 2007 and it's anticipated that data from this logger will be retrieved in October 2008.

[15] Source: Tobago Dive Experience (www.tobagpdiveexperience.com)

Figure 8.5: Members of the team conducting video monitoring at the Japanese Garden and Angel Reef sites in Speyside, Tobago.

8.4.1.3 Data Processing and Analysis

Two (2) videotapes containing 20 video transects were labeled and submitted to the CMS along with metadata and the field report. A total of 1,362 discrete non-overlapping images were captured from the video transects. Processing of the tapes and the analysis of the images generally followed the procedure outlined in section 1.3.2.2. The tape catalogue and image capture logs are presented in Appendix 3 & 4.

8.4.2 Results

8.4.2.1 Benthic Substrate Cover

The sites monitored at Speyside, Tobago were dominated by macroalgae (25.44%), sponges (21.15%), gorgonians (16.80%) and hard coral (15.88%) which together accounted for approximately 80% of the benthic cover. The remaining living components of the benthic cover were comprised of coralline algae (2.13%), zoanthids (0.93%) and other unidentified living organisms (0.01%). Sand, pavement and rubble (13.57%) made up the remainder of the benthic cover. A summary of these results is presented in Table 8.1 and illustrated in Figure 8.6. The general appearance of the Japanese Garden and Angel Reef assemblage is illustrated in Figure 8.7.

Table 8.1: Summary of mean percentage cover for the substrate categories at Japanese Garden and Angel Reef at Speyside in Tobago, October 2007

MAJOR CATEGORY (% of transect)	MEAN	STD. DEV.	STD. ERROR
HARD CORAL	15.88	17.76	3.97
GORGONIANS	16.80	9.23	2.06
SPONGES	21.15	11.45	2.56
ZOANTHIDS	0.93	1.23	0.27
MACROALGAE	25.44	10.87	2.43
OTHER LIVE	0.01	0.03	0.01
DEAD CORAL WITH ALGAE	0.48	0.76	0.17
CORALLINE ALGAE	2.13	2.27	0.51
DISEASED CORALS	0.00	0.00	0.00
SAND, PAVEMENT, RUBBLE	13.57	6.16	1.38
UNKNOWNS	3.61	3.08	0.69
TAPE, WAND, SHADOW	6.98	3.66	0.82
Sum (excluding tape+shadow+wand)	100.00		

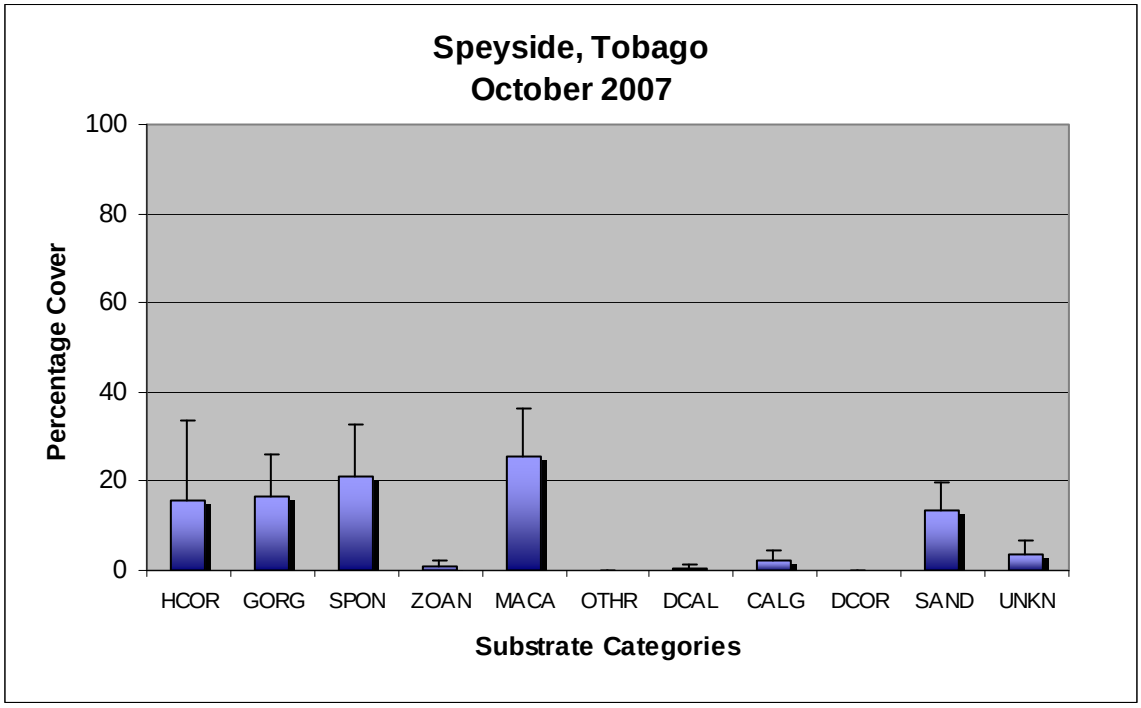

Figure 8.6: Graph illustrating the mean percentage cover of the different substrate categories found at Japanese Garden and Angel Reef at Speyside in Tobago during October 2007. Error bars represent Standard Deviation (STD. DEV.). (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; SPON – Sponge; ZOAN – Zoanthids; MACA– Macroalgae; OTHR – Other, live; DCAL - Dead coral with algae; CALG – Coralline algae; DCOR– Diseased coral; SAND – Sand, rubble, rock and boulder; UNKN – Unknown.)

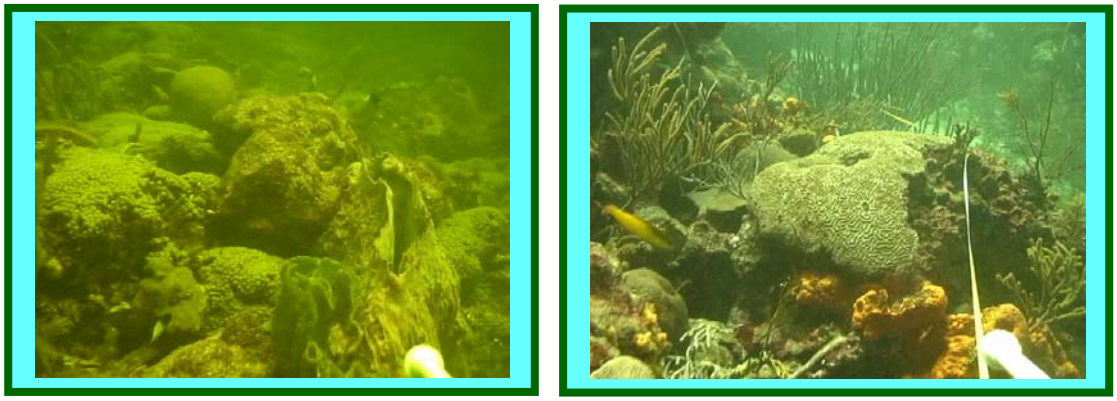

Figure 8.7: Images of the coral reefs assemblage at the Japanese Garden and Angel Reef monitoring sites at Speyside, Tobago.

8.4.2.2 CORAL SPECIES

There were twenty (19) hard coral species observed during the monitoring exercise which made up 15.88% of the total benthic cover. The most commonly occurring species was *Madracis mirabilis* (9.54%) and to a much lesser extent *Montastraea faveolata* (1.61%) (Figure 8.8). The remaining 17 species individually represented less than 1% of the coral cover. Table 8.2 provides as summary of the percentage cover of the coral species occurring at Japanese Garden and Angel Reef and some of the coral species observed are illustrated in Figure 8.8.

Table 8.2: Hard Coral species identified at Japanese Garden and Angel Reef, Tobago (Octacorals not included)

CORAL SPECIES	MEAN	STD. DEV.	STD. ERROR
Acropora palmata	0.01	0.03	0.01
Agaricia agaricites	0.24	0.40	0.09
Agaricia undata	0.01	0.03	0.01
Colpophyllia natans	0.06	0.26	0.06
Coral (general)	0.37	0.39	0.09
Diploria strigosa	0.77	1.91	0.43
Favia fragum	0.02	0.08	0.02
Leptoseris cucullata	0.06	0.15	0.03
Madracis mirabilis	9.54	18.62	4.16
Meandrina meandrites	0.22	0.45	0.10
Millipora alcicornis	0.33	0.51	0.11
Millipora complanata	0.70	1.36	0.30
Montastraea annularis	0.25	1.03	0.23
Montastraea cavernosa	0.25	0.39	0.09
Montastraea faveolata	1.61	5.02	1.12
Mycetophyllia aliciae	0.04	0.18	0.04
Porites astreoides	0.43	0.45	0.10
Porites furcata	0.04	0.10	0.02
Siderastrea siderea	0.91	0.81	0.18
Solenastrea hyades	0.01	0.05	0.01
Total % Coral Cover	15.88		
Number of known species	19		

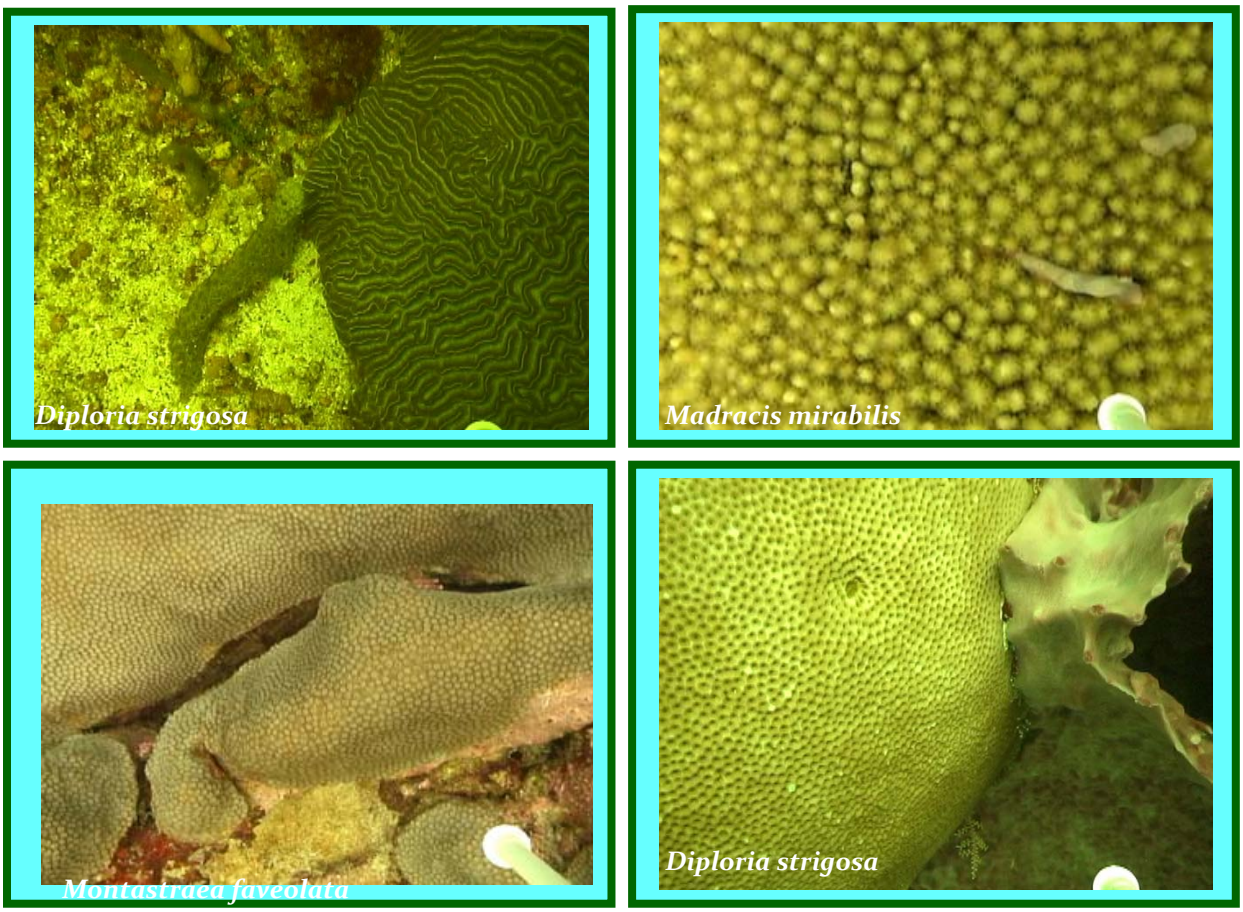

Figure 8.8: Images of some of the coral species observed at Japanese Garden and Angel Reef in Tobago; *Diploria strigosa, Madracis mirabilis, Montastraea faveolata and Siderastrea siderea*.

8.5 DISCUSSION

Based on field observations the Japanese Garden site had many large barrel sponges with small colonies of hard corals growing on rocky substrate. This rocky substrate made it difficult to drive in the stakes to establish transects. However, the substrate at Angel Reef was mainly sand with gorgonians and hard corals growing in this sandy bottom. In photo-quadrat surveys conducted by Laydoo (1985) on the reef crest and upper forereef (0- 30 feet) at Goat Island, 13 hard coral species were reported. Species recorded by Laydoo (1985) but not observed in this survey were *Diploria labyrinthformis*, *Madracis decastis*, *Eusmilia fastigiata* and *Mussa angulosa*. Species recorded in this survey but not by Laydoo (1985) were *Porites furcata*, *Mycetophyllia aliciae*, *Agaricia undata*, *Favia fragum*, *Leptoseris cucullata*, *Madracis mirabilis*, *Millipora complanata*, *Montastrea cavernosa*, *Monastrea faveolata* and *Solenastrea hyades*[16]. Also, during this survey

[16]Comment by R. Juman: There may be discrepancies in the identification of species particularly Porites furcata/ porites and Madracis mirabilis/decatis and Montstraea annularis / faveol

there was no evidence of coral bleaching although bleaching was observed in 2005, at time when mass bleaching was seen throughout the Caribbean region. A more detailed evaluation of the two studies needs to be carried out before a conclusion can be drawn about these results.

CHAPTER 9

SUMMARY OF CORAL REEF MONITORING RESULTS

The objective of the Coral Reef Monitoring for the Organization of Eastern Caribbean States and Tobago project was to strengthen the coral reef monitoring network in the region and to conduct an assessment of the coral reefs in these participating countries. The project was implemented by providing technical support in the areas of training, monitoring, data analysis and report preparation. The data collected and reported on in this document is intended to represent the first in the series of monitoring exercise forming the long term coral reef monitoring programme for the OECS and Tobago.

The long term monitoring programme will assist in documenting the changes taking place on the coral reefs over time and will attempt to determine the reasons for the observed changes. In the monitoring programme coral reef health was assessed by determining coral cover, but it must be noted that coral reefs are an assemblage of many marine organism of which the corals was just one component and hence there are additional methods that can be utilized.

In Table 9.1 below is the mean percentages cover for the different substrate categories for each of the countries monitored. Two sets of data are presented for Antigua who started monitoring in 2007 but because of technical delays repeated the monitoring in 2008. The results shows that the monitoring sites selected in each country had varying levels of coral cover ranging from 3.80% in Antigua (2008) to 29.18% in St Vincent. Dominica, Grenada, St Kitts and Saint Lucia had coral cover at about 10% while Tobago had 15.88%. Gorgonians were not very abundant in all the islands ranging from 0.97% 3.56% with the exception of Tobago which had 16.80% mean percentage cover. Sponges also found in the highest abundance in Tobago with 21.15%, St Vincent had a little over half that amount with 12.07%, while St Kitts and Saint Lucia had 7.49% and 7.07% respectively. The other three countries had less than 4% gorgonian cover. The zoanthids represented a very small proportion of the benthic cover in all the countries ranging from 0.00% to 0.93%. Also not well represented were the coralline algae which ranged from 0.00% to 0.90% for all countries except Tobago which had a higher cover of 2.13%. Disease corals were observed in limited amounts in Antigua (2007), Dominica, St Kitts and St Vincent.

Of significance for all the countries was the high level of macroalgae combined with dead coral and algae observed with the reefs in Antigua (2007) having a combined value of 56.22%, Dominica having 66.55%, Grenada with the highest at 84.24% and St Kitts at 76.02%. Tobago (25.92%) and St Vincent (39.57%) exhibited the lowest levels of macroalgae combine with dead coral and algae, while Antigua – 2008 (44.87%) and Saint Lucia (44.36%) had intermediate levels. These combined results of the monitoring are illustrated in Figure 9.1.

Table 9.1: Combined summary of the mean percentage cover for the substrate categories at the coral reef sites in Antigua, Dominica, Grenada, St Kitts, Saint Lucia, St Vincent and Tobago monitored during the period September 2007 to April 2008.

MAJOR CATEGORY (% of transect)	Mean Percentage Cover							
	Antigua 2007	Antigua 2008	Dominica	Grenada	St Kitts	St Lucia	St Vincent	Tobago
HARD CORAL	3.98	3.80	11.40	10.09	10.25	9.53	29.18	15.88
GORGONIANS	2.30	2.43	0.97	1.13	1.02	1.35	3.56	16.80
SPONGES	0.20	0.95	3.68	0.17	7.49	7.07	12.07	21.15
ZOANTHIDS	0.22	0.03	0.04	0.15	0.09	0.00	0.00	0.93
MACROALGAE	27.75	33.76	11.64	41.78	73.77	44.11	36.51	25.44
OTHER LIVE	0.00	0.00	0.71	0.14	0.13	0.97	0.99	0.01
DEAD CORAL WITH ALGAE	28.47	11.11	54.91	42.46	2.25	0.25	3.06	0.48
CORALLINE ALGAE	0.23	0.00	0.09	0.01	0.05	0.90	0.00	2.13
DISEASED CORALS	0.12	0.00	0.04	0.00	0.04	0.00	0.13	0.00
SAND, PAVEMENT, RUBBLE	36.29	47.75	16.27	4.04	4.86	33.26	14.34	13.57
UNKNOWNS	0.43	0.16	0.25	0.02	0.06	2.56	0.15	3.61
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

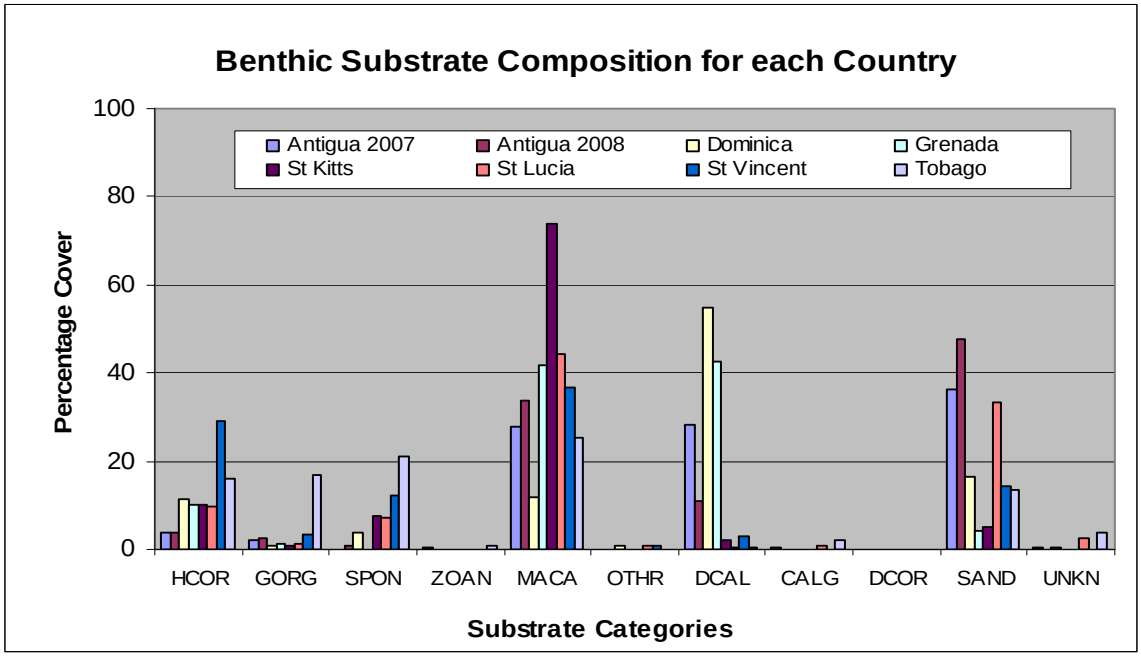

Figure 9.1: Graph illustrating the mean percentage cover for the different substrate categories found at the coral reefs sites in Antigua, Dominica, Grenada, St Kitts, Saint Lucia, St Vincent and Tobago monitored during the period September 2007 to April 2008. (Substrate categories: HCOR - Hard coral; GORG - Gorgonians; SPON – Sponge; ZOAN – Zoanthids; MACA– Macroalgae; OTHR – Other, live; DCAL - Dead coral with algae; CALG – Coralline algae; DCOR– Diseased coral; SAND – Sand, rubble, rock and boulder; UNKN – Unknown.)

During the monitoring exercise a total of 41 coral species were observed in addition to other unidentified coral species and coral juveniles. The most widely distributed species were *Diploria strigosa*, *Montastraea annularis, Montastraea cavernosa, Porites astreoides* and *Siderastrea siderea,* which were found in all countries and *Agaricia agaricites, Meandrina meandrites, Millipora complanata* and *Porities porities* which occurred in six of the seven countries. Just under half (18) of the species identified were found in only one or two countries, with remaining 15 species occurring in 3-5 countries. These results are presented n Table 9.2 below.

Table 9.2: Hard Coral species identified at the coral reef sites in Antigua, Dominica, Grenada, St Kitts, Saint Lucia, St Vincent and Tobago monitored during the period September 2007 to April 2008.

CORAL SPECIES	Antigua 2007	Antigua 2008	Dominica	Grenada	St Kitts	St Lucia	St Vincent	Tobago
Acropora cervicornis	1.57	0.06					0.04	
Acropora palmata								0.01
Agaricia agaricites	0.04	0.06	0.12		0.04	0.02	0.86	0.24
Agaricia fragilis			0.02					
Agaricia grahamae			0.11					
Agaricia undata								0.01
Colpophyllia breviserialis		0.01					0.01	
Colpophyllia natans			0.09		0.12	0.52	0.38	0.06
Dendrogyra cylindrus							0.17	
Dichocoenia stokesi					0.02	0.01	0.37	
Diploria clivosa			0.02	0.03			0.14	
Diploria labyrinthiformis	0.04	0.27		0.03	0.23	0.06	0.02	
Diploria strigosa	0.08	0.39	0.31	0.28	0.06	1.13	1.79	0.77
Eusmilia fastigiata					0.10	0.08	0.16	
Favia fragum			0.03		0.01		0.10	0.02
Isophyllia sinuosa							0.01	
Leptoseris cucullata								0.06
Madracis decactis						0.02		
Madracis mirabilis					0.16	0.80	0.76	9.54
Manicina areolata			0.07				0.02	
Meandrina meandrites			1.41	0.03	0.30	0.63	1.56	0.22
Millipora alcicornis				0.04		0.04	0.07	0.33
Millipora complanata			0.15	0.12	0.01	0.26	0.01	0.70
Millipora squarrosa					0.02		0.39	
Montastraea annularis	0.17		0.61	0.77	0.91	0.32	5.55	0.25
Montastraea cavernosa	0.53	0.36	0.87	0.59	0.38	0.17	1.29	0.25
Montastraea faveolata		0.01			1.15	0.41	0.03	1.61
Montastraea franksi						0.05		
Mussa angulosa			0.06					
Mycetophyllia aliciae		0.03		0.01		0.03		0.04
Mycetophyllia ferox			0.02	0.01				
Mycetophyllia lamarckiana					0.07		0.03	
Porites astreoides	0.67	1.47	3.04	2.59	5.81	1.97	8.07	0.43
Porites divaricata							0.01	
Porites furcata		0.03		0.01	0.04	0.01	0.26	0.04
Porites porites	0.13	0.37	1.41	5.17	0.05	1.87	0.35	
Scolymia lacera			0.04					
Siderastrea radians	0.24	0.14	0.38	0.09	0.01		0.02	
Siderastrea siderea		0.40	1.80	0.32	0.72	0.70	6.57	0.91
Solenastrea bournoni			0.05		0.03		0.12	
Solenastrea hyades			0.78					0.01
Inidentified Corals	0.50	0.18	0.01		0.02	0.42	0.04	0.37
Coral juvenile		0.01					0.01	
Total % Coral Cover	3.98	3.80	11.40	10.09	10.25	9.53	29.18	15.88
Number of Known Species	9	13	21	15	21	20	29	19

Figure 9.2 below provides a summary of the hard coral data collected during this study. In Antigua the site selected for monitoring had the lowest percentage cover (3.98 and 3.80%) when compared to the other islands and also the lowest number of coral species (9 and 13). St Vincent on the other had had the highest percentage cover (29.18%) and the highest number of species (29).

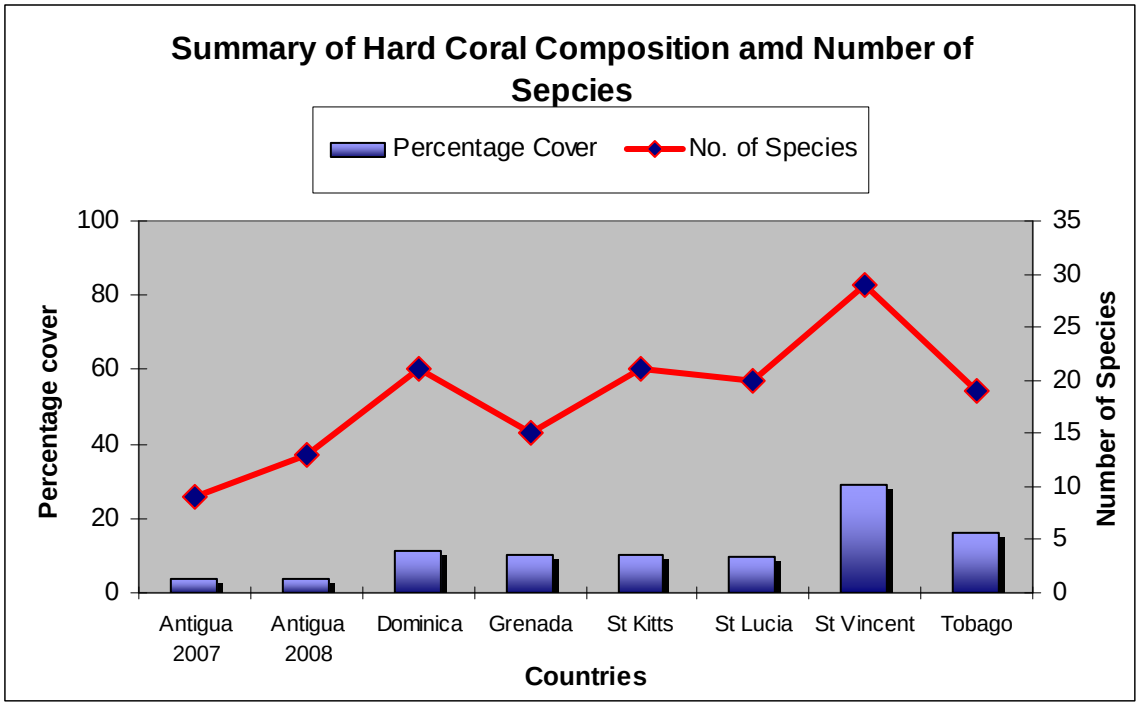

Figure 9.2: Graph summarising the hard coral composition (percentage cover and number of species) at the monitoring sites in Antigua, Dominica, Grenada, St Kitts, Saint Lucia, St Vincent and Tobago monitored during the period September 2007 to April 2008.

CHAPTER 10

RECOMMENDATIONS

The coral reef monitoring programme was successfully implemented in the Eastern Caribbean and Tobago and plans are being formulated to conduct monitoring for a second year. Below are a number of recommendations coming out of this monitoring exercise that should be considered for incorporation in any future monitoring programme.

10.1 Monitoring Review Workshop

- A Monitoring Review Workshop should be held to include all the participating institutions to conduct a thorough review of the monitoring protocol and the data collected. Challenges and technical/logistical difficulties should be discussed and resolved with proposed solutions incorporated into the program for future monitoring.

10.2 Training

- A review of the training should be carried with the persons who participated in the training workshop to fine-tune and clarify the video monitoring protocol with specific emphasis on the data processing and analysis sections, which were not covered in sufficient detail due to time constraints.
- Also training should be provided to additional persons in the countries that request this, focusing on their specific areas of need.

10.3 Site Selection

- Each country should review the site selected to ensure, based on the experience of the first monitoring exercise, that these sites are representative of the area being studied and are suitable for the long term monitoring programme. Once suitable sites have been decided on permanent transects should be established where these have not been done to ensure that the same transects are monitoring over the long term. These sites should be geo-referenced.

10.4 Monitoring

- Persons involved in the actual videotaping should endeavour to adhere to the protocol as much as possible. The protocol, which has been developed and field tested over a number of years, provides data that is statistically rigorous if executed as designed.

- Field checking of the camera equipment is recommended prior to monitoring to ensure full functionality. Problems were experienced with leaking camera housings and fogging lens. These problems could have been address if camera equipment were checked prior to monitoring.

- The video monitoring exercise should always include the filming of additional footage, particularly panoramic views of the reefs. These additional footages are particularly useful for illustrating the condition of the reefs in reports, presentations and documentaries.

- Tapes should be reviewed at the end of the day to ensure good quality footage. The taping should be repeated if the footage is not of an acceptable quality.

- It is very important that a field report and metadata accompany all tapes whether they are processed and analysed in-country or sent to the CMS. This information is invaluable in interpreting the information that is on the tapes and for review at a later date.

- Each country should ensure that temperature readings are available for each of the Operational Areas through the deployment of the HoboTemp loggers.

10.5 Data Processing and Analysis

- There should be an increased focus on in country coral species identification and data analysis particularly by the persons knowledgeable about the specific monitoring sites.

10.6 Supplementary Studies

- Provision in the programme should be made to monitoring during coral bleaching events to determine the extent of bleaching and the rate and nature of recovery. The CREWS network in the Caribbean provides the information which allows predictions of potential bleaching events.

- Closely associated to coral bleaching are the increase incidences of coral diseases which are now being linked indirectly to increased sea surface temperatures. Provision should also be made to include the monitoring of carol diseases where they occur.

- Where possible, other indicators for assessing and monitoring coral reef health should be undertaken such as but not limited to coral recruitment, coral size distribution, recruitment of juvenile, fish species and abundance, abundance of herbivores and physical parameters.

- Each country should gather all other relevant data related to the site selected for monitoring related to anthropogenic issues such as pollution, over-fishing, sedimentation, turbidity and physical damage, which interact with climate factors and affect the status of the coral reefs.

10.7 Video versus still photography

A brief desktop assessment of the use of still photographs as opposed to video images was carried out.

- While it is the view that still photographs might generally offer better resolution than video images, the high-resolution video technology which is now available is adequate for monitoring benthic cover on coral reefs, the objective of this protocol. In addition, videotaping is easier and faster than still photography (Miller & Rogers, 2002).

- The images are not as sharp as those from the current generation of digital SLRs cameras but the current camcorders from Sony and Canon capture images as good as the digital cameras from a few years ago (Lang, 2006).

- Examination of the time and monetary constraints associated with the sampling protocol showed that digital video collected more data per unit time than visual estimation, planar point intercept and photo quadrats (NOAA, 2003).

- Underwater videography is considered expensive because of the initial investment but when time underwater is the limiting factor the quality of the data collected can justifies the expense (NOAA, 2003).

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- Environment Tobago (www.environmenttobago.net)
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- The Columbia Encyclopedia. 6th Edition. 2007. Columbia University Press. (www.bartleby.com)
- Tobago Dive Experience (www.tobagodiveexperience.com)

Sources of Maps

- Map of countries - www.lib.utexas.edu/maps/americas/
- Location of Coral Reefs maps - UNEP-WCMC www.reefbase.org
- Location of Operational Areas and monitoring sites - www.google - earth
- Maps of Tobago and Speyside - Institute of Marine Affairs, Trinidad and Tobago

Appendix 1: Regional Training Workshop

Regional Training Workshop in Coral Reef Monitoring for the Organisation of the Eastern Caribbean States and Tobago held at Coco Palm Hotel and Soufriere Marine Management Association, St Lucia, September 10-13, 2007.

Workshop Trainees

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Appendix 2: Monitoring Schedule and Sites

Country	Dates	Operational Area	Monitoring Site(s)	Dive Teams
Antigua & Barbuda	Oct 16, 2007 April 9-11, 2008	Little Bird Island	17° 09.922'N 61° 44.487'W.	Peter Wilson-Kelly Mark Archibald Brent Simon Hilroy Simon Mitsuhiro Ishida,
Dominica	Nov 13- 15, 2007	Soufriere/Scott's Head Marine Reserve	Soufriere Pinnacle (15°13.987N - 061°21.891W), Danglebens (15°14.213N – 061°22.207W), Point Guignard (15°14.488N – 061°22.370W) Champagne (15°14.700N – 061°22.425W).	Peter Gayle Candy Stoute Jullian Defoe Derrick Theophile Arun Madisetti
Grenada	Oct 31-Nov 2, 2007	Grand Anse Reef System	Boss Reef (12°02'28.19"N – 061°45'49.09"W) Middle Boss Reef (12°02'14.74"N – 061°46'16.50"W) Bottom Boss Reef (12°01'25.52"N – 061°47'07.311"W) Northern Exposure (12°02'36.60"N – 061°45'58.98"W)	Peter Gayle Jerry Mitchell Steve Nimrod Craston Isaac Adrian Blackman
St Kitts & Nevis	Nov 4-9, 2007	Sandy Point	Paradise Reef	Peter Wilson Kelly Lynn Wilkins, Graeme Brown
St Lucia	Sep 12-14, 2007	Soufriere Marine Management Area	Turtle Reef Anse Chastanet Reef Grand Caille Coral Gardens Malgretoute	Sean Green Peter Wilson-Kelly Marcia Creary Kia Wulf Laudianan Laurence Hazelann Prospere Susanna Scott

				Daniel Medar
St Vincent & the Grenadines	Oct 23-24, 2007	Castle Bay, Kingstown	(Site 1- 13 9.35N 61 14.31W) (Site 2 - 13 9.36N, 61 13.64W). .	Sean Green Lucille Grant Sophie Steele Lucine Edwards Dale Mascal Kay Wilson Ronnel Small
Trinidad & Tobago	Oct 16-17, 2007	Speyside, Tobago	Japanese Gardens (11 17.86N 60 31.167W) and Angel Reef (11 17.954N 60 31.290W).	Sean Green Kerwin Sampson Addison Titus Jonathan Gomez Kahlil Hassanali Kirwin Redman Kurt Lemon

Appendix 3: Catalogue of Video Tapes

Country	Tape #	Date	Site	Transect #s
Antigua	AG01	16-Oct-07	Little Bird Island	Transects 1-5
	AG02	9-Apr-08	Little Bird Island	Transects 1-4
	AG02	10-Apr-08	Little Bird Island	Transects 5-10 (No #6)
	AG03	11-Apr-08	Little Bird Island	Transects 11-20
Dominica	DM01	13-Nov-07	Soufriere Pinnacle	Transects 1-7
	DM02	14-Nov-07	Dangle Bends	Transects 8-14 (No #9)
	DM03	15-Nov-07	Point Guinard	Transects 15-20
	DM04	15-Nov-07	Champagne	Transects 21-22
Grenada	CDs	31-Oct-07	Boss Reef	Transects 1-7
		1-Nov-07	Middle Boss Reef	Transects 8-11
		2-Nov-07	Bottom Boss Reef	Transects 12-15
		2-Nov-07	Nothern Exposure	Transects 16-20
St Kitts	KN01	5-Nov-07	Paradise Reef	Transects, 19, 18, 15, 2, 1, 5, 14, 20
	KN02	5-Nov-07	Paradise Reef	Transects 7,8,9,12,13,16,11,17,6
	KN03	5-Nov-07	Paradise Reef	Transect 1
St Lucia	LC 01	14-Sep-07	Grande Caille	Transect 1-4
	LC 02	12-Sep-07	Turtle Reef	Transect 6-8
	LC 02	14-Sep-07	Turtle Reef	Transect 9
	LC 03	12-Sep-07	Anse Chastenet	Transects 10-13
	LC 04	14-Sep-07	Coral Gardens and Margretoute	Transect 14-21
St Vincent	VG01	23-Oct-07	Castle Bay	Transects 1-8
	VG02	24-Oct-07	Castle Bay	Transects 9-10
	VG03	24-Oct-07	Castle Bay	Transects 11-20
Tobago	TT01	16-17, Oct 07	Speyside, Japanese Garden	Transects 1-10
	TT02	17-Oct-07	Speyside, Angel Reef	Transects 11-20

Appendix 4: Image Capture Logs

	Little Bird Island, Antigua									
	October 2007 and April 2008									
	Image Capture Log									
Date	**Location**	**Tape #**	**Transect #**		**Folder Name**	**# Images**	**Captured by**	**Renamed by**	**Analysed by**	**Comments**
16-Oct-07	Little Bird Island	AG01	1		01AGBI07	55	D. Henry	M. Creary	D Henry	
			2		02AGBI07	45	D. Henry	M. Creary	D Henry	
			3		03AGBI07	46	D. Henry	M. Creary	D Henry	
			4		04AGBI07	55	D. Henry	M. Creary	D Henry	
			5		05AGBI07	30	D. Henry	M. Creary	D Henry	
	Total images					*231*				
9-Apr-08	Little Bird Island	AG02	1	A1	01AGLB08	38	D. Henry	M. Creary	D Henry	
			2	A2	02AGLB08	42	D. Henry	M. Creary	D Henry	
			3	B1	03AGLB08	45	D. Henry	M. Creary	D Henry	
			4	B2	04AGLB08	46	D. Henry	M. Creary	D Henry	
10-Apr-08	Little Bird Island		5	C1	05AGLB08	51	D. Henry	M. Creary	D Henry	
			6	C2	06AGLB08					Transect incomplete
			7	D1	07AGLB08	58	D. Henry	M. Creary	D Henry	
			8	D2	08AGLB08	61	D. Henry	M. Creary	D Henry	
			9	E1	09AGLB08	41	D. Henry	M. Creary	D Henry	
			10	E2	10AGLB08	33	D. Henry	M. Creary	D Henry	
11-Apr-08	Little Bird Island	AG03	11	F1	11AGLB08	49	D. Henry	M. Creary	D Henry	
			12	F2	12AGLB08	36	D. Henry	M. Creary	D Henry	
			13	G1	13AGLB08	53	D. Henry	M. Creary	D Henry	
			14	G2	14AGLB08	51	D. Henry	M. Creary	D Henry	
			15	H1	15AGLB08	45	D. Henry	M. Creary	D Henry	
			16	H2	16AGLB08	52	D. Henry	M. Creary	D Henry	
			17	I1	17AGLB08	48	D. Henry	M. Creary	D Henry	
			18	I2	18AGLB08	53	D. Henry	M. Creary	D Henry	
			19	J1	19AGLB08	51	D. Henry	M. Creary	D Henry	

			20	J2	20AGLB08	55	D. Henry	M.Creary	D Henry	
	Total images					*908*				

Soufriere/Scott's Head Marine Reserve, Dominica									
November 2007									
Image Capture Log									
Date	Location	Tape #	Transect #	Folder Name	# Images	Captured by	Renamed by	Analysed by	Comments
13-Nov-07	Soufriere Pinnacle	DM01	1	01DMSB07	60	D. Henry	M. Creary	D. Chin	
		DM01	2	01DMSB07	57	D. Henry	M. Creary	D. Chin	
		DM01	3	03DMSB07	40	D. Henry	M. Creary	D. Chin	
		DM01	4	04DMSB07	52	D. Henry	M. Creary	D. Chin	
		DM01	5	05DMSB07	57	D. Henry	M. Creary	D. Chin	
		DM01	6	06DMSB07	48	D. Henry	M. Creary	D. Chin	
		DM01	7	07DMSB07	41	D. Henry	M. Creary	D. Chin	
14-Nov-07	Danglebens	DM02	8	08DMSB07	67	D. Henry	M. Creary	D. Chin	
		DM02	9	09DMSB07					No transect #9
		DM02	10	10DMSB07	76	D. Henry	M. Creary	D. Chin	
		DM02	11	11DMSB07	70	D. Henry	M. Creary	D. Chin	
		DM02	12	12DMSB07	59	D. Henry	M. Creary	D. Chin	
		DM02	13	13DMSB07	51	D. Henry	M. Creary	D. Chin	
		DM02	14	14DMSB07	60	D. Henry	M. Creary	D. Chin	
15-Nov-07	Point. Guignard	DM03	15	15DMSB07	61	D. Henry	M. Creary	D. Chin	
		DM03	16	16DMSB07	55	D. Henry	M. Creary	D. Chin	
		DM03	17	17DMSB07	60	D. Henry	M. Creary	D. Chin	
		DM03	18	18DMSB07	61	D. Henry	M. Creary	D. Chin	
		DM03	19	19DMSB07	62	D. Henry	M. Creary	D. Chin	
		DM03	20	20DMSB07	73	D. Henry	M. Creary	D. Chin	
15-Nov-07	Champagne	DM04	21	21DMSB07	77	D. Henry	M. Creary	D. Chin	
		DM04	22	22DMSB07	78	D. Henry	M. Creary	D. Chin	
	Total images				1265				

Grand Anse Reef System, Grenada									
October/November 2007									
Image Capture Log									
Date	**Location**	**Tape #**	**Transect #**	**Folder Name**	**# Images**	**Captured by**	**Renamed by**	**Analysed by**	**Comments**
31-Oct-07	Boss Reef		1	01GDGA07	61	P. Gayle	M. Creary	D. Chin	
			2	02GDGA07	61	P. Gayle	M. Creary	D. Chin	
			3	03GDGA07	63	P. Gayle	M. Creary	D. Chin	
			4	04GDGA07	60	D. Henry	M. Creary	D. Chin	
			5	05GDGA07	66	D. Henry	M. Creary	D. Chin	
			6	06GDGA07	56	D. Henry	M. Creary	D. Chin	
			7	07GDGA07	53	D. Henry	M. Creary	D. Chin	
1-Nov-07	Middle Boss Reef		8	08GDGA07	47	D. Henry	M. Creary	D. Chin	
			9	09GDGA07	68	D. Henry	M. Creary	D. Chin	
			10	10GDGA07	43	D. Henry	M. Creary	D. Chin	
			11	11GDGA07	53	D. Henry	M. Creary	D. Chin	
2-Nov-07	Bottom Boss Reef		12	12GDGA07	59	D. Henry	M. Creary	D. Chin	
			13	13GDGA07	52	D. Henry	M. Creary	D. Chin	
			14	14GDGA07	55	D. Henry	M. Creary	D. Chin	
			15	15GDGA07	65	D. Henry	M. Creary	D. Chin	
2-Nov-07	Northern Exposure		16	16GDGA07	58	D. Henry	M. Creary	D. Chin	
			17	17GDGA07	61	D. Henry	M. Creary	D. Chin	
			18	18GDGA07	59	D. Henry	M. Creary	D. Chin	
			19	19GDGA07	56	D. Henry	M. Creary	D. Chin	
			20	20GDGA07	69	D. Henry	M. Creary	D. Chin	
	Total images				1165				

Paradise Reef, Sandy Point, St Kitts									
November 2007									
Image Capture Log									
Dates	Location	Tape #	Transect #	Folder Name	# Images	Captured by	Renamed by	Analysed by	Comments
4-5 Nov 2007	Sandy Point	KN01	1	01KNPR07	53	D. Henry	M. Creary	I Kenny	
		KN01	2	02KNPR07	71	D. Henry	M. Creary	I Kenny	
		KN03	3	03KNPR07	109	D. Henry	M. Creary	I Kenny	
		KN03	4	04KNPR07	103	D. Henry	M. Creary	I Kenny	
		KN01	5	05KNPR07	67	D. Henry	M. Creary	I Kenny	
		KN02	6	06KNPR07	65	D. Henry	M. Creary	I Kenny	
		KN02	7	07KNPR07	72	D. Henry	M. Creary	I Kenny	
		KN02	8	08KNPR07	73	D. Henry	M. Creary	I Kenny	
		KN02	9	09KNPR07	66	D. Henry	M. Creary	I Kenny	
			10	10KNPR07					No Transect #10
		KN02	11	11KNPR07	54	D. Henry	M. Creary	I Kenny	
		KN02	12	12KNPR07	69	D. Henry	M. Creary	I Kenny	
		KN02	13	13KNPR07	70	D. Henry	M. Creary	I Kenny	
		KN01	14	14KNPR07	59	D. Henry	M. Creary	I Kenny	
		KN01	15	15KNPR07	54	D. Henry	M. Creary	I Kenny	
		KN02	16	16KNPR07	74	D. Henry	M. Creary	I Kenny	
		KN02	17	17KNPR07	72	D. Henry	M. Creary	I Kenny	
		KN01	18	18KNPR07	67	D. Henry	M. Creary	I Kenny	
		KN01	19	19KNPR07	61	D. Henry	M. Creary	I Kenny	
		KN01	20	20KNPR07	72	D. Henry	M. Creary	I Kenny	
	Total images				1331				

Soufriere Marine Management Area, Saint Lucia									
September 2007									
Image Capture Log									
Date	Location	Tape #	Transect #	Folder Name	# Images	Captured by	Renamed by	Analysed by	Comments
14-Sep-07	Grand Caille	LC01	1	01LCSM07	67	D. Henry	M. Creary	L. Jones smith	
		LC01	2	02LCSM07	73	D. Henry	M. Creary	L. Jones smith	
		LC01	3	03LCSM07	59	D. Henry	M. Creary	L. Jones smith	
		LC01	4	04LCSM07	68	D. Henry	M. Creary	L. Jones smith	
			5	05LCSM07					Omitted
12-Sep-07	Turtle Reef	LC02	6	06LCSM07	72	D. Henry	M. Creary	L. Jones smith	
		LC02	7	07LCSM07	60	D. Henry	M. Creary	L. Jones smith	
		LC02	8	08LCSM07	74	D. Henry	M. Creary	L. Jones smith	
		LC02	9	09LCSM07	43	D. Henry	M. Creary	L. Jones smith	
12-Sep-07	Anse Chastanet	LC03	10	10LCSM07	63	D. Henry	M. Creary	L. Jones smith	
		LC03	11	11LCSM07	73	D. Henry	M. Creary	L. Jones smith	
		LC03	12	12LCSM07	73	D. Henry	M. Creary	L. Jones smith	
		LC03	13	13LCSM07	73	D. Henry	M. Creary	L. Jones smith	
14-Sep-07	Mangretoute	LC04	14	14LCSM07	40	D. Henry	M. Creary	L. Jones smith	
		LC04	15	15LCSM07	42	D. Henry	M. Creary	L. Jones smith	
		LC04	16	16LCSM07	45	D. Henry	M. Creary	L. Jones smith	
		LC04	17	17LCSM07	40	D. Henry	M. Creary	L. Jones smith	
14-Sep-07	Coral Gardens	LC04	18	18LCSM07	33	D. Henry	M. Creary	L. Jones smith	
		LC04	19	19LCSM07	31	D. Henry	M. Creary	L. Jones smith	
		LC04	20	20LCSM07	32	D. Henry	M. Creary	L. Jones smith	
		LC04	21	21LCSM07	28	D. Henry	M. Creary	L. Jones smith	Replaced #5
	Total images				1089				

Castle Bay, Kingstown, St Vincent									
October 2007									
Image Capture Log									
Date	**Location**	**Tape #**	**Transect #**	**Folder Name**	**# Images**	**Captured by**	**Renamed by**	**Analysed by**	**Comments**
24-Oct-07	Castle Bay	VG01	1	01VGCR07	90	D. Henry	M. Creary	I. Kenny	
		VG01	2	02VGCR07	89	D. Henry	M. Creary	I. Kenny	
		VG01	3	03VGCR07	88	D. Henry	M. Creary	I. Kenny	
		VG01	4	04VGCR07	90	D. Henry	M. Creary	I. Kenny	
		VG01	5	05VGCR07	94	D. Henry	M. Creary	I. Kenny	
		VG01	6	06VGCR07	77	D. Henry	M. Creary	I. Kenny	
		VG01	7	07VGCR07	87	D. Henry	M. Creary	I. Kenny	
		VG01	8	08VGCR07	82	D. Henry	M. Creary	I. Kenny	
24-Oct-07		VG02	9	09VGCR07	82	D. Henry	M. Creary	I. Kenny	
		VG02	10	10VGCR07	92	D. Henry	M. Creary	I. Kenny	
23-Oct-07		VG03	11	11VGCR07	75	D. Henry	M. Creary	I. Kenny	
		VG03	12	12VGCR07	72	D. Henry	M. Creary	I. Kenny	No ID on slate
		VG03	13	13VGCR07	77	D. Henry	M. Creary	I. Kenny	
		VG03	14	14VGCR07	70	D. Henry	M. Creary	I. Kenny	
		VG03	15	15VGCR07	89	D. Henry	M. Creary	I. Kenny	
		VG03	16	16VGCR07	81	D. Henry	M. Creary	I. Kenny	
		VG03	17	17VGCR07	52	D. Henry	M. Creary	I. Kenny	
		VG03	18	18VGCR07	85	D. Henry	M. Creary	I. Kenny	
		VG03	19	19VGCR07					Lens fogged
		VG03	20	20VGCR07					Lens fogged
	Total images				1472				

Speyside, Tobago									
October 2007									
Image Capture Log									
Date	Location	Tape #	Transect #	Folder Name	# Images	Captured by	Renamed by	Analysed by	Comments
16-17 Oct 07	Japanese Garden	TT01	1	01TTSS07	64	D. Henry	M. Creary	L. Jones	
		TT01	2	02TTSS07	75	D. Henry	M. Creary	L. Jones	
		TT01	3	03TTSS07	74	D. Henry	M. Creary	L. Jones	
		TT01	4	04TTSS07	76	D. Henry	M. Creary	L. Jones	
		TT01	5	05TTSS07	73	D. Henry	M. Creary	L. Jones	
		TT01	6	06TTSS07	78	D. Henry	M. Creary	L. Jones	
		TT01	7	07TTSS07	79	D. Henry	M. Creary	L. Jones	
		TT01	8	08TTSS07	78	D. Henry	M. Creary	L. Jones	
		TT01	9	09TTSS07	75	D. Henry	M. Creary	L. Jones	
		TT01	10	10TTSS07	71	D. Henry	M. Creary	L. Jones	
17-Oct-07	Angel Reef	TT02	11	11TTSS07	58	D. Henry	M. Creary	L. Jones	
		TT02	12	12TTSS07	66	D. Henry	M. Creary	L. Jones	
		TT02	13	13TTSS07	54	D. Henry	M. Creary	L. Jones	
		TT02	14	14TTSS07	53	D. Henry	M. Creary	L. Jones	
		TT02	15	15TTSS07	62	D. Henry	M. Creary	L. Jones	
		TT02	16	16TTSS07	72	D. Henry	M. Creary	L. Jones	
		TT02	17	17TTSS07	66	D. Henry	M. Creary	L. Jones	
		TT02	18	18TTSS07	62	D. Henry	M. Creary	L. Jones	
		TT02	19	19TTSS07	66	D. Henry	M. Creary	L. Jones	
		TT02	20	20TTSS07	60	D. Henry	M. Creary	L. Jones	
	Total images				1362