

TOBAGO COASTAL ECOSYSTEMS MAPPING PROJECT

RESULTS OF COMMUNITY AND SCIENTIFIC WORK

MARCH – DECEMBER 2007

- Prepared for -

Integrated Watershed and Coastal Area Management in Small Island Developing States of the Caribbean (IWCAM)

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Executive Summary

Coral Cay Conservation (CCC), in close collaboration with the Buccoo Reef Trust (BRT) and the Tobago House of Assembly (THA), has been operating in Tobago as part of the Tobago Coastal Ecosystems Mapping Project (TCEMP) since March 2007. One of the main aims of the project is to gather baseline data on the coral reef, mangrove and seagrass habitats of Tobago.

Between March and December 2007, CCC completed a total of 187 50-metre transects on fringing coral reefs in northwest Tobago between Buccoo and Castara. Initial findings indicate that all the reefs surveyed are showing varying signs of stress. High levels of coral disease, particularly Yellow Blotch Disease, have been observed. Most reef areas surveyed had over a third of coral colonies infected with coral diseases. *Aspergillosis* affected over half of sea fans observed. In order to quantify the extent and severity of coral disease, an additional disease monitoring programme has been initiated.

Overall coral reef health varied considerably between survey sites. Hard coral cover was generally found to be low, with many sites showing less than 5% live hard coral cover. A few sites, particularly at Mount Irvine had over 15% coral cover. Coral diversity between sites and two survey depths (7 metres and 12 metres) was very similar. In general, bedrock and macroalgal cover was considerably greater than live hard coral cover. Reef fish densities for a number of commercially fished families such as Groupers and Snappers were low at 7 m. depth. The lack of snappers at this depth band is of particular concern. Key invertebrate species such as Queen Conch and Lobsters displayed very low densities of overall abundance indicating severe over-harvesting.

To date, the TCEMP has received a total of 23 scholarship students from Trinidad and Tobago whom have partaken in a variety of scholarship programmes offered by CCC. In addition to the highly successful scholarship programmes, a range of other outreach and education initiatives have been undertaken. These include an educational puppet show programme, attendance at various science fairs and the development of a teacher training workshop. Further initiatives are planned to commence over the next six months of the project.

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Introduction

The coral reefs of Tobago, like many of those throughout the wider Caribbean region, are in crisis (see Gardner et al., 2003) and the overriding cause is thought to be human activity (see Mora, 2008). Threats to reef health, caused by both natural and anthropogenic factors include overfishing, habitat degradation, land-based pollution stresses and climate change induced events. The impact of natural threats has been illustrated recently with the destructive force of Hurricane Ivan, which caused considerable damage to coastal areas and the shallow marine environment. The large-scale bleaching event of 2005 is an example of a major climate change induced event that has significantly affected the coral reefs around Tobago.

Aside from these natural and regional disturbances, Tobago's coral reefs are also subjected to localised, man-made threats resulting from coastal zone development, untreated wastewater discharge and overfishing. The mitigation and minimisation of these pressures can be achieved through an integrated sustainable management approach to the use of the coastal zone and its associated marine resources. Action taken to reduce these pressures to the reefs will also give it a far greater chance of withstanding and recovering from global stressors such as climate change. It is imperative that such initiatives strive to include all stakeholders (local and national government agencies, NGOs and resource users such as fisherfolk and tourism operators).

Management decisions and sustainable initiatives however, require accurate and current information on the status of the resources in question. At present, baseline data on Tobago's coastal resources are limited primarily to the Buccoo Reef area in the south-west. The condition of the remainder of Tobago's extensive reef network is virtually undocumented.

The ever-increasing demands placed on government agencies responsible for the management of the coastal zone will require (1) a scientifically sound database of natural resources, (2) increased capacity for the use of decision-support tools (e.g. GIS) and (3) improved public awareness. The ***Tobago Coastal Ecosystem Mapping Project*** encompasses activities to address all three needs.

Coral Cay Conservation

Effective coastal zone management, including conservation of coral reefs, requires a holistic and multi-sectoral approach, which is often a highly technical and costly process and one that many developing countries cannot adequately afford. With appropriate training, non-specialist volunteer divers are able to provide useful data for coastal zone management at little or no cost to the host country (Hunter and Maragos, 1992; Mumby et al., 1995; Wells, 1995; Darwall and Dulvy, 1996). This technique has been pioneered and successfully applied by Coral Cay Conservation (CCC), a British not-for-profit organisation.

Founded in 1986, CCC is dedicated to '*providing resources to protect livelihoods and alleviate poverty through the protection, restoration and sustainable use of coral reefs and tropical forests*'. CCC works in collaboration with government and non-governmental organisations within a host country and does not charge that country for the services provided. CCC is primarily self-financed through a pioneering volunteer participatory scheme whereby international volunteers are given the opportunity to join a phase of each project in return for a financial contribution towards the project costs. Upon arrival at a project site, volunteers undergo a training programme in marine life identification and underwater survey techniques, under the

guidance of qualified marine scientists, prior to assisting in the acquisition of data. Finances generated from the volunteer programme allow CCC to provide a range of services, including data acquisition, assimilation and synthesis, conservation education, technical skills training and other capacity building programmes. CCC is associated with the Coral Cay Conservation Trust (the only British-based charity dedicated to protecting coral reefs). CCC has been successfully running volunteer based conservation programmes in developing countries over the past 20 years with notable conservation successes in Belize (formation of the Belize Reef Marine Park and World Heritage Site) and the Philippines (creation of the Danjungan Island Marine Reserve in Negros Occidental).

For further information regarding CCC's aims and achievements, please visit our website at: www.coralcay.org

Project Background

After the 2005 Caribbean-wide bleaching event, CCC assisted the Tobago House of Assembly (THA) and the Buccoo Reef Trust (BRT) with technical resources and manpower to undertake a survey of the extent of this event on the coral reefs of Tobago.

Following this successful collaboration, CCC and BRT established a programme of systematic study with the Tobago House of Assembly and with support from the United Nations Development Programme (UNDP). This study, named the Tobago Coastal Ecosystem Mapping Project (TCEMP), was initiated in March 2007 with three aims:

- Firstly, to provide baseline data on the current status of the coral reef, mangrove and seagrass ecosystems surrounding Tobago;
- Secondly, to increase awareness about Tobago's marine resources through educational programmes;
- Thirdly, to build in-country capacity through CCC's scholarship programmes.

The collection of baseline data was designed to provide relevant information for effective policy-making and management of coastal resources. The data will be used by the Integrated Watershed and Coastal Area Management in Small Island Developing States of the Caribbean (IWCAM) programme to provide the necessary information to government bodies. The TCEMP also has strong community education and capacity-building components. These include training opportunities for local counter-parts through the CCC scholarship programme, as well as environmental awareness programmes for schoolteachers and students. Such initiatives are increasing public awareness and building lasting local capacity to assist in the effective management of Tobago's valuable coral reefs.

Aim of report

The primary aim of this report is to provide a summary of the progress of the TCEMP over the first ten months of the project. Progress on baseline and coral reef monitoring surveys is provided. An initial analysis of survey data collected is given in both chart format and through Geographical Information Systems (G.I.S.), plotted on satellite maps. Local community work has been summarised on a month-by-month basis.

Progress of Community Work and Capacity Building Programmes

This section provides a summary of the community educational work and capacity building programmes that CCC has developed alongside the biophysical survey programme. These project components are designed to raise environmental awareness of the local community, provide marine science training to local scholars and strengthen ties with local counterparts and government bodies. CCC's community and capacity building programmes are key aspects of the TCEMP project and have been adapted from successful and proven initiatives, tried and tested in other host countries where CCC operates. These programmes continue to be improved and expanded upon. New initiatives are discussed in the future activities sub-section.

CCC Scholarship Programme

CCC is currently running three scholarship programmes in Tobago. The scholarships are open to residents of Trinidad and Tobago wishing to make an active contribution towards the protection and sustainable use of Tobago's coral reefs. This includes tourism professionals, local fishers, government employees, university students, graduates and educators.

Each programme runs once every four weeks. CCC can also run additional one-day workshops for particular groups if required. The structure of these workshops is flexible and can be adapted to suit a particular audience. To date three Reef Check Scholars, seven Reef Conservation Scholars and 13 Coastal Zone Management Scholars have been trained.

The three main types of scholarships offered are:

- Coastal Zone Management Workshop (CZM)

This one-day course includes training in snorkelling, identification of reef invertebrates, major fish and coral groups plus discussions of coral reef ecology, threats to the marine environment and potential management options through a series of lectures and case studies.

- Reef Check Scuba Award

This two-week award includes certification to PADI Advanced Open Water Diver, identification of target marine life forms and training in Reef Check survey techniques.

- Reef Conservation Scuba Award

This intensive four-week programme involves scholars staying at the expedition site seven days a week. Training includes PADI Advanced Open Water Diver certification, identification of over 300 marine life forms and rigorous scientific surveying of coral reef ecosystems.



Figure 1 Chris Carter - Reef Conservation Scholar and UWI undergraduate student.

“The staff were all very helpful and approachable outside of class time and always took time to answer my many questions and tried to address any problems I had. All in all, I am very glad I did the course and hope to meet the other scholars and do something to get a local reef initiative started.”

Environmental Education Puppet Show

Developed by CCC Tobago volunteers and based on the successful variant used in the Philippines, the Puppet Show programme has proved very popular. Designed for children between the ages of 5 and 13, it is a fun and interactive way of introducing them to marine life and to some of the local marine conservation issues. The programme consists of an introductory talk, a puppet show and a series of games designed to review and reinforce the ideas presented.



Figure 2 Puppet show Introduction; ‘This is how a coral polyp feeds’. Mount Pleasant Community Centre. August 2007.

Summary of Meetings and Activities

This section provides a list and short description of the main meetings and events that CCC field staff and volunteers have attended over the first six months of the TCEMP project:

April

- 18th Meeting between representatives of CCC, BRT, the UNDP, headed by Richard Leydoo and representatives from the national steering committee (NSC).
- 23rd-24th State of unknowing: vanishing species. Symposium and exhibition held at the Hilton resort in collaboration with Earthwatch 2007.

The TCEMP project begins. Most of April was spent meeting local counterparts, developing community programmes, and 'fine tuning' the survey techniques and target species list. CCC started to participate in beach patrols with Save Our Sea Turtle's Giancarlo Lalsingh at Turtle Beach twice a week during the turtle nesting season from March to September. .

May

- 18th Meeting with DMRF Director, Mr. Kenneth Caesar
- 24th Workshop for Maine Maritime Institute undergraduate students

Twenty-four students from Maine Maritime Institute, on a field course to Tobago, visited the CCC base for a day of lectures on marine conservation and a snorkel with CCC volunteers on the house reef.

June

- 24th Owen Washington, CCC Tobago's first Reef Conservation Scholar begins.
- 26th Project launch at the Arnos Vale Hotel.
- 27th Environmental Education Puppet Show for local school at the BRT office, Carnbee
- 26th Steering Committee meeting between BRT, ET and CCC.

Our much anticipated project launch was very successful with an impressive turn out from His Excellency Eric Jenkinson The British High Commissioner, representatives from THA, BRT, DNRE, DMRF, Environment Tobago, SOS Tobago and the dive shop association with good press coverage and public interest.

July

- 4th Environmental Education Puppet Show at Bethesda primary school, Plymouth
- 12th Coastal Zone Management Workshop
- 9th-20th Sun Sea Science fortnight with BRT
- 26th Environmental Education Puppet show for Environment Tobago summer camp at Goodwood School, Goodwood.

31st Meeting with Education team and Miss Prescott, Director, at DNRE.
 31st Meeting with Mr Caesar, Director of DMRF



Figure 3 The Buccoo Reef Trust's 'On the Job Trainees' attend a CZM workshop.

This year CCC assisted BRT with their Sun, Sea, Science programme for local students. The programme involved a wide variety of activities including lectures, snorkels, boat trips, and try-dive scuba sessions in a pool. BRT joined CCC at our base in Arnos Vale for a one-day workshop of similar content to our CZM workshop and CCC staff assisted with SCUBA sessions.

August

4th Coastal Zone Management Workshop
 4th Chris Carter, Reef Conservation Scholar begins
 9th Sea grass project at Nylon Pool with DMRF
 9th Environmental Education Puppet Show, Mount Pleasant Community Centre
 10th Meeting with the Director, Miss Prescott, and the Education team at DNRE.
 Discussion focused on World Food Day and Teacher Training Workshops.
 13th Gian Lalsingh and Bridget Lee-Chow, Reef Check Scholars begin.
 11th Environmental Education Puppet Show at Scarborough Methodist School
 15th Meeting with Alvin Douglas, the President of the Divers Association, to discuss
 Reef Check training for scuba instructors
 21st Four Jack Petchey Foundation recipients beginning their 4-week expedition with
 CCC.

By August CCC's two main education programmes, the CZM workshop and environmental education puppet show, were running smoothly on schedule with two puppet shows and one CZM workshop per month, undertaken by staff and volunteers. The project scientist was also in discussions with the various governing bodies working hard to develop future Teach training Days programmes and Reef Check training for the dive operators, see 'future plans' section below for details.

September

8 th	Coastal Zone Management Workshop
8 th	Imran Khan, Reef Conservation Scholar begins
17 th	Meeting at DNRE, Teacher training workshops
25 th	Meeting at DNRE, Carl Hector, international beach clean up
26 th	Science fair at Speyside Secondary School
28 th	Environment Tobago's (ET) 'Keep It Clean' Schools Project launch
28 th	Reef Check training meetings at Dive shops
29 th	International Coastal Clean-up in collaboration with DNRE and DMRF: Rubbish collection on beaches and shallow reefs.

October

6 th	Coastal Zone Management workshop
6 th	Melissa Phillips, Reef Conservation Scholar begins
15 th	Meeting at DNRE
17 th & 18 th	World Food Day exhibit at Dwight Yorke stadium
25 th & 26 th	Tourism Fair at Lowlands Mall



Figure 4. CCC interactive display at World Food Day, held at the Dwight Yorke Stadium.

November

- 3rd Suraiya Laloo, Reef Conservation Scholar begins.
- 23rd Environmental Education Puppet show at Scarborough Methodist School
- 24th Coastal Zone Management workshop
- 26th-1st Judges of Environment Tobago's 'Keep It Clean' Schools Competition
- 26th Rondel Bailey, Reef Check Scholar begins



Figure 5 Rondel Bailey, Reef Check Scholar, receives certificate from CCC staff member.

December

- 5th Coral Reef Information Board completed and on display at Arnos Vale Bay.
- 11th World Resources Institute Lecture on 'The Economic Value of Coral Reefs' by Laurretta Burke.
- 29th Judges of Environment Tobago's 'Keep Tobago Clean' schools poster competition



Figure 6. CCC's Coral Reef Information Board on display at Arnos Vale Bay.

January

- 8th 12 Maine Maritime Institute Undergraduate Students attend Coral reef Ecology & Careers workshop
- 18th & 25th Environmental Education Puppet Shows at Black Rock Comprehensive School and Plymouth's Anglican School.
- 19th Coastal Zone Management Workshop
- 23rd ET's 'Keep A Clean School Competition Prize Giving'
- 26th Scholars reunion



Figure 7 Judging Environment Tobago's 'Keep It Clean' schools poster competition.

Future Activities

CCC plans to run a Reef Check training programme specifically for Scuba Instructors in Tobago. This programme will train the instructors as Reef Check trainers. This in turn would enable them to teach the Reef Check EcoDiver programme and organise Reef Check surveys. Not only will this increase awareness through the diving community but it will also greatly increase coral reef monitoring capacity in Tobago.

CCC will continue to train scholars to the current high standards. We anticipate that with the scholarship system up and running since June 2007, awareness of this opportunity for Trinidad and Tobago nationals will continue to increase through word of mouth leading to an increase in the number of CCC scholars per month. One of the long-term aims of the scholarship system is to encourage the formation of an advocacy group through the scholars alumni group. Currently the first reunion has been arranged for the end of January. CCC aim to secure the attendance of all previous scholars survey for a day of surveying, to refresh their knowledge, meet one another and strength existing ties.

Currently, CCC are developing a Teacher Training Day workshop in conjunction with both BRT and DNRE designed specifically for secondary school science teachers. The workshop will be based on the one-day CZM programme but will be adapted to suit the specific needs of the teachers. The course will focus on techniques to increase student's environmental awareness and knowledge, and will integrate into the Tobago schools curriculum.

The training day will introduce a number of themes concerning reef ecology and coastal zone management, each of which will be accompanied by ideas for classroom sessions and activities. A teaching aid support package will also be developed for teachers to take away with them and use to educate their students. CCC has recently recruited an Educational Officer to develop this important aspect of the TCEMP project.

Another potential initiative is the formation of a coral reef information board for the popular Mount Irvine Beach to increase coral reef awareness. CCC also looks forward to continuing to participate again in beach patrols with Save Our Sea Turtles come the start of nesting season in March 2008.

Scientific Methods

History and rationale

CCC's quantitative baseline survey technique was designed to provide a comprehensive assessment of shallow coastal ecosystems quickly and effectively. Originally used on CCC projects in Fiji, it has been adapted for use on the TCEMP. CCC survey data are used primarily to describe and classify the nature of coastal habitats. Surveys are performed mainly on the fore reef but it is sometimes necessary to conduct back reef and lagoon surveys as well. Regardless of the location on the reef, the technique used does not vary. Aerial or satellite imagery is used extensively to guide the survey work in the field, since this allows ground surveys to be positioned for efficient classification of the habitats visible on the image. Survey sites are located at set 'stations', every 250 metres (m) along the coastline. Surveys are conducted parallel to the reef crest, which is usually parallel to the coast. Surveys are run contiguously, and in the direction of the next survey location. For example, a survey starting at site AV01 would be conducted towards AV02 (usually in a north-easterly direction for the north coast of Tobago). Some areas of known sandy bottoms (such as Stonehaven beach) have been omitted but otherwise, surveys are conducted every 250m between Buccoo Reef and Castara.

Survey Technique

The technique itself uses teams of four divers comprised of two buddy pairs. The team surveys along a set number of replicate transects at five pre-determined depth bands. Two 50m transect lines are laid along every depth contour for each station. Each survey team can complete one 50m transect on a dive. Each depth band will therefore require a minimum of two survey teams to complete it. The start position of each 50m transect is indicated by the survey team by releasing a Surface Marker Buoy (SMB) to the surface which is marked from the support vessel using a Global Positioning System (GPS).

Individual reef transects are orientated parallel to the reef crest (perpendicular to reef slope). Each transect is surveyed at a pre-determined depth band: 2m, 7m, 12m, 16m and 22m. Whether a particular depth band is completed depends on the substrata present. At some locations, not all depth bands may be available for surveying due to a lack of reef area or limitations in depth.

The survey team collects baseline data on coral reef fauna and flora, focussing on a range of target organisms representing the main functional groups present on Caribbean reefs, including sessile benthic organisms, motile invertebrates, and reef fish.

Buddy pair 1

Diver 1 is responsible for recording the abundance of all the targeted commercial and pelagic fish species along the 50m transect in a belt 5m wide and 5m high (Figure 8). Diver 1 also records the size of selected fish families and target species into four size categories (0-10 cm, 11-20 cm, 21-40 cm and >40 cm TL). Diver 2 records the abundance of demersal and more cryptic reef fish families and targeted species along the same belt transect. Fish of less than 5cm length are generally not

included unless the adult phase is less than this size. The fish surveyors swim slowly in a straight line at about 4m per minute (12-13 min per 50m transect), being directed by diver 3 behind them.

Buddy Pair 2

Diver 1 of buddy pair 2, known as the physical diver, is responsible for leading the dive and indicating to the rest of the survey team where the transect is to be undertaken. Diver 1 is responsible for finding the right depth contour and bearing as well and guiding the fish observers along the correct contour and heading. They note the abiotic factors and underwater impacts. Diver 1 furthermore estimates the percentage of colonies affected by coral bleaching and coral diseases within four, ten-metre belts within each 50m transect. The coral colony species is recorded as well as the coral disease present on that coral colony. In addition to this, the number of infected colonies and the total number of colonies is recorded. Diver 2 is responsible for correctly laying down the survey line along the pre-determined depth band.

On the return run back along the 50 metre line, Diver 1 records the type of substratum or benthic organism (sessile) under each 50 cm point along the transect line for 2 x 20m transects with a 5m gap between transects (45-25m and 20-0m). Each transect contains 40 points. Each depth contour has four transects and thus contains 160 benthic survey points in total. Coral recruits and bleached corals are also recorded along if they are found directly underneath a point. Diver 2 becomes responsible for recording the abundance of all motile invertebrates, sea fans, sea rods, black corals, sea plumes and anemones on the return run. This is done along two 20 m belts, which are 2m wide (45-25m and 20-0m).

During the course of each survey, certain oceanographic data and observations of obvious anthropogenic impacts and activities are recorded at depth by the divers and from the surface support vessel. Sea surface temperature ($\pm 0.5^{\circ}\text{C}$) and tide level are taken from the survey boat. The survey team below records the depth of the transect, the temperature at the maximum survey depth (i.e. at the start of the survey), reef rugosity and the reef zone. Visibility, a surrogate for turbidity (sediment load) is recorded both vertically and horizontally. A Secchi disc is used to measure the vertical visibility. Horizontal visibility through the water column is measured by divers' estimates while underwater.

Survey divers qualitatively assess the strength and direction of water currents at each survey site. Similarly, the boat marshal on the support vessel qualitatively estimates the strength and direction of the wind at each survey site. Cloud cover is measured by the boat marshal on a scale of 1 to 8 Octas.

Natural and anthropogenic impacts are assessed both from the surface from the survey boat and at depth by the divers during each survey. Surface impacts are categorised as 'driftwood', 'algae', 'litter', 'sewage', 'nets' and 'other'. Sub-surface impacts are categorised as 'coral fragmentation', 'major overgrowth', 'fish bite damage', 'litter', 'human' and 'other'. All data is collected as 'present/absent' and then converted to binary data for analysis. Any boats seen during a survey are recorded along with information on the number of occupants and its activity. Data from each survey are recorded onto data forms and checked prior to being entered into the TCEMP database, which is compatible with a range of Geographical Information Systems (GIS) software used for data analysis.



Figure 8 Schematic representation of TCEMP baseline surveys conducted at each depth band.

Geographical Information System

Survey data is entered into a database, which is connected to GIS software where it can then be manipulated geographically. Once appropriate analysis techniques have been applied to the data, managers and decision makers can use the final product to make informed decisions concerning coastal zone management. The visual nature of GIS outputs facilitates the interpretation of such data by non-technical persons who may nonetheless be key decision-makers. CCC divers record the start position of each survey with a handheld GPS unit, which allows the surveys to be positioned relative to each other on a satellite image.

Relationships between the data from various survey sites can then be explored to highlight geographical regions of key interest. Information can be represented in many ways in a GIS, from simple placement techniques (“this was found here”) to more intricate mapping techniques such as data contour mapping (“this area is ‘better’ than that area”). It is important to bear in mind that the outputs are produced from the data themselves; the maps are not merely ‘coloured in’ at particular places. This is because the GIS links the map and the database intrinsically, and

any data that are required for visual examination can be 'called up' on the screen. GIS is therefore not just a mapmaker; it is a tool that allows ongoing interaction between the decision maker and the data. When further geographic/ ecological data are gathered in the future, they can be added to the GIS, making a custom built instrument for visual interpretation of any data that can be represented at any point on Earth, above or below the sea.

When sufficient data has been collected for a sector of coastline, extensive habitat maps can be created. The GIS contour maps contained in this report were created using the Inverse Distance Weighted function in the Spatial Analyst of ArcView 8.3 (ESRI software).

Survey Progress

Between April and December 2007, CCC survey teams conducted 187, 50-metre transects on fringing coral reefs along the north-west coast of Tobago between Buccoo and Castara (Figure 9). This amounted to a total of 14,960 benthic survey records, 18,708 invertebrate records and 26,848 fish records. Figure 10 illustrates the total number of surveys completed each month over the first nine months of the TCEMP.

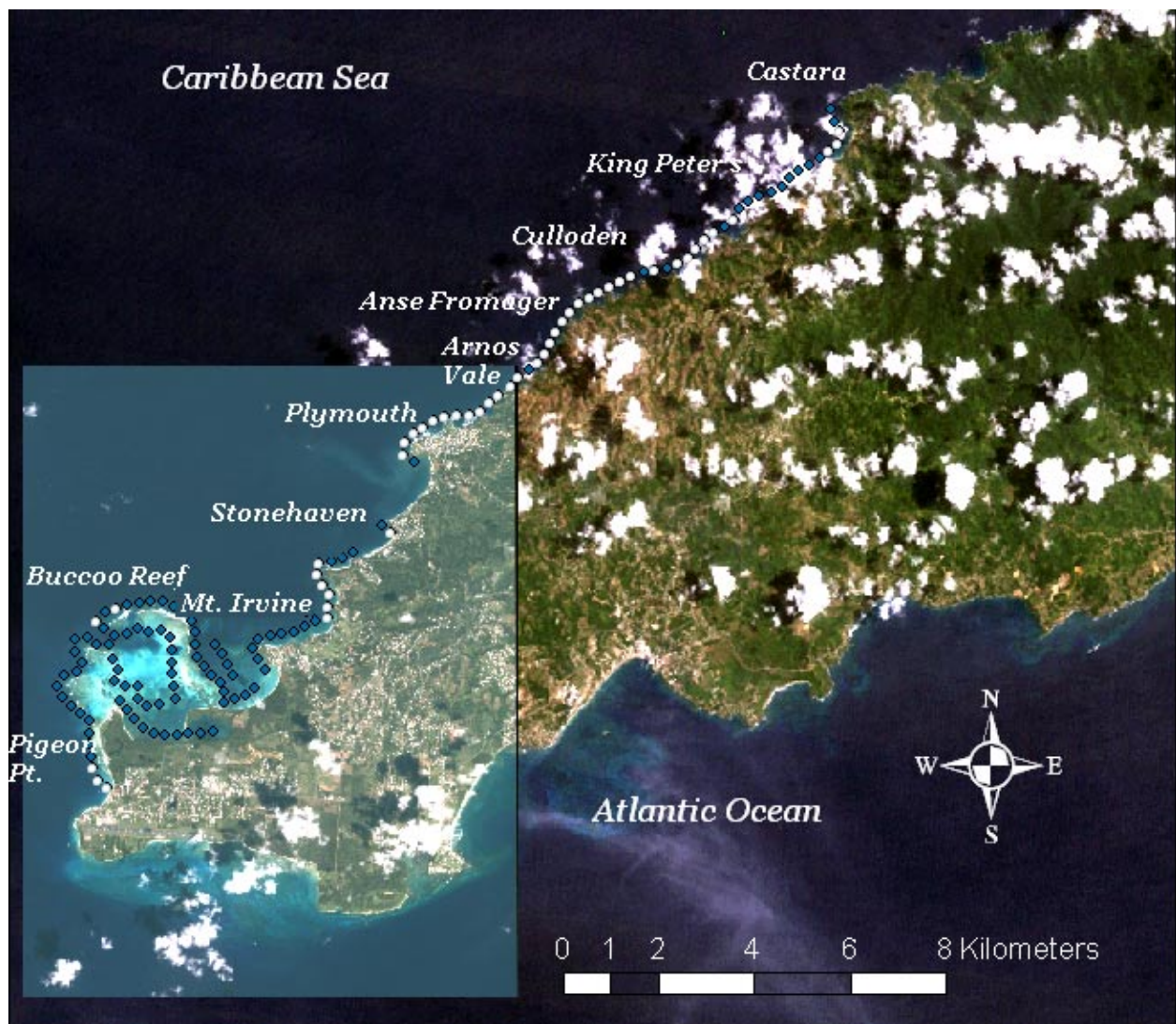


Figure 9 CCC baseline survey stations between Buccoo Reef and Castara. White points indicate stations visited between March and December 2007. Blue points indicate stations still to be visited. *Note – A white point does not necessarily mean that the station has been completed as there are 5 depth bands to be surveyed at each station*

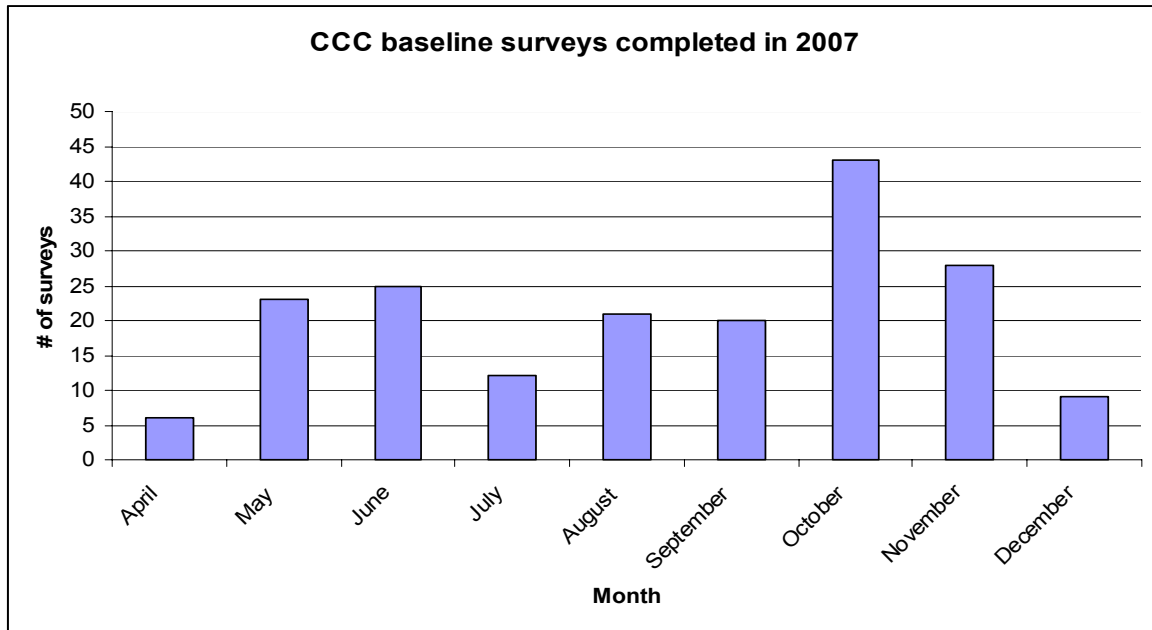


Figure 10 Number of CCC baseline surveys conducted between April and December of 2007.

For this report we shall focus on the data collected at one particular depth band, 7 metres. At this depth a total of 27 surveys have been completed, representing 54 50-metre sections. The location of completed survey stations for the 7 m depth band is presented in Figure 11.

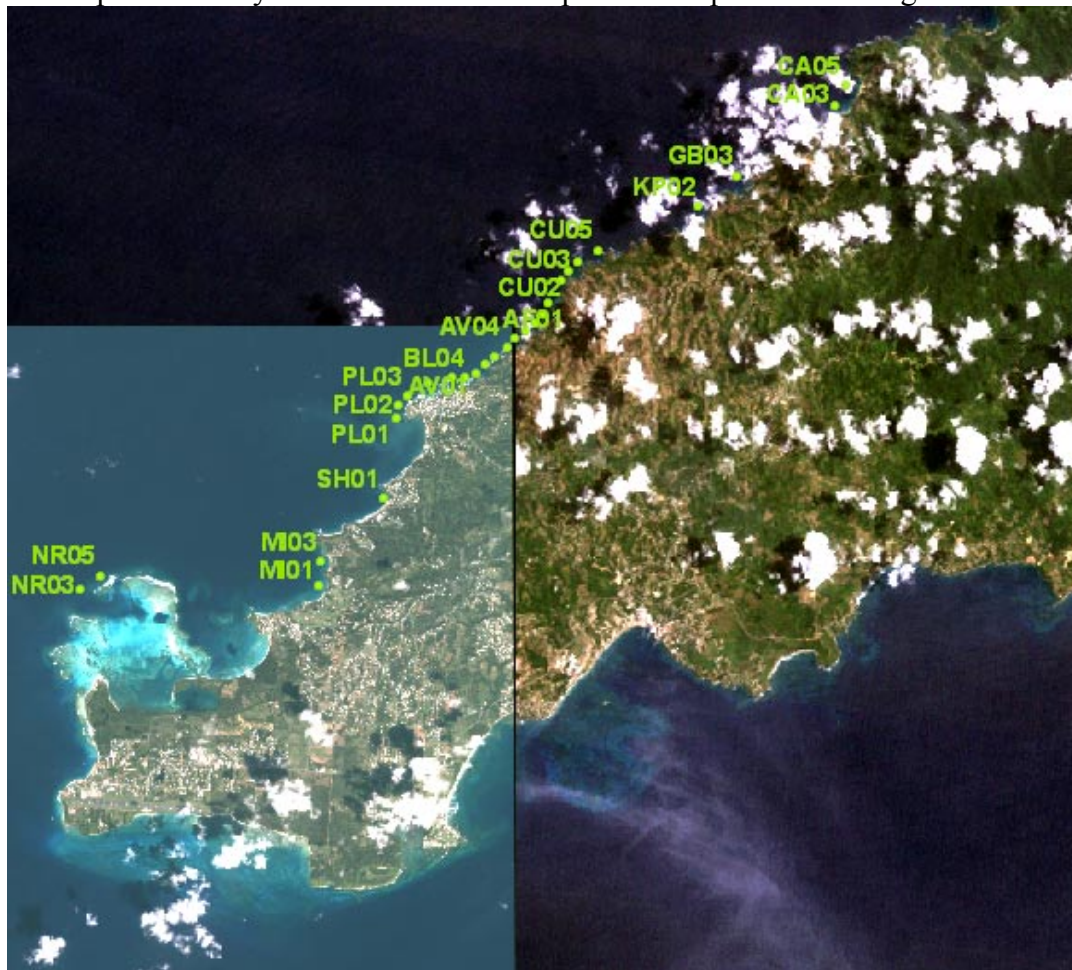


Figure 11 Surveys completed at 7 metres depth. The area between Plymouth and Culloden has been used for the presentation of GIS contour maps.

Results

At this early stage of the TCEMP, there is not enough survey data to produce an overall conservation assessment of the coastal areas between Buccoo and Castara. However, a number of key biophysical variables have been selected to illustrate trends found in the area where most of the surveys have been conducted thus far. This area is made up of the fringing reefs between Plymouth and Culloden on the Caribbean side of Tobago. The depth contour chosen was 7m as it provided the most consistent dataset between Plymouth and Culloden. This depth is also considered to have the most diverse reef habitats. A map of the surveys conducted at 7m depth can be seen in Figure 11. The biotic variables are displayed in GIS contour maps. As further surveys are completed, a complete picture can be formed of the coastal resources of Tobago and habitat maps can be developed of the area which will greatly aid in the sustainable management of the area.

Certain target taxa or abiotic categories have been shown to be effective indicators of overall reef health (Hodgson, 1999) and a number of these have been selected here to outline initial findings. Depending on the particular target, these variables can indicate a history of overfishing, nutrient pollution, sedimentation and the removal of organisms for the curio or aquarium trade. In this analysis, the indicator organisms have been adapted from those defined by the Reef Check Foundation (Hodgson, 1999), which are recognised as robust gauges of general reef health. In addition to these indicators, some focus has also been given to coral disease prevalence in the area as this is currently a subject of great concern for the reefs of Tobago.

Benthic Cover

Table 1 indicates the different taxa of hard coral that have been recorded on surveys to date. A total of 38 hard coral targets were observed with *Millepora spp.* the most abundant, recorded on 233 survey points (21.5% of all surveys). *Montastrea cavernosa* and *Diploria strigosa* were also commonly recorded, with 172 and 170 survey records equivalent to 20.4 and 18.8 % of all surveys respectively. Generally, hard corals that were seen on a relatively large proportion of total survey points were also seen on a relatively high number of survey transects.

Table 1 Most commonly recorded hard corals on the north-west coast of Tobago during 2007.

Coral Species	Number of recorded points	Percentage of all surveys
<i>Mycetophyllia aliciae</i>	1	0.5
<i>Mycetophyllia ferox</i>	1	0.5
<i>Porites porites</i>	1	0.5
<i>Tubastrea coccinea</i>	1	0.5
<i>Acropora cervicornis</i>	2	1.1
<i>Isophyllastrea rigida</i>	2	1.1
<i>Mycetophyllia lamarckiana</i>	2	1.1
<i>Favia fragum</i>	3	1.6
<i>Mussa angulosa</i>	3	1.6
<i>Porites divaricata</i>	3	1.1
<i>Madracis formosa</i>	4	1.1
<i>Solenastrea hyades</i>	4	1.6
<i>Eusmilia fastigiata</i>	5	2.2
<i>Manicina areolata</i>	6	2.7
<i>Dendrogyra cylindrus</i>	7	1.6
<i>Solenastrea bournoni</i>	9	3.8
<i>Stephanocoenia intersepta</i>	9	4.8
<i>Acropora palmata</i>	12	3.8
<i>Helioseris cucullata</i>	12	3.8
<i>Porites furcata</i>	13	4.3
<i>Scolymia spp</i>	17	5.9
<i>Dichocoenia stokesi</i>	24	8.6
<i>Diploria labyrinthiformis</i>	25	8.1
<i>Madracis mirabilis</i>	31	1.6
<i>Siderastrea radians</i>	40	12.4
<i>Porites astreoides</i>	55	10.8
<i>Madracis decactis</i>	56	9.1
<i>Agaricia spp</i>	61	13.4
<i>Meandrina meandrites</i>	73	14.5
<i>Colpophyllia natans</i>	79	13.4
<i>Montastraea franksi</i>	88	9.1
<i>Diploria clivosa</i>	109	10.8
<i>Siderastrea siderea</i>	123	17.7
<i>Montastraea annularis</i>	130	10.8
<i>Montastraea faveolata</i>	148	15.6
<i>Diploria strigosa</i>	170	20.4
<i>Montastrea cavernosa</i>	172	18.8
<i>Millepora spp</i>	233	21.5

Figure 12 displays the hard coral composition at two survey depths, 7 and 12 m. *Diploria spp.* were more abundant in shallower (7m) waters whereas *Montastrea spp.* (including *M. cavernosa* which has been analysed separately) were more common on deeper reefs (12m). Overall hard coral composition was otherwise very similar between these two depth bands. It is also worth noting that *Acropora* species comprised less than 1% of the hard coral composition at 7 m depth. Before the White-Band Disease outbreaks between 1977 and 1982, they were the dominant family of reef building coral on shallow water reefs (Wilkinson, 2004).

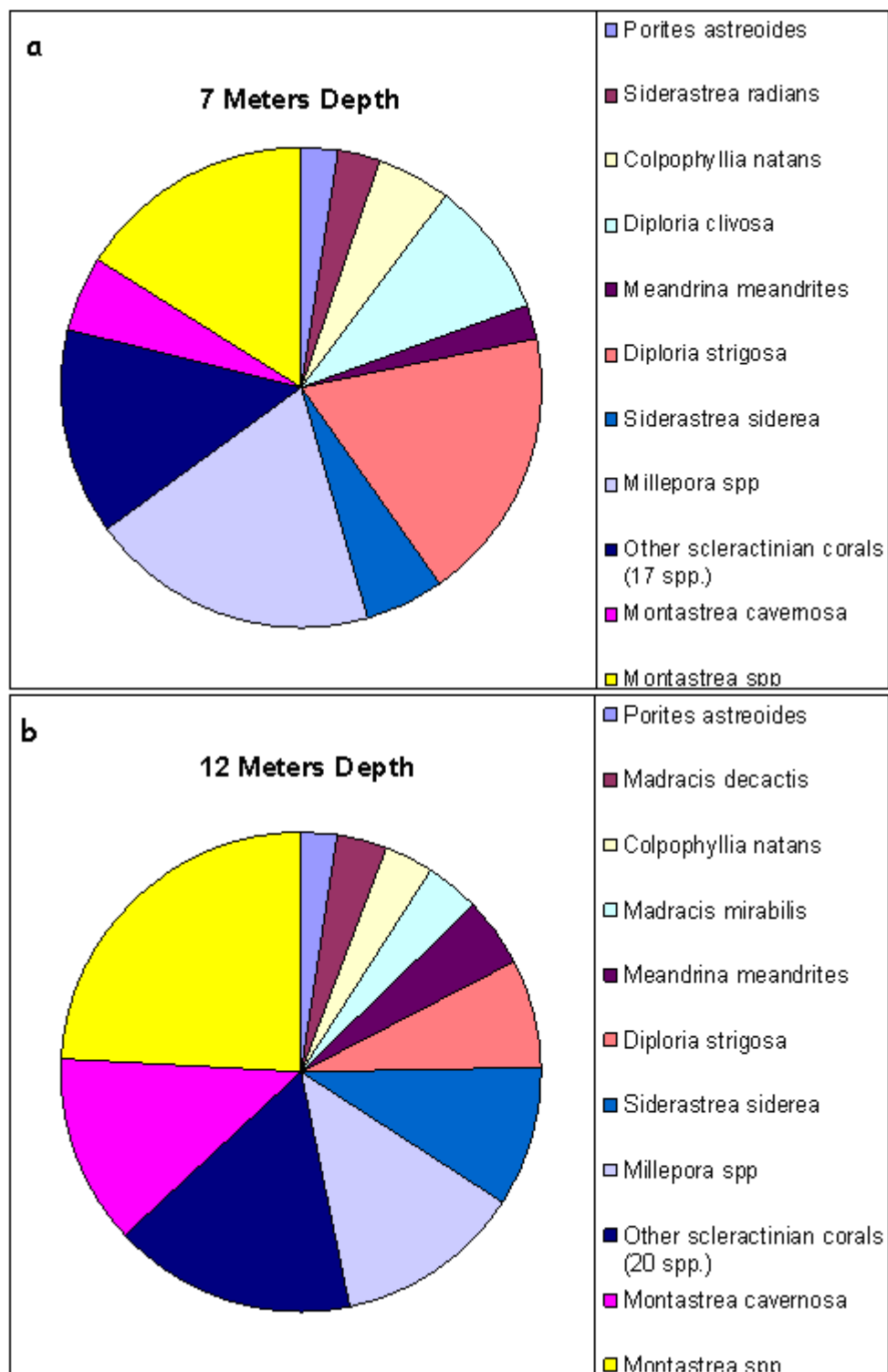


Figure 12 Scleractinian (Hard) Coral Composition at two depth bands. 7 metres (12a.) and 12 metres (12b.)

The most common benthic substratum found at all depths was sand. Other main substrata were rock, rubble and macroalgae. Figure 13 shows the percentage cover of dominant and/or important substrata for survey sites between Plymouth and Culloden at 7m depth. Live hard coral was low (<10 %) for all areas surveyed. *Acropora spp.* were only observed at Culloden.

Macroalgal cover was high throughout the area but particularly so at Anse Fromager and Arnos Vale (25% and 24% respectively)

Mean hard coral cover at all sites surveyed (and completed) at 7m was 5.25% (SD = 4.1). At 12m, hard coral cover was generally higher at 8.3% (SD = 6.7). Figure 14 presents live hard coral cover for individual survey stations at 2 depth zones. Hard coral cover was highest in Mt. Irvine and some sites at Anse Fromager but rarely exceeded 10% cover at 7 m. or 15% at 12 m. Areas of highest coral cover were MI03 (17%) at 7m and MI04 (22%) at 12m. Lowest coral cover was found at AV04 (1%) at 7m and AV03 (2%) at 12m.

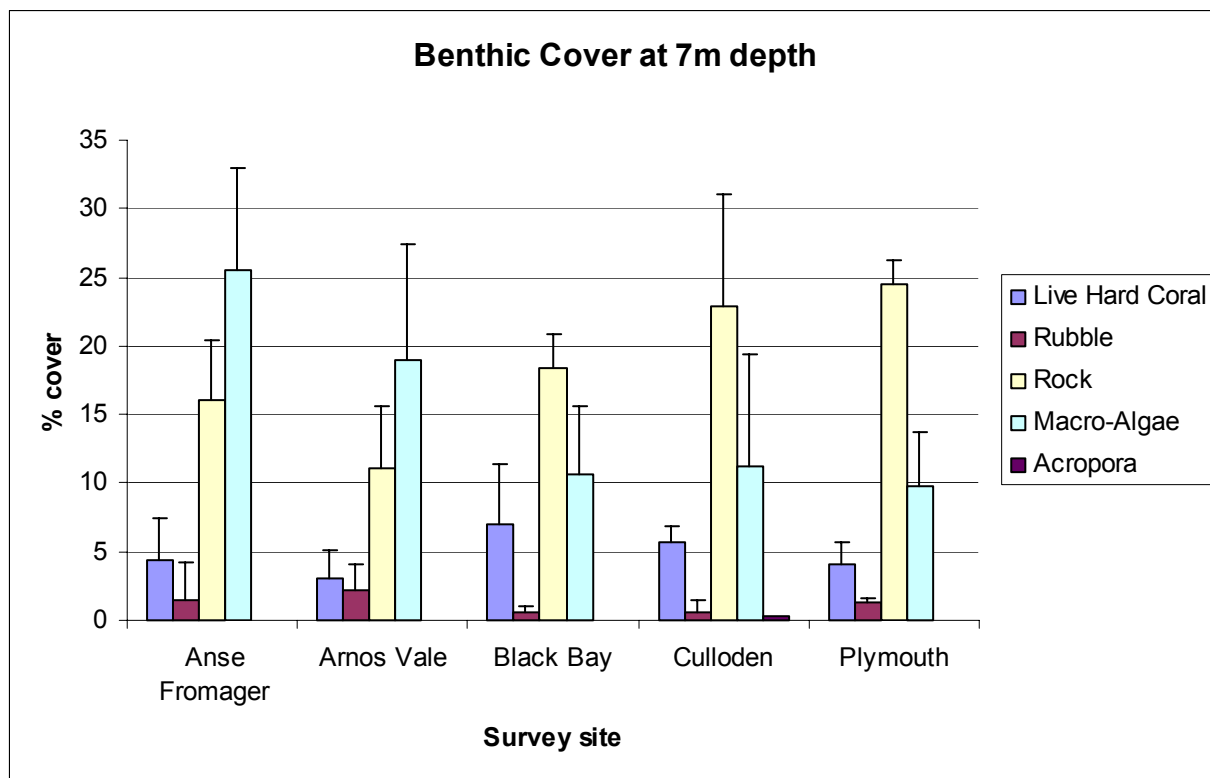


Figure 13 Mean benthic cover of dominant substrata (excluding ‘sand’) for survey sites between Plymouth and Culloden at 7 me depth. Error bars indicate standard deviation.

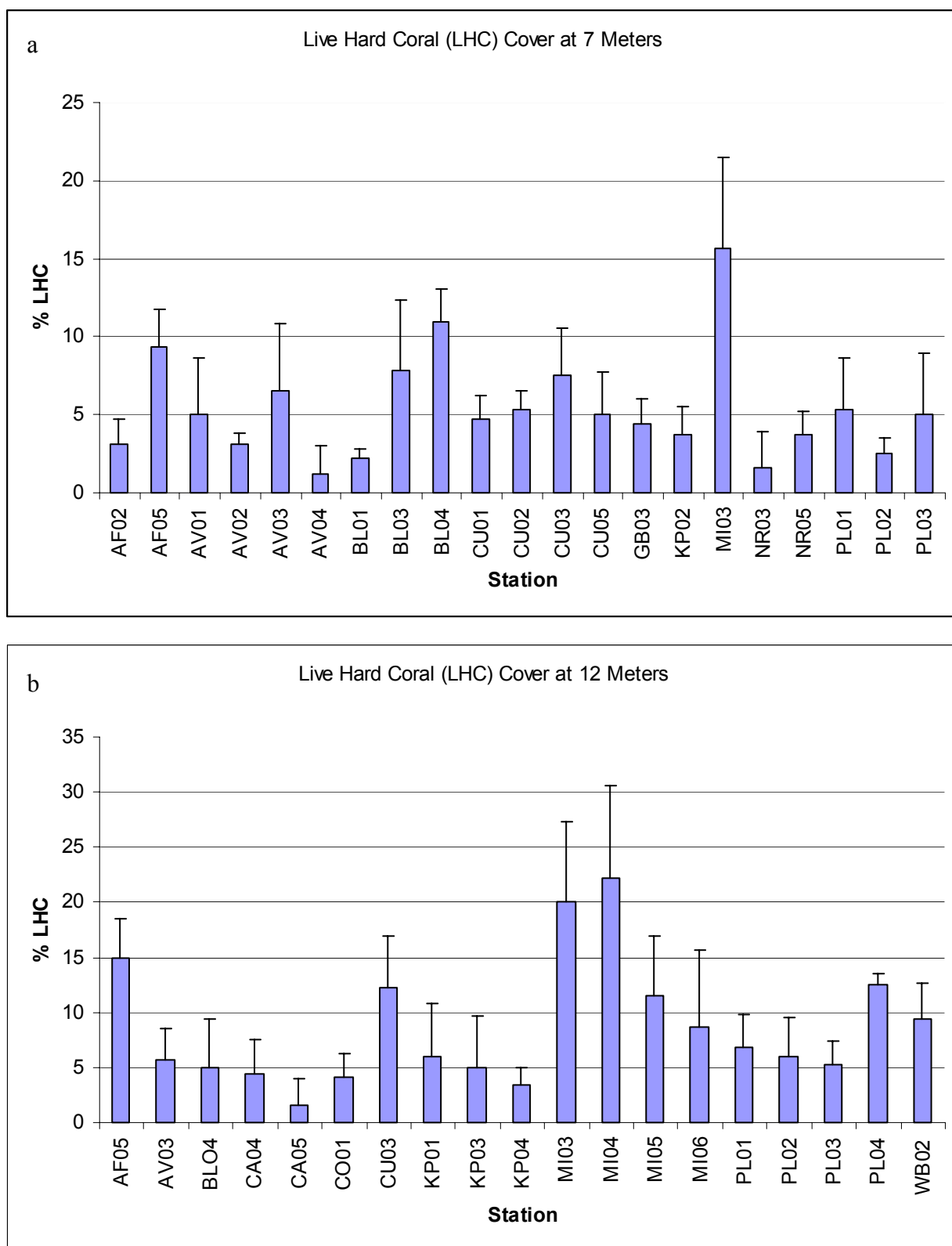


Figure 14 Live Hard Coral (LHC) cover of reefs at 7 m (14a.) and 12 m (14b.) survey depths. Surveys selected were those where all four replicates had been completed. Error bars indicate standard deviation. *Note: Surveys where there was over 90% benthic cover of sand were excluded from this analysis.*

Coral Disease Studies

Coral disease prevalence has become a serious contributor to coral reef degradation in Tobago following the 2005 bleaching event (see BRT or CCC website for full report). For this reason, CCC is closely monitoring the prevalence and severity of common and easily identifiable coral diseases. Here we present some initial trends for diseases recorded during baseline surveys. Monitoring stations of tagged coral colonies have been set up in Arnos Vale Bay and Plymouth in order to collect quantitative data on the spread rate of diseases.

Figure 15 depicts the prevalence of 4 different coral diseases as a percentage of the total amount of colonies observed during the disease component of the baseline surveys. *Aspergillosis* which is a fungal disease affecting sea fans was recorded on over half the sea fans observed. Yellow Blotch Disease (YBD), which is a bacterial induced disease infecting massive corals (mainly *Montastrea* spp.) was observed on a third of coral colonies.

Figure 16 depicts the most common diseases which infect three live hard coral categories. Corals of the *Montastrea* family are commonly affected by two types of disease, YBD (70%) and White Plague Disease (WPL, 30%). Most diseased Brain corals were infected with WPL disease (92%) and 8% were infected with YBD. Diseased *Siderastrea* spp. suffered from WPL disease, (71%) and Dark Spot Syndrome (DSS, 29%).

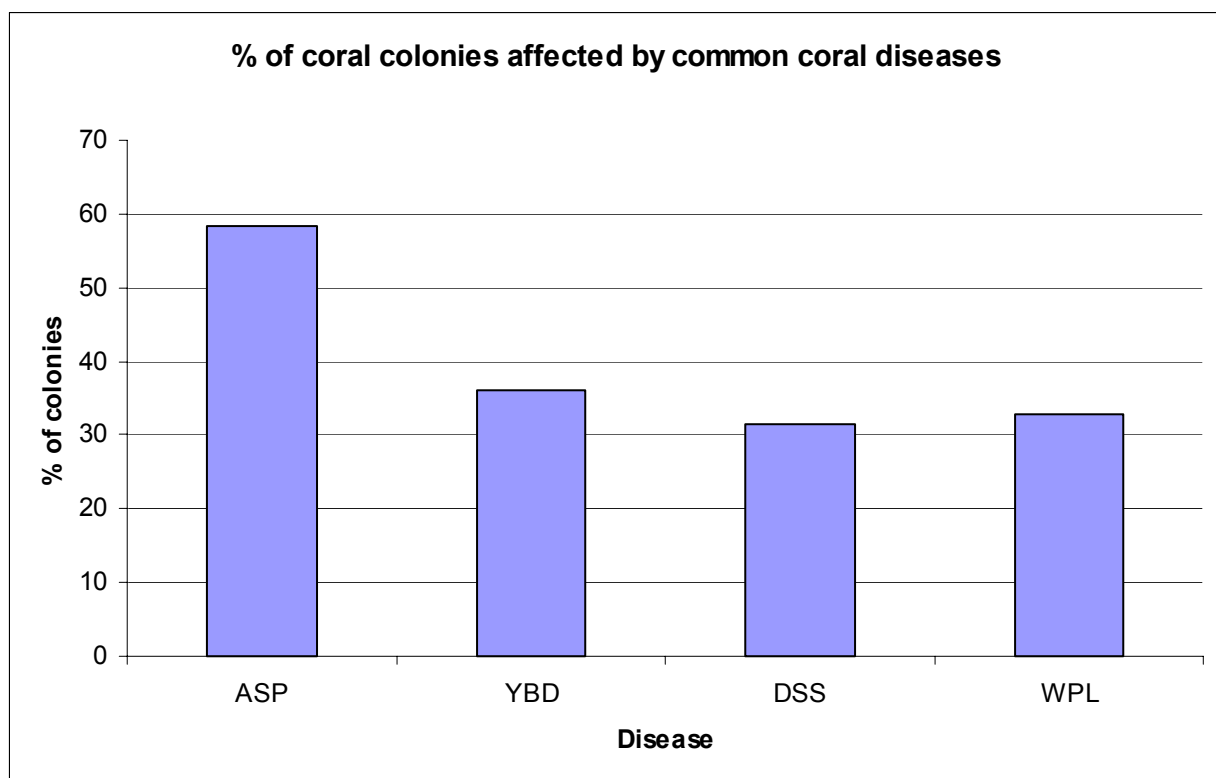


Figure 15 Percentage of coral colonies affected by 4 coral diseases expressed as a ratio of the colonies surveyed for disease. Where: ASP = Aspergillosis, YBD = Yellow Blotch Disease, DSS = Dark Spot Syndrome, WPL = White Plague Disease. ASP is expressed as a ratio between diseased/healthy Seafans.

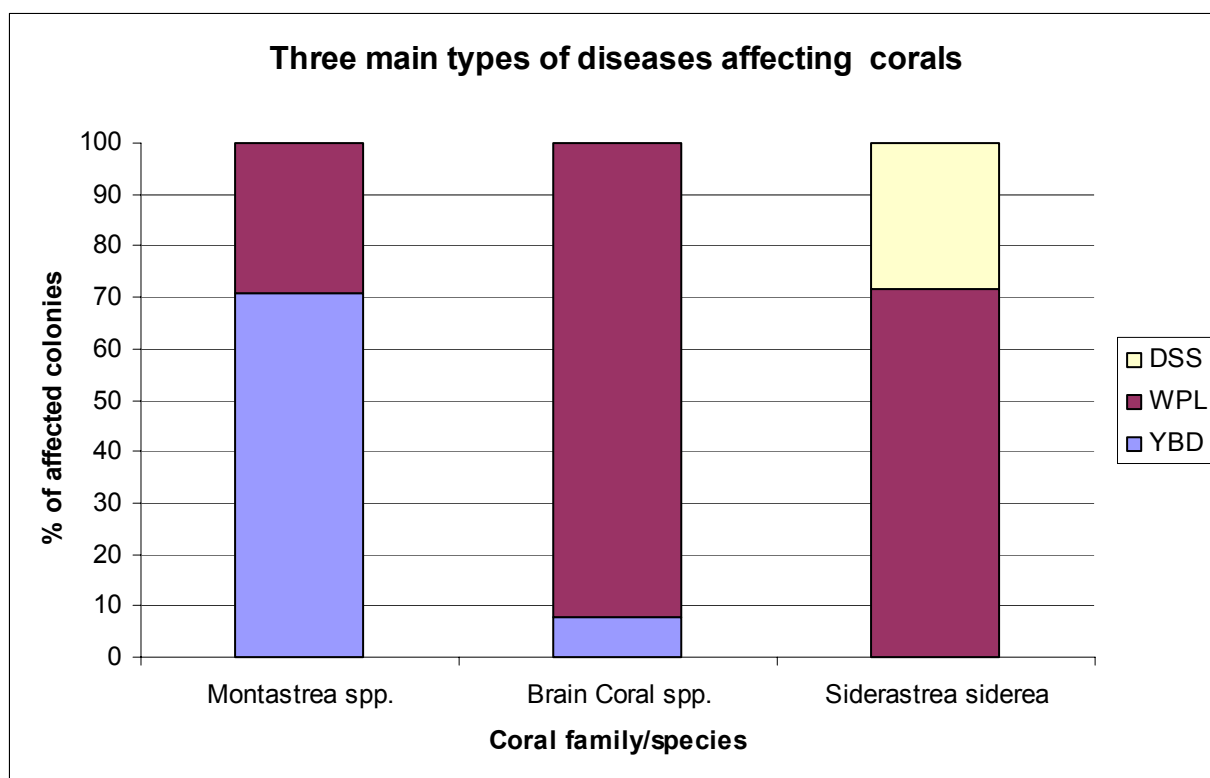


Figure 16 Most common and abundant diseases affecting three main hard coral categories

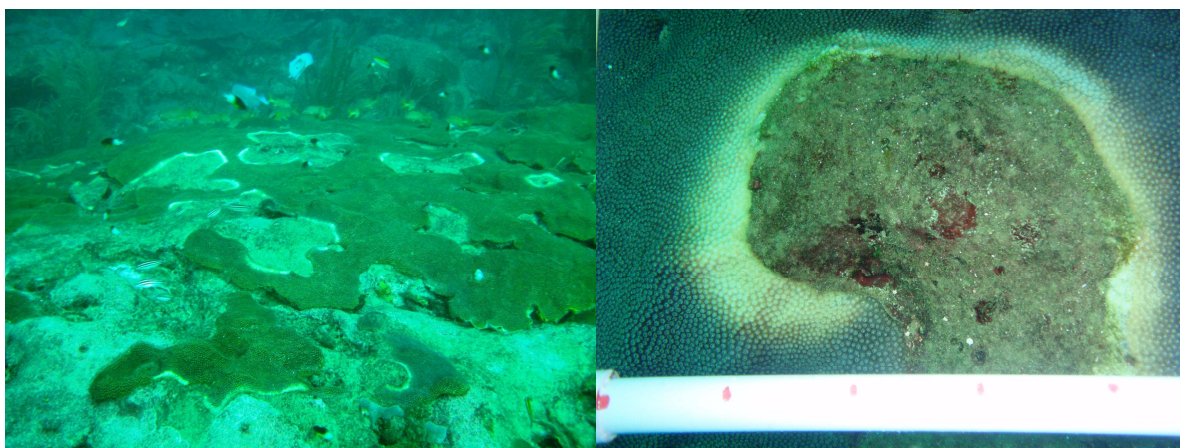


Figure 17 Yellow Blotch Disease (YBD) on a *Montastrea* coral colony on the left and a closer view of a YBD area on the right. The paler areas are diseased and dying coral. The bare area in the centre was originally covered in live coral polyps. The disease causes significant reduction in colony size, often reducing live tissue to thin patches.

In response to sightings of bleached coral colonies in August 2007, CCC and BRT undertook a number of dedicated survey dives (Peterson et al., 2007). The initial sightings were of bleached coral colonies in Arnos Vale Bay. Several small colonies appeared totally bleached and many colonies showed initial signs of bleaching, paleness and loss of colour. Surveys at three locations, Plymouth, Culloden and Mount Irvine, indicated varying levels of bleaching at all sites. High levels of coral disease were also observed at all three sites.

Monitoring of sites at Plymouth and Arnos Vale Bay, began in September 2007. The monitoring programme currently underway has two components. Firstly, 10 individual colonies affected by bleaching or disease were tagged, and are regularly revisited and photographed in order to record

temporal changes in disease prevalence. Secondly the percentage of affected colonies is estimated. Environmental parameters such as salinity, temperature and sediment are also recorded.

Since the beginning of the monitoring, many coral colonies have regained some or all of their colour but there are still some colonies that appear to be suffering from bleaching. However, the overall extent of bleaching has decreased. Recovery in diseased colonies has not been widely observed. Many of the diseases are progressing at concerning rates and loss of the entire colony is expected in most cases. Monitoring of these colonies and areas, as well as possible factors that affect bleaching, is continuing.

Reef Fish

Reef fish density was calculated for five selected target families and one species recorded at 18 survey stations between Plymouth and Colluden. Data is presented as the mean number of individuals per hectare of reef area (where one 50m transect is equivalent to 250m²) for each of the five survey sectors (Figures 18 and 19). All reef fish data presented was recorded at the 7m depth contour.

Figure 18 indicates that mean densities of Parrotfish (Scaridae) were consistently higher than those for Grunts (Haemulidae) and considerably higher than those for Snappers, Groupers or Butterflyfish (Figure 19). Highest densities of Parrotfish were recorded at Plymouth, Black Bay and Colluden with values falling around 1000 individuals/ha. Counts between survey stations were highly variable for both Grunts and Parrotfish at Black Bay and Anse Fromager.

A particular species of Parrotfish, *Scarus guacamaia*, was selected for analysis as this is a key herbivore on Caribbean reefs. Densities generally ranged between 200 and 400 individuals/ha., although consistently low values were recorded at Arnos Vale leading to a mean density of 33 individuals/ha. (Figure 19).

Densities of Groupers (Serranidae) did not exceed 50 individuals/ha. with the exception of Black Bay (113 ind./ha.) and Arnos Vale (60 ind./ha.). Butterflyfish (Chaetodontidae) densities were consistently between 90 and 120 individuals/ha. Very few Snappers (Lutjanidae) were recorded on surveys for this stretch of coastline in northern Tobago with only one or two individuals observed per survey station at 7 metres depth leading to low densities per hectare (<30). The low counts and zero values also contributed to the high variability (S.D.) for Groupers and Butterflyfish (Figure 19).

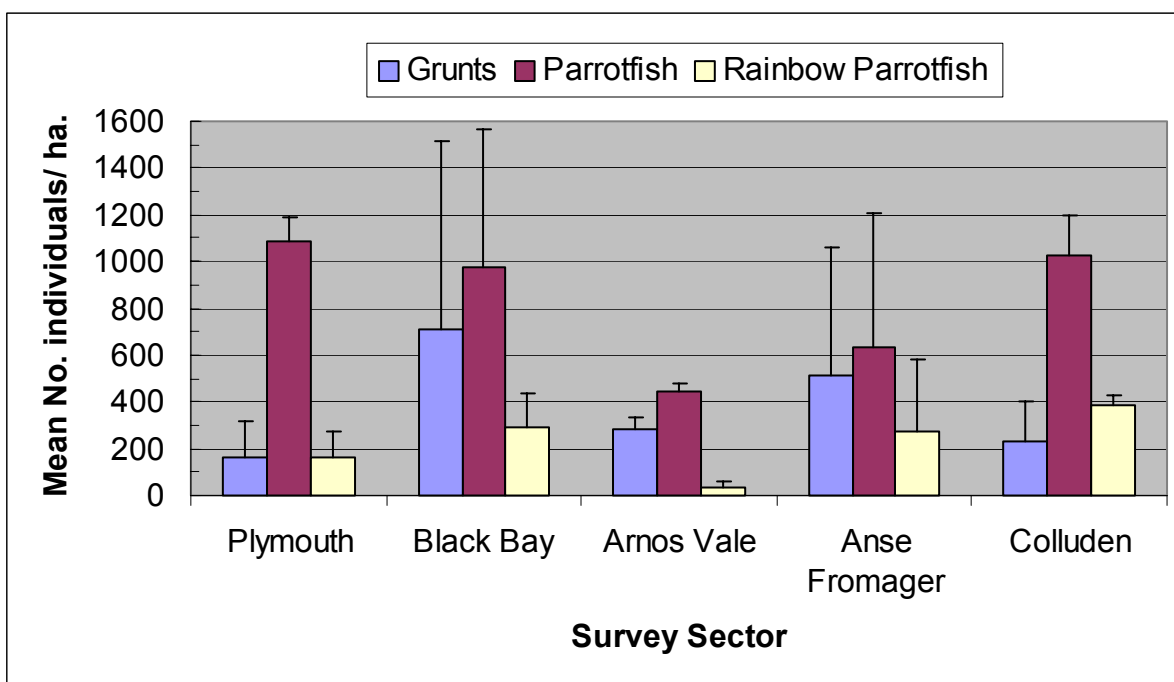


Figure 18 Density of Grunts and Parrotfish in five survey sectors along the northern coast of Tobago. Mean values + S.D. (n = 3-5).

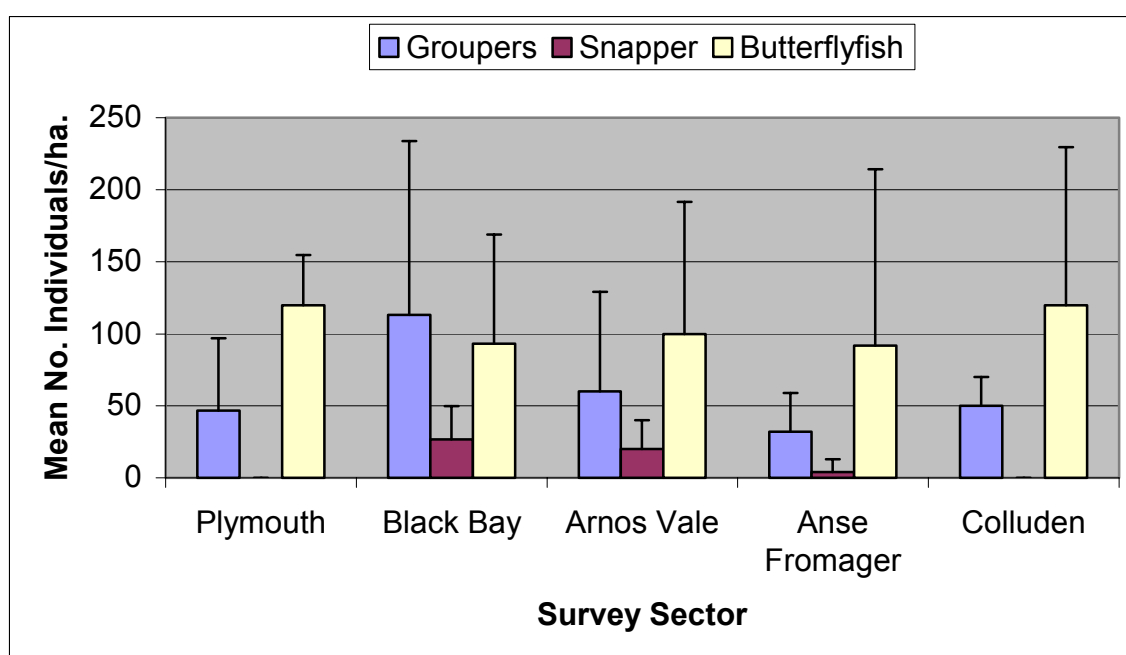


Figure 19 Density of Groupers, Snapper and Butterflyfish in five survey sectors along the northern coast of Tobago. Mean values + S.D. (n = 3-5).

Invertebrates

A number of important invertebrate indicator species were selected which are either commercially harvested or ecologically important. Abundances are presented in Figure 20. Long-spine sea urchins (*Diadema antillarum*) were recorded in two categories, namely “Adult” and “Juvenile” in order to monitor the recovery of these sea urchins after the disease outbreak in the 1980’s which killed over 90% of them. Major population changes can possibly highlight shifts in the ecological balance of the ecosystem. A sudden decrease in *Diadema* populations may result in overgrowth by macroalgae, outcompeting corals for light and space on the reef. Long-spine urchin density remains low with 55 adults and 54 juveniles recorded per hectare of reef area.

Pencil Urchins (*Eucidaris tribuloides*) and Queen Conch (*Strombus gigas*) species are often harvested for the curio trade and are becoming increasingly rare. Pencil Urchins are relatively common (62 per hectare) but Queen Conch’s were recorded on only 4 of the 186 survey dives indicating severe over-harvesting of these gastropods.

Two other popular but endangered consumption invertebrates are Sea Cucumbers (*Holothurians*) and Lobsters (*Panulirus* spp.). Recorded densities were very low, with only 5 individuals observed on all surveys. Spiny Lobsters were also a rare sighting and 12 individuals were encountered on 9 surveys of the total 186.

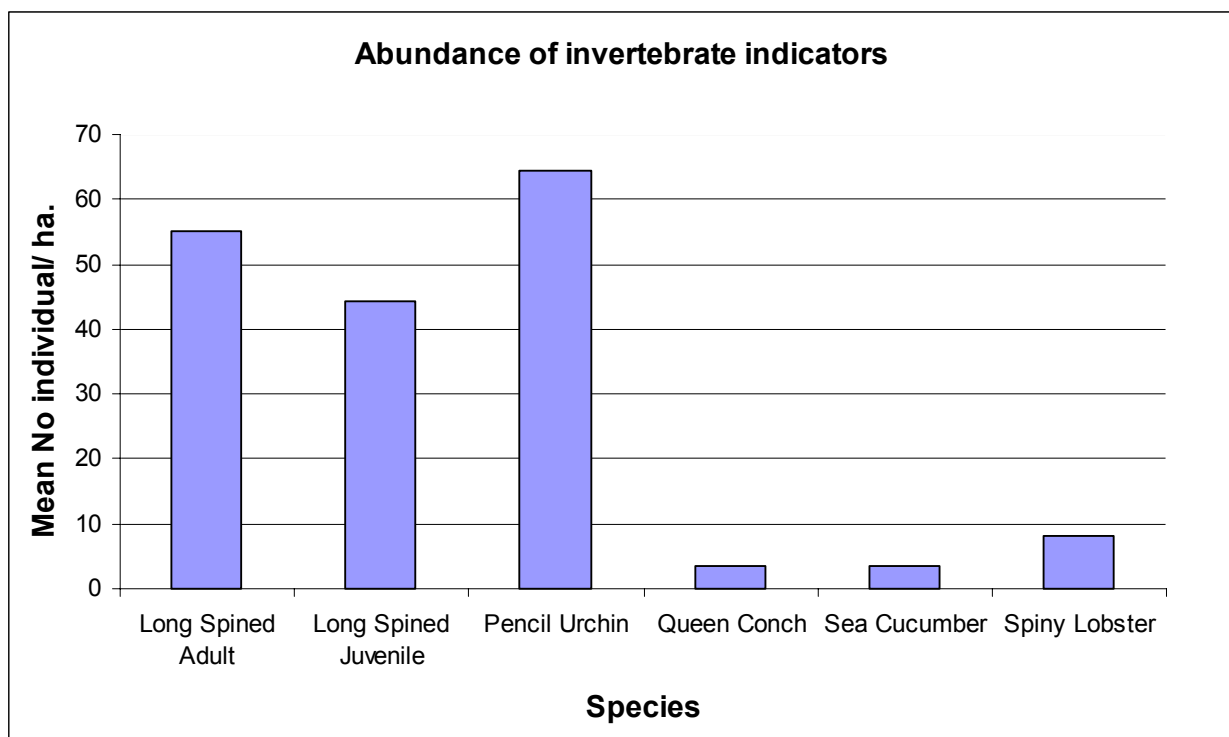


Figure 20 Abundance of selected invertebrate targets. Data is expressed as the total number of individuals per hectare for all surveys combined.

GIS Contour Mapping

The previous section provides information on average values for selected ecological criteria at particular depth bands on the northwest coast of Tobago. However, the data in this format does not pinpoint exactly where in the survey area there are high densities of reef fish or invertebrates or the parts of the reef systems with high coral cover.

Presentation of data as a series of contour maps enables spatial comparison of ecological criteria across the study area. In this section we present contour maps for a range of coral reef criteria for one of the depth bands surveyed (7 ± 1 m.). This depth was selected as it is the optimal depth for hard coral cover and diversity on most reef systems, which has been positively correlated with the abundance and diversity of motile fauna, particularly reef fish.

A total of ten biotic and abiotic coral reef variables are presented here, which is a subset of the range of variables that will be presented in subsequent TCEMP reports.

Benthic Cover

Percentage cover distributions of selected benthic categories are presented in Figures 21-23 below. Areas of high cover of bedrock were identified on fringing reefs adjacent to Anse Fromager and Colluden with values reaching 30% of all benthic cover at the former (Figure 21). Available bedrock was lowest at Plymouth and Black Bay where values reached 10-15 % cover.

Cover of live hard coral was generally low at the 7m depth band for the whole area of coast between Plymouth and Colluden (Figure 22) with the highest values recorded at Black Bay (11% cover). Fringing reefs adjacent to Plymouth revealed particularly low hard coral cover (<5%).

Macroalgal cover was generally higher than that for hard corals over the assessed area with most stations having more than 10% cover (Figure 23). Highest values were recorded at Plymouth (31%), followed by Arnos Vale (20-25%). Fringing reefs at Colluden revealed the lowest levels of macroalgae with up to 15% cover.

Figure 21 Percentage bedrock cover for the area of fringing reefs surveyed in northern Tobago between Plymouth and Colluden.

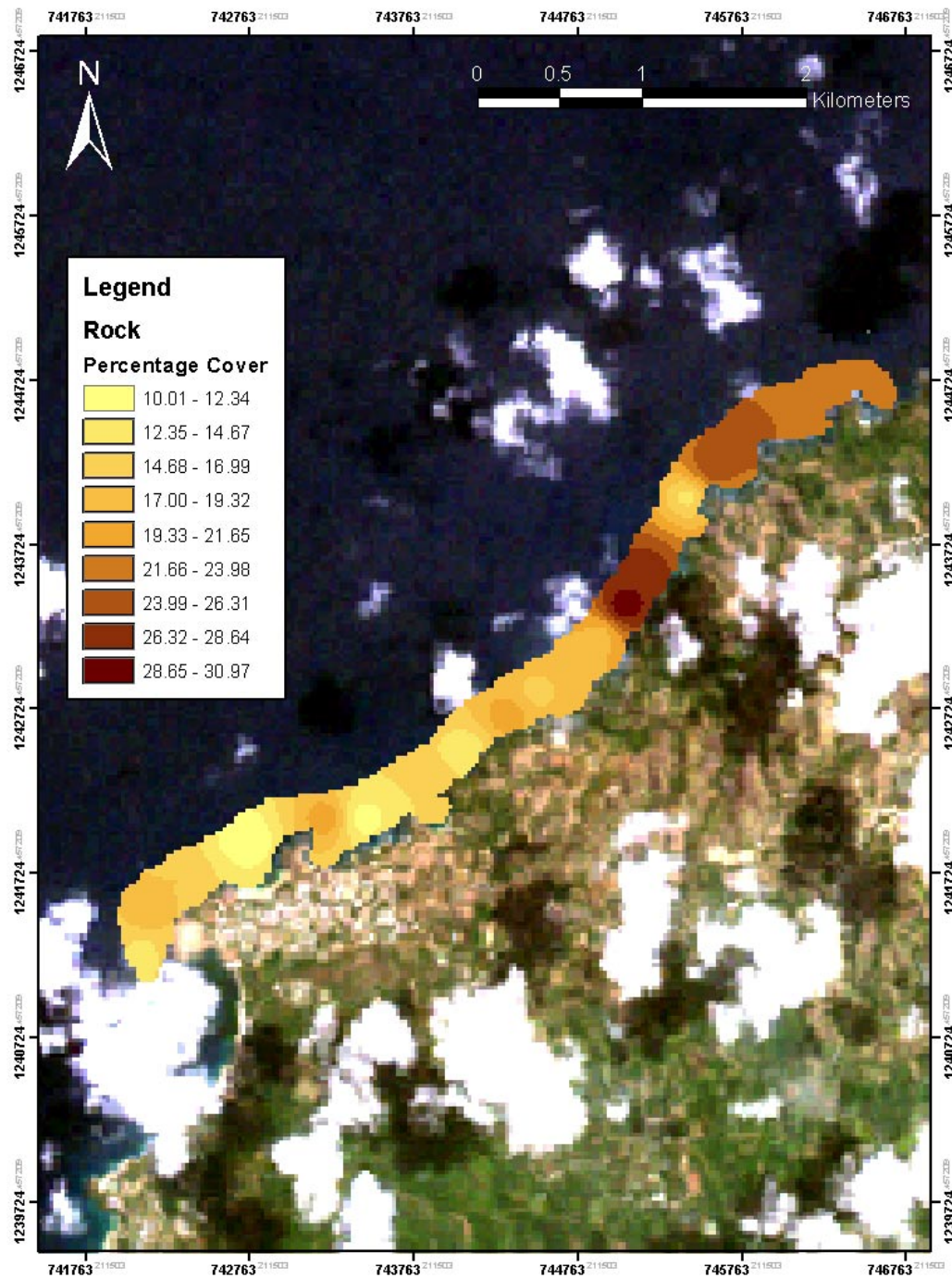


Figure 22 **Percentage hard coral cover for the area of fringing reefs surveyed in northern Tobago between Plymouth and Colluden.**

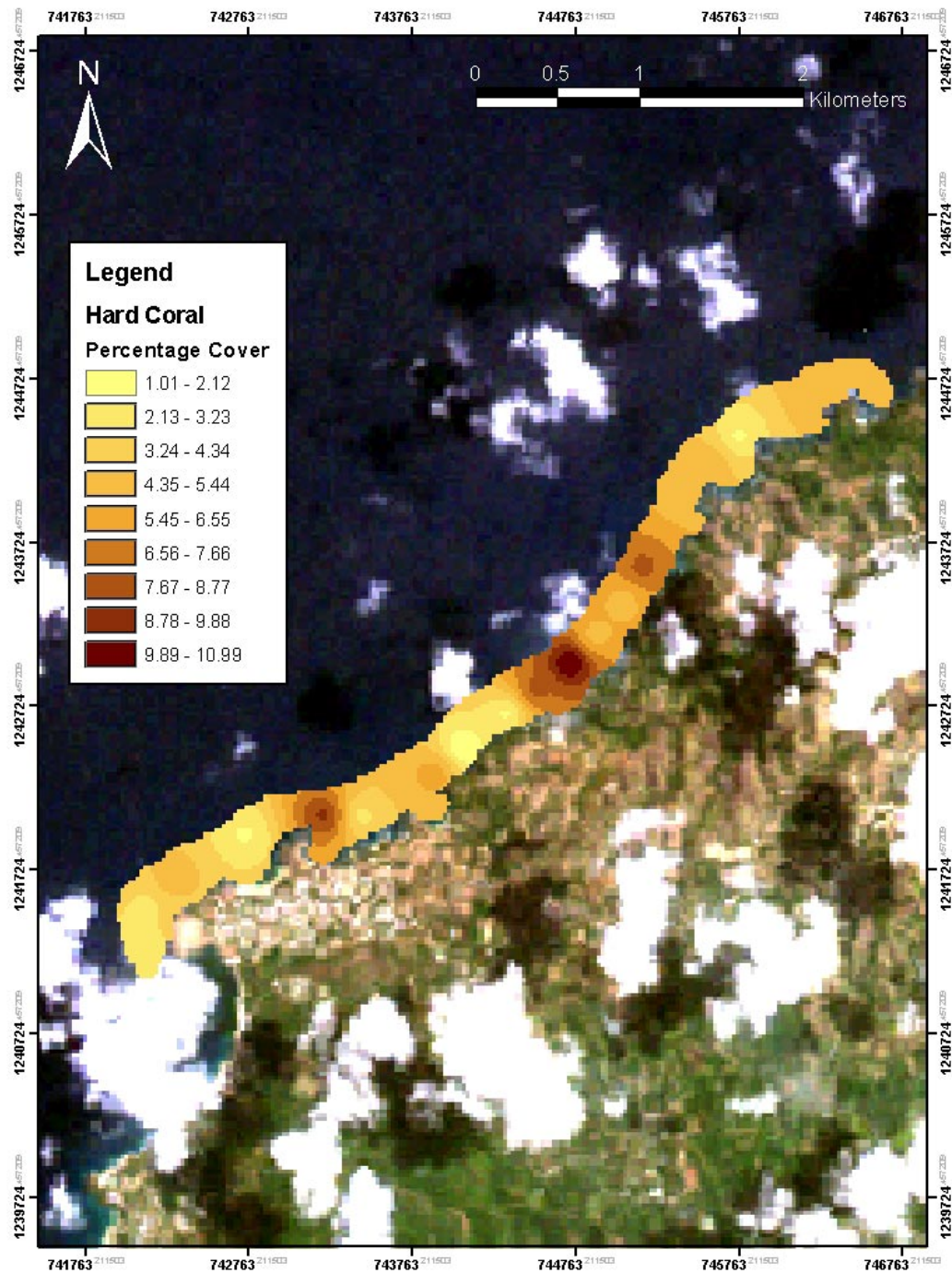
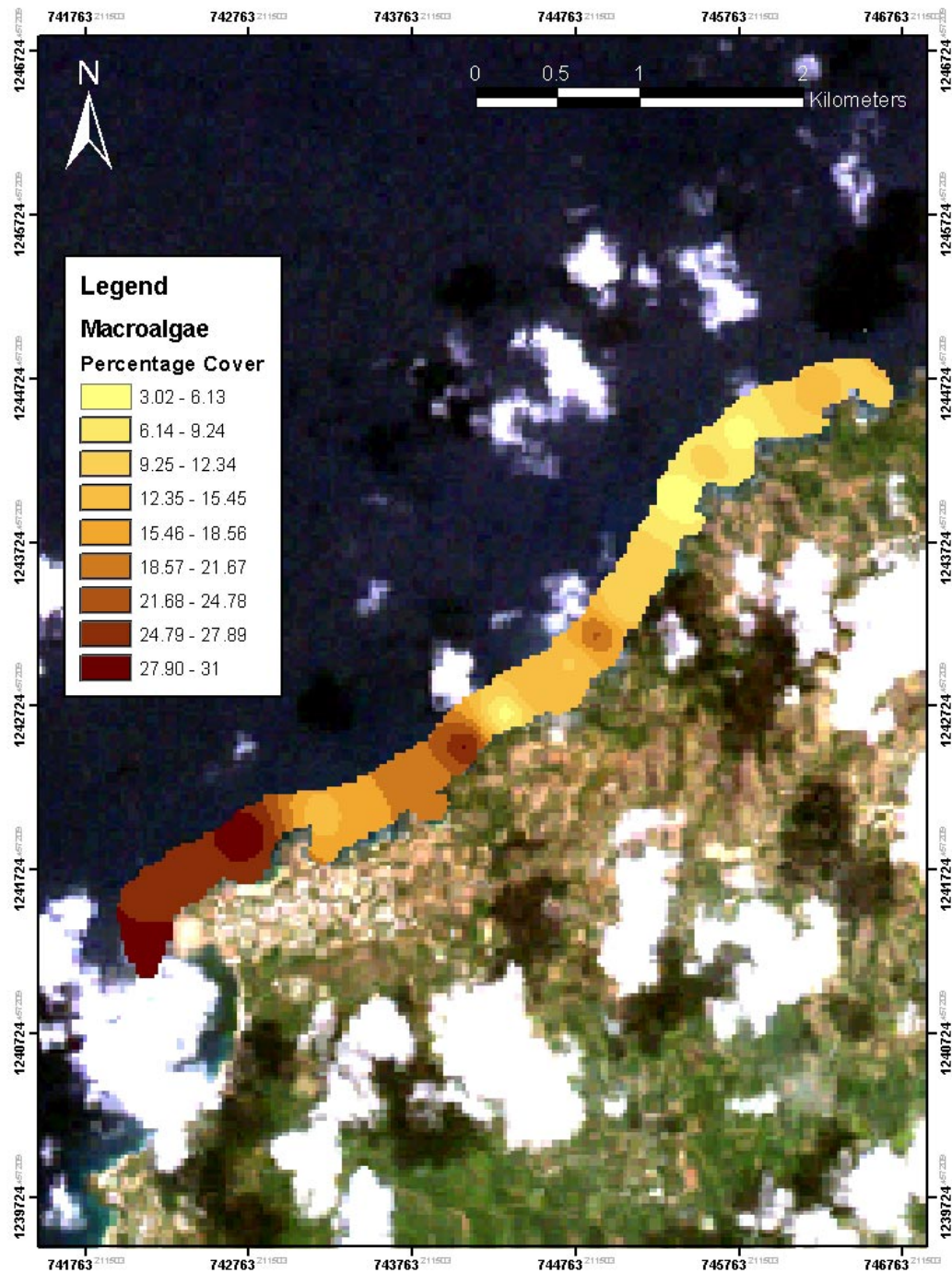


Figure 23 Percentage cover of macroalgae for the area of fringing reefs surveyed in northern Tobago between Plymouth and Colluden.



Reef Fish

Densities for five reef fish families and one species are presented in Figures 24-29 as the number of individuals per 250 m² of reef area. One of the key herbivores on coral reefs is the Parrotfish family (Scaridae). Contour maps of Parrotfish densities are provided in the first two figures in this section for the family as a whole (Figure 24) and for one particular species, *Scarus guacamaia*, the Rainbow Parrotfish (Figure 25).

Parrotfish densities generally ranged between 5 and 37 individuals/250 m² in the area surveyed. Highest densities were recorded adjacent to Plymouth (37-41.5 ind./250 m²) and at Anse Fromager (32-37 ind./250 m²). Densities were also consistently high adjacent to Colluden. Rainbow Parrotfish densities mirrored those observed for the Scarid family in general with highest densities recorded at Anse Fromager, Plymouth and Colluden (Figure 25). However maximum densities were observed at Anse Fromager (16-18 ind./250 m²) and not at Plymouth for this species. Again fringing reefs in the Colluden region had consistently higher densities of *Scarus guacamaia* than most other sectors surveyed.

Figures 26-28 depict the observed densities of three carnivorous reef fish families, Grunts, Groupers and Snappers, which are all commercially fished as a foodfish in Tobago. The distribution of Grunts (Haemulidae) was rather patchy (Figure 26) with two survey stations revealing high densities at Black Bay (36-41 ind./ 250 m²) and Arnos Vale (31-36 ind./ 250 m²). Groupers (Serranidae) and Snappers (Lutjanidae) were not recorded often on surveys at this depth band. A relatively high density of Groupers was recorded at one station adjacent to Plymouth but otherwise counts were consistently low (Figure 27). Snapper densities were also low with very few individuals observed for the whole coastline at 7 m depth (Figure 28), mainly at Black Bay.

The final contour map in this section (Figure 29) depicts observed densities of Butterflyfish (Chaetodontidae), a reef fish family often used as an indicator group for general reef health. The density of Butterflyfish was quite variable for the area assessed, with highest values recorded at Arnos Vale and Anse Fromager (6-8 ind./250 m²).

Figure 24 **Density of Parrotfish (*Scaridae*) per 250m² of reef area in northern Tobago between Plymouth and Colluden.**

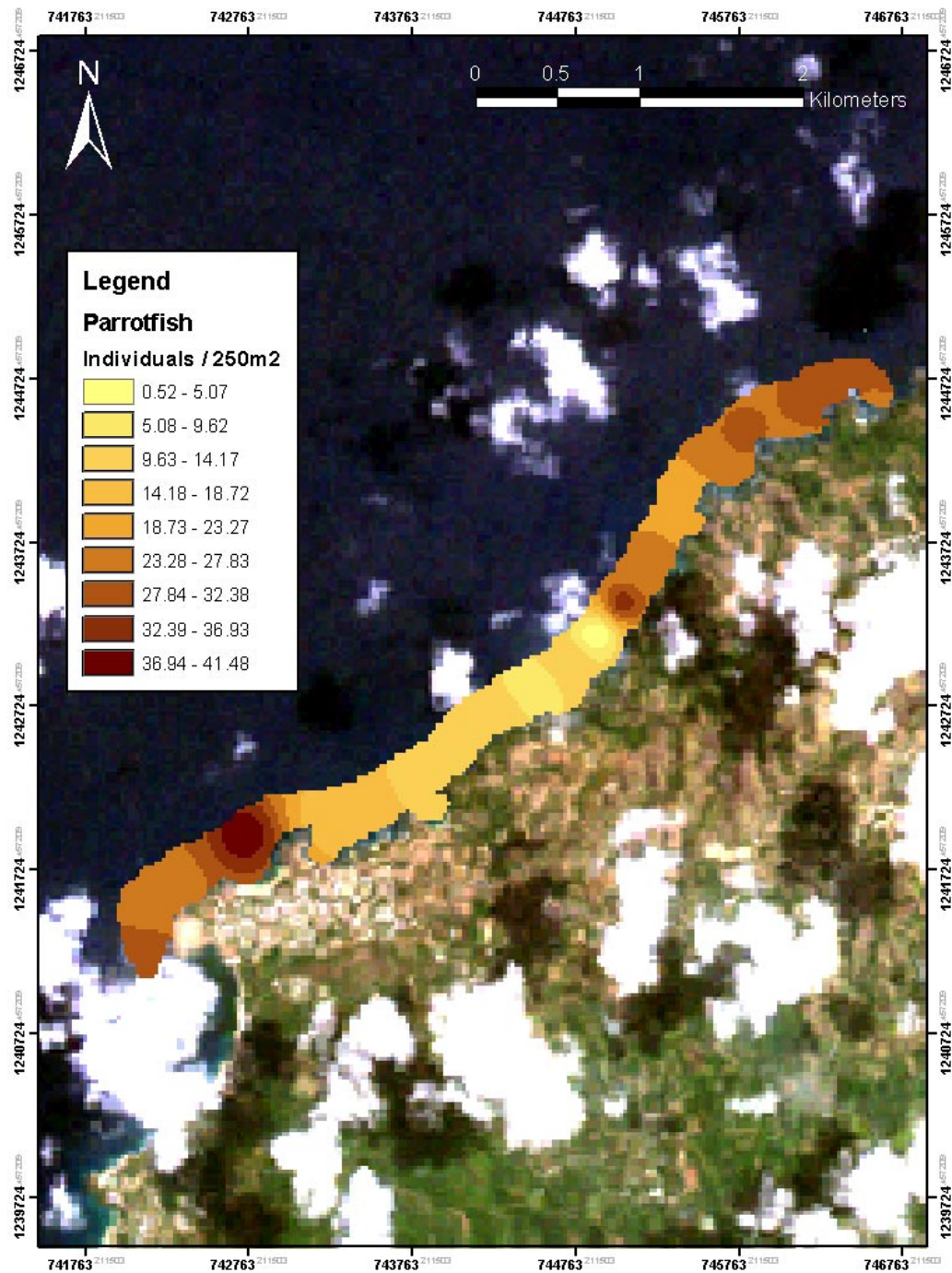


Figure 25 Density of Rainbow Parrotfish (*Scarus guacamaia*) per 250m² of reef area in northern Tobago between Plymouth and Colluden.

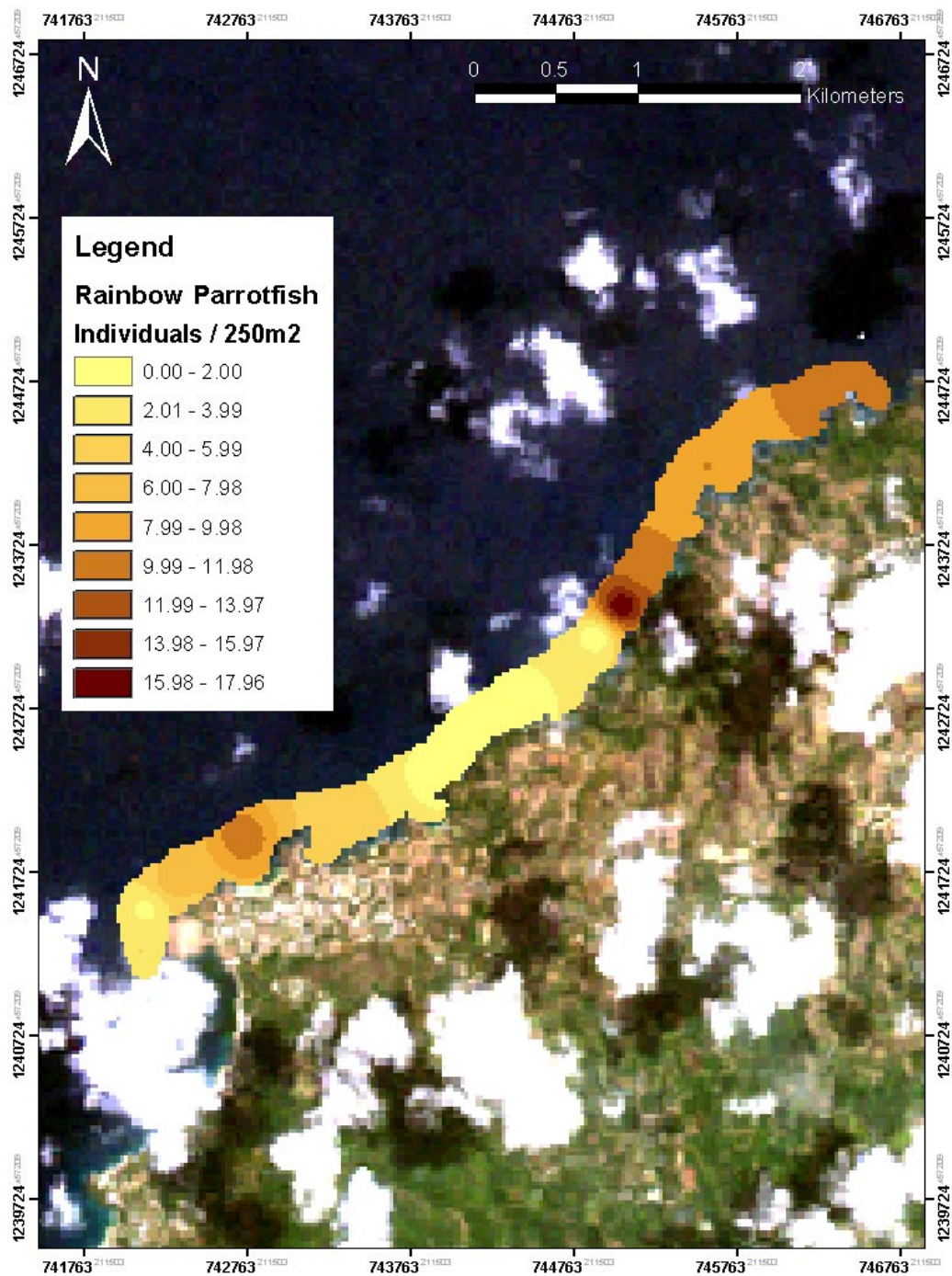


Figure 26 **Density of Grunts (*Haemulidae*) per 250m² of reef area in northern Tobago between Plymouth and Colluden.**

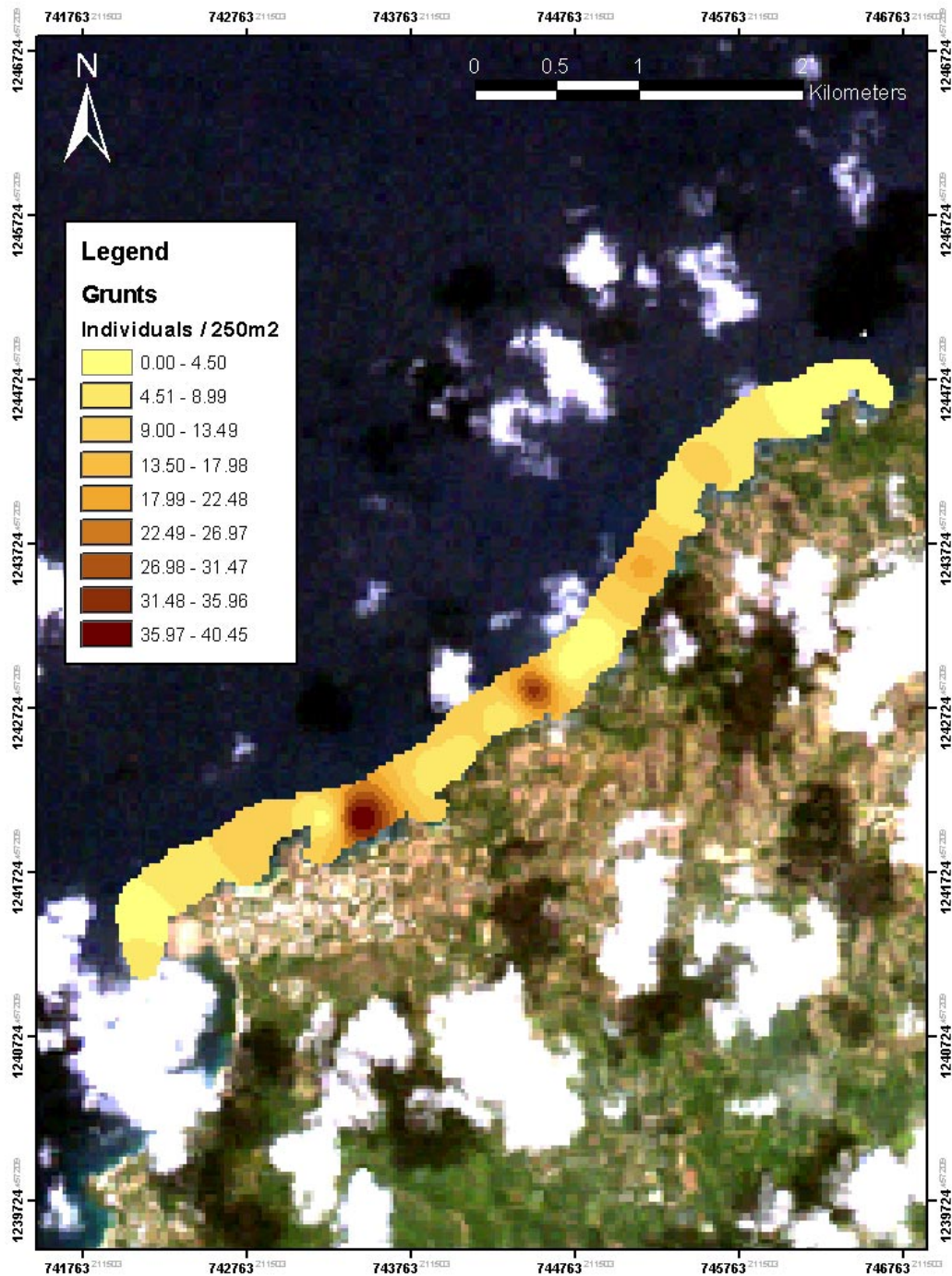


Figure 27 **Density of Groupers (*Serranidae*) per 250m² of reef area in northern Tobago between Plymouth and Colluden.**

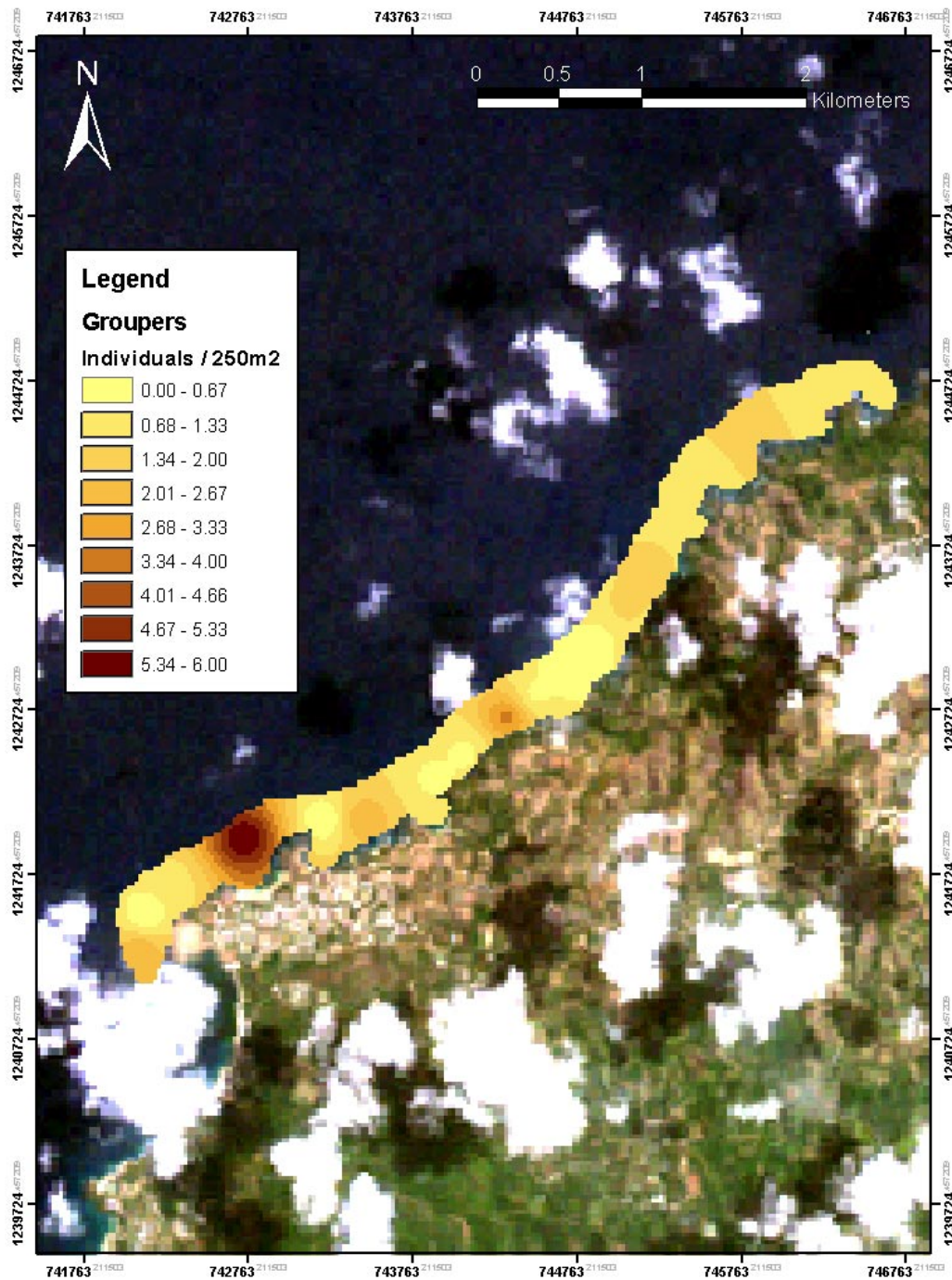


Figure 28 **Density of Snappers (*Lutjanidae*) per 250m² of reef area in northern Tobago between Plymouth and Colluden.**

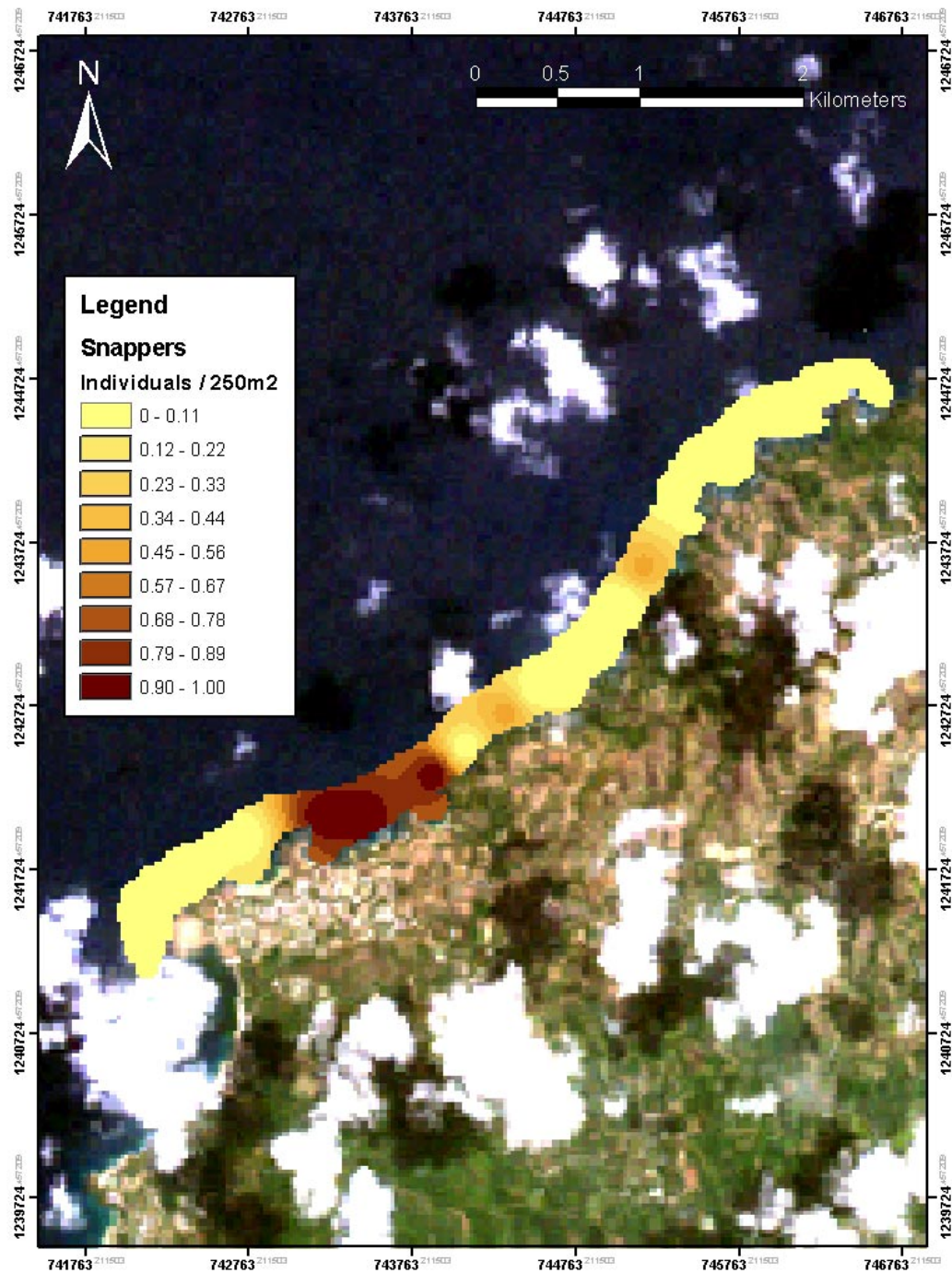
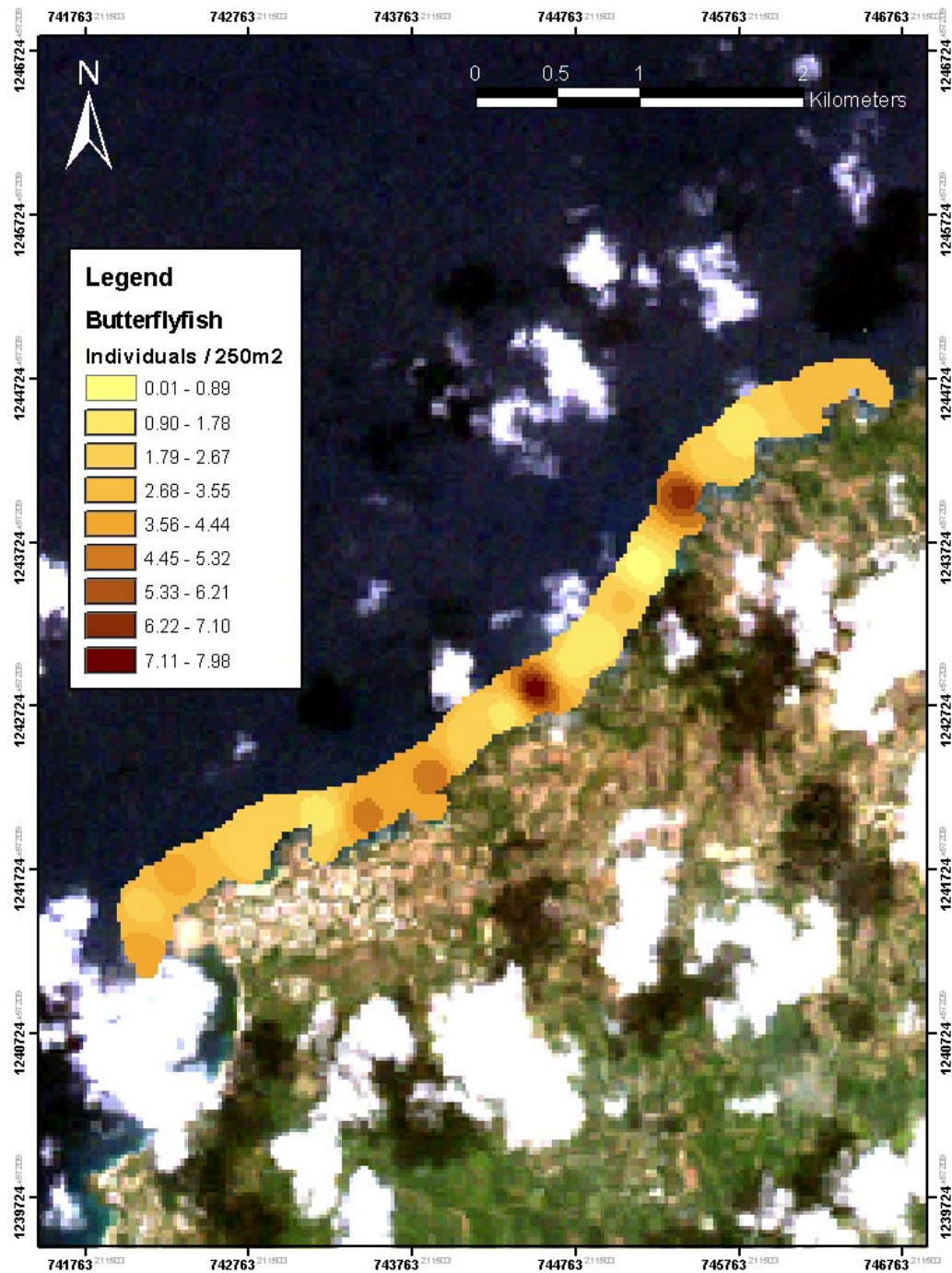


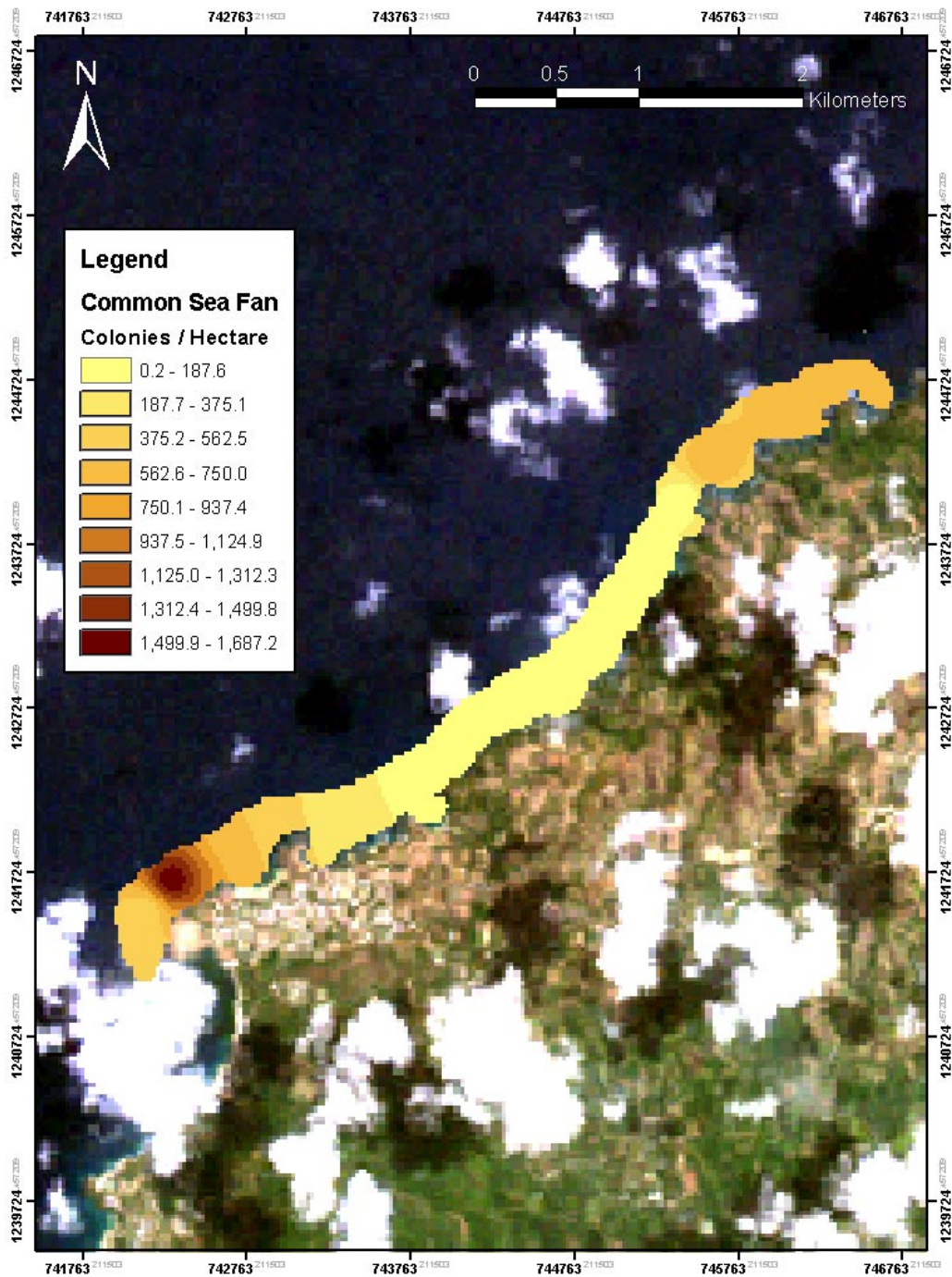
Figure 29 **Density of Butterflyfish (*Chaetodontidae*) per 250m² of reef area in northern Tobago between Plymouth and Colluden.**



Invertebrates

The lack of sightings of a number of important motile invertebrates (e.g. Queen Conch, Lobster, Holothurians) on fringing reefs between Plymouth and Colluden prevented the production of contour maps for these target organisms. However, we can present data for the distribution of the common sea fan (*Gorgonia ventalina*) a species currently susceptible to the fungal disease, *Aspergillosis*. The density of individual sea fan colonies is presented in Figure 30. Colony density was generally low (<375/ha.) for this coastline with two exceptions. Fringing reefs adjacent to the headland at Plymouth revealed the highest densities (~ 1500-1700 colonies/ha.) while intermediate densities were recorded at Colluden (500-750 colonies/ha.).

Figure 30 **Density of Common Sea Fans (*Gorgonia ventalina*) per hectare of reef area in northern Tobago between Plymouth and Colluden.**



Discussion

Live hard coral cover was generally found to be low at all sites. The reefs surveyed furthermore show high variation in live hard coral cover. *Millepora* and *Montastrea* corals were the most common families seen at 7 and 12 metres depth. Coral composition was similar between the two depths and between the survey locations. This indicates a homogenous spread of coral diversity throughout the survey region rather than a localised abundance of species to a particular area.

Some sites (Mt. Irvine, MI) show good overall reef health, with relatively high coral cover and species diversity, whilst the condition of others such as North Reef (NR), part of Buccoo Reef and parts of Arnos Vale (AV) is highly concerning. Initial observations suggest that reefs adjacent to coastlines with the least coastal development have the best overall reef health. The most encouraging findings to date were at Anse Fromager and Mount Irvine, both locations showing areas of relatively high coral cover and diversity. Although there is currently little data on the recovery of *Acropora* spp., there are indications that there is an increase in the abundance of this genus in at least some areas such as Arnos Vale. Due to their shallow-water habitat, they are particularly vulnerable to direct human impacts such as trampling and anchor damage. Increased awareness about the sensitivity of corals to human touch amongst tourists will increase the chances for a recovery of these corals.

Reef fish data presented indicates that a number of commercially fished families were rarely recorded on reef surveys. The lack of Groupers and Snappers on surveys at 7m depth is likely to be a result of overfishing of these finfish resources along the northern coast of Tobago. However, data for other depth bands needs to be assessed to determine whether this result is also a depth-related phenomenon.

The patchy distribution of Grunts is likely to be related to the diurnal behaviour of this fish family. Grunts form inactive schools during the day, which disperse at dusk when the fish become active foragers for invertebrate prey. The high densities of Grunts recorded at two survey stations may be a result of this behaviour pattern.

Parrotfish densities were more consistent than those for Grunts for the area assessed and are less than densities recorded on relatively healthy Caribbean reefs of Bonaire (J.C. Lang, 2003). The presence of reasonable densities of Rainbow Parrotfish merits fishery restriction and conservation measures for this key reef herbivore in order to enhance the resilience of coral reefs in Tobago.

Low abundances of key invertebrate species, particularly Queen Conch, Spiny Lobsters and Sea Cucumbers were found throughout the survey area, indicating serious over-harvesting. The low abundance of long-spine sea urchins can be attributed to the massive die-off in the 1980's from which there seems to be a slow but ongoing recovery.

A concerning level of coral diseases has been observed. Initial findings suggest that disease is most prevalent in reefs adjacent to areas of higher coastal development and/or agricultural land use. Sites at Plymouth, Black Bay and Culloden show particularly high levels of disease. It is worth noting that significant levels of coral disease were not observed on surveys conducted in 2005 after the mass coral bleaching outbreak (O'Farrell et al., 2005)

Yellow Band/Blotch Disease (YBD) was the most prevalent disease affecting hard corals and was commonly seen on *Montastrea* spp. There were also high levels of White Plague Disease (WPD), Dark Spot Syndrome (DSS) and *Aspergillosis*. YBD, WPL and DSS all attack massive, slow-growing coral colonies, some over a hundred years old. Elevated water temperatures have been shown to increase the rate of spread of YBD and induce greater coral mortality (Cervino et al., 2004).

These findings, combined with the likelihood of future bleaching outbreaks, are a major cause for concern considering current predictions on rising sea surface temperatures. In order to curb the damaging effects of these diseases, it is important to minimise human-induced impacts to Tobago's coral reefs such as overfishing, sedimentation and nutrification, all three of which are known to effect coral reef health. Furthermore, areas of resilience to coral disease and bleaching episodes will need to be identified, protected and managed. These areas will allow for a spillover of coral larvae into damaged reef areas to allow for recovery. In addition to disease, coral bleaching has also been observed at several sites. Results from 13 tagged colonies affected by coral disease and bleaching, in combination with the baseline data, will give a better understanding of the prevalence and severity of coral disease and bleaching outbreaks on the reefs of Tobago.

Disturbingly, all of the reefs visited for surveys are showing some signs of stress. Although the signs vary, they generally include: coral disease, low coral cover, high sedimentation, elevated macro algal cover, low fish density, reduced species diversity and direct physical damage such as anchor damage. Whilst current reef health is a cause for genuine concern, it is likely that the reefs observed still retain the capacity to recover. Action to reduce anthropogenic impacts on the coral reefs and near-shore coastal environment would increase their resilience and enhance the potential for recovery.

Bibliography

- Cervino, J.M., Hayes, R.L., Polson, S.W., Polson, S.C., Goreau, T.J., Martinez R.J. and Smith. G.W. Relationship of *Vibrio* Species Infection and Elevated Temperatures to Yellow Blotch/Band Disease in Caribbean Corals. *Applied and Environmental Microbiology*, Nov. 2004, p. 6855–6864
- Darwall W.R.T., and Dulvy, N.K., 1996. An evaluation of the suitability of non-specialist volunteer researchers for coral reef fish surveys. Mafia Island, Tanzania—a case study. *Biological Conservation* 78:223-231
- Douglas, A. E. 2003. Coral bleaching – how and why? *Marine Pollution Bulletin* 46, p. 385 – 392
- Hodgson, G. 1999. A Global Assessment of Human Effects on Coral Reefs. *Marine Pollution Bulletin* 38, p. 345-355
- Hunter, C. and Maragos, J. 1992. Methodology for Involving Recreational Divers in Long-term Monitoring of Coral Reefs. *Pacific Science* 46: 381-382.
- Gardner, T. A., Cote, I. M., Gill, J. A., Grant, A. and Watkinson, A. R. 2003. Long-Term Region-Wide Declines in Caribbean Corals. *Science* 301, p. 958 – 960.
- J.C. Lang (ed.), Status of Coral Reefs in the western Atlantic: Results of initial Surveys, Atlantic and Gulf Rapid Reef Assessment (AGRRA) Program. *Atoll Research Bulletin* 496, p. 591-598.
- Marshall, J., Siebeck, U., Jennings, K. and Hoegh-Guldberg, O. Coral Watch do it yourself coral health monitoring kit. V.T.H.R.C. & C.M.S., University of Queensland, Australia.
- Mumby, P.J., A.R. Harborne, P.S. Raines and J.M. Ridley. 1995. A Critical Assessment of Data Derived from Coral Cay Conservation Volunteers. *Bulletin of Marine Science* 56: 737-751
- Mora, C. 2008. A clear human footprint in the coral reefs of the Caribbean. *Proceedings of the Royal Society B*. doi:10.1098/rspb.2007.1472 (published online).
- O'Farrell, S., and Day, O. 2005. Report On The 2005 Mass Coral Bleaching Event In Tobago. Part I. Results From Phase 1 Survey. Buccoo Reef Trust, Trinidad and Tobago and Coral Cay Conservation, London. 42 pp.
- Oliver, J, P. Marshall, N. Setiasih and L. Hansen. 2004. A global protocol for assessment and monitoring of coral bleaching. WorldFish Center, Penang, Malaysia and WWF Indonesia, Jakarta. 35 pp.
- Peterson, A., Yates, K. and Gibson, K. 2007. Confirmation of coral bleaching at sites along Tobago's Caribbean coast. Buccoo Reef Trust, Trinidad and Tobago and Coral Cay Conservation, London.
- Wilkinson, C., 2004. Status of Coral Reefs of the World: 2004. GCRMN, ICRI, AIMS

Appendix: TCEMP Target Species

BENTHIC CATEGORIES

19-Jun-07

		Lifeform	Species			Lifeform	Species			Lifeform	Species
SUBSTRATES				SESSILE INVERTEBRATES				HARD CORALS cont.			
Rock	>15cm diameter	1		<i>Porifera</i> (Sponges)		14	30	Smooth Star	<i>S bourmoni</i>	28	67
Sand	<0.5cm diameter	2		Encrusting		14	31	Knobby Star	<i>S hyades</i>	28	68
Silt/Clay	clouds when wafted	3		Barrel		14	32	Elliptical Star	<i>D stokesi</i>	42	69
Rubble	0.5 to 15cm diameter	5		Vase		14	33	Golfball	<i>F fragum</i>	42	70
Recently Killed Coral		4		Tube		14	34	Mustard Hill	<i>P pastreoides</i>	29	71
Other Animal *		6		Branching		14	35	Lesser Starlet	<i>S radians</i>	30	72
				Ball		14	36	Massive Starlet	<i>S siderea</i>	30	73
				Rope		14	37				
MICRO-ALGAE				Lumpy		14	38				
Cyano-Bacteria: Blue-Green		7		Red Boring Sponge		14	39				
				Coral Encrusting Sponge		14	39				
MACRO-ALGAE											
<i>Chlorophyta</i> : Green											
Green Filamentous		8	1	<i>Cnidarians</i>							
Acetabularia		8	2	Zoanthid		15	40	Knobby Brain	<i>D clivosa</i>	31	74
Avrainvillea spp.		8	3	Hydroid		15	41	Symmetrical Brain	<i>D strigosa</i>	31	75
Caulerpa spp.		8	4	Corallimorph		15	42	Grooved Brain	<i>D labyrinthiformis</i>	31	76
Halimeda spp.		8	5	Encrusting Gorgonian		15	43	Maze	<i>M meandrites</i>	31	77
Codium spp.		8	6					Rose	<i>M areolata</i>	31	78
Neomeris spp.		8	7	<i>Tunicates</i>		16		Boulder Brain	<i>C natans</i>	31	79
Udotea spp.		8	8								
Ulva spp.		8	9	<i>Bryozoans</i>		17		Sunray Lettuce	<i>H cucullata</i>	32	80
<i>Phaeophyta</i> : Brown				HARD CORALS							
Dictyota sp.		9	11	Lace	<i>S roseus</i>	18		Lettuce	<i>A agaricites</i>	33	81
Padina sp.		9	12					Thin Leaf Lettuce	<i>A tenuifolia</i>	33	82
Lobophora sp.		9	13	Fire spp.	<i>Millepora</i> spp.	19		Low Relief Lettuce	<i>A humilis</i>	33	91
Stypopodium zonale		9	14					Other Lettuce	<i>Agaricia</i> spp.	33	83
Turbinaria sp.		9	15	Staghorn	<i>A cervicornis</i>	20	50				
Sargassum sp.		9	17	Fused Staghorn	<i>A prolifera</i>	20	51	Ridged Cactus	<i>M lamarckiana</i>	34	84
				Elkhorn	<i>A palmata</i>	20	52	Knobby Cactus	<i>M aliciae</i>	34	85
								Rough Cactus	<i>M ferox</i>	34	86
<i>Rhodophyta</i> : Red											
Encrusting Coralline Algae		10	18	Thin Finger	<i>P divaricata</i>	21	53	Rough Star	<i>I rigida</i>	41	93
Galaxaura sp.		10	19	Branched Finger	<i>P furcata</i>	21	54				
Amphiroa sp.		10	20	Clubtip Finger	<i>P porites</i>	21	55	Spiny Flower	<i>M angulosa</i>	35	87
Jania sp.		10	21					Smooth Flower	<i>E fastigiata</i>	36	88
Red Filamentous		10	22	Pillar	<i>D cylindrus</i>	22		Orange Cup	<i>T coccinea</i>	37	89
Sheet		10	23								
Wrangelia penicillata		10	24	Diffuse Ivory Bush	<i>O diffusa</i>	23		Misc Cup Corals		40	92
Laurencia spp.		10	25								
Liagora spp.		10	26	Yellow Pencil	<i>M mirabilis</i>	24	58	Scolymia spp.		38	90
				Eight-Ray Finger	<i>M formosa</i>	24	59				
Other Macro Algae *		11		Ten-Ray Star	<i>M decactis</i>	24	60	Other Live Hard Coral *		39	
MARINE PLANTS				Blushing Star	<i>S intersepta</i>	25					
Seagrass											
Turtle		12	28	Boulder Star Complex		26	62				
Manatee		12	29	Lobed Star	<i>M annularis</i>	26	63				
Halophila		12	30	Mountainous Star	<i>M faveolata</i>	26	64				
				Boulder Star	<i>M franksi</i>	26	65				
Mangroves		13									
				Great Star	<i>M cavernosa</i>	27					

* If substrate, algae or coral falls into 'other' category please justify with a description or an identification in notes.

CORAL RECRUIT

A new coral colony, i.e. those < 5cm in diameter.

CORAL BLEACHING

Coral made white through expulsion of their symbiotic algae.

Demersal Fish Species				18-Jun-07			
<u>BUTTERFLY</u>	1	<u>HAMLETS</u>	25	<u>SQUIRRELFISH</u>	50	<u>BOXFISH</u>	75
Spotfin	2	Barred	26	<u>BIG EYES</u>	51	Cowfish	76
Foureye	3	Indigo	27	<u>CARDINALFISH</u>	52	Trunkfish	77
Banded	4	Yellowbelly	28	<u>GOBIES</u>	53		
Reef	5	Shy	29	<u>BLENNIES</u>	54	<u>TRIGGERFISH</u>	78
Longsnout	6	Black	30	<u>JAWFISH</u>	55	Queen	79
		Butter	31	<u>FLOUNDER</u>	56	Black Durgon	80
<u>ANGEL</u>	7	Yellowtail	32	<u>BATFISH</u>	57		
Rock Beauty	8	Golden	216	<u>TOADFISH</u>	58	<u>FILEFISH</u>	81
Queen	9			<u>SCORPIONFISH</u>	59	Scrawled	82
French	10	<u>BASS</u>	33	<u>FROGFISH</u>	60	Orangespotted	83
Gray	11	Harlequin	34	<u>FLYING GURNARD</u>	61	Whitespotted	84
Cherubfish	12	Tobacco	35	<u>LIZARDFISH</u>	62		
		Fairy Basslet	36	<u>SEAHORSE</u>	65	<u>GOATFISH</u>	85
<u>SURGEON</u>	13	Blackcap	37	<u>PIPEFISH</u>	66	Spotted	86
Ocean	14	Greater Soapfish	38	<u>HAWKFISH</u>	67	Yellow	87
Doctor	15	Creolefish	39	<u>TRUMPETFISH</u>	68		
Blue Tang	16			<u>CORNETFISH</u>	69	<u>DRUM</u>	88
		<u>WRASSE (TP only)</u>	40	<u>TILEFISH</u>	70	Spotted	89
<u>DAMSELFISH</u>	17	Spanish Hogfish	41			Highhat	90
Yellowtail	18	Puddingwife (also IP)	42	<u>PUFFER</u>	71		
Bicolour	19	Creole (also IP)	43	Bandtail	72	<u>SWEEPERS</u>	91
Sergeant Major	20	Yellowhead	44	Sharpnose	73		
Night Sergeant	21	Slippery Dick	45			<u>EELS</u>	92
Blue Chromis	22	Blue Head	46	<u>PORCUPINEFISH</u>	74	Moray	93
Brown Chromis	23	Clown	47			Conger	94
Sunshine Fish	24	Blackear	48			Garden	95
		Rosy Razorfish	49			Snake	96

Commercial and Pelagic Fish				Target Invertebrates		18-Jun-07	
MISC SILVERY		97	GROUPE	141	ANNELIDS		ECHINODERMS
Needlefish	105	Goliath / Jewfish	142	Lugworm	169	Feather Star	194
Barracuda spp.	106	Nassau	143	Xmas Tree Worm	170	Sea Star	195
Boga	107	Comb	144	Feather Duster Worm	171	Brittle Star	196
Bonefish	108	Black	145	Spaghetti Worm	172	West Indian Sea Egg	197
White Mullet	109	Yellowfin	146	Fireworm	173	Long Spined Urchin	
Saucereye Porgy	110	Yellowmouth	147			Adult	199
Mojarra spp.	111	Tiger	148	ARTHROPODS		Juvenile	200
Tarpon	112	Marbled	149	Spiny Lobster	175	Pencil Urchin	201
Chub	113	Red Hind	150	Slipper Lobster	176	Sea Cucumber	202
Spadefish	114	Rock Hind	151	Banded Coral Shrimp	230		
		Graysby	152	True Shrimp	177	FLATWORMS	203
		Coney	153	Mantis Shrimp	178		
MACKERELS				Hermit Crab	184	CNIDARIANS	
Cero	101	WRASSE		Porcelain Crab	180	Jellyfish	204
Spanish Mackerel	102	Hogfish (all phases)	154	Spider Crab	179	Anemone (Sea)	214
King Mackerel	103			Batwing Coral Crab	182	Anemone (Tube)	215
Little Tunny	104	JACKS	155	Yellowline Arrow Crab	183		
		Bar	156	Other Crab	181	OCTOCORALS	
GRUNTS (adults)	116	Horse-eye	157			Common Seafan	205
Bluestriped	117	Yellow	158	MOLLUSCS		Deepwater Seafan	206
Spanish	118	Permit	98	Queen Conch	185	Rod	207
Smallmouth	119	Palometa	99	Triton Trumpet	186	Plume	208
Striped	120	Scad spp.	100	Bivalve	187	Red Sea Whip	209
White	121	Blue Runner	115	Cowrie	188	Flat Sea Whip	210
Ceasar	122			Seahare	189	Corky Sea Finger	211
Cottonwick	123	PARROT (TP + IP)	159	Nudibranch	190		
French	124	Queen TP	160	Sea Slug	228	BLACK CORALS	
Tomtate	125	Rainbow TP	161	Flamingo Tongue	191	Black Coral Bushy	212
Margate	126	Princess TP	162	Octopus	192	Black Coral Wire	213
Black Margate	127	Blue TP	163	Squid	193		
Porkfish	128	Striped TP	164	Other Snail	229		
Latin	129	Midnight TP	165				
Black	130	Stoplight TP	166				
Corocoro	131	Redband TP	167				
		Yellowtail TP	168				
SNAPPER	132	Redtail TP	169				
Schoolmaster	133	Queen IP	218				
Mahogany	134	Rainbow IP	219				
Dog	135	Princess IP	220				
Gray	136	Blue IP	221				
Mutton	137	Striped IP	222				
Lane	138	Midnight IP	223				
Yellowtail	139	Stoplight IP	224				
Cubera	140	Redband IP	225				
		Yellowtail IP	226				
		Redtail IP	227				