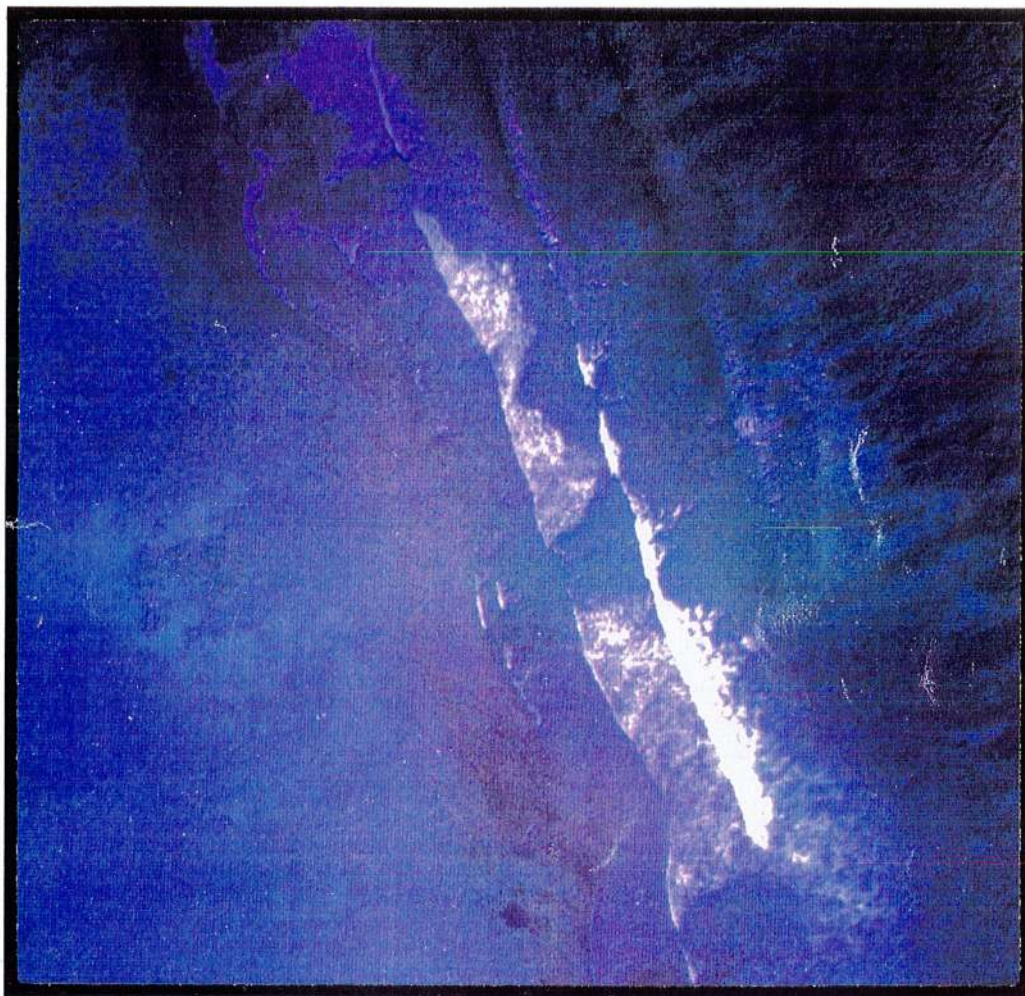


PROJECT TITLE:
BUDGET HEADING:

BELIZE COASTAL ZONE MANAGEMENT PROGRAMME
B7-5040/93

BACALAR CHICO MARINE RESERVE PROJECT



CORAL CAY CONSERVATION FINAL REPORT

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<u>CONTENTS</u>	<u>PAGE</u>
EXECUTIVE SUMMARY	iii
ACKNOWLEDGEMENTS	v
LIST OF FIGURES	vi
LIST OF MAPS	vi
LIST OF ABBREVIATIONS	vii
1. THE BACALAR CHICO PROJECT	1
1.1 Background	1
1.2 European Commission support	1
1.3 The Bacalar Chico area	3
1.4 The European Commission funded project	6
1.5 CCC's role	6
1.6 CCC's resources	7
2. OPERATIONAL PROGRAMME	8
2.1 Summary of CCC project work in relation to the Bacalar Chico Marine Reserve	8
3. MAPPING THE PROPOSED MARINE RESERVE	10
3.1 Basemap production	10
3.2 Field surveys	10
3.3 Digitisation of the survey data	11
4. DATA ANALYSES	13
4.1 Introduction	13
4.2 Justification of habitat labels	13
5. RESULTS OF SURVEYING	15
5.1 Habitat classes	15
5.2 Habitat map	19
5.3 General description of the area	20
5.4 Habitat descriptions	29
5.5 Commercially and ecologically important findings	40
6. MAPS PRODUCED FROM SATELLITE DATA	43
6.1 Analyses of satellite habitat map	43
6.2 The satellite habitat map	43
6.3 Analyses of satellite bathymetric map	43
6.4 Application of the satellite data	44

7.	RECOMMENDATIONS AND ZONING PLAN FOR THE MANAGEMENT OF THE BACALAR CHICO NATIONAL PARK AND MARINE RESERVE	47
7.1	Zoning recommendations	47
7.2	Socioeconomic recommendations	49
7.3	Future management	50
8.	TRAINING	52
9.	EDUCATION	52
9.1	Environmental education course	52
9.2	Coral collection	52
9.3	Environmental educator	53
9.4	Schedule of environmental education work	53
10.	PROJECT MANAGEMENT	55
10.1	Staffing	55
10.2	Presentations	55
10.3	Publicity	56
11.	PROJECT FINANCES	57
11.1	Allocation of funds	57
11.2	Bridging loan	57
11.3	Delay in funding	57
11.4	Cost of project	58
11.5	Education costs	60
12.	REFERENCES	61

MAPS

APPENDICES

EXECUTIVE SUMMARY

In February 1994, the European Commission provided ECU570,000 to the Belize Coastal Zone Management Programme (B7-5040/93) to assist the Coastal Zone Management Unit (CZMU), of the Government of Belize, with the establishment of a national park and marine reserve at Bacalar Chico, north Ambergris Cay. The Bacalar Chico area is of great biological, physical and archaeological interest, has supported local communities for generations and is of transboundary importance.

Coral Cay Conservation received ECU210,000 to collect biological and physical survey data for the development of the marine reserve component of the project, to implement marine environmental education and widen its training programme to increase in-country awareness and expertise for the protection of the coastal biodiversity.

Following the collection and preliminary analyses of remotely sensed imagery, a field base camp was identified and detailed plans were developed for the marine surveying and expedition logistics. Throughout June-July 1994 and July-August 1995, 48 CCC volunteers and two CCC field staff, conducted 301 marine surveys, utilising SCUBA, throughout the reef and lagoon environments within the proposed Bacalar Chico Marine Reserve. Analyses of the data collected during these surveys resulted in detailed biological and physical descriptions of the existing habitats and the associated characteristic species. The extent of each habitat type was then overlaid onto a geo-rectified and geo-referenced base map, developed by CCC, to produce a habitat description map. The classification system utilised to define the habitats represents the first use of a nationally approved system within Belize. Further analyses of the data included median abundances and frequency of occurrence statistics for species/lifeforms recorded within each habitat and a complete species list for the area. The parameters of wind and current strength and direction, both surface and underwater impacts, temperature, pH, salinity, turbidity, nitrate were recorded as well as boating activity.

All the data collected were subsequently applied to a coastal zone management framework to develop recommendations for the management of the area, including a zoning plan detailing user activity within the proposed marine reserve.

The CCC training instructor provided practical training courses in SCUBA diving techniques, small watercraft operation, navigation and maintenance for the Bacalar Chico biologists and rangers. Belizean nationals were also trained in SCUBA diving, marine ecology, species identification and marine surveying techniques as part of the annual Fisheries Department/CCC/University College of Belize scholarship programme. The EC funds also have provided a Belizean with the opportunity to obtain recognised SCUBA Instructor status.

A Belizean education specialist was sub-contracted through the Belize Audubon Society to undertake some aspects of the education component of the project. An education package, developed by CCC, was distributed free to schools and colleges throughout Belize. EC funding has enabled a general marine brochure applying to all marine protected areas in Belize to be developed (including printing costs). The EC funded education activities will be completed by the end of April 1996.

Throughout this project the transefer of European expertise has resulted in a number of sustainable initiatives being implemented for the protection of the natural resources and the local communities of the Bacalar Chico area and Belize in general. The total cost of this successful project was ECU345,481 with the EC contributing ECU210,000.

Collection of the marine biological and physical data was instrumental in Bacalar Chico being included in an application to the IUCN for inclusion as a World Heritage site.

ACKNOWLEDGEMENTS

Coral Cay Conservation would like to thank the European Commission for supporting this project.

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University College of Belize
UNDP/GEF Coastal Zone Management Project
United Nations Development Programme
Jim Wojcik, ESRI
World Conservation Union

And finally all the CCC Bacalar Chico volunteers and volunteer staff for their efforts.

LIST OF FIGURES

- Figure 1.** Map of Belize showing the positions of Ambergris Cay and the planned boundaries for the proposed Bacalar Chico Marine Reserve.
- Figure 2.** The locations of the main geographical features within the proposed Bacalar Chico Marine Reserve. Also shown are the Differential Global Positioning System ground control points used for the geo-rectification of the base map.
- Figure 3.** The dendrogram resulting from cluster analysis of the back reef survey data.
- Figure 4.** The ordinations resulting from multi-dimensional scaling of the back reef survey data.
- Figure 5.** Reef profile at transect R22
- Figure 6.** Reef profile at transect R4.
- Figure 7.** Reef profile at transect R40.
- Figure 8.** Reef profile at transect R53.
- Figure 9.** A typical profile of the deep reef in the Bacalar Chico area.
- Figure 10.** Summary of the current data collected within the proposed Bacalar Chico Marine Reserve.
- Figure 11.** Summary of the wind data collected within the proposed Bacalar Chico Marine Reserve.
- Figure 12.** Preliminary classification of the marine habitats of the proposed Bacalar Chico Marine Reserve from a Landsat TM image.
- Figure 13.** Estimated bathymetry of the proposed Bacalar Chico Marine Reserve from a Landsat TM image.

LIST OF MAPS

- Map 1.** The DGPS ground control points collected for geo-rectification of the basemap for the proposed Bacalar Chico Marine Reserve.
- Map 2.** The positions of CCC's 1994 and 1995 survey transects in the proposed Bacalar Chico Marine Reserve.
- Map 3.** The CCC habitat map for the proposed Bacalar Chico Marine Reserve.
- Map 4.** A preliminary zoning plan for the proposed Bacalar Chico Marine Reserve.

LIST OF ABBREVIATIONS

BAS	- Belize Audubon Society
CCC	- Coral Cay Conservation
CECC	- Corozal Environmental Conservation Carnival
CZMP	- Coastal Zone Management Project
CZMU	- Coastal Zone Management Unit
DGPS	- Differential Global Positioning System
EC	- European Commission
ECU	- European Currency Unit
GEF	- Global Environment Facility
GIS	- Geographic Information System
GOB	- Government of Belize
GPS	- Global Positioning System
ITCF	- International Tropical Conservation Foundation
IUCN	- World Conservation Union
LIC	- Land Information Centre
MDS	- Multi- Dimensional Scaling
MOU	- Memorandum of Understanding
NHM	- The Natural History Museum
NGO	- Non Government Organisation
PRIMER	- Plymouth Routines in Marine Ecological Research
SIMPER	- Similarity Percentage
SCUBA	- Self Contained Underwater Breathing Apparatus
TM	- Thematic Mapper
TNC	- The Nature Conservancy
UCB	- University College of Belize
UNDP	- United Nations Development Programme
UTM	- Universal Transverse Mercator

1. THE BACALAR CHICO PROJECT

1.1 Background

Increasing development pressures and utilisation of the coastal zone of Belize has resulted in a rising concern from both the Belizean and international communities for the existing natural resources. A holistic and dynamic approach is required to ensure the sustainable development and management of the coastal resources (Price *et al.*, 1992). However, the knowledge of the basic biological attributes within coral reef systems in general is limited and the available data relating to the demands on the Belizean coastal natural resources in particular are often found to be anecdotal and sporadic.

As a response to the requirement for an interdisciplinary and integrative approach to managing Belizean coastal resources, a workshop was held during August 1989 entitled 'Coastal Zone Management'. Following this workshop a draft planning document 'Guidelines for Developing a Coastal Zone Management Plan' was produced by the World Conservation Union (IUCN) and the Department of Fisheries, Government of Belize (GOB; Price *et al.*, 1992). Within the Department of Fisheries, the Coastal Zone Management Unit (CZMU) was formed with the remit to manage and conserve the country's coastal resources. A management framework was developed which stressed the requirement to gather in-depth ecological, socio-economic and other related information about the coastal zone.

In order to fulfil these recommendations, Coral Cay Conservation (CCC) was invited to continue in its work gathering baseline data on the Belizean coral reef system for the . Since 1989, CCC has been providing technical skills and resources to gather baseline data on the Belizean reef and lagoon systems to fulfil the management information requirements of the CZMU. A renewed Memorandum of Understanding (MOU) with the Fisheries Department (Appendix 1) has extended the surveying programme to encompass a number of specific geographic locations on the reef which require data for the preparation of management plans (Figure 1). CCC in collaboration with the University College of Belize (UCB) and the GOB has also developed a Marine Research Centre (MRC) on Turneffe Atoll which aims to become a centre of national and international education and research.

Since 1993, the CZMU has been assisted by the Coastal Zone Management Project, a United Nations Development Programme/Global Environment Facility funded project which aims to develop the capabilities of the CZMU for the management and conservation of resources within the coastal zone.

1.2 European Commission support

It is recognised that there is an urgent need to develop coastal zone management programmes before the existing natural resources are depleted or lost. Particular emphasis is placed on small-scale initiatives which are easier to control, develop, implement and manage and are more likely to result in successful management. Initial support for the collection of baseline data on the extent and status of the resources is a fundamental necessity for effective management (Spencer-Davies and Brown, 1992).

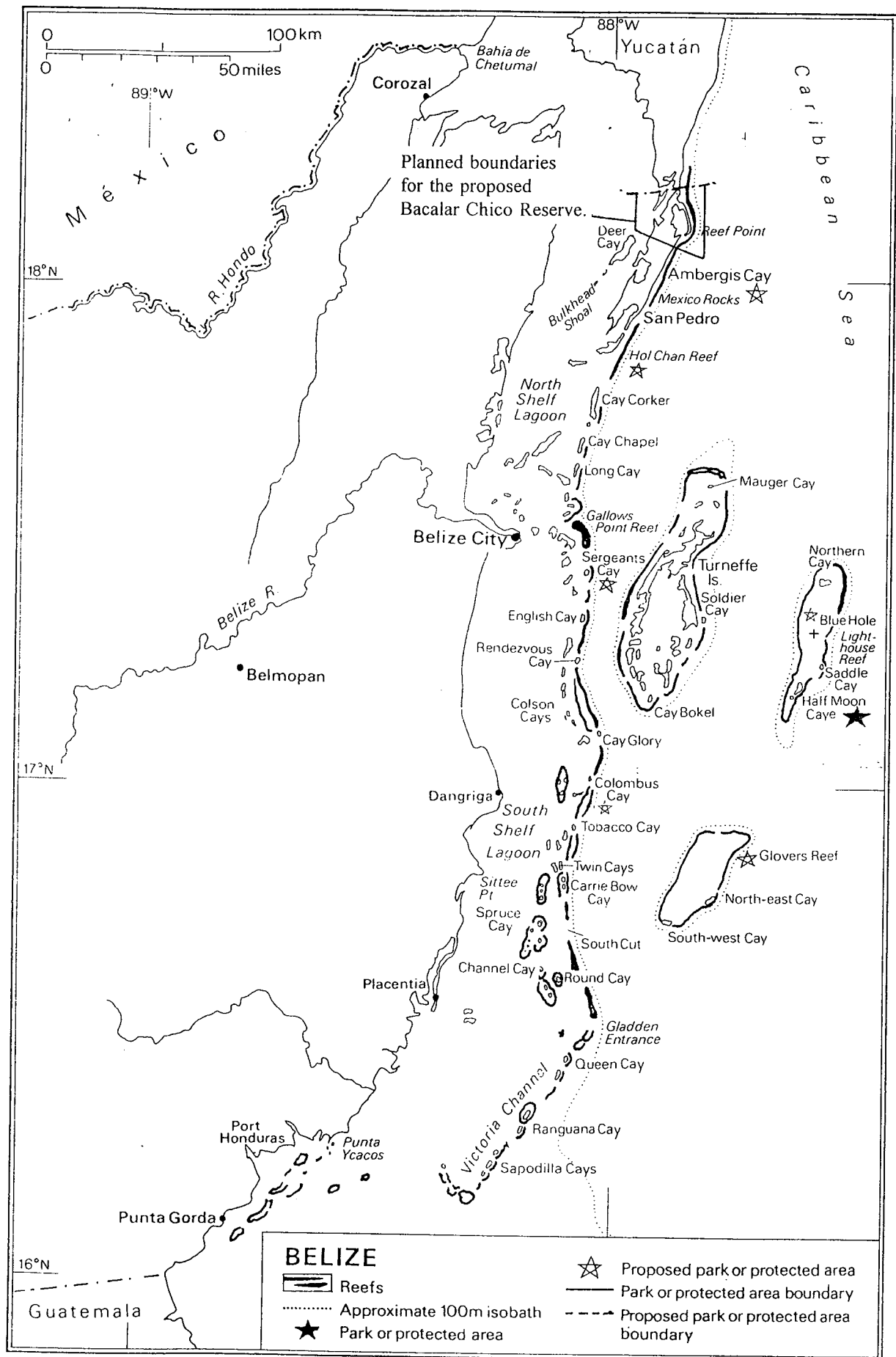


Figure 1. Map of Belize showing the position of Ambergris Cay and the planned boundaries for the proposed Bacalar Chico Reserve. (Source: Coral Reefs of the World, UNEP/IUCN 1988).

Under the Lome IV Convention, one of the EC budget lines is specifically for the protection of the environment in developing countries and in particular the conservation of biodiversity. It has been recognised by the EC that NGO's can play an important role in the implementation of programmes and projects financed through their budget headings (Spencer-Davies and Brown, 1992).

Following local community requests, the Bacalar Chico area, north Ambergris Cay, Belize (Figure 1), was identified as a feasible project to be funded by the EC, which could protect of the area from unregulated fishing by Mexicans and relieve the visitor pressure on the Hol-Chan Marine Reserve. The EC recognised that this project would encompass the expertise available within CCC, the International Tropical Conservation Foundation (ITCF) and the World Conservation Union (IUCN), enhance interdepartmental cooperation within the GOB (Harborne *et al.*, 1995) and ultimately benefit the coastal zone in a holistic and efficient manner.

The EC committed ECU570,000 in February 1994 to the tripartite project between CCC, the ITCF and the IUCN (comprising ECU220000 for ITCF; ECU210000 for CCC; ECU140000 for IUCN) to assist the CZMU with the establishment of a National Park and marine reserve at Bacalar Chico.

1.3 The Bacalar Chico area

1.3.1 The reef environment

The land and sea resources between the Boca Bacalar Chico and Robles Point (Figure 2) has been recommended as a multiple use World Heritage Site. It is a unique place in the world where a barrier reef meets the land. The reef itself supports a high diversity of marine species, many of which the coastal communities depend on. Furthermore, its physical size and shape affords protection to the nearby shores along Ambergris Cay. The area is also important as spawning grounds for nassau and yellowfin grouper (*Epinephelus striatus* and *Mycteroperca venenosa* respectively; Perkins, 1983).

In the Bacalar Chico area the mangrove, lagoon and reef environments are found in close proximity. These habitats are intrinsically linked and of fundamental importance for the productivity of the Bacalar Chico area.

1.3.2 The mangroves

The mangroves provide stability to the coastline, act as nurseries for many marine species, provide living habitat to both terrestrial and aquatic organisms and are crucial to the cycle of nutrients in the coastal marine ecosystem. The mangrove communities on Ambergris Cay are unique as they are the only ones in Belize which grow on rock outcrops (Forestry Dept pers. comm.). In addition, all four species of Caribbean mangrove are found (*Rhizophora mangle*, *Avicennia germinans*, *Laguncularia racemosa* and *Erythalis fruticosa*). Notably, each species has its own specific habitat requirements and associated species thus adding to the biodiversity of the region.

Figure 2. The locations of the main geographical features within the proposed Bacalar Chico Marine Reserve. Also shown are the Differential Global Positioning System ground control points used for the geo-rectification of the base map.

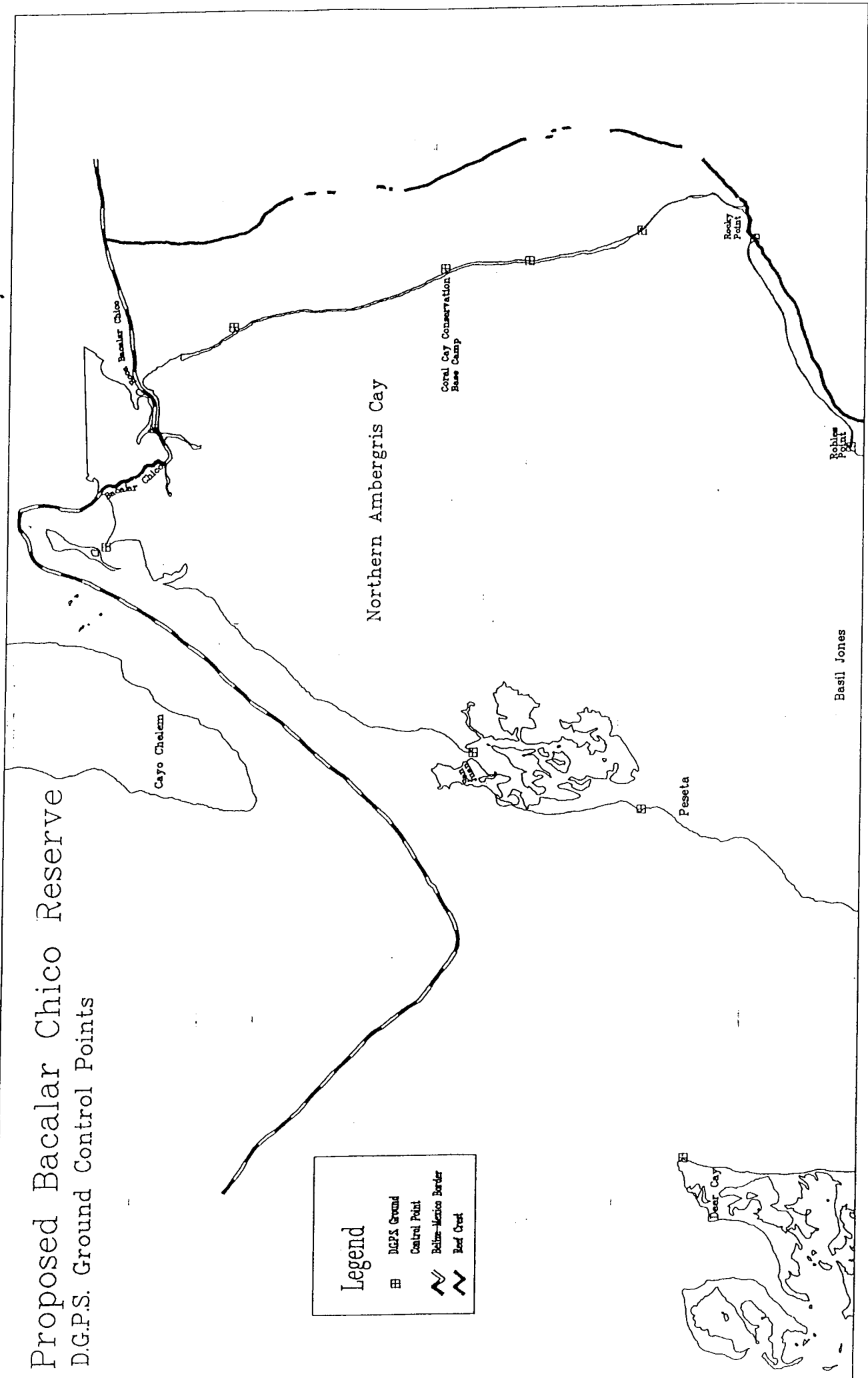
Proposed Bacalar Chico Reserve D.G.P.S. Ground Control Points

Legend

DGPS Ground Control Point

Belize-Mexico Border

Red Crest



Scale 1:40,000

1.3.3 The lagoon environment

The Bacalar Chico area has two distinct lagoon environments. The inner lagoon, the Laguna de Cantena, is an enclosed body of water which, from anecdotal reports, has a low degree of water movement. The outer lagoon, a large expanse of water, separates the western side of Bacalar Chico and the eastern coast of the mainland.

Most lagoonal areas found in Belize support an abundance of seagrass and algae which are important for primary productivity. The seagrass itself supports a number of specific species and acts to intercept sediment in the water. The result is clear water, which is crucial for coral survival and a soft, sediment substratum which is utilised by a number of species. Many important fish and invertebrate species use the lagoon especially during the juvenile phase. The threatened manatee (*Trichechus manatus*) and the American crocodile (*Crocodylus acutus*) have both been reported in the lagoon areas of Bacalar Chico.

1.3.4 Terrestrial fauna

At Bacalar Chico there are confirmed records of endemic Yucatan birds, many of which are close to the southern end of their distribution range (Dotherow, 1995). Important roosting sites are also evident within the area. A survey by Smith (Dotherow, 1995) demonstrated that 31 species of mammal occur in the area many of which are designated as rare or threatened species. Smith also conducted a reptile survey which identified 35 species (Dotherow, 1995). Those which are considered threatened are the American crocodile (*Crocodylus acutus*) and the marine turtles which utilise beaches in the area for nesting.

1.3.5 Archaeology

The ancient Mayan civilization utilised the Bacalar Chico area, especially around San Juan (Figure 2), as a staging post for international trade. The archaeological resources lying within the overgrown areas of north Ambergris Cay are at present subject to conjecture.

1.3.6 Paleontology

There are reports of outcrops of fossilized reef and the associated benthic communities throughout the interior of north Ambergris Cay. Potentially of extreme importance, the presence of the fossilized reefs would give rise to an unusual scenario where ancient and modern reefs could be compared at the same locale.

1.3.7 Cross-boundary importance

The Boca Bacalar Chico (Figure 2) represents an international border with Mexico and as such is of strategic importance. As Mexico also shares the barrier reef, positive environmental action close to their border may encourage international cooperation for the protection of this special area. This is imperative as without Mexican support there is a constant threat of uncontrollable pollution from Mexican sources to the north and the west.

1.3.8 Fishing

The reef and the marine life are extremely important natural resources within the Bacalar Chico area. The coastal communities have relied on the fish based resources for generations.

Commercial spearfishing for the large groupers (*Epinephelus* and *Myctoperca* sp.), and snappers (*Lutjanus* spp.) is prevalent and is having an adverse effect. The result of this is that

the spear fishermen are concentrating on the lower quality fish such as parrotfish (*Scarus* and *Sparisoma* sp.) and triggerfish (*Balistes* sp.). As well as being crucial to the ecological balance of the reefs, these fish are very attractive and colourful which adds to the aesthetic value of the reef.

As the Belizean coastal waters are bordered by a number of other countries, the potential for illegal fishing, especially at the boundaries is a constant problem.

1.3.9 Development

Owing to the precious resources of the Bacalar Chico area, pressures to develop it have increased. During 1993, a US-based group, the Broadhead Group, presented a proposal to develop the area for resort and retiring community purposes (Dotherow, 1995). This proposal, although including some details relating to protected area status, was lacking in content especially in relation to the interests of the local population. Also, the appropriate data was not available to enable a sustainable development plan to be implemented. For successful, sustainable development there is a primary requirement to compile baseline data that gives a full description of the environment to be protected.

1.4 The European Commission funded project

The principal objectives outlined in the project proposal were:

- 1- To support the CZMU of Belize and other relevant Government bodies in the formulation and adoption of a national coastal zone management programme.
- 2- To provide training in coastal marine ecology, resource assessment and management, including the provision of equipment and educational materials.
- 3- To provide assistance to the CZMU in coastal marine surveys, data collection, compilation and analysis, for the purpose of preparing marine protected area management plans.
- 4- To provide technical and managerial support for the designation and establishment of Bacalar Chico region of northern Ambergris Cay as a marine reserve and wildlife sanctuary.
- 5- To convene a meeting of relevant European Community, African, Caribbean and Pacific coastal zone management experts for the purpose of formulating policies, methodologies and criteria for the establishment of integrated coastal zone management plans, with particular reference to coral reefs.

1.5 CCC's Role

CCC's role in the Bacalar Chico project was to provide the data necessary for the establishment of the marine reserve component and to assist with the production of the management plan for the area. The other major role was to develop education, training programmes and materials to increase environmental awareness of the marine ecosystem amongst Belizean nationals and visitors to the country. CCC were also tasked with training the reserve managers in marine survey techniques.

CCC's specific activities within the Bacalar Chico project were to:

- 1- Assist in the establishment of management measures for the Bacalar Chico Marine Reserve, through the undertaking of underwater and hydrological surveys and the application of satellite imagery.
- 2- Extend the existing programme of training in SCUBA diving, resource assessment and tropical marine ecology for Belizeans associated with the programme, and the preparation of educational and training material.
- 3- Appoint a project coordinator together with part-time staff for SCUBA instruction and marine ecology training. CCC were also to purchase satellite pictures for mapping purposes and SCUBA equipment for the training programme.
- 4- Develop a training course in marine sciences in a co-operative programme between CCC and UCB, on the basis of the working agreement signed between CCC and UCB in February 1993. CCC was to provide teams of survey divers and backstopping from its UK office.

1.6 CCC's Resources

The existing infrastructure and facilities available to CCC include administrative offices in the UK and Belize; diving and surveying equipment; audiovisual teaching aids; recognised techniques for data compilation, analyses and preparation of Marine Protected Areas management plans (specifically within Geographic Information Systems; GIS); specifically designed education and training programmes; institutional collaboration.

2. OPERATIONAL PROGRAMME

2.1 Summary of CCC project work in relation to Bacalar Chico Marine Reserve *(1st April 1994 - 31st March 1996 inclusive)*

<u>Month</u>	<u>Activity</u>
1994	
April	Start of project; Appointment of Project Coordinator, SCUBA Instructor and Training Instructor.
May-June	Collation of existing aerial photography and satellite imagery; Flyovers for additional aerial photography by TNC; Location of site for base camp. Provision of University College of Belize Marine Environmental Conservation course; SCUBA dive training for students of the above course; Interviews for Fisheries Department/CCC Summer Dive Scholarship Programme.
June-July	Fisheries Department/CCC Summer Dive Scholarship Programme trained 24 Belizeans in SCUBA and the CCC tropical marine ecology, identification and surveying course; Advanced team established Bacalar Chico base camp; Rapid assessment of main habitats and bathymetry; Development of logistics and detailed plan for surveying.
Late July -Sept	Arrival of main volunteer survey team; Volunteers undertook CCC tropical marine ecology, identification and surveying course; Surveys of reef on eastern margin of proposed Bacalar Chico Reserve; Establishment of Differential Global Positioning System (DGPS) base station at camp site; Collection of DGPS ground control points for geo-referencing maps; Identification of possible permanent monitoring sites.
Sept-Nov	Data entered into database; Digitising of colour aerial photographs (land perimeters and apparent marine habitats); Geo-rectification of aerial photographs; Preliminary analyses of data (habitats, species, bathymetry); Production of preliminary habitat description maps within GIS; First six-monthly meeting of Programme Management Group.
Dec	Compilation and writing of interim report.
1995	
Jan	Completion and submission of interim report; Appointment of new Project Coordinator requiring a review of current status of the project. Appointment of Assistant Project Coordinator (CCC funded).
Feb	Assistant Project Coordinator attended a number of meetings to become familiar with project and personnel involved; Assistance with draft of Bacalar Chico Management Plan; Accessing satellite data;

March	Meeting of all CCC Bacalar Chico staff at London office to produce action plans for each staff member; Review of CCC training and surveying technique in light of appraisal by UNDP/GEF independent consultant; Extra digitizing of Bacalar Chico basemap; Project Coordinator ¹ leave of absence.
April	Data analyses, generation of habitat classes and descriptions including characteristic species and application to preliminary habitat map; Highlighting gaps in survey programme that required to be addressed during 1995 field season and identification of new survey transects.
May	Second meeting of Programme Management Group; Planning of summer field work; Purchase of five sets of SCUBA equipment; Training of Bacalar Chico biologists and staff at the CCC field base.
June	Discussions with Belize Audubon Society regarding Environmental Educator; Advanced party to field site to set up base camp.
July	Appointment of Environmental Educator; Main survey team on site, undertook training and collected baseline survey data.
August	Second survey team underwent training and collected data; Water quality sampling; Data entry into database with copy deposited at CZMU; Landsat TM satellite image classified.
Sept-Oct	Presentation at Newcastle Conference based on data analyses of April; Extra digitisation of aerial photographs; Further data entry; Overlay of transect locations onto map; Cleaning up of digital map and reclassification with standard scheme; Further data analyses to describe habitats.
Nov-Dec	Third and final meeting of Programme Management Group; Technical meeting regarding standardisation of habitat classifications; Application of standard habitat classifications to proposed Bacalar Chico Marine Reserve map; Production of final marine habitat map; Meeting to present draft recommendations based on CCC collected data, followed by production of final recommendations.
1996	
Jan-Feb	Completion of data analyses for whole data set relating to habitat characteristic species, species lists and frequency of occurrence; Final production of classified satellite images; Compilation of details for final report.
Mar-Apr	Completion of final report and submission with statement of use of EC finances.

3. MAPPING THE PROPOSED MARINE RESERVE

3.1 Basemap production

The original basemap (Raines *et al.*, 1995) was produced in 1994 using a set of 1:24,000 scale aerial photographs obtained through The Nature Conservancy (TNC). In exchange for these photographs CCC trained a group of volunteers and Belizeans to undertake surveys utilising TNC methods in the Snake Cays area, Southern Belize during October 1994.

The outlines of the islands (cays) and the sub-sea features apparent from the photographs (polygons) were traced to acetate sheets and subsequently digitised utilising ARC/INFO GIS software. To geo-reference the map, eleven ground control points, accurate to +/-5m (Kruczynski, 1990), were established using a Differential Global Positioning System (DGPS). The positions of the ground control points are shown on Map 1.

Following the field surveying of 1995 it was deemed appropriate, through CZMU discussions, to extend the proposed reserve boundaries further to the south. The additional aerial photographs were then digitised and linked to the coverage of the original basemap to complete the map.

The deeper parts of the reef were not visible from the aerial photographs and therefore the original map was assigned an arbitrary polygon for the deeper reef areas. As a result of the data collected from the diving surveys a 30 metre depth contour (this is the depth to which dives were limited) was interpolated from the GPS starting coordinate of each survey transect to represent the deeper areas.

The base map and the aerial photographs were utilised as a tool to direct the surveys during field work within the proposed reserve.

3.2 Field surveys

For both periods of field work (June/July 1994; July/August 1995) a base camp was set up within the proposed reserve by kind agreement with Lois Hartley and Anne Sutherland, who own the site and also the existing pier and buildings.

In 1994 and 1995, 29 and 19 volunteers respectively were recruited through CCC's self funding volunteer programme. The volunteers were accompanied throughout the 1995 field work by David Bishop and Alastair Harborne, the CCC Project Scientist, who acted as the Expedition Leader and Science Officer respectively.

On arrival at the field site the volunteers undertook the standard CCC training programme in tropical marine ecology, identification and surveying (Raines *et al.*, 1992; CCC, 1995). Once the required skill level was attained, the volunteers undertook diving surveys within the proposed Bacalar Chico Marine Reserve which described the type and extent of the marine habitats and identified the associated species.

3.2.1 Surveying method

The CCC marine survey technique has been developed, tested and successfully implemented since 1989. The technique used teams divers who recorded the physical and biological characteristics of habitats encountered along a plot-less belt transect. The position of each transect was marked with a buoy and its geographical location was recorded by a Global Positioning System (GPS). The teams were made up of two pairs of divers. The lead pair navigated along the transect while collecting data on the physical composition of the substrata (including bathymetry) and the fish species present. The second pair recorded data on the species of macroalgae, invertebrates and hard corals encountered and the sponge and soft coral lifeforms present within each habitat. Each of the species or lifeforms encountered by the divers were assigned a semi-quantitative abundance rating ranging from 0 (absent) to 5 (abundant) (CCC, 1995).

During 1995, an independent assessment by an UNDP/GEF consultant lead to official approval of the methods. CCC has also conducted validity tests on the technique with the results published in the Bulletin of Marine Science (Mumby *et al.*, 1995).

Through the surveying, species lists for the area were also constructed by the CCC science staff, with any tentative species records positively identified by referring to the appropriate expert source.

3.2.2 Reef surveys

The surveying of the reef habitats was conducting according to the standard CCC technique. The divers surveyed the reef along a predetermined compass bearing from 30m depth along the profile of the reef towards the reef crest, known as a survey transect. This method covered the habitats apparent from the aerial imagery.

3.2.3 Back reef surveys

The shallow back reef area forms a major component of the marine environment encompassed by the proposed reserve. Similar survey methods to those utilised on the reef were applied to the backreef area. The transects were orientated to cover the different zones apparent in the aerial photographs. This was typically in an east-west direction from the reef crest into the shore and undertaken by snorkelling and SCUBA.

3.2.4 Lagoon surveys

Surveys of the main lagoon in the west of the proposed reserve were orientated to cover the different areas apparent in the aerial photographs. Exploratory surveys were also conducted at specific sites of interest which were located through close examination of the aerial photographs.

3.3 Digitization of the survey data

3.3.1 Data entry to database

The Bacalar Chico project utilised CCC's ARC/INFO GIS compatible database which had previously been developed to assimilate all the survey data that were collected from CCC's Turneffe Atoll programme. The survey data for both field seasons at Bacalar Chico were manually entered into the database at either the CCC London or Belize office in the months following the field work. Each individual survey was assigned a transect code which allowed

database query of characteristics relating to each survey dive. Each individual habitat was assigned a habitat code which allowed query of individual habitat characteristics.

Within the proposed Bacalar Chico Marine Reserve, CCC completed 56 survey transects consisting of 204 individual dives and recorded data on 303 individual habitats. This habitat data incorporated over 14,000 separate species records.

3.3.2 Transect map and database link

Once the survey data had been sorted, compiled and analysed it was then returned to Belize and incorporated within ARC/INFO GIS facilities housed within the Coastal Zone Management Project.

The location of survey transects were plotted from the GPS coordinates collected at the beginning and end of each survey dive. The coordinates were converted into the UTM-16N reference system and imported into an ARC/INFO GIS. The transects were then split into individual habitats and overlaid onto the basemap. Owing to differences in accuracy of the GPS and DGPS readings, the transects were moved manually within the GIS into their correct position, known from the subsea descriptions and habitat types apparent in the aerial photographs (Map 2). Each habitat was linked to the database containing the survey data by unique identifiers, allowing spatial analysis of the data if required.

The GIS facilities at the Coastal Zone Management Project were also used to produce and print the final resource description maps (Sections 5.2 and 7.1).

4. DATA ANALYSES

4.1 Introduction

Prior to production of the marine habitat map it was first necessary to classify the habitat types encountered during the survey work. Studying the validity of each habitat was based on a number of parameters including examining the data for a distinct biological community or unique substratum and/or geomorphology. Once the validity of each of the apparent habitats was established it was then possible to produce the habitat classification scheme. The habitat labels were then applied to the map and the data summarised to provide descriptions of each habitat. The data analyses also produced details such as the dominant species, the occurrence of rare species and the species richness within each habitat.

4.2 Justification of habitat labels

Some habitats surveyed were found to have a unique geo-morphology that made them recognisable in the field and in aerial photographs without studying the associated biota. Other areas surveyed by the volunteers which did not have unique geo-morphological characteristics required both the benthos and the substratum data to be examined for determination of the habitat types present. In this case, the data were grouped together and tested to establish any distinct biological communities using cluster analysis and non-metric multi-dimensional scaling (MDS) within the software package PRIMER (Plymouth Routines in Marine Ecological Research). Cluster analysis produces a dendrogram and MDS produces an ordination where the distance between the points (each representing one CCC biological form from one habitat type) represents the dissimilarity between the biological communities. Thus two points that are placed far apart have different communities. Points from the same habitat type form "clusters" that are discrete from the clusters of other habitat types (Clarke, 1993). Both analyses were based on the Bray-Curtis similarity coefficient without transformation of the data. Any data points that did not cluster conclusively were assigned to a habitat class on the basis of their position within particular polygons on the the habitat map.

Once each of the survey forms was assigned to a habitat class the data were summarised, assigned an appropriate label by examining the dominant species and substratum types and then a description was produced. For each habitat type the data were summarised using both univariate and multivariate techniques. The main summary technique used similarity percentage (SIMPER) analysis, calculated within PRIMER. SIMPER shows the percentage to which each species is "characteristic" of that habitat type (Clarke and Warwick, 1994) and summarises the dominant benthic components of each habitat type.

For extra clarity the SIMPER analysis was supplemented with the univariate parameters median abundance and frequency of occurrence of each species. Univariate statistics are particularly useful for analysing data from habitats where the sample size is too small for SIMPER analysis (<3 records).

The median was calculated using the formula (Zar, 1984):

$$\text{median} = Li + \{(0.5n - C)/Ni\} \times I$$

where Li = lower limit of interval
 C = cumulative frequency of the previous classes
 Ni = number of observations in interval
 I = interval size

Frequency of occurrence (FoO) for each species in each habitat type was calculated as follows:

$$\text{FoO} = (\text{Number of sightings/Number of surveys}) \times 100$$

The SIMPER analysis and the calculation of univariate parameters was repeated for the fish data obtained from each habitat. These data were summarised and added to the descriptions for each habitat type.

Invertebrate data were represented as a species list for each habitat surveyed. However, the median abundance and frequency of occurrence of the commercially important species *Strombus gigas* (Queen Conch) and *Panulirus argus* (Caribbean spiny lobster) were calculated for each habitat type.

5. RESULTS OF SURVEYING

5.1 Habitat classes

The geo-morphological data distinguished six habitat classes without the need to study the biological communities. These habitats were defined as: spurs and grooves, the distinct patch reefs, shallow seagrass, sand with patches of bedrock, coral drop-off and reef crest. A series of single surveys revealed further unique habitat types. These were a coral knoll, a false reef crest, a sandy drop-off and a sand plateau. The artificial reef situated close to San Juan was also designated as a distinct habitat type.

The remaining data were then analysed using cluster analyses and MDS to distinguish distinct habitat types. Owing to the capacity of the PRIMER software (Carr, 1994) the reef and back reef sections were analysed separately.

5.1.1 *Back reef*

The back reef data were based on 98 individual survey forms. Of these, 11 forms were excluded from the analysis because they represented surveys on the distinct patch reefs, shallow seagrass and sand with patches of bedrock habitats that had previously been distinguished. The data from the remaining 87 forms were then analysed using cluster analysis. The resulting dendrogram (Figure 3) was split into three main groups plus two outliers. A comparative, clear MDS ordination of all 87 points is not possible within PRIMER and, therefore, MDS analysis was used on each of the three main groups. Using the MDS ordinations and dendrogram together, the back reef data were split into a further six habitat types. These habitat groupings are shown on the three MDS's in Figure 4.

The data for each habitat type were then pooled and the summary statistics were carried out. This enabled each habitat to be assigned an appropriate label. The final list of back reef habitats is shown in Table 1.

5.1.2 *Reef*

CCC undertook 203 individual surveys on the reef at Bacalar Chico. Only 74 of these were further analysed using MDS and cluster, the remainder were assigned the geo-morphologically distinct habitat types. The resulting MDS and dendrogram highlighted four habitat types. Similarly to the back reef, the data was pooled in order to assign each habitat an appropriate label. The final list of habitats which were applied to the final habitat map is shown in Table 1.

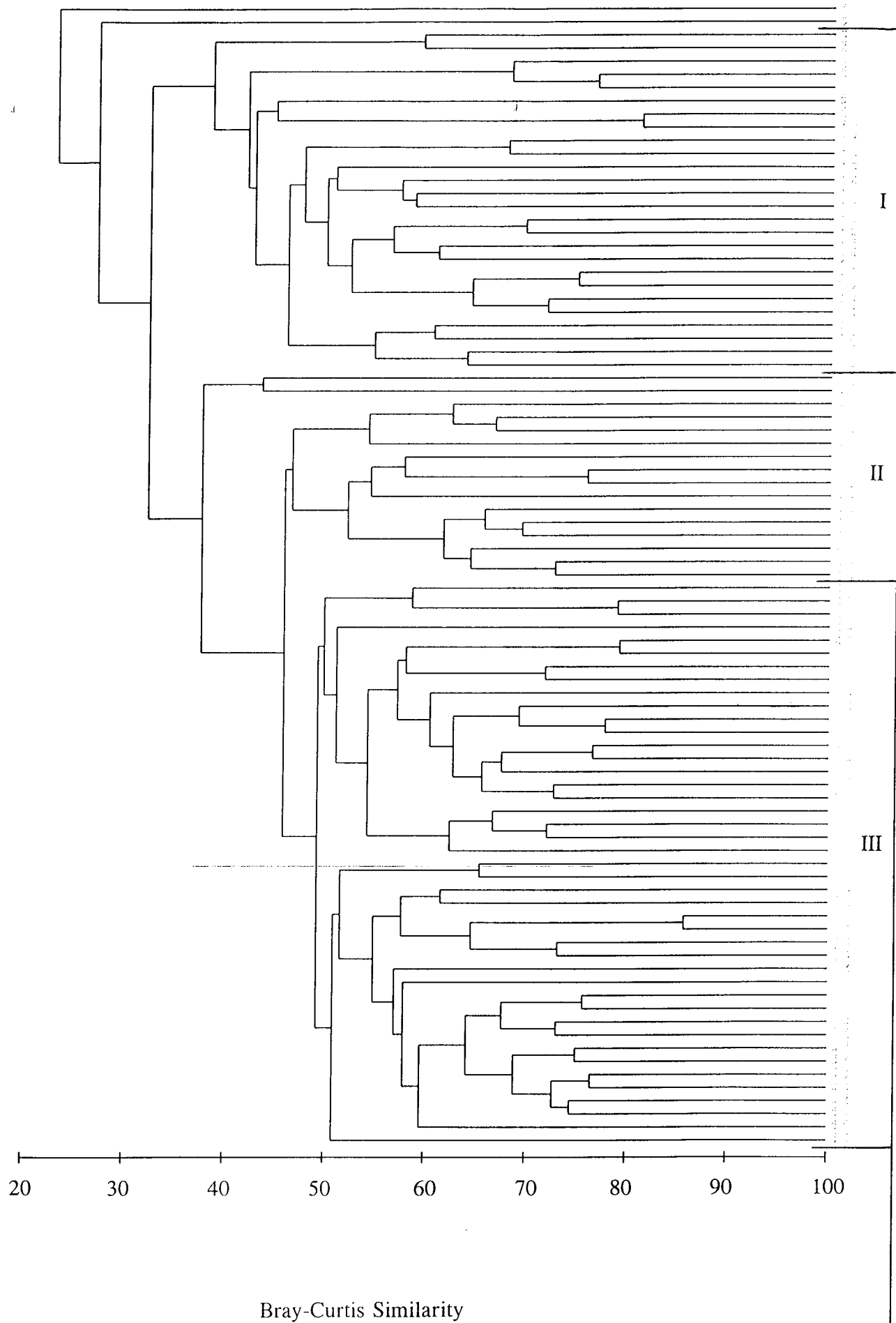


Figure 3. The resulting dendrogram from cluster analysis of the 87 back reef biological forms from Bacalar Chico. Lines indicate the three groups used for further analysis by MDS.

HABITAT LABEL	HABITAT CODE	NUMBER OF SURVEYS
Sparse seagrass	2.1	15
Medium to dense seagrass	2.2	40
Shallow seagrass	2.2.3	6
Seagrass with distinct coral heads	2.3	8
Distinct patch reef	3.1.1	5
Diffuse patch reef	3.1.2	10
Reef crest matrix	3.2	2
Gorgonian plain	3.3	60
Spurs and grooves - spurs	3.4	98
Spurs and grooves - grooves		8
Sand and coral matrix	3.5	1
Sparse mixed community on rubble	4.1.1	1
Medium to dense mixed community on rubble	4.2.1	0
Sand	5.2	0
Sand with patches of bedrock	5.2.2	5
Sand with sparse mixed algae	5.2.3	3
Sand with algae and gorgonians	5.2.4	11
Hard bottom with sand and sparse coral heads	5.4.1	2
Hard bottom with mixed corals, sponges and algae	5.4.2	2
Artificial reef	-	1
Coral drop-off	-	8
Sand drop-off	-	1
Coral knoll	-	1
Reef crest	-	9
False reef crest	-	1
Sand plateau	-	1

Table 1. The final list of habitat types determined by CCC surveys at Bacalar Chico. Each habitat was assigned a label and numerical code. The table also shows the number of individual surveys carried out in each habitat type. (Note: two surveys are unaccounted for in this table which relate to a habitat not visible in the aerial photograph and therefore not represented on the final habitat map).

5.2 Habitat map

5.2.1 Background

The preliminary habitat map (Raines *et al.*, 1995) was updated after analyses of the 1994 and 1995 survey data. The original habitat classification scheme that had been adopted was revised in light of further data analyses and as a result of discussions between Government and NGO representatives concerning the habitat classes utilised by CCC. This meeting, at the request of the EC Programme Management Group, sought to unify the classification system applied to maps detailing Belize's marine habitats. A hierarchical design, classified by class, type and sub-type, was adopted so that whoever is collecting future information can apply it by choosing the appropriate level to which their data refers. In essence, more specific scientific data relating to the habitats can be added to the resource description map which has been constructed through data collected at the level of major habitat type. The classification scheme is outlined in Section 5.2.2.

The habitat labels for each polygon were updated within the GIS by comparing the position of each data point and the corresponding habitat type within the classification scheme. The Bacalar Chico Marine Reserve habitat map, based on the data collected by CCC, constitutes the first test of the new classification scheme (Map 3).

5.2.2 Classification system for Belize marine environments as applied to the Bacalar Chico area

Classified by class, type, and subtype.

1. Land

- 1.1 Mangrove
- 1.2 Sand Beaches

2. Seagrass and algae

- 2.1 Sparse seagrass and algae
- 2.2 Medium to dense seagrass and algae
 - 2.2.1 Shallow (<0.5m) seagrass turf
- 2.3 Sparse seagrass with distinct coral heads

3. Reef

- 3.1 Patch reef
 - 3.1.1 Distinct patch reef
 - 3.1.2 Diffuse patch reef
- 3.2 Reef crest matrix
- 3.3 Gorgonian plain
- 3.4 Spurs and grooves
- 3.5 Sand and coral matrix

4. Mixed community

- 4.1 Sparse mixed community
 - 4.1.1 Sparse mixed community on rubble
- 4.2 Moderate mixed community
 - 4.2.1 medium to dense mixed community on rubble

5. Bare bottom

5.2 Sand

- 5.2.1 Sandy shoals and sand bars
- 5.2.2 Sand with patches of bedrock
- 5.2.3 Sand with sparse mixed algae
- 5.2.4 Sand with algae and gorgonians

5.4 Hard bottom

- 5.4.1 Hard bottom with sand and sparse coral heads
- 5.4.2 Hard bottom with mixed corals, sponges and algae

Notes:

- Each classified habitat is distinguishable from remotely sensed imagery. Groundtruthing may be necessary for the distinction of types and subtypes.
- Reefs have coral (hard & soft) as dominant lifeform and at least 10% ground cover.
- Seagrass and algae class has seagrass and algae as dominant lifeforms with at least 10% ground cover.
- Patch reefs are distinct coral assemblages covering at least 30 - 40 m².
- Mixed community has no one dominant lifeform, but at least 10% ground cover in areas other than those designated as reef.

5.3 General description of the area

5.3.1 Introduction

The area encompassed by the proposed Bacalar Chico Marine Reserve contains three distinct regions: the lagoonal area west of Ambergris Cay, the back reef both north and south of Rocky Point and the barrier reef running continuously along the eastern margin of the reserve area (Map 1). The following general descriptions outline the physical and biological characteristics of each region. The habitats contained within each region are described in more detail in Section 5.4 (see also Map 3).

5.3.2 Lagoon

The physical and biological attributes of the lagoon on the western side of Ambergris Cay, which extends to the mainland coast, was generally homogeneous, with a low topographic relief and water depth rarely greater than 5m. Initially, the substratum appeared to be deep silt/sand, however, limited investigation by CCC revealed the silt to be a thin covering on a bedrock base. The lagoon supported a low diversity of fauna and flora.

5.3.3 Back reef

An extensive back reef area both north and south of Rocky Point was found. It was apparent that the back reef was intrinsically linked with the reef itself because of the extensive water and, presumably, biological exchange through the breaks in the reef crest which divides the two areas (Map 3). The two sections of the back reef north and south of Rocky Point differed considerably. The southern back reef was shallower (less than 2m) and narrower, reaching a maximum width of 300m. In contrast, the northern area was a maximum of 1km wide and had water depths less than 6m.

5.3.4 Reef

The reef section of the barrier reef was found to have four distinct profiles along its length.

The most common of these (Figure 5) consisted of a spur and groove zone followed by a gorgonian plain culminating in the reef crest. This profile was found at all the reef transects between the double reef crest area on the northern border and Rocky Point (Map 2, transects R8-35) and between Rocky Point and Robles Point (Map 2, transects R41-50). As can be seen in Figure 5, the spurs and grooves started at approximately 30m being replaced by the gorgonian plain at approximately 10m. The spur and groove zone and the gorgonian plain were typically separated by a narrow sand channel (approximately 10m wide). Figure 5 also shows how the spurs and grooves declined in relief from east to west.

The second profile was found close to the northern reserve boundary where the reef was found to have a "double reef crest" (Figure 6). This unusual area was characterised by two coral drop-offs that surrounded a flat sand bed approximately 200m wide, lying at a depth of around 20m. In addition to the main reef crest, the top of the eastern drop-off was characterised by a second reef crest. This second reef crest was similar to the main reef crest although it was found deeper and had more sporadic stands of *Acropora palmata*. Furthermore, the second reef crest was found not to be continuous along the length of the eastern drop-off and was occasionally broken by deeper areas of the adjoining gorgonian plain. The two drop-offs eventually joined at the southern apex of the sand bed (Map 2, transect R6). East of the second drop-off the zonation was typical of the remainder of the reef, with a gorgonian plain merging into a spur and groove zone at a depth of 7-8m.

The third distinct profile was at Rocky Point, where the gorgonian plain was found to extend out to the 30m contour without any spur and groove development (Figure 7). CCC surveys were unable to reveal whether any deeper spurs and grooves existed, although echo-sounder readings revealed the steep escarpment to start at approximately 45m.

The final atypical reef profile was found south of Robles Point, shown in Figure 8. In this area the deep, high relief spurs and grooves merged after approximately 170m, at a depth of 15m, with a sand channel similar to many other areas of the reef. However, rather than a gorgonian plain starting after the sand bed there was an area of low relief spurs and grooves. This second area of spurs and grooves then merged into a sand and coral matrix at approximately 10m. As can be seen in Map 2, transect R53 (represented in Figure 8) was located at the narrowest section of the second spur and groove habitat and data from transect R55 indicated that the low relief spurs and grooves extended into shallower water further south of Robles Point.

5.3.5 Deep reef

A limited amount of topographic information was generated relating to the steep escarpment via an echo-sounder positioned at the latitude of selected survey transects using a G.P.S.. A typical result of this echo-location is shown in Figure 9 and reflects that the escarpment descended steeply until at least 150m. Observations by divers at shallower depths revealed that the majority of the benthic fauna and flora ceased below approximately 45m and the rest of the escarpment was almost totally bare sand.

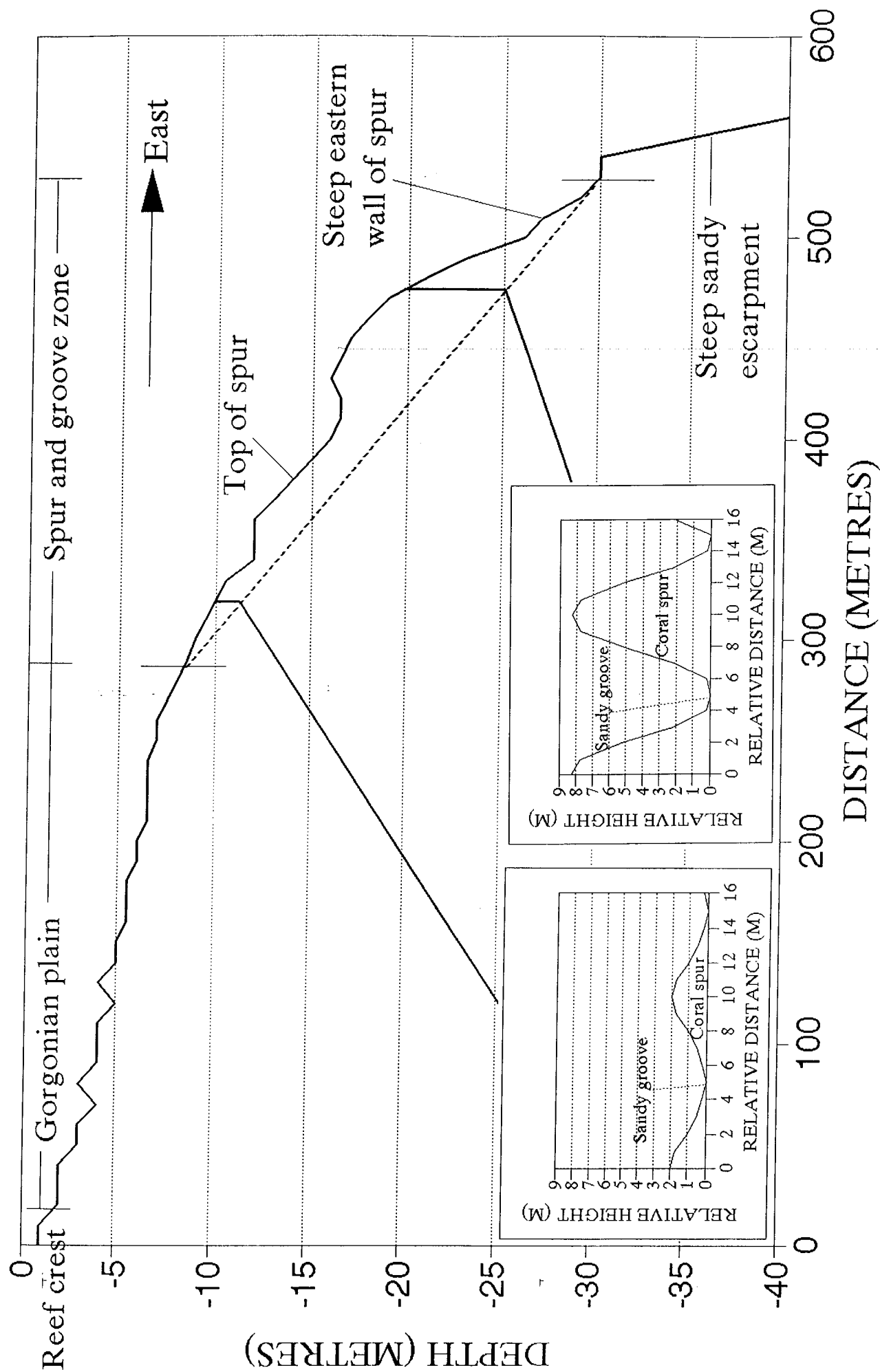


Figure 5. Reef profile at survey transect R22. This profile is typical of the majority of the reserve area surveyed. The dotted line represents the surface of the intersecting sandy grooves. Inset: Two cross sections showing how the spur and groove formations change from high to low relief in a westwards direction.

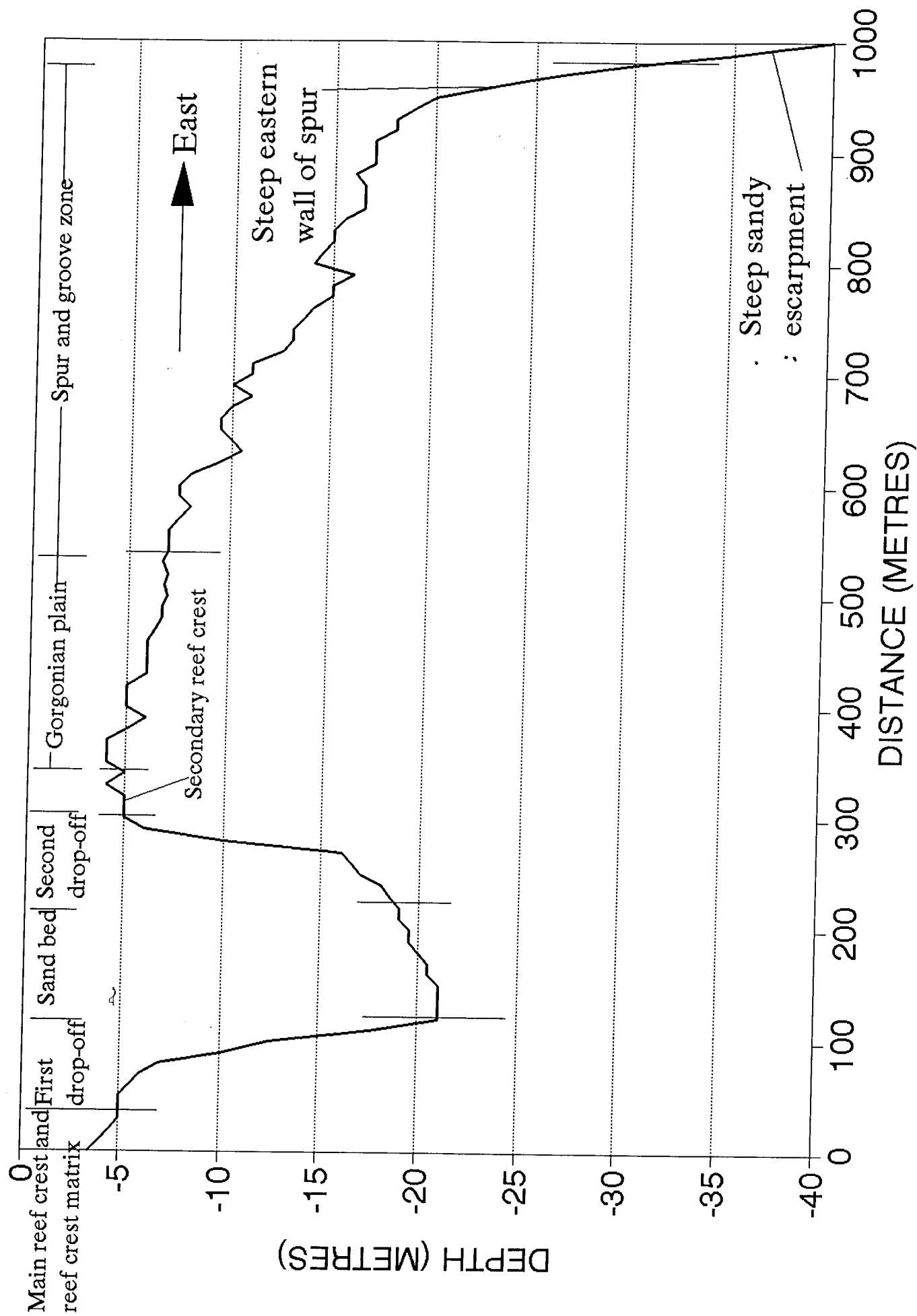


Figure 6. Reef profile at survey transect R4. The profile shows the two drop-offs and reef crests characteristic of the northern section of the reef.

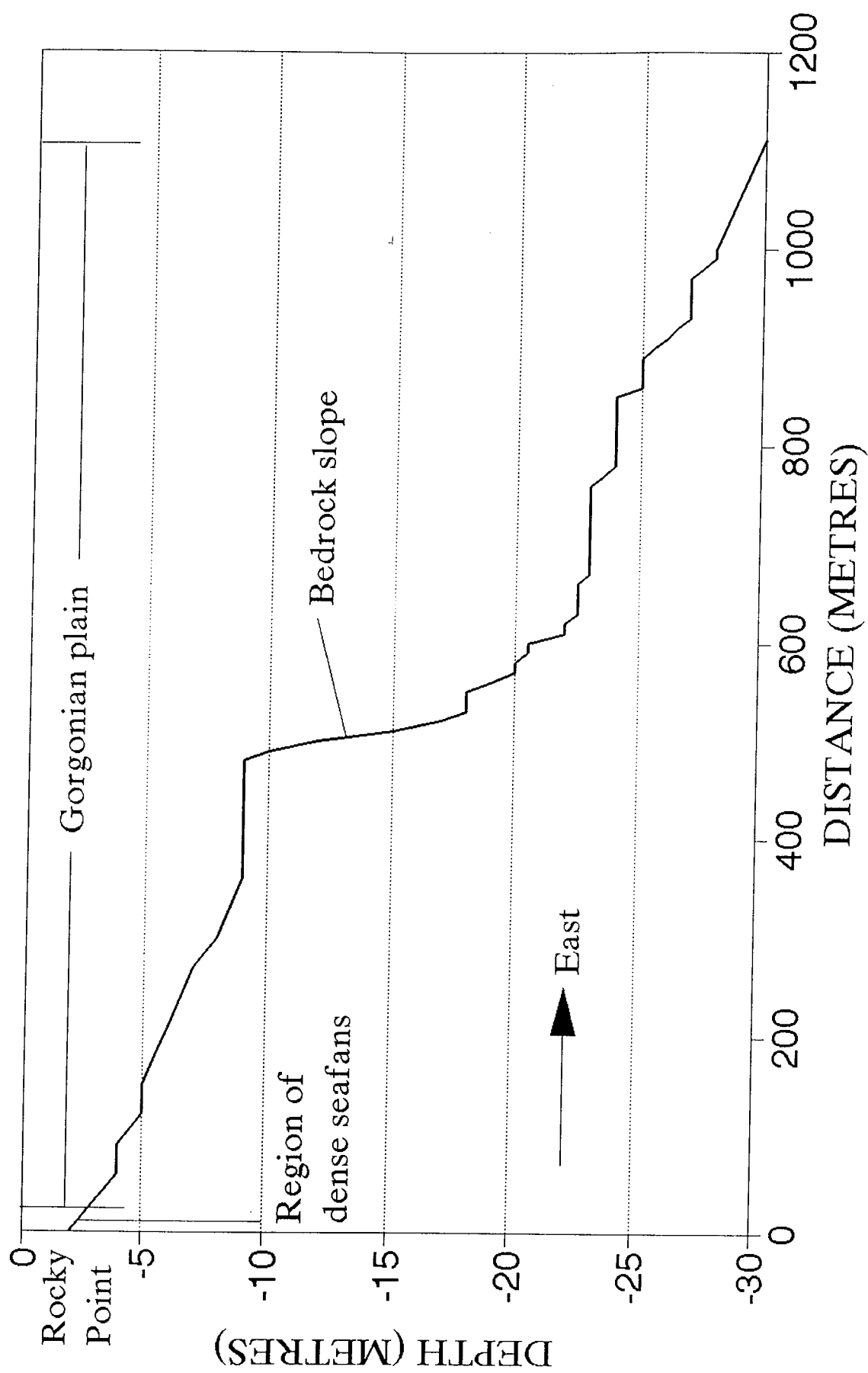


Figure 7. Cross profile of the reef at transect R40. This profile shows how the gorgonian plain extended to the 30m contour without the normal spur and groove zone.

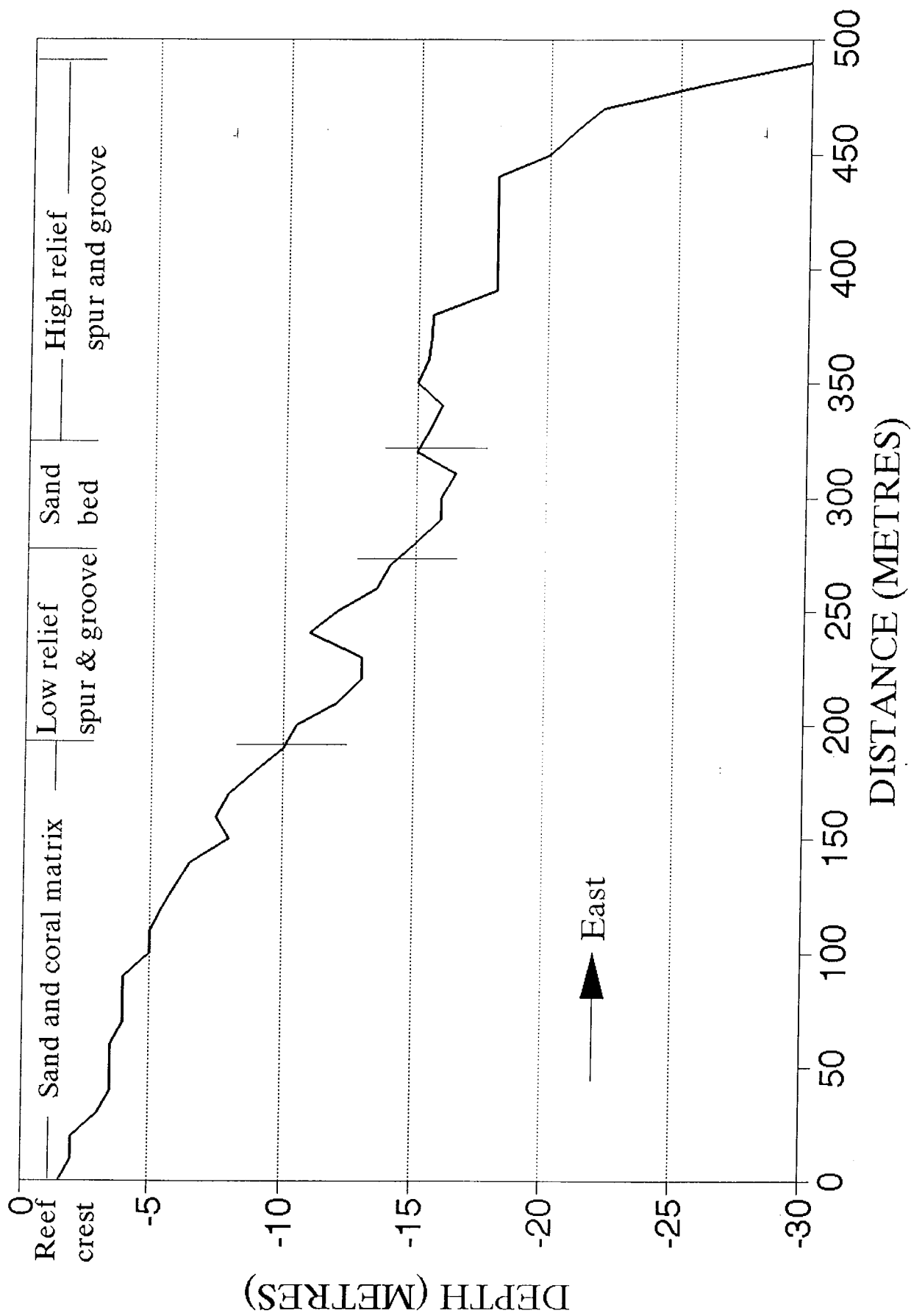


Figure 8. Cross profile of the reef at transect R53. This profile represents the most southern section of the reserve area and highlights the two spur and groove zones and the unusual sand and coral matrix habitat.

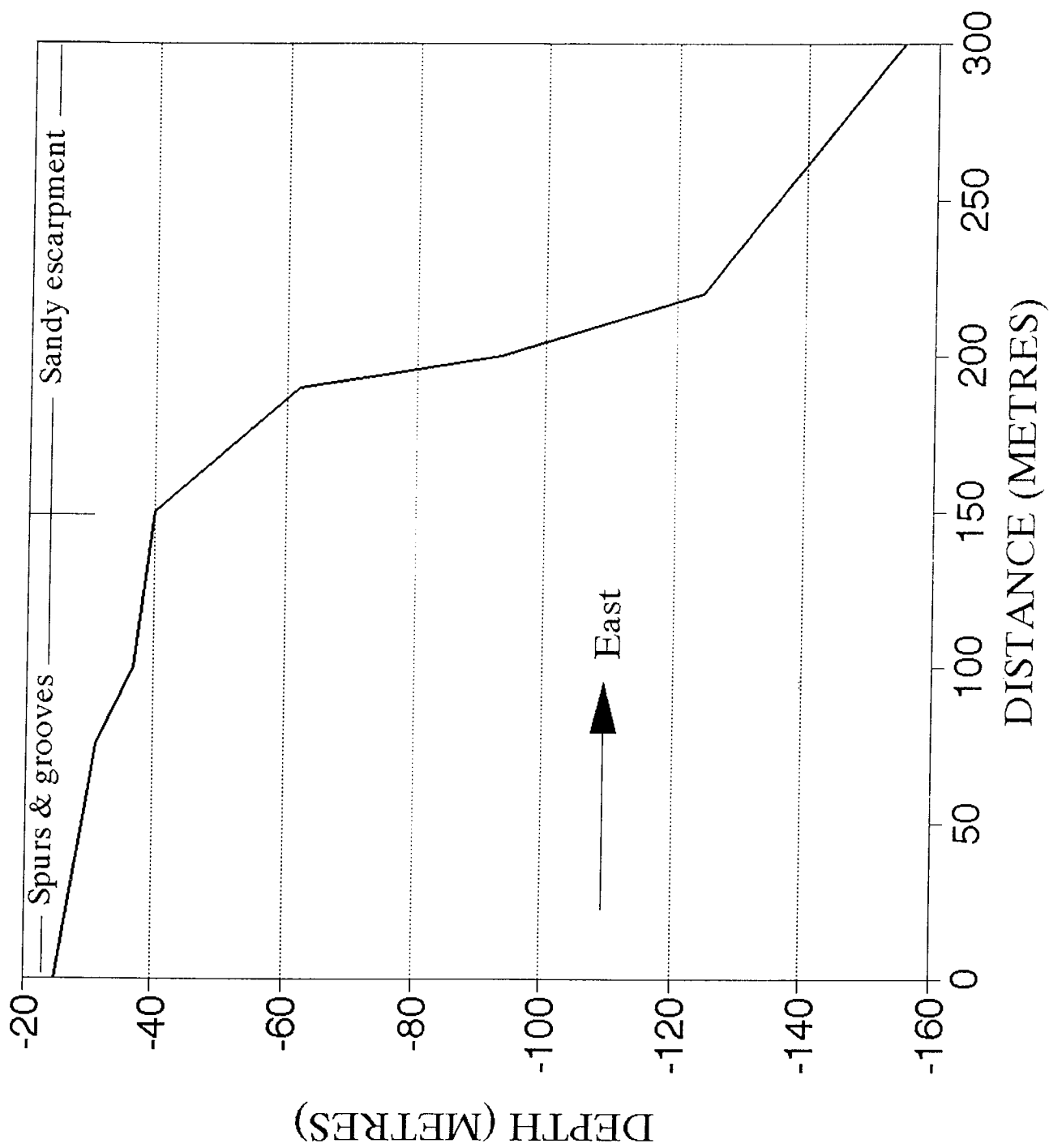


Figure 9. A typical profile of the deep reef in the Bacalar Chico area. This profile was discovered using an echo-sounder.

5.3.6 Physical parameters

The CCC survey technique included collecting physical data on winds and currents, boat activity, underwater visibility and surface and underwater impacts.

The boat activity data showed that 56 boats were seen during the 204 surveys conducted by CCC. These boats contained an average of 2.8 people with 58.9% of the boats involved in fishing. The other boats were engaged in either commercial (8.9%) or pleasure (32.1%) activities. The average visibility was 17.2m (+/-7.2m) with a maximum of 50m and a minimum of 5m. A total of 103 surface and 29 underwater impacts were recorded during the surveys. The surface impacts were dominated by drifting algae (72.8%) with litter (14.6%) and driftwood (22.3%) also seen. Only two categories of underwater impacts were recorded, dominated by coral damage (79.3%) with 20.7% of the impacts being litter.

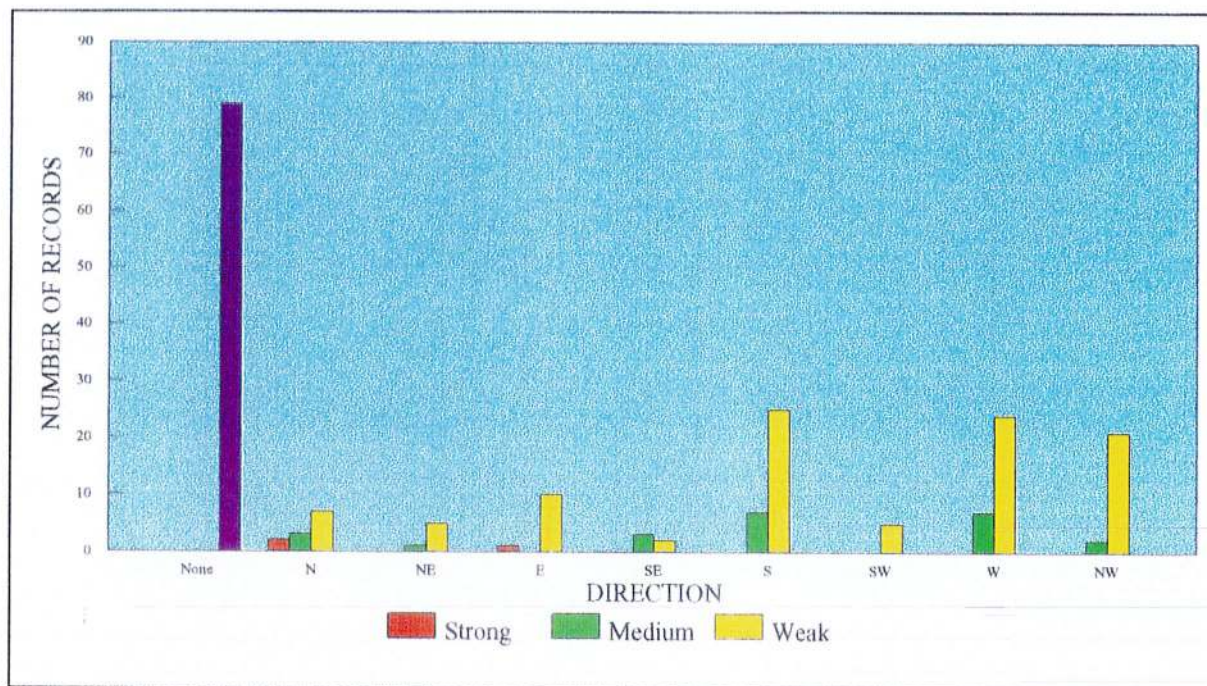
Figure 10 shows that the prevailing wind was from the east and usually rated a 1 or 2 on the beaufort scale. The Bacalar Chico area was found not to have significant currents (Figure 11). However, when currents were apparent they were usually weak and heading towards the south, west or north-west.

5.3.7 Water quality parameters

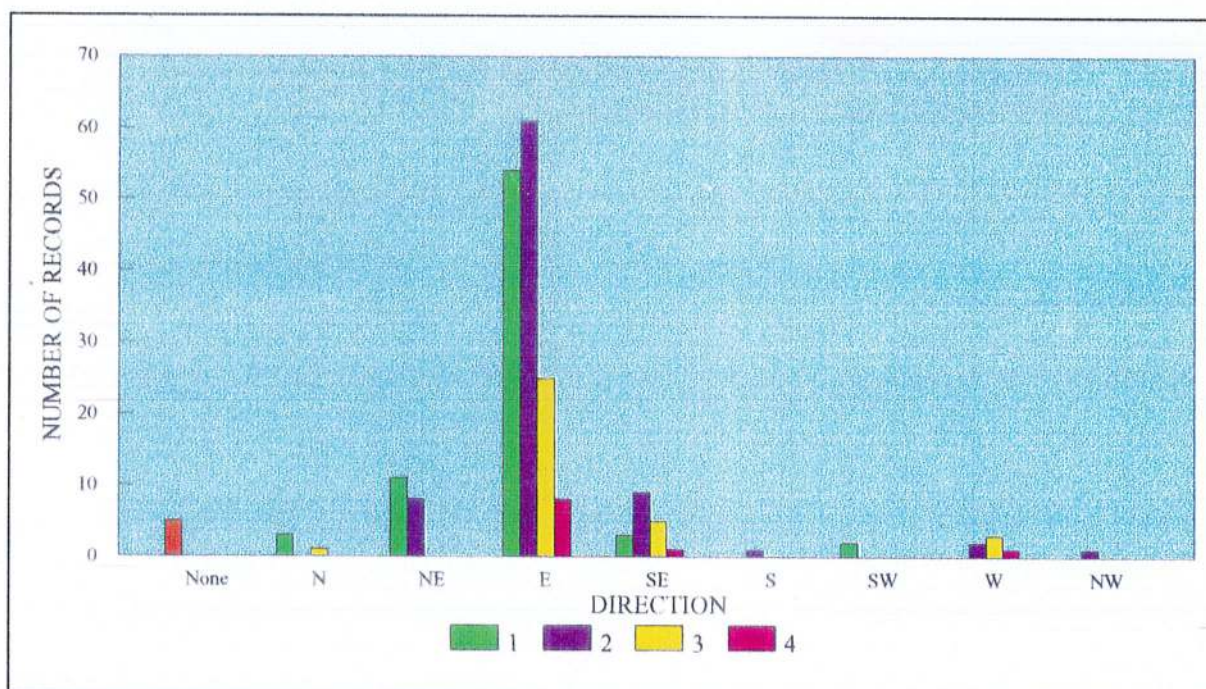
Specific gravity and temperature measurements were recorded by the Bacalar Chico Marine Biologist (Table 2) and used to determine the salinity of the water. It appears that the west lagoon had lower salinity than the Boca Bacalar Chico and the eastern, reef section of the Bacalar Chico area.

LOCATION	SALINITY (Specific Gravity)		TEMPERATURE (°C)	
	MEAN	S.D.	MEAN	S.D.
San Juan	1.0080	0.0053	26.8	2.3
West Boca Bacalar Chico	1.0173	0.0061	26.2	2.5
Mid Boca Bacalar Chico	1.0310	0.0507	26.6	2.4
Cantena	1.0160	0.0042	26.2	2.7
East Boca Bacalar Chico	1.0214	0.0040	26.9	2.1
Back Reef	1.0242	0.0007	27.5	1.3

Table 2. Salinity and temperature readings taken within the proposed Bacalar Chico Marine Reserve between November 1995 and February 1996. S.D.= Standard Deviation.



(10)



(11)

Figures 10 and 11. Summary of the current (10) and wind (11) data collected within the proposed Bacalar Chico Marine Reserve.

Nitrate and pH levels of the waters of the Bacalar Chico area (Table 3; L. Balchin, pers. comm.) were found to be comparable with the average nitrate levels of seawater (Barnes and Hughes, 1988).

LOCATION	pH	NITRATE (ppm)
Seagrass Bed off Base Camp	8.0	2.2
Back Reef	8.2	4.4
Boca Bacalar Chico	8.2	4.4
West Lagoon	8.4	1.1

Table 3. pH and nitrate readings for four sample sites within the proposed Bacalar Chico Marine Reserve.

These parameters will continue to be recorded at intervals throughout the year to give temporal information on water quality.

5.4 Habitat descriptions

The following habitat descriptions have been compiled using the results of the SIMPER analysis on the pooled data for the benthos, substratum and fish associated with each habitat type, supplemented with the median and frequency of occurrence statistics. In addition to these descriptions, Appendix 2 contains species lists for each of the habitat types. It should be noted that to account for volunteer mis-identifications a species was only marked as present if it was found on over 5% of the biological forms from that habitat type. The 5% figure was derived from the mean level of erroneous identifications for coral and macro-algal species calculated during the CCC data validation exercise (Mumby *et al.*, 1995). The presence of each species recorded within each habitat type is represented by its frequency of occurrence. For comparison the total number of species from each of the six taxonomic classes in each habitat is summarised in Table 4.

Appendix 2 also shows the final species list for hard corals and fish species within the whole Bacalar Chico as compiled by CCC science staff. This list shows that a total of 47 scleractinians, 2 black corals, 3 hydrocorals and 176 fish species were seen. Some of these species, detailed in Section 5.5.1, are new records for CCC surveys in Belize.

HABITAT TYPE	NUMBER OF SPECIES SEEN ON GREATER THAN 5% OF THE SURVEYS						
	Scleractinians and hydrocorals	Octocoral growth forms	Sponge growth forms	Macro-algae and seagrasses	Fish	Inverts	Total
Sparse seagrass	17	5	1	30	49	9	102
Medium to dense seagrass	12	4	3	26	24	21	69
Shallow seagrass	15	5	2	33	24	12	79
Seagrass with distinct coral heads	26	6	3	36	56	6	127
Distinct patch reef	20	4	1	20	37	7	82
Diffuse patch reef	28	5	3	33	63	14	132
Reef crest matrix	24	4	1	20	33	1	82
Gorgonian plain	28	5	6	38	61	27	138
Spurs & grooves - spurs	38	6	7	35	79	36	165
Spurs & grooves- grooves	20	4	4	24	46	6	98
Sand and coral matrix	5	3	0	8	31	1	47
Sparse mixed community on rubble	3	1	1	5	17	5	27
Sand	-	-	-	-	-	-	-
Medium to dense mixed community on rubble	-	-	-	-	-	-	-
Sand with patches of bedrock	0	0	0	3	0	1	4
Sand with sparse mixed algae	0	1	1	10	1	6	19
Sand with algae and gorgonians	20	5	3	24	53	5	110
Hard bottom with sand and sparse coral heads	10	3	1	16	28	6	64
Hard bottom with mixed corals, sponges and algae	21	6	2	14	48	6	97
Artificial reef	0	0	1	3	16	1	21
Coral drop-off	36	3	5	31	71	10	116
Sand drop-off	4	3	1	4	7	0	19
Coral knoll	9	2	0	4	21	1	37
Reef crest	10	6	1	31	35	8	91
False reef crest	6	4	1	12	25	3	51
Sand plateau	7	0	0	7	31	0	45

Table 4. The number of species, from the six main taxonomic groups recorded by CCC during survey work, seen in each habitat type. Only species seen on greater than 5% of the surveys in that habitat type are included (see text). Habitats ordered as in Table 1.

5.4.1 Sparse seagrass

Sparse seagrass was a common habitat type in the back reef of the Bacalar Chico area. Almost exclusively growing in a sandy substratum (median abundance 4.8), the seagrass beds were dominated by *Thalassia testudinum*. On 60% of surveys *Syringodium filiforme* was also present. In contrast to the medium to dense seagrass habitat (see Section 5.4.2), the median abundances of *T. testudinum* and *S. filiforme* were only 2.3 and 0.7 respectively. The seagrass was also interspersed with a number of algal species, including *Halimeda tuna*, *H. incrassata*, *Penicillus* spp. and *Dictyota* spp. There were also occasional soft corals present, with *Pseudoplexaura* spp. and *Gorgonia ventalina* found on 60% of the surveys. Hard coral species diversity and abundance was low, with *Siderastrea radians* and *Manicina areolata* the most commonly found (frequency of occurrence 40%). Sponges were almost entirely absent, with only encrusting sponges found (frequency of occurrence 20%).

There were few fish inhabiting the sparse seagrass habitat. The fish recorded were the herbivorous surgeonfish, most commonly *Acanthurus coeruleus* (frequency of occurrence 66.7%), the snapper *Ocyurus chrysurus* and other reef dwellers which were associated with the occasional coral heads. These included the damselfish *Abudefduf saxatilis*, *Stegastes partitus* and *Microspathodon chrysurus*, the wrasse *Thalassoma bifasciatum* and gobies.

5.4.2 Medium to dense seagrass

The medium to dense seagrass habitat type was dominant in the back reef of the Bacalar Chico area. Similarly to the sparse seagrass beds, the substratum was mainly sand (median abundance 4.8) with occasional patches of dead coral. These beds were almost always (85%) composed of mixed *Thalassia testudinum* and *Syringodium filiforme* with the remaining 15% being solely *T. testudinum*. The median abundances for *T. testudinum* (4.0) and *S. filiforme* (2.4) were higher than for the sparse seagrass beds. There were abundant algae amongst the seagrass, especially *Halimeda incrassata* (median abundance 2.3) and also *Avrainvillea* spp., *Halimeda tuna* and *Udotea flabellum*. Soft corals were uncommon, with *Pseudoplexaura* spp. the most frequent (frequency of occurrence 37.5%). The most common hard coral was *Manicina areolata*, found on 70% of the surveys within this habitat, with a median abundance of 0.9. Sponges were rare, with the most frequently found being encrusting sponges (frequency of occurrence 37.5%).

Similarly to the sparse seagrass habitat, the medium to dense seagrass habitat did not have an abundant fish community. The species present were again a combination of the wrasse *Halichoeres bivittatus* and *Thalassoma bifasciatum*, the herbivorous surgeonfish (*Acanthurus* spp.), and the damselfish found on the sporadic coral heads (*Stegastes* spp.). Triggerfish known to frequent seagrass beds searching for urchins (Humann, 1994) were also recorded with *Balistes vetula* found on 15% of the surveys.

5.4.3 Shallow seagrass

The shallow seagrass habitat was restricted to one polygon in the back reef area, just north of Rocky Point (Map 3). Compared to the other seagrass habitats, this area was very shallow with depths less than 1m (some places less than 0.5m) and was therefore assigned a separate habitat label. The benthic community, however, was very similar to the other seagrass beds with substratum dominated by sand and a mixture of both *Thalassia testudinum* and *Syringodium filiforme* (50% occurrence) and *T. testudinum* alone. There was abundant algae,

particularly *Halimeda* spp., *Penicillus* spp. and *Rhipocephalus phoenix*. In comparison to the other seagrass habitats the hard corals were slightly more abundant. *Siderastrea siderea* was found on 66.7% of the surveys and *Montastrea annularis*, *Manicina areolata*, *Diploria* spp., *Siderastrea radians* and *Porites astreoides* had a frequency of occurrence of 50%. The fire coral *Millepora alcicornis* was also abundant (median abundance 0.8).

The surgeonfish (*Acanthurus* spp.), the damselfish (*Stegastes* spp.) and the wrasse *Halichoeres bivittatus* and *Thalassoma bifasciatum* were dominant (median abundance 0.3 - 1.5). The grunt *Haemulon flavolineatum* was common (frequency of occurrence 50%).

5.4.4 Seagrass with distinct coral heads

The seagrass with distinct coral heads habitat was occasionally encountered in the back reef area, especially just behind the reef crest. The habitat consisted of a mix of normal seagrass beds punctuated with numerous and above average sized coral heads or areas of coral that were too small to be classed as patch reefs. The summary statistics showed a dominance of sand (median abundance 4.3) but also significant dead coral (median abundance 1.3) upon which the living corals were growing.

The biotic community representative of this habitat was more diverse than the other seagrass beds although *Thalassia testudinum* and the algae *Halimeda incrassata* and *Dictyota* spp. were still numerically dominant. The coral communities consisted of significant numbers of soft corals, especially *Pseudoplexaura* spp. and *Gorgonia ventalina* (median abundances 1.8 and 2.0 respectively) and hard corals. The hard corals found included *Porites astreoides*, *Montastrea annularis*, *Siderastrea siderea* and *Dichocoenia stokesii* (median abundance > 0.8). The fire coral *Millepora alcicornis* was also found on 75% of the surveys.

The fish community of this habitat was more diverse and abundant than the other seagrass habitats. Characteristic of this habitat were the surgeonfish *Acanthurus coeruleus* with a median abundance of 2.1, the wrasse *Thalassoma bifasciatum* (median abundance 1.7) and the parrotfish *Sparisoma viride* (median abundance 1.7). There were also a number of species that live on and around the coral heads such as the damselfish *Abudefduf saxatilis*, the grunt *Haemulon sciurus*, the butterflyfish *Chaetodon capistratus* and a variety of gobies.

5.4.5 Distinct patch reef

CCC surveyed five distinct patch reefs in the back reef north of Rocky Point (Map 3). These represented significant areas of hard substratum supporting a mixed fauna and flora. The patch reefs surveyed were between approximately 15 and 50m across. The substratum was composed mainly of dead coral (median abundance 2.9) with some bedrock (median abundance 1.1). Each patch reef was surrounded by a halophytic ring of clear sand, thought to be through the grazing action of herbivores.

The patch reefs supported many algae, the most characteristic of which were *Halimeda tuna*, *H. discoidea*, *Dictyota* spp. and *Turbinaria* spp. (median abundance > 1.0). There were numerous soft corals, particularly *Gorgonia ventalina* and *Pseudopterogorgia* spp. (median abundance 2.0 and 1.8 respectively). The most characteristic hard corals were *Porites astreoides*, *Agaricia tenuifolia*, *Dichocoenia stokesii*, *Siderastrea radians* and *Montastrea annularis* (median abundance > 0.8). There was a poor sponge fauna, with only encrusting

sponges present (frequency of occurrence 40%).

The fish community was relatively abundant, the grunt (both adult and numerous juveniles) *Haemulon flavolineatum* being the most characteristic species (median abundance 1.3). Other common species were the wrasse *Thalassoma bifasciatum*, the damselfish *Abudefduf saxatilis* and *Microspathodon chrysurus*, the surgeonfish *Acanthurus coeruleus* and the parrotfish *Sparisoma viride* (median abundance > 0.8).

5.4.6 Diffuse patch reef

In the back reef, particularly behind the line of the reef crest, there were large areas of coral dominated habitat which could not be classified as distinct patch reefs. This habitat represented a transition between the reef and the back reef environments. These areas were classified as diffuse patch reefs, referring to the dense aggregations of coral heads usually separated by sand. The substratum summary statistics reflected these features with the dominant components being dead coral (median abundance 3.0) and sand (median abundance 2.5). The sand separating the coral areas occasionally supported *Thalassia testudinum* (30% occurrence).

The dead coral supported a similar community to the distinct patch reefs. There were numerous algal species, most commonly *Halimeda tuna*, *Penicillus* spp., *Rhypocephalus phoenix* and *Dictyota* spp. (median abundance > 1.7). There were numerous soft corals, with *Gorgonia ventalina* and *Pseudoplexaura* spp. particularly abundant (median abundance of both 1.8). *Montastrea annularis* was the most characteristic species (median abundance 3.1) with *Porites astreoides*, *Diploria strigosa*, *Agaricia tenuifolia*, *Siderastrea siderea* and *Acropora cervicornis* also abundant (median abundance > 0.9). The only frequent sponges encountered were the encrusting and branching forms (frequency of occurrence 70% and 30% respectively).

The diffuse patch reef habitat contained an abundant fish community. The wrasse *Thalassoma bifasciatum*, the surgeonfish *Acanthurus coeruleus*, the parrotfish *Sparisoma viride* and the grunts *Haemulon flavolineatum* and *H. sciurus* were all found in median abundances greater than 1.8. Other characteristic species of this habitat were the damselfish *Stegastes diencaeus* and the wrasse *Halichoeres garnoti*.

5.4.7 Reef crest matrix

This habitat was restricted to the top of the westward drop-off in the northern section of the reef (refer to Map 3). It covered a small area and, therefore, CCC only carried out two surveys within this habitat. The limited data revealed an interesting habitat based on dead coral and bedrock (median abundance 3.5 and 1.5 respectively). There were abundant algae, mainly *Dictyota* spp., *Sargassum* spp. and *Halimeda* spp.. The most abundant corals were *Montastrea annularis*, *Acropora palmata*, *Siderastrea* spp., *Porites astreoides*, *Agaricia agaricites*, *Agaricia agaricites* forma *danai* and *A. tenuifolia*. The soft corals *Pseudoplexaura* spp. were also recorded. The fish community was abundant and dominated by the wrasse *Thalassoma bifasciatum*, the chromid *Chromis cyanea*, the surgeonfish *Acanthurus coeruleus* and the damselfish *Stegastes diencaeus*.

5.4.8 Gorgonian plain

The gorgonian plain was one of the two major habitats on the barrier reef at Bacalar Chico. It ran most of the length of the reef, tapering out south of Robles Point. The gorgonian plain was particularly wide at Rocky Point. Between transects R34 and R41 (Map 2) it extended out to at least the 30m contour which was the maximum depth surveyed by CCC. The substratum of the gorgonian plain habitat was dominated by a mixture of dead coral and bedrock (median abundances 2.1 and 1.9 respectively), forming a flat and mostly featureless plain.

The biota was dominated by a variety of soft coral growth forms and species. *Pseudopterogorgia* spp., *Pseudoplexaura* spp. and *Gorgonia ventalina* had median abundances of 3.0, 2.9 and 2.4 respectively. Algae, although not diverse, were abundant, particularly *Halimeda tuna* and *Dictyota* spp. (median abundances 2.3 and 2.0 respectively). The fire coral *Millepora alcicornis* was also common (median abundance 1.5). Hard coral growth appeared to be restricted, with the most abundant species being colonies of *Dichocoenia stokesii*, *Diploria strigosa*, *Porites astreoides* and *Montastrea cavernosa* (median abundance 1.2 to 1.5). Encrusting sponges were relatively common (median abundance 1.2) and tube and vase sponges were found on over 40% of surveys within this habitat. Giant barrel sponges (*Xestospongia muta*) were more common on the wide section of the gorgonian plain at Rocky Point than on the rest of the reef.

Although the gorgonian plain is a reefal habitat the fish population was sparse. Only the wrasse *Thalassoma bifasciatum* and the damselfish *Stegastes partitus* had a median abundance of greater than 2.0. Other species recorded were the surgeonfish *Acanthurus* spp., the wrasse *Halichoeres garnoti*, the angelfish *Holacanthus tricolor* and the squirrelfish *Holocentrus adscensionis*. The squirrelfish (*Holocentrus* sp. and *Neoniphon marianus*) were particularly common, hiding in holes or depressions in the substratum (pers. obs.).

5.4.9 Spurs and grooves

The spur and grooves were the second major habitat type of the reef. This habitat apparently ran down the entire length of the reef within the proposed reserve. The only break in this habitat appeared to be at Rocky Point where the gorgonian plain extended out to the 30m contour. CCC were unable to check for the presence of spurs and grooves beyond this depth. The spur and groove habitat consisted of alternating coral spurs and sandy grooves aligned perpendicular to the line of the reef crest. The spurs decreased in height from a maximum of 15m in the east to less than 1m in the west. This alternating substratum was reflected in the summary statistics show that the dominant substratum alternated between dead coral (median abundance 2.9) and sand (median abundance 1.6).

The spurs supported a rich community composed of a wide variety of algae, the most characteristic species were *Dictyota* spp., *Halimeda tuna*, *H. discoidea*, *H. copiosa*, *H. goreau* and *Lobophora variegata* (median abundance 1.2). There were numerous soft corals, particularly *Pseudopterogorgia* spp. and *Pseudoplexaura* spp. which had median abundances of 2.7 and 2.4 respectively. The hard corals were dominated by *Montastrea annularis* (median abundance 2.8) which was found in a variety of growth forms, including sheets protruding from the sides of the spurs. There were numerous other hard corals with the most characteristic being *Montastrea cavernosa*, *Agaricia agaricites*, *Porites astreoides*,

Dichocoenia stokesii, *Meandrina meandrites* and *Siderastrea siderea* (median abundance > 1.2). The fire coral *Millepora alcicornis* was also found on 73.5% of the surveys. The commonest sponges on the spurs were the encrusting, tube and vase forms (median abundance > 0.5).

A poor floral and faunal community was associated with the sandy grooves. There were some soft corals (particularly *Pseudopterogorgia* spp. and *Pseudoplexaura* spp.) and the algae *Dictyota* spp., *Halimeda* spp. and *Lobophora variegata* (median abundance > 0.7). The hard corals were restricted to growth on small patches of dead coral and consisted of colonies *Siderastrea siderea*, *Dichocoenia stokesii* and *Montastrea cavernosa* (median abundances between 1.0 and 1.2).

The structural diversity of the spur and groove habitat supported a rich fish community. This was dominated by the wrasse *Thalassoma bifasciatum* and *Halichoeres garnoti*, the damselfish *Stegastes partitus*, the chromid *Chromis cyanea* and the surgeonfish *Acanthurus coeruleus* (median abundance > 1.5). There were also a number of other corallivorous and herbivorous species including the butterflyfish *Chaetodon capistratus*, the parrotfish *Sparisoma viride* and *Scarus taeniopterus* and the angelfish *Holacanthus tricolor*, as well as shoals of the grunt *Haemulon flavolineatum*.

Within the spur and groove habitat, CCC discovered only one area of unusual heterogeneity. This was at the start of the transect R24 (visible on Map 2) where the normal pattern of spurs and grooves followed by gorgonian plain changed and consisted of a reef profile with a sand and coral matrix habitat followed by the gorgonian plain. This section was narrow, with the normal spur and grooves habitat visible in the distance both to the south and north.

The data for this section came from two surveys. The limited data revealed an area dominated by sand and rubble (median abundance 2.0 for both) with occasional patches of dead coral. There was considerable blue-green algae (*Schizothrix calcicola*, median abundance 3) and the green and brown algae *Dictyota* spp., *Halimeda* spp. and *Lobophora variegata*. There were numerous soft corals, particularly *Pseudopterogorgia* spp. and *Pseudoplexaura* spp. (median abundance 3.0 and 2.0 respectively). The dominant hard corals were *Montastrea annularis* and *M. cavernosa* (median abundance 2.5 and 2.0 respectively). Numerous sponges, especially the encrusting, ball and vase growth forms were encountered (median abundance > 0.9). The fish community was dominated by the chromid *Chromis cyanea* and the wrasse *Thalassoma bifasciatum* (median abundance 3.0).

5.4.10 Sand and coral matrix

This habitat type was recorded exclusively on the reef south of Robles Point. It was found shoreward of the spur and groove habitat and replaced the more common gorgonian plain habitat. Originally only a small section of this habitat was inside the proposed reserve area but owing to the extension of the reserve boundary a considerable section is now included within the reserve. As the boundary extension was made after the field survey work was undertaken the data available were from just one survey.

The limited data showed a substratum of sand with patches of bedrock, similar to the sand and coral matrix habitat frequently observed on the forereef at Turneffe Atoll (CCC, 1995).

The most abundant algae were *Dictyota* spp. and *Lobophora variegata* (abundances of 3.0). Only the corals *Acropora palmata*, *Dichocoenia stokesii*, *Diploria strigosa* and *Diploria clivosa* present and the fire coral *Millepora alcicornis* were recorded. The fish community was dominated by the surgeonfish *Acanthurus* spp., damselfish *Stegastes* and *Microspathodon* spp., parrotfish *Scarus* spp. and numerous gobies and blennies.

5.4.11 Sparse mixed community on rubble

This habitat was restricted to one small area inside the reef crest just south of the main cuts in the reef and opposite the CCC base camp (Map 2). It was surveyed once by CCC which revealed a community based on a substratum of rubble with sand (median abundances 3.0 and 2.0 respectively). The algae were sparse with *Caulerpa* spp. dominant (median abundance 2.0) and *Rhipocephalus phoenix*, *Ventricaria* spp. and *Sargassum* spp. also present. There was a small amount of the seagrass *Thalassia testudinum*. The coral community was restricted to *Stephanocoenia michelini*, *Dichocoenia stokesii*, *Gorgonia ventalina* and *Millepora alcicornis*. The most abundant fish were the damselfish *Stegastes partitus* and the wrasse *Halichoeres bivittatus* (median abundances 2.0).

5.4.12 Medium to dense mixed community on rubble

Medium to dense mixed community on rubble was a relatively extensive habitat in the back reef area south of Rocky Point. However, because of its very shallow nature (< 0.5m) and the general inaccessibility of this area no CCC surveys were conducted. The area was examined by CCC's project scientist who found a substratum almost completely dominated by rubble. The habitat was classified as a medium to dense mixed community because of the abundance of the blades of the seagrass *Thalassia testudinum* which were growing between the pieces of rubble. The algae *Cladophora* spp. and the coral *Porites porites* were also present. There were very few fish but a number of bonefish (*Albula vulpes*) were sighted.

5.4.13 Sand with patches of bedrock

The sand with patches of bedrock habitat, one of the two major habitat types in the lagoon on the west side of Ambergris Cay, was shallow (< 5m) consisting of a sand/silt substratum with occasional patches of bedrock. It appeared that there was bedrock underlying the sand/silt as a limited number of samples showed the sediment to be only 15cm deep in some places. The sand/silt appeared to support only an algal crust (verification to the identity is being sought from the NHM). The only species supported by the bedrock was the algae *Batophora* sp. or *Dasycladus* sp. (median abundance 2.0) and a bivalve. (Expert identification of this species is presently taking place at the NHM). A limited amount of the seagrass *Thalassia testudinum* was found close to the shoreline.

5.4.14 Sand with sparse mixed algae

The sand with sparse mixed algae habitat, represented by only one polygon on the habitat map (Map 3), surrounded the patch reefs in the northern back reef area. The habitat was of plain sand with some limited algae, mainly *Penicillus* spp. (median abundances between 0.8 and 1.0) and also some *Halimeda* spp., *Sargassum* spp. and *Thalassia testudinum*. The only coral found was *Pseudoplexaura* spp. (median abundance 0.3) and only one goby was recorded.

5.4.15. Sand with algae and gorgonians

Three polygons on the reef represent the sand with algae and gorgonians habitat (Map 3): (1) the sand bed lying between the two drop-offs in the northern section of the reef (Figure 9); (2) the sand channel separating the spurs and grooves from the gorgonian plain and (3) the small polygon within the gorgonian plain opposite the CCC base camp. The three areas varied in topographic nature but all support a similar, limited fauna and flora on a sand dominated substratum (median abundance 4.4). Area (1) was deep (over 20m) and over 150m wide. Area (2) was only a few metres wide and usually found at approximately 10m. Finally, area (3) was 80m wide and relatively shallow (< 5m). Area (3) was, unusually, preceeded by a "false" reef crest consisting of rubble and sand and supporting typical reef crest species such as the algae *Padina* spp., the coral *Diploria clivosa* and *Millepora alcicornis*.

The sand substratum supported a series of algae, dominated by *Halimeda tuna* (median abundance 1.8). However, *Dictyota* spp., an unidentified gelatinous red algae (to be identified by NHM), *Halimeda discoidea* and *H. incrassata* were also recorded (median abundance > 0.3). There was very limited coral growth although *Pseudopterogorgia* spp. and *Pseudoplexaura* spp. were found (median abundance 1 and 0.6 respectively). The only hard corals encountered regularly were *Siderastrea siderea* and *Dichocoenia stokesii* (median abundance 0.6 and 0.3 respectively). The fish community was sparse and limited to a few individuals around the dead and live coral heads. The commonest species seen were the damselfish *Stegastes partitus*, the angelfish *Pomacanthus arcuatus*, the wrasse *Thalassoma bifasciatum* and the triggerfish *Balistes vetula*.

5.4.16 Coral knoll

In the sand bed between the two drop-offs in the northern section of the reef, CCC surveyed a small coral knoll on transect R3 (Map 2). This unusual feature, approximately 5m high and 30m across the base, supported a greater fauna and flora than the surrounding sand. The knoll itself was constructed from a combination of bedrock and dead coral.

The benthic community on the knoll was diverse, with the dominant algae being *Halimeda incrassata*, *H. tuna* and *Udotea* spp. (abundances of 4, 3 and 4 respectively). The dominant corals were *Montastrea annularis* and *M. cavernosa* (abundances of 4 and 3 respectively), *Siderastrea siderea*, *Agaricia agaricites*, *Colpophyllia natans*, *Porites astreoides*, the soft corals *Pseudopterogorgia* spp. and *Pseudoplexaura* spp. were also found (abundance of 2). No sponges were recorded. The fish community was diverse, abundant and dominated by shoals of grunts *Haemulon* spp., the snapper *Ocyurus chrysurus*, the chromid *Chromis cyanea*, parrotfish (*Scarus* spp.) and the wrasse *Thalassoma bifasciatum* and *Halichoeres garnoti*.

5.4.17 Hard bottom with sand and sparse coral heads

Just one habitat in the back reef area north of Rocky Point, surrounding the large diffuse patch reef represented the hard bottom with sand and sparse coral heads habitat. It appeared to be a normal sand bed, however, the sand was very shallow in depth and underlaid with bedrock. Upon this substratum were patches of live and dead hard coral. There were numerous soft corals, particularly *Pseudoplexaura* spp. and *Gorgonia ventalina* (median abundances 2.5). The most common hard corals were *Montastrea annularis*, *M. cavernosa*, *Agaricia tenuifolia*, *Acropora palmata*, *Favia fragum*, *Siderastrea radians*, *Porites astreoides*

and *Diploria strigosa* (median abundances > 0.9). The algae were sparse with *Halimeda tuna* being the most abundant (median abundance 2.0). The coral heads also supported an abundant fish community, with the wrasse *Thalassoma bifasciatum*, the damselfish *Stegastes partitus* and the surgeonfish *Acanthurus coeruleus* all recorded with a median abundance of 3.0. Other common fish were the parrotfish *Sparisoma viride*, the damselfish *Abudefduf saxatilis* and the grunt *Haemulon flavolineatum* (median abundance 2.5).

5.4.18 Hard bottom with mixed corals, sponges and algae

The Hard bottom with mixed corals, sponges and algae habitat represented by one polygon inside the main cut in the reef opposite the site of the CCC base camp was contiguous with the gorgonian plain (Map 3). It consisted of a bedrock base (median abundance 4.0) with sand patches which varied in size (median abundance 2.0). The sand became gradually more dominant until the hard bottom merged into the seagrass beds typical of much of the back reef zone.

The flora was dominated by *Dictyota* spp. (median abundance 3.0) with the gelatinous red algae (unidentified) and *Halimeda tuna* also common (median abundance 2.5). Soft corals were common, with *Pseudoplexaura* spp., *Pseudopterogorgia* spp. and *Gorgonia ventalina* all found with median abundances > 2.4. The most abundant coral was *Siderastrea siderea* (median abundance 2.5), *Diploria strigosa*, *D. clivosa*, *Agaricia tenuifolia*, *Porites astreoides* and *Dichocoenia stokesii* were also common (median abundances > 1.4). The fire coral *Millepora alcicornis* and encrusting sponges were common (median abundances 2.5 and 1.5 respectively). The most abundant fish species were the wrasse *Thalassoma bifasciatum* (median abundance 2.5), the grunts *Haemulon flavolineatum* and *H. sciurus* and the surgeonfish *Acanthurus coeruleus* (median abundances of 2.0).

5.4.19 Artificial reef

An "artificial reef" was known to exist close to San Juan on the western side of Ambergris Cay (represented by the transect AR1 on Map 2). The reef was constructed from numerous stone blocks and a few large tree branches, located at a depth of 0.5m to 1.5m and ran continuously for approximately 150m. There was no coral growth on the blocks but there were some small tube sponges present. There was a considerable amount of *Batophora* or *Dasycladus* (species to be confirmed by NHM; abundance of 4) and a small amount of *Acetabularia* spp. and *Syringodium filiforme* near the shore. In contrast the fish life was very abundant in between and around all of the blocks. The most common species were the commercially important grunts, particularly *Haemulon sciurus* and snappers, *Lutjanus griseus* and *L. apodus* (abundances of 4, 3 and 2 respectively). Other common species included the surgeonfish *Acanthurus* spp. and the damselfish *Abudefduf saxatilis*.

5.4.20 Coral drop-off

CCC conducted a series of surveys both along and up the two coral drop-offs found surrounding the sand bed in the northern section of the reef (Figure 10). Both of the drop-offs were comparable, although the western one was steeper and higher than the eastern and possessed more diverse flora and fauna. The drop offs were formed from a combination of dead coral and bedrock (median abundance 2.5 and 1.8 respectively). At its highest point, the western coral drop-off rose from beyond 30m up to 7m (Map 2, transect R1). Owing to their topographic nature, neither of the coral drop-offs could be represented by a polygon on

Map 3.

The coral drop-offs supported a rich diversity of species, with the most characteristic algae being *Halimeda tuna*, *H. discoidea*, *H. copiosa*, *H. goreau*, *Dictyota* spp. and *Lobophora variegata* (median abundance > 1.4). The soft corals *Pseudoplexaura* spp. and *Pseudopterogorgia* spp. were abundant (median abundances of 2.0 and 1.2 respectively). There was a high diversity of hard corals with the dominant species being *Montastrea annularis*, *M. cavernosa*, *Agaricia tenuifolia*, *A. lamarcki*, *Porites astreoides*, *Siderastrea siderea* and *Colpophyllia natans* (median abundances > 0.9). Furthermore, because the drop-offs often reached within a few metres of the surface some stands of *Acropora palmata* were found (median abundance 1.0). The most characteristic fish species of this habitat were the wrasse *Thalassoma bifasciatum*, the chromid *Chromis cyanea*, the surgeonfish *Acanthurus* spp. and the snapper *Ocyurus chrysurus* (median abundances > 1.9). There were also numerous damselfish (*Stegastes* and *Microspathodon* spp.) and fairy basslets (*Gramma loreto*) around the coral heads (median abundances > 1.4).

Although the coral drop-offs were steep, on one transect (Map 2, R3), the western drop-off was interrupted by a sandy plateau. This plateau was approximately 30m wide and at a depth of approximately 12m. The substratum was dominated by sand (abundance 4) but there was also a significant amount of dead coral and rubble. The benthic community of the plateau was abundant, though not diverse, represented in particular by the algae species *Halimeda* spp., the unidentified gelatinous red algae and *Padina* spp.. The dead corals supported a limited community of hard corals, the most common being *Colpophyllia natans*, *Diploria strigosa*, *Agaricia agaricites* forma *danai* and *Siderastrea siderea*. An abundant fish community existed with fish both associated with the coral heads and numerous open water fish. The most abundant species were the surgeonfish *Acanthurus coeruleus*, the damselfish *Stegastes partitus* and *Abudefduf saxatilis* and the wrasse *Thalassoma bifasciatum* (abundances 3).

5.4.21 Sand drop-off

A sand drop-off was encountered once, at the point where the two coral drop-offs joined at the southern apex of the central sand bed in the northern section of the reef (Map 2, R6). The sand drop-off was 10m high and consisted of a mainly sandy substratum (abundance 3) with some rubble and dead coral. The benthic community was sparse. The most abundant species were the soft corals *Pseudopterogorgia* spp. and *Gorgonia ventalina* (abundance 2). The abundant algae was *Dictyota* spp., *Halimeda tuna*, *H. discoidea* and *Sargassum* spp. were also present. The only hard corals recorded were *Diploria strigosa* and *Dichocoenia stokesii*, and the fire coral *Millepora alcicornis*. The commonest fish species was the wrasse *Halichoeres garnoti* (abundance 2), with the surgeonfish *Acanthurus* spp., the wrasse *Thalassoma bifasciatum*, the parrotfish *Sparisoma* spp. and the grouper *Epinephelus fulvus* also recorded.

5.4.22 Reef crest

The reef crest marked the western extent of the reef and was the most obvious feature of the reef, delineated by breaking waves. The waves, caused by the shallow depth of the reef crest dissipates much of the sea's wave energy (Alevizon *et al.*, 1985). This rendered the reef crest very difficult to survey, hence only nine surveys were conducted during calm weather. The substratum encountered typically consisted of bedrock and dead coral (median abundances

2.3 and 2.0 respectively) with some sand. However, within the proposed Bacalar Chico reserve area there were two unusual sections of the reef crest. The most obvious of these was located at Rocky Point where the reef crest reached the shoreline and thus did not have a fauna similar to other areas. The other section, opposite Robles Point had similar benthos but the reef crest was constructed from large amounts of stacked rubble and large blocks of bedrock which broke the surface of the water.

The high wave energy of the reef crest is an important abiotic factor determining the species present in this habitat (Alevizon *et al.*, 1985). Most of the coral species recorded were relatively hardy or fast growing. The most characteristic species representative of this habitat were the fire corals *Millepora alcicornis* and *M. complanata* (median abundance 2.8). The commonest hard coral species present were *Diploria clivosa*, *Siderastrea siderea* and *Dichocoenia stokesii* (median abundance > 0.9). *Acropora palmata*, commonly associated with shallow reef crest environments (Humann, 1993), was found with a median abundance of 0.8. Algal growth was abundant, with *Turbinaria* spp., *Dictyota* spp., *Halimeda tuna*, *Padina* spp. and *Sargassum* spp. particularly characteristic (median abundances > 0.9). Soft corals were also abundant with *Pseudoplexaura* spp. and *Gorgonia ventalina* having median abundances of greater than 1.9. *Gorgonia ventalina* was particularly abundant in the small section of reef adjoining Rocky Point (median abundance 4.0). The sponge most typical of the reef crest was the encrusting lifeform (median abundance 1.0). The fish community was relatively limited, only the surgeonfish *Acanthurus coeruleus* and *A. chirurgus*, the wrasse *Thalassoma bifasciatum*, the damselfish *Stegastes partitus* and blennys had median abundances of greater than 0.9.

Along the length of the reef crest there were found a number of cuts or breaks which are important for both water movement and for boat access. The benthos within these cuts was transitional between the gorgonian plain and the back reef habitats. However, on one transect (Map 2, R15) CCC surveyed a sandy patch within the cut which was almost an entirely plain sand substratum (median abundance 4.0) with no coral species. There was some algal growth, particularly *Udotea flabellum* and *Halimeda tuna* (median abundance 1.0) and few fish were present. The most common fish was the surgeonfish *Acanthurus coeruleus* (median abundance 1.0).

5.3.23 Sand

The sand habitat was the second major habitat in the lagoon on the western side of Ambergris Cay. The habitat consists of a plain sand bed of low topographic complexity at a depth of less than 5m. No CCC surveys were carried out in this habitat type because of the extremely poor fauna and flora. A limited examination by CCC science staff found no evidence of macroalgae, marine plants or coral growth. The only lifeform appeared to be a crusty algae (pending definitive identification by NHM).

5.5 Commercially and ecologically important findings

During the survey work a number of species sightings represented important, discrete factors to be incorporated into the resulting management recommendations. These sightings included rare or previously unrecorded species for Belize, data regarding the commercially important *Strombus gigas* (Queen conch) and *Panulirus argus* (Caribbean spiny lobster), unusual

morphotypes and high phenotypic diversity.

5.5.1 Previously unrecorded species

The most interesting finding of the CCC survey work was numerous sightings of the coral *Porites branneri* (blue crust coral). The scientific literature shows that this coral has not been recorded in Belize (Cairns, 1982). This species has also not been recorded by CCC at any of the other sites throughout Belize where surveys have been conducted. Numerous colonies of *P. branneri* were found on the northern patch reefs, the distinct patch reef close to Rocky point (known as Banana reef owing to its shape) and the diffuse patch reefs situated behind the reef crest. With permission from the Fisheries Department a sample of *P. branneri* was collected for the coral collection at the UCB.

Furthermore, three fish species previously unrecorded by CCC were also sighted in the Bacalar Chico Marine Reserve. These were *Chaenopsis ocellata* (bluethroat pikeblenny), *Xanthichthys ringens* (Sargassum triggerfish) and *Enchelycore carychroa* (chestnut moray).

5.5.2 Commercially important species

Commercial fishing effort within Belize concentrates particularly on *Strombus gigas* (Queen conch) and *Panulirus argus* (Caribbean spiny lobster). Therefore, data on these two species are particularly important for management.

HABITAT	NO. OF SURVEYS	<i>Panulirus argus</i>			<i>Strombus gigas</i>			
		NO. OF RECORDS	ABUNDANCE RATING		NO. OF RECORDS	ABUNDANCE RATING		
			1	2		1	2	3
Coral drop-off	8	1	1	-	-	-	1	-
Coral knoll	1	-	-	-	1	3	-	-
Diffuse patch reef	10	-	-	-	3	3	-	-
Gorgonian plain	60	3	3	-	7	6	-	1
Medium to dense seagrass	40	1	1	-	19	18	1	-
Reef crest	9	1	1	-	-	-	-	-
Sand with sparse mixed algae	3	-	-	-	2	2	-	-
Sand and sparse coral heads	2	-	-	-	1	1	-	-
Sand with algae and gorgonians	11	-	-	-	2	1	-	1
Seagrass with distinct coral heads	8	-	-	-	3	3	-	-
Shallow seagrass	6	-	-	-	1	1	-	-
Sparse seagrass	15	-	-	-	5	4	1	-
Spurs and grooves	98	8	7	1	1	1	-	-

Table 5. A summary of the sightings of *Strombus gigas* (Queen conch) and *Panulirus argus* (Caribbean spiny lobster) in the Bacalar Chico Marine Reserve. Abundance rating refers to the ordinal scale (0-5) used during CCC surveys, where 1 = 1-5, 2 = 6-20 and 3 = 21-50 individuals sighted.

Table 5 shows that the spurs and grooves are particularly important for *P. argus*, since within this habitat (representing 32.3% of the total data collected) there were 57.1% of the sightings. In contrast, the medium to dense seagrass habitat (13.2% of the total data) was the location for 42.2% of the sightings for *S. gigas*. However, the most abundant concentrations of *S. gigas* (abundances of 3) were within the gorgonian plain just north of Rocky Point (Map 2, transect R35) and in the sand with algae and gorgonians habitat between the two drop-offs (Map 2, transect R2).

In addition to *P. argus* and *S. gigas* the other commercially important species seen included numerous species of snappers, grunts, groupers and jacks (Appendix 2). Estimations of fin fish populations were inappropriate through the surveying technique utilised. CCC also found colonies of the black coral *Antipathes* spp., which is threatened through harvesting, within the spur and groove habitat. The bonefish *Albula vulpes*, popular with sport fishermen, was recorded in the back reef close to Robles Point.

5.5.3 Phenotypic variation

The intra-specific colour variation within corals of the genus *Agaricia* is reported throughout Belize (Fenner, pers. com.) and was conspicuous in the Bacalar Chico area. This phenotypic and possibly genetic diversity of *Agaricia* serves as an important rationale for protection. Survey work also recorded an unusual white-spotted phenotype of the chub *Kyphosus sectatrix*.

6. MAPS PRODUCED FROM SATELLITE DATA

6.1 Analyses of satellite habitat map

A 1994 Landsat TM image of Ambergris Cay was obtained from the Belize Land Information Centre (LIC), Department of Natural Resources, GOB. The image was cut to correspond to the area of the Bacalar Chico reserve. The different spectral bands utilised by the satellite to produce the image were separated for analyses. Radiometric correction was performed using established data algorithms and the image was geo-referenced using control points from the original Bacalar Chico basemap.

Prior to classification, the image was separated into three regions, the western lagoon, the back reef and eastern lagoon and the forereef. This minimized the error caused by the varying water depth over the area that the image represented. Each of the three regions were classified using a combination of spectral image bands corresponding in their water penetration capabilities to the general depth in the area. The shallow western lagoon area was classified using a combination of blue, green and red spectral bands along with a texture pseudochannel. The backreef and eastern lagoon were classified similarly, but without the aid of the red band. The deeper forereef area presented a problem because of the limited depth penetration of all but the blue band of the spectrum. The use of texture was not feasible because of the depth of the water and the level of background noise from wave action. Rather than use the blue band alone, two pseudochannels were derived to aid the classification. These were the first principal component of the blue and green bands and the logarithmically transformed radiances of the blue band.

6.2 The satellite habitat map

Zonation in the forereef area is strongly dependent on depth and this is reflected in the resulting satellite classification (Figure 12) which distinguished between the habitat classes spur and groove, sand and gorgonian plain. Through the satellite imagery, reliable depth penetration was accomplished to 30 metres, with the line of the reef at this depth being more distinct than it was on the aerial photographs. Therefore, the satellite image provided the additional information required on some features not easily distinguishable from the aerial photographs.

The work with satellite images established a comparative method for habitat mapping. Although the resolution of aerial photographs is greater, providing better accuracy for small scale mapping, the classification of satellite images is faster and delineates most of the habitats seen on the aerial photographs. Satellite data combines several image bands to create signatures for classification and the signatures themselves provide a way to quantify the reflectance values of each bottom type. Furthermore, the satellite images also provide a basis for future monitoring, such as for habitat change detection.

6.3 Analyses of satellite bathymetric map

A map of estimated bathymetry was produced using a single band algorithm. This algorithm (from Stoffle and Halmo, 1991) transformed the observed Landsat TM blue band radiances logarithmically into a linear index of water depth independent of bottom type. The results

were then calibrated to known depth points to produce the actual map. For the purposes of this algorithm, the water attenuation coefficient was assumed to be constant, and the signal owing to scattering was removed. The algorithm used was:

$$Z = -1/2k \ln(V-VS) + 1/2k(\ln VO)$$

where Z = depth
V = observed radiance
VS = signal due to scattering
k = water attenuation coefficient
VO = sensitivity factor

The map produced (Figure 13) should only be used as an indication of water depth, not as an absolute representation. Both the bathymetric map and the satellite habitat map were groundtruthed and corrections made where necessary.

6.4 Application of the satellite data

The satellite images presently available can be used in conjunction with aerial photography and groundtruthing to give managers a good representation of the extent and status of the natural resources. Successive images obtained of the area can display the status of resources over time and can be assimilated into the management process hence providing dynamism which is crucial for effective management of resources. As technology advances, satellite imagery is becoming more accurate and accessible and will therefore increase in importance as an effective management tool for the Bacalar Chico National Park and Marine Reserve.

Figure 12. Preliminary classification of the marine habitats of the proposed Bacalar Chico Marine Reserve from a Landsat TM image.

Preliminary Bacalar Chico marine classification

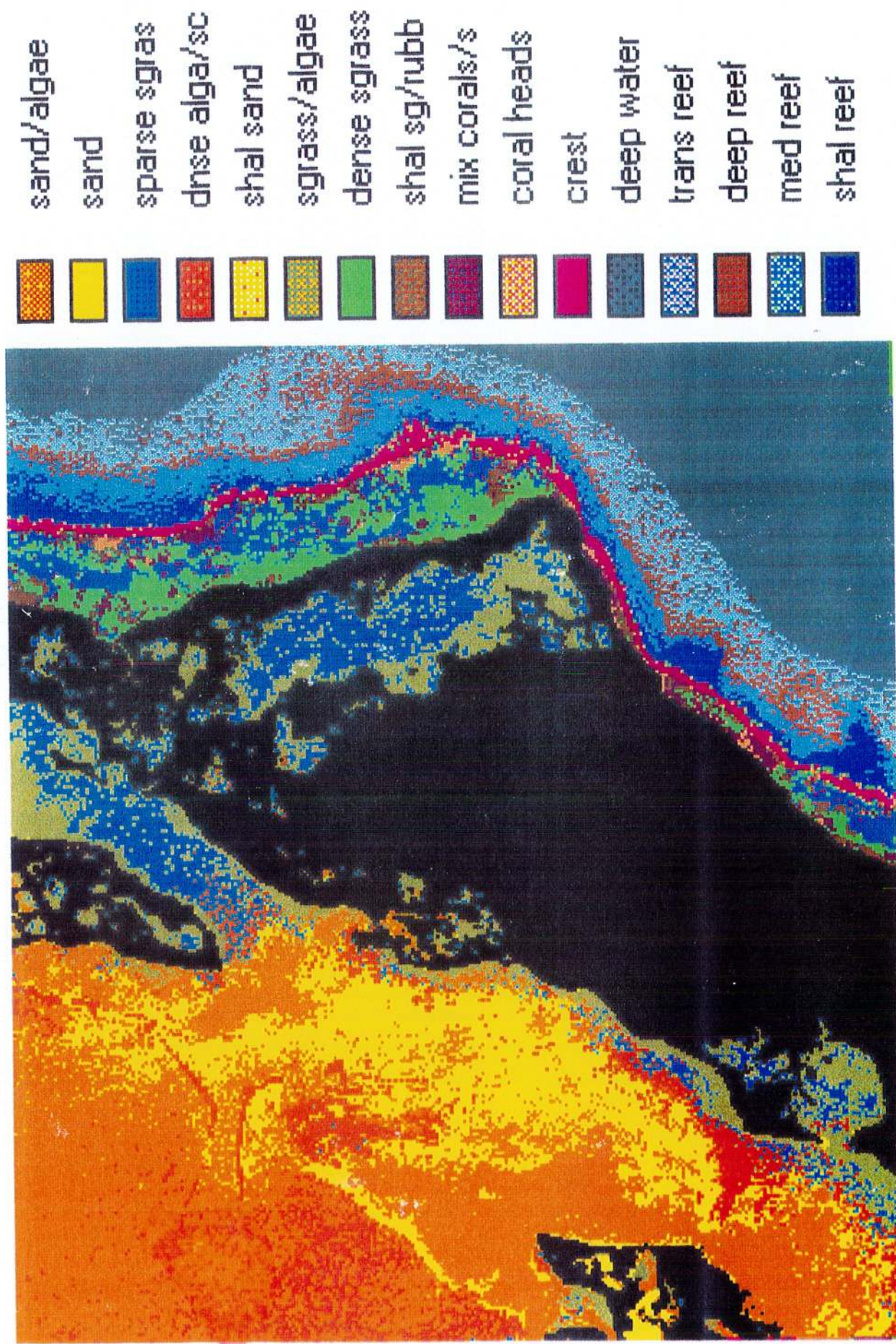
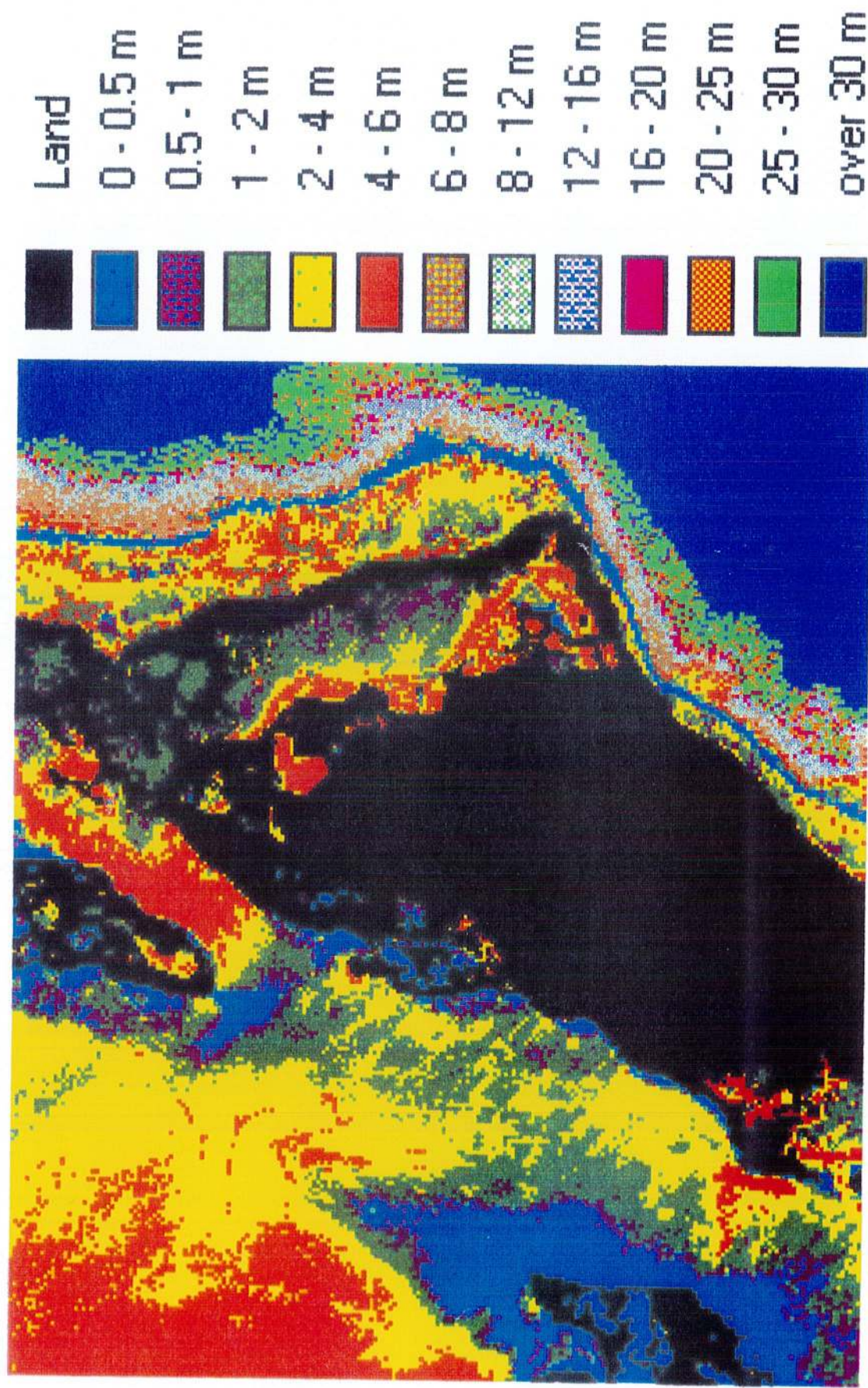


Figure 13. Estimated bathymetry of the proposed Bacalar Chico Marine Reserve from a Landsat TM image.

Bacalar Chico estimated bathymetry



Meters



5,000.00



7. RECOMMENDATIONS AND ZONING PLAN FOR THE MANAGEMENT OF THE BACALAR CHICO NATIONAL PARK AND MARINE RESERVE

The following recommendations are extensions of the preliminary findings which were presented to the CZMP in December 1995. These findings were supplied for incorporation into the initial management planning and draft zoning scheme for the proposed Bacalar Chico National Park and Marine Reserve. The recommendations presented here summarise the preliminary findings and further details resulting from the final data analyses. The aim is for these recommendations to be incorporated into the final zoning plan presented to the local communities.

7.1 Zoning recommendations

The Bacalar Chico area has some outstanding features and an abundance of life in an area which is valued by many people who utilise or visit it. A zoning scheme was designed to present clearly the information relating to the management of the area for the sustainable benefit of both the reef, its inhabitants and the human users (Table 6). The scheme shows users of the reserve where certain activities can take place with minimal impact on the reef environment and on each other. It was also designed to be dynamic to take account of future changes which may occur. Each zone designated in Table 6 is related on a scale of restrictions with 'General Use' being the least restrictive.

ACTIVITY	GENERAL USE	RECREATIONAL	REFUGE	SANCTUARY
RECREATIONAL				
DIVING	Yes	Yes	Yes	No
SNORKELLING	Yes	Yes	Yes	No
SPEARFISHING	No	No	No	No
CANOEING	Yes	Yes	Yes	No
SPORT FISHING	Yes	Yes	No	No
BOATING	Yes	Yes	Yes	Yes
COMMERCIAL				
CONCH/LOBSTER	Yes	Yes	No	No
FISH TRAPS	Yes	No	No	No
TRAWLING	Yes	No	No	No
NETTING	Yes	Yes	No	No
COLLECTING				
GROUP EDUCATION	Permit	Permit	Permit	No
SCIENTIFIC RESEARCH	Permit	Permit	Permit	Permit

Table 6. The proposed zoning scheme for the Bacalar Chico Marine Reserve and National Park along with suggested restrictions for activities within each zone.

7.1.1 Rationale for zoning

To support the above zoning scheme the following recommendations detail the reasoning behind the scheme based on the physical and biological data collected and analysed by CCC.

(Please refer to the zoning map - Map 4):

1. No fishing zones should be placed at the boundaries of the reserve to stop illegal fishing, particularly at the northern border with Mexico. Secondly these zones clearly define the perimeter of the reserve. Refuge zones both north and south have been recommended extending over both the reef and back reef. The southern boundary of the northern zone is positioned to incorporate all the double reef crest area. The northern boundary of the southern zone utilises the obvious geographical feature of Robles Point which should help visitor and fisherman orientation.
2. The northern refuge zone also protects the northern patch reefs from fishing. These patch reefs provide excellent snorkelling, encounters with unusual fish, good populations of *Porites branneri* and unusually large heads of *Porites* sp..
3. Within the boundary refuge zones a sanctuary zone is recommended. This allows the sanctuary to be buffered on both sides and acts to protect examples of the different reef profiles and habitats in this area. The northern sanctuary includes spur and groove and gorgonian plain habitats and the double reef crest (including the central sand channel with conch populations). The southern sanctuary encompasses spur and groove, the sandy channel and the sand and coral matrix.
4. A sanctuary zone should be designated in the back reef south of Rocky Point to protect the turtle nesting beaches.
5. In response to a request from the Fisheries Department for a monitoring control area, a sanctuary zone has been placed across half of the patch reef just north of Rocky Point (known as 'Banana Reef'; transect BR0 on Map 2). The seaward side was chosen since it has healthy stands of *Acropora palmata*, is not suitable for snorkelling because of its proximity to the reef crest and allows greater buffering by the surrounding refuge zone. The rest of Banana Reef lies within a refuge zone which gives this excellent snorkelling area protection from fishing. The refuge zone also incorporates the diffuse patch reef slightly further north. This diffuse patch reef is not ideal for snorkelling because it is very shallow but it has a number of *Porites branneri* and *A. palmata* colonies.
6. A refuge zone has been placed around Rocky Point because of the conch population and unusual reef profile. It was decided not to use a sanctuary zone because of the attraction of the area (where the reef meets the mainland). A refuge zone should offer sufficient protection to the area, including the deep slope which is reportedly a grouper spawning area. The northern extent of this zone is positioned just north of Rocky point along transect R34 (see Map 2) which marks the transition between normal spur and groove and the gorgonian plain. The southern boundary marks the transition back to spurs and grooves from the gorgonian plain around Rocky Point.

7. The rest of the reef has been designated as a recreational zone allowing a range of commercial and recreational activities.

8. A refuge zone has been placed just inside the reef crest opposite the site of CCC's base camp to protect the unusual hard bottom and sparse rubble habitats. The hard bottom habitat especially has abundant fish populations and offers an interesting, shallow dive in very calm conditions.

9. The remaining back reef has been designated as a general use zone.

10. In the lagoon, the interesting artificial reef has been placed in a refuge zone to protect it from fishing and then buffered by a recreational zone. This recreational zone will also allow control of the area around the proposed San Juan ranger station.

11. The major "sand with patches of bedrock" polygon has been designated nominally as a special management area until the importance of the mollusc populations has been investigated further.

12. Access to the Laguna de Cantena and Chetumal Bay through the Boca Bacalar Chico has been designated a special management area with a no wake policy. Boat operators need to be aware and adhere to no wake zones within the mangrove channels. There are a number of species which use the mangrove roots at the edges of the channels for shelter and nurseries, as well as delicate species which attach to the roots, some of which have yet to be scientifically identified. These channels have also been identified as important for sport fishing.

13. The remaining lagoon has been designated as a general use zone.

14. Information needs to be gathered with respect to possible areas within the wildlife sanctuary which are used by migrating species. This is biologically important and also of interest to specific groups of tourists who congregate to identify the migratory species.

15. Monitoring sites were not set up within the marine reserve as the national monitoring guidelines have not yet been published. The zoning plan, however, can be used to locate these sites in the future. The sanctuary zones have restricted access and can act as the control site while adjoining zones with the same habitat can be monitored and compared to the control. It is recommended that the monitoring sites be located in the spur and groove and gorgonian plain habitats within these designated sanctuary zones.

7.2 Socioeconomic recommendations

1. Any development needs to address the problem of lack of freshwater supplies. Waste water could affect the limited freshwater supplies which are thought to be an oasis for many creatures within the area.

2. Any dredging which is to be undertaken needs to be reviewed with specific attention being paid to impact assessment on the marine resources and the archaeological resources which may be affected. Archaeological excavation of sites can precede any dredging hence

combining the requirements of the different parties.

3. The beach front areas, particularly those near mangrove stands needs to plan for stabilisation to counter erosion and sedimentation on to the reef and important patch reef areas.

4. Areas need to be identified where sport fishing can be conducted and protected from commercial fishing pressures. This will not only keep the fish stocks at relatively constant levels but will also bring in separate revenue. Fishermen are more likely to pay if they know the fishing grounds are good and protected. The fishermen can also get involved in a countrywide tag and release programme which can gather data on fisheries with application to management.

5. Catches of fish through spearfishing should be controlled especially as the large groupers and snappers are reducing in numbers according to the local fishermen. A limited number of permits for this method of fishing should be issued and a total ban on SCUBA spearfishing should be strictly enforced.

6. In order to protect the reefs of Bacalar Chico from anchor damage, moorings buoys should be placed within the recreational and refuge zones.

7. Any diving activity around overhangs, swim throughs and caves needs to be regulated in order to minimise bubble damage to species particularly the ahermatypic corals which inhabit these shaded areas. The divers also need to be made aware of the damage that can occur through their actions.

8. A special development plan needs to be adopted for the eastern coast. This has already begun through the Ambergris Cay Development Plan. This plan, however, needs to take account of the recommendations of the Bacalar Chico National Park and Marine Reserve management plan.

9. Depending on the general attitudes towards the level of protection afforded to the marine reserve as a whole it may be deemed necessary to select a general use zone on the reef itself.

7.3 Future management

It is likely that other activities will need to be added to the zoning plan in future. The zoning plan was designed to be dynamic, however, any further restrictions which are to be designated must be outlined clearly and concisely.

In the future, coastal zone management studies should investigate techniques which assess the recoverability of an area: fast growing corals or colonisers should be identified and related to the area in question. If there are areas of this nature then user activity can be allowed owing to the potential the site has for relatively rapid recovery.

This approach has been suggested by Done (1995) who presents a rationale for assigning a biodiversity value to a site and outlines criteria which could be used for making zoning judgements based on the value. After the appropriate data has been collected the Reserve

managers can balance the values and what it would mean to lose certain areas, sites or species. As an example from the Bacalar Chico data, the twin reef crest is a unique feature which is possibly a relic of past sea levels. This feature is not known in many areas and would not occur very often through time, if it were lost it would take millenia to reappear, if at all. Thus, a high value would be placed on the double reef crest for its protection in perpetuity.

8. TRAINING

Throughout the project a total of 48 Belizeans were trained through the annual Fisheries Department/CCC Scholarship programme. Any Belizean national who has an interest in learning about and protecting his/her marine environment can apply for a scholarship which is funded by the CCC Trust Fund. If the equipment being used was purchased through EC funds then each participant was notified (Appendix 3). Following training in swimming and SCUBA (to PADI approved standards) the scholars then joined the CCC volunteers in one of the tropical marine ecology, identification and surveying courses held at Calabash Cay, Turneffe Atoll. This initiative has increased the in-country expertise and has also allowed Belizeans to take part in the data gathering process. Two of these scholars took part in the Bacalar Chico surveying work.

The two biologists and three rangers who were employed by the ITCF as part of the EC grant were trained by CCC in a number of skills detailed in Table 7.

	Marine ID and Surveying	PADI Open Water	PADI Advanced Open Water	PADI Medic 1st Aid	Boat Handler	Outboard Maintenance
Marine Biologist	x	x	x	x	x	x
Terrestrial Biologist	x	x	-	-	x	x
Ranger 1	x	x	x	x	x	x
Ranger 2	x	x	x	x	x	x
Ranger 3	x	x	x	-	x	x

Table 7. The courses taught to the Bacalar Chico Marine Reserve and Wildlife Sanctuary staff whilst training at the Marine Research Centre facility on Calabash Cay, Turneffe and at Bacalar Chico.

9. EDUCATION

9.1 Environmental education course

A course entitled 'Marine Environmental Conservation' was designed, taught and examined by Dr Andrew Gill at the UCB, over a two week period during summer 1994. A total of 20 students participated and received SCUBA training as part of this course. The students went on to establish the UCB Sub-Aqua Club, the first of its kind in Belize. This club will encourage interest in diving and the coastal marine environment and promote marine conservation throughout Belize.

9.2 Coral collection

A 30 year old collection of coral skeletons belonging to Father Diekman of St John's College,

Belize City was identified as being possibly the second largest collection of Caribbean species in the world by CCC Scientific Staff. Some of this collection was on display at the college but many other examples were stored away in boxes. Father Diekman has since allowed the collection to be displayed on campus at the UCB where Dr Doug Fenner labelled the specimens. Following training through the CCC programme two UCB students were able to continue the sorting and labelling of the specimens. Father Diekman has since been taken to the Marine Research Centre on Calabash Cay, Turneffe Atoll, to see live specimens of corals in their natural habitat.

9.3 Environmental educator

The initial budget specified no Belizean posts for educators and provided only for a five month contract for a European specialist. Education is high on the agenda of the Belizean Government and it became apparent that the EC funds could be applied more appropriately by employing a Belizean Environmental Educator.

It was subsequently recognised that the Belize Audubon Society (BAS), an established NGO, had an existing Coastal Zone Management Educator whose responsibilities coincided with those required of CCC under the terms of the EC contract. BAS were looking to improve and expand upon its involvement in environmental education nationally. As a result CCC entered into an agreement with BAS to sub-contract the Environmental Education aspect of the EC contract and therefore to make the best use of EC funds allocated for education purposes.

This sub-contract began on 1st July 1995 and will continue until 30th April 1996 to allow all the obligations to be fulfilled. One of the main objectives of the Environmental Education post was to distribute the 'Life on the Coral Reef' poster and activity cards as a focus for marine environment awareness amongst the Belizean population (Appendix 4).

9.4 Schedule of environmental education work

1995

- July** Organised the Corozal Environmental Conservation Carnival which involved the distribution of posters, colouring books, other education materials and costumes for environmental educational plays; Attended Youth Summer Environmental Workshop which aimed to train participants the relevant skills to teach environment studies to students within Belize City; Anti-litter youth campaign; presentation on marine and coastal zone ecology to Youth Camp; Regional Workshop on coral reef conservation and management.
- Aug** Sea and Air festival; Workshop entitled 'Integrating Environmental Education into the Classroom; Teacher training workshops relating to Marine ecosystems; Marine Training of Trainers Workshop; Corozal Community College presentation
- Sept** Preparations for Corozal Environmental Conservation Carnival (CECC); Presentations and workshops.
- Oct** Environment education Carnival at Tapir Mountain Nature Reserve; Editing of A-Z of Belizean Wildlife; assistance with two UK based education specialists; General

marine brochure preparation; Marine Research Centre workshop; Attendance at CECC

- Nov** Compilation of information relating to environmental education materials available in Belize; Environmental Education Strategy Coordination Workshop; State of the Coastal Zone Workshop; Continuation of CECC; attendance at international workshop 'Institutional Development for Biodiversity Management'.
- Dec** Distribution of coral reef poster and activity packs; CECC continued; Terms of reference for general marine brochure.

1996

- Jan** Finalised tender for general marine brochure; presentation at Ecotourism Workshop 'Wildlife Resource & Environmental Conservation in Belize'; Assisted in the launch of A-Z of Wildlife of Belize; Assisted with preparation of warden training session 'Presentation and Customer Service'; Continuation of Environmental Conservation Carnival; general meetings
- Feb** Mid-term report to CCC; Warden training presentation; finalisation of plans for mangrove workshop; Marine Life Training Workshop action planning for implementation in schools and at community level; Presentation to local communities at Tapir Mountain Nature Reserve; Presentations on 'Marine Ecosystems of Belize' and 'Environmental Advocacy'; Continuation of Environmental Conservation Carnival; follow-up session on Principles of Environmental Enforcement Workshop.
- Mar** Compile list of existing environmental education materials and produce final document; community outreach education programme; Investigation of current environmental issues affecting Belize; Assist with marine environmental education through Marine Research Centre; Report to CZMP for supplementary funds; coordinate development and production of materials relating to general marine brochure; Send questionnaire to recipients of 'Life on the Coral Reef' poster; Participation in public forums and consultation activities by CZMU.
- Apr** Meeting to review need for environmental education materials; Community outreach education programme; Investigation of current environmental issues; Assist with marine environmental education through Marine Research Centre; Production of general marine brochure and associated pamphlets relating to protected areas; Compilation and appraisal of questionnaire; Participation in public forums and consultation activities by CZMU; Writing and production of final report to CCC including financial statement and education recommendations.

The contracting out of the environmental education component of the Belize Coastal Zone Management Project proved to be the most efficient and effective use of the funds allocated. Through the existing Belize Audubon Society programme, education relating to the marine environment was incorporated to present a holistic view of the natural environments Belize possesses. To date 60 schools, 11539 students and 668 teachers have been received education material through the Environmental Educator. The response from those attending the presentations has been very supportive of the whole programme (Appendix 5).

10. PROJECT MANAGEMENT

10.1 Staffing

The original project coordinator Ms S. Wells was employed from May 1994 until December 1994 when she resigned her appointment. Dr Andrew Gill was appointed her successor on 1st January 1995. CCC funded an Assistant Project Coordinator.

The EC funds as per the interim report financing structure (Raines *et al.*, 1995) were allocated to appropriately qualified staff for the remainder of the project (see Appendix 6).

The Belizean SCUBA Instructor was relieved of his duties during August 1995 as he did not fulfil his contractual obligations.

CCC funded staff during the first ten months of the project were (percentage of time dedicated to EC project in parentheses): CCC Director (50%), Project Administrator (25%), Science Officer (100%); Technical Supervisor (25%); Belize Office Administrator (25%) and Belizean Expedition Leader (100%).

For the remainder of the project the CCC funded staff were: CCC Director (25%); Technical Supervisor (25%); Assistant Project Coordinator (50%).

10.2 Presentations

At the International Boundaries Research Unit third conference (April 1994), the Project Scientist presented a talk entitled 'The Bacalar Chico Reserve: A case study in Government and NGO collaboration in conservation projects'.

The Project Coordinator and the Project Scientist both attended the International Society of Coral Reef Studies Third European conference held at the University of Newcastle during September 1995. Alastair Harborne, the Project Scientist presented a paper entitled 'Refining a classification of marine habitats using discriminator and characteristic species' which was based on the Bacalar Chico data set.

The Project Coordinator and the Project Scientist will both attend the International Society for Coral Reef Studies conference to be held in Panama at the end of June 1996 where they will both present papers or posters based on the Bacalar Chico work.

A workshop held in Costa Rica entitled 'Institutional Development for Biodiversity Management' was attended by the Environmental Educator who presented a talk outlining the education work within Belize.

The Environmental Educator presented a paper entitled 'Environmental awareness at the Grassroots level' at the Second Symposium on the State of Belize's Environment held in Belize City, during October 1995.

CCC contributed to a workshop at the Royal Geographic Society entitled 'Digital mapping for Expeditions'. A talk presented a case study outlining the application of the digital

technology to CCC's expeditions including the example of Bacalar Chico.

CCC's scientific staff are to attend the Eight International Coral Reef Symposium, Panama during June 1996 where talks will be presented utilising information collected through the Bacalar Chico project.

10.3 Publicity

The Marine Research Centre, an education and research based collaborative project by UCB, GOB and CCC on Turneffe Atoll, was officially opened by Prime Minister Esquivel in September 1995 with the event covered on channel 5 of Belizean television.

There was a visit by BBC Breakfast time newsreporter Brian Barron who was featuring Belize over a number of days broadcast to a British television audience.

An article relating to the CCC's work in Belize was printed in the magazine Sport Diver, 1996.

11. PROJECT FINANCES

11.1 Bridging loan

To cover the spending incurred during the first phase of the project CCC decided to wave the first 10% offered by the EC in favour of a bridging loan which gave CCC the necessary finances for the implementation of the project. A loan of US\$49,400 was secured through negotiations with TNC, a Washington based NGO. This was paid back in full with 7% interest in May 1995.

11.2 Allocation of funds

The initial budget for the CCC component of the project covering May to December 1994 is shown in Appendix 6. The total cost for this first phase was ECU119,400 of which the EC funds contributed ECU38,501. The remaining funds for the project were ECU171,499. A revised budget (Appendix 6) was submitted and approved with the interim report.

11.3 Delay in funding

Although there was a delay in the release of EC funds at the appropriate time (March 1995) CCC completed the work within the originally set out timetable.

11.4 Cost of the project

11.4.1 Summary of total expenditure (ECU)

Please refer to Appendices 5 and 6 for details of expenditure.

	<i>ORIGINAL BUDGET</i>	EC (to Dec 94)	<i>REVISED BUDGET</i>	EC (to Apr 96)	CCC FUNDS	TOTAL COSTS
UNIT PRICE:						
1. Fees						
Project Coordinator	60000	18877	30720	28544		47421
CCC Director (50%)					23290	23290
UK Project Manager			13500	14670		14670
Project Scientist			17280	20310	5392	25702
Assistant Project Coordinator (50%)					8712	8712
Technical Supervisor (25%)					8006	8006
Training Instructor	30000		11760	10832		10832
SCUBA Instructor	20000		3000	2850		2850
UK Project Administrator (25%)					2867	2867
Bze Project Administrator			8800	8384	732	9116
Education Specialist	17000		14560	14560		14560
2. Management Costs	5125	3865	13000	13008	2091	18964
Sub-Total	132125	22742	112620	113158	51090	186990
COST PRICE:						
1. Purchase of Satellite Images	7500					
2. Aerial Photography	12000	7255				7255
3. Processing and Interpretation	10000		1000	1007		1007
4. Field Survey Work					44049	44049

5. 5 Sets SCUBA Materials	3125		7125	7125		7125
6. SCUBA Instructor Training			4507	4622		4622
7. Education and Training Materials	25000	408	24592	24593		25001
8. Travel (incl. Insurance)	8250	6037	9714	9689		15726
9. Reporting	2000	386	1614	1614		2000
10. Accommodation	10000	691	11309	11998	16513	29202
Sub-Total	77875	14777	59861	60648	60562	135987
ALL INCLUSIVE PRICE:						
Equipment Hire					10067	10067
Medical Supplies					2486	2486
Equipment purchase and repair/renewal					8120	8120
Supply Vessel Charter					1258	1258
Casual Labour					573	573
Sub-Total					22504	22504
TOTAL BUDGET	210000		172481			
TOTAL EXPENDITURE		37519		173806	134156	345481

Table 8. A summary of the budget set out for the project and the total expenditure relating to EC and CCC contributions.

11.2.1 At unit price

The total cost of wages relating to the project was ECU168026 (Table 8) of which the EC contributed ECU119027. A proportional amount of the time of CCC employees was also allocated to the project at a cost of ECU48999.

Owing to a surplus of funds allocated to the Fees heading, the wages for the Project Scientist were continued for until March 1996. This was crucial for the final analyses and interpretation of the field data. The accounts, shown in Appendix 7, are continued until the end of April 1996 as the initial expenditure was taken from 1st May 1994.

The remaining funds from the SCUBA Instructor were reallocated after approval by the EC to the SCUBA Instructor training and SCUBA Materials budget (see Appendix 7).

Management fees were split into an equal budget per month to cover office and management expenses.

11.4.2 At cost price

The total expenditure at cost price was ECU135987 (Table 8), representing a contribution of ECU75425 by the EC and ECU60562 by CCC.

The funds allocated under the heading Education/Training⁴ has been earmarked to fund the Marine Research Associate post at UCB which is a position concerned directly with education on a national and international level.

The replacement Belizean dive instructor trainee has still to undertake his course due to work commitments and securing a course placement at an appropriate time.

11.4.3 At all inclusive price

The All Inclusive Price costs were met through CCC contributions totalling ECU22504 (Table 8).

11.5 Education costs

As the funds for the Education component of the project were sub-contracted to the Belize Audubon Society, a separate summary of the education budget and accounting section is presented (Appendix 7). Full details of the use of this budget heading are to be submitted with a final report to CCC on 1st May 1996. This report will be sent on to the EC.

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Map 1

The DGPS ground control points collected for georectification of the basemap for the proposed Bacalar Chico Marine Reserve and National Park.

Map 2

The positions of CCC's 1994 and 1995 survey transects in the proposed Bacalar Chico Marine Reserve and National Park.

Processed Regular China National Daily & Marine Document

Map 3

The CCC habitat map for the proposed Bacalar Chico
Marine Reserve and National Park.

Map 4

A preliminary zoning plan for the proposed Bacalar Chico
Marine Reserve and National Park.

Appendix 1

The Memorandum of Understanding between the
Department of Fisheries, Government of Belize and Coral
Cay Conservation.

MEMORANDUM OF UNDERSTANDING
FOR COOPERATIVE RESEARCH IN THE
COASTAL ZONE MANAGEMENT PROGRAM
B E T W E E N
THE FISHERIES DEPARTMENT OF THE MINISTRY OF AGRICULTURE
A N D
CORAL CAY CONSERVATION LIMITED

W H E R E A S, the group CORAL CAY CONSERVATION LIMITED ("CCC") has agreed with THE FISHERIES DEPARTMENT OF THE MINISTRY OF AGRICULTURE to participate in the development of a Coastal Zone Management Plan under the Coastal Zone Management Program, A N D;

W H E R E A S, it is recognized that the Coastal Zone Management Unit (CZMU) of the Fisheries Department has the mandate to expand the Marine Protected system in Belize and to prepare an Integrated Coastal Action Plan, A N D;

W H E R E A S, the CZMU presently lacks the personnel and funds to carry out the planning process for all Marine Protected Areas, A N D;

W H E R E A S, the representative of Coral Cay Conservation Limited has participated in discussions and informally agreed to the leadership and administrative arrangements made by the Fisheries

Department including the establishment of the CZMU:

N O W T H E R E F O R E, the parties A G R E E to the following:

ARTICLE 1. Coral Cay Conservation Limited agrees to participate in the Coastal Zone Management Program; such cooperation includes but is not limited to:

- (a) Collection of physical and biological data in areas identified by the CZMU;
- (b) Assist in the preparation of management plans as requested by the CZMU;
- (c) Selection of technical assistance as is required to discharge its obligations;
- (d) Provision of technical assistance to the CZMU, specifically coral reef survey and monitoring, remote sensing, and water quality analysis;
- (e) Assist in the provision of education and training programmes as requested by the CZMU.

ARTICLE 2. Data and Reporting Policy:

- A. **RECOGNISING** that one of the main objectives of the CZMU is to assemble a body of data for the purpose of contributing to the better understanding of coastal ecosystems and productivity;
and

- B. **RECOGNISING** also, that for this purpose, the data gathered will be utilized by the CZMU;
- C. **RECOGNISING** also that the usefulness of such data depends upon the timely submission of reports;
- D. **RECOGNISING** also that the usefulness of such data depends upon the publication of the data;
- E. For the above reasons, CCC and CZMU **ACCEPT** that all publication rights to the data base generated by the participants reside with the Fisheries Department.
- F. The CCC **ACCEPTS** as well, that the only condition for utilization of the data, is the acknowledgement that the data were collected in conjunction with the CZMU and that they belong to the Coastal Zone Management Programme as a whole.

ARTICLE 3. The Fisheries Department will administer the Coastal Zone Management Programme for the benefit of all participating institutions. This will include but is not limited to:

- a) Administration of the CZMU through the Project Coordinator by the organization of regular meetings;
- b) Timely communication with the CCC and consultation on major program decisions;
- c) Facilitating the import of equipment through processing and supporting relevant request for duty exemption on imported items.

ARTICLE 4. The initial term of this agreement is three (3)

years commencing on signing. The undersigned hereby acknowledge that this **MEMORANDUM OF UNDERSTANDING** shall remain in force until otherwise indicated and agreed upon by the parties concerned.

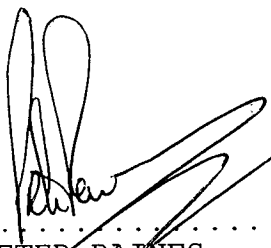
S I G N E D by the)
Hon. Russell Garcia)
Minister of)
Agriculture.)

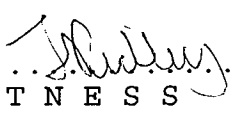

.....
HON RUSSELL GARCIA


.....
W I T N E S S
Permanent Secretary
Ministry of Agriculture

23 Aug 1994
.....
DATE

S I G N E D by)
Mr Peter Raines)
Director, Coral Cay)
Conservation Ltd)


.....
MR PETER RAINES


.....
W I T N E S S
Mr Jonathon Ridley
Director
Coral Cay Conservation Ltd

24/8/94
.....
DATE

Appendix 2

The species list of flora and fauna recorded at Bacalar Chico during the field seasons June/July 1994 and July/August 1995. The body of the tables shows the frequency of occurrence of each species for that habitat type. Only species with a frequency of abundance of greater than 5% are shown.

In habitats surveyed only once, "X" denotes the species recorded. "-" shows no species list collated.

Habitat codes

CCC	-	CCC science staff species list
SPSG	-	Sparse seagrass
MDSG	-	Medium to dense seagrass
SHSG	-	Shallow seagrass
SG&C	-	Seagrass with distinct coral heads
PARE	-	Distinct patch reef
DPAR	-	Diffuse patch reef
RCMA	-	Reef crest matrix
GORG	-	Gorgonian plain
SPAG	-	Spurs and grooves - spurs
SAGR	-	Spurs and grooves - grooves
SACM	-	Sand and coral matrix
SPRU	-	Sparse mixed community on rubble
SAPB	-	Sand with patches of bedrock
SASA	-	Sand with sparse mixed algae
SAAG	-	Sand with algae and gorgonians
S&CH	-	Hard bottom with sand and sparse coral heads
HABO	-	Hard bottom with mixed corals, sponges and algae
AR	-	Artificial reef
CODO	-	Coral drop-off
SADO	-	Sand drop-off
COKN	-	Coral knoll
RECR	-	Reef crest
FARC	-	False reef crest
SAPL	-	Sand plateau

GRUNT - HAEMULIDAE		CCC	SPSG	NDSG	SHSG	SG&C	PARE	DPAE	RCMA	CORG	SPAG	SAGR	SACM	SPRU	SAPB	SASA	SAAG	SACH	HLBO	AR	CODO	SADO	COKN	RECR	FARC	SAPL	
Black margate	<i>Anisotremus surinamensis</i>	X																									
Portfish	<i>Anisotremus virginicus</i>	X					20	10	50		17.5	14.3									25						
Margate	<i>Haemulon album</i>	X																			12.5						
Tontate	<i>Haemulon aurolineatum</i>	X	13.3			12.5	20	20	50	10	7.2	14.3		X	X		27.3		50	X				16.7			
Cesar grunt	<i>Haemulon carbonarium</i>	X				25	40	20			20.6			X			9.1				12.5	X				X	
French grunt	<i>Haemulon flavilinctum</i>	X	33.3		50	62.5	100	10	100	40	72.2	42.9	X		X		9.1	100	100	X							
Black grunts	<i>Haemulon macrostomum</i>	X				12.5		10													12.5						
Shiner grunt	<i>Haemulon plumieri</i>	X																									
White grunt	<i>Haemulon sciurus</i>	X	26.7			25	40	30		21.7	21.6						9.1	50	50	X	25			16.7		X	
Bluestriped grunt	<i>Haemulon sciurus</i>	X	31.3			62.5	60	80	50	30	53.6	28.6	X						100	X	50		X				
Striped grunt	<i>Haemulon striatum</i>	X									7.2								30								
SNAPPER - LUTJANIDAE																											
Mutton snapper	<i>Lutjanus analis</i>	X				12.5																					
Schoolmaster	<i>Lutjanus apodus</i>	X	20			16.7	60	60		13.3	36.1		X	X			18.2		50	X	25			X			
Gray snapper	<i>Lutjanus griseus</i>	X				37.5		20			10.3	28.6		X			9.1										
Yellow snapper	<i>Lutjanus jaco</i>	X																			25						
Male snapper	<i>Lutjanus mahogoni</i>	X					20												50		12.5					X	
Lane snapper	<i>Lutjanus synagris</i>	X					10										9.1										
Yellowtail snapper	<i>Ocyurus chrysurus</i>	X	46.7	7.5	33.3	50	40	70	50	43.3	58.8	42.9	X				27.3		50	X	87.5	X		50	X	X	
DAMSELFISH - POMACENTRIDAE																											
Sergeant major	<i>Abudefduf saxatilis</i>	X																									
Blue chromis	<i>Chromis cyanea</i>	X	40	10	16.7	75	80	80	50	20	9.3		X	X			9.1	100	50	X	50			16.7	X	X	
Sundheadfish	<i>Chromis leucostoma</i>	X	6.7						100	31.7	89.7	57.1	X				9.1		50		100		X	16.7			
Yellow chromis	<i>Chromis multilineata</i>	X																			12.5						
Yellow damselfish	<i>Microgobiodon chrysurus</i>	X	40			62.5	80	70	50	30	10.3	28.6	X				9.1	50	50		62.5			50	X	X	
Dusky damselfish	<i>Neogobius brunneus</i>	X	26.7	12.5	16.7	37.5	40	40	100	10	54.6								50		12.5						
Dusky damselfish	<i>Neogobius fluviatilis</i>	X	6.7			37.5	40	100	100	28.3	54.6	14.3	X	X			9.1	50	50		12.5			50	X	X	
Beaugorgy	<i>Neogobius niger</i>	X	40			16.7	40	10	100	21.7	39.2	14.3					18.2	50	50		37.5						
Bicolor damselfish	<i>Neogobius partitus</i>	X	40	10	16.7	37.5	20	50	50	81.3	93.8	57.1	X	X			63.6	100	100		75			66.7	X	X	
Threespot damselfish	<i>Neogobius planifrons</i>	X				12.5	20	70	50	25	50.5	14.3	X				9.1	50	50		37.5			16.7	X	X	
Cocoa damselfish	<i>Neogobius variabilis</i>	X	6.7	20	33.3	37.5	20	40	50	13.3	21.6	14.3		X				100			25			16.7			
SEABASS - SERRANIDAE																											
Graysby	<i>Cephalopholis argenteata</i>	X																									
Croaker	<i>Cephalopholis fulva</i>	X				25		20		50	18.6	28.6	X				18.2		50		37.5	X			X	X	
Rock hind	<i>Epinephelus fuscoguttatus</i>	X						10			7.2																
Red hind	<i>Epinephelus guttatus</i>	X						10		10	14.4																
Nassau grouper	<i>Epinephelus striatus</i>	X									20.6	14.3									25						
Yellowbelly hamlet	<i>Hypoclinemus abramis</i>	X																									
Shy hamlet	<i>Hypoclinemus ulceratus</i>	X							50	6.7	8.2																
Indigo hamlet	<i>Hypoclinemus guianensis</i>	X																									
Black hamlet	<i>Hypoclinemus nigricans</i>	X																			12.5				X		
Barrel hamlet	<i>Hypoclinemus ruber</i>	X							50												12.5						
Black hamlet	<i>Hypoclinemus sp.</i>	X																									
Black grouper	<i>Myrioperca basiji</i>	X																									
Tiger grouper	<i>Myrioperca tigris</i>	X																									
Yellowfin grouper	<i>Myrioperca venenosa</i>	X																									
Greater snappers	<i>Rypticus apomacrus</i>	X	6.7					10	50	10	7.2						18.2										
Tobaccofish	<i>Serranus tiliacanthus</i>	X	13.3				20		50	31.7	35.1	42.9	X				27.3				37.5		X				
Hariquet bass	<i>Serranus tigrinus</i>	X																									
BASSLET - GRAMMATIDAE																											
Fairy basslet	<i>Gramma lutea</i>	X	20	7.5		12.5		40	50	16.7	44.3	14.3		X			9.1	50			62.5				X		
PARROTFISH - SCARIDAE																											
Midnight parrotfish	<i>Scarus coelestinus</i>	X																									
Blue parrotfish	<i>Scarus coeruleus</i>	X																									
Rainbow parrotfish	<i>Scarus guacamaia</i>	X	13.3			12.5					5.2								50		25			16.7			
Striped parrotfish	<i>Scarus lerti</i>	X	13.3			62.5	40	70		31.7	51.5	14.3	X				9.1	50	50	X	25						
Princess parrotfish	<i>Scarus taeniogrammus</i>	X	26.7			62.5	40	30		51.7	68	71.4					9.1				50		X	16.7	X	X	
Queen parrotfish	<i>Scarus velatus</i>	X				12.5				10	22.7										25			33.3	X		
Redband parrotfish	<i>Spartanops acanthopterus</i>	X																									
Yellowtail parrotfish	<i>Spartanops chrysipinnatus</i>	X	13.3	7.5	16.7	50	20	30	50	36.7	50.5	14.3					9.1	50	50	X	62.5	X		16.7	X	X	
Bucktooth parrotfish	<i>Spartanops radiatus</i>	X				12.5				6.7											12.5						
Yellowtail parrotfish	<i>Spartanops rubripinnatus</i>	X				16.7																					
Spotlight parrotfish	<i>Spartanops viride</i>	X	20			87.5	80	90	100	56.7	80.4	57.1	X	X			27.3	100	100	X	62.5	X			X	X	

WYASSE - LABRIDAE	CCC	SFSG	MDSG	SHSG	SQ&C	PARE	DPAIR	RCMA	GORG	SPAG	SAGR	SACM	SPRU	SAPB	SASA	SAAG	S4C6E	HABO	AR	CODD	SADO	COKN	RECR	FARC	SAPL
<i>Bodianus nigrus</i>	X				37.5	20	20		30	57.7	42.9						50			50					X
<i>Cheilodactylus parrot</i>	X								18.3	23.7						9.1			50	12.5					X
<i>Haliclaeides bivittatus</i>	X	26.7	40	31.3	62.5	20	80	50	30	10.3	28.6		X			27.3	50		50	12.5			50		X
<i>Haliclaeides cynogobius</i>	X															9.1									
<i>Haliclaeides gurnard</i>	X															27.3									
<i>Haliclaeides maculipinna</i>	X	20	7.5	16.7	62.5	20	70	50	61.7	81.4	71.4	X	X						50	87.5	X	X		X	X
<i>Haliclaeides maculipinna</i>	X	13.3			12.5	20	10	50	20	16.5										12.5			16.7		X
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ALGAE	CCC	SPSG	MDSG	SHSG	SG&C	FARE	DPAR	RCMA	GORG	SPAG	SAGR	SACM	SPRU	SAPB	SASA	SAAG	S&CH	HABO	AR	CODO	SADO	COKN	RECR	FARC	SAPB
GREEN																									
<i>Acetabularia</i> spp.	-			7.5																					
<i>Avrainvillia</i> spp.	-		66.7	70	50	62.5	40	80	50	31.7	9.2			X		9.1	50		X	12.5			14.3	X	
<i>Caulerpa cupressoides</i>	-		6.7	7.5	16.7	25	30																		
<i>Caulerpa prolifera</i>	-		6.7		16.7	12.5					12.5														
<i>Caulerpa verticillata</i>	-				25																				
<i>Caulerpa</i> spp.	-			7.5																					
<i>Cladocarpella lucasfascis</i>	-		6.7	16.7	16.7	37.5	20	100	6.7				X			18.2				12.5			14.3		
<i>Cladophora prolifera</i>	-		6.7	35	50	12.5	50		13.3	7.1	12.5	X				9.1	50			12.5			14.3		
<i>Dicranophora carinata</i>	-		6.7		16.7				13.3	5.1															
<i>Entomomorpha flexuosa</i>	-		20	40	20	62.5	100	100	45	67.3	75					27.3				87.5			14.3		X
<i>Halimeda capitata</i>	-		40	20	33.3	62.5	100	40	100	61.7	70.4	25				45.5	50			100	X		14.3	X	X
<i>Halimeda alcockiae</i>	-		6.7	95	50	100	60	20	50	26.7	65.3	62.5				27.3				62.5			14.3	X	
<i>Halimeda gracilis</i>	-		73.3	95	50	100	60	50	20	26.7	20.4	50				33.3	36.4	50		12.5			14.3	X	X
<i>Halimeda montile</i>	-		26.7	22.5	33.3	62.5	20	10	11.7	9.2	12.5										X				
<i>Halimeda opuntia</i>	-																								
<i>Halimeda opuntia</i>	-																								
<i>Halimeda rupestris</i>	-		86.7	60	83.3	87.5	100	100	15	22.4	12.5					9.1	50			25			14.3	X	
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Appendix 3

Statement of EC donation of equipment used for the training
of the local population.

IMPORTANT NOTICE

EUROPEAN COMMISSION DONATED EQUIPMENT

The equipment that you will use was purchased through a grant from the European Commission DGVIII for Developing Countries, Brussels, Belgium. The aim of this funding is to support initiatives for the protection of the environment in developing countries and in particular the conservation of biodiversity through education.

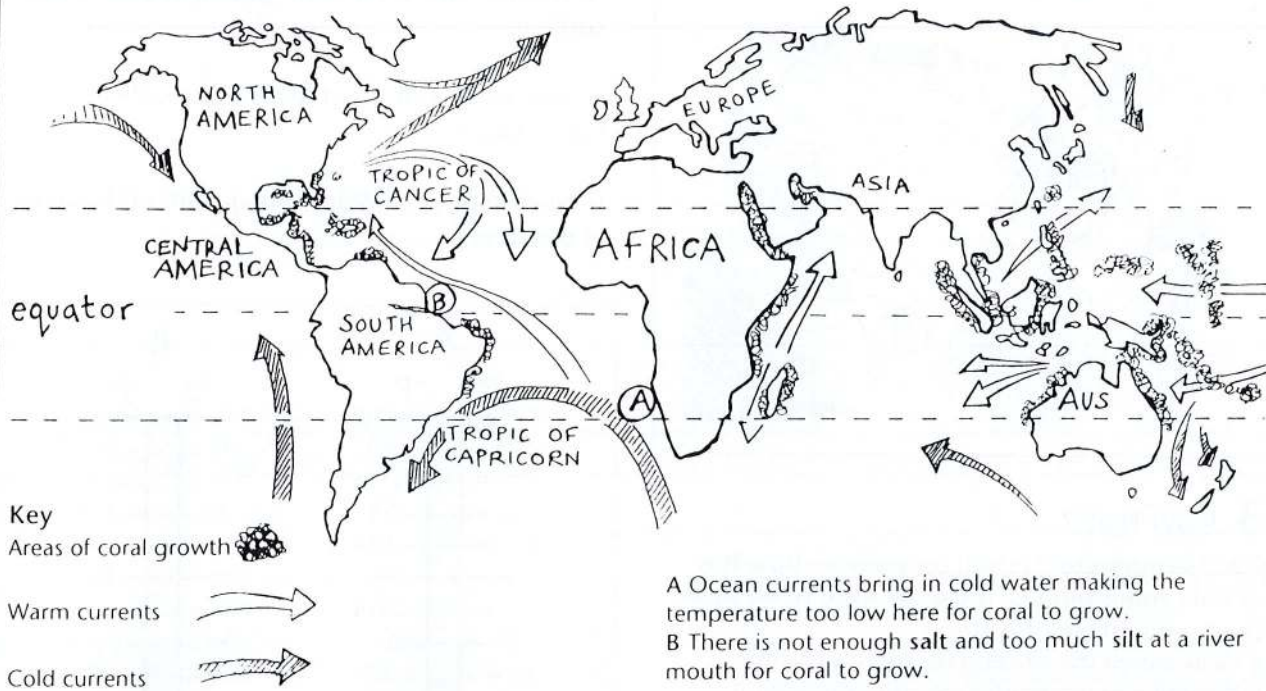
Appendix 4

The Life on the Coral Reef education poster and activity cards.

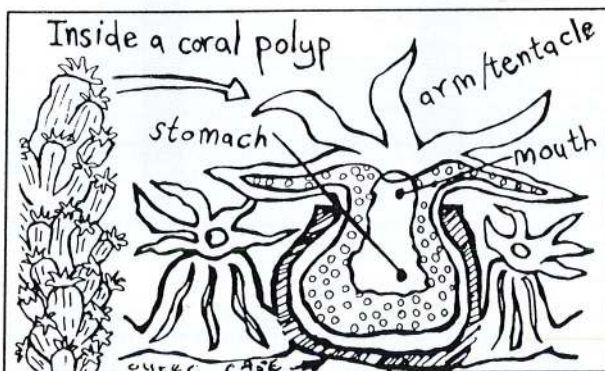
Reef Building FACTS

Belize has the largest barrier reef in the Caribbean. Look at the map to see where coral reefs grow.

Most corals live in shallow water where there is plenty of sunlight. Like any other living thing corals need certain conditions to grow. Corals like warm, salt water that is clear and pollution free.



A Ocean currents bring in cold water making the temperature too low here for coral to grow.
B There is not enough salt and too much silt at a river mouth for coral to grow.

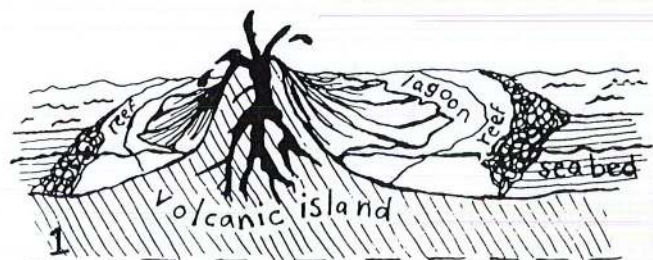
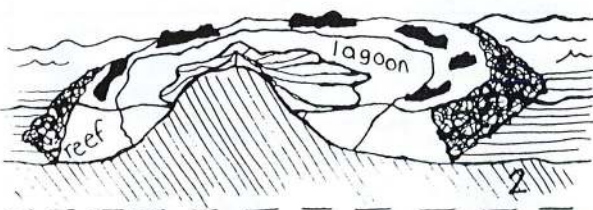


Stony corals and their limestone skeletons are the building blocks of the reef. Inside the case is a small soft animal called a Polyp. It has small plant like organisms called algae living within it. The polyp and plants are in **partnership** and live by exchanging nutrients and shelter.

Hundreds of stony corals grow on top of each other to form a reef. Coral also feed by catching small animals with their stinging tentacles. Corals are slow growers. They are eaten by animals on the reef and are also damaged by wave action.

There are three main types of reef, they grow very slowly over many years, changing from one type into another. Reefs often form around volcanoes, but if the sea conditions are right they grow off the mainland, developing in a similar way

1. Volcanic activity produces an island. Slowly corals begin to grow close to the shore. The island is edged by a **Fringing Reef**.



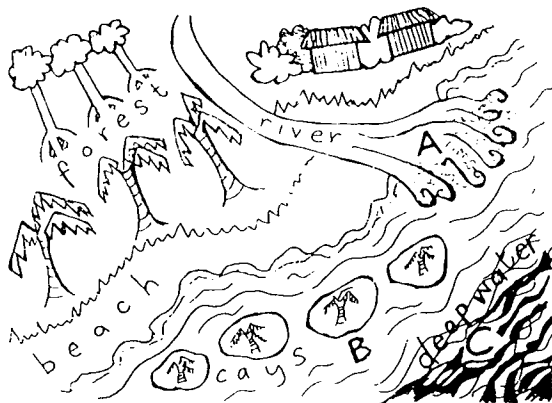
2. The Island slowly begins to sink into the sea. The coral is still growing. The channel becomes wider and deeper this reef is called a **Barrier Reef**.



3. A large lagoon forms on the inside of the reef. When an island disappears completely a ring of coral reef is left, this is the **Coral Atoll**.

1 Where does it grow ?

- a Where on this map will coral reef grow? A,B,or C,
b Explain your answer



3 How Hot ?

- ☼ A thermometer is used to measure how hot or cold something is. It can be used to measure the temperature of water.

- a Write down the reading for thermometer A
b Write down the reading for thermometer B

- ☼ Coral is able to grow at a temperature between the two values shown on the thermometers.

- c What is the average temperature at which coral will grow ? (To find an average you must add the two numbers and divide by the number of items you added together - in this case you will divide by two)

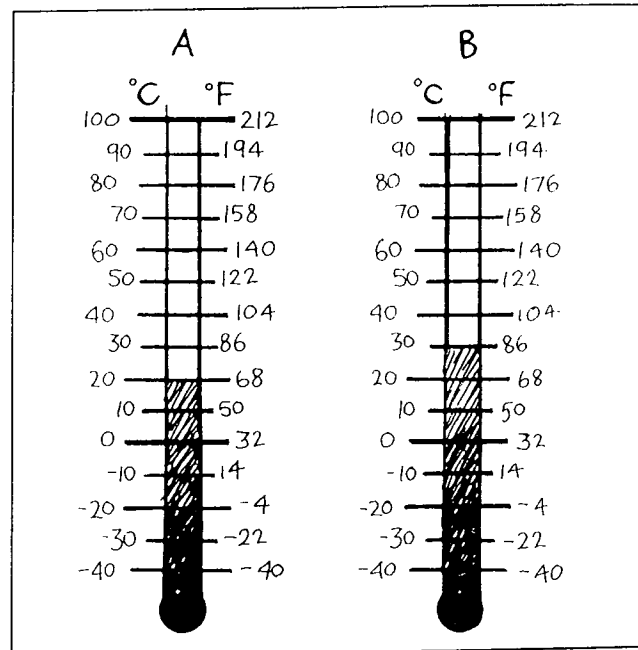
2 Slow Grower

- ☼ Under perfect conditions Elkhorn Coral grows at a rate of 15cm every year.

At present the coral is 3m (300 cm) below the surface.

- a How long will it take the coral to reach the surface ?

- b What things could slow the growth of the coral in this time ?



4 How does it grow ?

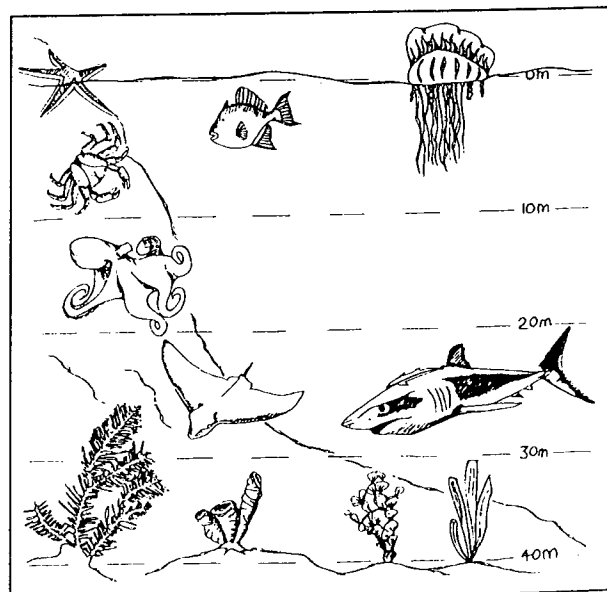
- a Draw and label a diagram of a coral polyp.

- b Describe in your own words how a coral reef is built.

5 Where do they live ?

Corals like to grow in shallow water

- a How deep is the coral growing at the bottom in this picture?
b What animals can you see living in the top 10m ?
c What animals can you see between 20m and 30m?



6 Reef Reasons

- a Explain with the help of diagrams how a coral atoll is formed
b Which other countries in the world, other than Belize, have a coral reef ?
c What are the advantages to having a coral reef ?
d Can you think of any disadvantages ? If you can, write them down.

Living Groups ACTIVITIES

Read the information on the other side of this card. Look at the poster for ideas and help.

1 Special Features

These boxes contain some facts showing the special features of two animals.

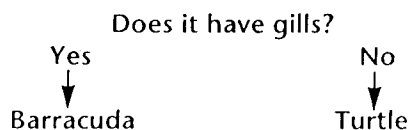
Turtle

4 legs, hard shell, lungs, backbone

Barracuda

gills, scales, backbone,

Keys are useful to find the name of an organism. To separate the turtle from the barracuda you could write a key like this.



- What other features could you use to separate or identify these two animals?
- Write it out in the same way as shown above.

b How could you divide these groups into smaller groups (with less people in each group) Think about what other features other people have that differ from person to person?

c Use 4 pupils in your class. Make a key which will identify all of them. Start with an easy question that will make two groups, e.g. *is it a girl* ? Now continue.

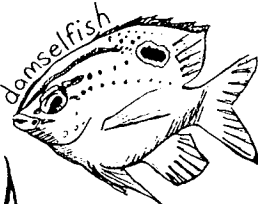
3 Animals

- Give an example of an animal in each of these classes: fish, amphibians, reptiles, birds, mammals.
- Name a special feature of each animal you have chosen.

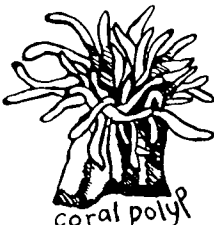
4 Sea Creatures

- Invent and draw your own sea creature.
- Label all its special features.
- Which animal class does it belong to?

5 Similar but different



damselfish



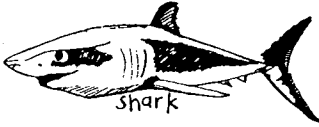
coral polyp



coconut palm



mangrove



shark



anemone

- Write down two physical features about each animal and each plant in this diagram.
- Do any of the animals have similar features ? What are they ?
- Design a key to identify each of the organisms shown. Include the plants. Think about what will be the first question.

6 What am I? Use the clues in these boxes to name the organisms.

a

- I am very small
- I have arms with stinging cells
- I have a hard case

b

- I make my own food
- I have long thin leaves

c

- I live in a shell
- I am a type of snail
- I eat simple plants (algae)
- Humans eat me

• I catch small drifting plankton

• I am green

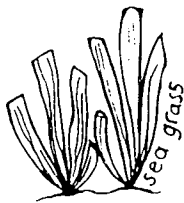
The Classification of Living Things

Millions of different living things have been found and named. More are being found all the time. Living things or **organisms** are sorted into groups. Organisms in the same group have something in common. They have certain features or characteristics they share.

The task of sorting living things into groups is called **Classification**. Living things are first divided into very large groups called Kingdoms. Most organisms are in the **Plant Kingdom** or the **Animal Kingdom**.

Plants

Plants can be divided by many different features. To be able to name a plant exactly you would need to look at its structure more closely. The shape of the leaves, flowers and stem are often a good guide. Most plants are either flowering or non flowering.



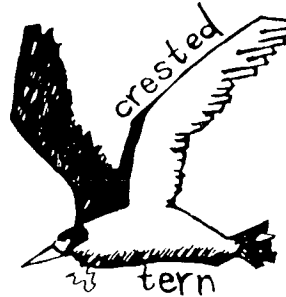
flowering



non-flowering

Animals

Animals are divided into two groups. Those with a backbone are **vertebrates**. Those without a backbone are **invertebrates**.



vertebrate

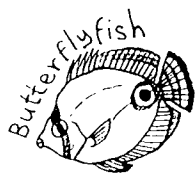
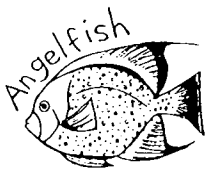


invertebrate

Most vertebrates can also be placed into five main groups known as **classes**.

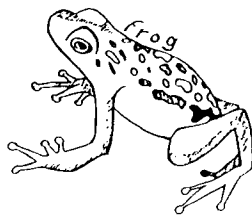
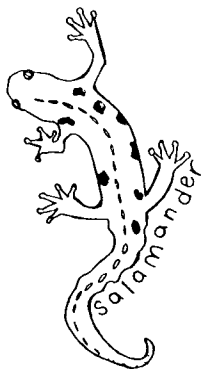
FISH

scales
fins
lay eggs
have gills



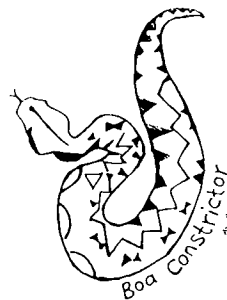
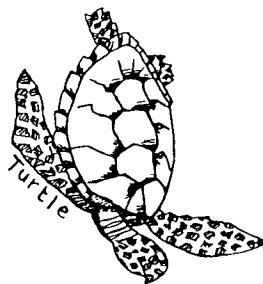
AMPHIBIANS

moist skins
live in water
and on land
lay eggs
have lungs



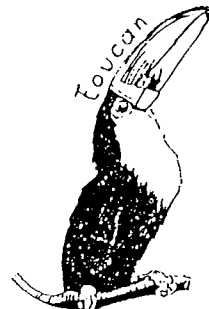
REPTILES

dry scaly skin
lay eggs
have lungs



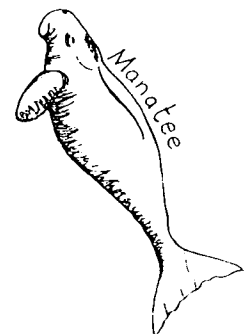
BIRDS

feathers
beak
warm blooded
have lungs
lay eggs



MAMMALS

skin with hair
warm blooded
suckle their
young
born live
have lungs



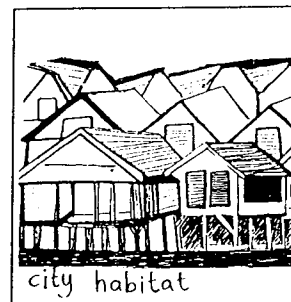
The coral reef is a place where many animals and plants live, feed and hide. They are all connected with each other and need each other.

All plants and animals are grouped together as living things or **organisms**. The place where an organism lives is called a **habitat**.

All the plants and animals of the reef belong to the **reef community**. They all depend on each other for food and shelter.

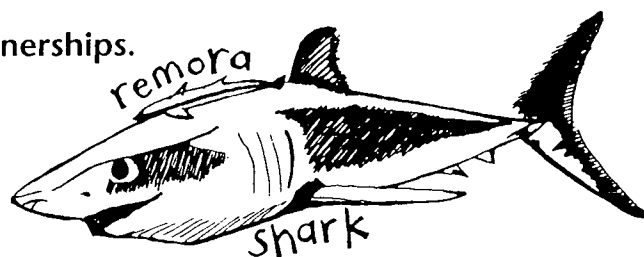
Do you live in the country or the city? These are both examples of human habitats.

Lagoons and reefs are examples of habitats for marine creatures.



Some plants and animals have formed special partnerships.

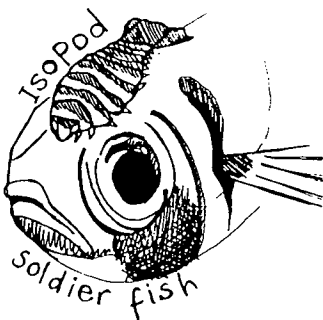
These fish called **remoras** attach themselves to sharks, turtles and rays using a sucking disk on the top of their heads. They don't harm their host but they don't help them either.



In some examples both parties benefit from the relationship, sea anemones and hermit crabs have this kind of relationship. The sea anemone can't move about the reef to catch food so it grows on the shell of a crab. The crab doesn't mind because its passenger hides it from animals that want to eat it, and gives it protection because of its stinging tentacles.



Some relationships are more selfish, only one of the organisms gains from it. This bug like creature is called an **isopod**. It lives on the blood of its victim or host. This relationship is one way. The soldierfish gets nothing from the isopod and is in fact harmed. The isopod is called a **parasite**.



A very important partnership takes place in the corals which make up the reef. **Coral polyps** are small animals with soft bodies and a hard skeleton outside. Thousands grow together to form the reef. Within the polyps are small plant like organisms called **algae**. The polyp and the algae both benefit from living like this.

All algae trap and use the sun's energy to make food. Much of this is used by the polyp. In return the polyp gives the algae shelter and nutrients that it needs. A partnership that is useful to both organisms is called **mutualism**.

All the organisms on the coral reef need food and shelter. They compete with each other for these things. To get ahead in the competition for the resources available, many of the reef dwellers have special features or adaptations. These adaptations give the plant or animal a better chance of surviving without being eaten.

A good way to make sure you are not eaten by others is to be a large hunter or top predator e.g. a shark or a barracuda. Both animals have **razor sharp** teeth for killing their prey.

The puffer fish has a clever way of not becoming a meal for a larger fish - it **puffs up** its body when in danger so that its predator is unable to swallow it.

Octopus can change colour with their background so they are almost invisible. They are **camouflaged**. If an octopus is unlucky enough to be seen by a predator then it will squirt ink so that it can escape in a dark cloud.

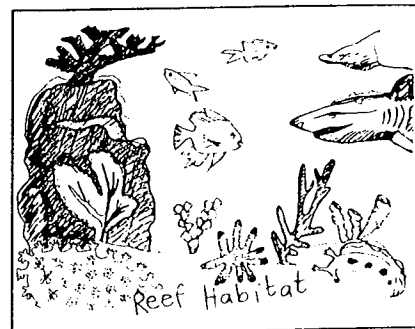
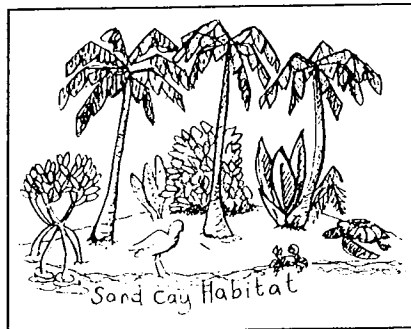
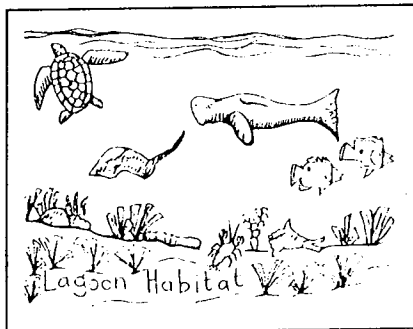
Read the information on the other side of this card. Look at the poster for ideas and help.

1 Homes and habitats

a What type of habitat do you live in? Draw a picture of your habitat.

b Write down the names of four living things (organisms) in your habitat.

c Add these to the picture of your habitat.



3 Reef Relationships

a Explain why corals and algae need each other.

b What type of a relationship do they have?

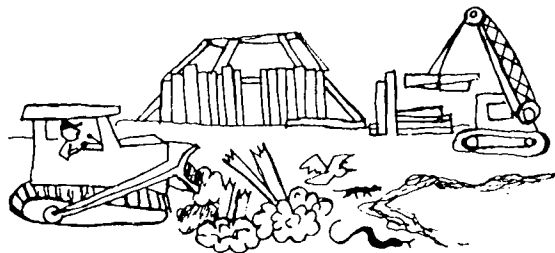
c Give an example of a one way relationship.

Extinction

Plants and animals on the reef are under threat. The poster shows some of the things that effect marine life. When the numbers of a plant or animal fall and they are in danger of disappearing, they are said to be endangered.

If the organism does disappear they are then extinct. We cannot bring them back. Some of the reasons why plants and animals become extinct are:

1 The place where they live, their habitat, is destroyed.



2 Animals are hunted and used as food, pets and for their skins. Plants are taken because they are attractive or useful to humans.

2 Animals and plants

a Write down some of the animals and plants that live in each of the habitats below.

b Choose one of the habitats and draw it, write about the plants and animals that live there.

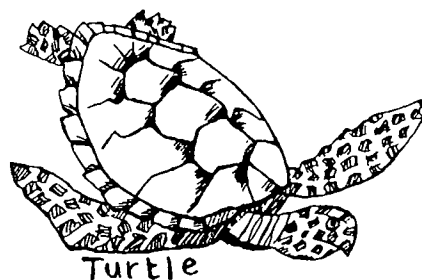
c Do any of the organisms have a special partnership?

4 Survival

Animals and plants have special features to help them live.

a Write about the way one organism has adapted to live on the reef.

Endangered The Hawksbill Turtle



5 Threats and protection

Lobster, conch and many types (species) of turtle are at risk.

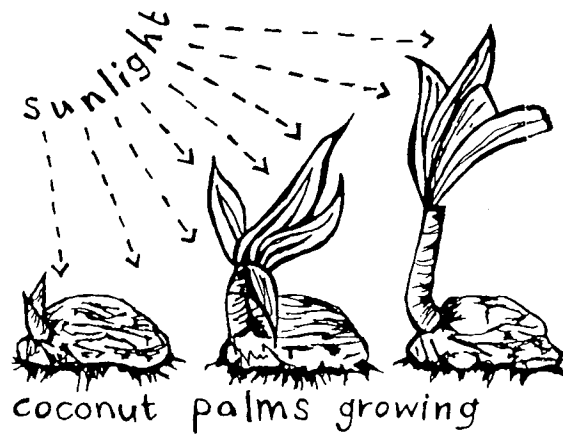
a What is being done to protect these species?

b Describe how natural and human actions can be a threat to the coral reefs and marine life of Belize.

c How do you feel about trying to protect endangered wildlife? Use a particular example or write about the subject in general. Start by noting down the important points. Try to include points from the opposite view. Then put forward your view and why you hold that view.

All life on earth depends on sunlight

- ☀ Animals get their **energy** from eating plants or by eating other animals that have eaten plants.
- ☀ Generally, plants do not eat other living things. Plants **make** their food. They need a number of things to do this including **water** and **sunlight**.
- ☀ The green parts of a plant trap the sun's **energy** and use it to make food. This process is called **photosynthesis**.

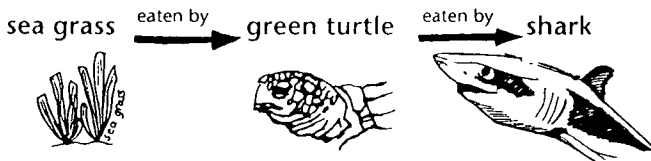


Animals eat (consume) their food. They are called **Consumers**.

Plants make (produce) their own food. They are called **Producers**.

Food Chains

On the reef as elsewhere, all the living things feed on each other. Lets look at an example. In a lagoon green turtles eat seagrass, and sharks eat the green turtles. This is called a **food chain**.

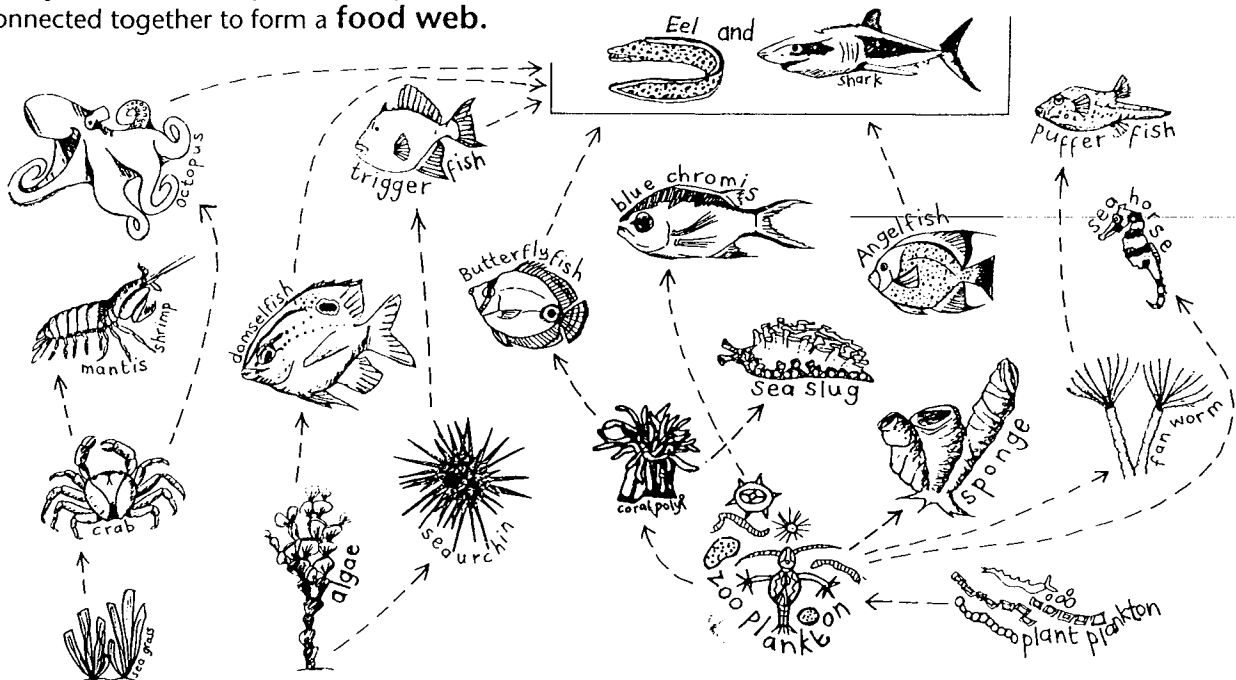


Energy

Energy in a food chain moves from the plant to the first animal, and on to the second animal. At each stage **energy** is used for many things. Seagrass uses some of its **energy** to flower and make seeds. The turtle uses its **energy** to breed and move about.

Food chains tell us about **one** feeding relationship. In a place like a lagoon or the reef, there are **many** different feeding relationships which are connected together to form a **food web**.

Food webs are not fixed because feeding relationships can change. In the food web below all the plants and animals depend on each other.



The very small (microscopic) plants and animals called plankton are an important food for many reef animals.

If the numbers of plankton dropped then there would be less food for everyone. If the number of butterflyfish drop, what will happen to the shark?

Read the information on the other side of this card. Look at the poster for ideas and help.

1 Hungry Animals

Conch eat algae. Humans eat conch.

a Draw a food chain to show this. Make sure your arrows point the right way.

b Write out this food chain, algae, sea urchin, triggerfish

c Find and write down a food chain ending with pufferfish, and a food chain ending with the reef shark.

d Why might somebody else have a different food chain ending with the reef shark?

2 Food Chain

a Make up three food chains of your own.

b Draw a poster showing one of your food chains.

c How many food chains can you find in the coral reef food web on the other side of this card ?

3 Food Web

• Sea urchins and damselfish eat algae.

• Groupers eat damselfish.

• Triggerfish eat sea urchins.

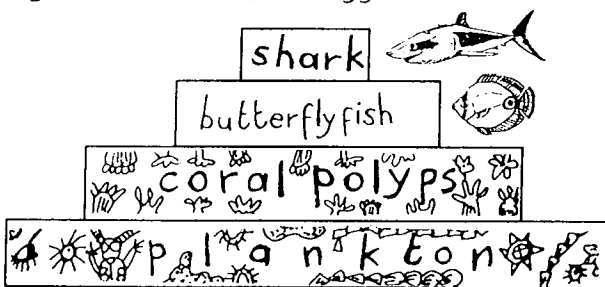
• Humans eat triggerfish, groupers and sharks.

• Sharks eat groupers.

a Draw a food web using this information

4 Animal Pyramid

Information from a food chain that takes account of the numbers of plants or animals at each stage, is called a **Pyramid of Numbers**. This pyramid shows the numbers of plankton, fish and so on for a coral reef food chain. The higher the numbers, the bigger the box.



a Draw a pyramid of numbers for a food chain that you have written.

b All pupils need to learn about feeding relationships on the reef.

Make a small leaflet or book with diagrams to help younger students understand about the reef. What age group is your leaflet for?

c Green turtles and loggerhead turtles may only be hunted for part of the year to protect their numbers.

Write points for and against opening the hunting season to all year.

5 Fussy Eaters

Animals that eat only plants are called **Herbivores**. Animals that eat only animals are called **Carnivores**. Animals that eat both plants and animals are called **Omnivores**.

a Sort out the animals in the coral reef food web (on the other side of this card) under these three headings.

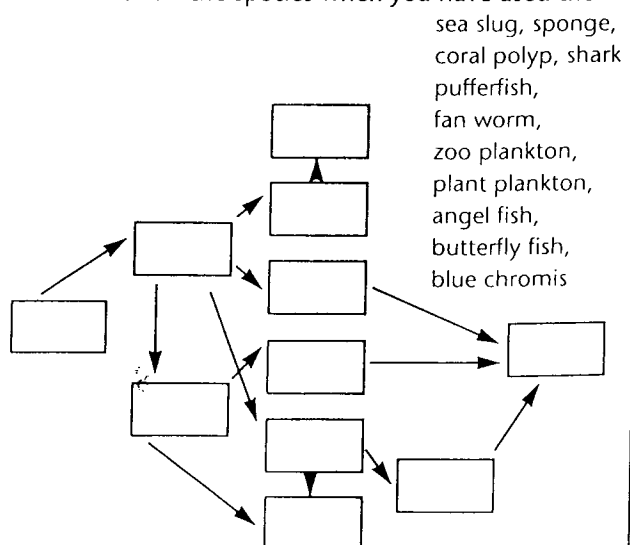
6 Solve a Puzzle

a Copy out the boxes arrows and species list onto a whole page and fill in the answers.

Facts to help you,

- Plankton are very small, there are two types: plants and animals.
- Food chains start with a plant.
- Arrows show the movement of energy.
- Sea slugs eat sponges and coral polyps.
- Puffer fish eat fan worms.
- Animal plankton eat plant plankton.
- Coral polyps eat animal plankton.
- Sharks eat angel fish, butterfly fish and blue chromis.
- Fanworms eat plankton.
- Butterfly fish eat coral polyps.
- Blue chromis eat animal plankton.
- Angelfish eat sponges.
- Sponges eat animal plankton.

Tick off the species when you have used them.



Appendix 5

Statements of support for the environmental education programme run by the CCC/BAS Environmental Educator.

LETTER OF COMMENDATION



British
High Commission
Belmopan

11 December 1995

Mr Terry Wright
Belize Center for
Environmental Studies
P O Box 666
Belize City

Dear Mr Wright

COROZAL ENVIRONMENTAL CONSERVATION CARNIVAL

Many thanks for all your help with the arrangements for the visit which my wife and I paid to the Carnival at Libertad last Wednesday. It was a truly delightful experience which we both thoroughly enjoyed. We were very impressed indeed by the imagination and thoroughness which had gone into the preparations, as well as by the enthusiasm and talent of the presentations team from BCES, the Belize Audubon Society and the Zoo. Please pass on my warm congratulations to all concerned.

I very much hope that my wife and I will have the chance to see another CECC presentation before the season is over. Gareth O'Brien would also like to see one. We will be in touch with you about that after Christmas.

Yours sincerely,

Gordon Baker

G M Baker
High Commissioner

SAMPLE EVALUATION FORM AND QUESTIONNAIRE

(Please note that a full analysis of evaluation forms and questionnaires will be carried out in the final project report)

Corozal Environmental Conservation Carnival

COMMENTARY SHEET

School: Libertad R.C.S.

Date: 6th Dec. 1995

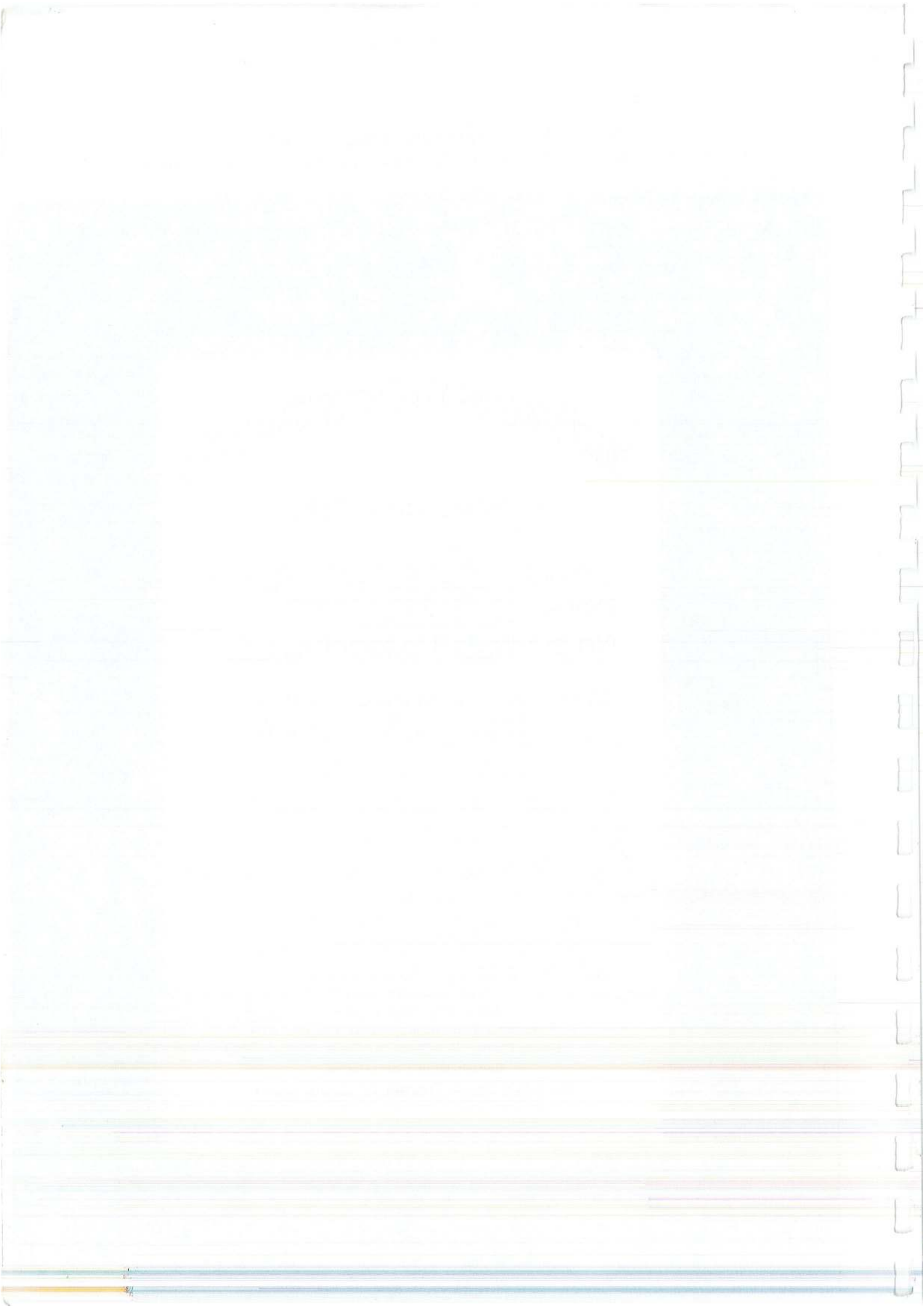
No. pupils: 20 / No. teachers: 7

The programme was wonderful. The students and teachers all learned a lot. It was most educational and informative. The teachers will be doing follow up lessons at the various class level. Congratulations to the Corozal Environmental Conservation Carnival.

Belize Audubon Society
Coatl Cay Conservation
Coastal Zone Management Project
Belize Center For Environmental Studies
British High Commission
The Belize Zoo & Tropical Education Center

Your presentation
were
Excellent

P.T.O.



Appendix 6

Detailed breakdown of the expenditure relating to the Bacalar Chico project between May and December 1994.

CORAL CAY CONSERVATION (CCC): BUDGET HEADING B7-5040/93 - Interim Financial Report (May - December 1994)

A.	AT UNIT PRICE:-	OTHER	CEC (Ecu)	Others (Ecu)	CCC (Ecu)	Total (Ecu)	Invoice Reference	Exchange Rate Used
		Month	Price					
OFFICE - RENT & SERVICES:-								
i)	Belize	May	\$ 150		128	128	CCC/UP7	As per page (i)
		June	\$ 150		124	124	"	
		July	\$ 150		123	123	"	
		August	\$ 150		124	124	"	
		September	\$ 150		121	121	"	
		October	\$ 150		117	117	"	
		November	\$ 150		122	122	"	
		December	\$ 150		123	123	"	
ii)	UK	May	£ 600		773	773	CCC/UP8	As per page (i)
		June	£ 600		766	766	"	
		July	£ 600		755	755	"	
		August	£ 600		757	757	"	
		September	£ 600		763	763	"	
		October	£ 600		766	766	"	
		November	£ 600		768	768	"	
		December	£ 600		772	772	"	
ACCOMODATION - CCC STAFF:-								
				(1)				
		May	\$ 106	90	273	363	CCC/UP9	As per page (i)
		June	\$ 106	87	264	351	"	
		July	\$ 106	87	261	348	"	
		August	\$ 106	87	263	350	"	
		September	\$ 106	85	258	343	"	
		October	\$ 106	82	249	331	"	
		November	\$ 106	86	261	347	"	
		December	\$ 106	87	262	349	"	
ADMINISTRATION & MANAGEMENT:-								
				(2)				
		May	£1 300	502	1 173	1 675	CCC/UP10	As per page (i)
		June	£1 300	498	1 162	1 660	"	
		July	£1 300	490	1 144	1 634	"	
		August	£1 300	492	1 149	1 641	"	
		September	£1 300	496	1 158	1 654	"	
		October	£1 300	498	1 162	1 660	"	
		November	£1 300	499	1 164	1 663	"	
		December	£1 300	390	1 299	1 689	"	
Sub-total Unit Price:				4 556	18 604	23 160		
TOTAL UNIT PRICE:				23 433	38 827	62 260		

(1) - CEC contribution = 25% of unit cost

(2) - CEC contribution = 30% of unit cost

CORAL CAY CONSERVATION (CCC): BUDGET HEADING B7-5040/93 - Interim Financial Report (May - December 1994)

B. AT COST PRICE

CEC Others CCC Total Invoice Exchange
(Ecu) (Ecu) (Ecu) Ref. Rate Used

		<u>Quantity</u>	<u>Unit Price</u>				
FIELD SURVEY WORK:-							
Flights (Europe-Belize)	25	£	535	16 831	16 831	CCC/CP1	0.794652
Food & accomodation	25 persons	£	207	6 512	6 512	CCC/CP2	"
Training material (books)	18	£	18 408		408	CCC/CP3	"
Fuel	700 galls	\$	1.2	688	688	CCC/CP4	1.22114

STAFF TRAVEL & MEDICAL INSURANCE:-

Project Coordinator	1	£	79	102	102	CCC/CP5	0.77630
CCC Director	1	£	79	102	102	"	"
Science Officer	1	£	79	102	102	"	"
Technical Supervisor	1	£	79	102	102	"	"

STAFF FLIGHTS (Europe-Belize):-

Project Coordinator	2	£	650	1 674	1 674	CCC/CP6	0.77630
CCC Director	2	£	650	1 660	1 660	"	0.783289
Science Officer	1	£	650	830	830	"	"
Technical Supervisor	1	£	650	837	837	"	0.77630
MRC Counterpart ⁽¹⁾	1	\$	650	832	832	"	0.781480

AERIAL PHOTOGRAPHY ⁽²⁾:-

Project area	1 set	\$	9 000	7 255	7 255	CCC/CP7	1.24050
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REPORTING:-

Interim report	10 copies	£	30	386	386	CCC/CP9	0.777016
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TOTAL COST PRICE: 14 086 24 235 38 321

⁽¹⁾ - Travel costs for one Belizean counterpart to visit Europe to meet with European research and education agencies.

⁽²⁾ - Aerial images of the project site (valued at \$9,000) were provided by the US Nature Conservancy (TNC) in exchange for survey work (of a similar value) undertaken on behalf of the TNC by a CCC research team at a locality elsewhere within Belize.

CORAL CAY CONSERVATION (CCC): BUDGET HEADING B7-5040/93 - Interim Financial Report (May - December 1994)

C. AT ALL-INCLUSIVE PRICE

CEC (Ecu)	Others (Ecu)	CCC (Ecu)	Total (Ecu)	Invoice Reference	Exchange Rate Used
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FIELD SURVEY WORK:-

	Price					
Equipment hire	£8 000		10 067	10 067	CCC/AIP1	0.794652
Medical supplies	£1 000		1 258	1 258	CCC/AIP2	"
Equipment:- purchase	£3 000		3 775	3 775	CCC/AIP3	"
repairs & renewals	£1 500		1 888	1 888	CCC/AIP4	"
Supply vessel charter	£1 000		1 258	1 258	CCC/AIP5	"
Casual labour	\$ 700		573	573	CCC/AIP6	1.22114

TOTAL ALL-INCLUSIVE PRICE:	18 819	18 819
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GRAND TOTAL (A + B + C)

	CEC (Ecu)	Others (Ecu)	CCC (Ecu)	Total (Ecu)
A. AT UNIT PRICE:	24 415	-	37 845	62 260
B. AT COST PRICE:	14 086	-	24 235	38 321
C. AT ALL-INCLUSIVE PRICE:	-	-	18 819	18 819
GRAND TOTAL:	38 501	-	80 899	119 400

CORAL CAY CONSERVATION (CCC): BUDGET HEADING B7-5040/93 - Interim Financial Report (May - December 1994)

BALANCE ACCOUNT: - CEC FINANCING TO CCC

	Opening Balance (ECU)	Expenditure (ECU)	Closing Balance (ECU) (to Dec. 1994)
A. UNIT PRICE			
1. FEES (European)			
Project Coordinator	60 000	18 877	41 123
Scuba Instructor	20 000	-	20 000
Training Instructors	30 000	-	30 000
Education Specialist	17 000	-	17 000
2. MANAGEMENT COST	5 125	3 865	1 260
Sub-total unit price CCC:	132 125	22 742	109 383
B. COST PRICE			
1. Purchase of satellite images	7 500	-	7 500
2. Aerial photography	12 000	7 255	4 745
3. Processing and interpretation	10 000	-	10 000
4. 5 sets of SCUBA materials	3 125	-	3 125
5. Educational and training materials	25 000	408	24 592
6. Travel (Europe-Belize) x 11	8 250	6 037 ⁽¹⁾	2 213
7. Reporting	2 000	386	1 614
8. Accomodation CCC staff in Belize	10 000	691	9 309
Sub-total cost price CCC:	77 875	14 777	63 098
TOTAL CCC:	210 000	37 519	172 481

⁽¹⁾ - Inclusive of staff travel & medical insurance

**REQUESTED ALTERATION OF CEC PROJECT FINANCING STRUCTURE
FOR THE PERIOD JANUARY 1995 TO APRIL 1996 INCLUSIVE**

A. UNIT PRICE

1. FEES

Project Coordinator (1 x 16 months; E)	16	1 920	30 720
Project Scientist (1 x 12 months; E)	12	1 440	17 280
UK Project Manager (1 x 10 months; E)	10	1 350	13 500
Training Instructor (1 x 8 months; E)	8	1 470	11 760
Education Specialist (1 x 16 months; B)	16	910	14 560
SCUBA Instructor (1 x 16 months; B)	16	500	8 000
Project Administrator (1 x 16 months; B)	16	550	8 800

2. MANAGEMENT COSTS

13 000

Sub-total unit price CCC: 117 620

B. COST PRICE

1. Satellite imagery - processing & interpretation	1 000
2. Education & training materials	24 592
3. SCUBA Instructor - training	3 507
4. 5 sets SCUBA materials	3 125
5. Travel: Flights (Europe-Belize) x 11	9 000
Insurance x 7	714
6. Reporting	1 614
7. Accomodation - Belize office rent & services	2 000
CCC staff	9 309

Sub-total cost price CCC: 54 861

TOTAL CCC: 172 481

E = European

B = Belizean

Appendix 7

Detailed breakdown of monthly expenditure relating to the
Bacalar Chico project between January 1995 and April
1996.

Month: January 95	Currency	ECU	Invoice	Fees	Management	Sat. Imagery	Educ/Training	Scuba Training	Scuba Equip	Travel: Flights	Travel: Insurance	Report/Publish.	Belize Office	Staff Accom.	GRAND TOTAL
Exchg. Rate(£): 0.814	Outgoings	Outgoings	Reference	UNIT	UNIT	COST	COST	COST	COST	COST	COST	COST	COST	COST	
Exchg. Rate(\$): 1.270															
TOTAL BUDGET				104620	13000	1000	24592	3507	3125	9000	714	1614	2000	9309	172481
UNIT:															
Project Coordinator (E)	£1452	1784	CCC213	1784											
Project Scientist (E)	£1102	1354	CCC132	1354											
UK Project Manager (E)	£1194	1467	CCC140	1467											
Training Instructor (E)															
Education Specialist (B)															
SCUBA Instructor (B)															
Project Administrator (B)	\$666	524	CCC Bze1	524											
Management Cost	£662	813		813											
COST:															
Rtn Flight LON-MIA x2	£690	848	9/1							848					
Rtn Flight MIA-BZE x2	£400	491	Cash Book							491					
Accommodation MIA	\$216	170	9/1												
BzFlat Rent	\$430	339	17/1											170	
														339	
BzOffice Rent	\$166	131	#463668										131		
TOTAL OUTGOINGS		7921		5129	813	0	0	0	0	1339	0	0	131	509	7921
BUDGET REMAINING				99491	12187	1000	24592	3507	3125	7661	714	1614	1869	8800	164560

Month: February 95	Currency	ECU	Invoice	Fees	Management	Sat. Imagery	Educ/Training	Scuba Training	Scuba Equip	Travel: Flights	Travel: Insurance	Report/Publish	Belize Office	Staff Accom.	GRAND TOTAL
Exchg. Rate(£): 0.814	Outgoings	Outgoings	Reference	UNIT	UNIT	COST	COST	COST	COST	COST	COST	COST	COST	COST	
Exchg. Rate(\$): 1.270															
TOTAL BUDGET				99491	12187	1000	24592	3507	3125	7661	714	1614	1869	8800	164560
UNIT:															
Project Coordinator (E)	£1452	1784	CCC213	1784											
Project Scientist (E)	£1102	1354	CCC132	1354											
UK Project Manager (E)	£1194	1467	CCC140	1467											
Training Instructor (E)															
SCUBA Instructor (B)															
Project Administrator (B)	\$666	524	CCCBze1	524											
Education Specialist (B)															
Management Costs	£662	813			813										
COST:															
Hotel Miami	\$56	44	46/2											44	
BzOffice Rent	\$166	131	#637										131		
BzFlat Rent	\$430	339	s/o 17/2											339	
Advert Bze Times	\$50	39	7/10 Bz					39							
Advert Pulse	\$50	39	7/11 Bz					39							
Advert Reporter	\$50	39	7/13 Bz					39							
Advert San Pedro Sun	\$45	35	7/14 Bz					35							
Advert Amandala	\$63	50	7/15 Bz					50							
Imaging	\$300	236	CCCBze3			236									
TOTAL OUTGOINGS		6894		5129	813	236	0	202	0	0	0	0	131	383	6894
BUDGET REMAINING				94362	11374	764	24592	3305	3125	7661	714	1614	1738	8417	157666

Month: March 95		Currency	ECU	Invoice	Fees	Management	Sat. Imagery	Educ/Training	Scuba Training	Scuba Equip	Travel: Flights	Travel: Insurance	Report/Publish	Belize Office Staff Accom.	GRAND TOTAL
Exchg. Rate(£): 0.814		Outgoings	Outgoings	Reference	UNIT	UNIT	COST	COST	COST	COST	COST	COST	COST	COST	
Exchg. Rate(\$): 1.270															
TOTAL BUDGET															
UNIT:															
Project Coordinator (E)	£1452		1784	CCC213	1784			24592	3305	3125	7661	714	1614	1738	157666
Project Scientist (E)	£1102		1354	CCC132	1354										
UK Project Manager (E)	£1194		1467	CCC140	1467										
Training Instructor (E)															
SCUBA Instructor (B)															
Project Administrator (B)	\$666		524	CCCBze1	524										
Education Specialist (B)															
Management Costs	£662		813			813									
COST:															
BzOffice Rent	\$166		131	#1683											
BzFlat Rent	\$430		339	s/o 17/3										131	
Dive Instructor	\$450		354	8/17 Bz											339
Food costs - meeting	\$67		53	10/12 Bz					354						
Inland Flight	\$67		53	29/3							53				
UKOffice Rent (50%)	£935		1149	3/3										1149	
TOTAL OUTGOINGS			8021		5129	813	0	0	354	0	53	0	53	131	8021
BUDGET REMAINING					89233	10561	764	24592	2951	3125	7608	714	1561	1607	149645

Month: May 95		Currency	ECU	Invoice	Fees	Management	Sat. Imagery	Educ/Training	Scuba Training	Scuba Equip	Travel: Flights	Travel: Insurance	Report/Publish	Belize Office	Staff Accom	GRAND TOTAL
Exchg. Rate(£): 0.814	Outgoings	UNIT	UNIT	UNIT	UNIT	UNIT	COST	COST	COST	COST	COST	COST	COST	COST	COST	
Exchg. Rate(\$): 1.270	Reference															
TOTAL BUDGET																
UNIT:																
Project Coordinator (E)	£1452	1784	CCC213	1784												
Project Scientist (E)	£1102	1354	CCC132	1354												
UK Project Manager (E)	£1194	1467	CCC140	1467												
Training Instructor (E)	£1102	1354	CCC256	1354												
SCUBA Instructor (B)	\$803	475	CCCBze4	475												
Project Administrator (B)	\$666	524	CCCBze1	524												
Education Specialist (B)																
Management Costs	\$662	813				813										
COST:																
BzOffice Rent	\$166	131	20/14 Bz													
BzFlat Rent	\$430	339	s/o 17/5													
Rtn Flight LON-BZE x2	£1136	1396	46/5								1396				339	
Books	£54	65	81/6													
Conference Fees	£240	288	Cash Book										65			
Hotel	\$45	35	29/7										288		35	
TOTAL OUTGOINGS		10025			6958	813	0	0	0	0	1396	0	353	131	374	10025
BUDGET REMAINING					75317	8935	764	24592	2951	3125	6182	714	1208	1345	6216	131349

Month: June 95	Currency	ECU	Invoice	Fees	Management	Sat. Imagery	Educ/Training	Scuba Training	Scuba Equip.	Travel: Flights	Travel: Insurance	Report/Publish.	Belize Office Staff Accom.	GRAND TOTAL
Exchg. Rate(£), 0.814	Outgoings	Outgoings	Reference	UNIT	UNIT	COST	COST	COST	COST	COST	COST	COST	COST	
Exchg. Rate(\$), 1.270														
TOTAL BUDGET				75317	8935	764	24592	2951	3125	6182	714	1208	1345	131349
UNIT:														
Project Coordinator (E)	£1452	1784	CCC213	1784										
Project Scientist (E)	£1102	1354	CCC132	1354										
UK Project Manager (E)	£1194	1467	CCC140	1467										
Training Instructor (E)	£1102	1354	CCC256	1354										
SCUBA Instructor (B)	\$603	475	CCCBze4	475										
Project Administrator (B)	\$666	524	CCCBze1	524										
Education Specialist (B)														
Management Costs	£662	813			813									
COST:														
BzOffice Rent	\$166	131	#484621										131	
BzFlat Rent	\$430	339	s/o 17/6											
Rtn Flight LON-BZE	£590	725	10/6							725			339	
Insurance (PS)	£111	133	83/6								133			
Boat Hand Course	£65	78	49/6											
Scientific Equipment	£6	7	85/6					78						
Food Costs - meeting	\$51	41	24/21 Bz											
Rtn Flight LON-BZE	£597	733	10/6							733		41		
Insurance (EL)	£138	170	83/6								170			
Hotel	\$45	35	56/7											35
UKOffice Rent (50%)	\$931	1144	22/6											1144
TOTAL OUTGOINGS		11307		6958	813	7	0	78	0	1458	303	41	131	11307
BUDGET REMAINING				68359	8122	757	24592	2873	3125	4724	411	1167	1214	120042

Month: July 95		Currency	ECU	Invoice	Fees	Management	Sat. Imagery	Educ/Training	Scuba Training	Scuba Equip	Travel: Flights	Travel: Insurance	Report/Publish.	Belize Office Staff Accom.	GRAND TOTAL	
Exchg. Rate(£): 0.814	Outgoings	UNIT	Reference	UNIT	COST	COST	COST	COST	COST	COST	COST	COST	COST	COST		
Exchg. Rate(\$): 1.270	Outgoings	UNIT	Reference	UNIT	COST	COST	COST	COST	COST	COST	COST	COST	COST	COST		
TOTAL BUDGET																
UNIT:																
Project Coordinator (E)	£1452		1784	COC213	1784			24592	2873	3125	4724	411	1167	1214	4698	120042
Project Scientist (E)	£1102		1354	COC132	1354											
UK Project Manager (E)	£1194		1467	COC140	1467											
Training Instructor (E)	£1102		1354	COC256	1354											
SCUBA Instructor (B)	\$603		475	COCBze4	475											
Project Administrator (B)	\$666		524	COCBze1	524											
Education Specialist (B)				EducTrng												
Management Costs	£662		813		813											
COST:																
BzOffice Rent	\$166		131	#484691										131		
BzFlat Rent	\$430		339	s/o 17/7												
Rtn Flight LON-HOU	£538		645	54/7							645				339	
Flight SEA-BZE	£605		743	53/7							743					
Scientific Equipment	£19		23	36/7			23									
Belize Audubon Society	£17953		22055	NWB 12/5				22055								
SCUBA Equipment	£1330		1634	44/7						1634						
SCUBA Equipment	£482		592	46/6						592						
TOTAL OUTGOINGS																
Fund Transfer			33933		813	23		22055	0	2226	1388	0	0	131	339	33933
BUDGET REMAINING																
					7309	734		17097	2873	899	3336	411	1167	1083	4359	86109

Month: August 95		Currency	ECU	Invoice	Fees	Management	Sat. Imagery	Educ/Training	Scuba Training	Scuba Equip	Travel: Flights	Travel: Insurance	Report/Publish.	Belize Office Staff Accom.	GRAND TOTAL
Exchg. Rate(£): 0.814	Outgoings	Reference	UNIT	COST	COST	COST	COST	COST	COST	COST	COST	COST	COST	COST	
Exchg. Rate(\$): 1.270	UNIT	UNIT	UNIT	UNIT	UNIT	UNIT	UNIT	UNIT	UNIT	UNIT	UNIT	UNIT	UNIT	UNIT	
TOTAL BUDGET															
UNIT:															
Project Coordinator (E)	£1452	1784	CCC213	1784											
Project Scientist (E)	£1102	1354	CCC132	1354											
UK Project Manager (E)	£1194	1467	CCC140	1467											
Training Instructor (E)	£1102	1354	CCC256	1354											
SCUBA Instructor (B)	\$603	475	CCCBze4	475											
Project Administrator (B)	\$666	524	CCCBze1	524											
Management Costs	£662	813			813										
COST:															
BzOffice Rent	\$166	131	#585027												
BzFlat Rent	\$430	339	s/o 17/8												
Scientific Equipment	£110	132	44/8												
Hotel	\$45	35	6/8												
Imaging	\$500	394	CCCBze3												
TOTAL OUTGOINGS		8802		6958	813	526	0	0	0	0	0	0	0	131	374
BUDGET REMAINING				39883	6496	208	17097	2873	899	3336	411	1167	952	3985	77307

Month: September 95		Currency	ECU	Invoice	Fees	Management	Sat. Imagery	Educ/Training	Scuba Training	Scuba Equip	Travel: Flights	Travel: Insurance	Report/Publish	Belize Office Staff Accom.	GRAND TOTAL
Exchg. Rate(£): 0.814	Outgoings	Outgoings	Reference	UNIT	UNIT	UNIT	COST	COST	COST	COST	COST	COST	COST	COST	
Exchg. Rate(\$): 1.270															
TOTAL BUDGET				39883	6496		208	17097	2873	899	3336	411	1167	3985	77307
UNIT:															
Project Coordinator (E)	£1452	1784	CCC213	1784											
Project Scientist (E)	£1102	1354	CCC132	1354											
UK Project Manager (E)	£1194	1467	CCC140	1467											
Training Instructor (E)	£1102	1354	CCC256	1354											
SCUBA Instructor (B)	\$603	475	CCCBze4	475											
Project Administrator (B)	\$666	524	CCCBze1	524											
Management Costs	£662	813			813										
COST:															
BzOffice Rent	\$166	131	#240776											131	
BzFlat Rent	\$430	339	s/o 17/9												
Insurance (TI)	£97	119	47/9									119		339	
Travel	£38	47	57/8									47			
UKOffice Rent (50%)	£924	1135	22/9											1135	
TOTAL OUTGOINGS		9542		6958	813		0	0	0	0	0	166	0	131	9542
BUDGET REMAINING				32925	5683		208	17097	2873	899	3336	245	1167	821	67765

Month: October 95		Currency	ECU	Invoice	Fees	Management	Sat. Imagery	Educ/Training	Scuba Training	Scuba Equip	Travel: Flights	Travel: Insurance	Report/Publish	Belize Office Staff	Accom.	GRAND TOTAL
Exchg. Rate(£): 0.814		Outgoings:	Outgoings:	Reference:	UNIT	UNIT	COST	COST	COST	COST	COST	COST	COST	COST	COST	
Exchg. Rate(\$): 1.270																
TOTAL BUDGET					32925	5683	208	17097	2873	899	3336	245	1167	821	2511	67765
UNIT:																
Project Coordinator (E)	£1452		1784	COC213	1784											
Project Scientist (E)	£1102		1354	COC132	1354											
UK Project Manager (E)	£1194		1467	COC140	1467											
Training Instructor (E)	£1102		1354	COC256	1354											
SCUBA Instructor (B)																
Project Administrator (B)	\$666		524	CCCBze1	524											
Management Costs	£662		813			813										
COST:																
BzOffice Rent	\$166		131	#240776												
BzFlat Rent	\$430		339	s/o 17/10										131		
Rtn Flight LON-BZE	£547		672	25/10											339	
Inland Flight Bze	\$28		22	10 Bz							672					
Scientific Equipment	£15		18	2/10							22					
Food Costs - meeting	\$50		39	6018038z			18									
Insurance (PC)	£97		119	47/9								119				
Rtn Flight BZE-LON	£480		590	61/10							590					
TOTAL OUTGOINGS			9226		6483	813	18	0	0	0	1284	119	39	131	339	9226
BUDGET REMAINING					26442	4870	190	17097	2873	899	2052	126	1128	690	2172	58539

Month: November 95		Currency	ECU	Invoice	Fees	Management	Sat	Imagery	Educ/Training	Scuba	Training	Scuba	Equip	Travel	Flights	Travel	Insurance	Report/Publish	Belize Office	Staff	Accom	GRAND TOTAL
Exchg. Rate(£): 0.814		Outgoings:	Outgoings:	Reference	UNIT	UNIT	COST	COST	COST	COST	COST	COST	COST	COST	COST	COST	COST	COST	COST	COST	COST	
Exchg. Rate(\$): 1.270																						
TOTAL BUDGET					26442	4870	190	17097	2873	899	2052	126	1128	690	2172							58539
UNIT:																						
Project Coordinator (E)		£1452	1784	CCC213	1784																	
Project Scientist (E)		£1102	1354	CCC132	1354																	
UK Project Manager (E)																						
Training Instructor (E)		£1102	1354	CCC256	1354																	
SCUBA Instructor (B)																						
Project Administrator (B)		\$666	524	CCCBze1	524																	
Management Costs		£662	813			813																
COST:																						
BzOffice Rent		\$166	131	#601868																		
BzFlat Rent		\$430	339	s/o 17/11																		
Visa		\$13	10	Cash Book																		
Hotel		\$45	35	44/11																		
TOTAL OUTGOINGS			6344		5016	813	0	0	0	0	0	0	0	0	10	0	0	0	131	374		5344
BUDGET REMAINING					21426	4057	190	17097	2873	899	2042	126	1128	559	1798							52195

Month: December 95		Currency	ECU	Invoice	Fees	Management	Sat. Imagery	Educ/Training	Scuba Training	Scuba Equip	Travel: Flights	Travel: Insurance	Report/Publish.	Belize Office	Staff Accom.	GRAND TOTAL
Exchg. Rate(£): 0.814		Outgoings	Outgoings	Reference	UNIT	UNIT	COST	COST	COST	COST	COST	COST	COST	COST	COST	
Exchg. Rate(\$): 1.270																
TOTAL BUDGET					21426	4057	190	17097	2873	899	2042	126	1128	559	1798	52195
UNIT:																
Project Coordinator (E)	£1452	1784	CCC213		1784											
Project Scientist (E)	£1102	1354	CCC132		1354											
UK Project Manager (E)																
Training Instructor (E)																
SCUBA Instructor (B)																
Project Administrator (B)	\$666	524	CCCBze1		524											
Management Costs	£662	813				813										
COST:																
BzOffice Rent	\$166	131	#312501													
BzFlat Rent	\$430	339	s/o 17/12											131		
Rtn Flight LON-BZE	£502	617	34/2												339	
Flight Supplement	£30	37	13/1								617					
Hotel	\$45	35	Pending								37					
UKOffice Rent (50%)	892	1096	14/12												35	
															1096	
TOTAL OUTGOINGS		6730			3662	813	0	0	0	0	654	0	0	131	1470	6730
BUDGET REMAINING					17764	3244	190	17097	2873	899	1388	126	1128	428	328	45465

Month: January 96		Currency	ECU	Invoice	Fees	Management	Sat. Imagery	Educ/Training	Scuba Training	Scuba Equip	Travel: Flights	Travel: Insurance	Report/Publish.	Belize Office	Staff Accom.	GRAND TOTAL
		Outgoings	Outgoings	Reference	UNIT	UNIT	COST	COST	COST	COST	COST	COST	COST	COST	COST	
TOTAL BUDGET					17764	3244	190	17097	2873	899	1388	126	1128	428	328	45465
UNIT:																
Project Coordinator (E)		£1452	1784	CCC213	1784											
Project Scientist (E)		£1102	1354	CCC132	1354											
UK Project Manager (E)																
Training Instructor (E)																
SCUBA Inst. (B) Transfer																
Project Administrator (B)		\$666	524	CCCBze1	524											
Management Costs		£662	813			813										
COST:																
BzOffice Rent		\$166	131	#312554										131		
BzFlat Rent		\$430	339	s/o 17/1											339	
Imaging		\$250	197	CCCBze3			197									
TOTAL OUTGOINGS			5142		3662	813	197	0	0	0	0	0	0	131	339	5142
Fund Transfer					5000				1000	4000						
BUDGET REMAINING					9102	2431	-7	17097	3873	4899	1388	126	1128	297	-11	40323

Month: February 96		Currency	ECU	Invoice	Fees	Management	Sat. Imagery	Educ/Training	Scuba Training	Scuba Equip	Travel: Flights	Travel: Insurance	Report/Publish	Belize Office Staff	Accom.	GRAND TOTAL
Exchg. Rate(£): 0.814		Outgoings		Reference	UNIT	UNIT	COST	COST	COST	COST	COST	COST	COST	COST	COST	
Exchg. Rate(\$): 1.270																
TOTAL BUDGET																
UNIT:																
Project Coordinator (E)	£1452	1784	CCC213		1784											
Project Scientist (E)	£1102	1354	CCC132		1354											
UK Project Manager (E)																
Training Instructor (E)																
SCUBA Instructor (B)																
Project Administrator (B)	\$666	524	CCCBze1		524											
Management Costs	£662	813			813											
COST:																
BzOffice Rent	\$166	131	Pending											131		
BzFlat Rent	\$430	339	s/o 17/2											339		
TOTAL OUTGOINGS																
BUDGET REMAINING																
		4945			3662	813	0	0	0	0	0	0	0	131	339	4945
					5440	1618	-7	17097	3873	4899	1388	126	1128	166	-350	35378

Month: March 96	Currency	ECU	Invoice	Fees	Management	Sat. Imagery	Educ/Training	Scuba Training	Scuba Equip	Travel: Flights	Travel: Insurance	Report/Publish	Belize Office	Staff Accom	GRAND TOTAL
Exchg. Rate (£): 0.814	Outgoings	Outgoings	Reference	UNIT	UNIT	COST	COST	COST	COST	COST	COST	COST	COST	COST	
Exchg. Rate (\$): 1.270				5440	1618	-7	17097	3873	4899	1388	126	1128	166	-350	35378
TOTAL BUDGET															
UNIT:															
Project Coordinator (E)	£1452	1784	CCC213	1784											
Project Scientist (E)	£1102	1354	CCC132	1354											
UK Project Manager (E)															
Training Instructor (E)															
SCUBA Instructor (B)															
Project Administrator (B)	\$666	524	CCCBze1	524											
Management Costs	£662	813			813										
COST:															
BzOffice Rent	\$166	131	Pending										131		
BzFlat Rent	\$430	339	s/o 17/3											339	
Instructor Course	£1762	2165	Quote					2165							
Hotel - Course	£1038	1275	Quote					1275							
PADI Membership	£278	342	Quote					342							
Flight BZE-MIA - Course	£192	236	Quote							236					
Per Diem @ £12	£168	206	Quote					206							
Flights Panama x2	£938	1152	Pending							1152					
Insurance Panama x2	£82	101	Pending								101				
TOTAL OUTGOINGS		10422		3662	813	0	0	3988	0	1388	101	0	131	339	10422
BUDGET REMAINING				1778	805	-7	17097	-115	4899	0	25	1128	35	-689	24956

Month: April 96		Currency	ECU	Invoice	Fees	Management	Sat. Imagery	Educ/Training	Scuba Training	Scuba Equip	Travel: Flights	Travel: Insurance	Report/Publish	Belize Office Staff Accom.	GRAND TOTAL
Exchg. Rate(£): 0.814	Exchg. Rate(\$): 1.270	Outgoings	Outgoings	Reference	UNIT	UNIT	COST	COST	COST	COST	COST	COST	COST	COST	
TOTAL BUDGET					1778	805	-7	17097	-115	4899	0	25	1128	35	24956
UNIT:															
Project Coordinator (E)	£1452		1784	CC0213	1784										
Project Scientist (E)															
UK Project Manager (E)															
Training Instructor (E)															
SCUBA Instructor (B)															
Project Administrator (B)	\$666		524	CCCBze1	524										
Management Costs	£662		813			813									
COST:															
Report Production	£918		1128	Pending											
Belize Audubon Society	£5173		6355	Pending 31/4/96				6355					1128		
SCUBA Materials	£3988		4899	Pending						4899					
EducTrng + poster print	£8743		10741	Pending				10741							
TOTAL OUTGOINGS			26244		2308	813	0	17096	0	4899	0	0	1128	0	26244
BUDGET REMAINING					-530	-8	-7	1	-115	0	0	25	0	35	-1288

Appendix 8

Statement of the use of funds by the sub-contractor, Belize Audubon Society upto January 1996 and projected expenditure relating to the education component of the Bacalar Chico project.

CCC/BAS ENVIRONMENTAL EDUCATOR FINANCIAL STATEMENT

Actual Expenses 1st July - 31st December 1995
Projected Expenses 1st January - 30th April 1996

In Belize Dollars (\$)

	CCC/EC Funds	Expenses Incurred	Projected Expenses
1. Project Personnel Costs			
Salaries	21,466.00	8,465.50	13,000.50
Benefits	1,541.00	191.10	1,349.50
Transportation	3,000.00	299.10	2,700.90
2. Project Costs			
(a) Bacalar Chico Promotional materials			
Poster	5,000.00	0.00	5,000.00
(General Marine Brochure)			
General Marine Brochure	20,000.00	0.00	20,000.00
(b) Corozal Environmental Conservation Carnival			
Personnel:			
Per Diem	1,500.00	500.00	1,000.00
Accommodation	2,000.00	559.64	1,440.36
Contingency	250.00	0.00	250.00
Transportation:			
Fuel	1,000.00	0.00	1,000.00
Maintenance	300.00	0.00	300.00
Rental	500.00	0.00	500.00
Flights	225.00	0.00	225.00
Materials:			
Posters, Brochures, Booklets, Handouts)	5,000.00	0.00	5,000.00
Photocopies	1,600.00	460.00	1,140.00
Communication:			
Letters	50.00	0.00	50.00
Radio Adverts	100.00	0.00	100.00
Photocopy	400.00	0.00	400.00

3. Direct Project Costs

Communication:

Telephone/fax	2,000.00	0.00	2,000.00
Postage	850.00	0.00	850.00
Office Supplies	2,000.00	766.86	1,233.14
Financial Audit	840.00	0.00	840.00
Incidentals	3,082.00	0.00	3,082.00
TOTAL	72,704.00	11,242.20	61,461.80

