

CORAL CAY CONSERVATION - BELIZE '89

EXPEDITION REPORT III

**A Detailed Study of The Reef and Lagoon Ecosystems
At South Water Cay, Belize**

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1 - ABSTRACT

This document presents the results of survey work carried out on South Water Cay, Belize in July and August 1989, during the course of 'Coral Cay Conservation -Belize 1989' a Joint-British Universities Expedition.

Following a preliminary survey of the state of the reef and its physical profile, 100m survey lines were laid at six representative sites corresponding to the following positions: Lagoon; Backreef; Reefcrest; Inner Fore-Reef; Outer Fore-Reef; Drop-Off. Surveys were carried out to assess the populations of the major fish groups at the six sites. Sixty-six 1m quadrats were laid along the survey lines. Coral, algae and other invertebrate species were mapped and each quadrat photographed. Conch and spiny lobster populations were assessed at three 100m² survey sites around the island. The size range of the conch population was recorded. Detailed projects were conducted on the following subjects: Sediment structure; Meiofaunal assemblages; Seagrass epiphyte populations; Bioerosion of coral species. Two new species have been described and the following publications are currently in preparation:-

McCorry, D., Hughes, R.G., O'Toole, L.B., Raines, P.S., Trett, M.W. (1991). An assessment of coral assemblages on the Belize Barrier Reef system using multivariate analytical techniques. *Journal Marine Biological Association* (In Prep).

McCorry, D., Hughes, R.G., O'Toole, L.B., Raines, P.S., Trett, M.W. (1991). An assessment of fish populations at South Water Cay, Belize. *Journal Marine Biological Association* (In Prep).

Trett, M.W., Forster, S.J., Feil, R.H. (1991). Meiofaunal indices as indicators of prevailing environmental conditions in coral reef ecosystems. I. The Belize Barrier Reef. *Journal of Marine Biology and Ecology* (In Prep).

Trett, M.W., Forster, S.J. (1991). The Genus *Croconema* (Nematoda; Desmodoridae), its taxonomic status with descriptions of new species from coral reef:seagrass habitats in Belize and Papua New Guinea. *Zoologic Scripta*. (In Prep).

Kaehler, S., Hughes, R.G. (1991). The biology of interactions between hydroid (Cnidaria:Hydroidea) assemblages on the seagrass *Thalassia testudinum* on the Belize Barrier Reef. *Journal Marine Biological Association*. (In Prep).

Trett, M.W., Forster, S.J. (1991). The detection of disturbance and stress in coral reef systems using meiobenthic assemblages. *Marine Pollution Bulletin*. (In Prep).

2 - CORAL CAY CONSERVATION - BELIZE 1989

The Coral Cay Conservation expeditions began in 1986 when a small research team from Britain visited Belize to assess the impacts of tourism and the fishing industry on the ecological balance of reefs and lagoons along the Belize barrier reef. Repeat surveys by a similar sized expedition were made at the same locations in 1987.

Coral cay Conservation - Belize '89 was a joint British Universities expedition formed mainly of staff and students from the universities of London, Wales and St Andrews. The primary aim of the expedition was to survey the varied marine habitats adjacent to South Water Cay as a prelude to the development of a management plan for the sustainable use of marine resources in the area.

The research programme undertaken by the expedition was formulated after consultation with the appropriate government and non-government organisations in Belize; the ministry of Agriculture and Fisheries, the Belize Audubon Society and the Belize Centre for Environmental Studies. The research programme was also endorsed by the following organisations:

The Universities of London, Wales and St Andrews
The Royal Society
The British Ecological Society
The Marine Conservation Society
The Royal Geographical Society.

Between July and August 38 expedition members carried out some 800 survey dives over the two month period. The expedition was equipped with three inflatable boats, three dive compressors, 2 generators as well as an extensive mobile laboratory and library. The survey work was directed by four qualified marine biologists. Over half of the team were biology undergraduates with the remainder being new to reef ecology. Extensive training was given to all survey participants before each stage of work.

Coral Cay Conservation Belize '89 was financed by personal contributions from each expedition member and by sponsorship from other organisations. A full list of sponsors is gratefully acknowledged in Appendix 1.

The results presented here form part of an ongoing research programme currently being undertaken by Coral Cay Conservation to provide data for the Coastal Zone Management Plan for Belize.

LIST OF EXPEDITION MEMBERS

Peter Raines	- Expedition Leader
Guy Sutton	- Deputy Expedition Leader
Denise McCorry	- Scientific Officer
Liam O'Toole	- Scientific Officer
Jon Ridley	- Photographic Officer
Steve Coppinger	- Medical Officer
Mary Black	- Medical Officer
Peter Andrews	- Assistant Medical Officer
Gary Davies	- Assistant Medical Officer
Julia Birkett	- Logistics Officer
Andrew Phillips	- Equipment Officer
Tony Dobinson	- Diving Officer

Jenny Baer
Maria Bavins
Richard Baxter
Julia Bucknall
Frank Eckhardt
Simon Foster
Julia Garthwaite
Jaboury Ghazoul
Claire Higgins
Deepak Jazuram
Sven Kaehler
Justin Kerridge
Peter Ladell
Matthew Lawrence
John Miller
Steve Partridge
Chris Reid
Neil Rose
Bill Sanderson
Clive Seymour
Jane Taylor
Kevin Tyler
Justin Wall
Bill Williams
Andrew Wood
Dave Woodward

3 - INTRODUCTION

3.1 - Belize and The Atlantic Barrier Reef

Belize is situated on the Caribbean Sea between Mexico and Guatemala. It has an area of 22,963 sq km and a population of approximately 150,000 inhabitants.

The Belize barrier reef has been described as unique in the Western Hemisphere on account of its size, its array of reef types and the luxuriance of corals thriving in such pristine condition (Dahl et al, 1974; Perkins, 1983).

250km long and between 10-32km wide (Purdy et al 1973; James et al 1976), the reef is the largest uninterrupted reef system in the Atlantic (Smith 1948). Amongst the geophysical features that make this barrier particularly interesting are: the nearly continuous barrier perched on the edge of a narrow continental shelf; the large number of patch reefs and faroes found in the deep shelf lagoon areas and the unusual diversity of reef types found in such a small geographical area.

The reef can be divided up into three distinct provinces; the Northern, Central and Southern province. This report concerns the Central province area which forms 62% of the total reef. It stretches from Gallows point to Gladden Spit and is characterised by long wide stretches of uninterrupted reef only cut by two major channels. The longest of these stretches can be found in the area east of Dangriga.

The first major study on the reefs and cays of Belize was carried out by the 'Cambridge Expedition to British Honduras' in 1959-60 (Thorpe and Stoddart, 1962). Work prior to that had been largely confined to personal collecting trips made by visitors and inhabitants of the colony. Stoddart continued to study many aspects of the biology of the cays (Stoddart, 1962a & b, 1963, 1969 1974). A team from Rice University carried out a series of studies throughout the 1960's, focusing primarily on the geology of the barrier reef complex (Wantland and Pusey, 1975). The establishment by the Smithsonian Institution of a field station on Carrie Bow Cay in 1972, has spawned a steady stream of publications on the physical and biological characteristics of the reef system. This work has been brought together in a volume by Rutzler and MacIntyre (1982) and the Smithsonian regularly publishes an annual report of its work in the area.

In addition, organisations such as Wildlife Conservation International (WCI), the New York Natural History Society as well as expeditions from numerous universities have carried out studies on the reef (Perkins and Carr, 1985; UNEP/IUCN, 1988).

In August 1989 a Belize Coastal Zone Management Workshop was held at Ambergris Cay. Fifty-five participants from nine countries drew up draft recommendations for action by the Government of Belize, Non-Governmental organisations and Educational Institutions. These recommendations included a programme of research involving small scale marine habitat mapping and status assessment, plus the study of the biology, ecology and life history of threatened and endangered species. This was followed in April 1990 by a Draft Planning Document, produced by the IUCN, WCI and the Belizean Department of Fisheries entitled

“Guidelines for Developing a Coastal Zone Management Plan” (Price, Heinanen and Gibson, 1990). The authors present a framework for the development of a Coastal Zone Management Plan for Belize (Appendix 1). Phase 1 of this framework entitled, ‘Data Collection and Compilation’, stresses the need to gather in-depth ecological, socio-economic and related information about the coastal zone .

3.2 - Aims of the Present Study

The aim of the present study was to gather practical data on the ecology of the area around South Water Cay, that would be of direct practical use in the future development and sustainable management of the marine resources in the area. Special attention has been paid to the commercially important species.

4 - PRELIMINARY SURVEYS

4.1 Methods

Initial surveys were carried out with three main aims in mind:-

- 1) To assess the overall condition of the reef and qualitatively compare it with previous experience.
- 2) To ascertain the local reef profile.
- 3) To identify survey sites representative of the different reef zones.

Survey lines consisting of 100m lengths of rope permanently marked off in 10m sections, were laid at the pre-designated sites on the reef. Lines were kept in place either by weights or by attachment to rocks. This was done in such a way as to avoid damaging the reef. Surface marker buoys at the end of the survey lines served as identification devices and avoided the use of anchors on the reef itself.

These preliminary studies were conducted by the professional biologists on the team and those non-scientists with extensive reef-diving experience.

4.2 Results - A General Description of the Study Area

South Water Cay is a narrow island approximately 500m by 100m made of reef rubble and sand. It is separated from the mainland by a deep and wide lagoon (Figure 1). Close to the cays, the lagoon shallows to form sea grass beds, patch reefs and mangrove cays. Immediately west of the island is the back reef. This is a shallow area consisting largely of mud, sand and coral fragments varying in depth from 0.5m to 1m. It is banded on the island side by a narrow mangrove stand. The narrow intertidal reef crest separates the back reef from the inner fore reef. It is open to the full force of wave action and characterised by coral debris. The inner fore-reef slopes down from a depth of a few meters to the outer fore reef at about 15m. This is separated from a steep inner reef ridge, by a narrow stretch of sand at 30m. The ridge climbs back to 15m before dropping off into the abyss. Figure 2 shows a representative reef profile.

The six chosen sites corresponded to the lagoon, back reef, reef crest, inner fore-reef, outer fore-reef and drop-off. Lines were laid in a North-South orientation parallel to the island except at the drop-off site, where a line was laid descending the reef to a depth of 50m in order to obtain depth profile data. Aerial photographs were taken (Figure 3) to show the position of the surface marker buoys on each survey line (photographs were kindly taken by the Royal Air Force).

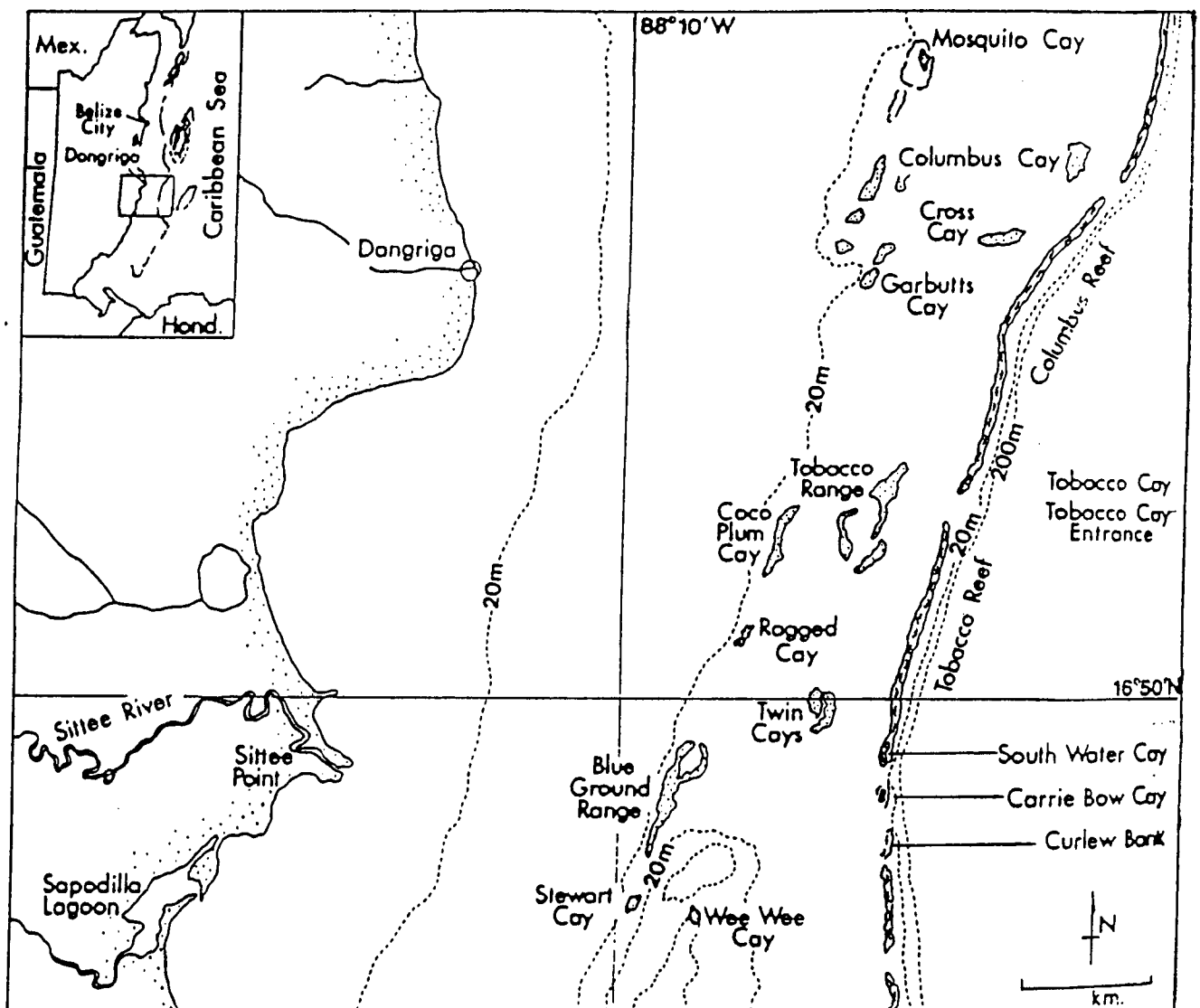


Figure 1

Map of the Survey Site, Showing the Position of South Water Cay in Relation to Mainland Belize.

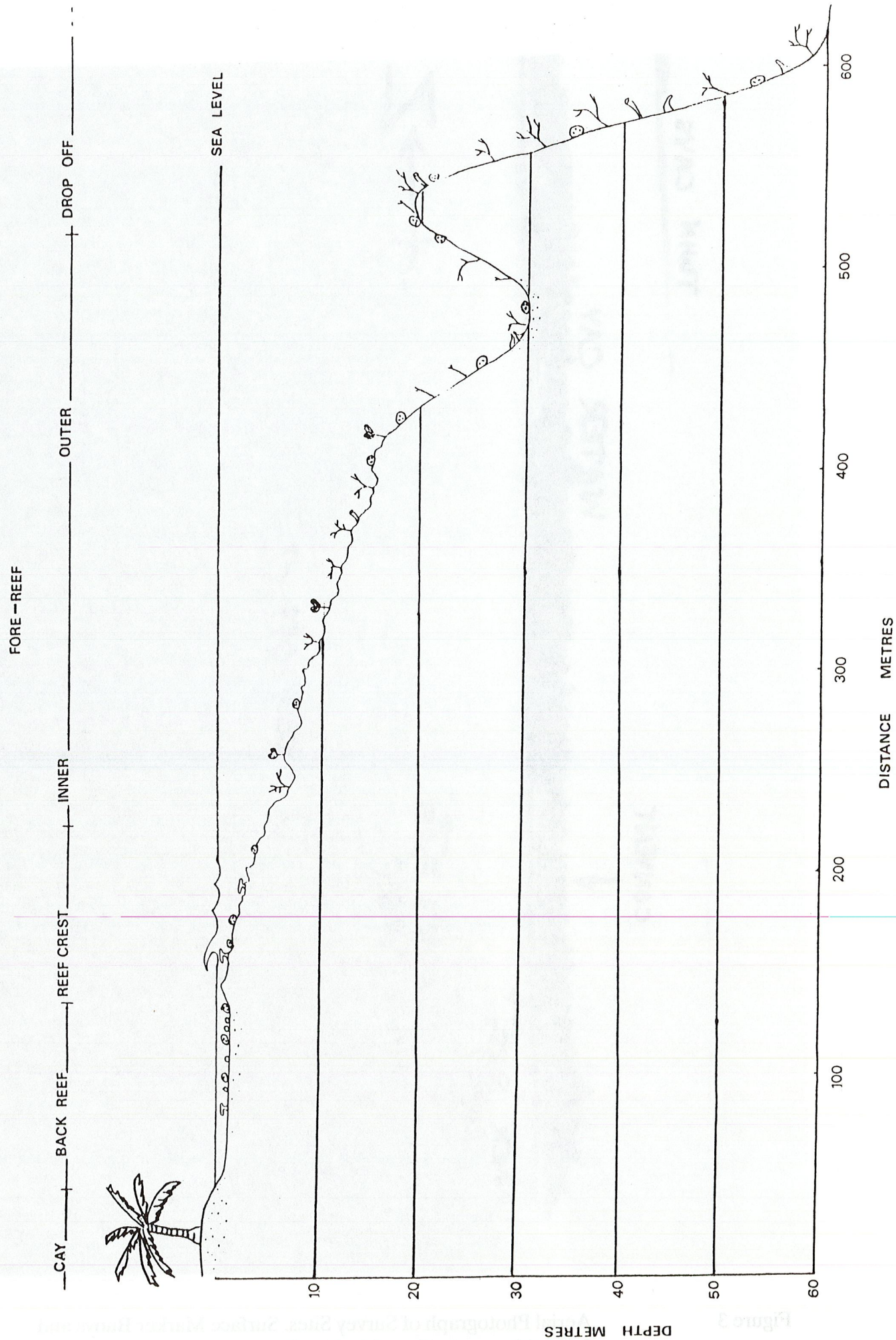


Figure 2

A Reef Profile Showing Positions of the Six Survey Sites

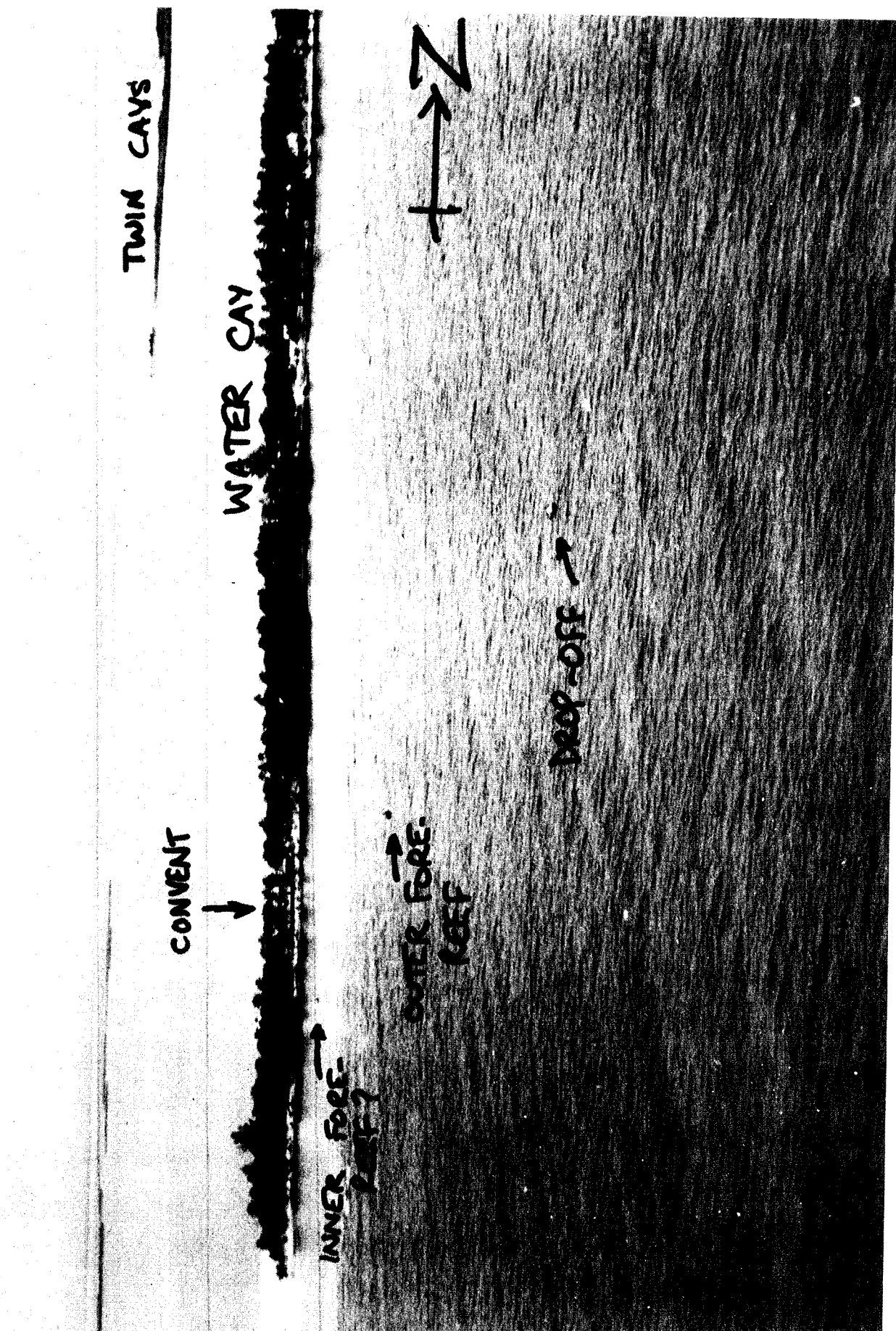


Figure 3

Aerial Photograph of Survey Sites. Surface Marker Buoys and Inflatables can be Seen Marking Positions of the Transects (Photograph - The RAF).

4 - CORAL COMMUNITIES

4.1 - Background

The zonation of the reef in the vicinity of South Water Cay has been described as being representative of the barrier reef as a whole and of sharing many similarities with the reefs of Jamaica (Burke, 1982). Rutzler and Macintyre (1982) have surveyed a transect across the northern end of the neighbouring Carrie Bow Cay.

4.2 - Methods

Surveys conducted adhered as closely as was practically possible to the recommendations laid out by the United Nations Environment Programme and the UNESCO Division of Marine Science (SPC/UNEP, 1984).

A detailed survey of the invertebrate species present along each survey line was carried-out in the following way. 1m aluminium quadrats were placed at 11 sites 10m apart along each survey line. A team of divers identified the species in each quadrat, recorded estimations of numbers, percentage cover and then mapped each quadrat on a writing tablet. Each quadrat was then photographed to provide a second permanent record of its contents. Organisms were identified, wherever possible to species if not to genus. When identification was not possible very small samples were taken for examination in the laboratory.

4.3 - Results

The results of surveying eleven 1m quadrats along each of the survey lines is presented in 4 ways.

A. Tables of percentage cover of species in each quadrat at each survey site - appendix 2.

B. Photographic records of each quadrat presented here as prints of negatives taken from colour transparencies - appendix 3.

C. Dendrograms showing percentage similarity between coral species and percentage similarity between all invertebrate species - Figures 4 & 5.

D. K-dominance curves for each survey site - Figure 6.

The coral, invertebrate and algae in each quadrat was assessed as a percentage cover. Data relating to species abundance (percentage cover) were assembled using a spreadsheet (supercalc 4). The dendrogram comparing the coral species at the different sites (Figure 4), was calculated using Sorensons index (Sorenson, 1948). Weighted faunal abundancies of all organisms at each site (Figure 5) was calculated after Green, Queen Mary and Westfield College University of London, UK.

The species present at each of the sites compares favourably with those described by Ruetzler and Macintyre (1982) for Carrie Bow Cay. The only major differences being the absence of mangrove and land separating the back reef area described by Ruetzler and Macintyre and the absence of the classical spur and groove reef structure on the South Water Cay fore reef

4.4 - Discussion

This study aims to both collect data on the marine resources around South Water Cay and also to analyse it in a manner that will be of use in the future management of these resources. In recent years the need to measure the effects of man-made disturbances on benthic marine communities has meant a move away from the use of established methods, such as the use of indicator species and laboratory-based toxicological studies, towards the measurement of longer term effects on growth and reproduction over several generations. Most recent studies have concentrated on designing methods to examine changes in multispecies assemblages over a long period of time (Mair et al 1987; Warwick 1988). Use of recently improved techniques available for group average sorting and multidimensional scaling (MDS), allow us to examine both spatially and temporally changes in community structures (Newell et al 1990a & b). These methods are particularly sensitive when used on data from a diverse assemblage structure, such as a coral reef.

The binary dendrogram presented in Figure 4 demonstrates the percentage similarity of the different survey sites measured in terms of the presence or absence of a particular species. The primary factors governing zonation across the reef profile, are thought to be depth and water movement (Ruetzler and Macintyre, 1982). The reef crest is under constant wave action and consequently its coverage is dominated by dead coral fragments. Its species compliments are very similar to that of the inner fore reef which shares a similar depth range. Species compliments can be seen to gradually change with increasing depth of survey site. The lagoon and back reef share both a low diversity and the absence of large numbers of coral species.

The weighted dendrogram in figure 5 takes into account the percentage cover of the coral species present and therefore reflects the success of individual coral species. Once again there appears to be a gradation in similarity with depth. However here the shallower transects show species assemblages that are more closely related. This method of presentation may reflect the role of exposure in shaping the coral community structures at different sites.

K - dominance curves, such as those presented in Figure 6 can act as a useful tool to measure small alterations in community structure. Species assemblages can be compared between sites along the reef to examine changes in community types. Perhaps more importantly, once baseline data has been gathered for a particular site, surveys can be quickly and regularly repeated to monitor the health of the site. Natural or anthropogenic alterations in a species assemblage can be detected by a change in the slope of the k-dominance curve. This method is potentially much more sensitive than other measures of community disturbance. Once a multispecies assemblage has been documented from a particular site, it

Figure 4

Binary Presence/Absence Dendrogram Comparing Species
Complements (Coral, Invertebrates, Algae).

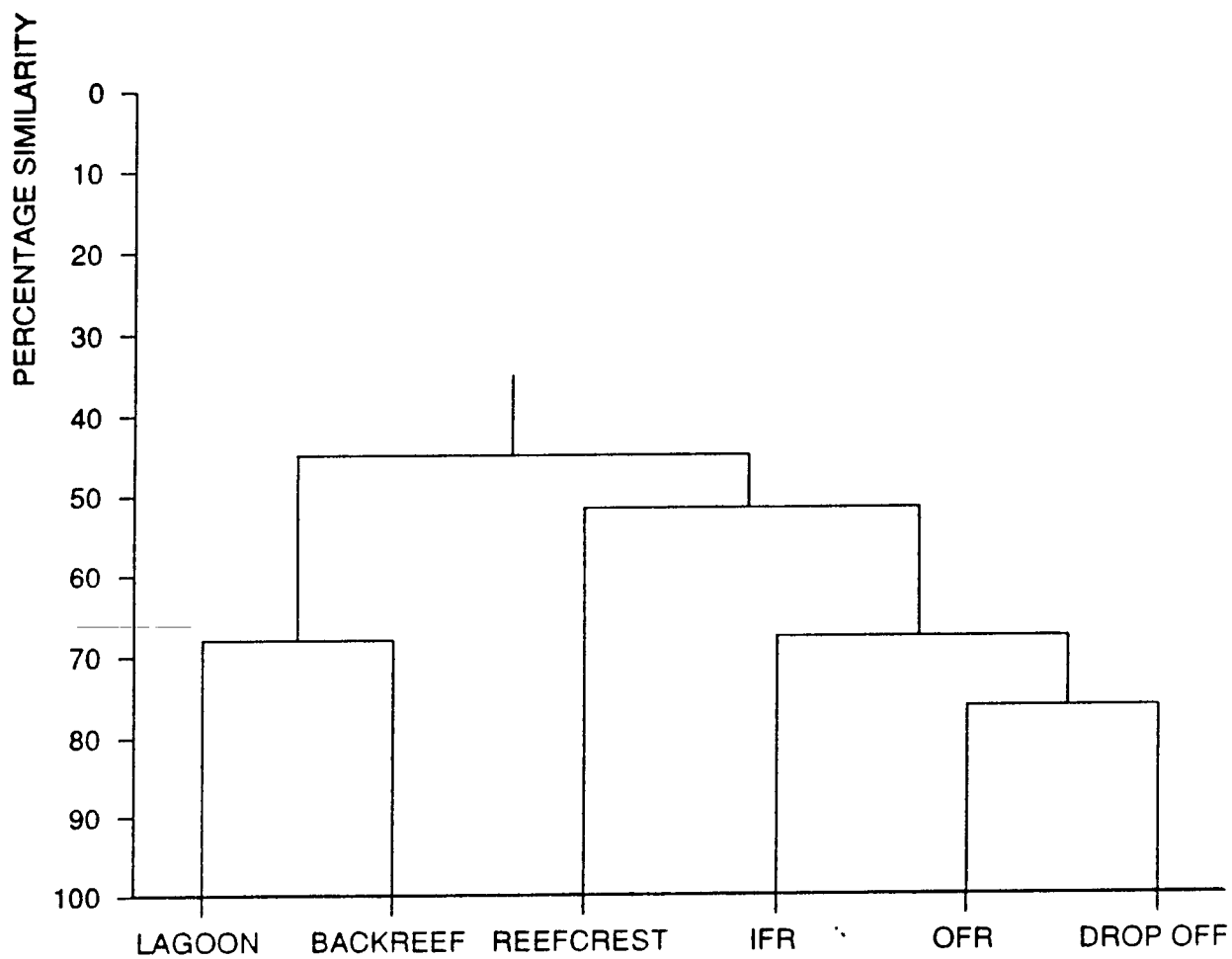
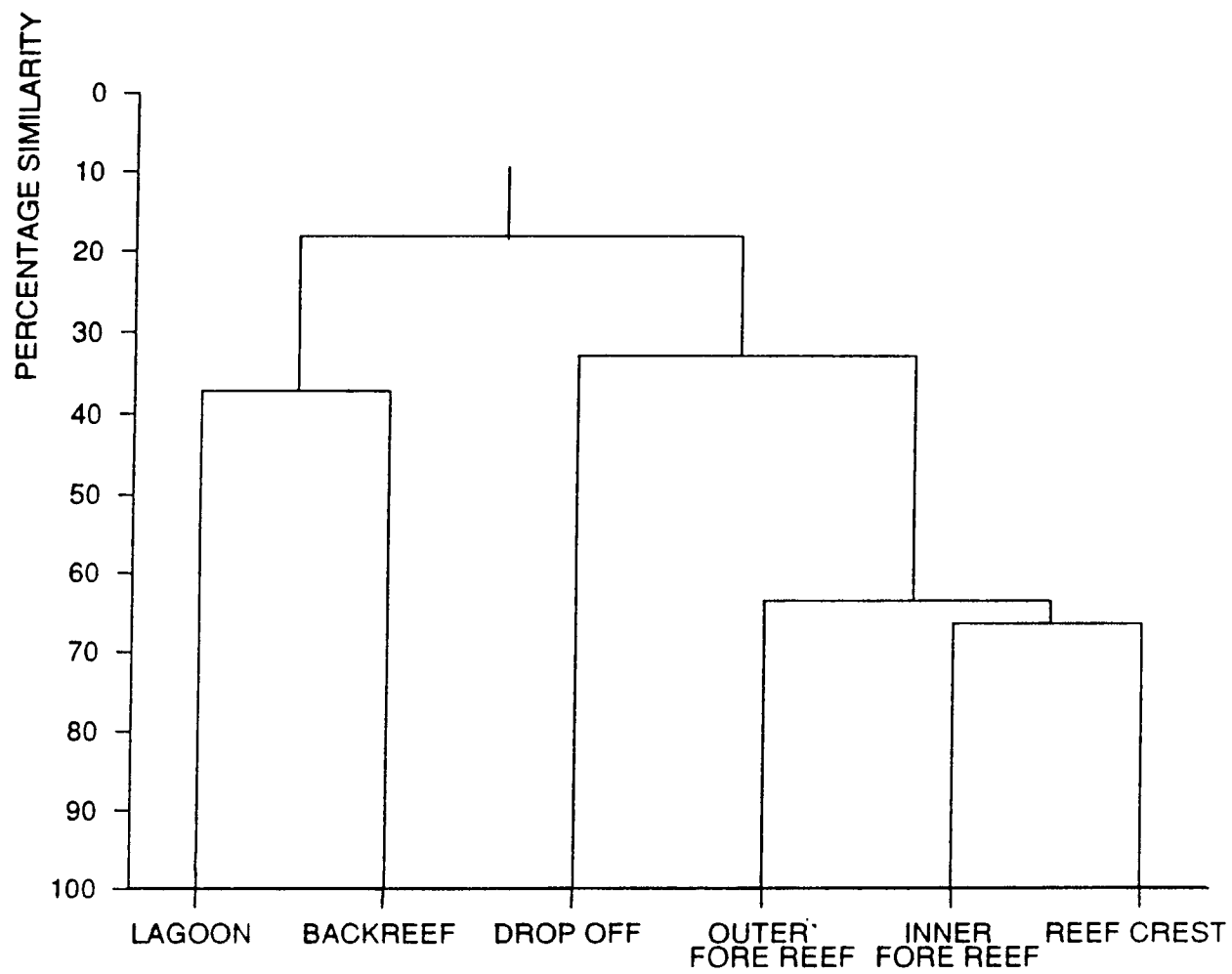


Figure 5

Weighted Dendrogram of Percentage Similarity of Coral Species



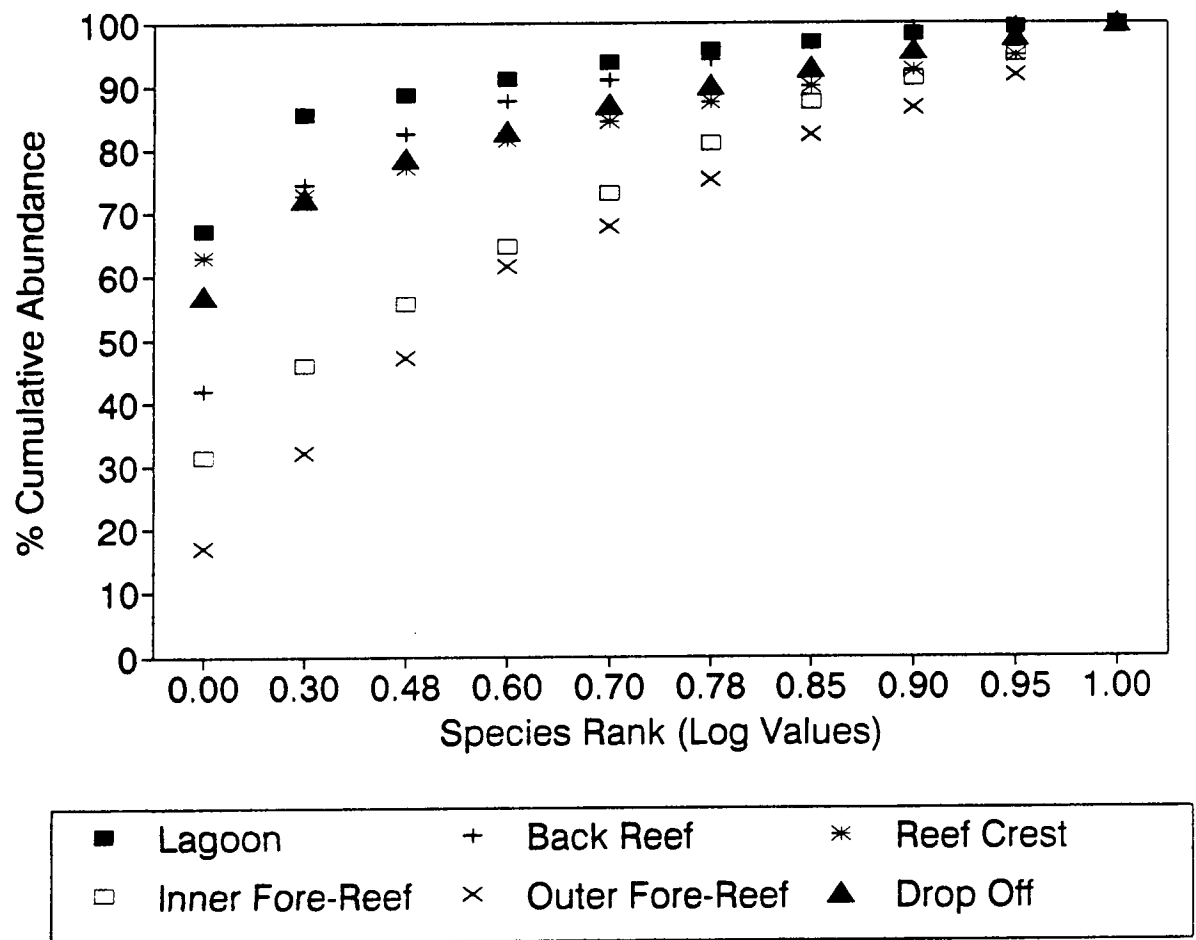
should be possible to monitor the community structure by counting only a small number of key species. Indeed, Warwick (1988), has suggested that discrimination to family level may be sufficient for the identification of the effects of pollution on benthic communities.

Figure 6 shows that the lagoon represents a community with a relatively low species diversity, dominated by sea grass (*Thalassia testudinum*). The lagoon, back reef and reef crest are all physically unstable environments exposed to high disturbance levels. Fluctuations in turbulence, temperature, salinity or increased silting, make these areas tough to live in. However they benefit from high light intensity and nutrient input. These areas, particularly the reef crest, are dominated by opportunistic species (r-selected). There is a gradual decrease in the importance of physical factors in the shaping of species assemblages as one moves down the fore-reef. The drop off zone may represent a climax community, dominated by k-selected species. The physical characteristics are stable and light intensity lower and competition between species plays the major role in shaping the community.

Future management strategies for this area would need to bear in mind, that the deeper k-selected species on the drop off, will have little tolerance for most forms of physical disturbance, particularly increased silting and the slow-growing species may not quickly replace the effects of physical damage. The shallow reef crest and inner fore reef areas whilst coping well with physical disturbance may be unstable in the longer term due to the relatively low densities of many coral species.

Figure 6

k-Dominance Curves for the Six Survey Sites



5 - FISH COMMUNITIES

5.1 - Background

Although the ichthyofauna of Belize has been well studied, very little is known about fish population sizes, species dynamics or community structure (Sedberry, 1989). An accurate knowledge of fish community structures can be a useful management tool in assessing changes in a particular area of reef. Staff at the Hol Chan Marine Reserve, Ambergris Cay, have initiated a fish community monitoring study that aims to measure differences in community structure between protected and unprotected areas (Barrick, 1990). It is therefore important to establish the baseline data necessary to institute a fish monitoring programme should similar developments take place in the South Water Cay area.

5.2 - Methods

Species lists for the fourteen major fish groups were drawn up based on initial observations, results of previous expeditions and available literature. Fish groups were then surveyed, two or three per survey dive. This limited the amount of learning necessary prior to each set of survey. The Groups were divided thus:-

- A - Butterflyfish, Damselfish and Angelfish
- B - Groupers, Triggerfish and Pufferfish
- C - Chromids and Surgeons
- D - Wrasses, Squirrelfish and Gobies
- E - Parrots, Grunts and Snappers

Buddy pairs of survey divers swam along the 100m survey lines, one on either side of the line. Divers recorded numbers of survey species for 2.5m on their side of the line and also the presence of any other species of interest in the area. 100m sweep of the survey line was treated as a single survey.

5.3 - Results

8878 fish were counted from 63 different species. Data collected for individual species is presented in Appendix 4. Data for commercially important species are discussed in section 6.3. Figure 7 shows the number of species observed at each survey site.

5.4 - Discussion

Sedberry (1990) and Barrick (1990) recently stressed the need for accurate assessments of the structure of fish communities for effective management of marine resources. Within the

complex ecology of the coral reef environment, fish play an important role in maintaining the integrity of the reef itself. The potential importance of herbivorous and corallivorous fish in controlling the distribution and abundance of reef building corals, has been studied by Littler et al (1988).

Both the above mentioned authors use the stationary visual census technique of Bohnsack and Bannerot, 1986 . The data from the present study has been presented in the same manner as that of Sedberry (1990) and Barrick (1990) and although comparisons can be made, it should be borne in mind that the survey techniques differ markedly.

As can be seen in Figure 7, the number of fish species present increases with depth from the reef crest out to the drop off. The drop off represents a particularly broad range of habitats from sandy bottomed at 30m up to climax coral community at 15m and then down the reef wall to 50m (see Figure 2). This is reflected in the number of species observed.

Overall numerical dominance in the lagoon area is displayed by the snappers, yellowtail followed by dog snappers. The back reef is particularly low in fish numbers partly due to the shallow depth and lack of protective cover. The dominant fish species here is the cocoa damselfish. Damselfish are also dominant at the reef crest, with the dusky damselfish the most abundant, closely followed by the bluehead wrasse. Surgeonfish are also well represented along this transect.

The three most abundant fish along the inner fore-reef are the dusky damselfish, yellowtail damselfish and the blue tang. On the outer fore-reef this changes to the threespot damselfish, bicolor damselfish and then the blue chromis.

At the drop off the dominant species is the creole wrasse followed by the bicolor damselfish and blue chromis.

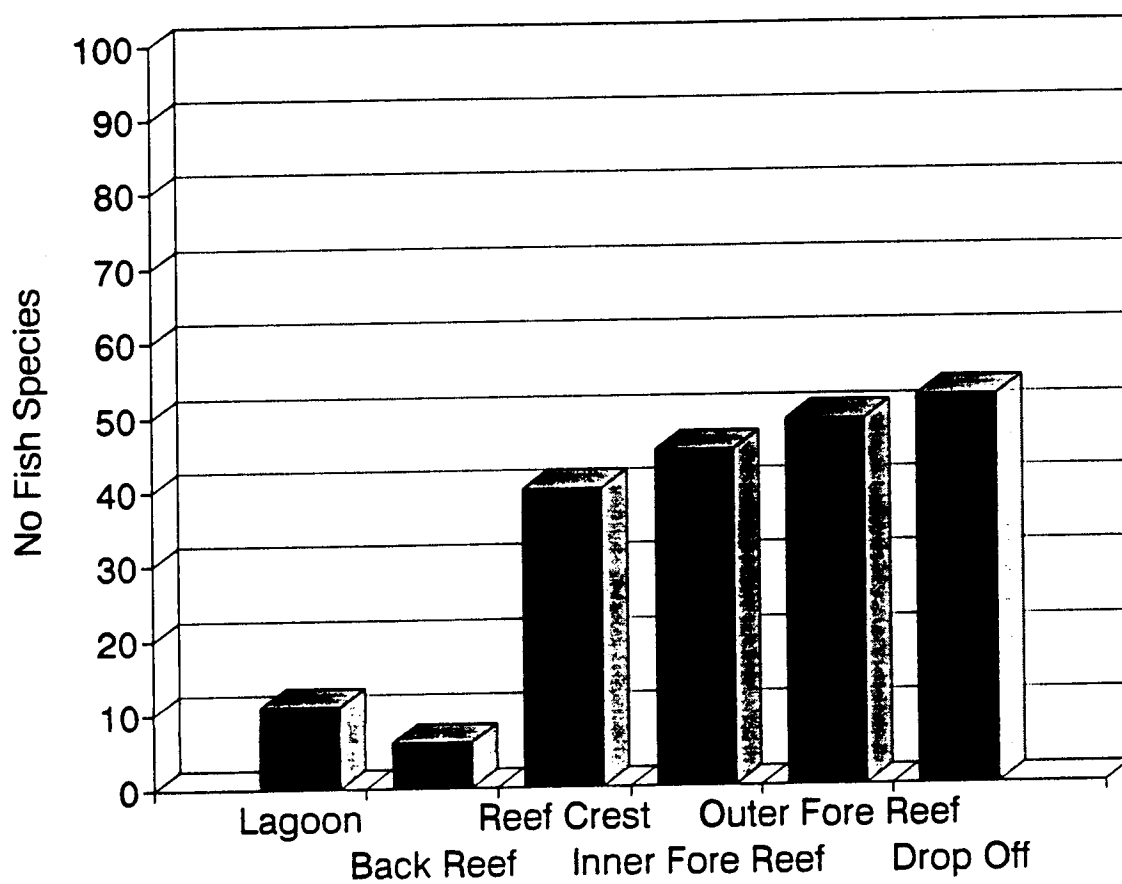
Sedberry (1990), working on the offshore atolls of Glovers Reef and Lighthouse Caye, pooled the results from surveys at different sites and ranked fish species in terms of overall dominance. He ranked the blue chromis, creole wrasse, bluehead wrasse, bicolor damselfish and brown chromis as the top five most abundant species. A similar treatment of results from the Ambergris Caye area ranked bluestriped grunt highest, followed by bluehead wrasse, bicolor damselfish then sergeant major (Barrick, 1990).

Over the six survey sites around South Water Cay, by far the most abundant species observed, is the dusky damselfish. This is followed by the threespot damselfish then the bicolor damselfish, creole and bluehead wrasses.

As Sedberry (1990) found on the atolls, the dominant species are small planktivorous and herbivorous species important at the base of the fish food pyramid. These act as a food supply for the larger, less abundant piscivores such as the grouper. Differences in the dominant fish species found at different sites are difficult to interpret. It has been suggested that chance colonisation may play the major role in determining the structure of a fish community (Sale, 1975). The value of these fish community structures lies in their use as a long-term monitoring tool to assess the health of a reef community. The data presented here represents important baseline information on which future monitoring programmes can be based.

Figure 7

The Number of Fish Species at the Six Survey Sites. Total Number of Species Observed is Plotted Against Survey Site.



6 - ECONOMICALLY IMPORTANT SPECIES

6.1 - Introduction

Surveys were carried out of those species previously identified as under threat.

Queen conch (*Strombus gigas*) and Spiny Lobster (*Panulirus argus*) were surveyed at three main sites around the island representing different habitat types: the inner fore reef, outer fore reef and lagoon. A survey area of 100 sq m was marked off using surface marker buoys. Groups of up to 15 divers or snorkellers, under the control of several marshalls, were assembled along one edge of the square. A 'sweep' was conducted across the area, numbers of lobster and conch were recorded and the size of conch measured. These surveys could only be carried out once at a minimum of sites due to the logistical and safety considerations involved in underwater survey work on this scale. The grouper were surveyed as part of the fish census.

6.1 - Conch

Background

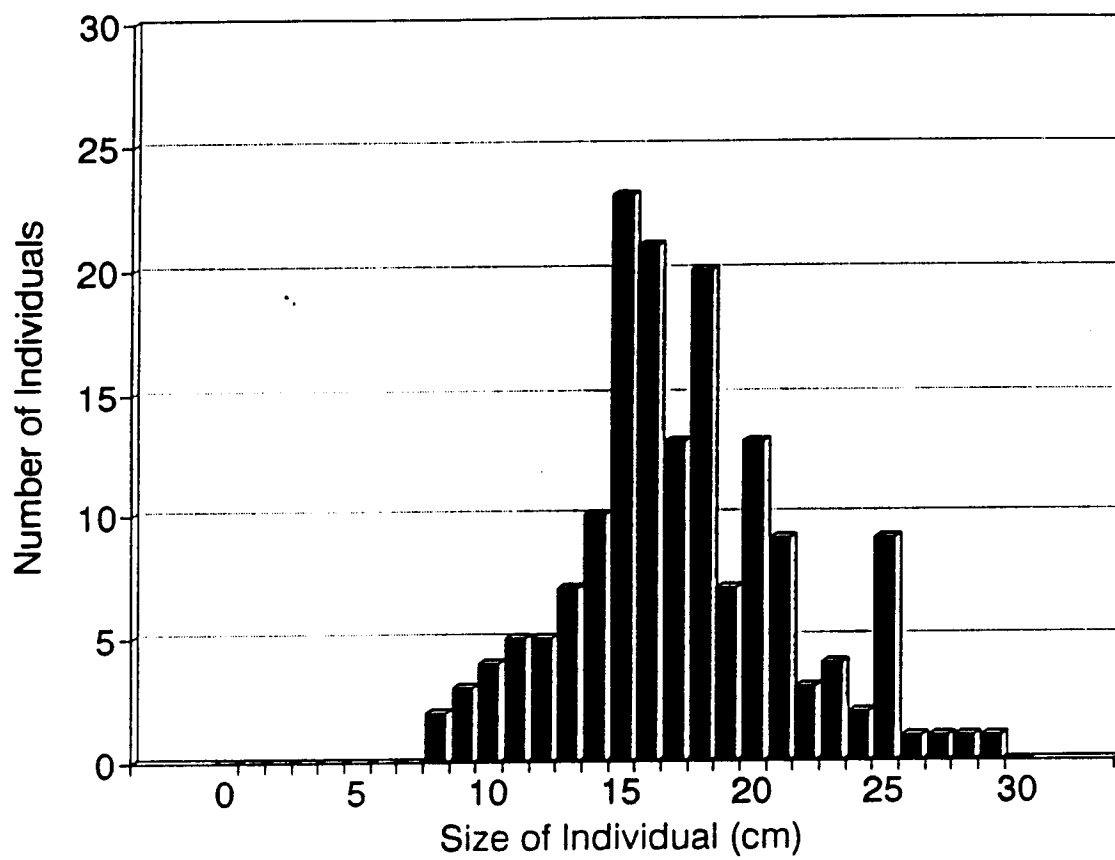
The Queen Conch, *Strombus gigas*, is native to the Caribbean and ranges from Bermuda to Venezuela. It has long been an important fishery in Belize. In 1972 the conch fishery exported a massive 1.2 Million lbs. Since then it has declined to the 1989 level of 250,000 lbs per year (Reyes 1990). The state of the Queen conch hatchery was recently reviewed by Strasdine (1988) as part of the International Development Research Centre (IDRC) Conch Project. Her findings and information from other sources, suggest that overfishing has severely depleted the natural stock populations and that the commercial viability of conch fishery is now under threat (Reyes 1989). As well as initiating a research programme (The Belize Fisheries Department/US-AID Conch hatchery Project), the Government has implemented certain control measures including a closed season during the breeding period, from July 1st until September 30th, and a minimum size requirement of 3 ounces meat weight and 17.8cm minimum limit on shell length. However, recent studies suggest that this current limit on shell length is less than the predicted size of first capture at which yield-per-recruit can be maximised (21.7cm) and that present regulations allow conch to be caught before they are able to reproduce (Strasdine, 1988).

Results

No conch were observed on either the inner or outer fore reef survey sites. 164 conch were observed in an area of turtle grass in the lagoon of 100 m². Figure 8 shows both the numbers of conch observed in the survey area and their size distribution.

Figure 8

The Size Distribution of Conch in the Lagoon



Discussion

The absence of Queen conch from both the inner and outer fore reef areas is perhaps not surprising. Whilst these molluscs are found on sandy beds close to reef areas, their preferred habitat is the turtle grass beds where they can graze on the microalgae found on *Thalassia* fronds. The size distribution of the conch population found in the lagoon, does raise cause for concern. Only 13.4% of the population are above the length of first capture suggested by Strasdine (1988) as being necessary to maximise the yield-per-recruit for the fishery. Similarly the majority of the population found in the South Water Cay Lagoon area are of a size which suggests that they are not yet reproductively mature.

6.2 - Spiny Lobster

Background

The spiny lobster *Panulirus argus* in Belize has been studied on several occasions, the most recent of which was an assessment of the condition of stocks, carried out by Glahout (1986) on behalf of the Belize Fisheries Department. He concluded that the lobster fishery was undergoing a period of rapid change. The average size of the lobster and catch per unit effort were decreasing whilst the number of fishermen, gear efficiency and capital investment in the industry were increasing. He also highlighted the need for more detailed information on all stages of the biology of the spiny lobster in Belize.

Results

Two mature lobster were recorded on the inner fore reef site, none on either of the other sites.

Discussion

The absence of spiny lobster in the lagoon is as one may have expected. Counts for the area of inner fore-reef are relatively low. These surveys were carried-out in the middle of the day when the nocturnal lobsters are difficult to find. The lifestyle of spiny lobsters make it difficult to find their daylight hiding places even for the experienced eye. The need for a sweep of divers to move together in formation inhibits the searching activities of individual divers. The results recorded may be underestimated due to these recording restraints. However, anecdotal evidence from expedition members with experience on previous Coral Cay Conservation studies in the area, suggest a general decrease in the numbers of lobster encountered.

6.3 - Grouper

Background

Together with snappers, groupers form the major portion of the commercial fish catch in this region of the Caribbean (Carter, 1989a). The flesh of the Nassau Grouper (*Epinephelus striatus*) is amongst the most highly prized of the commercially important fish species and its populations are suffering accordingly. A combined research and education programme is currently being carried out by Wildlife Conservation International. Initial studies have concentrated on the reproductive biology of the species. Nassau spawn between late December and mid-January in aggregations at a limited number of sites along the reef. These traditional aggregation sites have come under intensive fishing pressure, resulting in the removal of reproductively active individuals before they have a chance to spawn. More information is needed before the effects of these fishing activities can be fully documented, however as there is little evidence that these fish mate anywhere else other than these aggregation sites, large-scale harvesting can be assumed to be detrimental (Carter 1990).

Results

Table 1 shows the number of groupers observed at each of the survey sites. In a total of sixty survey dives, ten on each of the six sites, 48 sitings of grouper were recorded. Of these, 9 were of the Nassau. No assessment of the size of each fish was attempted.

Table 1 The Total Number of Grouper Observed at the Six Survey Sites (n=10).

	Lagoon	Back Reef	Reef Crest	Inner Fore-Reef	Outer Fore-Reef	Drop Off	Total
Nassau Grouper	0	0	2	1	3	3	9
Tiger Grouper	0	0	0	2	0	2	4
Black Grouper	0	0	3	0	1	1	5
Rockhind	0	0	2	1	0	3	6
Redhind	0	0	0	0	3	1	4
Coney	0	0	0	2	3	2	7
Graysby	0	0	0	2	11	0	13

Discussion

At the time of the year when these surveys were carried out, Nassau groupers of all sizes are territorial and lead a solitary existence (Carter, 1989b). The individuals encountered in repeat runs of these surveys are probably repeat sitings of the same individuals. Experiments with sonically tagged fish have revealed that Nassau exhibit peak activity immediately

after sunrise and just prior to sunset (Carter, 1990). The overall numbers recorded in the present studies may be underestimates as most surveys were conducted mid-morning and mid-afternoon. However, Barrick (1990) suggests that a swimming transect census, such as the one employed in this study, may be more accurate than a stationary census in assessing numbers of large predatory fish such as grouper. The majority of sitings being confined to the deeper waters of the outer fore reef/drop-off are consistent with the preferred habitats of these fish. Anecdotal evidence from expedition members who had surveyed in previous years suggested a decline in both size and number of the groupers in general.

8 - UNDERGRADUATE PROJECTS

Introduction

Several biology students on their final year of study, elected to conduct their honours projects as part of the Coral Cay Conservation research programme. Extensive planning and advice was taken as to feasibility and relevance of projects, before departure. Project reports were submitted for external examination as a significant part of BSc Honours Degree at the University of London.

8.1 - An examination of the size and sorting characteristics of sediment on the Belize Barrier Reef - J. Birkett

Sediment samples were taken from survey sites in the lagoon, back reef, reef crest, fore reef and on the Cay itself. Samples were dried, sieved and then the clay and silt fractions separated by disaggregation using Calgon. Sand samples were separated into particle size using six sieves and a range of the Wentworth scale. Carbonate constituents were determined using Alizarine Red for calcite and x-ray diffraction for aragonite. The sediment at South Water Cay was found to be bimodal with both Halimeda and coral grit sand present. The sediment shows subtle but not marked changes across the five zones. There is a grading in mean particle size along an east-west line, with the coarsest sediments being found further offshore. Size of particle size appears to depend on structural skeleton of the reef biota rather than wave energy of the particular zone and all samples examined appeared poorly sorted. Size distribution data is plotted each fraction as a % of the total sample and the mean size and standard deviation (sorting) for each sample calculated using the methodology of moments. The classification scale used by Folk (1974) is used. Results are compared with those of Folk (1974) in Mexico and Maxwell et al (1964) from Heron Island Australia.

8.2 - A study of meiofaunal assemblages around South Water Cay, Belize - S.J. Forster

Meiofaunal assemblages were examined from 11 sites on two transects between open coral sand and seagrass (*Thalassia testudinum*) beds. 18 invertebrate phyla were examined and 187 meiofaunal taxa identified. Of these 151 were nematode taxa, representing 32 families, of which Desmodoridae displayed an overall dominance. Differences in the composition of and feeding types of nematodes were found to correlate to particle size distributions and organic carbon contents of the sediments. Microbivorous and non-selective epigrowth feeders/diatomivorous feeders were abundant in the coarser sediments with low organic content. Multivariate (cluster) analyses of community data indicate the existence of major groups of assemblages related to both transect sampled and the position in relation to substrate types. Two new species are described.

8.4 The effect of bioerosion on the structural strength and stability of coral on the Belizian Barrier Reef. - A.G. Wood.

Methods adpted from those used by Highsmith et al (1983), were used to measure the bioerosional effects on 3 species of massive coral. *Montastrea annularis* was affected most extensively by boring followed by *Montastrea cavernosa*, *Porites astreoides* incurred the least damage due to bioerosion. A maximum amount of boring by sponges, bivalves, polychaetes, sipunculids and echinoids was found to occur at 20 metres depth. This relationship between bioerosion and depth is a significant departure from the work of Highsmith et al (1983). The subject of long term bioerosion of corals is discussed in the light of the present results.

8.5 An investigation into the distribution of Caribbean reef building corals, with specific reference to their nutritional requirements. - D.J. Woodward.

It has been postulated that polyp size of reef building corals is related to nutritional pressures. Larger polyps being more important at depth when corals place more reliance on capture of prey rather than photosynthesis (Porter, 1976). A study was conducted of the relationship between the diameter of the polyps of different coral species and the depths at which the respective corals were found. Polyp size increased with depth and larger polyped forms were generally favoured over the reef. Smaller polyped corals only dominated in the shallower waters of the reef crest. Results are discussed and compared with the literature, special attention is given to possible roles played by factors other than ambient light intensity on coral distributions.

8.6 - Marine Pollution Studies

A specific project was carried out to assess the environmental impact of expedition members on the meiofaunal assemblages of the back reef. 120ml sediment samples were collected using core samplers constructed from 55mm diameter PVC tubing. Samples were collected in the area surrounding the toilet facilities situated overhanging the back reef. Samples were fixed in the field laboratory using 5ml formaldehyde (40%, B.D.H., Poole, U.K.). Samples were brought back to the U.K. and await further analysis.

9 - CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The data gathered by the 1989 Coral Cay Conservation Expedition represents an important step in establishing baseline data for use in the future development and management of the marine resources in the South Water cay area.

Recommendations

DATA COLLECTION - It is vitally important for the future management of marine resources in Belize to have accurate data on the species and communities present in different areas. This data must be in a form that will be readily accessible and practically useful to future managers of these resources. Data collection from one particular area must therefore be directly comparable to that gathered elsewhere on the reef. Coral Cay Conservation is aware of this need for compatibility and proposes to liaise closely with governmental and Non-Governmental Organisations in Belize working on the marine environment. In particular:

Fish census: Coral Cay Conservation in future will adopt the visual census technique of Bonsack and Bannerot (1986) as used by: Hol Chan Marine Reserve, Jacques Carter, Patricia Barrick, George Sedberry etc. Thus allowing direct comparisons with data collected by other workers and making the information directly interpretable for future management decisions.

Coral Monitoring: Similarly Coral Cay Conservation will continue to develop their coral monitoring techniques with a view to establishing permanent monitoring sites in the South Water Cay area. Once again, this will be done in a manner that will be compatible with other techniques currently in use in Belize.

Commercially Important Species: Data collection must be aimed at feeding into the existing monitoring programmes.

10 - BIBLIOGRAPHY

- Barrick, P. (1990). Comparison of community fish structure - Ambergris cay. Proceedings of the International Coastal Resources Management Workshop, San Pedro, Ambergris Caye, Belize, 1989, pp 69-88.
- Bohnsack, J.A. and Bannerot, S.P. (1986). A stationary visual census technique for assessing community structure of coral reef fishes. NOAA Tch Rep. NMFS 41:15pp.
- Carter, J. (1990). Biology and management of the Nassau grouper in Belize, Central America. Proceedings of the International Coastal Resources Management Workshop, San Pedro, Ambergris Caye, Belize, 1989, pp 60-68.
- Coxon, C. (1986). Coral Cay Conservation Expedition Report.
- Coxon, C. (1987). Coral Cay Conservation Expedition Report.
- Carter, J. Grouper mating ritual on a Caribbean reef (1990). Underwater Naturalist 17(1):8-11.
- Dahl, A.L., Macintyre, I.G., Antonius, A. (1974). A comparative survey of coral reef research sites. In, M.H. Sachet and A.L. Dahl, eds, Comparative Investigations of Tropical Reef Ecosystems: Background for an integrated coral reef program Atoll Res Bull 172:37-120.
- Folk, R.L. (1974). 'Petrology of Sedimentary Rocks'.
- Folk, R.L. (1962). Sorting of some carbonate beaches in Mexico. Trans New Y Acad Sci ser II 25:222-224.
- Glaholt, R.D. (1986) Belize spiny lobster stock assessment and management plan.
- Highsmith, R.C., Leuptow, L., Schonberg, S.G. (1983). Growth and erosion of 3 massive corals on the Belize barrier reef. Marine Ecology.
- James, N.P., Gainsburg, R.N., Marszalek, D.S., Choquette, P.W. (1976). Facies and fabric specificity of early subsea sediments in shallow Belize (British Honduras) reefs. J Sed Petrol 46:523-544.
- Littler, M.M., Taylor, P.R. and Littler, D.S. (1989). Complex interactions in the control of coral zonation on a Caribbean reef flat. Oecologia 80:331-340.
- Mair, J., Matheson, I., Appelbee, J.F. (1987). Offshore macrobenthic recovery in the Murcheson Field following the termination of drill-cutting discharges. Mar Pollut Bull 18:628-634.
- Maxwell, W.G.H., Jell, J.S., McKellar, R.G. (1964). Differentiation of carbonate sedimentation in the Heron island Reef. J Sed Petrol 34(2):294-308.

Newell, P.F., Newell, R.C., Trett, M.W. (1990a). Environmental impact of an acid-iron effluent on macrobenthic and macrofaunal assemblages of the St Lawrence River. *The Science of the Total Environment* 97/98:771-781.

Newell, R.C., Newell, P.F., Trett, M.W. (1990b). Assessment of the impact of liquid wastes on benthic faunal assemblages. *The Science of the Total Environment* 97/98:855-867.

Perkins, J. (1983). *The Belize Barrier Reef Ecosystem: an assessment of its resources, conservation status and management*. New York Zoological Society.

Perkins, J.S., Carr III, A. (1985). The Belize Barrier Reef: Status and prospects for conservation management. *Biological Conservation* 31:291-301.

Price, A.R.G., Heinanen, A.P., Gibson, J.P., Young, E.R. (1990). Guidelines for developing a coastal zone management plan for Belize.

Reyes, L. (1990). Status of the conch hatchery in Belize. *Proceedings of the International Coastal Resources Management Workshop, San Pedro, Ambergris Caye, Belize, 1989*, pp 57-59.

Rutzler, K., Macintyre, I.G. (1982). *The Atlantic Barrier Reef Ecosystem at Carrie Bow cay, Belize I*. Smithsonian Contributions to Marine Science 12, Smithsonian Institution Press.

Sale, P.F. and Dyahl, R. (1975). Determinants of community structure for coral reef fishes in an experimental habitat. *Ecology* 56(6):1345-1355.

Sedberry, G. (1990). Comparison of fish populations of two Belize atolls. *Proceedings of the International Coastal Resources Management Workshop, San Pedro, Ambergris Caye, Belize, 1989*, pp 89-104.

SPC/UNEP (1984). *Coral reef monitoring handbook. Reference Methods for Marine Pollution Studies* 25, UNEP 1984.

Stoddart, D.R. (1962a). Three Caribbean Atolls: Turneffe Islands, Lighthouse Reef and Glover's Reef, British Honduras. *Atoll Res Bull* 87:1-151.

Stoddart, D.R. (1962b). Catastrophic storm events on the British Honduras reefs and cays. *Nature* 196:512-515.

Stoddart, D.R. (1963). Effects of Hurricane Hattie on the British Honduras reefs and cays, October 30-31, 1961. *Atoll Res Bull* 95:1-142.

Stoddart, D.R. (1969). Post hurricane changes on the British Honduras reefs and cays: re-survey, 1965. *Atoll Res Bull* 131:1-31.

Stoddart, D.R. (1974). Post hurricane changes on the British Honduras reefs and cays: re-survey, 1972. In, A.M. Cameron, B.M. Campbell, A.B. Cribb, R. Endean, J.S. Jell, O.A. Jones, P. Mather and F.H. Talbot, eds *Proceedings of the Second International Coral Reef Symposium*, 2:473-483.

Strasdrine, S.A. (1988) The queen conch fishery of Belize: an assessment of the resource, harvest sector and management.

Thorpe, J.E. and Stoddart, D.R. (1962). Cambridge Expedition to British Honduras. Geography Journal 128:158-171.

UNEP/IUCN (1988). Coral Reefs of the World Volume I: Atlantic and Eastern Pacific.

Wantland, K.K. and Pusey III, W.C. (1975). Editors of Belize Shelf-Carbonate Sediments, Clastic Sediments and Ecology. The American Association of Petroleum Geologists, Studies in Geology 2:599pp. Tulsa Oklahoma.

Warwick, R.M. (1988). The level of taxonomic discrimination required to detect pollution effects on marine benthic communities. Mar Pollut Bull 19:259-268.

11 - APPENDICES

APPENDIX 1

LIST OF SPONSORS - 1989

The British Sub-Aqua Club Jubilee Trust	£1500.00
The Royal Geographical Society	£500.00
University of Wales	£1000.00
Ove Arup Partners	£500.00
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Outboard Marine (UK)	"
Scout Shops	"

APPENDIX 2

SPECIES	LAGOON	BACK REEF	REEF CREST	INNER FORE-REEF	OUTER FORE-REEF	DROP OFF
CORAL						
Acropora cervicornis	0	0	1.2	0	3.7	0
Acropora palmata	0	0	2.5	10.6	0.5	0
Acropora sp.	0	0	0	0.2	0	0
Agaricia agaricites	0	0.2	0	0.5	0	0.2
Agaricia grahamae	0	0.4	0	0	0	0.4
Agaricia sp.	0	2.5	5.6	3.1	3.9	2.7
Agaricia tenuifolia	0	2.5	2.4	0.2	0.8	2.8
Briareum asbestinum	0	0.3	0	0	0	0
Dead coral	0	0	35.8	0.8	4.4	0
Dichocoenia stokesi	0	0	0.7	0.4	0	0
Diploria clivosa	0	0	0.1	0.5	0.1	0
Diploria labyrinthiformis	0	0	0.7	0.5	0	0
Diploria sp.	0	0	0	0.3	1.3	0
Diploria strigosa	0	0	0.3	0.5	1.1	0
Favia fragum	0	0.5	0.1	0.4	0.1	0
Gorgonia mariae	0	0	0	0	0.1	0
Gorgonia sp.	0	0	0.3	2.5	3.9	1
Gorgonia ventalina	0	0.9	0	0.1	0.2	0
Isophylla sinuosa	0	0	0.1	0.2	0.2	0
Madracis mirabilis	0	0	0	0	0.2	0
Millepora complanata	0	0.1	1.4	3.3	0.7	0
Montastraea annularis	0	0	0.2	4.9	1	0
Montastraea cavernosa	0	1.1	0	0.1	1.9	1.2
Montastraea sp.	0	0.1	0.5	0	0	0.1
Muricea pinnata	0	0	0	0	0.4	0
Mussa angulosa	0	0	0	0.1	0	0
Mycetophylla aliciae	0	0.1	0	0	0	0.6
Plexaura homomalla	0	0	0	0	0.1	0
Porites astreoides	0	0	1.6	0.3	0.4	0
Porites divaricata	0	0.3	0	0	0	0
Porites porites	0.1	1.7	0	2	1.2	1.1
Pseudogorgonia	0	0	0	0.5	0	0
Pseudopterorgia sp.	0	0	0.1	0.1	1.6	0
Scolymia lacera	0	0.1	0	0	0	0.1
Siderastrea radians	0	1.2	0	0.5	1.3	1.3
Siderastrea sidera	0	2	0	1.2	0	0.3
Siderastrea sp.	0	3.7	0.2	0	1.3	4.1
Stichopathes lutkeni	0	0	0	0	0	0.1
INVERTEBRATES						
Agelus sp.	0	0	0	0	0.1	0
Ascidian	0.1	0.1	0	0	0	0.1
Cyphoma gibbosum	0	0	0	0	0.1	0
Echinometra lacunter	0	0	0	0.1	0.1	0
Echinometra viridis	0	0	0.1	0.1	0	0
Eupolymnia nebulosa	0	0	0	0.1	0	0.1
Halidona rubens	0	0.1	0	0	0	0.1
Ircinia strobilina	0.1	0.1	0	0	0	0.1
Lytechinus williamsi	0	0	0.1	0	0	0
Mycale laevis	0	0	0	0	0.1	0.3
Ophiothrix suensoni	0.1	1.6	0	0.1	0	0.1
Pagurus sp.	0.1	0.1	0	0	0	0.1
Phymanthus crucifer	0	0.5	0	0	0	0
Ricordea florida	0	0	0	0	0.2	0
Sabellastarte magnifica	0.1	0.1	0	0	0	0.1
Spirobranchus giganteus	0	0.1	0.1	0.1	0	0
Stenorhynchus seticornis	0.1	0.1	0	0.3	0	0
Stomatopoda sp.	0	0.1	0	0	0	0
Tridachia crispata	0	0	0.1	0	0	0
Verongia fistularis	0	0	0	0	0	0.1
Verongia lacunoso	0	0	0	0	0.1	0
Verongia longissima	0	0.5	0	0	0	0.1

SPECIES	LAGOON	BACK REEF	REEF CREST	INNER FORE-REEF	OUTER FORE-REEF	DROP OFF
ALGAE						
Amphiroa brasiliiana	0	0.8	0.8	0.2	0	0
Amphiroa fragilissima	0.9	0	0	0	0	1
Amphiroa rigida	0	0.1	0	0	0	0
Amphiroa sp.	0	0.6	0	0	0	0
Amphiroa tribulus	0	0.1	0.1	0	0	0
Avrainvillea sp.	0.3	0.9	0	0	0	0.3
Caulerpa cupressoides	0	0.1	0	0	0	0
Caulerpa racemosa	0	0	0.2	0	0	0
Caulerpa sp.	0	0.8	0.5	0	0	0.7
Centroceras clavatum	0	0.1	0.2	0.5	0	0
Ceramium sp.	0	0	0	0	0.2	0
Chamaledoris penicillum	0	0.1	0	0	0	0.1
Cladophora prolifera	0	0	0	0.1	0	0
Coelthrix irregularis	0	0.2	0.4	0	0	0
Corallina sp.	0.3	1.3	0	0	0.2	0
Cymopolia barbata	0	0	1	0	0	
Derbesia sp.	0	0		0	0	
Dictyopteris delicatula	0	0.3		1	0	0
Dictyosphaeria cavernosa	0	1.5		0.3	0	0
Dictyota divaricata	0	2.9		0.1	0	0.3
Dictyota linearis	0.1	0.3	0	0	0.6	0.1
Dictyota sp	0	0.1	0.2	0.4	0	0
Dudresnaya crassa	0	0.1	0	0	0	0.1
Galaxaura sp.	0	0	0	0	2	0
Galaxaura subverticillata	0	0	0	0.1	0	0
Gelidium pusillum	0	0	0.3	0	0	0
Halimeda copiosa	0.5	0.8	0	0.2	0	0.9
Halimeda discoidea	0	0	0.1	0	0.2	0.3
Halimeda goreauii	0	0.3	0.8	0.1	0	1.9
Halimeda incrassata	0.6	5.8	0	0	0	0
Halimeda opuntia	0.4	3.6	0.3	2.7	0.8	0.2
Halimeda sp.	0	0	0	1.4	1.8	0
Halimeda tuna	0	0.2	0.5	0.2	0	0.9
Halymenia duchassaingii	0	0.1	0	0	0	0.2
Hydrolithon boergeresii	0	0.1	0	0.3	0	0
Hypnea sp.	0	0.1	0	0	0	0
Kallymenia sp.	0	0	0	0.1	0	0
Laurencia papillosa	0	0.3	0	0	0	0
Lobophora variegata	0	0	0.1	0	0.3	1
Meristiella echinocarpum	0.1	0.8	0	0	0	0.1
Microdictyon marinum	0	0.2	0	0	0	0
Neogoniolithon strictum	0	0	0.4	0.2	0	0
Penicillus capitatus	0.2	0.1	0	0	0	0.2
Penicillus dumetosus	0.1	0.9	0	0	0.2	0
Penicillus pyriformis	0	0.1	0	0	0	0.1
Peyssonnelia sp.	0	0.1	0.1	0	0	0
Rhypocephalus phoenix	0	0	0	0.5	0	0
Rhypocephalus sp.	0	0	0	0.1	0	0
Rosenvingea sanctae-crucis	0	0.2	1.5	0.8	1	1.5
Sargassum hystrix	0	0.1	0	0	0	0.2
Sargassum pliceratium	0	0.2	0.1	0	0	0
Syringodium filiforme	9.1	33.6	0	0	0	10
Thalassia testudinum	33.6	46.8	0	0	0	37
Turbinaria turbinatus	0	0	0	0	0.1	0
Udotea cyathiformis	0	0	0	0	0.1	0
Udotea flabellum	0.7	0.1	0	0	0	0.8
Valonia macrophysa	0	0.2	0	0	0	0
Valonia ventricosa	0	0	0	0	0.1	0
Wrangelia argus	0	0	0.1	0.2	0	0

APPENDIX 3

APPENDIX 4

FISH SURVEYS FOR THE LAGOON (n=10)

	MEAN No	% TOTAL	FREQ	(%)
	FISH	FISH		FREQ
DAMSELFISH				
Sergeant Major	0.0	0.0	0	0
Yellowtail Damselfish	0.0	0.0	0	0
Honey Damselfish	0.0	0.0	0	0
Duskey Damselfish	0.0	0.0	0	0
Cocoa Damselfish	0.0	0.0	0	0
Bicolor Damselfish	0.0	0.0	0	0
Threespot Damselfish	0.1	1.1	1	10
Beaugregory	0.2	2.2	2	20
Sunshine Damselfish	0.0	0.0	0	0
BUTTERFLYFISH				
Foureye Butterflyfish	0.0	0.0	0	0
Reef Butterflyfish	0.0	0.0	0	0
Banded Butterflyfish	0.0	0.0	0	0
Longsnout Butterflyfish	0.0	0.0	0	0
Spotfin Butterflyfish	0.0	0.0	0	0
ANGELFISH				
Rockbeauty	0.0	0.0	0	0
Gray's Angelfish	0.1	1.1	1	10
French Angelfish	0.0	0.0	0	0
Queen Angelfish	0.0	0.0	0	0
Blue Angelfish	0.0	0.0	0	0
GROUPERS				
Nassau Grouper	0.0	0.0	0	0
Tiger Grouper	0.0	0.0	0	0
Black Grouper	0.0	0.0	0	0
Rockhind	0.0	0.0	0	0
Coney	0.0	0.0	0	0
Redhind	0.0	0.0	0	0
Graysby	0.0	0.0	0	0
Red Grouper	0.0	0.0	0	0

FISH SURVEYS FOR THE LAGOON (n=10)

	MEAN No FISH	% TOTAL FISH	FREQ	(%) FREQ
TRIGGERFISH				
Queen Triggerfish	0.0	0.0	0	0
Ocean Triggerfish	0.0	0.0	0	0
Black Surgeon	0.0	0.0	0	0
PUFFERFISH				
Sharpnose Pufferfish	0.2	2.2	2	20
Spiny Pufferfish	0.0	0.0	0	0
Purcupine Pufferfish	0.2	2.2	2	20
CHROMIDS				
Blue Chromis	0.0	0.0	0	0
Brown Chromis	0.0	0.0	0	0
SURGEONFISH				
Blue Tang	0.0	0.0	0	0
Ocean Surgeonfish	0.0	0.0	0	0
Doctorfish	0.0	0.0	0	0
WRASSE				
Bluehead Wrasse	0.5	5.5	3	30
Yellowhead Wrasse	0.0	0.0	0	0
Creole Wrasse	0.0	0.0	0	0
Slippery Dick	0.3	3.3	1	10
Clown Wrasse	0.0	0.0	0	0
SQUIRRELFISH				
Squirrel	0.0	0.0	0	0
Logjaw Squirrelfish	0.0	0.0	0	0
Dusky Squirrelfish	0.0	0.0	0	0
Longspine Squirrelfish	0.0	0.0	0	0

FISH SURVEYS FOR THE LAGOON (n=10)

	MEAN No FISH	% TOTAL FISH	FREQ	(%) FREQ
Blackbar Squirrelfish	0.0	0.0	0	0
GOBIES				
Neon Goby	0.0	0.0	0	0
PARROTFISH				
Queen Parrotfish	0.0	0.0	0	0
Blue Parrotfish	0.0	0.0	0	0
Rainboow Parrotfish	0.0	0.0	0	0
Redband Parrotfish	0.0	0.0	0	0
Midnight Parrotfish	0.0	0.0	0	0
Princess Parrotfish	0.0	0.0	0	0
Striped parrotfish	0.0	0.0	0	0
Grey Parrotfish	0.9	9.9	3	30
Stoplight Parrotfish	0.0	0.0	0	0
GRUNTS				
French Grunt	0.0	0.0	0	0
White Grunt	0.0	0.0	0	0
Bluestriped Grunt	0.1	1.1	1	10
Smallmouth Grunt	0.0	0.0	0	0
PorkFish	0.0	0.0	0	0
Spanish Grunt	0.0	0.0	0	0
SNAPPERS				
Yellowtail Snapper	4.8	52.7	6	60
Grey Snapper	0.0	0.0	0	0
Lane Snapper	0.0	0.0	0	0
Dog Snapper	1.7	18.7	1	10

FISH SURVEYS FOR THE BACK REEF (N=10)

	MEAN No	% TOTAL	FREQ	(%)
	FISH	FISH		FREQ
DAMSELFISH				
Sergeant Major	0.0	0.0	0	0
Yellowtail Damselfish	0.0	0.0	0	0
Honey Damselfish	0.3	3.9	1	10
Duskey Damselfish	1.0	15.7	3	30
Cocoa Damselfish	4.5	70.6	7	70
Bicolor Damselfish	0.0	0.0	0	0
Threespot Damselfish	0.0	0.0	0	0
Beaugregory	0.3	3.9	1	10
Sunshine Damselfish	0.0	0.0	0	0
BUTTERFLYFISH				
Foureye Butterflyfish	0.0	0.0	0	0
Reef Butterflyfish	0.0	0.0	0	0
Banded Butterflyfish	0.1	2.0	1	10
Longsnout Butterflyfish	0.0	0.0	0	0
Spotfin Butterflyfish	0.0	0.0	0	0
ANGELFISH				
Rockbeauty	0.0	0.0	0	0
Gray's Angelfish	0.0	0.0	0	0
French Angelfish	0.0	0.0	0	0
Queen Angelfish	0.0	0.0	0	0
Blue Angelfish	0.0	0.0	0	0
GROUPERS				
Nassau Grouper	0.0	0.0	0	0
Tiger Grouper	0.0	0.0	0	0
Black Grouper	0.0	0.0	0	0
Rockhind	0.0	0.0	0	0
Coney	0.0	0.0	0	0
Redhind	0.0	0.0	0	0
Graysby	0.0	0.0	0	0
Red Grouper	0.0	0.0	0	0

FISH SURVEYS FOR THE BACK REEF (N=10)

	MEAN No FISH	% TOTAL FISH	FREQ	(%) FREQ
TRIGGERFISH				
Queen Triggerfish	0.0	0.0	0	0
Ocean Triggerfish	0.0	0.0	0	0
Black Durgeon	0.0	0.0	0	0
PUFFERFISH				
Sharpnose Pufferfish	0.0	0.0	0	0
Spiny Pufferfish	0.0	0.0	0	0
Purcupine Pufferfish	0.0	0.0	0	0
CHROMIDS				
Blue Chromis	0.0	0.0	0	0
Brown Chromis	0.0	0.0	0	0
SURGEONFISH				
Blue Tang	0.0	0.0	0	0
Ocean Surgeonfish	0.0	0.0	0	0
Doctorfish	0.0	0.0	0	0
WRASSE				
Bluehead Wrasse	0.0	0.0	0	0
Yellowhead Wrasse	0.0	0.0	0	0
Creole Wrasse	0.0	0.0	0	0
Slippery Dick	0.0	0.0	0	0
Clown Wrasse	0.0	0.0	0	0
SQUIRRELFISH				
Squirrel	0.0	0.0	0	0
Logjaw Squirrelfish	0.0	0.0	0	0

FISH SURVEYS FOR THE BACK REEF (N=10)

	MEAN No	% TOTAL	FREQ	(%)
	FISH	FISH		FREQ
Dusky Squirrelfish	0.0	0.0	0	0
Longspine Squirrelfish	0.0	0.0	0	0
Blackbar Squirrelfish	0.0	0.0	0	0
GOBIES				
Neon Goby	0.0	0.0	0	0
PARROTFISH				
Queen Parrotfish	0.0	0.0	0	0
Blue Parrotfish	0.0	0.0	0	0
Rainboow Parrotfish	0.0	0.0	0	0
Redband Parrotfish	0.0	0.0	0	0
Midnight Parrotfish	0.0	0.0	0	0
Princess Parrotfish	0.2	3.9	2	20
Striped parrotfish	0.0	0.0	0	0
Grey Parrotfish	0.0	0.0	0	0
Stoplight Parrotfish	0.0	0.0	0	0
GRUNTS				
French Grunt	0.0	0.0	0	0
White Grunt	0.0	0.0	0	0
Bluestriped Grunt	0.0	0.0	0	0
Smallmouth Grunt	0.0	0.0	0	0
PorkFish	0.0	0.0	0	0
Spanish Grunt	0.0	0.0	0	0
SNAPPERS				
Yellowtail Snapper	0.0	0.0	0	0
Grey Snapper	0.0	0.0	0	0
Lane Snapper	0.0	0.0	0	0
Dog Snapper	0.0	0.0	0	0

FISH SURVEYS FOR REEF CREST (N=10)

	MEAN No FISH	% TOTAL FISH	FREQ	(%) FREQ
DAMSELFISH				
Sergeant Major	0.8	0.3	3	30
Yellowtail Damselfish	25.8	10.1	8	80
Honey Damselfish	0.6	0.2	4	40
Duskey Damselfish	53.1	20.9	8	80
Cocoa Damselfish	10.3	4.0	8	80
Bicolor Damselfish	0.6	0.2	2	20
Threespot Damselfish	3.0	1.2	7	70
Beaugregory	0.0	0.0	0	0
Sunshine Damselfish	0.6	0.2	3	30
BUTTERFLYFISH				
Foureye Butterflyfish	5.0	2.0	8	80
Reef Butterflyfish	0.0	0.0	0	0
Banded Butterflyfish	0.9	0.3	4	40
Longsnout Butterflyfish	0.0	0.0	0	0
Spotfin Butterflyfish	0.0	0.0	0	0
ANGELFISH				
Rockbeauty	0.0	0.0	0	0
Gray's Angelfish	0.8	0.3	3	30
French Angelfish	0.0	0.0	0	0
Queen Angelfish	0.0	0.0	0	0
Blue Angelfish	0.1	0.0	1	10
GROUPERS				
Nassau Grouper	0.2	0.1	2	20
Tiger Grouper	0.0	0.0	0	0
Black Grouper	0.3	0.1	2	20
Rockhind	0.2	0.1	2	20
Coney	0.0	0.0	0	0
Redhind	0.0	0.0	0	0
Graysby	0.0	0.0	0	0
Red Grouper	0.0	0.0	0	0

FISH SURVEYS FOR REEF CREST (N=10)

	MEAN No FISH	% TOTAL FISH	FREQ	(%) FREQ
TRIGGERFISH				
Queen Triggerfish	0.0	0.0	0	0
Ocean Triggerfish	0.0	0.0	0	0
Black Durgeon	0.0	0.0	0	0
PUFFERFISH				
Sharpnose Pufferfish	0.0	0.0	0	0
Spiny Pufferfish	0.0	0.0	0	0
Purcupine Pufferfish	0.2	0.1	2	20
CHROMIDS				
Blue Chromis	0.0	0.0	0	0
Brown Chromis	0.1	0.0	1	10
SURGEONFISH				
Blue Tang	25.6	12.6	10	100
Ocean Surgeonfish	18.7	9.2	10	100
Doctorfish	2.9	1.4	8	80
WRASSE				
Bluehead Wrasse	36.8	14.4	8	80
Yellowhead Wrasse	3.1	1.2	6	60
Creole Wrasse	0.1	0.0	1	10
Slippery Dick	0.0	0.0	0	0
Clown Wrasse	0.0	0.0	0	0
SQUIRRELFISH				
Squirrel	0.4	0.1	1	10
Logjaw Squirrelfish	0.0	0.0	0	0

FISH SURVEYS FOR REEF CREST (N=10)

	MEAN No	% TOTAL	FREQ	(%)
	FISH	FISH		FREQ
Dusky Squirrelfish	0.0	0.0	0	0
Longspine Squirrelfish	0.1	0.0	1	10
Blackbar Squirrelfish	0.0	0.0	0	0
GOBIES				
Neon Goby	0.9	0.3	0	0
PARROTFISH				
Queen Parrotfish	5.5	2.7	9	90
Blue Parrotfish	0.2	0.1	1	10
Rainboow Parrotfish	0.9	0.4	4	40
Redband Parrotfish	3.1	1.5	9	90
Midnight Parrotfish	0.0	0.0	0	0
Princess Parrotfish	8.3	4.1	8	80
Striped parrotfish	2.4	1.2	6	60
Grey Parrotfish	2.2	1.1	5	50
Stoplight Parrotfish	13.5	6.6	10	100
GRUNTS				
French Grunt	0.8	0.4	5	50
White Grunt	1.7	0.8	7	70
Bluestriped Grunt	0.8	0.4	5	50
Smallmouth Grunt	0.3	0.1	3	30
PorkFish	0.1	0.0	1	10
Spanish Grunt	0.0	0.0	0	0
SNAPPERS				
Yellowtail Snapper	1.2	0.6	6	60
Grey Snapper	0.1	0.0	1	10
Lane Snapper	0.0	0.0	0	0
Dog Snapper	0.0	0.0	0	0

FISH SURVEYS FOR INNER FORE REEF (N=10)

	MEAN No	% TOTAL	FREQ	(%)
	FISH	FISH		FREQ
DAMSELFISH				
Sergeant Major	4.9	2.5	10	100
Yellowtail Damselfish	28.7	14.7	10	100
Honey Damselfish	0.2	0.1	2	20
Duskey Damselfish	36.2	18.6	10	100
Cocoa Damselfish	11.0	5.6	10	100
Bicolor Damselfish	0.0	0.0	0	0
Threespot Damselfish	3.5	1.8	9	90
Beaugregory	0.0	0.0	0	0
Sunshine Damselfish	0.0	0.0	0	0
BUTTERFLYFISH				
Foureye Butterflyfish	4.7	2.4	9	90
Reef Butterflyfish	0.2	0.1	2	20
Banded Butterflyfish	0.2	0.1	1	10
Longsnout Butterflyfish	0.0	0.0	0	0
Spotfin Butterflyfish	1.6	0.8	3	30
ANGELFISH				
Rockbeauty	0.7	0.4	4	40
Gray's Angelfish	0.4	0.2	3	30
French Angelfish	0.0	0.0	0	0
Queen Angelfish	0.0	0.0	0	0
Blue Angelfish	0.0	0.0	0	0
GROUPERS				
Nassau Grouper	0.1	0.1	1	10
Tiger Grouper	0.2	0.1	1	10
Black Grouper	0.0	0.0	0	0
Rockhind	0.1	0.1	1	10
Coney	0.2	0.1	2	20
Redhind	0.0	0.0	0	0
Graysby	0.2	0.1	2	20
Red Grouper	0.0	0.0	0	0

FISH SURVEYS FOR INNER FORE REEF (N=10)

	MEAN No FISH	% TOTAL FISH	FREQ	(%) FREQ
TRIGGERFISH				
Queen Triggerfish	0.0	0.0	0	0
Ocean Triggerfish	0.0	0.0	0	0
Black Surgeon	0.7	0.4	4	40
PUFFERFISH				
Sharpnose Pufferfish	0.0	0.0	0	0
Spiny Pufferfish	0.0	0.0	0	0
Purcupine Pufferfish	0.0	0.0	0	0
CHROMIDS				
Blue Chromis	0.0	0.0	0	0
Brown Chromis	0.0	0.0	0	0
SURGEONFISH				
Blue Tang	25.9	13.3	10	100
Ocean Surgeonfish	3.6	1.8	7	70
Doctorfish	4.3	2.2	4	40
WRASSE				
Bluehead Wrasse	15.9	8.2	10	100
Yellowhead Wrasse	5.4	2.8	7	70
Creole Wrasse	0.0	0.0	0	0
Slippery Dick	0.0	0.0	0	0
Clown Wrasse	0.0	0.0	0	0
SQUIRRELFISH				
Squirrel	1.0	0.5	6	60
Logjaw Squirrelfish	0.2	0.1	1	10

FISH SURVEYS FOR INNER FORE REEF (N=10)

	MEAN No	% TOTAL	FREQ	(%)
	FISH	FISH		FREQ
Dusky Squirrelfish	0.5	0.3	4	40
Longspine Squirrelfish	2.0	1.0	7	70
Blackbar Squirrelfish	0.0	0.0	0	0

GOBIES

Neon Goby	5.0	2.6	6	60
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PARROTFISH

Queen Parrotfish	5.4	2.8	6	60
Blue Parrotfish	0.2	0.1	2	20
Rainboow Parrotfish	1.5	0.8	5	50
Redband Parrotfish	3.0	1.5	6	60
Midnight Parrotfish	0.0	0.0	0	0
Princess Parrotfish	6.2	3.2	7	70
Striped parrotfish	1.4	0.7	3	30
Grey Parrotfish	1.5	0.8	6	60
Stoplight Parrotfish	13.3	6.8	9	90

GRUNTS

French Grunt	0.6	0.3	2	20
White Grunt	0.3	0.2	2	20
Bluestriped Grunt	0.3	0.2	1	10
Smallmouth Grunt	0.1	0.1	1	10
PorkFish	0.0	0.0	0	0
Spanish Grunt	0.1	0.1	1	10

SNAPPERS

Yellowtail Snapper	2.5	1.3	3	30
Grey Snapper	0.5	0.3	2	20
Lane Snapper	0.1	0.1	1	10
Dog Snapper	0.3	0.2	1	10

FISH SURVEYS FOR OUTER FORE REEF (N=10)

	MEAN No	% TOTAL	FREQ	(%)
	FISH	FISH		FREQ
DAMSELFISH				
Sergeant Major	0.4	0.2	2	20
Yellowtail Damselfish	0.8	0.3	4	40
Honey Damselfish	0.1	0.0	1	10
Duskey Damselfish	14.8	5.6	10	100
Cocoa Damselfish	15.5	5.8	10	100
Bicolor Damselfish	28.2	10.6	10	100
Threespot Damselfish	47.9	18.0	10	100
Beaugregory	0.0	0.0	0	0
Sunshine Damselfish	0.4	0.2	0	0
BUTTERFLYFISH				
Foureyeye Butterflyfish	5.3	2.0	9	90
Reef Butterflyfish	0.0	0.0	0	0
Banded Butterflyfish	0.1	0.0	0	0
Longsnout Butterflyfish	0.0	0.0	0	0
Spotfin Butterflyfish	0.4	0.2	2	20
ANGELFISH				
Rockbeauty	2.1	0.8	8	80
Gray's Angelfish	0.5	0.2	3	30
French Angelfish	0.2	0.1	1	10
Queen Angelfish	0.3	0.1	2	20
Blue Angelfish	0.0	0.0	0	0
GROUPERS				
Nassau Grouper	0.3	0.1	1	10
Tiger Grouper	0.0	0.0	0	0
Black Grouper	0.1	0.0	0	0
Rockhind	0.0	0.0	0	0
Coney	0.3	0.1	0	0
Redhind	0.3	0.1	2	20
Graysby	1.1	0.4	5	50
Red Grouper	0.0	0.0	0	0

FISH SURVEYS FOR OUTER FORE REEF (N=10)

	MEAN No FISH	% TOTAL FISH	FREQ	(%) FREQ
TRIGGERFISH				
Queen Triggerfish	0.0	0.0	0	0
Ocean Triggerfish	0.0	0.0	0	0
Black Durgeon	0.0	0.0	0	0
PUFFERFISH				
Sharpnose Pufferfish	2.2	0.8	5	50
Spiny Pufferfish	0.0	0.0	0	0
Purcupine Pufferfish	0.0	0.0	0	0
CHROMIDS				
Blue Chromis	20.8	7.8	10	100
Brown Chromis	5.8	2.2	2	20
SURGEONFISH				
Blue Tang	8.6	3.2	10	100
Ocean Surgeonfish	2.0	0.8	7	70
Doctorfish	3.1	1.2	7	70
WRASSE				
Bluehead Wrasse	6.9	2.6	10	100
Yellowhead Wrasse	4.7	1.8	10	100
Creole Wrasse	11.1	4.2	3	30
Slippery Dick	0.0	0.0	0	0
Clown Wrasse	0.0	0.0	0	0
SQUIRRELFISH				
Squirrel	0.2	0.1	2	20
Logjaw Squirrelfish	0.1	0.0	1	10

FISH SURVEYS FOR OUTER FORE REEF (N=10)

	MEAN No	% TOTAL	FREQ	(%)
	FISH	FISH		FREQ
Dusky Squirrelfish	0.0	0.0	0	0
Longspine Squirrelfish	11.5	4.3	10	100
Blackbar Squirrelfish	0.0	0.0	0	0
GOBIES				
Neon Goby	6.8	2.6	8	80
PARROTFISH				
Queen Parrotfish	5.0	1.9	9	90
Blue Parrotfish	0.2	0.1	2	20
Rainboow Parrotfish	2.9	1.1	3	30
Redband Parrotfish	7.7	2.9	10	100
Midnight Parrotfish	0.3	0.1	1	10
Princess Parrotfish	18.7	7.0	10	100
Striped parrotfish	5.1	1.9	6	60
Grey Parrotfish	0.6	0.2	2	20
Stoplight Parrotfish	11.9	4.5	8	80
GRUNTS				
French Grunt	4.8	1.8	8	80
White Grunt	2.0	0.8	7	70
Bluestriped Grunt	1.4	0.5	4	40
Smallmouth Grunt	0.1	0.0	1	10
PorkFish	0.3	0.1	3	30
Spanish Grunt	0.0	0.0	0	0
SNAPPERS				
Yellowtail Snapper	1.6	0.6	4	40
Grey Snapper	0.0	0.0	0	0
Lane Snapper	0.1	0.0	1	10
Dog Snapper	0.0	0.0	0	0

FISH SURVEYS FOR DROP OFF (N=10)

	MEAN No	% TOTAL	FREQ	(%)
	FISH	FISH		FREQ
DAMSELFISH				
Sergeant Major	0.2	0.1	1	10
Yellowtail Damselfish	0.1	0.0	1	10
Honey Damselfish	2.0	0.9	4	40
Duskey Damselfish	8.6	3.7	8	80
Cocoa Damselfish	6.7	2.9	8	80
Bicolor Damselfish	39.7	17.0	10	100
Threespot Damselfish	24.3	10.5	10	100
Beaugregory	0.7	0.3	2	20
Sunshine Damselfish	2.0	0.9	2	20
BUTTERFLYFISH				
Foureye Butterflyfish	5.9	2.5	9	90
Reef Butterflyfish	0.0	0.0	0	0
Banded Butterflyfish	0.3	0.1	0	0
Longsnout Butterflyfish	0.4	0.2	4	40
Spotfin Butterflyfish	0.2	0.1	2	20
ANGELFISH				
Rockbeauty	1.0	0.4	5	50
Gray's Angelfish	0.6	0.2	3	30
French Angelfish	0.0	0.0	0	0
Queen Angelfish	0.0	0.0	0	0
Blue Angelfish	0.0	0.0	0	0
GROUPERS				
Nassau Grouper	0.3	0.1	1	10
Tiger Grouper	0.2	0.1	2	20
Black Grouper	0.1	0.0	1	10
Rockhind	0.3	0.1	3	30
Coney	0.2	0.1	2	20
Redhind	0.1	0.0	1	10
Graysby	0.0	0.0	0	0
Red Grouper	0.0	0.0	0	0

FISH SURVEYS FOR DROP OFF (N=10)

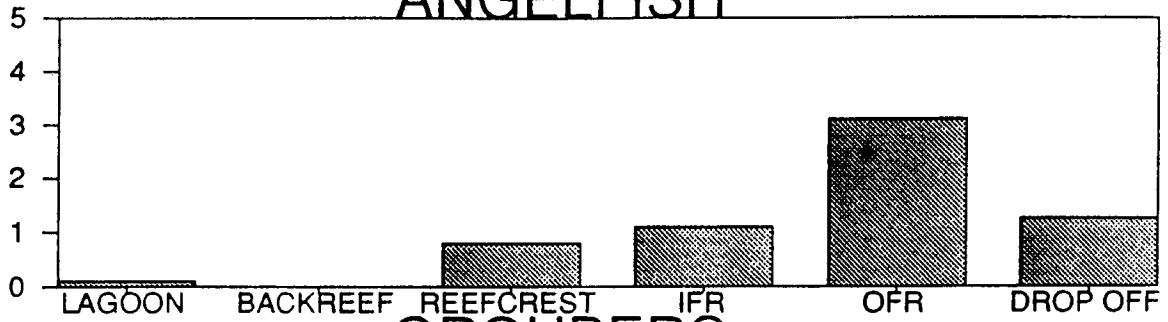
	MEAN No FISH	% TOTAL FISH	FREQ	(%) FREQ
TRIGGERFISH				
Queen Triggerfish	0.0	0.0	0	0
Ocean Triggerfish	0.0	0.0	0	0
Black Surgeon	0.0	0.0	0	0
PUFFERFISH				
Sharpnose Pufferfish	1.6	0.7	4	40
Spiny Pufferfish	0.0	0.0	0	0
Purcupine Pufferfish	0.0	0.0	0	0
CHROMIDS				
Blue Chromis	36.1	15.5	8	80
Brown Chromis	1.8	0.8	3	30
SURGEONFISH				
Blue Tang	4.6	2.0	6	60
Ocean Surgeonfish	2.2	1.0	3	30
Doctorfish	2.9	1.2	7	70
WRASSE				
Bluehead Wrasse	2.6	1.1	6	60
Yellowhead Wrasse	3.0	1.3	7	70
Creole Wrasse	56.7	24.3	7	70
Slippery Dick	0.0	0.0	0	0
Clown Wrasse	0.2	0.1	0	0
SQUIRRELFISH				
Squirrel	0.3	0.1	3	30
Logjaw Squirrelfish	0.4	0.2	3	30

FISH SURVEYS FOR DROP OFF (N=10)

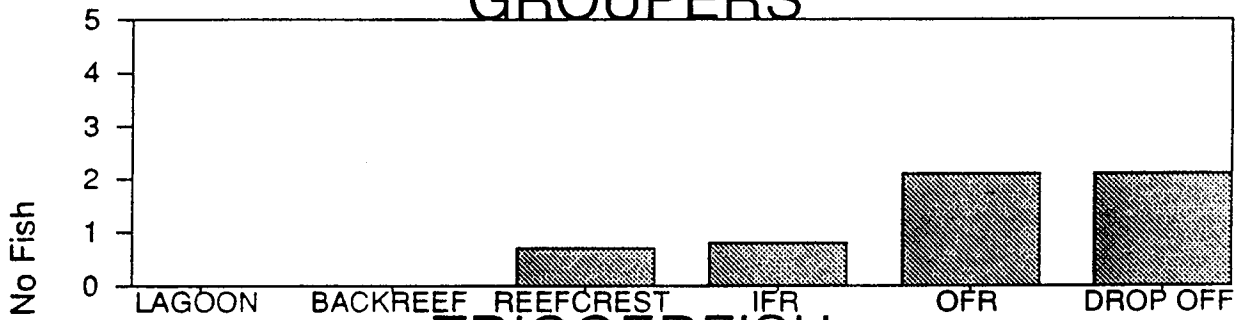
	MEAN No	% TOTAL	FREQ	(%)
	FISH	FISH		FREQ
Dusky Squirrelfish	0.1	0.0	1	10
Longspine Squirrelfish	1.7	0.7	7	70
Blackbar Squirrelfish	0.0	0.0	0	0
GOBIES				
Neon Goby	2.2	1.0	6	60
PARROTFISH				
Queen Parrotfish	0.4	0.1	2	20
Blue Parrotfish	0.3	0.1	1	10
Rainboow Parrotfish	0.3	0.1	1	10
Redband Parrotfish	0.9	0.3	4	40
Midnight Parrotfish	0.1	0.0	1	10
Princess Parrotfish	7.3	2.8	8	80
Striped parrotfish	2.5	1.0	3	30
Grey Parrotfish	0.1	0.0	1	10
Stoplight Parrotfish	1.9	0.7	5	50
GRUNTS				
French Grunt	1.4	0.5	6	60
White Grunt	1.1	0.4	5	50
Bluestriped Grunt	0.1	0.0	1	10
Smallmouth Grunt	0.8	0.3	4	40
PorkFish	0.4	0.1	3	30
Spanish Grunt	0.0	0.0	0	0
SNAPPERS				
Yellowtail Snapper	7.3	2.8	6	60
Grey Snapper	0.6	0.2	3	30
Lane Snapper	0.0	0.0	0	0
Dog Snapper	0.0	0.0	0	0

APPENDIX 5

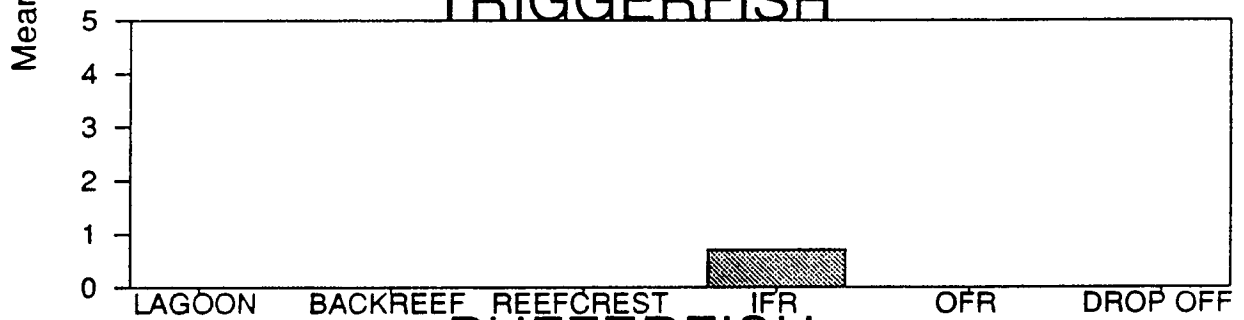
ANGELFISH



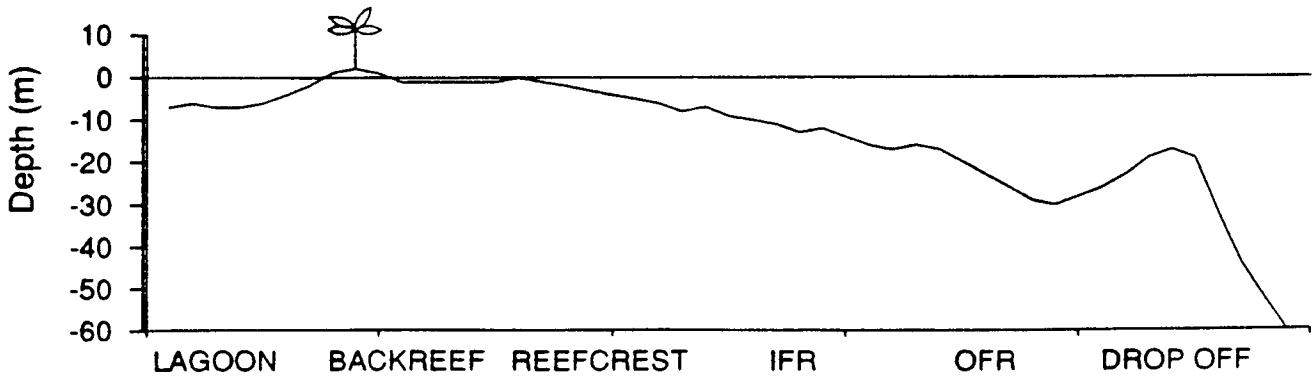
GROUPERS



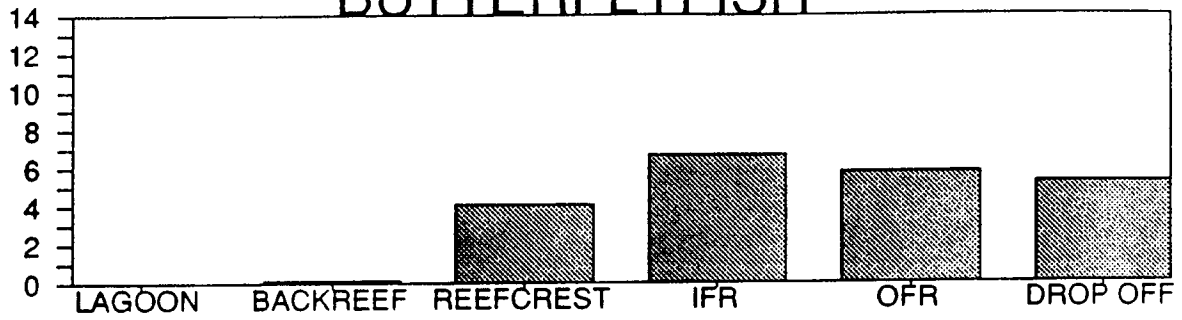
TRIGGERFISH



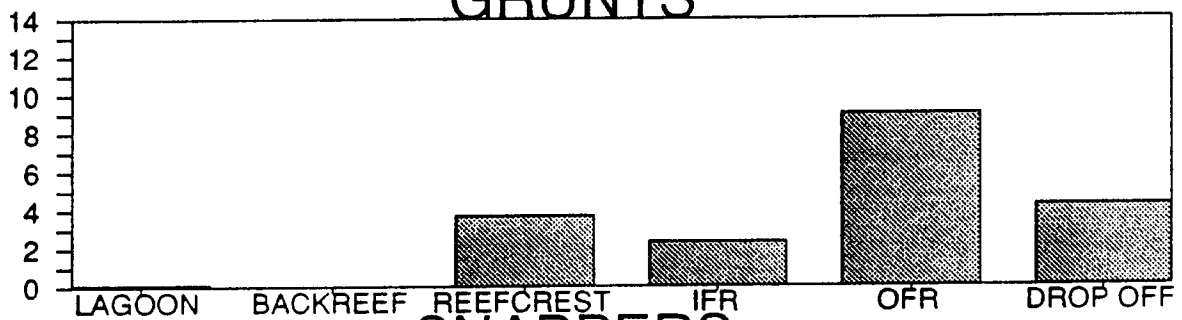
PUFFERFISH



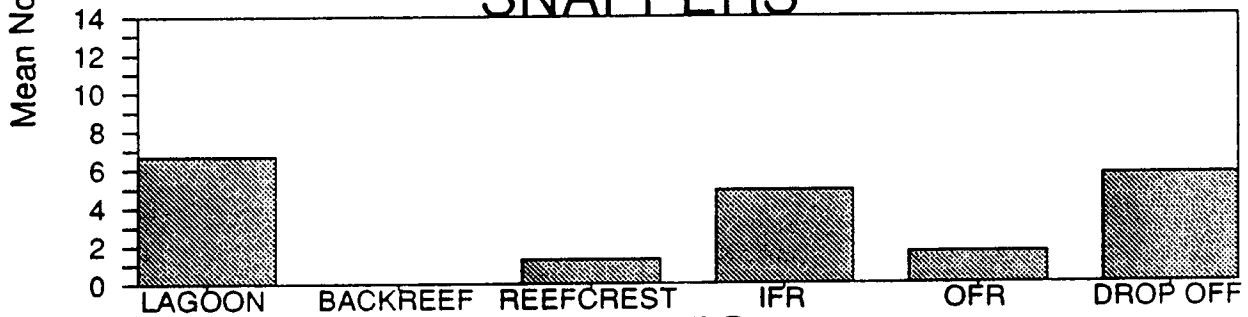
BUTTERFLYFISH



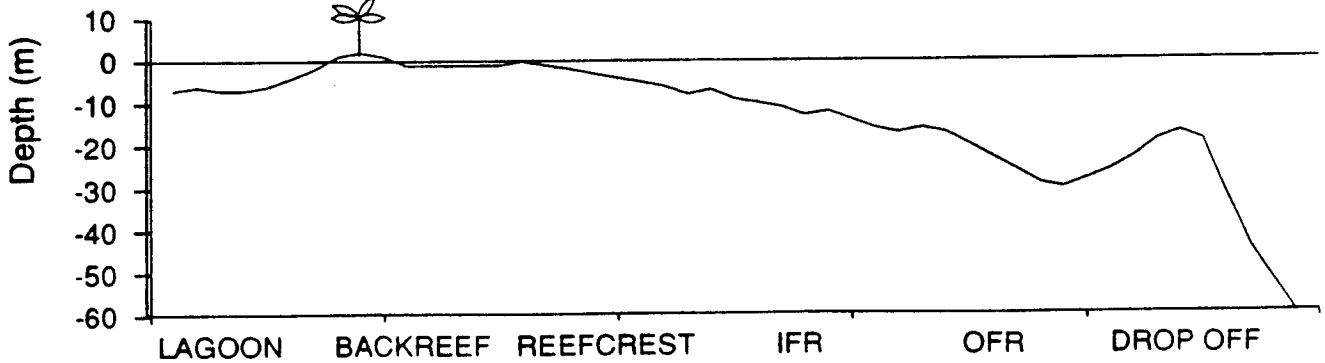
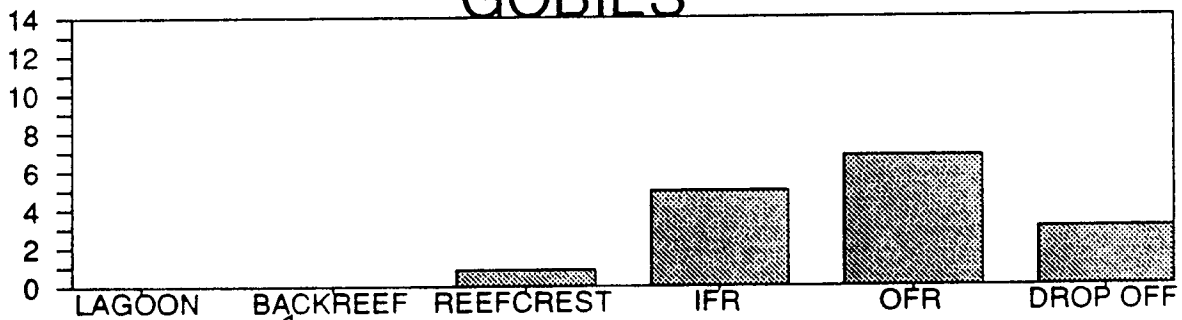
GRUNTS



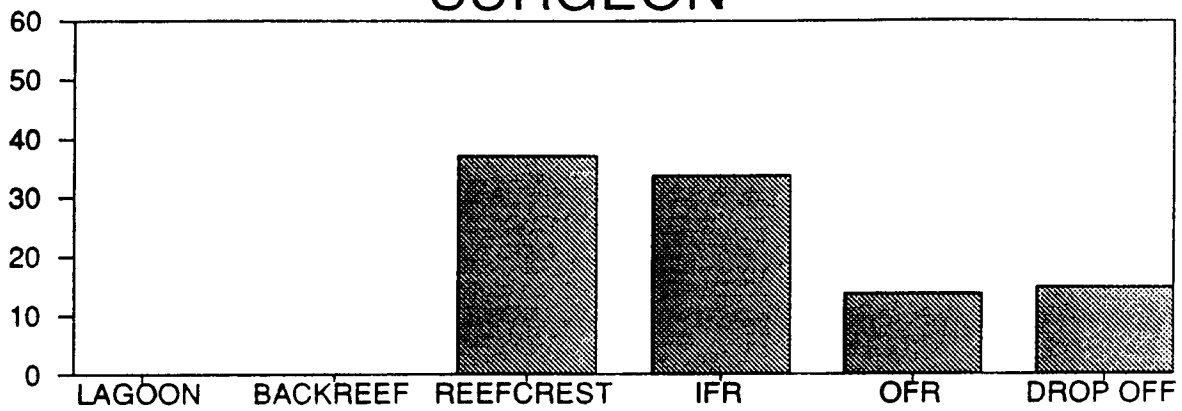
SNAPPERS



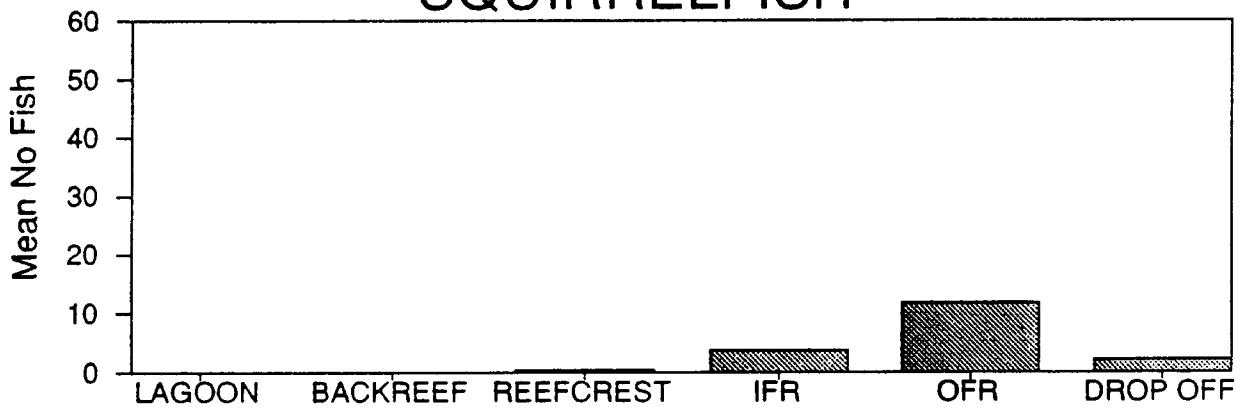
GOBIES



SURGEON



SQUIRRELFISH



PARROTFISH

