

CCC
Bel
19

**Discrete Group Fish Census
The First Analysis
July 1993**

ABSTRACT

In this study 4 reef subzones, at 4 sites, each 1 kilometre apart on the Belize Barrier Reef were surveyed by the Coral Cay Conservation Volunteer diver workforce. The method used was the Discrete Group Fish Census, whereby 3 divers survey a 100m transect, each diver looking for a discrete group of species. This is an analysis of the first months data from an ongoing project. The data was very consistent, showing distinct community differences between subzones. The average species richness did not vary significantly between sites or subzones. The shallowest subzone, the Inner-fore at 5m held the largest number of individuals with the largest proportion of juveniles. Biological and physical attributes were poor predictors of overall species richness. Only sand cover correlated significantly with depth. The subzones inhabited by groups of species are represented graphically.

By : Tim Cox - CCC Assistant Science Coordinator

President: DAVID BELLAMY
Honorary President: JONATHON PORRITT
Directors: PETER RAINES JONATHON RIDLEY
Patrons:

FIELD MARSHAL SIR JOHN CHAPPLE GCB CBE (President, Zoological Society of London)
CHRISTIAN IDE (President, CMAS) NIC FLEMMING (Science Advisor, CMAS)
DEREK ELLERBY (British Sub-Aqua Club) MIKE HOLBROOK (British Sub-Aqua Club)
BRIG. CHRISTOPHER ELLIOT (Director, Army Recruiting) BRIG. RICHARD LAMBE MBE (Chief of Staff, UNFICYP) BRIG. IAIN JOHNSTONE (Commander, British Forces Belize)
PROF. ERIC SUNDERLAND Ph.D F.Inst.Biol. (Vice-Chancellor, University of Wales) PROF. STEWART SUTHERLAND MA HonLLD (Vice-Chancellor, University of London)
PROF. STRUTHER ARNOTT FRSE FRS (Vice-Chancellor, University of St. Andrews) DAVID MACKILLIGAN (British High Commissioner, Belize)

CORAL CAY CONSERVATION LTD.,
"THE IVY WORKS" 154 CLAPHAM PARK ROAD, LONDON SW4 7DE, UK
TEL: 071-498 6248 (24hr) FAX: 071-498 8447
Registered VAT No. 574 1738 23 Company Registration No. 2590980

CONTENTS		Page no.
1	Introduction	2
2	Aims and Objectives	3
3	Survey Methods and Sites	4
	3.1 Introduction	4
	3.2 The Barrier Reef	4
	3.3 Survey Methods	5
	3.4 Survey Procedure	6
	3.5 The Discrete Groups	7
4	Results	8
	4.1 Introduction	8
	4.2 Diversity	8
	4.3 Numbers of Individuals	9
	4.4 Dominant species	10
	4.5 Biological and Physical Attributes	10
	4.6 Subzone Preferences	10
5	Discussion	12
6	Bibliography	13
7	Appendix	14
	7.1 Figure 1 Site Map	
	7.2 Figure 2 Reef Profile	
	7.3 Figure 3 DGFC Recording Form	
	7.4 Tables 2 and 3	
	7.5 Graphs 3 to 22	
	7.6 Grouped Raw Data	

1 Introduction

Structural complexity and the relative stable physical environment of tropical coral reefs are generally believed to provide a considerable amount of niche diversification, leading in turn to high species richness. The excellent cover tropical reef fishes derive from a complex reef framework is equally effective in rendering most standard fishery sampling methods inadequate.

A new visual assessment method, called Discrete Group Censuring, was devised and used to assess and monitor five coral reef assemblages in the Key Largo National Marine Sanctuary, Florida, USA by Greene and Alevizon (1989). Before the commencement of the survey work a sampling strategy was devised with a series of spot dives in the identified survey site to compile an accurate species list. The species listed were then combined into discrete groups on the basis of similar appearance or distribution.

This subdivision of species to be censured into small discrete groups may be the most accurate method yet tested of visually censuring reef fish. The accuracy of Discrete Group Censuring probably results from the simple fact that it allows the censurer to form a more specific 'search image' of species with similar behaviour patterns, appearance or distribution (Greene and Alevizon 1989).

Coral Cay Conservation, a non profit making UK based organisation have been working in association with the Belize government to set up a marine reserve around South Water Cay, see site map in appendix. In November 1992, CCC allocated the volunteer work force based at South Water Cay to assist in an innovative pilot project designed by Dr Barry Blake, head of the Fisheries section at NRI (ODA). The project investigated the feasibility of fish stock assessment with the applications of remote sensing and Geographical Information Systems (GIS). A component of the work was preliminary trials using the Discrete Group Fish Census survey method.

The results of the DGFC survey work were very encouraging. The dataset exhibited a strong consistency in the volunteer generated data and provided solid information on the fish group assemblages and distributions in the different habitats identified (Matheson *etal.* 1993 unpublished).

On coral reefs, most fishes are dependant on the substrate for shelter, as well as for food. It may be expected, therefore, that the nature of the substrate will influence the species composition and diversity of fishes in an area. Several studies have examined relationships between various substratum variables and the species richness and abundance of resident fish communities on coral reefs, but many of the results contradict each other. This study correlates the biological and physical attributes of each transect, measured on an abundance scale of 1-5, with species richness and depth.

During 1993, Coral Cay Conservation will utilise its volunteer work force to develop a DGFC technique specific to Belize. There is a general lack of quantitative fisheries data for the South Water Cay area, and more information concerning the standing stocks of commercially important species and other fish groups is an important component of the management plan for the area.

2 Aims and objectives of the DGFC project:

The aims of the DGFC project are multi-faceted and stem from the very obvious need for detailed fisheries information for the South Water Cay marine reserve. The objectives of the work include:

(i) The study will act as an assessment of the stability of fish populations in the different habitats surveyed. In the scientific community, especially among the reef fisheries ecologists there is a lot of disagreement as to whether coral reef fish communities are highly unstable and varied over time (the "stochastic hypothesis") or whether they are in fact highly ordered.

(ii) Fish stock assessment: A two-fold investigative study which will provide datasets of fish abundances from which essential information concerning the numbers of commercially important species can be obtained for the South Water Cay area. This is important information for the Fisheries Department in their holistic approach to fisheries management for the entire barrier reef complex. Also, with analysis of the datasets, results may indicate whether specifically identified subzone types contain similar fish populations over time, or, whether temporal or periodic variations can be detected from the census work.

(iii) With the use of permanent transects it is anticipated that assessment of the diurnal behavioural patterns of the identified fish populations can be made. The return to these permanent transects will allow for the assessment of seasonal variation in the fish species observed and the abundance of the fish species identified.

(iv) It is also anticipated that with the continued collaboration of CCC and NRI, the fisheries data can be tied into satellite imagery. Using the immense baseline dataset that CCC has compiled for the South Water Cay area, habitat types can be accurately defined and identified on the satellite image. Thus providing a powerful tool for the Fisheries Department in terms of fish stocks, fish species richness and viability of areas for commercial fisheries use.

(v) With the expertise of the Land Information Centre, Ministry of Natural Resources, Belmopan, the fish census datasets can be mapped with Arc/info. Geographical Information System (GIS), providing accurate distribution maps for identified species in the South Water Cay area.

(vi) A longer term potential for the fish census work especially

with the use of permanent transects is the assessment of impacts of disturbance. Knowledge of point source pollution in the area may be detected by (i) obvious fish die-offs (ii) changes in the fish assemblages and numbers.

This paper presents the first analysis of DGFC data generated by CCC volunteers. Survey work was undertaken in May 1993 on four sites 1,2,3 and 4 kilometres north of South Water Cay, Belize.

3 Survey Methods and Sites

3.1 Introduction

Surveys were conducted along transect lines in various reef subzones with teams of divers counting the numbers of fish within preset discrete groupings of fish species. The end result of the survey was the completion of a number of **'DGFC recording forms'** (Figure 3) that describe the biological and physical attributes of the area being surveyed and the relative abundance of fish.

3.2 The Barrier Reef

Sections of the Belize Barrier Reef exhibit distinct zonation patterns which reflect (primarily) water depth and the prevailing wave and current regime. In the case of the reef profile directly east of South Water Cay, 6 discrete habitats corresponding to subzones can be identified (figure 2 and below). Survey work will be carried out in each one respectively.

- | | | |
|-----------------|---|--|
| Outer Drop-Off | - | 30m depth contour to the top of the ridge. |
| Ridge | - | from the top of the outer drop-off to the beginning of the inner drop-off. |
| Inner Drop-Off | - | from the westward end of the ridge to the eastward end of the sand gully. |
| Sand Gully | - | from the base of the inner drop-off to the westward base of the outer fore-reef. |
| Outer Fore Reef | - | from the westward end of the sand gully to the 12m contour (or approximately halfway between the sand gully and reef crest). |
| Inner Fore Reef | - | from the westward end of the outer fore-reef to the reef crest. |

Variations of these subzones have been necessary wherever the reef topography dictates. In the southern areas (south of Curlew Cut), there is no distinct sand gully or ridge. Subsequently, only three subzones are identified; the outer drop-off, outer

fore-reef and inner fore-reef. In northern areas (near Tobacco Cay), much of the reef profile is too deep for divers to survey in detail. The reef here is therefore divided into the inner fore-reef and outer fore-reef (extending eastward to the 30m contour). It was this northern part of the area that was surveyed first.

3.3 Survey Methods

The fish censuring methodology is a two-part process;

Part 1 - Involves laying a 100 metre transect line in a specified lagoon or reef habitat/subzone and performing a physical and biological assessment along the width of the transect.

Part 2 - Involves a team of divers proceeding along the transect line at a set speed with individuals recording the numbers of fish in the discrete groups.

There is a minimum of a 24 hour period between parts 1 and 2 to allow for 'settlement of disturbance' (ie. to allow the return of those species of fish that will leave the transect area due to diver disturbance).

Transect Line Laying Procedure

Transect lines consist of 100m of fine nylon cord, weighted every 5m and marked with labels, in cumulative intervals of 10m and of sufficient size to be read by divers. There is an extra 3m of line at the beginning and end of the 100m section to allow the attachment of the line to the substrate, (dead coral or boulders).

The laying of the transect line involves a team of four divers.

Diver 1 - Navigates north and maintains a constant depth within the chosen subzone/habitat.

Diver 2 - Unreels the transect line from a spool following Diver 1.

Diver 3 - Lays the line on the substrate, keeps the line tight, straight and avoids damage to corals and other marine life.

Diver 4 - Performs a biological and physical assessment of the substratum and the biological cover within the vicinity of the transect line. This is backed up by six photographs which should include:

- * Landscape shots of the habitat
- * Dominant growth forms
- * Main substratum types
- * Unusual structures - natural/anthropogenic
- * Impacts - natural/anthropogenic

Laying on the reef

The transects will run north to south following a constant depth contour that maintains the line within the subzone. Since each subzone can occupy a range of depths the transect line is laid at a depth that is considered representative of the chosen subzone at any location along the barrier reef.

Due to the relative sizes of the Inner Fore Reef and the Outer Fore Reef, and the variation in biological and physical characteristics within these zones, two transect lines are located at different depth contours within these subzones. Therefore, the transect lines will be laid at Inner fore 5m, Inner Fore 9m, Outer Fore 15m and Outer Fore 24m, Sand Gully 30m, Inner Drop-Off 24m, Ridge 18m, and Outer Drop-Off 24m, Figure 3.

To prevent unnecessary wastage of dive time a bathymetric survey of the intended survey site is performed prior to deployment of divers. This ranges from a simple depth check along the length of the intended transect line with an echo sounder, to a hydrographic mapping of the reef profile with combined G.P.S. and echosounder inputs. This is necessary if sections of the reef are complex and a representative 100m stretch of a particular subzone is not present.

Divers mark the beginning and end of the transect lines with a buoyed line to the surface and these buoys are accurately positioned using G.P.S.

A classic reef profile with all transect lines in place will therefore consist of 8 workable transects, labelled F1 to F8. These lines are located approximately parallel to each other in a West to East orientation allowing a 100 metre section of the reef profile to be censured. These 'slices' of the reef will be considered as individual sites and labelled R1, R2, R3, ...etc. Sites will be surveyed along the length of the reef at 1000 metre intervals to allow a comparison of subzones at different locations.

3.4 Discrete Group Fish Censuring Survey Procedure

A team of 3 divers descend the buoy at the beginning of the transect line and swim along the centre of the line surveying a 5m wide pathway, $2\frac{1}{2}$ m either side. The divers move along the line at a speed of 10 metres every 2 minutes, in one direction only and as one body in the shape of a triangle. Each diver counts the number of individuals (adults and juveniles) in discrete groups of fish. The bottom pair of divers in the triangle monitoring those groups encountered on or near the bottom while the top diver counts pelagic and those fish found free-swimming away from bottom.

For those transects lying on steeply sloping or vertical reef faces, (i.e. Inner Drop-Off, Outer Drop-Off), it is necessary for

the divers to swim along the deeper half of the transect so that fish can be observed under the overhangs and crevices found in such locations.

3.5 The Discrete Fish Groups

The fish species to be observed and counted along each transect line are divided into the following groups which reflect the physical attributes i.e appearance and habitat preference of the fish. There are five fish groupings (detailed on page 3 and 4 of the survey form in the appendix) which are titled as follows:

- Group 1: Bottom dwellers
- Group 2: Angelfish, small ovals and cryptic species
- Group 3: Heavy bodied and sloping headed
- Group 4: Swimmers
- Group 5: Odd shaped swimmers

There are also the additional sections:

- A: Important commercial/rare or endangered species
- B: Additional species
- C: Further species details

These characterisations do not always relate perfectly to each species in the groups, therefore these groups have been further subdivided between the three divers as follows.

Diver 1	Diver 2	Diver 3
Butterflyfish	Parrotfish	Surgeonfish
Damsel fish	Wrasse	Angelfish
Hamlets	Bass	Snapper
Cardinal fish	Grouper	Grunts
Squirrelfish	Goatfish	Jacks
Pufferfish	Morays	Triggerfish
Filefish	Trumpetfish	
Bottom Dwellers	Cornetfish	
	Tilefish	

4 Results

4.1 Introduction

During the month of May CCC volunteers carried out a total of 58 surveys. The position of these is detailed in table (1), below.

QUANTITIES OF SURVEYS				
SITE	IF 5	IF 9	OF 15	OF 24
R 140	5	5	2	1
R 130	4	4	4	5
R 120	4	3	4	5
R 110	3	4	4	1

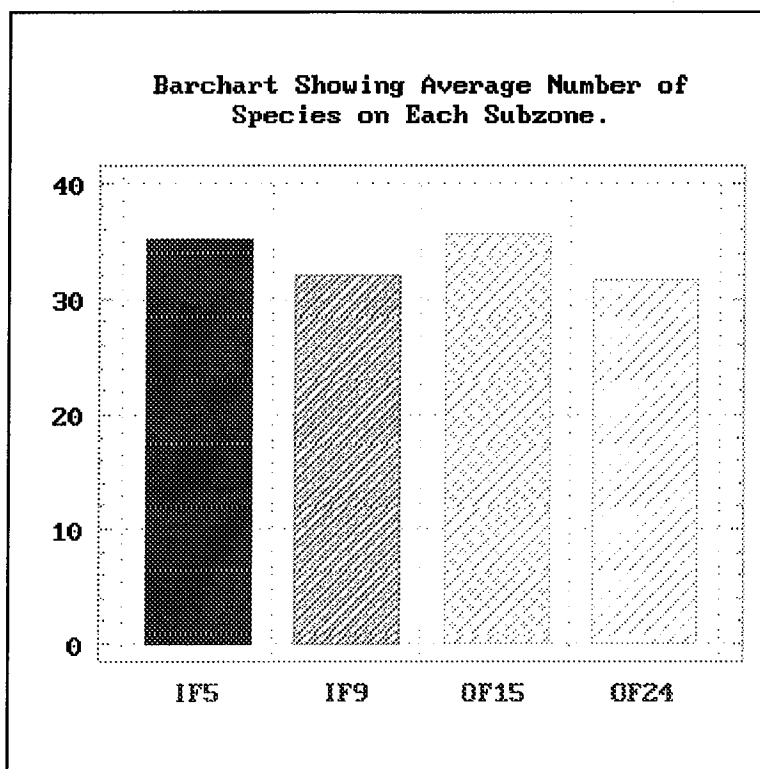
The inconsistency of the number of surveys conducted on each transect is partially due to a small number of survey forms not being returned to the UK in time for analysis, and partially due to dive logistics and the discretion of the CCC Science Officer. This first analysis will be carried out by lumping the 162 species into 21 families or discrete groups. These are:-

Bottom Dwellers	Grunts	Swimmers
Morays	Groupers	Sharks and Rays
Angelfish	Parrotfish	Big eyes (Cardinalfish and
Surgeonfish	Snapper	Squirrelfish)
Butterflyfish	Wrasse	Odd Shaped Swimmers
Damsels	Bass	Turtles
Hamlets	Jacks	Mammals
		Invertebrates

All statistical analysis was performed by Statgraphic Plus 6.0

4.2 Diversity

Diversity was measured purely by the species richness of each survey. Kruskal-Wallace tests were performed for differences between sites and subzones. No significant differences were found. Numbers of species surveyed ranged from 24 to 44, see graph (1) for average numbers of species.



Graph 1

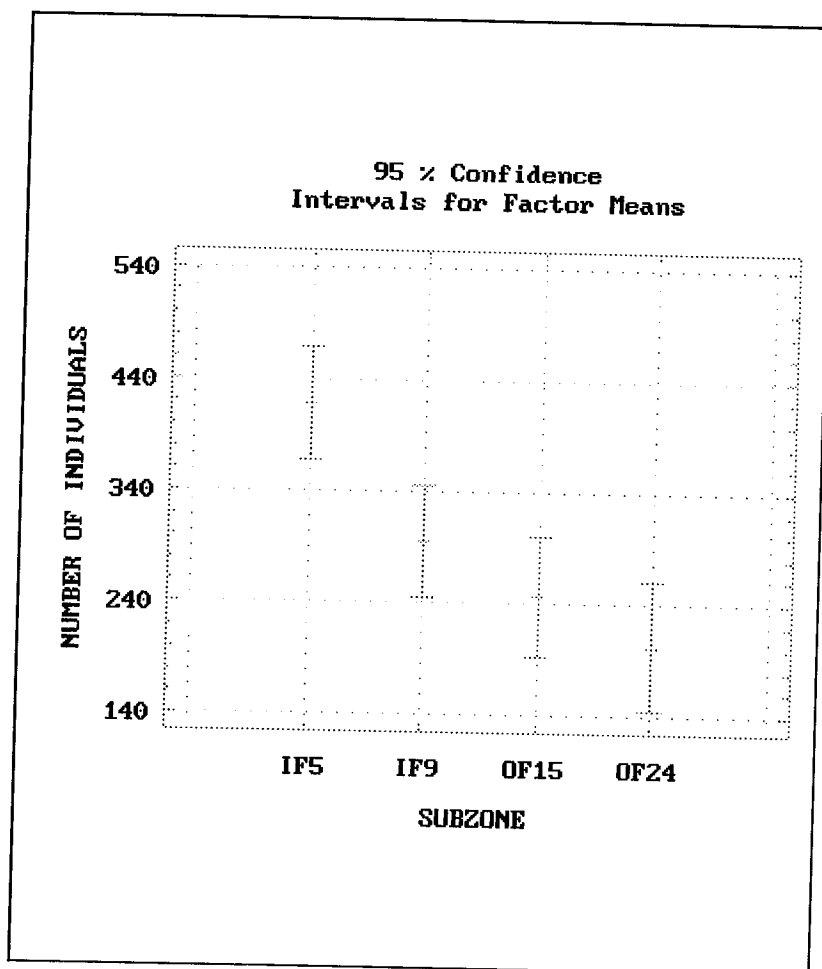
4.3 Numbers of Individuals

The total number of individuals seen on each survey were tested for variance between the sites and subzones again with the Kruskal-Wallace test. The difference in numbers seen between the subzones was found to be significant, whereas the difference between sites was not significant. See Table (2) for statistics and Graph (2) for fish seen on each subzone. The inner-fore 5 meter subzone can be seen to hold statistically more fish, and the numbers of individuals can be seen to be dropping with increased depth.

The average number of fish seen on an Inner-fore 5m transect was 416.8 of which 41.3% were juveniles. The average number of fish seen on an Inner-fore 9m transect was 303.8 of which 32.7% were juveniles. The average number of fish seen on an Outer-fore 15m transect was 250.3 of which 24.6% were juveniles. The average number of fish seen on an Outer-fore 24m transect was 209.75 of which 25.6% were juveniles.

4.4 Dominant species

Overall the dominant group of species was found to be the Damsel fish, by number, at each site and in each subzone. Table (3) shows the three most abundant groups in order. In the Inner-fore subzone the Wrasse were the second most abundant group followed by the Parrotfish. In the deeper subzones the Parrotfish were second most abundant followed by the Wrasse (with two exceptions). At site 130 OF15 the Parrotfish were most abundant and at site 140 OF24 the Snapper were third most abundant.



Graph 2

4.5 Biological and Physical Attributes

The biological and physical descriptions of the transects, live coral cover, sand cover, hard corals, soft corals were recorded as an abundance scale. These parameters were correlated with the species richness of the transects and the depth. The only significant correlation found was between sand cover and depth $r=-0.5083$ ($p=0.0444$).

4.6 Subzone Preferences

Subzone preferences of the groups of species are presented in multiple box and whisker plots, see appendix graphs 3 to 22. The Kruskal-Wallis test for variance was performed on these populations, see Table 2, between sites and subzones.

Graph 3 shows the Bottom-dwellers fairly evenly distributed, the variance between subzones was not significant. However there was significant variation between sites with very few sightings at site 130.

Graph 4 shows the Morays. Here it is impossible to draw any conclusions due to the small number of sightings.

Graph 5 shows the surgeon fish. The variance between subzones was found to be significant due to the small numbers observed on the Outer-fore 24m subzone.

Graph 6 shows the Angelfish. The variance here is significant due to the large numbers observed on the Outer-fore 15m subzone.

Graph 7 shows the Butterflyfishes. The population variance between the Inner-fore and Outer-fore is significant.

Graph 8 shows the Damselfish. Large numbers were observed on each subzone of the reef. The variance was not significant.

Graph 9 shows that significantly more Hamlets were observed on the Outer-fore subzones.

Graph 10 shows the Grunts. The variance is significant with more sightings on the Outer-fore 15m subzone.

Graph 11 shows the Groupers to be observed more often in the Inner-fore 9m and Outer-fore 15m subzones. The variance is significant.

Graph 12 shows the Parrotfish abundance to decrease with depth. The variance was significant.

Graph 13 shows the Snappers, where there was no significant variance.

Graph 14 shows the Wrasse to be significantly more abundant on the Inner-fore 5m subzone.

Graph 15 shows the distribution of Bass, with no significant variation.

Graph 16 shows the variance of the Jacks to be insignificant.

Graph 17 shows the Swimmers. A significant variance was found due to small numbers observed on the Outer-fore 15m subzone.

Graph 18 shows the Sharks and Rays with no significant variation.

Graph 19 shows the Bigeyes with no significant variation.

Graph 20 shows the Odd-shaped Swimmers with no significant variation.

Graph 21 shows the Turtles. The variance was significant with the majority of sightings on the deepest subzone.

Graph 22 shows the Invertebrate sightings with no significant variation.

5 Discussion

These first results of the DGFC show the volunteer generated data to be remarkably consistant , as shown by the differences between subzones and similarities between sites. However it would be useful to test for differences between surveys conducted by inexperienced volunteers and those by the more experienced ones to see if the training period was long enough or the volunteers were still learning identification skills whilst trying to survey.

It should be mentioned that the visual census method can only account for the more ubiquitous fish species of the suprabenthic reef community and do not account for many of the cryptic or secretive species and can only give a relative measure of community. However, Jones and Thompson (1978) contended that the ratio of relative abundance among the more commonly occurring (visible) suprabenthic species is representative of a given reef fish community.

The results show no significant change in the species richness between the subzones. This contradicts the findings of Roberts and Ormond (1987) who found a trend of increasing species richness with depth. However, although the mean number of species in several communities may be nearly equal, they are not necessarily the same species (Jones and Thompson 1978).

The large numbers of fish surveyed on the Inner-fore reef 5M subzone contained the largest proportion of juveniles. The numbers of individuals went down as did the proportion of juveniles with depth. This shows the Inner-fore to be an important nursery habitat.

Sale (1980) has stated that as adults reef fish are markedly sedentary and make considerable distinctions among different types of reef habitat, as shown by the habitat preference graphs. This lends itself to the argument that after their pelagic larval stage, reef fish have some mechanism by which they are recruited to a particular zone of the reef.

From the correlations between the biological and physical parameters and species richness and depth the only significant correlation was a negative one between sand cover and depth. This implies that as depth increases the amount of sand cover decreases, presumably due to more, or a different form of coral growth. However no other correlations were found which casts doubt on the accuracy of the abundance scales. The results do support the findings of Roberts and Ormond (1987), who found none of their measures of structural complexity to be significantly correlated to species richness.

Luckhurst and Luckhurst (1978) found their 'substrate rugosity' index to be highly correlated to species richness. They stated that substrate complexity is an important factor in determining fish species richness and diversity. However none of their measures of percentage substrate cover showed any significant

correlations with the community parameters. Sale (1984) found that the structural attributes of reefs, other than size, were of little value in predicting the structure of the fish assemblages formed on patch reefs.

The biological and physical attributes were not correlated to individual species for this report, but some doubt has been cast on their accuracy. In future it may be useful to abandon these abundance scales in favour of an index of coral diversity (possibly based upon the presence or absence of indicator species) or habitat complexity, in an attempt to gain significant correlations for use in prediction exercises.

Of the important commercial species Grunts, Groupers, Parrotfish, Snapper, Wrasse, Jacks and the pelagic Swimmers, the data shows some habitat preferences, ie Groupers on the 5 and 15 meter subzones and Wrasse on the 5 meter subzone. However it is obvious that more data is required to compile an accurate distribution pattern of many of the species.

6 Bibliography

Greene LE and Alevizon WS 1989. Comparative Accuracies Of Visual Assessment Methods For Coral Reef Fishes. Bulletin Of Marine Science. 14(2) 889-912.

Jones RS and Thompson MJ 1978. Comparison Of Florida Reef Fish Assemblages Using A Rapid Visual Technique. Bulletin Of Marine Science. 28(1) 159-172.

Luckhurst BE and Luckhurst K 1978. Analysis Of The Influence Of Substrate Variables On Coral Reef Fish Communities. Marine Biology. 49 317-323.

Matheson K et al. 1993. Report On The Application Of Remote Sensing Techniques To The Study Of Coral Reef Habitats In Belize. NRI ODA Unpublished.

Roberts CM and Ormond RFG 1987. Habitat Complexity And Coral Reef Fish Diversity And Abundance On Red Sea Fringing Reefs. Marine Ecology-Progress Series. 41 1-8.

Sale PF 1980. The Ecology Of Fishes On Coral Reefs. Oceanography and Marine Biology Annual Review. 18 376-421.

Sale PF and Douglas WA 1984. Temporal Variability In The Community Structure Of Fish On Coral Patch Reefs And The Relation Of Community Structure To Reef Structure. Ecology 65(2) 409-422.

Appendix

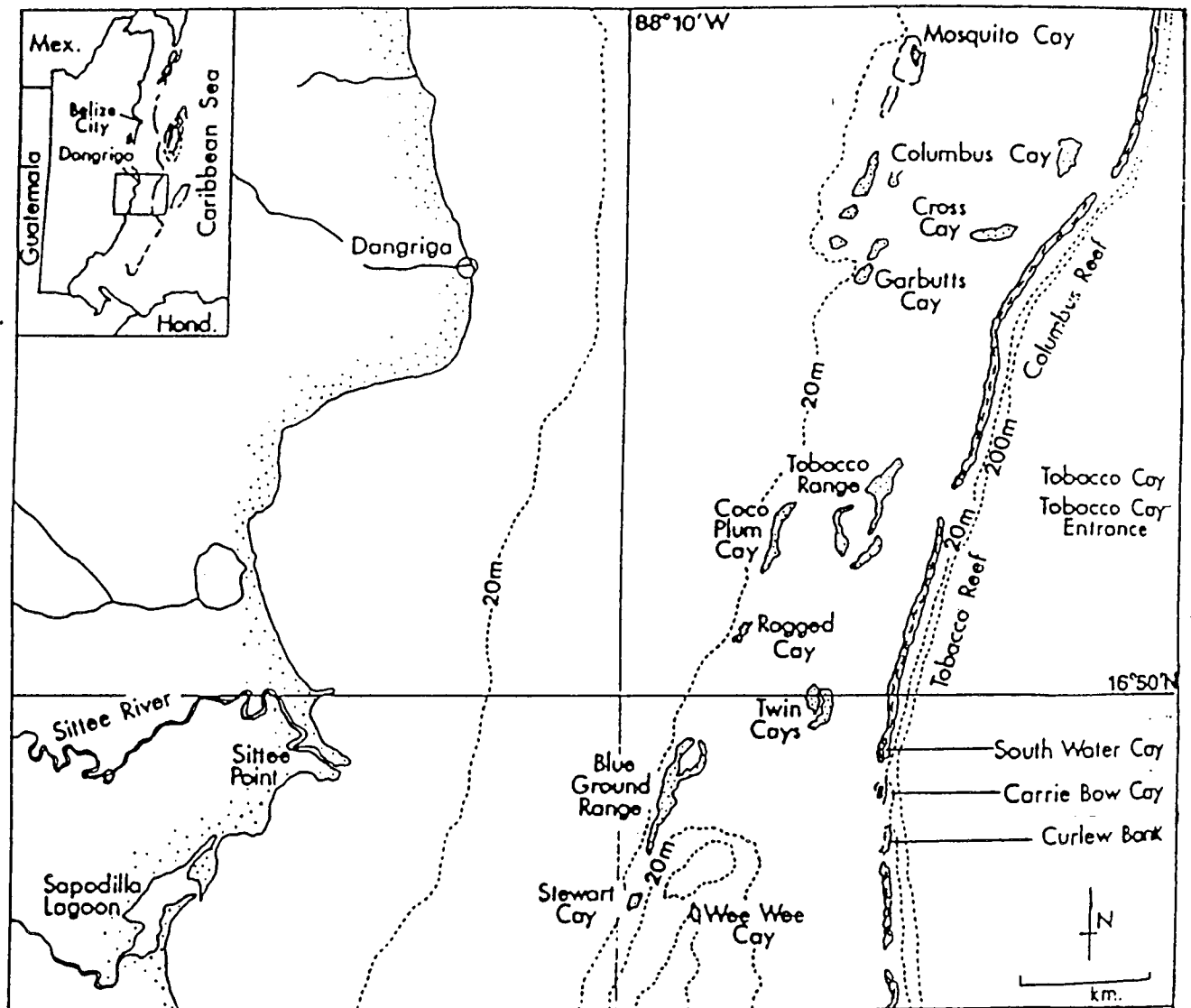
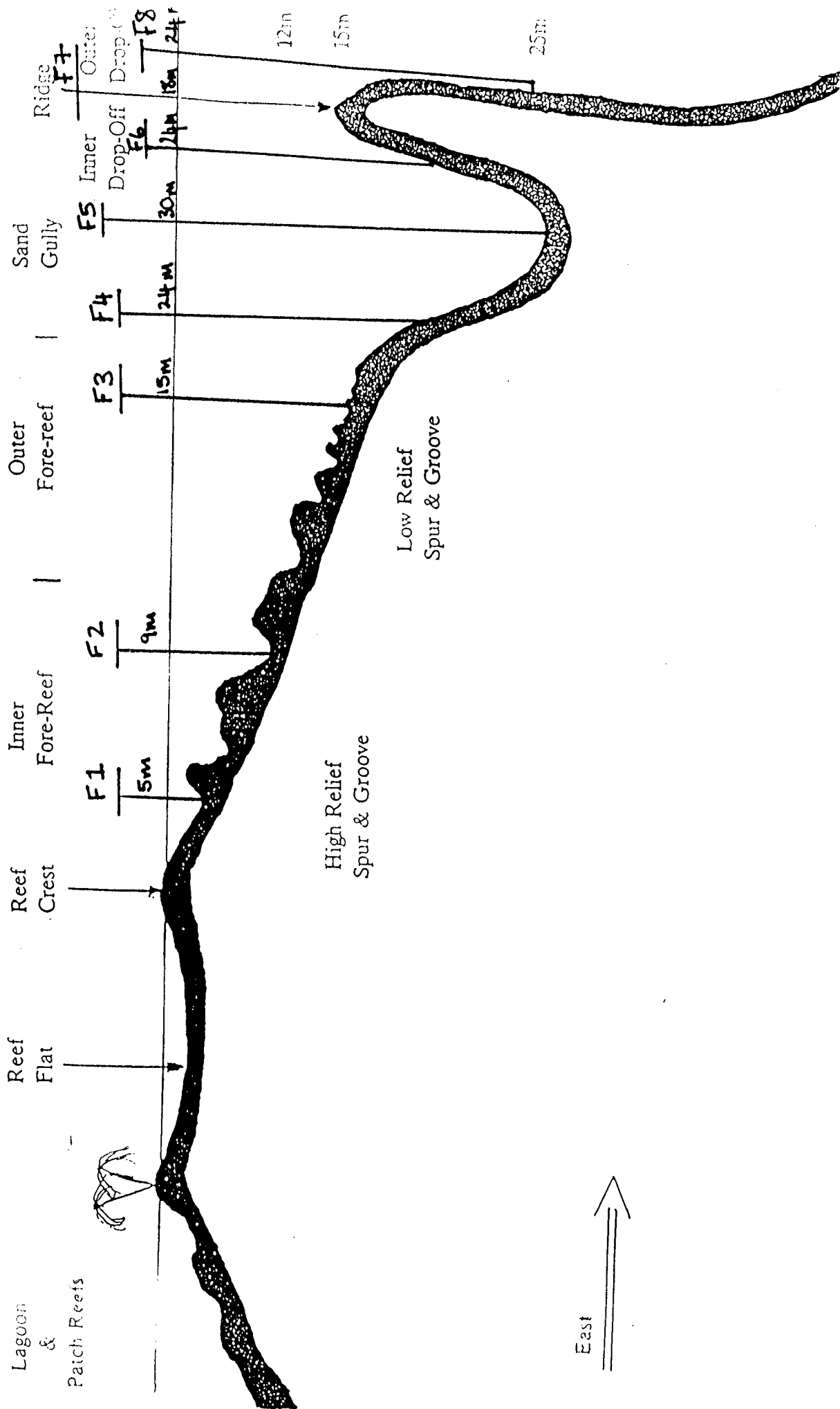


Figure 1

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

Figure 2

Location of Transects



DISCRETE GROUP FISH CENSUS RECORDING FORM

Site No: _____

Date: ____ / ____ / ____

Transect No: _____

Start Time: ____ : ____

Subzone: _____

End Time: ____ : ____

Survey Length _____ m.

	First	Last	No. Dives/snorkels	
Recorders			in Belize	
names	_____	_____	_____	
	_____	_____	_____	
	_____	_____	_____	
	_____	_____	_____	

Depth Limits: Upper _____ m
Lower _____ m

Underwater visibility: _____ m

ZONE

Barrier reef

- ☐ Back reef
- ☐ Reef crest
- ☐ Inner fore
- ☐ Outer fore
- ☐ Ridge
- ☐ Inner drop off
- ☐ Outer drop off

SUBSTRATUM

(0-5)*

- Live corals ☐
- Dead corals ☐
- Bedrock ☐
- Sand ☐
- Mud ☐
- Rubble ☐
- Mangrove ☐

BIOLOGICAL COVER

(0-5)*

- Live hard corals ☐
- Soft corals ☐
- Sponges ☐
- Invertebrates ☐
- Algae ☐
- Seagrass ☐
- Mangrove ☐

Lagoon

- ☐ Sediment
- ☐ Seagrass
- ☐ Patch reef
- ☐ Mangrove
- ☐ Other _____

*these figures need not add up to 5 total

PHOTOGRAPHY

Film Code: _____

Frames Taken: _____

Frame No.	Description (depth / details)

IMPACTS

Litter ☐

Sewage ☐

Coral Damage ☐

Lobster Potting ☐

Fish Traps ☐

Other ☐

Details: _____

GROUP 4 - SWIMMERS

Jacks:

Barjack
Horse-eye
Yellow
Crevale

Porgy
Chub
Mojarra
Flyingfish

Spadefish
Barracuda
Mackeral
Tarpon
Bonefish
Snook
Needlefish
Bonnetmouth
Cobia
Silverside

Sharks & Rays:

Nurse
Blacktip
Spotted Eagle
Southern
Yellowtail
Manta

GROUP 5 - ODD SHAPED SWIMMERS

Cardinalfish:

**Belted
Barred
Flamefish**

Trumpetfish
Cornetfish
Tilefish

Triggerfish:

Queen
Ocean
Black Durgon

Squirreelfish:

Longjaw
Longspine
Dusky
Reef
Blackbar
Bigeye

Remora

Boxfish

Pufferfish:

Smooth
Spiny

Filefish:

Scrawled
White Spotted

Goatfish

IMPORTANT COMMERCIAL SPECIES

Turtles:

Green
Hawksbill
Loggerhead
Leatherback

Mammals:

Dolphin
Manatee

Invertebrates:

Spiny Lobster
Conch
Long-spined Sea Urchin

ADDITIONAL SPECIES:

FURTHER SPECIES DETAIL: (eg. the species of goby entered under `Gobies`)

KRUSKAL-WALLACE ANALYSIS OF DIFFERENCE BETWEEN:-		
GROUPS	SUBZONES	SITES
BOTTOM DWELLERS	0.54495	0.01370
MORAYS	0.52248	0.67070
ANGELFISH	0.00190	0.10050
SURGEONFISH	0.00011	0.98867
BUTTERFLYFISH	0.03704	0.68940
DAMSELS	0.08008	0.45750
HAMLETS	0.01047	0.17670
GRUNTS	0.00005	0.65110
GROUPERS	0.04655	0.48710
PARROTFISH	0.02057	0.41410
SNAPPER	0.12014	0.27470
WRASSE	0.00001	0.51950
BASS	0.46450	0.00062
JACKS	0.96945	0.13123
SWIMMERS	0.00955	0.17195
SHARKS AND RAYS	0.22360	0.67480
BIG EYES	0.07098	0.45110
ODD-SHAPED	0.38630	0.50827
TURTLES	0.00690	0.05895
MAMMALS	0.80000	0.80125
INVERTEBRATES	0.45819	0.23350
NUMBER OF SPECIES	0.09570	0.17079
TOTAL NUMBERS	0.00003	0.36901

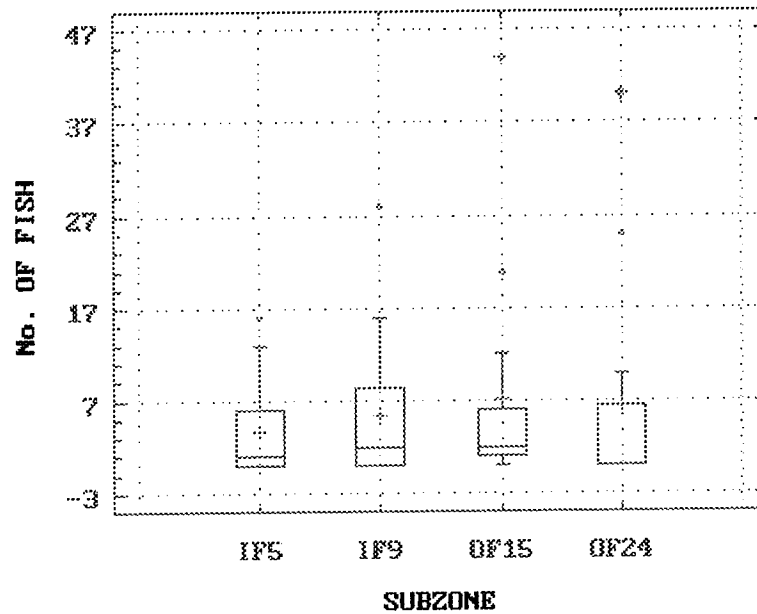
Table 2.

H₁= Samples come from the same population.
 If $X < 0.05$ H₁ is rejected.
 Confidence level =95%

DOMMINANT SPECIES AT EACH SITE. IN DECENDING ORDER					
SITE		IF5	IF9	OF15	OF24
110	1	DAMSELS	DAMSELS	DAMSELS	DAMSELS
110	2	WRASSE	PARROTFISH	PARROTFISH	PARROTFISH
110	3	PARROTFISH	WRASSE	WRASSE	WRASSE
120	1	DAMSELS	DAMSELS	DAMSELS	DAMSELS
120	2	WRASSE	WRASSE	PARROTFISH	PARROTFISH
120	3	PARROTFISH	PARROTFISH	WRASSE	WRASSE
130	1	DAMSELS	DAMSELS	PARROTFISH	DAMSELS
130	2	WRASSE	PARROTFISH	DAMSELS	PARROTFISH
130	3	PARROTFISH	WRASSE	WRASSE	WRASSE
140	1	DAMSELS	DAMSELS	DAMSELS	DAMSELS
140	2	WRASSE	PARROTFISH	WRASSE	PARROTFISH
140	3	PARROTFISH	WRASSE	PARROTFISH	SNAPPER

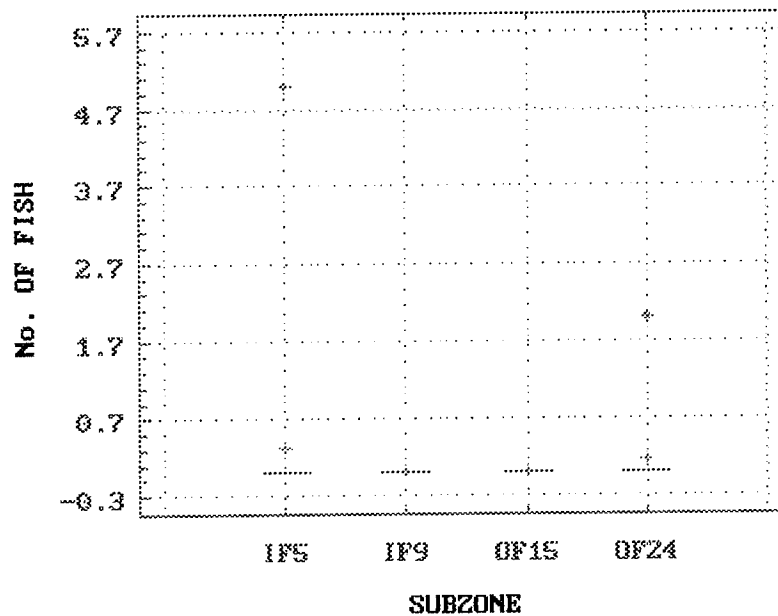
Table 3

**Multiple Box-and-Whisker Plot Showing
Bottom-dwellers at Each Subzone.**



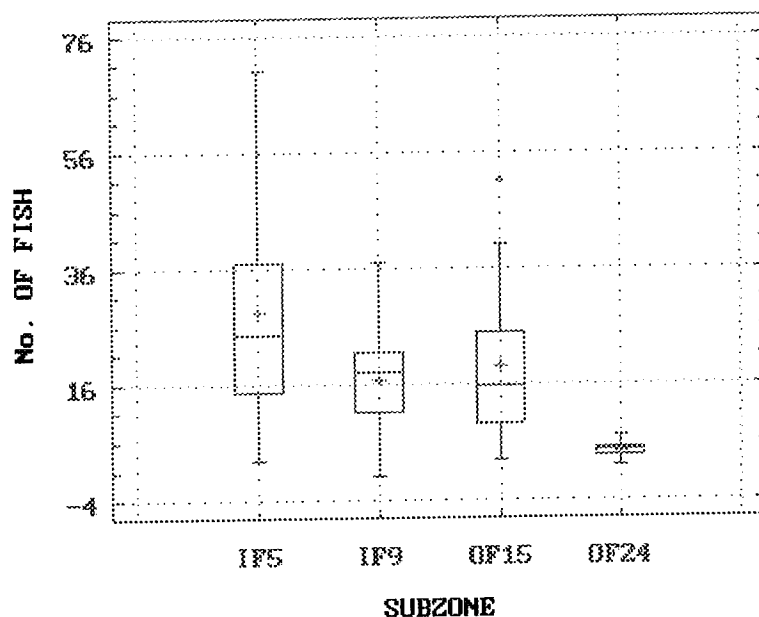
Graph 3

**Multiple Box-and-Whisker Plot Showing
Morays at Each Subzone.**



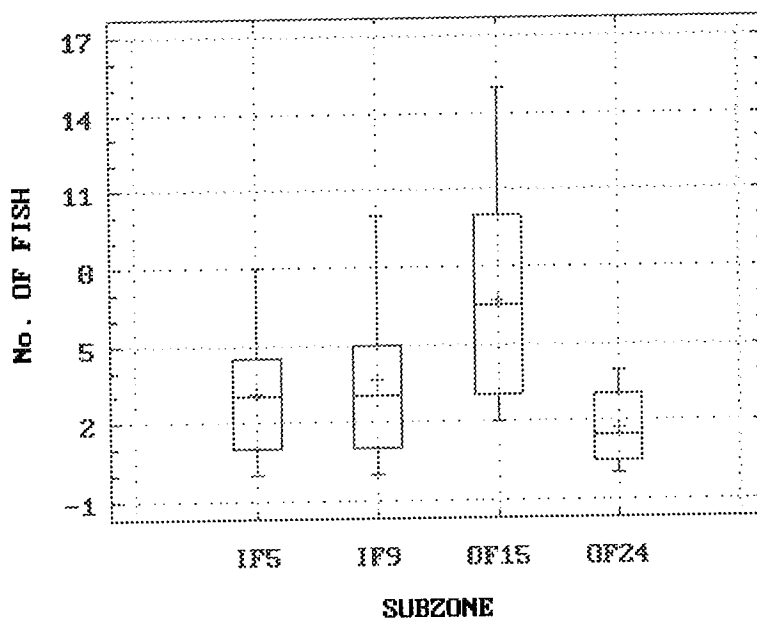
Graph 4

**Multiple Box-and-Whisker Plot Showing
Surgeonfish at Each Subzone.**



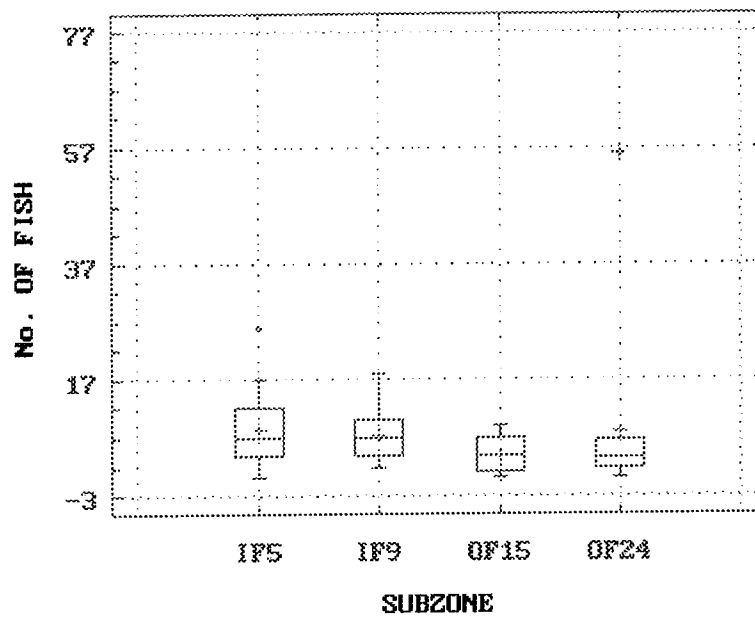
Graph 5

**Multiple Box-and-Whisker Plot Showing
Anglefish at Each Subzone.**



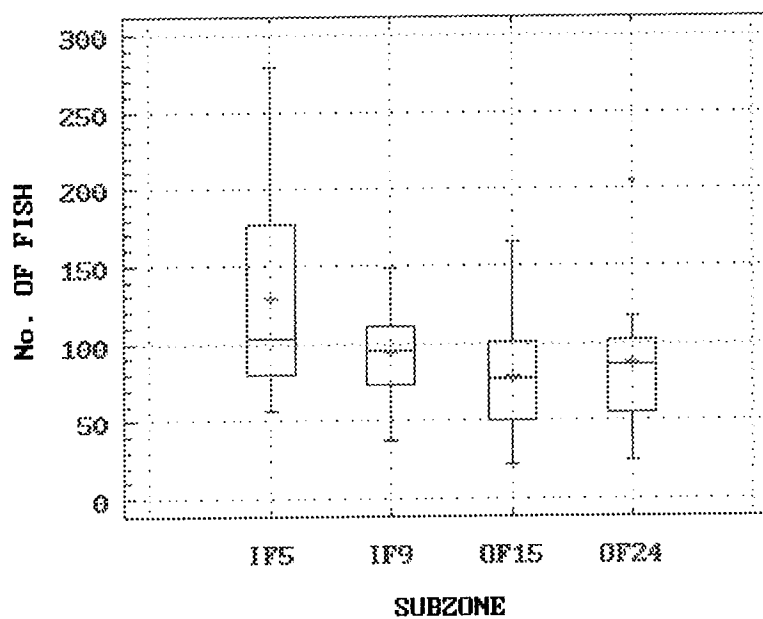
Graph 6

**Multiple Box-and-Whisker Plot Showing
Butterflyfish at Each Subzone.**



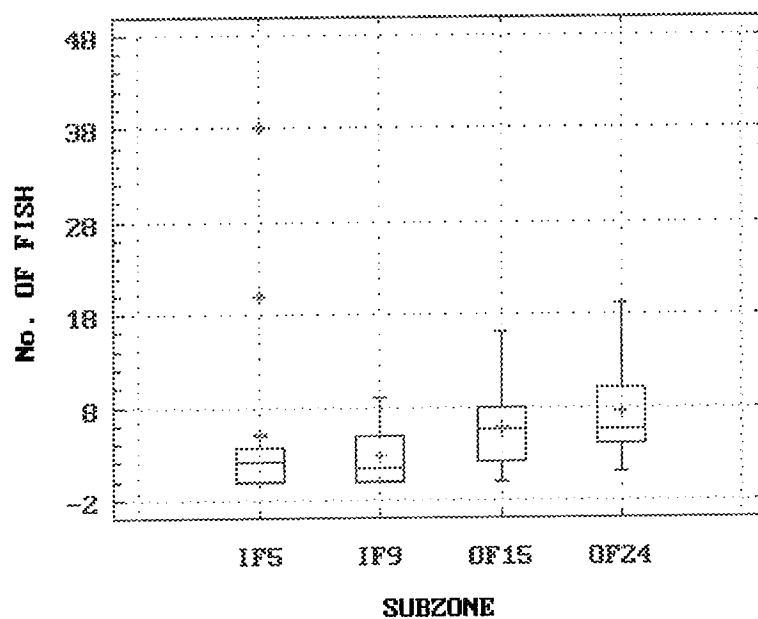
Graph 7

**Multiple Box-and-Whisker Plot Showing
Damselfish at Each Subzone.**



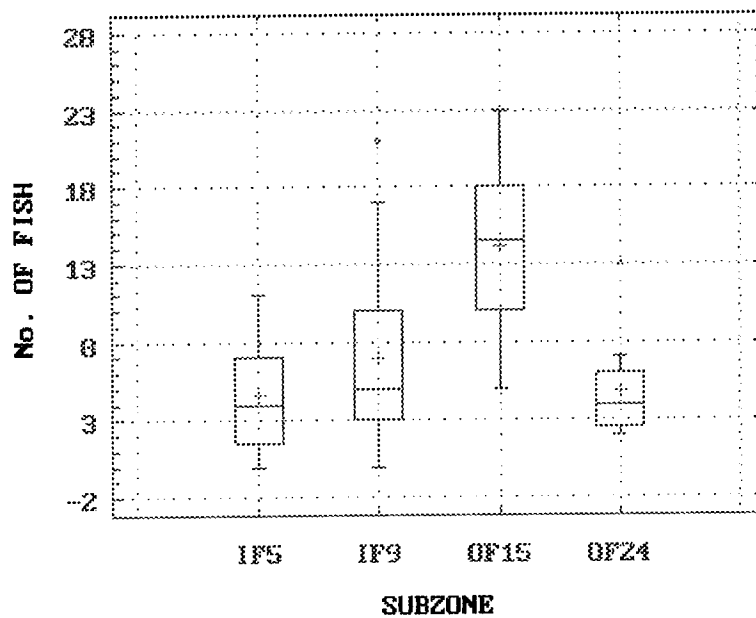
Graph 8

**Multiple Box-and-Whisker Plot Showing
Hamlets at Each Subzone.**



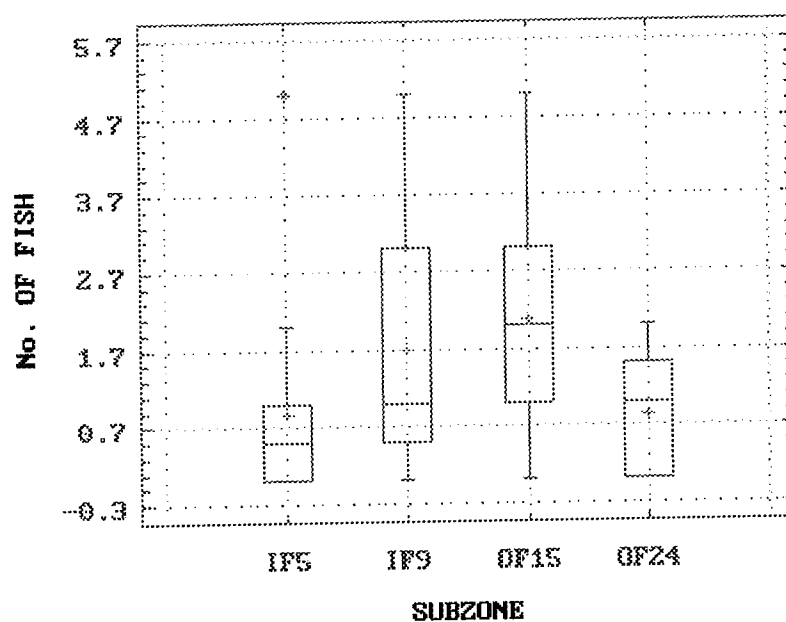
Graph 9

**Multiple Box-and-Whisker Plot Showing
Grunts at Each Subzone.**



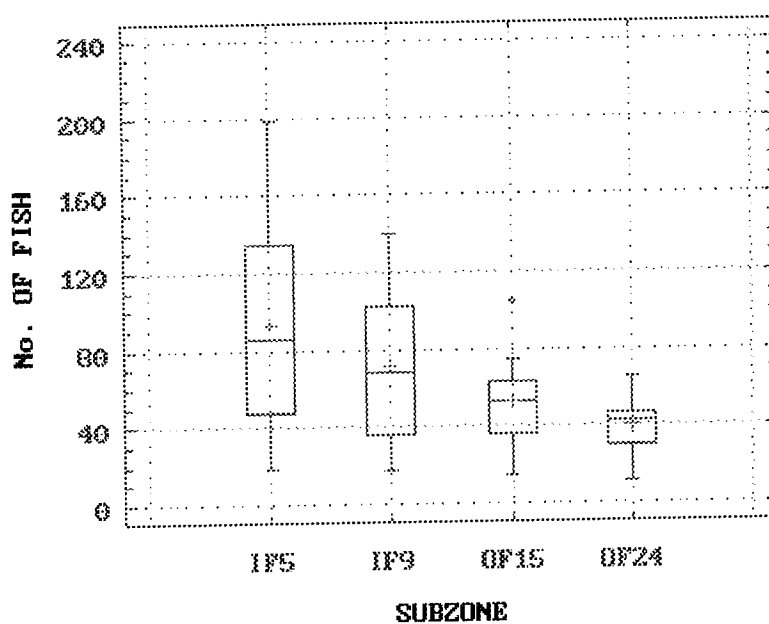
Graph 10

**Multiple Box-and-Whisker Plot Showing
Groupers at Each Subzone.**



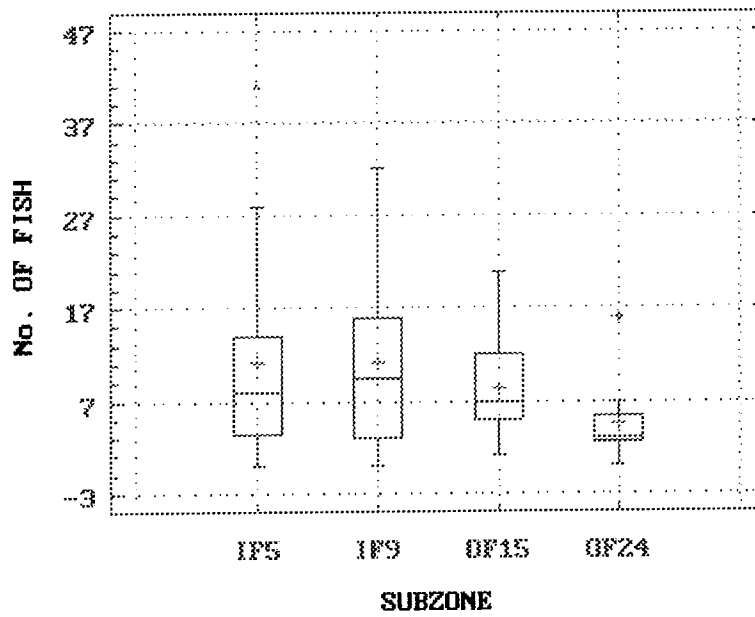
Graph 11

**Multiple Box-and-Whisker Plot Showing
Parrotfish at Each Subzone.**



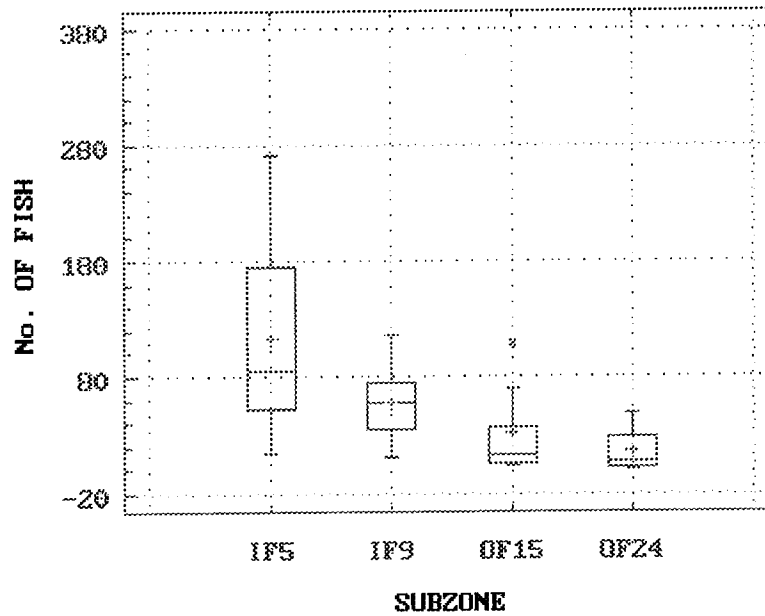
Graph 12

**Multiple Box-and-Whisker Plot Showing
Snapper at Each Subzone.**



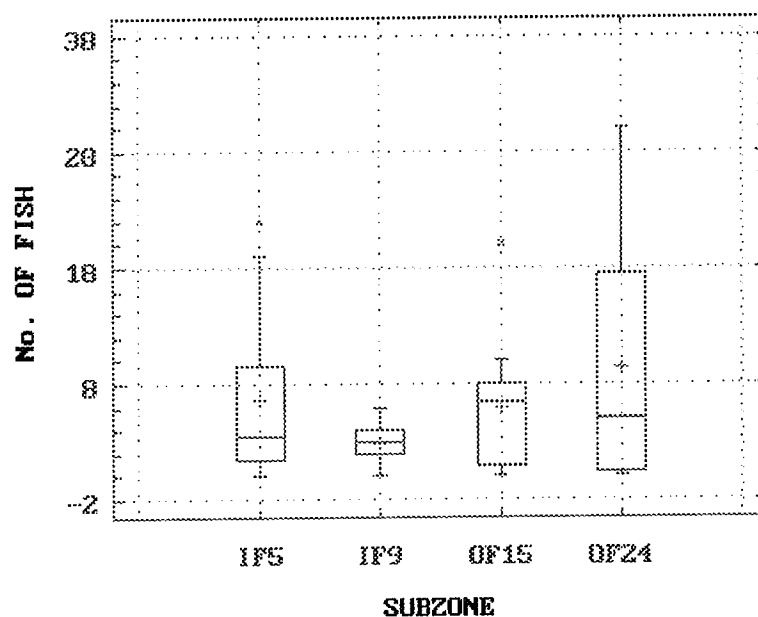
Graph 13

**Multiple Box-and-Whisker Plot Showing
Wrasse at Each Subzone.**



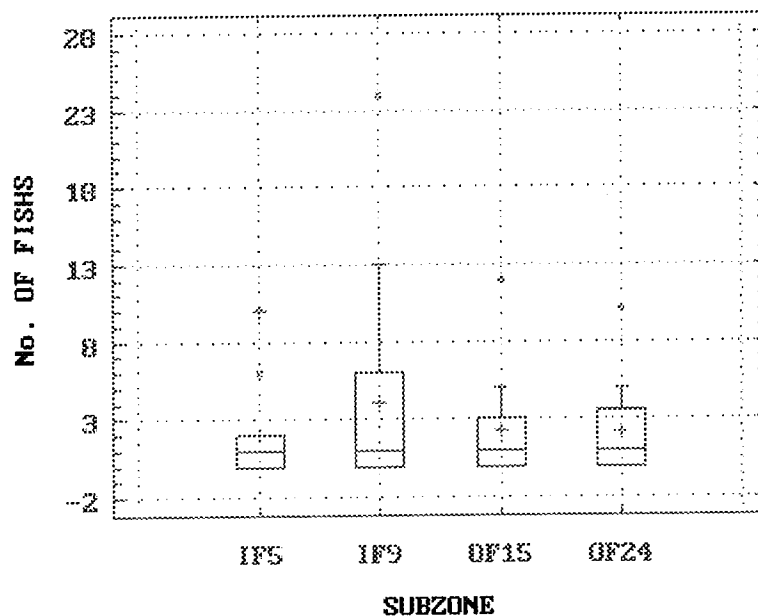
Graph 14

**Multiple Box-and-Whisker Plot Showing
Bass at Each Subzone.**



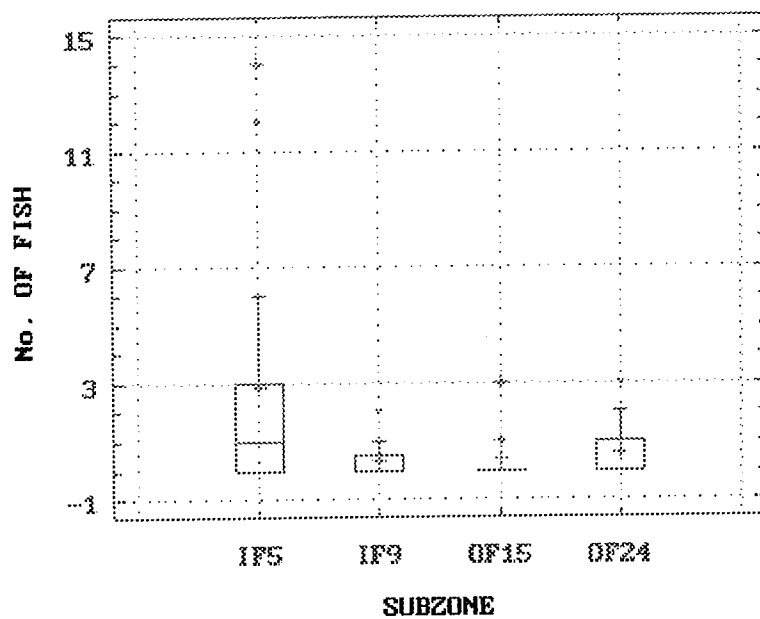
Graph 15

**Multiple Box-and-Whisker Plot Showing
Jacks at Each Subzone.**



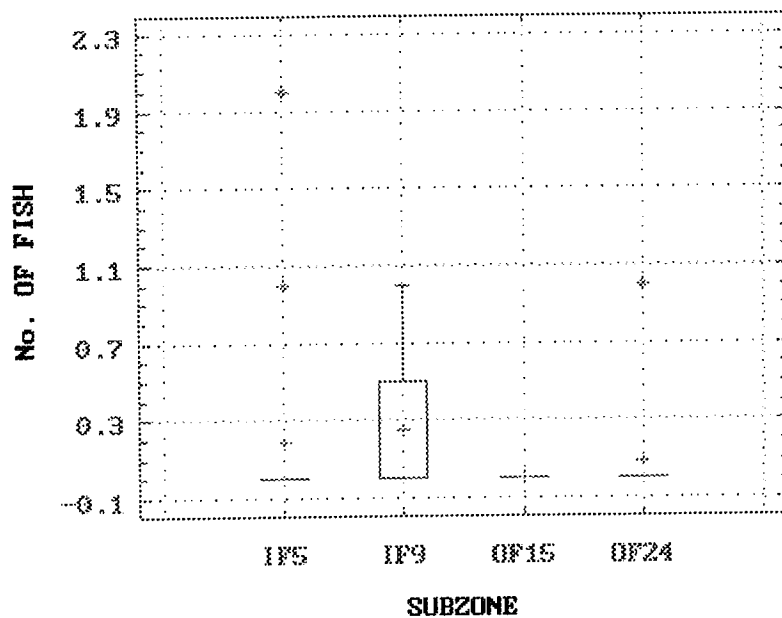
Graph 16

Multiple Box-and-Whisker Plot Showing Swimmers at Each Subzone.



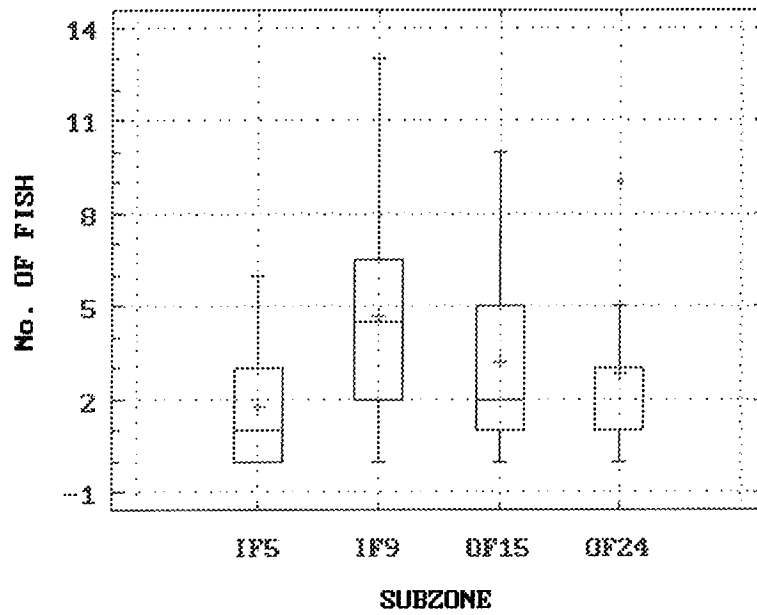
Graph 17

Multiple Box-and-Whisker Plot Showing Sharks and Rays at Each Subzone.



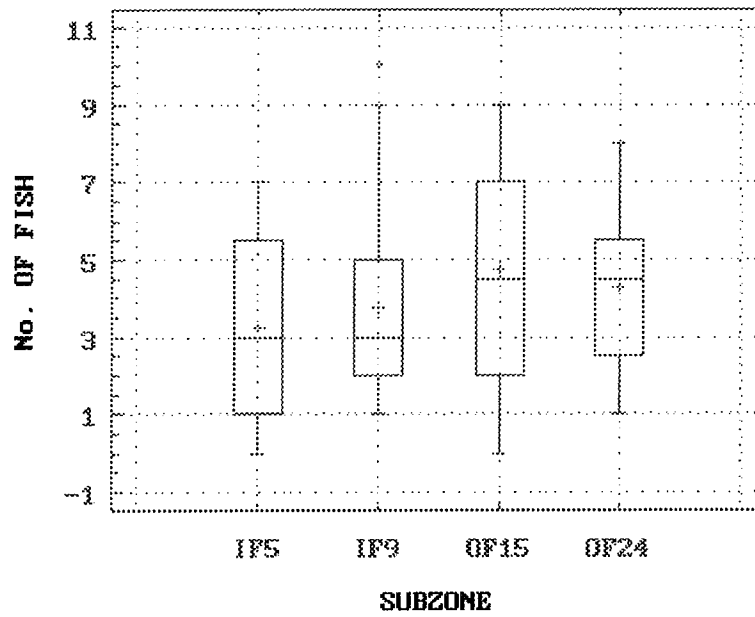
Graph 18

**Multiple Box-and-Whisker Plot Showing
Bigeyes at Each Subzone.**



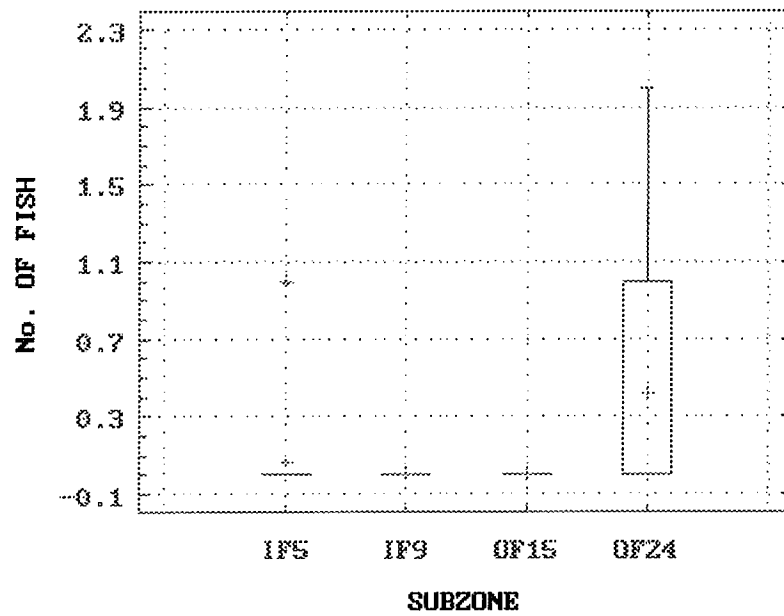
Graph 19

**Multiple Box-and-Whisker Plot Showing
Odd-Shaped Swimmers at Each Subzone.**



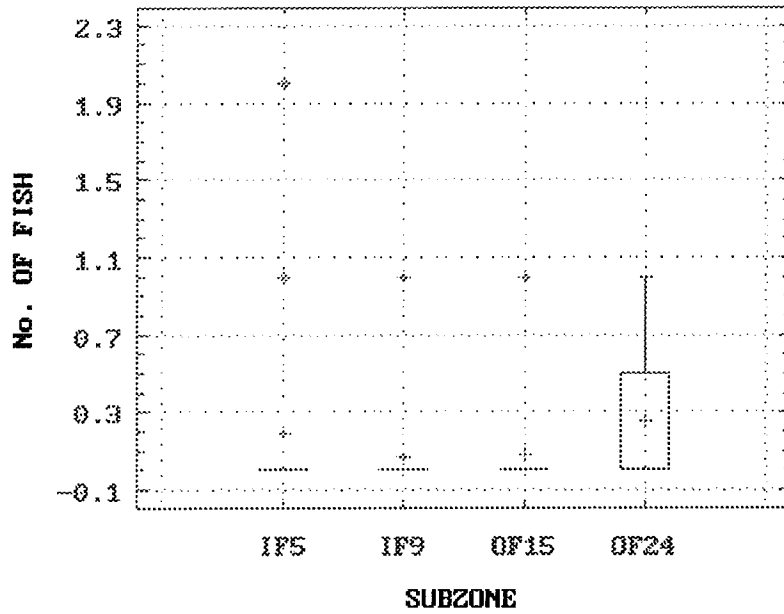
Graph 20

**Multiple Box-and-Whisker Plot Showing
Turtles at Each Subzone.**



Graph 21

**Multiple Box-and-Whisker Plot Showing
Invertebrates at Each Subzone.**



Graph 22

DGFC SITES 110-140 GROUPS

SUBZONE	SITE	BOTTOM DWELLERS	MORAYS	ANGELFIS	SURGEONFISH	BUTTERFLYFISH	DAMSELS
IF5	110	0	0	5	4	13	120
IF5	110	13	0	0		5	95
IF5	110	0	0	4	24	6	176
IF9	110	0	0	6	16	10	108
IF9	110	2	0	0	9	8	72
IF9	110	0	0	1	13	2	38
IF9	110	16	0	3	19	4	76
OF15	110	2	0	3	18	8	165
OF15	110	4	0	10	19	2	84
OF15	110	21	0	12	25	4	87
OF15	110	44	0	11	14	1	47
OF24	110	0	0	4	16	5	87
IF5	120	6	0	1	4	13	204
IF5	120	1	0	1	29	0	94
IF5	120	3	0	1	13	8	144
IF5	120	10	5	1	17	9	106
IF9	120	2	0	9	26	9	108
IF9	120	7	0	4	21	11	111
IF9	120	0	0	1	14	4	70
OF15	120	0	0	7	37	9	124
OF15	120	6	0	5	5	8	71
OF15	120	12	0	3	51	1	52
OF15	120	2	0	2	10	3	37
OF24	120	25	0	3	40	3	117
OF24	120	0	0	0	2	3	25
OF24	120	0	0	0	4	4	98
OF24	120	0	0	1	5	5	204
OF24	120	10	0	0	5	0	97
IF5	130	1	0	2	5	2	279
IF5	130	0	0	4	25	3	179
IF5	130	0	0	8	61	5	57
IF5	130	0	0	2	64	7	100
IF9	130	0	0	10	19	4	93
IF9	130	0	0	5	25	3	110
IF9	130	2	0	1	22	7	88
IF9	130	0	0	3	20	10	67
OF15	130	0	0	3	5	5	50
OF15	130	0	0	3	9	4	101
OF15	130	2	0	7	35	1	88
OF15	130	1	0	6	9	7	22
OF24	130	0	0	3	15	8	41
OF24	130	0	2	2	3	2	84
OF24	130	40	0	4	3	56	46
OF24	130	0	0	2	6	1	65
OF24	130	0	0	1	4	8	86
IF5	140	6	0	3	7	17	80
IF5	140	0	0	3	70	26	220
IF5	140	4	0	5	44	3	81
IF5	140	16	0	3	3	7	77
IF5	140	0	0	7	7	11	64
IF9	140	2	0	3	30	18	90
IF9	140	28	0	3	9	11	117
IF9	140	10	0	4	14	6	149
IF9	140	14	0	5	18	5	120
IF9	140	2	0	1	0	7	98
OF15	140	1	0	7	24	3	109
OF15	140	4	0	15	17	0	64
OF24	140	3	0	1	3	2	106

DGFC SITES 110-140 GROUPS

HAMLETS	GRUNTS	GROUPERS	PARROTFISH	SNAPPER	WRASSE	BASS	JACKS	SWIMMERS
5	5	0	96	22	84	16	0	0
0	2	2	108	4	56	6	0	0
2	0	0	51	0	187	0	0	0
2	6	4	39	2	61	4	4	0
0	2	3	76	0	67	4	1	0
0	0	0	18	2	11	2	0	0
0	5	5	110	6	82	3	0	1
11	16	2	50	5	6	8	2	0
0	9	5	63	13	37	8	12	0
2	23	4	23	8	22	1	0	0
3	15	1	60	6	26	3	1	3
12	4	0	65	3	15	5	0	0
38	1	2	133	8	251	0	0	3
2	11	0	100	3	57	3	0	1
0	11	1	54	17	24	4	6	1
1	3	1	31	7	45	2	0	0
0	5	1	26	4	59	2	0	0
2	4	1	21	22	43	0	13	0
1	3	2	64	16	39	4	1	2
8	9	0	50	5	13	1	5	0
6	12	2	36	1	10	7	1	0
5	10	0	74	5	105	7	0	0
1	19	1	33	8	6	3	0	0
1	4	1	45	6	49	1	1	2
4	13	0	27	5	1	0	10	0
5	2	0	29	5	15	11	1	1
19	7	2	61	3	11	23	5	0
16	2	1	48	3	2	2	0	0
5	10	0	65	8	158	8	2	2
2	6	1	165	28	162	22	2	1
2	4	0	136	10	86	19	2	0
2	4	0	190	11	189	10	2	2
4	21	1	130	12	113	6	0	0
8	17	3	94	28	57	5	0	0
9	4	2	69	6	24	3	0	1
2	11	0	34	32	75	2	0	0
9	15	3	55	4	5	10	3	1
16	13	3	104	12	70	20	0	0
2	5	2	52	9	6	9	5	1
2	18	3	53	21	10	6	1	0
3	2	0	11	3	2	0	3	0
4	4	1	45	0	41	5	0	0
7	7	1	37	7	4	13	0	0
6	5	0	46	1	3	30	0	1
8	3	2	40	2	48	22	2	0
2	2	1	198	0	65	1	2	14
0	1	0	75	2	48	2	0	3
0	4	0	21	11	112	2	6	6
0	1	5	19	7	14	9	0	1
20	8	1	44	41	272	1	10	12
6	3	0	68	13	75	0	10	1
1	11	0	58	16	20	4	24	0
7	2	1	79	10	32	0	1	0
0	7	1	110	9	51	4	7	0
1	9	3	140	0	116	3	5	0
8	14	3	72	3	12	0	0	0
7	21	0	14	18	110	0	1	0
4	5	2	30	16	2	0	4	3

DGFC SITES 110-140 GROUPS

SHARKS&RAYS	BIGEYES	ODDSHAPED	TURTLES	MAMMALS	INVERTS	NO.IND'S
0	6	0	0	0	1	377
0	3	0	0	0	0	318
1	2	7	1	0	0	453
1	6	6	0	0	0	268
0	8	4	0	0	0	260
0	1	2	0	0	0	96
0	6	10	0	0	0	345
0	10	7	0	0	0	314
0	0	8	0	0	0	280
0	2	4	0	0	0	227
0	2	2	0	0	1	242
0	3	5	0	0	0	212
0	0	0	0	0	2	691
0	0	4	0	0	0	290
0	1	7	0	0	0	299
0	3	2	0	0	0	252
0	1	1	0	0	0	248
1	2	9	0	0	0	265
0	3	1	0	0	0	248
0	3	6	0	0	0	245
0	2	4	0	0	0	222
0	4	6	0	0	0	294
0	1	5	0	0	0	162
0	3	7	0	0	0	270
0	3	4	0	0	0	99
0	0	2	0	0	0	178
0	3	8	0	0	0	357
0	5	4	0	0	0	195
0	1	5	0	0	0	573
0	0	1	0	0	0	637
2	4	4	0	0	0	403
0	2	3	0	0	0	543
0	2	4	0	0	0	425
1	9	2	0	0	0	364
0	2	2	0	0	0	240
1	4	2	0	0	1	249
0	1	7	0	0	0	180
0	5	9	0	0	0	395
0	0	4	0	0	0	202
0	0	0	0	0	0	165
0	0	3	1	0	1	84
0	2	1	0	0	1	197
0	9	5	1	0	1	244
0	3	6	1	0	0	174
0	3	5	2	0	0	239
0	1	6	0	0	0	468
0	1	3	0	0	0	428
0	0	7	0	0	0	265
0	0	1	0	0	0	167
0	4	2	0	0	0	527
0	5	1	0	0	0	304
0	7	4	0	0	0	318
0	6	4	0	0	0	329
0	13	2	0	0	0	348
0	0	6	0	0	0	415
0	7	2	0	0	0	258
0	8	2	0	0	0	267
1	0	1	0	0	0	185