12. APPENDIX D

ASSESSMENT OF FISH COMMUNITIES IN JOHN PENNEKAMP CORAL REEF STATE PARK AND KEY LARGO CORAL REEF MARINE SANCTUARY WITH COMMENTS ON THE USE OF A RAPID VISUAL TECHNIQUE

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12.1. INTRODUCTION

High species richness, high species diversity and high density of individuals are characteristic of the fish fauna of coral reefs. Coral reef habitat and associated fish fauna are present in only a limited area near the continental United States. The only extensive living coral reef on the continental shelf of the United States is the Florida reef tract, the majority of which extends approximately from Fowey Light off Miami 241 km southwest to Key West (Smith, 1971; Hoffmeister, 1974) (Fig. 1a). The reef tract terminates approximately 65 km west of Key West, although, well-developed living coral reefs surround the Dry Tortugas, 97 km west of Key West.

Public concern over the preservation of coral reefs has led to the establishment of four conservation areas on the tract: John Pennekamp Coral Reef State Park in 1961, Key Largo National Coral Reef Marine Sanctuary in 1975, Biscayne National Park in 1980 (established from Biscayne National Monument which originated in 1968), and the Looe Key National Marine Sanctuary in 1981. Biologists and natural resource managers are recognizing the importance of developing effective, non-destructive methods of obtaining qualitative and quantitative data in order to properly monitor and manage fish communities in these areas.

Much of the early work on fish community assessment involved collection of specimens using ichthyocides (Randall, 1963; Starck, 1968; Wass, 1967; Emery, 1973; Smith, 1973, and others) or explosives (Starck, 1968; Talbot and Goldman, 1973). Visual methods, until recently, consisted of enumeration of fishes over measured areas (transects, quadrats, or other fixed areas). Brock (1954), Ebeling *et al.* (1971), Risk (1972), Key (1973), McCain and Peck (1973), Smith and Tyler (1973), Hobson (1974), Chave and Eckert (1974), Itzkowitz (1974), Jones and Chase (1975), and Alevizon and Brooks (1975) are among those who have either developed or used methods in this category.

Jones and Thompson (1978) pioneered a simple, rapid, visual technique that alleviated most of the equipment and time-consuming measurements required by previous methods. Thompson and Schmidt (1977) and Bohnsack (1979) have used this method for studies on Florida reefs, and it is the method used in this study pursuant to the specifications of NOAA contract no. NA-79-SAC-00813.

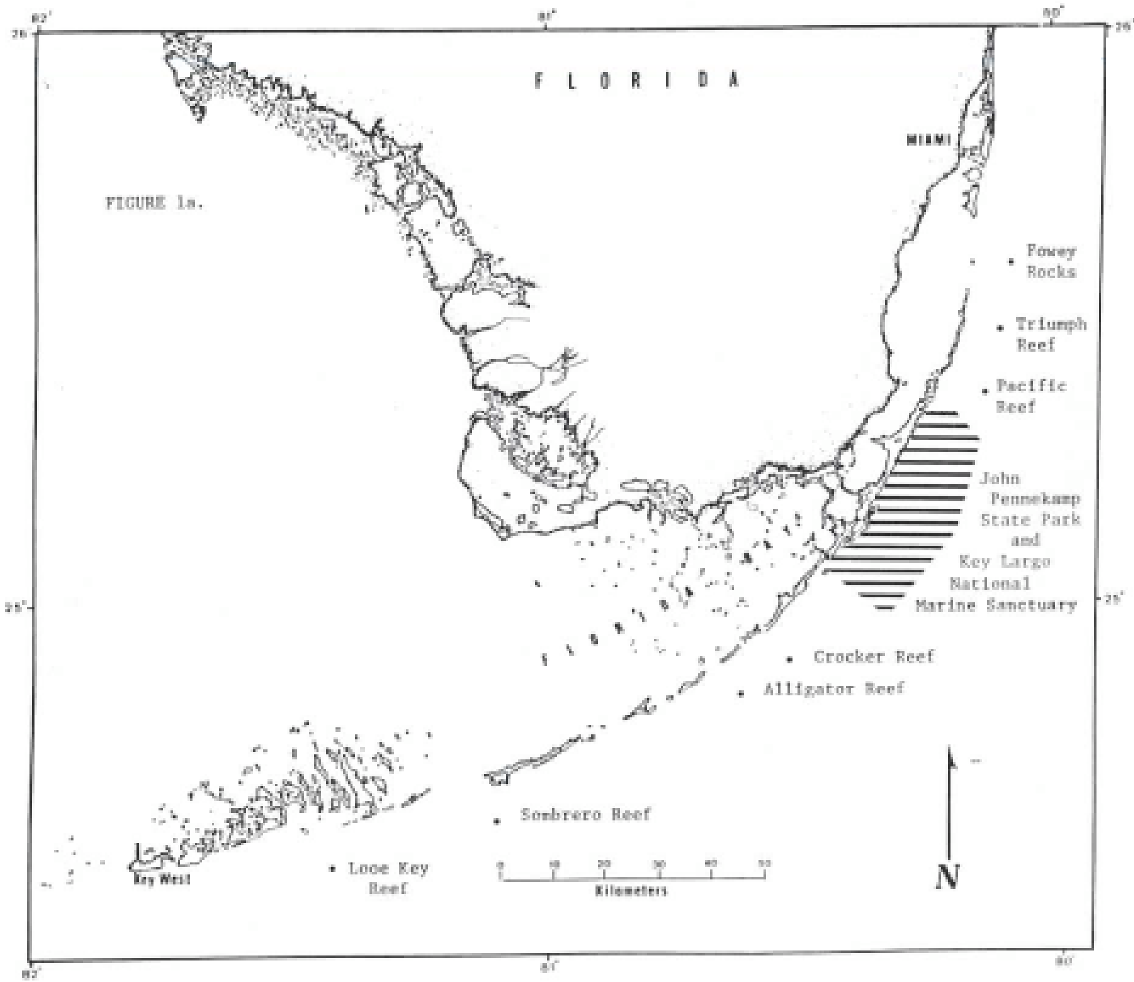

Figure 1a. Map showing the main portion of the Florida reef tract extending from Fowey Rocks off Miami 241 km southwest to Key West, and the position of the study area on the tract.

Several authors have demonstrated weaknesses in the species/time technique (STT) of Jones and Thompson (1978) subsequent to the time this contract was written (DeMartini and Roberts 1982, Sanderson and Solonsky 1980). While the STT is superior to other methods for efficient and rapid enumeration of species, the use of species scores to characterize community structure of reef fishes is suspect. Bohnsack and Bannerot (1983) have developed and tested a visual method which produces data more appropriate for analysis of community structure, but is more time consuming than the STT.

The general purpose of this study was to describe and compare the fish fauna at seventeen sites, within the boundaries of John Pennekamp State Park and Key Largo Marine Sanctuary off Key Largo, Florida Keys. The STT provides data on species diversity which is adequate in most cases for this purpose. Sites from a number of habitats representative of the area were selected. The habitats were grouped into four major categories: (1) offshore reefs, (2) intermediate reefs, (3) inshore patch reefs, and (4) turtle grass and hardground sites. Extent and type of usage by the public varied between sties. In addition to the primary objective of describing and comparing fish faunas specified in the contract, we have attempted to qualitatively assess possible differences between sites due to user impact and to point out

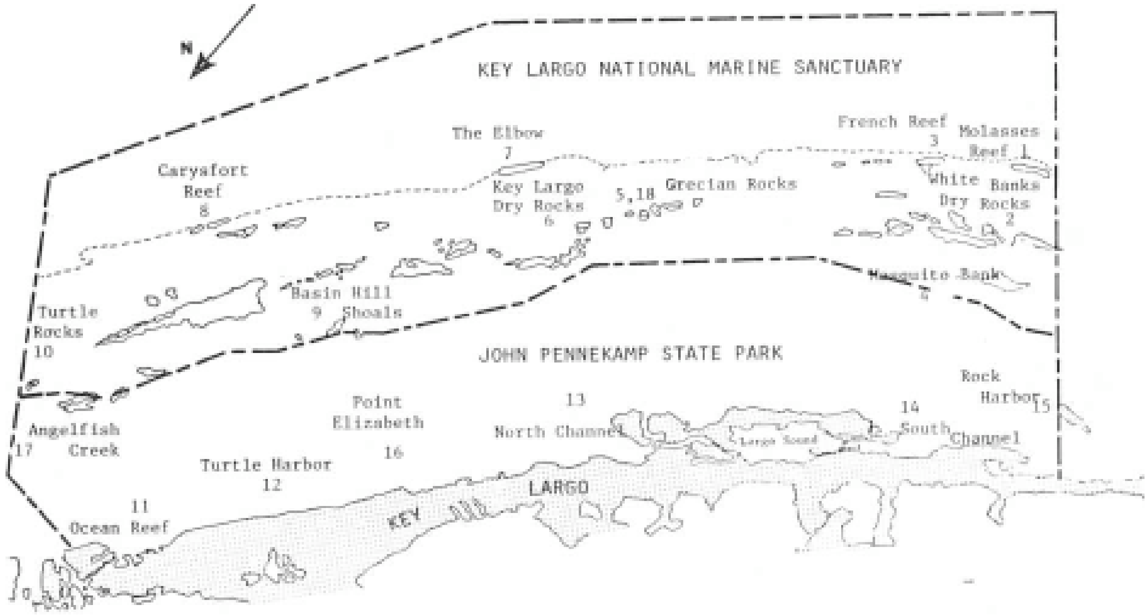

Figure 1b. Map showing John Pennekamp State Park and Key Largo National Marine Sanctuary. The number and name for each of the 17 study sites are given at the respective locations.

problems with using species scores from the STT to characterize fish community structure. All data were collected between March and October of 1980 and 1981.

12.2. THE STUDY AREA

Figure 1b shows the area encompassed by Pennekamp Park and Key Largo Marine Sanctuary including the study sites. Table 1 defines habitat types and describes the approximate type and degree of usage at each site. Voss (1983) gives detailed descriptions of each of the sites. Features of these habitats important to the fish censuses are described below.

12.2.1. Offshore Reefs

The offshore reef sites include Carysfort, French, and Molasses Reefs and the Elbow. Jones and Thompson (1978) provide general habitat descriptions of the first three. The latter three are similar in that the major hard coral complexes of the fore-reef slope give way to sandy plateaus in the offshore direction at approximately 10.7 m depth. Among these, Molasses Reef and the Elbow each have fairly similar spur and groove structure on the outer face and extensive back reef rubble zones. The spur and groove at French Reef is less defined; the spurs are dominated by massive *Montastrea annularis* growth and are often interlaced with caves and passages. Carysfort Reef exhibits a typical Caribbean reef zonation (Goreau, 1959), unlike the other offshore sites, although it lacks any extensive shallow spur and groove formation offshore of the *Acropora palmata* stands of the reef crest. The fore-reef slope gives way to a narrow gently sloping octocorallian community that ends abruptly in extensive thickets of *Acropora cervicornis* (at approximately 14 m depth) which are not found on any of the other offshore reef sites.

Table 1. List of study sites by number and name with habitat type, depth range of fish census, and approximate extent and type of usage by visitors. Habitat definitions are (1) offshore reef (OR) - a major aggregation of scleractinian corals occurring on a contour approximately 6 km offshore defined by the outermost lighthouses on the Florida reef tract; (2) intermediate reef (IR) - a scleractinian coral aggregation usually within 1 km of the offshore reef line; (3) inshore patch reef (IPR) - an aggregation or group of various sized aggregations of scleractinian corals usually at least 2 km inshore of the outer reef line; (4) turtle grass (TG) - an area dominated by turtle grass, *Thalassia testudinum*, bottom; (5) hardground (H) - bedrock areas featuring numerous octocorals, various sponges, and encrusting and small head scleractinian corals. The term "diving" includes non-consuming recreational SCUBA and snorkeling, the only consumptive usage being the taking of lobsters in season. "Fishing" refers only to hook and line fishing, most of which is recreational (spearfishing and fish traps are illegal in both conservation areas). Boat traffic is only considered for turtle grass or hardground sites less than 4.9 m depth where bottom disturbance from wakes and prop turbulence is most noticeable. The extent of the various activities are strictly subjective impressions obtained by one of the authors during 6 years of diving experience in the area and by both authors during the course of the study (no quantitative data such as boat counts were obtained on a regular basis). H = heavy usage, M = moderate usage, L = light usage, 0 = very little or no usage.

				Approx. Extent and Type of Usage		
Site No.	Name	Habitat	Depth Range of Fish Census	Diving	Fishing	Boat Traffic
1	Molasses Reef	OR	3.1-12.8	H	M	
2	White Bank Dry Rocks	IR	0.6-7.6	M	L	- - -
3	French Reef	OR	4.0-13.7	H	M	- - -
4	Mosquito Bank	IPR	0.9-4.6	L	M to L	- - -
5	Grecian Rocks	IR	0.3-9.1	H	L	- - -
6	Key Largo Dry Rocks	IR	0.6-10.7	H	L	- - -
7	The Elbow	OR	2.4-9.1	H to M	M	- - -
8	Carysfort Reef	OR	4.6-15.2	M	M to L	- - -
9	Basin Hill Shoals	IPR	0.2-2.4	L	L	- - -
10	Turtle Rocks	IPR	4.6-6.1	L	L	- - -
11	Ocean Reef	TG	3.1-3.7	0	0	M
12	Turtle Harbor	TG	3.7-4.7	0	0	L
13	North Channel	TG/H	2.7-4.3	0	0	M
14	South Channel	TG/H	4.0	0	0	H
15	Rock Harbor	TG	2.4-3.4	0	0	H to M
16	Point Elizabeth	TG/H	4.0-4.6	0	0	L
17	Angelfish Creek	IPR	3.1-5.8	L	L	- - -

12.2.2. Intermediate Reefs

White Bank Dry Rocks, Grecian Rocks, and Key Largo Dry Rocks are categorized as intermediate reefs based on their structure and distance from the offshore margin of the Florida reef tract. Each of these sites is 2.6 km or less from the 60 ft (18.3 m) contour. The environmental characteristics are intermediate between, those of the offshore reefs and sites further inshore. Visibility, for example, at these sites is often not as good as visibility at offshore locations, but better than the visibility at inshore locations.

Size and complexity of coral formations at the intermediate reef sites are less than that found at offshore reef sites. Key Largo Dry Rocks and Grecian Rocks are the most similar to offshore sites of the group. Grecian Rocks has a back-reef, a well-defined reef crest consisting primarily of densely packed *Acropora palmata*, and a short fore-reef slope ending in a flat, sandy plateau at around 8.2 m depth. Key Largo Dry Rocks lacks a well-defined, reef crest, but does have a back reef-rubble zone area and large scleractinian coral development that approximates spur and groove formation.

White Bank Dry Rocks, unlike Key Largo Dry Rocks and Grecian Rocks, lacks any morphological similarity to offshore reefs. White Bank Dry Rocks, however, is a more consolidated patch reef area than those sites in the next category.

12.2.3. Inshore Patch Reefs

Basin Hill Shoals, Mosquito Bank, Turtle Rocks, and Angelfish Creek are patch reef sites occurring over 2.7 km away from the 60 ft (18.3 m) contour. The former two are large, shallow banks of turtle grass dotted with patches of mixed scleractinian and octocorallian corals. Turtle Rocks is a loose aggregation of patch reefs consisting of a variety of scleractinian coral species separated by turtle grass (*Thalassia testudinum*) beds and sand. Angelfish Creek is an isolated patch reef surrounded by turtle grass.

12.2.4. Turtle Grass and Hardground

Six sites were located within 1.8 km of shore. Site numbers 11, 12, and 15 were on bottom dominated by turtle grass. Site numbers 13, 14, and 16 were in areas of turtle grass mixed with regions termed hardground. Hardground consisted of bedrock featuring numerous octocorals, sponges, and small head corals (primarily genus *Siderastrea*).

These sites are probably more affected by boat traffic than other study sites due to their shallow depth and location near channels and navigation routes. While the purpose of the study was to describe the fish fauna at each of these sites, we believe it is useful to give some idea of possible boating impact on the different areas. It is possible that such impact could be one of several variables responsible for differences in fish communities at these sites.

Each of these six sites represented a unique combination of habitat type and extent of user impact caused by boat traffic. Depth does not exceed 16 ft (4.9 m) at any site, and turbulence from power boat propellers and wakes causes varying degrees of agitation of sediments and disturbance of plant and animal communities depending on the size of the boat.

Site 15 (Rock Harbor) experiences the most boat traffic of the three turtle grass sites (11, 12, 15). The site is just offshore of Port Largo. A large number of private boats, several dive and charter fishing boats, and a number of commercial fishing boats must pass through this vicinity to go offshore.

Site 11 (Ocean Reef) is just off the entrance to an exclusive private resort club (Ocean Reef Club) on northern Key Largo. A number of larger yachts and offshore sport fishing vessels traverse this site as they enter or leave the club. While the average size of the vessels is somewhat larger than at Rock Harbor, the number passing through is smaller.

Site 12 (Turtle Harbor) is not near any main channel or passage route to popular offshore fishing or diving areas. No docks or marinas occur directly inshore of it. As a result it experiences very little boat traffic.

Site 14 (South Channel) is subjected to more boat traffic than the other turtle grass/hardground sites (13, 14, 16), followed by site 13 (North Channel). Most of the traffic from Largo Sound and Pennekamp Park Marina passes through this channel to go to the more popular dive sites such as Molasses Reef, French Reef, and the Benwood Wreck. The traffic includes a large sight-seeing vessel, dive charter boats, private boats, and a fleet of rental boats from park headquarters. The channel is narrow, forcing all traffic through a small area. For these reasons site 14 probably experiences more impact from boats than any other of the six sites near shore.

Site 13 (North Channel) also has considerable traffic. Private, dive charter, and commercial fishing boats from Largo Sound and Garden Cove Marina use this channel. The inshore section of North Channel is nearly as narrow as South Channel, but depths between this section and the most offshore channel marker (red number 2) allows safe passage of boats of most sizes over a wide area, lessening the impact of whatever traffic occurs at this channel.

Site 16 (Point Elizabeth) is not immediately offshore of any development or marina and, like site 12 (Turtle Harbor), has fewer boats passing through.

12.3. METHODS

The STT of Jones and Thompson (1978) was used without modification at all study sites. Jones and Thompson discuss the adaptation of the technique from species-area (Oosting, 1956) and species-time (Beals, 1960) techniques used in other sub-disciplines of ecology. A single STT count consisted of a 50 min SCUBA dive during which the diver actively searched for and recorded as many species as possible. Species were recorded in order of encounter, being listed only once per count. Counts were subdivided into 10 minute intervals. Fish species were then assigned scores based on the first interval in which they were observed within each 50-minute count. Species observed during the first 10 minutes of a count received a score of 5, with second-, third-, fourth- and fifth-interval species receiving scores of 4, 3, 2, and 1, respectively.

We recorded all species with pencil on underwater paper attached to aluminum clipboards. Most species were identified on sight. Species that we could not identify by inspection were collected, usually following the STT count, and brought back to the laboratory for identification.

Jones and Thompson (1978) used the P_k statistic of Gaufin *et al.* (1956) to choose *a priori* the number of samples needed to census 90% or more of the fish species at their offshore reef sites. They chose 8 replicates per site. We used 8 replicates per site during 1980, in which we sampled the 9 odd-numbered sites. We were able to obtain 12 replicates per site during 1981 at which time we sampled the 8 even-numbered sites. We also sampled site 5 (Grecian Rocks) a second time in 1981 in an attempt to get some idea of year to year variability in a fish community as determined by using the STT. A total of 180, 50-minute STT counts were made during the two year study (9 sites x 8 replicates for 1980 + 9 sites x 12 replicates for 1981), resulting in over 150 man-hours of bottom time.

Data analysis follows the general procedure of Jones and Thompson (1978), as specified by NOAA contract No. NA-79-SAC-00813. Using this procedure also provides a comparison with their first test of the STT. We will, however, discuss some of their assumptions in greater detail.

Fish communities at each of the 18 sites (9 sites in 1980, 8 new sites plus one repeat site in 1981) were compared on the basis of mean number of species and mean scores using one-way analysis of variance (ANOVA). We considered each site to be a unique entity rather than a randomly sampled representative of a certain class; e.g., site 11 (Ocean Reef) is a turtle grass community subjected to a unique level of boat traffic; the structural features and locations of Carysfort, French, and Molasses reefs and the Elbow make each a unique site; and so on for the other sites. The result is that our data approximately conform to the specifications of Model I rather than Model II ANOVA (Eisenhart, 1947; Sokal and Rohlf, 1981). Thus we analyzed the data according to the general model

$$Y_{ij} = \mu + \square_i + \square_j \qquad (1)$$

where i = site number, j = individual STT count number, Y_{ij} = number of species (or total species score) at site i on the STT count j, μ = mean number of species or mean total score over all STT counts at all sites, $\square_i$ = the "treatment effects" of being at site i (i.e. the influence that being at site i has on the mean number of species observed or mean total score of species observed) and $\square_j$ = an independent, normally distributed random error term. The variable $\square_j$ represents the stochastic nature of differences in number of species (or total species scores) at different sites due to recruitment, colonization, an extinction of species on a relatively short time horizon. For these comparisons, 1980 and 1981 sample sizes were equalized by randomly selecting 8 of 12 possible counts per species for each of the 1981 sites.

Multiple comparisons to distinguish which means or groups of means are significantly different from others were carried out subsequent to the ANOVA. A number of applicable multiple comparison procedures exist and are discussed by Federer (1955), Harter (1957, 1970), Steel and Torrie (1960), Dunnett (1970), Boardman and Moffit (1971), Carmer and Swanson (1973), Zar (1974) and Kleinbaum and Kupper (1978). Several other procedures are suitable for our data, but the contract specifies Duncan's Multiple Range Test (DMRT), which also provides a comparison with the results of Jones and Thompson (1978).

Further between-site comparisons were made using the Shannon-Weaver diversity function, evenness values of Pielou (1966), and the Bray and Curtis Index (1957). We followed the community ordination procedure adapted from Bray and Curtis (1957) by Beals (1960), as did Jones and Thompson (1978). We computed, the Shannon-Weaver diversity function using base 10 logs and species scores, denoted H' to distinguish these values from the conventional H computed from species abundance. Jones and Thompson (1978) defend the substitution of STT scores for counts of individuals in the Shannon-Weaver diversity function. We believe this substitution is questionable but worth presenting to provide a third tool for between-site comparisons, in addition to the ANOVA-DMRT and Bray and Curtis Index-ordination comparison methods. For all between-site Bray and Curtis Index comparisons, 1980 and 1981 site sample sizes were made equal by randomly selecting 8 of 12 possible counts per species for each of the 1981 sites as for the ANOVA-DMRT.

We prepared a rank order of all species censused over all sites and STT counts during the two year study. We also prepared a ranked list of species censused for each of the four major habitat categories: (1) offshore reefs, (2) intermediate reefs, (3) inshore patch reefs, and (4) turtle grass and hardground based on summed species scores. Scores presented in these tables were rounded to the nearest integer. In calculating these summed species scores, 1981 site scores were adjusted to equalize the number of counts used per site with 1980 scores. Rather than eliminate 4 STT counts for rank order analysis of 1981 sites, which would have entailed loss of some species, we adjusted 1981 data for effort by multiplying individual scores by 8/12 (0.67).

12.4. RESULTS AND DISCUSSION

12.4.1. Descriptive Information on Species Composition

All fish species are listed in taxonomic order following Robins *et al.* (1980). Table 2 lists the fish species censused in 1980, total score per species per site by site number, and total score per species for all sites. The highest possible total score over all sites in 1980 is 360.

Table 3 lists the fish species censused in 1981. Note that site 18 is Grecian Rocks, which is site 5 in 1980. The highest possible total score over all sites in 1981 is 540. No species attained these maximum total scores in either 1980 or 1981. This is not surprising considering the wide variety of habitats censused and the relatively low fish abundance and diversity at some of the sites.

The data in Tables 2 and 3 show that 198 and 202 total species were censused in 1980 and 1981 respectively, compared to 146 species observed off Key Largo by Jones and Thompson (1978). The greater number of species observed in the present study may be due primarily to the larger number of man-hours of bottom time (over 150 compared to 50) and wider variety of habitats sampled. For example, members of family Batrachoididae, Ophichthidae, Gobiesocidae, Syngnathidae, and Dactyioscopidae were censused in habitats not sampled by Jones and Thompson (1978). A number of blenniids, clinids, and gobiids were also recorded from inshore areas. In other cases, our longer list appears to be due to increased bottom time resulting in observations of relatively uncommon offshore reef inhabitants (for example *Apogon robinsi*, *A. lachneri*, and *Astrapogon stellatus* of family Apogonidae and *Lactophrys polygonia* and *L. trigonus* of family Ostraciidae). Expending 33% more sampling effort in 1981 resulted in only 4 more total species censused than in 1980 although only 174 species were common to both years. Twenty-five were censused only in 1980, while 31 appeared only in the data from 1981.

Table 4 is a list of total species and total species scores observed over the entire two year study. A maximum total score for any given species is 900. The table shows that 228 total species were censused by the STT in this study. This represents 38 to 46 percent of the approximately 500 to 600 species that may be found on or near the Florida reef tract. Starck (1968) found 389 coral-associated species after 9 years of collecting at Alligator Reef, Florida Keys. However some of these collections included the use of ichthyocides and even explosives. Longley and Hildebrand (1941) listed 440 species from the Dry Tortugas, but many were not coral reef species. These results indicate that the STT effectively generates a fairly comprehensive list of the more ubiquitous species in a relatively short time. It did not, however, account for many cryptic species, some of which are abundant in the areas sampled.

Table 2. List of fish species censused in 1980, total score per species by site number, and total score per species for all sites.

TIME SCORES BY SPECIES - 1980

SPECIES	Site numbers									
	1	3	5	7	9	11	13	15	17	TOTAL
SPHYRNIDAE:										
Sphyrna tiburo					4					4
DASYATIDAE:										
Dasyatis americana		2			5					7
Urolophus jamaicensis	5			8			13		10	36
MYLIOBATIDAE:										
Aetobatus narinari			1							1
ELOPIDAE:										
Megalops atlanticus		5								5
MURAENIDAE:										
Gymnothorax funebris	11			6	5					22
Gymnothorax moringa		1			10		3		4	18
Gymnothorax vicinus					2					2
Muraena miliaris			8							8
OPHICHTHIDAE:										
Ahlia egmontis						1				1
CLUPEIDAE:										
Harengula clupeola					5					5
Jenkinsia lamprotaenia			1							1
Jenkinsia sp.					11					11
SYNODONTIDAE:										
Synodus intermedius	5	7		4			4		4	24
BATRACHOIDIDAE:										
Opsanus beta						3		5		8
EXOCOETIDAE:										
Hemiramphus brasiliensis					5					5
BELONIDAE:										
Tylosurus crocodilus	5		20		5					30
ATHERINIDAE:										
Atherinomorus stipes			2					4		6

Table 2. List of fish species censused in 1980, total score per species by site number, and total score per species for all sites (cont.).

SPECIES	Site numbers									
	1	3	5	7	9	11	13	15	17	TOTAL
HOLOCENTRIDAE:										
Holocentrus adscensionis	12	24		7						43
Holocentrus rufus	4	19		9					7	39
Holocentrus vexillarius	21	35		10						66
Myripristis jacobus	16	16								32
AULOSTOMIDAE:										
Aulostomus maculatus	36	22	21	36					5	120
SYNGNATHIDAE:										
Cosmocampus albirostris								3		3
Hippocampus erectus						5				5
Hippocampus zosterae								4		4
CENTROPOMIDAE:										
Centropomus undecimalis	3	1								4
SERRANIDAE:										
Diplectrum formosum						23	21	6		50
Epinephelus adscensionis		1								1
Epinephelus cruentatus	34	32	18	18					11	113
Epinephelus guttatus	1	5		2	3					11
Epinephelus itajara		4								4
Epinephelus morio			2				4			6
Epinephelus striatus	12	18	13	10	22		3			78
Hypoplectrus aberrans	2	3								5
Hypoplectrus gemma	18	29		3	16				24	90
Hypoplectrus indigo				4					9	13
Hypoplectrus nigricans		15		8	3				3	29
Hypoplectrus puella	5	10	1	10	25				5	56
Hypoplectrus unicolor	23	36	17	28	24				33	161
Liopropoma rubre	3	8	3	2						16
Mycteroperca bonaci	14	4	16	10	17				8	69
Mycteroperca tigris		3		2						5
Serranus baldwini	5	8	6	8					10	37
Serranus tabacarius		13		2					4	19
Serranus tigrinus	34	37	15	31					23	140
GRAMMISTIDAE:										
Rypticus saponaceus	7	12		9						28
PRIACANTHIDAE:										
Priacanthus arenatus	4	7								11
Priacanthus cruentatus	20	15	5	30						70

Table 2. List of fish species censused in 1980, total score per species by site number, and total score per species for all sites (cont.).

SPECIES	Site numbers									
	1	3	5	7	9	11	13	15	17	TOTAL
APOGONIDAE:										
Apogon binotatus		6	4	7						17
Apogon maculatus	7	2	13		3		1	1	5	32
Apogon townsendi	7	5	3							15
Astrapogon stellatus								6	1	7
MALACANTHIDAE:										
Malacanthus plumieri	9	11		18						38
ECHENEIDAE:										
Echeneis naucrates	6	20	1	11	3				4	45
CARANGIDAE:										
Caranx bartholomaei					12		15	4	5	36
Caranx crysos					1	9	2			12
Caranx ruber	31	10	34	31	33	5	6	5	17	172
Oligoplites saurus								3		3
Seriola dumerili			3							3
Trachinotus falcatus				3						3
LUTJANIDAE:										
Lutjanus analis	15	3	33	17	6		6	3		83
Lutjanus apodus	23	24	27	24	10					108
Lutjanus griseus	39	27	33	40	33			9		181
Lutjanus jocu	14	19	8	10						51
Lutjanus mahogoni	35	29	13	36						113
Lutjanus synagris		26		5			3	13		47
Ocyurus chrysurus	40	40	36	40	40	4	15	8	40	263
GERREIDAE:										
Gerres cinereus					5					5
HAEMULIDAE:										
Anisotremus surinamenis	19	19	15	11			1		5	70
Anisotremus virginicus	30	33	25	24	39		12	3	31	197
Haemulon album	12	6								18
Haemulon aurolineatum			6			1		10		17
Haemulon carbonarium	37	38	31	40						146
Haemulon chrysargyreum	39	30	30	40					3	142
Haemulon flavolineatum	40	40	39	39	39		11	28	25	261
Haemulon macrostomum	33	34	19	29						115
Haemulon melanurum			6	6			4			16
Haemulon parra	1	23	23	37						84
Haemulon plumieri	31	38	32	30	40	6	18	12	40	247
Haemulon sciurus	40	34	35	40	35		5	8	35	232
Haemulon sp. 1									5	5

Table 2. List of fish species censused in 1980, total score per species by site number, and total score per species for all sites (cont.).

SPECIES	Site numbers								
	1	3	5	7	9	11	13	15	17	TOTAL
SPARIDAE:										
Calamus bajonado	3		6		7		5			21
Calamus calamus	8	22	22	3	35	2	9	5	36	142
Lagodon rhomboides						2		2		4
SCIAENIDAE:										
Equetus acuminatus	10	5	9	7	13		35	12	16	107
Equetus lanceolatus		7								7
Equetus punctatus	3	7	4	12	10		2			38
Odontoscion dentex	31	33		22	3					89
MULLIDAE:										
Mulloidichthys martinicus	35	29	37	38						139
Pseudupeneus maculatus	14	27	10	31					16	98
PEMPHERIDAE:										
Pempheris schomburgki	34	39	38	40						151
KYPHOSIDAE:										
Kyphosus sectatrix	19	34	29	39						121
EPHIPPIDAE:										
Chaetodipterus faber	3	4			9	4				20
CHAETODONTIDAE:										
Chaetodon capistratus	32	39	6	29	31		7		10	154
Chaetodon ocellatus	33	23	14	27	5		1		19	122
Chaetodon sedentarius	5		21	5	5		4			40
Chaetodon striatus	30	27		10					21	88
POMACANTHIDAE:										
Holocanthus bermudensis	9	3	15		28		6		34	95
Holocanthus tricolor	38	40	3	25						106
Holocanthus ciliaris	25	16	31	22	14		4	3	21	136
Pomacanthus arcuatus	20	21	25	15	27	7	31	11	40	197
Pomacanthus paru	18	13	31	12			5	7		86
POMACENTRIDAE:										
Abudefduf saxatilis	40	39	39	39	39		1		30	227
Chromis cyanea	34	40	5	40						119
Chromis insolata	4									4
Chromis multilineata	27	25	13	37						102
Chromis scotti	6	18		3						27
Microspathodon chrysurus	30	39	40	40						149

Table 2. List of fish species censused in 1980, total score per species by site number, and total score per species for all sites (cont.).

SPECIES	Site numbers 1	3	5	7	9	11	13	15	17	TOTAL
Pomacentrus diencaeus	33	39	38	32	19				2	163
Pomacentrus leucostictus	6	5	22	7	35		15	2	24	116
Pomacentrus partitus	40	40	40	40	39				40	239
Pomacentrus planifrons	39	38	40	40	40				38	235
Pomacentrus variabilis	20	10	29	17	40		21	12	39	188
CIRRHITIDAE:										
Amblycirrhitus pinos	8	10		8						26
LABRIDAE:										
Bodianus rufus	28	36	30	40						134
Clepticus parrae	17	19	1	13						50
Halichoeres bivittatus	26	24	37	32	18	2	5		38	182
Halichoeres garnoti	40	40	25	39	1				5	150
Halichoeres maculipinna	40	40	40	37	3				40	200
Halichoeres poeyi			4		2					6
Halichoeres radiatus	33	17	40	36	8				23	157
Hemipteronotus martinicensis									10	10
Hemipteronotus novacula		10		6						16
Hemipteronotus splendens	5	25	24	25			5			84
Lachnolaimus maximus	8	22	21	37	34		14	5	34	175
Thalassoma bifasciatum	40	40	40	40	39		2		40	241
SCARIDAE:										
Cryptotomus roseus			13			5		10	11	39
Scarus coelestinus	20	23	33	24	29				18	147
Scarus coeruleus	25	32	25	7	38		5		14	146
Scarus croicensis	36	30	40	39	40	1	16	22	40	264
Scarus guacamaia	17	10	13	11	7					58
Scarus taeniopterus	28	26	25	21					14	114
Scarus vetula	35	40	34	35						144
Sparisoma aurofrenatum	40	40	39	38	20				40	217
Sparisoma chrysopterum	35	30	38	35	32	9	25	14	39	257
Sparisoma radians	10	28	16	12	21		8	5	28	128
Sparisoma rubripinne	24	30	39	18	9				30	150
Sparisoma viride	40	35	40	40	40		4	8	40	247
SPHYRAENIDAE:										
Sphyraena barracuda	34	16	32	15	31	4	5		18	155
OPISTOGNATHIDAE:										
Opistognathus aurifrons	19	12		12					10	53
Opistognathus maxillosus							14		2	16

Table 2. List of fish species censused in 1980, total score per species by site number, and total score per species for all sites (cont.).

SPECIES	Site numbers									
	1	3	5	7	9	11	13	15	17	TOTAL
DACTYIOSCOPIDAE:										
Platygillelus rubrocinctus					3					3
CLINIDAE:										
Acanthemblemaria sp. 2				1	1				9	11
Acanthemblemaria sp. 3									16	16
Acanthemblemaria sp. 4									4	4
Hemiemblemaria simulus	4	15							7	26
Malacoctenus aurolineatus			2							2
Malacoctenus roseus					8					8
Malacoctenus sp. 1					6		5		10	21
Malacoctenus triangulatus					3				4	7
Paraclinus sp. 1						1	17	11		29
BLENNIIDAE:										
Blenniidae juvenile spp.							4			4
Blenniidae sp. 1					6		1			7
Ophioblennius atlanticus	5			3						8
Parablennius marmoreus			3						3	6
Scartella cristata			16		19		6		2	43
CALLIONYMIDAE:										
Callionymus bairdi	4	5							3	12
GOBIIDAE:										
Barbulifer sp.								5		5
Coryphopterus dicrus	7	14	12	13	16		10		23	95
Coryphopterus glaucofraenum	21	22	18	21	36		25	33	20	196
Coryphopterus personatus	11	28		18	14					71
Gnatholepis thompsoni	27	34	21	28	21		1		38	170
Gobionellus saepepallens								5		5
Gobiosoma grosvenori					8	19	15	9		51
Gobiosoma macrodon					5	1	34	5		45
Gobiosoma oceanops	13	24	30	13	37		11		22	150
Ioglossus calliurus	12	12	8	8					15	55
Microgobius carri		15	5				12			32
Microgobius microlepis					4	2	16	38		60
ACANTHURIDAE:										
Acanthurus bahianus	40	40	39	40	32		13	3	40	247
Acanthurus chirurgus	21	31	33	16	34		15		34	184
Acanthurus coeruleus	40	40	40	40	36				38	234

Table 2. List of fish species censused in 1980, total score per species by site number, and total score per species for all sites (cont.).

SPECIES	Site numbers									
	1	3	5	7	9	11	13	15	17	TOTAL
SCOMBRIDAE:										
Scomberomorus regalis	1	15		10	2	2				30
SCORPAENIDAE:										
Scorpaena plumieri					3					3
BOTHIDAE:										
Bothus lunatus							1			1
Bothus sp. 1									2	2
Bothus sp. 2							4			4
BALISTIDAE:										
Aluterus schoepfi									4	4
Aluterus scriptus	16	9	10	16	1				6	58
Balistes capriscus						5	3			8
Balistes vetula				5					13	18
Cantherhines macrocerus	3									3
Cantherhines pullus	23	38	12	18						91
Canthidermis sufflamen	3		6	20					14	43
Monacanthus ciliatus						13				13
Monacanthus tuckeri	5		2							7
OSTRACIIDAE:										
Lactophrys bicaudalis	3	6	5	13	5					32
Lactophrys polygonia									5	5
Lactophrys quadricornis							4			4
Lactophrys trigonus		3								3
Lactophrys triqueter	11	18	9	25	8				19	90
TETRAODONTIDAE:										
Canthigaster rostrata	35	34	17	33	4				19	142
Sphoeroides spengleri							5			5
DIODONTIDAE:										
Diodon holocanthus	5			5	1	4			1	16
Diodon hystrix	5	3	2	8	4				2	24

Table 3. List of fish species censused in 1981, total score per species by site number, and total score per species for all sites.

SPECIES	Site numbers									
	2	4	6	8	10	12	14	16	18	TOTAL
ORECTOLOBIDAE:										
Ginglymostoma cirratum		8						1		9
CARCHARHINIDAE:										
Carcharhinus leucas			4						5	9
DASYATIDAE:										
Dasyatis americana			2	1	3					6
Urolophus jamaicensis	13	8			16		13	9	4	63
MYLIOBATIDAE:										
Aetobatus narinari			5	1					1	7
MURAENIDAE:										
Gymnothorax funebris	8		9							17
Gymnothorax moringa		5	4	2	9		4			24
Muraena miliaris	2			3					2	7
CLUPEIDAE:										
Harengula clupeola		5					3			8
Harengula sp.		7								7
Jenkinsia lamprotaenia	9		15	4					5	33
Jenkinsia sp.				1			1			2
Sardinella aurita		9					11			20
SYNODONTIDAE:										
Synodus intermedius	9	17	8	5		2	1	3		45
BATRACHOIDIDAE:										
Opsanus beta								5		5
GOBIESOCIDAE:										
Gobiesox strumosus						4		2		6
EXOCOETIDAE:										
Hemiramphus brasiliensis	4									4
BELONIDAE:										
Strongylura notata							16			16
Tylosurus crocodilus			5	3					23	31
ATHERINIDAE:										
Atherinomorus stipes				5			1			6

Table 3. List of fish species censused in 1981, total score per species by site number, and total score per species for all sites (cont.).

SPECIES	Site numbers									
	2	4	6	8	10	12	14	16	18	TOTAL
HOLOCENTRIDAE.										
Holocentrus adscensionis			2	7						9
Holocentrus rufus	1	5	8	16	5				1	36
Holocentrus vexillarius				6						6
AULOSTOMIDAE:										
Aulostomus maculatus	33	8	34	50	28				46	199
SYNGNATHIDAE:										
Cosmocampus albirostris						1				1
Hippocampus erectus						8				8
SERRANIDAE:										
Diplectrum formosum			1		1	43	28	18	3	94
Epinephelus afer			1							1
Epinephelus cruentatus	25	5	32	48	20				34	164
Epinephelus guttatus				3	2					5
Epinephelus morio			2		21		15	21		59
Epinephelus striatus	9	5	13	13	9				10	59
Hypoplectrus aberrans				12						12
Hypoplectrus chlorurus				2						2
Hypoplectrus gemma	10	5	4	51	7				5	82
Hypoplectrus guttavarius				10						10
Hypoplectrus indigo			14	12					4	30
Hypoplectrus nigricans	3	13	18	21	4				12	71
Hypoplectrus puella	33	15	23	13	7				15	106
Hypoplectrus unicolor	39	23	34	50	15		4		23	188
Liopropoma rubre			2	6						8
Mycteroperca bonaci	13	23	32	14	7		2	5	18	114
Mycteroperca tigris			3							3
Mycteroperca venenosa		2								2
Serranus baldwini				8	5					13
Serranus tabacarius	2		5						2	9
Serranus tigrinus	25		53	47	15				36	176
GRAMMISTIDAE:										
Rypticus saponaceus	2			4					4	10
PRIACANTHIDAE:										
Priacanthus cruentatus	14		5	15					14	48

Table 3. List of fish species censused in 1981, total score per species by site number, and total score per species for all sites (cont.).

SPECIES	Site numbers 2	4	6	8	10	12	14	16	18	TOTAL
APOGONIDAE:										
Apogon binotatus			3	18					3	24
Apogon lachneri			5							5
Apogon maculatus	4	9	11	12	1				20	57
Apogon pseudomaculatus			4							4
Apogon robinsi									4	4
Apogon townsendi				13					5	18
Astrapogon stellatus				4			16			20
MALACANTHIDAE:										
Malacanthus plumieri			3						3	6
ECHENEIDAE:										
Echeneis naucrates	30		9	10	7	7			36	99
CARANGIDAE:										
Caranx bartholomaei	9	15	7		4		17		9	61
Caranx crysos		10			7	11	48	26		102
Caranx ruber	57	57	56	37	34	9	47	18	50	365
Trachinotus falcatus				2						2
LUTJANIDAE:										
Lutjanus analis	26	13	13	18	4		5		30	109
Lutjanus apodus	47	30	41	40	24				53	235
Lutjanus cyanopterus			7							7
Lutjanus griseus	46	58	47	26	10	4	43		40	274
Lutjanus jocu	8		8	2					10	28
Lutjanus mahogoni	31	10	34	49		10		1	23	158
Lutjanus synagris		40	11	7		3	19	29		109
Ocyurus chrysurus	59	49	60	57	57		4	4	58	348
GERREIDAE:										
Eucinostomus sp. 1						2	1	3	4	10
Eucinostomus sp. 2								10		10
Gerres cinereus		14	2				39		28	83
HAEMULIDAE:										
Anisotremus surinamenis	31			9	8				17	65
Anisotremus virginicus	48	41	41	42	31		21	22	34	280
Haemulon album	4		6						1	11
Haemulon aurolineatum	45	59	34	32	26				59	255
Haemulon carbonarium	45	2	37	47	21				55	207
Haemulon chrysargyreum	45		38	32	4				51	170
Haemulon flavolineatum	59	57	60	60	58	5	5		60	364
Haemulon macrostomum	47		53	46	5				51	202

Table 3. List of fish species censused in 1981, total score per species by site number, and total score per species for all sites (cont.).

SPECIES	Site numbers									
	2	4	6	8	10	12	14	16	18	TOTAL
Haemulon melanurum				1	18					19
Haemulon parra	16		23	17	10				29	95
Haemulon plumieri	56	60	59	53	60	46	36	55	55	480
Haemulon sciurus	56	60	57	55	31		42	4	54	359
Haemulon sp. 1						2		8		10
Haemulon sp. 2								7		7
SPARIDAE:										
Archosargus probatocephalus		4								4
Archosargus rhomboides		2				5	10			17
Calamus bajonado	9	9	3		28	7	4		4	64
Calamus calamus	17	11	2		20		3		8	61
Calamus penna	1									1
Lagodon rhomboides						37				37
SCIAENIDAE:										
Equetus acuminatus	28	19	19	2	34		26	33	23	184
Equetus lanceolatus			15	8					3	26
Equetus punctatus			3	3						6
Odontoscion dentex	46	4	1	13	6					70
MULLIDAE:										
Mulloidichthys martinicus	26		47	44	12				52	181
Pseudupeneus maculatus	40	17	11	19	40				33	160
PEMPHERIDAE:										
Pempheris poeyi	1									1
Pempheris schomburgki	46		27	41					51	165
KYPHOSIDAE:										
Kyphosus sectatrix	42	7	30	30					24	133
CHAETODONTIDAE:										
Chaetodon capistratus	25	44	35	52	12		4	1	26	199
Chaetodon ocellatus	25	28	26	41	29		5	5	22	181
Chaetodon sedentarius	10	8	20	31	39				19	127
Chaetodon striatus	9	8	1	15	18				13	64
POMACANTHIDAE:										
Holacanthus bermudensis	3	39		4	16		6		13	81
Holacanthus tricolor	1		20	49	9				21	100
Holacanthus ciliaris	41	9	14	32	49		14		32	191
Pomacanthus arcuatus	46	47	37	36	53	10	25	5	29	288
Pomacanthus paru	32		28	44	37				50	191

Table 3. List of fish species censused in 1981, total score per species by site number, and total score per species for all sites (cont.).

SPECIES	Site numbers 2	4	6	8	10	12	14	16	18	TOTAL
POMACENTRIDAE:										
Abudefduf saxatilis	55	49	59	56	6		9		60	294
Chromis cyanea	2			50	5					57
Chromis insolata				5						5
Chromis multilineata	13		22	26					15	76
Chromis scotti	6		7	10						23
Microspathodon chrysurus	51		60	57	5				59	232
Pomacentrus diencaeus	48	42	48	53					53	244
Pomacentrus leucostictus	30	30	16	20	20		21	8	33	178
Pomacentrus partitus	60	31	60	55	50			2	60	318
Pomacentrus planifrons	55	60	55	58	47				60	335
Pomacentrus variabilis	47	51	53	32	30		42	12	44	311
LABRIDAE:										
Bodianus rufus	59	9	43	36	11				46	204
Clepticus parrae			3	49					3	55
Halichoeres bivittatus	54	56	50	29	59	3	11	19	60	341
Halichoeres garnoti	37		25	57	41				34	194
Halichoeres maculipinna	56		58	48	60				47	269
Halichoeres poeyi	20				37				2	59
Halichoeres radiatus	51	10	53	40	49				55	258
Hemipteronotus martinicensis			1						1	2
Hemipteronotus novacula			1		4				3	8
Hemipteronotus splendens	14	2	4	5	14		3		10	52
Lachnolaimus maximus	28	40	30	13	47		22	5	24	209
Thalassoma bifasciatum	60	46	60	60	60				50	336
SCARIDAE:										
Cryptotomus roseus	5		3		1	4			1	14
Scarus coelestinus	40	41	37	48	33				24	223
Scarus coeruleus	35	45	19	19	21				23	162
Scarus croicensis	50	30	53	55	30		7	11	58	294
Scarus guacamaia	26	15	16	18	32				21	128
Scarus taeniopterus	31		47	42	27	5			35	187
Scarus vetula	44		53	58	8				51	214
Sparisoma aurofrenatum	60	59	60	59	60	19	23	22	55	417
Sparisoma chrysopterum	21	30	1	29	30	22	28	16	20	197
Sparisoma radians	27	10	18	42	54	4		5	11	171
Sparisoma rubripinne	35	11	41	36	50				57	230
Sparisoma viride	60	59	60	55	58			2	60	354
SPHYRAENIDAE:										
Sphyraena barracuda	48	2	26	15	18		34		37	180

Table 3. List of fish species censused in 1981, total score per species by site number, and total score per species for all sites (cont.).

SPECIES	Site numbers									
	2	4	6	8	10	12	14	16	18	TOTAL
OPISTOGNATHIDAE:										
Opistognathus aurifrons	8		4	3					6	21
Opistognathus sp. 1							3			3
Opistognathus whitehursti							2	2		4
CLINIDAE:										
Acanthemblemaria chaplini	9	11	7	3	14				7	51
Acanthemblemaria sp. 2	12	10	5		23				12	62
Acanthemblemaria sp. 3		17								17
Acanthemblemaria sp. 4	5	4								9
Chaenopsis ocellata		5			2			3		10
Emblemaria pandionis	2									2
Hemiemblemaria simulus			2	4	4					10
Malacoctenus roseus		2								2
Malacoctenus sp. 1	4									4
Malacoctenus triangulatus	3		4	3	5				5	20
Paraclinus sp. 1							6	2		8
BLENNIIDAE:										
Blenniidae sp. 1	5	1					5			11
Hypleurochilus aequipinnis							11			11
Hypleurochilus bermudensis							2			2
Ophioblennius atlanticus	4		4	4					9	21
Scartella cristata		8			5				7	20
CALLIONYMIDAE:										
Callionymus bairdi	2		1		2					5
Callionymus pauciradiatus								1		1
GOBIIDAE:										
Coryphopterus dicrus	46	44	48	6	16		5		24	189
Coryphopterus glaucofraenum	39	50	30	50	31	7	45	29	44	325
Coryphopterus lipernes				11						11
Coryphopterus personatus	5	10	25	36					7	83
Gnatholepis thompsoni	50	46	37	46	22		1		49	251
Gobionellus saepepallens							5			5
Gobiosoma grosvenori		4				20	38	11		73
Gobiosoma macrodon		9				3	37	33		82
Gobiosoma oceanops	49	48	49	32	16		4		43	241
Ioglossus calliurus	32		18	4	19				23	96
Microgobius carri	6	1	1		1					9
Microgobius microlepis							52	26		78
Nes longus		6					32	6		44

Table 3. List of fish species censused in 1981, total score per species by site number, and total score per species for all sites (cont.).

SPECIES	Site numbers 2	4	6	8	10	12	14	16	18	TOTAL
ACANTHURIDAE:										
Acanthurus bahianus	55	33	59	60	45		8	13	60	333
Acanthurus chirurgus	27	47	20	9	30		30	17	30	210
Acanthurus coeruleus	60	47	59	52	60				60	338
SCOMBRIDAE:										
Scomberomorus regalis	12		8	19	9				7	55
SCORPAENIDAE:										
Scorpaena plumieri		5								5
BALISTIDAE:										
Aluterus scriptus			4	10	8				2	24
Balistes vetula					5					5
Cantherhines macrocerus	4									4
Cantherhines pullus	19		14	32	5				29	99
Canthidermis sufflamen			5	22	5				1	33
Monacanthus ciliatus						28		21		49
Monacanthus tuckeri	4		5	5	2				2	18
OSTRACIIDAE:										
Lactophrys bicaudalis	5		2	15					13	35
Lactophrys polygonia					5				5	10
Lactophrys quadricornis	4		5				5	5		19
Lactophrys trigonus				5						5
Lactophrys triqueter	10	7	12	25	16				14	84
TETRAODONTIDAE:										
Canthigaster rostrata	42	3	53	54	37				41	230
Sphoeroides spengleri		3				16	2	4		25
DIODONTIDAE:										
Diodon holocanthus	9	7	4			2	4			26
Diodon hystrix		6	4	3	1				14	28

Table 4. List of fish species censused in both years combined, total score per species by site number, and total score per species for all sites.

SPECIES	TIME SCORES BY SPECIES - 1980 & 1981																		
	Site numbers																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOTAL
ORECTOLOBIDAE:																			
Ginglymostoma cirratum				8												1			9
CARCHARHINIDAE:																			
Carcharhinus leucas						4												5	9
SPHYRNIDAE:																			
Sphyrna tiburo									4										4
DASYATIDAE:																			
Dasyatis americana			2			2		1	5	3									13
Urolophus jamaicensis	5	13		8			8			16			13	13		9	10	4	99
MYLIOBATIDAE:																			
Aetobatus narinari					1	5		1										1	8
ELOPIDAE:																			
Megalops atlanticus			5																5
MURAENIDAE:																			
Gymnothorax funebris	11	8				9	6		5										39
Gymnothorax moringa			1	5		4		2	10	9			3	4			4		42
Gymnothorax vicinus									2										2
Muraena miliaris		2			8			3										2	15

Table 4. List of fish species censused in both years combined, total score per species by site number, and total score per species for all sites (cont.).

TIME SCORES BY SPECIES - 1980 & 1981

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOTAL
OPHICHTHIDAE:																			
Ahlia egmontis											1								1
CLUPEIDAE:																			
Harengula clupeola			5					5						3					13
Harengula sp.			7																7
Jenkinsia lamprotaenia		9		1	15		4											5	34
Jenkinsia sp.							1	11						1					13
Sardinella aurita			9											11					20
SYNODONTIDAE:																			
Synodus intermedius	5	9	7	17		8	4	5				2	4	1		3	4		69
BATRACHOIDIDAE:																			
Opsanus beta											3				5	5			13
GOBIESOCIDAE:																			
Gobiesox strumosus												4				2			6
EXOCOETIDAE:																			
Hemiramphus brasiliensis		4							5										9
BELONIDAE:																			
Strongylura notata														16					16
Tylosurus crocodilus	5				20	5		3	5									23	61

Table 4. List of fish species censused in both years combined, total score per species by site number, and total score per species for all sites (cont.).

SPECIES	TIME SCORES BY SPECIES - 1980 & 1981 Site numbers																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOTAL
ATHERINIDAE:																			
Atherinomorus stipes					2			5						1	4				12
HOLOCENTRIDAE:																			
Holocentrus adscensionis	12		24			2	7	7											52
Holocentrus rufus	4	1	19	5		8	9	16		5							7	1	75
Holocentrus vexillarius	21		35				10	6											72
Myripristis jacobus	16		16																32
AULOSTOMIDAE.																			
Aulostomus maculatus	36	33	22	8	21	34	36	50		28							5	46	319
SYNGNATHIDAE:																			
Cosmocampus albirostris												1			3				4
Hippocampus erectus											5	8							13
Hippocampus zosterae															4				4
CENTROPOMIDAE:																			
Centropomus undecimalis	3		1																4

Table 4. List of fish species censused in both years combined, total score per species by site number, and total score per species for all sites (cont.).

TIME SCORES BY SPECIES - 1980 & 1981

SPECIES	Site numbers																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOTAL
SERRANIDAE:																			
Diplectrum formosum						1				1	23	43	21	28	6	18		3	144
Epinephelus adscensionis			1																1
Epinephelus afer						1													1
Epinephelus cruentatus	34	25	32	5	18	32	18	48		20							11	34	277
Epinephelus guttatus	1		5				2	3	3	2									16
Epinephelus itajara			4																4
Epinephelus morio					2	2				21			4	15		21			65
Epinephelus striatus	12	9	18	5	13	13	10	13	22	9			3					10	137
Hypoplectrus aberrans	2		3					12											17
Hypoplectrus chlorurus								2											2
Hypoplectrus gemma	18	10	29	5		4	3	51	16	7							24	5	172
Hypoplectrus guttavarius								10											10
Hypoplectrus indigo						14	4	12									9	4	43
Hypoplectrus nigricans		3	15	13		18	8	21	3	4							3	12	100
Hypoplectrus puella	5	33	10	15	1	23	10	13	25	7							5	15	162
Hypoplectrus unicolor	23	39	36	23	17	34	28	50	24	15				4			33	23	349
Liopropoma rubre	3		8		3	2	2	6											24
Mycteroperca bonaci	14	13	4	23	16	32	10	14	17	7				2		5	8	18	183
Mycteroperca tigris			3			3	2												8
Mycteroperca venenosa				2															2
Serranus baldwini	5		8		6		8	8		5							10		50
Serranus tabacarius		2	13			5	2										4	2	28
Serranus tigrinus	34	25	37		15	53	31	47		15							23	36	316

Table 4. List of fish species censused in both years combined, total score per species by site number, and total score per species for all sites (cont.).

TIME SCORES BY SPECIES - 1980 & 1981

SPECIES	Site numbers																		TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
GRAMMISTIDAE:																			
Rypticus saponaceus	7	2	12				9	4										4	38
PRIACANTHIDAE:																			
Priacanthus arenatus	4		7																11
Priacanthus cruentatus	20	14	15		5	5	30	15										14	118
APOGONIDAE:																			
Apogon binotatus			6		4	3	7	18										3	41
Apogon lachneri						5													5
Apogon maculatus	7	4	2	9	13	11		12	3	1			1		1		5	20	89
Apogon pseudomaculatus						4													4
Apogon robinsi																		4	4
Apogon townsendi	7		5		3			13										5	33
Astrapogon stellatus								4						16	6		1		27
MALACANTHIDAE:																			
Malacanthus plumieri	9		11			3	18											3	44
ECHENEIDAE:																			
Echeneis naucrates	6	30	20		1	9	11	10	3	7		7					4	36	144

Table 4. List of fish species censused in both years combined, total score per species by site number, and total score per species for all sites (cont.).

TIME SCORES BY SPECIES - 1980 & 1981

SPECIES	Site numbers																		TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
CARANGIDAE:																			
Caranx bartholomaei		9		15		7			12	4			15	17	4		5	9	97
Caranx crysos				10					1	7	9	11	2	48		26			114
Caranx ruber	31	57	10	57	34	56	31	37	33	34	5	9	6	47	5	18	17	50	537
Oligoplites saurus															3				3
Seriola dumerili					3														3
Trachinotus falcatus							3	2											5
LUTJANIDAE:																			
Lutjanus analis	15	26	3	13	33	13	17	18	6	4			6	5	3			30	192
Lutjanus apodus	23	47	24	30	27	41	24	40	10	24								53	343
Lutjanus cyanopterus						7													7
Lutjanus griseus	39	46	27	58	33	47	40	26	33	10		4		43	9			40	455
Lutjanus jocu	14	8	19		8	8	10	2										10	79
Lutjanus mahogoni	35	31	29	10	13	34	36	49				10				1		23	271
Lutjanus synagris			26	40		11	5	7				3	3	19	13	29			156
Ocyurus chrysurus	40	59	40	49	36	60	40	57	40	57	4		15	4	8	4	40	58	611
GERREIDAE:																			
Eucinostomus sp. 1												2		1		3		4	10
Eucinostomus sp. 2																10			10
Gerres cinereus				14		2			5					39				28	88

Table 4. List of fish species censused in both years combined, total score per species by site number, and total score per species for all sites (cont.).

TIME SCORES BY SPECIES - 1980 & 1981

SPECIES	Site numbers																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOTAL
HAEMULIDAE:																			
Anisotremus surinamenis	19	31	19		15		11	9		8			1				5	17	135
Anisotremus virginicus	30	48	33	41	25	41	24	42	39	31			12	21	3	22	31	34	477
Haemulon album	12	4	6			6												1	29
Haemulon aurolineatum		45		59	6	34		32		26	1				10			59	272
Haemulon carbonarium	37	45	38	2	31	37	40	47		21								55	353
Haemulon chrysargyreum	39	45	30		30	38	40	32		4							3	51	312
Haemulon flavolineatum	40	59	40	57	39	60	39	60	39	58		5	11	5	28		25	60	625
Haemulon macrostomum	33	47	34		19	53	29	46		5								51	317
Haemulon melanurum					6		6	1		18			4						35
Haemulon parra	1	16	23		23	23	37	17		10								29	179
Haemulon plumieri	31	56	38	60	32	59	30	53	40	60	6	46	18	36	12	55	40	55	727
Haemulon sciurus	40	56	34	60	35	57	40	55	35	31			5	42	8	4	35	54	591
Haemulon sp. 1												2				8	5		15
Haemulon sp. 2																7			7
SPARIDAE:																			
Archosargus probatocephalus				4															4
Archosargus rhomboides				2								5		10					17
Calamus bajonado	3	9		9	6	3			7	28		7	5	4				4	85
Calamus calamus	8	17	22	11	22	2	3		35	20	2		9	3	5		36	8	203
Calamus penna		1																	1
Lagodon rhomboides											2	37			2				41

Table 4. List of fish species censused in both years combined, total score per species by site number, and total score per species for all sites (cont.).

TIME SCORES BY SPECIES - 1980 & 1981

SPECIES	Site numbers 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOTAL
SCIAENIDAE:																			
Equetus acuminatus	10	28	5	19	9	19	7	2	13	34			35	26	12	33	16	23	291
Equetus lanceolatus			7			15		8										3	33
Equetus punctatus	3		7		4	3	12	3	10				2						44
Odontoscion dentex	31	46	33	4		1	22	13	3	6									159
MULLIDAE:																			
Mulloidichthys martinicus	35	26	29		37	47	38	44		12								52	320
Pseudupeneus maculatus	14	40	27	17	10	11	31	19		40							16	33	258
PEMPHERIDAE:																			
Pempheris poeyi		1																	1
Pempheris schomburgki	34	46	39		38	27	40	41										51	316
KYPHOSIDAE:																			
Kyphosus sectatrix	19	42	34	7	29	30	39	30										24	254
EPHIPPIDAE:																			
Chaetodipterus faber	3		4						9		4								20
CHAETODONTIDAE:																			
Chaetodon capistratus	32	25	39	44	6	35	29	52	31	12			7	4		1	10	26	353
Chaetodon ocellatus	33	25	23	28	14	26	27	41	5	29			1	5		5	19	22	303
Chaetodon sedentarius	5	10		8	21	20	5	31	5	39			4					19	167
Chaetodon striatus	30	9	27	8		1	10	15		18							21	13	152

Table 4. List of fish species censused in both years combined, total score per species by site number, and total score per species for all sites (cont.).

TIME SCORES BY SPECIES - 1980 & 1981

SPECIES	Site numbers																		TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
POMACANTHIDAE:																			
Holacanthus bermudensis	9	3	3	39	15			4	28	16			6	6			34	13	176
Holacanthus tricolor	38	1	40		3	20	25	49		9								21	206
Holacanthus ciliaris	25	41	16	9	31	14	22	32	14	49			4	14	3		21	32	327
Pomacanthus arcuatus	20	46	21	47	25	37	15	36	27	53	7	10	31	25	11	5	40	29	485
Pomacanthus paru	18	32	13		31	28	12	44		37			5		7			50	277
POMACENTRIDAE:																			
Abudefduf saxatilis	40	55	39	49	39	59	39	56	39	6			1	9			30	60	521
Chromis cyaneus	34	2	40		5		40	50		5									176
Chromis insolata	4							5											9
Chromis multilineata	27	13	25		13	22	37	26										15	178
Chromis scotti	6	6	18			7	3	10											50
Microspathodon chrysurus	30	51	39		40	60	40	57		5								59	381
Pomacentrus diencaeus	33	48	39	42	38	48	32	53	19								2	53	407
Pomacentrus leucostictus	6	30	5	30	22	16	7	20	35	20			15	21	2	8	24	33	294
Pomacentrus partitus	140	60	40	31	40	60	40	55	39	50						2	40	60	557
Pomacentrus planifrons	39	55	38	60	40	55	40	58	40	47							38	60	570
Pomacentrus variabilis	20	47	10	51	29	53	17	32	40	30			21	42	12	12	39	44	499
CIRRHITIDAE:																			
Amblycirrhitus pinos	8		10				8												26

Table 4. List of fish species censused in both years combined, total score per species by site number, and total score per species for all sites (cont.).

TIME SCORES BY SPECIES - 1980 & 1981

SPECIES	Site numbers 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOTAL
LABRIDAE:																			
Bodianus rufus	28	59	36	9	30	43	40	36		11								46	338
Clepticus parrai	17		19		1	3	13	49										3	105
Halichoeres bivittatus	26	54	24	56	37	50	32	29	18	59	2	3	5	11		19	38	60	523
Halichoeres garnoti	40	37	40		25	25	39	57	1	41							5	34	344
Halichoeres maculipinna	40	56	40		40	58	37	48	3	60							40	47	469
Halichoeres poeyi		20			4				2	37								2	65
Halichoeres radiatus	33	51	17	10	40	53	36	40	8	49							23	55	415
Hemipteronotus martinicensis						1											10	1	12
Hemipteronotus novacula			10			1	6			4								3	24
Hemipteronotus splendens	5	14	25	2	24	4	25	5		14			5	3				10	136
Lachnolaimus maximus	8	28	22	40	21	30	37	13	34	47			14	22	5	5	34	24	384
Thalassoma bifasciatum	40	60	40	46	40	60	40	60	39	60			2				40	50	577
SCARIDAE:																			
Cryptotomus roseus		5			13	3				1	5	4			10		11	1	53
Scarus coelestinus	20	40	23	41	33	37	24	48	29	33							18	24	370
Scarus coeruleus	25	35	32	45	25	19	7	19	38	21			5				14	23	308
Scarus croicensis	36	50	30	30	40	53	39	55	40	30	1		16	7	22	11	40	58	558
Scarus guacamaia	17	26	10	15	13	16	11	18	7	32								21	186
Scarus taeniopterus	28	31	26		25	47	21	42		27		5					14	35	301
Scarus vetula	35	44	40		34	53	35	58		8								51	358
Sparisoma aurofrenatum	40	60	40	59	39	60	38	59	20	60		19		23		22	40	55	634

Table 4. List of fish species censused in both years combined, total score per species by site number, and total score per species for all sites (cont.).

TIME SCORES BY SPECIES - 1980 & 1981

SPECIES	Site numbers																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOTAL
Sparisoma chrysopterum	35	21	30	30	38	1	35	29	32	30	9	22	25	28	14	16	39	20	454
Sparisoma radians	10	27	28	10	16	18	12	42	21	54		4	8		5	5	28	11	299
Sparisoma rubripinne	24	35	30	11	39	41	18	36	9	50							30	57	380
Sparisoma viride	40	60	35	59	40	60	40	55	40	58			4		8	2	40	60	601
SPHYRAENIDAE:																			
Sphyraena barracuda	34	48	16	2	32	26	15	15	31	18	4		5	34			18	37	335
OPISTOGNATHIDAE:																			
Opistognathus aurifrons	19	8	12			4	12	3									10	6	74
Opistognathus maxillosus													14				2		16
Opistognathus sp. 1														3					3
Opistognathus whitehursti														2		2			4
DACTYIOSCOPIDAE:																			
Gillellus rubrocinctus									3										3
CLINIDAE:																			
Acanthemblemaria chaplini		9		11		7		3		14								7	51
Acanthemblemaria sp. 2		12		10		5	1		1	23							9	12	73
Acanthemblemaria sp. 3				17													16		33
Acanthemblemaria sp. 4		5		4													4		13
Chaenopsis ocellata				5						2						3			10
Emblemaria pandionis		2																	2

Table 4. List of fish species censused in both years combined, total score per species by site number, and total score per species for all sites (cont.).

TIME SCORES BY SPECIES - 1980 & 1981

SPECIES	Site numbers																		TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Hemiemblemaria simulus	4		15			2		4		4							7		36
Malacoctenus aurolineatus					2														2
Malacoctenus roseus				2					8										10
Malacoctenus sp. 1		4							6				5				10		25
Malacoctenus triangulatus		3				4		3	3	5							4	5	27
Paraclinus sp. 1											1		17	6	11	2			37
BLENNIIDAE:																			
Blenniidae juv. spp														4					4
Blenniidae sp. 1		5		1					6					1	5				18
Hypleurochilus aequipinnis															11				11
Hypleurochilus bermudensis															2				2
Ophioblennius atlanticus	5	4				4	3	4										9	29
Parablennius marmoreus					3												3		6
Scartella cristata				8	16				19	5				6			2	7	63
CALLIONYMIDAE:																			
Callionymus bairdi	4	2	5			1				2							3		17
Callionymus pauciradiatus																1			1
GOBIIDAE:																			
Barbulifer sp.															5				5
Coryphopterus dicrus	7	46	14	44	12	48	13	6	16	16			10	5			23	24	284
Coryphopterus glaucofraenum	21	39	22	50	18	30	21	50	36	31		7	25	45	33	29	20	44	521
Coryphopterus lipernes								11											11

Table 4. List of fish species censused in both years combined, total score per species by site number, and total score per species for all sites (cont.).

TIME SCORES BY SPECIES - 1980 & 1981

SPECIES	Site numbers																		TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Coryphopterus personatus	11	5	28	10		25	18	36	14									7	154
Gnatholepis thompsoni	27	50	34	46	21	37	28	46	21	22			1	1			38	49	421
Gobionellus saepepallens														5	5				10
Gobiosoma grosvenori				4							19	20	15	38	9	11			124
Gobiosoma macrodon				9							1	3	34	37	5	33			127
Gobiosoma oceanops	13	49	24	48	30	49	13	32	37	16			11	4			22	43	391
Ioglossus calliurus	12	32	12		8	18	8	4		19							15	23	151
Microgobius carri		6	15	1	5	1				1			12						41
Microgobius microlepis									4		2		16	52	38	26			138
Nes longus				6										32		6			44
ACANTHURIDAE:																			
Acanthurus bahianus	40	55	40	33	39	59	40	60	32	45			13	8	3	13	40	60	580
Acanthurus chirurgus	21	27	31	47	33	20	16	9	34	30			15	30		17	34	30	394
Acanthurus coeruleus	40	60	40	47	40	59	40	52	36	60							38	60	572
SCOMBRIDAE:																			
Scomberomorus regalis	1	12	15			8	10	19	2	9	2							7	85
SCORPAENIDAE:																			
Scorpaena plumieri				5					3										8
BOTHIDAE:																			
Bothus lunatus													1						1
Bothus sp. 1																	2		2
Bothus sp. 2													4						4

Table 4. List of fish species censused in both years combined, total score per species by site number, and total score per species for all sites (cont.).

TIME SCORES BY SPECIES - 1980 & 1981

SPECIES	Site numbers																		TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
BALISTIDAE:																			
Aluterus schoepfi																	4		4
Aluterus scriptus	16		9		10	4	16	10	1	8							6	2	82
Balistes capriscus											5		3						8
Balistes vetula							5			5							13		23
Cantherhines macrocerus	3	4																	7
Cantherhines pullus	23	19	38		12	14	18	32		5								29	190
Canthidermis sufflamen	3				6	5	20	22		5							14	1	76
Monacanthus ciliatus											13	28				21			62
Monacanthus tuckeri	5	4			2	5		5		2								2	25
OSTRACIIDAE:																			
Lactophrys bicaudalis	3	5	6		5	2	13	15	5									13	67
Lactophrys polygonia										5							5	5	15
Lactophrys quadricornis		4				5						4	5			5			23
Lactophrys trigonus			3					5											8
Lactophrys triqueter	11	10	18	7	9	12	25	25	8	16							19	14	174
TETRAODONTIDAE:																			
Canthigaster rostrata	35	42	34	3	17	53	33	54	4	37							19	41	372
Sphoeroides spengleri				3								16	5	2		4			30
DIODONTIDAE:																			
Diodon holocanthus	5	9		7		4	5		1		4	2		4			1		42
Diodon hystrix	5		3	6	2	4	8	3	4	1							2	14	52

12.4.2. Species Identification and Nomenclature

Several problems arose with regard to species identification on the STT counts. First, during the present study, Robertson and Allen (1981) reported that the honey damselfish, *Pomacentrus mellis*, is actually the juvenile form of a different species, the longfin damselfish, *P. diencaeus*. Thus, scores for *P. mellis* actually represented counts of juvenile *P. diencaeus*. In addition, adult *P. diencaeus* are often difficult to distinguish from adult dusky damselfish, *P. dorsopunicans*, in the field. Therefore, scores for juvenile and adult *P. dorsopunicans* were combined with an unknown proportion of adult *P. diencaeus* (as well as *P. mellis*) and listed as *P. diencaeus*.

Other systematic difficulties exist with *Coryphopterus personatus* and *C. hyalinus*. These two species are difficult to distinguish in the field. Because *C. hyalinus* normally occurs deeper than 30 m, we should have observed mostly *C. personatus* in this survey. The scores for *C. personatus* may, however, include some *C. hyalinus*.

Robins *et al.* (1980) no longer recognize two other gobies, *Ioglossus calliurus* and *I. helenae*, as separate species. Therefore, our counts for the two *Ioglossus* species were combined and listed as *I. calliurus*.

We had problems in 1980 counts with misidentifying *Sparisoma aurofrenatum* as *S. chrysopterum* on offshore reefs where *S. chrysopterum* is quite rare. This problem was corrected in 1981 by using the somewhat more blunt head morphology and difference in nasal cirri in *S. chrysopterum* as key characters. The result of this error was erroneously high scores for *S. chrysopterum* in 1980 on offshore reef sites. Jones and Thompson (1978) appear to have made the same error. On our last dive at Turtle Rocks we also noted another species of parrotfish, *S. atomarium*, mixed in with individuals we had been identifying as all *S. radians*. Thus the scores for *S. radians* at this site may include an occasional *S. atomarium* observation.

Several other species were identified only to genus in the field, such as some *Acanthemblemaria* species. We felt that taking the time to collect such individuals during the 50 min. STT count was an unacceptable expenditure of time that would bias the results. These fish were not identified to species level in cases where we could not relocate and collect the individual after the count. In at least two instances, rare species were fleetingly observed in caves. They could not be identified with confidence to the family level and were omitted from the data. However, we believe that these very cryptic or completely nocturnal species cannot be reasonably sampled with this type of visual technique.

12.4.3. Analysis of Fish Community Composition

Table 5 is a data summary for all study sites. Note that odd-numbered sites were censused in 1980, even-numbered sites in 1981, and that Grecian Rocks was site 5 in 1980 and site 18 in 1981. The mean number of species per SST count per site was 48.0 for 1980, 45.8 for 1981, and 46.1 for both years. Mean number of species per STT count at Grecian Rocks was 65.8 and 67.8 in 1980 and 1981 respectively, showing little difference between years despite a total species number of 108 in 1980 and 126 in 1981. Shannon-Weaver diversity index (H') and equitability of distribution (J') values were similar to, but slightly higher than, the values obtained by Jones and Thompson (1978) for Molasses, French, and Carysfort reefs. We censused more species than they did at each of these three sites (123 vs. 120, 126 vs. 118, 134 vs. 104 respectively). The greater number of replicates at Carysfort Reef in our study (12 vs. 8) probably explains most of the greater number of total species counted at that site. We had the same number of replicates (8) as Jones and Thompson (1978) at Molasses and

Table 5. Data summary for all study sites. Odd numbers correspond to 1980 sites, even numbers to 1981 sites, and site 5 (1980) = site 18 (1981) = Grecian Rocks. Shannon-Weaver indices (H') were computed using base 10 logs and species scores, rather than absolute species abundance.

SITE NO.	NAME	TOTAL SPECIES	TOTAL SCORES	SHANNON-WEAVER INDEX (H')	EQUITABILITY OF DISTRIBUTION (J')
1	Molasses Reef	123	2384	4.55	0.95
2	White Bank Dry Rocks	121	3232	4.48	0.94
3	French Reef	126	2672	4.63	0.96
4	Mosquito Bank	98	2169	4.20	0.92
5	Grecian Rocks (1980)	108	2137	4.43	0.95
6	Key Largo Dry Rocks	134	3040	4.48	0.92
7	The Elbow	118	2409	4.53	0.95
8	Carysfort Reef	131	3342	4.54	0.93
9	Basin Hill Shoals	91	1549	4.16	0.92
10	Turtle Rocks	109	2356	4.34	0.93
11	Ocean Reef	26	140	2.87	0.88
12	Turtle Harbor	31	349	2.98	0.87
13	North Channel	64	598	3.82	0.92
14	South Channel	65	1036	3.75	0.90
15	Rock Harbor	42	362	3.42	0.91
16	Point Elizabeth	48	570	3.47	0.90
17	Angelfish Creek	90	1629	4.21	0.93
18	Grecian Rocks (1981)	126	3233	4.50	0.93

French reefs. Our total species score at Molasses Reef was less (2384 vs. 2627) and at French Reef greater (2672 vs. 2640) than Jones and Thompson (1978). French Reef had the highest H' in our study, whereas Molasses Reef was the highest H' in their study. Our H' values indicated that species diversity is highest on offshore reefs, and generally decreases in proportion to the distance between these sites and the shore. The turtle grass sites (Ocean Reef, Turtle Harbor, and Rock Harbor) were the least diverse in terms of fish species.

Tables 6, 7, 8, 9 and 10 rank species according to total score over all STT counts in the two-year study (after weighting 1981 data for effort) for offshore reefs, intermediate reefs, inshore patch reefs, turtle grass/hardground, and total for all habitats respectively. Jones and Thompson (1978) give a similar table and refer to the species with higher total scores as "dominant." We do not interpret the species with highest rank according to STT scores as necessarily ecologically dominant components of the censused communities. DeMartini and Roberts (1982) demonstrated that STT scores tend to overemphasize the importance of widespread, rare species and under emphasize patchy, abundant species. They did, however, find a high correlation between STT scores and frequency of occurrence. Thus Tables 6- 9 provide, with some exceptions, a rough characterization of the readily visible component of fish communities within major habitat types. Several examples of these exceptions (anomalous rankings) are discussed below. In most of these cases, the rankings are based on what a diver is more likely to see first as he gets in the water rather than ecological dominance of a species.

Table 6. Rank order of offshore sites by species time score (with 1981 data adjusted for effort).

Relative Species Abundances Ranked by Species Scores

Offshore Reef Sites

Rank	Score	Species	Rank	Score	Species
1	160	*Acanthurus bahianus*	44	100	*Cantherhines pullus*
2	160	*Thalassoma bifasciatum*	45	99	*Scarus coelestinus*
3	159	*Haemulon flavolineatum*	46	98	*Lutjanus apodus*
4	158	*Ocyurus chrysurus*	47	97	*Caranx ruber*
5	157	*Pomacentrus partitus*	48	97	*Coryphopterus glaucofraenum*
6	157	*Halichoeres garnoti*	49	96	*Sparisoma rubripinne*
7	157	*Sparisoma aurofrenatum*	50	95	*Odontoscion dentex*
8	156	*Pomacentrus planifrons*	51	85	*Pseudupeneus maculatus*
9	155	*Abudefduf saxatilis*	52	84	*Holacanthus ciliaris*
10	155	*Acanthurus coeruleus*	53	84	*Hypoplectrus gemma*
11	152	*Sparisoma viride*	54	82	*Clepticus parrae*
12	151	*Haemulon sciurus*	55	81	*Coryphopterus personatus*
13	149	*Halichoeres maculipinna*	56	80	*Pomacanthus arcuatus*
14	149	*Scarus vetula*	57	78	*Sparisoma radians*
15	147	*Chromis cyanea*	58	77	*Scarus coeruleus*
16	147	*Microspathodon chrysurus*	59	77	*Chaetodon striatus*
17	146	*Haemulon carbonarium*	60	76	*Lachnolaimus maximus*
18	142	*Scarus croicensis*	61	75	*Sphyraena barracuda*
19	140	*Pempheris schomburgki*	62	75	*Priacanthus cruentatus*
20	139	*Pomacentrus diencaeus*	63	74	*Acanthurus chirurgus*
21	138	*Canthigaster rostrata*	64	72	*Pomacanthus paru*
22	136	*Holacanthus tricolor*	65	72	*Haemulon parra*
23	135	*Chaetodon capistratus*	66	71	*Gobiosoma oceanops*
24	134	*Haemulon plumieri*	67	71	*Lactophrys triqueter*
25	133	*Lutjanus mahogoni*	68	70	*Holocentrus vexillarius*
26	133	*Serranus tigrinus*	69	68	*Pomacentrus variabilis*
27	131	*Mulloidichthys martinicus*	70	58	*Hemipteronotus splendens*
28	130	*Haemulon chrysargyreum*	71	55	*Anisotremus surinamenis*
29	128	*Bodianus rufus*	72	50	*Scarus guacamaia*
30	127	*Haemulon macrostomum*	73	49	*Epinephelus striatus*
31	127	*Aulostomus maculatus*	74	48	*Holocentrus adscensionis*
32	123	*Lutjanus griseus*	75	48	*Aluterus scriptus*
33	120	*Hypoplectrus unicolor*	76	47	*Lutjanus analis*
34	120	*Gnatholepis thompsoni*	77	45	*Opistognathus aurifrons*
35	119	*Sparisoma chrysopterum*	78	44	*Lutjanus jocu*
36	116	*Epinephelus cruentatus*	79	44	*Echeneis naucrates*
37	115	*Anisotremus virginicus*	80	43	*Holocentrus rufus*
38	113	*Halichoeres radiatus*	81	39	*Scomberomorus regalis*
39	112	*Kyphosus sectatrix*	82	38	*Canthidermis sufflamen*
40	110	*Chaetodon ocellatus*	83	38	*Coryphopterus dicrus*
41	106	*Chromis multilineata*	84	38	*Malacanthus plumieri*
42	103	*Scarus taeniopterus*	85	37	*Hypoplectrus nigricans*
43	101	*Halichoeres bivittatus*			

Table 6. Rank order of species on offshore reef sites by species time score (with 1981 data adjusted for effort) (cont.).

Relative Species Abundances Ranked by Species Scores

Offshore Reef Sites

Rank	Score	Species	Rank	Score	Species
86	37	*Mycteroperca bonaci*	120	11	*Priacanthus arenatus*
87	36	*Lutjanus synagris*	121	11	*Ophioblennius atlanticus*
88	35	*Ioglossus calliurus*	122	10	*Diodon holocanthus*
89	34	*Chromis scotti*	123	10	*Epinephelus guttatus*
90	34	*Hypoplectrus puella*	124	9	*Callionymus bairdi*
91	33	*Calamus calamus*	125	8	*Monacanthus tuckeri*
92	32	*Myripristis jacobus*	126	7	*Hypoplectrus guttavarius*
93	32	*Lactophrys bicaudalis*	127	7	*Tylosurus crocodilus*
94	31	*Rypticus saponaceus*	128	7	*Haemulon melanurum*
95	31	*Pomacentrus leucostictus*	129	7	*Chaetodipterus faber*
96	31	*Chaetodon sedentarius*	130	7	*Chromis insolata*
97	29	*Inermia vittata*	131	7	*Coryphopterus lipernes*
98	26	*Serranus baldwini*	132	6	*Lactophrys trigonus*
99	26	*Amblycirrhitus pinos*	133	5	*Balistes vetula*
100	25	*Apogon binotatus*	134	5	*Mycteroperca tigris*
101	24	*Equetus punctatus*	135	5	*Megalops atlanticus*
102	23	*Equetus acuminatus*	136	4	*Epinephelus itajara*
103	22	*Hemiemblemaria simulus*	137	4	*Centropomus undecimalis*
104	21	*Haemulon aurolineatum*	138	4	*Trachinotus falcatus*
105	21	*Apogon townsendi*	139	3	*Calamus bajonado*
106	19	*Synodus intermedius*	140	3	*Atherinomorus stipes*
107	18	*Haemulon album*	141	3	*Jenkinsia lamprotaenia*
108	18	*Diodon hystrix*	142	3	*Astrapogon stellatus*
109	17	*Gymnothorax funebris*	143	3	*Cantherhines macrocerus*
110	17	*Apogon maculatus*	144	3	*Dasyatis americana*
111	17	*Liopropoma rubre*	145	2	*Malacoctenus triangulatus*
112	16	*Hemipteronotus novacula*	146	2	*Acanthemblemaria chaplini*
113	15	*Microgobius carri*	147	2	*Gymnothorax moringa*
114	15	*Serranus tabacarius*	148	2	*Muraena miliaris*
115	15	*Holacanthus bermudensis*	149	1	*Jenkinsia* sp.
116	13	*Hypoplectrus aberrans*	150	1	*Epinephelus adscensionis*
117	13	*Urolophus jamaicensis*	151	1	*Hypoplectrus chlorurus*
118	12	*Hypoplectrus indigo*	152	1	*Acanthemblemaria* sp. 2
119	12	*Equetus lanceolatus*	153	1	*Aetobatus narinari*

Table 7. Rank order of species on intermediate reef sites by species time score (with 1981 data adjusted for effort).

Relative Species Abundances Ranked by Species Scores

Intermediate Reef Sites

Rank	Score	Species	Rank	Score	Species
1	160	*Sparisoma viride*	43	93	*Coryphopterus glaucofraenum*
2	160	*Pomacentrus partitus*	44	91	*Coryphopterus dicrus*
3	159	*Acanthurus coeruleus*	45	91	*Serranus tigrinus*
4	158	*Haemulon flavolineatum*	46	90	*Halichoeres garnoti*
5	156	*Sparisoma aurofrenatum*	47	88	*Holacanthus ciliaris*
6	155	*Acanthurus bahianus*	48	84	*Acanthurus chirurgus*
7	155	*Abudefduf saxatilis*	49	81	*Hypoplectrus unicolor*
8	154	*Pomacentrus planifrons*	50	79	*Epinephelus cruentatus*
9	154	*Ocyurus chrysurus*	51	79	*Lutjanus analis*
10	153	*Microspathodon chrysurus*	52	76	*Lachnolaimus maximus*
11	153	*Thalassoma bifasciatum*	53	76	*Scarus coeruleus*
12	147	*Scarus croicensis*	54	75	*Pomacentrus leucostictus*
13	147	*Halichoeres maculipinna*	55	72	*Lutjanus mahogoni*
14	146	*Halichoeres radiatus*	56	68	*Haemulon parra*
15	146	*Halichoeres bivittatus*	57	66	*Pseudupeneus maculatus*
16	146	*Haemulon sciurus*	58	66	*Sparisoma chrysopterum*
17	145	*Haemulon plumieri*	59	63	*Chaetodon ocellatus*
18	142	*Caranx ruber*	60	63	*Chaetodon capistratus*
19	137	*Pomacentrus diencaeus*	61	58	*Mycteroperca bonaci*
20	132	*Scarus vetula*	62	56	*Equetus acuminatus*
21	129	*Bodianus rufus*	63	56	*Ioglossus calliurus*
22	127	*Sparisoma rubripinne*	64	55	*Scarus guacamaia*
23	125	*Gobiosoma oceanops*	65	54	*Chaetodon sedentarius*
24	124	*Pomacentrus variabilis*	66	53	*Sparisoma radians*
25	123	*Haemulon carbonarium*	67	53	*Cantherhines pullus*
26	122	*Lutjanus griseus*	68	51	*Echeneis naucrates*
27	121	*Pempheris schomburgki*	69	48	*Hypoplectrus puella*
28	120	*Mulloidichthys martinicus*	70	47	*Chromis multilineata*
29	120	*Lutjanus apodus*	71	47	*Anisotremus surinamensis*
30	119	*Haemulon chrysargyreum*	72	43	*Hemipteronotus splendens*
31	119	*Haemulon macrostomum*	73	39	*Calamus calamus*
32	112	*Gnatholepis thompsoni*	74	38	*Tylosurus crocodilus*
33	107	*Canthigaster rostrata*	75	36	*Apogon maculatus*
34	107	*Anisotremus virginicus*	76	35	*Epinephelus striatus*
35	106	*Sphyraena barracuda*	77	33	*Lactophrys triqueter*
36	104	*Pomacanthus paru*	78	32	*Odontoscion dentex*
37	101	*Scarus coelestinus*	79	31	*Holacanthus tricolor*
38	100	*Scarus taeniopterus*	80	26	*Holacanthus bermudensis*
39	100	*Pomacanthus arcuatus*	81	26	*Priacanthus cruentatus*
40	98	*Haemulon aurolineatum*	82	25	*Lutjanus jocu*
41	97	*Aulostomus maculatus*	83	25	*Coryphopterus personatus*
42	93	*Kyphosus sectatrix*	84	22	*Hypoplectrus nigricans*

Table 7. Rank order of species on intermediate reef sites by species time score (with 1981 data adjusted for effort) (cont.).

Relative Species Abundances Ranked by Species Scores

Intermediate Reef Sites

Rank	Score	Species	Rank	Score	Species
85	21	*Scartella cristata*	123	6	*Lactophrys quadricornis*
86	20	*Jenkinsia lamprotaenia*	124	6	*Carcharhinus leucas*
87	20	*Gerres cinereus*	125	5	*Aetobatus narinari*
88	19	*Cryptotomus roseus*	126	5	*Serranus tabacarius*
89	19	*Acanthemblemaria* sp. 2	127	5	*Clepticus parrae*
90	18	*Halichoeres poeyi*	128	5	*Lutjanus cyanopterus*
91	18	*Lactophrys bicaudalis*	129	4	*Rypticus saponaceus*
92	18	*Scomberomorus regalis*	130	4	*Liopropoma rubre*
93	17	*Calamus bajonado*	131	4	*Malacanthus plumieri*
94	17	*Caranx bartholomaei*	132	3	*Apogon pseudomaculatus*
95	16	*Chaetodon striatus*	133	3	*Apogon lachneri*
96	16	*Acanthemblemaria chaplini*	134	3	*Apogon robinsi*
97	14	*Aluterus scriptus*	135	3	*Seriola dumerili*
98	14	*Diodon hystrix*	136	3	*Diplectrum formosum*
99	13	*Hypoplectrus gemma*	137	3	*Epinephelus morio*
100	12	*Hypoplectrus indigo*	138	3	*Gymnothorax moringa*
101	12	*Equetus lanceolatus*	139	3	*Hemiramphus brasiliensis*
102	12	*Opistognathus aurifrons*	140	3	*Eucinostomus* sp.
103	12	*Ophioblennius atlanticus*	141	3	*Lactophrys polygonia*
104	12	*Urolophus jamaicensis*	142	3	*Cantherhines macrocerus*
105	11	*Gymnothorax funebris*	143	3	*Malacoctenus* sp. 1
106	11	*Synodus intermedius*	144	3	*Blenniidae* sp. 1
107	10	*Muraena miliaris*	145	3	*Parablennius marmoreus*
108	10	*Microgobius carri*	146	3	*Acanthemblemaria* sp. 4
109	10	*Canthidermis sufflamen*	147	3	*Hemipteronotus novacula*
110	9	*Diodon holocanthus*	148	2	*Hemipteronotus martinicensis*
111	9	*Monacanthus tuckeri*	149	2	*Malacoctenus aurolineatus*
112	9	*Chromis scotti*	150	2	*Callionymus bairdi*
113	8	*Haemulon album*	151	2	*Atherinomorus stipes*
114	8	*Apogon binotatus*	152	2	*Inermia vittata*
115	8	*Malacoctenus triangulatus*	153	2	*Mycteroperca tigris*
116	7	*Holocentrus rufus*	154	1	*Epinephelus afer*
117	7	*Lutjanus synagris*	155	1	*Holocentrus adscensionis*
118	6	*Haemulon melanurum*	156	1	*Pempheris poeyi*
119	6	*Chromis cyanea*	157	1	*Emblemaria pandionis*
120	6	*Equetus punctatus*	158	1	*Hemiemblemaria simulus*
121	6	*Apogon townsendi*	159	1	*Calamus penna*
122	6	*Serranus baldwini*	160	1	*Dasyatis americana*

Table 8. Rank order of species on inshore patch reef sites by species time score (with 1981 data adjusted for effort).

Relative Species Abundances Ranked by Species Scores

Inshore Patch Reef Sites

Rank	Score	Species	Rank	Score	Species
1	160	*Haemulon plumieri*	43	54	*Pseudupeneus maculatus*
2	158	*Sparisoma viride*	44	50	*Canthigaster rostrata*
3	151	*Ocyurus chrysurus*	45	49	*Pomacentrus diencaeus*
4	150	*Thalassoma bifasciatum*	46	48	*Hypoplectrus gemma*
5	149	*Pomacentrus planifrons*	47	46	*Lutjanus apodus*
6	145	*Acanthurus coeruleus*	48	45	*Hypoplectrus puella*
7	141	*Haemulon flavolineatum*	49	45	*Mycteroperca bonaci*
8	139	*Sparisoma aurofrenatum*	50	43	*Lactophrys triqueter*
9	133	*Pomacentrus variabilis*	51	38	*Scarus guacamaia*
10	133	*Pomacentrus partitus*	52	38	*Chaetodon striatus*
11	133	*Pomacanthus arcuatus*	53	36	*Chaetodon sedentarius*
12	132	*Halichoeres bivittatus*	54	33	*Serranus tigrinus*
13	131	*Haemulon sciurus*	55	33	*Halichoeres garnoti*
14	126	*Lachnolaimus maximus*	56	32	*Scarus taeniopterus*
15	124	*Acanthurus bahianus*	57	32	*Acanthemblemaria* sp. 2
16	120	*Scarus croicensis*	58	32	*Calamus bajonado*
17	119	*Acanthurus chirurgus*	59	31	*Epinephelus striatus*
18	118	*Anisotremus virginicus*	60	30	*Caranx bartholomaei*
19	111	*Caranx ruber*	61	29	*Aulostomus maculatus*
20	111	*Sparisoma chrysopterum*	62	29	*Scartella cristata*
21	110	*Coryphopterus glaucofraenum*	63	28	*Ioglossus calliurus*
			64	27	*Acanthemblemaria* sp. 3
22	106	*Abudefduf saxatilis*	65	27	*Halichoeres poeyi*
23	105	*Gnatholepis thompsoni*	66	27	*Epinephelus cruentatus*
24	102	*Gobiosoma oceanops*	67	27	*Lutjanus synagris*
25	99	*Holacanthus bermudensis*	68	26	*Urolophus jamaicensis*
26	96	*Scarus coeruleus*	69	25	*Pomacanthus paru*
27	96	*Scarus coelestinus*	70	23	*Gymnothorax moringa*
28	92	*Sparisoma radians*	71	21	*Coryphopterus personatus*
29	92	*Pomacentrus leucostictus*	72	18	*Hypoplectrus nigricans*
30	91	*Calamus calamus*	73	18	*Lutjanus analis*
31	83	*Halichoeres maculipinna*	74	17	*Canthidermis sufflamen*
32	82	*Hypoplectrus unicolor*	75	16	*Balistes vetula*
33	79	*Lutjanus griseus*	76	16	*Malacoctenus* sp. 1
34	79	*Sparisoma rubripinne*	77	16	*Acanthemblemaria chaplini*
35	79	*Coryphopterus dicrus*	78	15	*Haemulon carbonarium*
36	78	*Chaetodon capistratus*	79	15	*Apogon maculatus*
37	74	*Holacanthus ciliaris*	80	15	*Synodus intermedius*
38	71	*Halichoeres radiatus*	81	14	*Epinephelus morio*
39	65	*Equetus acuminatus*	82	14	*Gerres cinereus*
40	62	*Chaetodon ocellatus*	83	13	*Bodianus rufus*
41	62	*Sphyraena barracuda*	84	13	*Holocentrus rufus*
42	56	*Haemulon aurolineatum*	85	13	*Caranx crysos*

Table 8. Rank order of species on inshore patch reef sites by species time score (with 1981 data adjusted for effort) (cont.).

Relative Species Abundances Ranked by Species Scores

Inshore Patch Reef Sites

Rank	Score	Species	Rank	Score	Species
86	13	*Serranus baldwini*	121	5	*Scarus vetula*
87	12	*Echeneis naucrates*	122	5	*Kyphosus sectatrix*
88	12	*Haemulon melanurum*	123	5	*Haemulon* sp. 1
89	12	*Cryptotomus roseus*	124	5	*Harengula* sp.
90	12	*Aluterus scriptus*	125	5	*Gymnothorax funebris*
91	11	*Diodon hystrix*	126	5	*Hemiramphus brasiliensis*
92	11	*Gobiosoma macrodon*	127	5	*Tylosurus crocodilus*
93	11	*Gobiosoma grosvenori*	128	5	*Ginglymostoma cirratum*
94	11	*Jenkinsia* sp.	129	4	*Sphyrna tiburo*
95	10	*Anisotremus surinamenis*	130	4	*Epinephelus guttatus*
96	10	*Odontoscion dentex*	131	4	*Serranus tabacarius*
97	10	*Equetus punctatus*	132	4	*Callionymus bairdi*
98	10	*Malacoctenus triangulatus*	133	4	*Chaenopsis ocellata*
99	10	*Hemipteronotus splendens*	134	4	*Microgobius microlepis*
100	10	*Hemipteronotus martinicensis*	135	4	*Nes longus*
			136	4	*Aluterus schoepfi*
101	10	*Hemiemblemaria simulus*	137	3	*Cantherhines pullus*
102	10	*Opistognathus aurifrons*	138	3	*Archosargus probatocephalus*
103	9	*Malacoctenus roseus*	139	3	*Platygillelus rubrocinctus*
104	9	*Chaetodipterus faber*	140	3	*Parablennius marmoreus*
105	9	*Hypoplectrus indigo*	141	3	*Hemipteronotus novacula*
106	8	*Harengula clupeola*	142	3	*Inermia vittata*
107	8	*Mulloidichthys martinicus*	143	3	*Haemulon macrostomum*
108	8	*Scomberomorus regalis*	144	3	*Chromis cyanea*
109	8	*Lactophrys polygonia*	145	3	*Microspathodon chrysurus*
110	7	*Diodon holocanthus*	146	2	*Gymnothorax vicinus*
111	7	*Blenniidae* sp. 1	147	2	*Opistognathus maxillosus*
112	7	*Acanthemblemaria* sp. 4	148	2	*Microgobius carri*
113	7	*Lutjanus mahogoni*	149	2	*Sphoeroides spengleri*
114	7	*Haemulon parra*	150	2	*Bothus* sp. 1
115	7	*Dasyatis americana*	151	1	*Diplectrum formosum*
116	6	*Haemulon chrysargyreum*	152	1	*Astrapogon stellatus*
117	6	*Holacanthus tricolor*	153	1	*Monacanthus tuckeri*
118	6	*Sardinella aurita*	154	1	*Mycteroperca venenosa*
119	6	*Scorpaena plumieri*	155	1	*Archosargus rhomboides*
120	5	*Lactophrys bicaudalis*			

Table 9. Rank order of species on turtle grass and hardground sites by species time score (with 1981 data adjusted for effort).

Relative Species Abundances Ranked by Species Scores

Turtle Grass and Hardground Sites

Rank	Score	Species	Rank	Score	Species
1	128	*Haemulon plumieri*	43	13	*Coryphopterus dicrus*
2	112	*Coryphopterus glaucofraenum*	44	13	*Sparisoma viride*
			45	13	*Calamus bajonado*
3	110	*Diplectrum formosum*	46	12	*Lutjanus analis*
4	108	*Microgobius microlepis*	47	12	*Pomacanthus paru*
5	93	*Sparisoma chrysopterum*	48	12	*Microgobius carri*
6	89	*Gobiosoma macrodon*	49	11	*Opsanus beta*
7	88	*Gobiosoma grosvenori*	50	11	*Strongylura notata*
8	86	*Equetus acuminatus*	51	11	*Chaetodon capistratus*
9	76	*Pomacanthus arcuatus*	52	11	*Haemulon aurolineatum*
10	69	*Pomaoentrus variabilis*	53	10	*Archosargus rhomboides*
11	67	*Caranx crysos*	54	10	*Holacanthus bermudensis*
12	65	*Caranx ruber*	55	10	*Hippocampus erectus*
13	51	*Scarus croicensis*	56	10	*Lactophrys quadricornis*
14	50	*Lutjanus synagris*	57	8	*Balistes capriscus*
15	46	*Acanthurus chirurgus*	58	8	*Gobionellus saepepallens*
16	46	*Monacanthus ciliatus*	59	8	*Diodon holocanthus*
17	45	*Haemulon flavolineatum*	60	8	*Synodus intermedius*
18	44	*Haemulon sciurus*	61	8	*Lutjanus mahogoni*
19	44	*Anisotremus virginicus*	62	7	*Eucinostomus* sp.
20	43	*Sparisoma aurofrenatum*	63	7	*Chaetodon ocellatus*
21	41	*Lutjanus griseus*	64	7	*Abudefduf saxatilis*
22	37	*Lachnolaimus maximus*	65	7	*Sardinella aurita*
23	36	*Pomacentrus leucostictus*	66	7	*Hypleurochilus aequipinnis*
24	34	*Paraclinus* sp. 1	67	7	*Hemipteronotus splendens*
25	33	*Ocyurus chrysurus*	68	6	*Scartella cristata*
26	32	*Sphyraena barracuda*	69	6	*Haemulon* sp. 1
27	30	*Acanthurus bahianus*	70	6	*Gymnothorax moringa*
28	30	*Caranx bartholomaei*	71	5	*Atherinomorus stipes*
29	29	*Lagodon rhomboides*	72	5	*Echeneis naucrates*
30	29	*Halichoeres bivittatus*	73	5	*Haemulon* sp. 2
31	28	*Epinephelus morio*	74	5	*Malacoctenus* sp. 1
32	28	*Urolophus jamaicensis*	75	5	*Barbulifer* sp.
33	26	*Gerres cinereus*	76	5	*Scarus coeruleus*
34	25	*Nes longus*	77	4	*Gobiesox strumosum*
35	20	*Sphoeroides spengleri*	78	4	*Blenniidae* sp. 1
36	19	*Sparisoma radians*	79	4	*Blenniidae* juv. sp.
37	18	*Cryptotomus roseus*	80	4	*Bothus* sp. 2
38	18	*Calamus calamus*	81	4	*Haemulon melanurum*
39	17	*Astrapogon stellatus*	82	4	*Eucinostomus* sp. 1
40	16	*Holacanthus ciliaris*	83	4	*Chaetodon sedentarius*
41	14	*Opistognathus maxillosus*	84	4	*Chaetodipterus faber*
42	14	*Gobiosoma oceanops*	85	4	*Mycteroperca bonaci*

Table 9. Rank order of species on turtle grass and hardground sites by species time score (with 1981 data adjusted for effort) (cont.).

Relative Species Abundances Ranked by Species Scores

Turtle Grass and Hardground Sites

Rank	Score	Species	Rank	Score	Species
86	4	*Cosmocampus albirostris*	98	2	*Apogon maculatus*
87	4	*Hippocampus zosterae*	99	2	*Harengula clupeola*
88	3	*Epinephelus striatus*	100	2	*Equetus punctatus*
89	3	*Hypoplectrus unicolor*	101	1	*Pomacentrus partitus*
90	3	*Oligoplites saurus*	102	1	*Anisotremus surinamenis*
91	3	*Scarus taeniopterus*	103	1	*Ahlia egmontis*
92	2	*Thalassoma bifasciatum*	104	1	*Jenkinsia* sp.
93	2	*Opistognathus* sp. 1	105	1	*Bothus lunatus*
94	2	*Opistognathus whitehursti*	106	1	*Callionymus pauciradiatus*
95	2	*Chaenopsis ocellata*	107	1	*Hypleurochilus bermudensis*
96	2	*Gnatholepis thompsoni*	108	1	*Ginglymostoma cirratum*
97	2	*Scomberomorus regalis*			

Table 10. Rank order of species for all sites surveyed by species time score (with 1981 data adjusted for effort).

Relative Species Abundances Ranked by Species Scores

Total for All Sites

Rank	Score	Species	Rank	Score	Species
1	567	*Haemulon plumieri*	43	259	*Mulloidichthys martinicus*
2	503	*Haemulon flavolineatum*	44	257	*Serranus tigrinus*
3	496	*Ocyurus chrysurus*	45	255	*Haemulon chrysargyreum*
4	495	*Sparisoma aurofrenatum*	46	254	*Scarus coeruleus*
5	483	*Sparisoma viride*	47	253	*Aulostomus maculatus*
6	472	*Haemulon sciurus*	48	249	*Haemulon macrostomum*
7	469	*Acanthurus bahianus*	49	242	*Chaetodon ocellatus*
8	465	*Thalassoma bifasciatum*	50	242	*Sparisoma radians*
9	460	*Scarus croicensis*	51	238	*Scarus taeniopterus*
10	459	*Acanthurus coeruleus*	52	234	*Pomacentrus leucostictus*
11	459	*Pomacentrus planifrons*	53	230	*Equetus acuminatus*
12	451	*Pomacentrus partitus*	54	222	*Epinephelus cruentatus*
13	423	*Abudefduf saxatilis*	55	221	*Coryphopterus dicrus*
14	415	*Caranx ruber*	56	220	*Lutjanus mahogoni*
15	412	*Coryphopterus glaucofraenum*	57	213	*Pomacanthus paru*
			58	210	*Kyphosus sectatrix*
16	408	*Halichoeres bivittatus*	59	205	*Pseudupeneus maculatus*
17	394	*Pomacentrus variabilis*	60	186	*Haemulon aurolineatum*
18	389	*Pomacanthus arcuatus*	61	181	*Calamus calamus*
19	389	*Sparisoma chrysopterum*	62	173	*Holacanthus tricolor*
20	384	*Anisotremus virginicus*	63	156	*Chromis cyanea*
21	379	*Halichoeres maculipinna*	64	156	*Lutjanus analis*
22	365	*Lutjanus griseus*	65	156	*Cantherhines pullus*
23	339	*Gnatholepis thompsoni*	66	153	*Chromis multilineata*
24	330	*Halichoeres radiatus*	67	150	*Holacanthus bermudensis*
25	325	*Pomacentrus diencaeus*	68	147	*Haemulon parra*
26	323	*Acanthurus chirurgus*	69	147	*Lactophrys triqueter*
27	315	*Lachnolaimus maximus*	70	145	*Hypoplectrus gemma*
28	312	*Gobiosoma oceanops*	71	144	*Mycteroperca bonaci*
29	303	*Microspathodon chrysurus*	72	143	*Scarus guacamaia*
30	302	*Sparisoma rubripinne*	73	137	*Odontoscion dentex*
31	296	*Scarus coelestinus*	74	131	*Chaetodon striatus*
32	295	*Canthigaster rostrata*	75	127	*Hypoplectrus puella*
33	287	*Chaetodon capistratus*	76	127	*Coryphopterus personatus*
34	286	*Hypoplectrus unicolor*	77	125	*Chaetodon sedentarius*
35	286	*Scarus vetula*	78	120	*Lutjanus synagris*
36	284	*Haemulon carbonarium*	79	119	*Ioglossus calliurus*
37	280	*Halichoeres garnoti*	80	118	*Hemipteronotus splendens*
38	275	*Sphyraena barracuda*	81	118	*Epinephelus striatus*
39	270	*Bodianus rufus*	82	114	*Diplectrum formosum*
40	264	*Lutjanus apodus*	83	113	*Anisotremus surinamenis*
41	262	*Holacanthus ciliaris*	84	112	*Echeneis naucrates*
42	261	*Pempheris schomburgki*	85	112	*Microgobius microlepis*

Table 10. Rank order of species for all sites surveyed by species time score (with 1981 data adjusted for effort) (cont.).

Relative Species Abundances Ranked by Species Scores

Total for All Sites

Rank	Score	Species
86	101	*Priacanthus cruentatus*
87	100	*Gobiosoma macrodon*
88	99	*Gobiosoma grosvenori*
89	87	*Clepticus parrae*
90	80	*Caranx crysos*
91	79	*Urolophus jamaicensis*
92	77	*Caranx bartholomaei*
93	77	*Hypoplectrus nigricans*
94	74	*Aluterus scriptus*
95	70	*Apogon maculatus*
96	70	*Holocentrus vexillarius*
97	69	*Lutjanus jocu*
98	67	*Scomberomorus regalis*
99	67	*Opistognathus aurifrons*
100	65	*Canthidermis sufflamen*
101	65	*Calamus bajonado*
102	63	*Holocentrus rufus*
103	60	*Gerres cinereus*
104	56	*Scartella cristata*
105	55	*Lactophrys bicaudalis*
106	53	*Synodus intermedius*
107	52	*Acanthemblemaria* sp. 2
108	50	*Tylosurus crocodilus*
109	49	*Holocentrus adscensionis*
110	49	*Cryptotomus roseus*
111	46	*Monacanthus ciliatus*
112	45	*Halichoeres poeyi*
113	45	*Epinephelus morio*
114	45	*Serranus baldwini*
115	43	*Chromis scotti*
116	43	*Diodon hystrix*
117	42	*Equetus punctatus*
118	42	*Malacanthus plumieri*
119	39	*Microgobius carri*
120	35	*Rypticus saponaceus*
121	34	*Inermia vittata*
122	34	*Gymnothorax moringa*
123	34	*Paraclinus* sp. 1
124	34	*Acanthemblemaria chaplini*
125	34	*Diodon holocanthus*
126	33	*Hemiemblemaria simulus*
127	33	*Gymnothorax funebris*
128	33	*Apogon binotatus*
129	33	*Hypoplectrus indigo*
130	32	*Myripristis jacobus*
131	29	*Lagodon rhomboides*
132	29	*Haemulon melanurum*
133	29	*Nes longus*
134	27	*Acanthemblemaria* sp. 3
135	27	*Apogon townsendi*
136	26	*Haemulon album*
137	26	*Amblycirrhitus pinos*
138	24	*Equetus lanceolatus*
139	24	*Serranus tabacarius*
140	24	*Malacoctenus* sp. 1
141	23	*Ophioblennius atlanticus*
142	23	*Jenkinsia lamprotaenia*
143	22	*Hemipteronotus novacula*
144	22	*Sphoeroides spengleri*
145	21	*Balistes vetula*
146	21	*Liopropoma rubre*
147	21	*Astrapogon stellatus*
148	20	*Chaetodipterus faber*
149	20	*Malacoctenus triangulatus*
150	18	*Monacanthus tuckeri*
151	16	*Opistognathus maxillosus*
152	16	*Lactophrys quadricornis*
153	15	*Callionymus bairdi*
154	14	*Blenniidae* sp.
155	14	*Epinephelus guttatus*
156	13	*Hypoplectrus aberrans*
157	13	*Jenkinsia* sp.
158	13	*Sardinella aurita*
159	12	*Hemipteronotus martinicensis*
160	12	*Muraena miliaris*
161	11	*Priacanthus arenatus*
162	11	*Archosargus rhomboides*
163	11	*Haemulon* sp. 1
164	11	*Strongylura notata*
165	11	*Opsanus beta*
166	11	*Lactophrys polygonia*
167	11	*Dasyatis americana*
168	10	*Acanthemblemaria* sp. 4
169	10	*Harengula clupeola*

Table 10. Rank order of species for all sites surveyed by species time score (with 1981 data adjusted for effort) (cont.).

Relative Species Abundances Ranked by Species Scores

Total for All Sites

Rank	Score	Species	Rank	Score	Species
170	10	*Hippocampus erectus*	200	4	*Trachinotus falcatus*
171	10	*Atherinomorus stipes*	201	4	*Blenniidae juv. sp.*
172	9	*Malacoctenus roseus*	202	4	*Gobiesox strumosum*
173	8	*Balistes capriscus*	203	4	*Aluterus schoepfi*
174	8	*Gobionellus saepepallens*	204	4	*Bothus sp. 2*
175	8	*Hemiramphus brasiliensis*	205	4	*Sphyrna tiburo*
176	7	*Mycteroperca tigris*	206	3	*Archosargus probatocephalus*
177	7	*Hypoplectrus guttavarius*	207	3	*Platygillelus rubrocinctus*
178	7	*Eucinostomus* sp. 2	208	3	*Apogon robinsi*
179	7	*Eucinostomus* sp. 1	209	3	*Seriola dumerili*
180	7	*Chromis insolata*	210	3	*Oligoplites saurus*
181	7	*Hypleurochilus aequipinnis*	211	3	*Apogon pseudomaculatus*
182	7	*Coryphopterus lipernes*	212	3	*Apogon lachneri*
183	6	*Chaenopsis ocellata*	213	2	*Gymnothorax vicinus*
184	6	*Parablennius marmoreus*	214	2	*Bothus* sp. 1
185	6	*Lactophrys trigonus*	215	2	*Opistognathus* sp. 1
186	6	*Scorpaena plumieri*	216	2	*Opistognathus whitehursti*
187	6	*Cantherhines macrocerus*	217	2	*Malacoctenus aurolineatus*
188	6	*Aetobatus narinari*	218	1	*Emblemaria pandionis*
189	6	*Carcharhinus leucas*	219	1	*Callionymus pauciradiatus*
190	6	*Ginglymostoma cirratum*	220	1	*Hypleurochilus bermudensis*
191	5	*Megalops atlanticus*	221	1	*Bothus lunatus*
192	5	*Barbulifer* sp.	222	1	*Calamus penna*
193	5	*Lutjanus cyanopterus*	223	1	*Ahlia egmontis*
194	5	*Haemulon* sp. 2	224	1	*Epinephelus adscensionis*
195	5	*Harengula* sp.	225	1	*Hypoplectrus chlorurus*
196	4	*Cosmocampus albirostris*	226	1	*Epinephelus afer*
197	4	*Hippocampus zosterae*	227	1	*Mycteroperca venenosa*
198	4	*Centropomus undecimalis*	228	1	*Pempheris poeyi*
199	4	*Epinephelus itajara*			

The maximum possible score for species listed in Table 6 was 160, attained only by *Thalassoma bifasciatum* and *Acanthurus bahianus*. Of the 155 species censused at the four offshore sites, the 43 that attained scores of 100 or greater are relatively widespread and easily seen due to their size, color, and/or behavior. Below this arbitrary cutoff, less ubiquitous, less colorful or more secretive species begin to appear. For example, apogonids are extremely numerous at these sites but hide in deep caves and crevices during the day and as a result did not receive substantial species scores. Conversely, *Holacanthus ciliaris* is relatively rare but colorful and widely distributed. This species attained a score of 84, compared to a score of only 12 for *Acanthemblemaria chaplini*, a more abundant but patchily distributed, cryptic species.

Species censused at intermediate reef sites are ranked in Table 7. Acanthurids, pomacentrids, labrids, haemulids, and lutjanids dominate these rankings as they did those from offshore reefs, although several species such as *Caranx ruber*, *Pomacentrus variabilis* and *Gobiosoma oceanops* attained considerably higher ranks at intermediate compared to offshore sites.

The same families that dominated offshore and intermediate sites in terms of species scores also topped the rankings at inshore patch reefs (Table 8). However, the proportion of the 156 species recorded at inshore patch reefs which received high scores relative to the maximum possible score of 120 was less than in the preceding two habitat categories. Smaller, more cryptic species, such as members of the genus *Acanthemblemaria*, attained relatively higher ranks on inshore patch reefs. This may have been due to divers requiring less time to record the readily visible species (which were less numerous than those that dominated rankings in Tables 6 and 7). As a result, divers may have allocated more time earlier in each dive to searching for cryptic, secretive species, producing higher scores for these species. Other species, such as *Scartella cristata* and *Microgobius microlepis*, made their first appearance at inshore patch reefs.

Divers were able to spend virtually the entire time of the STT counts searching carefully for cryptic, small or rare species at turtle grass/hardground sites due to the general lack of abundance of readily visible species. The maximum possible score for these six sites was 240, yet the highest score attained in Table 9 was only 128 (*Haemulon plumieri*). Thus no species was particularly dominant at these sites, and families that were relatively rare elsewhere attained much higher rankings. For example, four of the first ten species listed in Table 9 are gobiids. A number of species and families were unique to these habitats, including several gobies, clinids, *Callionymus pauciradiatus*, and the families Batrachoididae (*Opsanus beta*), Gobiesocidae (*Gobiesox strumosus*), Ophichthidae (*Ahlia egmontis*), and *Cosmocampus albirostris*, *Hippocampus erectus*, and *Hippocampus zosterae* of family Syngnathidae.

12.4.4. Between-Community Comparisons

In addition to computation of Shannon-Weaver diversity indicies (H') and equitability of distribution (J') for each site, different sites were compared using one-way ANOVA with multiple comparisons (Duncan's Multiple Range Test) and also by community ordination. ANOVA-DMRT on all sites combined was not possible due to presence of excessive heteroscedasticity ($p < 0.05$ for Cochran's C, $p < 0.001$ for Bartlett-Box F). This violation of the assumptions underlying ANOVA was eliminated or mitigated by doing one-way ANOVA separately on each of the four major categories of habitat. Tables 11 through 18 give the results of ANOVA-DMRT for mean species and mean scores for offshore reefs, intermediate reefs, inshore patch reefs, and turtle grass/hardground sites respectively. Tables 11, 13, 15, and 17, ANOVA-DMRT of mean numbers of species per site, are of primary interest. The ecological significance and statistical validity of utilizing species scores from the STT for ANOVA-DMRT are suspect. Thus, Tables 12, 14, 16, and 18 are included to fulfill the contract and to

Table 11. ANOVA-DMRT of mean species on offshore reefs. Sites grouped by bars show no significant differences among means; all others show significant difference at α = 0.05.

ANOVA

Source of Variation	df	SS	MS	F*
Between groups	3	2.2796	0.7599	4.678
Within groups	28	4.5478	0.1624	
Total	31	6.8275		

(* P < 0.01)

DMRT

Site No.	Name	Mean Score	Square Root of Mean Score
8	Carysfort Reef	69.6	8.34
7	The Elbow	73.3	8.55
1	Molasses Reef	75.5	8.68
3	French Reef	82.5	9.07

Table 12. ANOVA-DMRT of mean species scores on offshore reefs. Sites grouped by bars show no significant differences among means; all others show significant difference at α = 0.05.

ANOVA

Source of Variation	df	SS	MS	F*
Between groups	3	12.7097	4.2366	6.157
Within groups	28	19.2670	0.6881	
Total	31	31.9767		

(* P < 0.01)

DMRT

Site No.	Name	Mean Score	Square Root of Mean Score
8	Carysfort Reef	272	8.34
7	The Elbow	301	8.55
1	Molasses Reef	298	8.68
3	French Reef	334	9.07

Table 13. ANOVA-DMRT of mean number of species on intermediate reefs. Sites grouped by bars show no significant differences among means; all others show significant difference at □ = 0.05.

ANOVA

Source of Variation	df	SS	MS	F*
Between groups	3	0.2045	0.0682	0.464
Within groups	28	4.1107	0.1468	
Total	31	4.3152		

(* P < 0.10)

DMRT

Site No.	Name	Mean Score	Square Root of Mean Score
5	Grecian Rocks (1980)	65.8	8.09
18	Grecian Rocks (1981)	66.1	8.13
6	Key Largo Dry Rocks	67.9	8.24
2	White Bank Dry Rocks	68.8	8.29

Table 14. ANOVA-DMRT of mean species scores on intermediate reefs. Sites grouped by bars show no significant differences among means; all others show significant difference at □ = 0.05.

ANOVA

Source of Variation	df	SS	MS	F*
Between groups	3	0.4553	0.1518	0.260
Within groups	28	16.3641	0.5844	
Total	31	16.8195		

(* P > 0.10)

DMRT

Site No.	Name	Mean Score	Square Root of Mean Score
5	Grecian Rocks (1980)	267	16.30
18	Grecian Rocks (1981)	260	16.11
6	Key Largo Dry Rocks	256	16.00
2	White Bank Dry Rocks	264	16.25

Table 15. ANOVA-DMRT of mean number of species on inshore patch reefs. Sites grouped by bars show no significant differences among means; all others show significant difference at α = 0.05.

ANOVA

Source of Variation	df	SS	MS	F*
Between groups	3	0.0078	0.0026	1.798
Within groups	28	0.0404	0.0014	
Total	31	0.0482		

(* P > 0.10)

DMRT

Site No.	Name	Mean Score	Square Root of Mean Score
9	Basin Hill Shoals	46.3	1.67
4	Mosquito Bank	46.6	1.68
10	Turtle Rocks	46.8	1.68
17	Angelfish Creek	50.8	1.71

Table 16. ANOVA-DMRT of mean species scores on inshore patch reefs. Sites grouped by bars show no significant differences among means; all others show significant difference at α = 0.05.

ANOVA

Source of Variation	df	SS	MS	F*
Between groups	3	0.0076	0.0025	2.037
Within groups	28	0.0347	0.0012	
Total	31	0.0423		

(* P > 0.10)

DMRT

Site No.	Name	Mean Scores	Log Base 10 of Mean Scores
9	Basin Hill Shoals	194	2.29
4	Mosquito Bank	184	2.27
10	Turtle Rocks	190	2.28
17	Angelfish Creek	204	2.30

Table 17. ANOVA-DMRT of mean number of species on turtle grass/hardground sites. Sites grouped by bars show no significant differences among means; all others show significant difference at α = 0.05.

ANOVA

Source of Variation	df	SS	MS	F*
Between groups	5	1.7346	0.3469	21.818
Within groups	42	0.6678	0.0159	
Total	47	2.4024		

(* P < 0.001)

DMRT

Site No.	Name	Mean Score	Log Base 10 of Mean Score
11	Ocean Reef	5.8	0.81
12	Turtle Harbor	9.0	0.99
15	Rock Harbor	12.1	1.09
16	Point Elizabeth	12.9	1.13
13	North Channel	19.9	1.30
14	South Channel	23.5	1.39

Table 18. ANOVA-DMRT of mean species scores on turtle grass/hardground sites. Sites grouped by bars show no significant differences among means; all others show significant difference at α = 0.05.

ANOVA

Source of Variation	df	SS	MS	F*
Between groups	5	1.7346	0.4668	24.870
Within groups	42	0.7882	0.0188	
Total	47	3.1220		

(* P < 0.001)

DMRT

Site No.	Name	Mean Scores	Log Base 10 of Mean Scores
11	Ocean Reef	18	1.25
12	Turtle Harbor	34	1.55
15	Rock Harbor	45	1.63
16	Point Elizabeth	51	1.71
13	North Channel	75	1.84
14	South Channel	84	1.93

provide a comparison between groupings produced from number of species and from species scores.

Square root transformation of both mean number of species and mean species scores achieved homogeneity of variances for offshore reefs ($p > 0.05$ for both Cochran's C and Bartlett-Box F). The results of one-way ANOVA show a significant difference ($p < 0.01$) between one or more of the four offshore reefs on the basis of both mean species (Table 11) and mean scores (Table 12). Duncan's Multiple Range Test (DMRT) grouped reefs on the basis of no significant difference between means at $p < 0.05$ according to mean species (Table 11) and mean scores (Table 12).

Carysfort Reef, the Elbow, and Molasses Reef comprised one group and Molasses and French reefs another by the mean species criterion. ANOVA-DMRT of mean scores separated French Reef from the other three sites.

Jones and Thompson (1978) grouped Molasses and French reefs and separated Carysfort Reef from these two by both mean species and mean scores using ANOVA-DMRT. Both studies, in addition to distinguishing Carysfort from the other two, recorded higher mean species at French Reef than any other study site. This result is consistent with our observation of the reef structure at this site. French Reef shares most of the basic physical attributes (back-reef, rubble zone, and approximate spur and groove fore-reef structure) with Molasses and Carysfort reefs. It has a much more extensive network of tunnels and caves (such as under huge *M. annularis* heads) than either of the other sites. While Carysfort Reef has an extensive *A. palmata* crest, *A. cervicornis* thickets, and steep drop-off, it was our impression that the cave system and extension of major scleractinian heads further seaward on French Reef were more amenable to increased numbers of species than the unique features of Carysfort Reef. This contention was supported by some exceptionally high individual STT counts at French Reef not obtained in any other area (over 100 species in several instances, including one count of 109 species).

Tables 13 and 14 indicate that intermediate reefs were indistinguishable on the basis of both mean species and mean scores. Square root transforms of both species and scores reduced but did not eliminate heteroscedasticity problems ($p = 0.01$ and 0.005 for Cochran's C and Bartlett-Box F respectively). Scheffé (1959), however, demonstrated that one-way ANOVA is fairly robust with a small number of groups and equal sample sizes. Furthermore, the confidence intervals around each mean overlap one another. Thus, we believe that there is no significant difference between intermediate reef sites by either the mean species or mean scores criterion. Intermediate reefs were less diverse than offshore reefs.

Tables 15 and 16 indicate a lack of significant differences between inshore patch reef sites by either the mean species or mean scores criterion. Common logarithmic transform (base 10) of both kinds of data achieved homogeneity of variance ($p > 0.05$ for both Cochran's C and Bartlett-Box F). While inshore patch reefs were indistinguishable from offshore reefs in terms of number of species, as were intermediate reefs, they were less diverse as a group than either intermediate or offshore reefs.

Logarithmic transformation of data on both number of species and species scores successfully eliminated hateroscedasticity ($p > 0.05$ for both Cochran's C and Bartlett-Box F) among the inshore sites. Tables 17 and 18 group turtle grass/hardground sites similarly based on mean species and mean scores. Ocean Reef, which is predominantly turtle grass, is significantly different from all other sites in this category. The mean species criterion groups Turtle Harbor and Rock Harbor, the two other turtle grass sites (Table 1), and North and South Channels, the two turtle grass/hardground sites. Point Elizabeth, a site consisting of part turtle grass and part hardground, is grouped with Rock Harbor.

Bottom habitat appears to be a stronger influence on number of species at given sites than does boat traffic. Ocean Reef and North Channel experience similar levels of boat traffic, yet have significantly different numbers of species (Tables 1 and 17). Similarly, while intensity of boat traffic at Rock Harbor and South Channel is comparable, number of species is significantly less at the former site. Sites with hardground tended generally to harbor more species than sites with only turtle grass habitat.

Hardground habitats contained a number of different features amenable to habitation by fishes that were not found in turtle grass, including small head corals, various sponges, patches of octocorals, and small ledges of bedrock. In addition to greater proportions of hardground, North and South Channel each feature a navigation marker around which various fish species congregate. South Channel had the highest mean number of species of this group, due at least in part to fish inhabiting a large pile of discarded batteries around the marker at the mouth of the channel.

Most user impacts, including recreational diving, hook and line fishing, and boat traffic, do not appear to affect species diversity at sites where activity levels are high relative to sites where user activity is lower.

The DMRT analysis indicated that the habitat at a given site has the largest influence on fish species diversity. In terms of Equation 1, $\square_i$ appears to be a stronger Influence than $\square_j$ on Y_{ij}. It is evident that Jones and Thompson (1978) also believed this to be the case in their study, because they explained their DMRT in terms of structural similarities between study areas. Species diversity was highly related to structural complexity and location of the study site. Thus, offshore reefs were the most diverse and near-shore turtle grass sites the least. Species diversity at study sites was generally inversely related to distance from offshore reefs. French Reef had higher fish diversity than any other site.

Two between-site analyses have been presented thus far: (1) Shannon-Weaver diversity functions - evenness of distribution indices (Table 5) and (2) ANOVA-DMRT (Tables 11 - 18). Jones and Thompson (1978) point out a potential weakness in both approaches. Although mean number of species may be statistically the same for two or more sites, they may be comprised of completely different species. Neither approach considers degree of overlap in species between sites. For this reason we compared sites using the ordination procedure of Beals (1960), based on the Bray and Curtis (1957) Index, in order to complement the other two analytical approaches.

The Bray and Curtis Index (C) was computed for each of the 153 possible pairwise combinations of the 18 sites (17 different sites, site 18 being the 1981 Grecian Rocks replicate). These similarity coefficients were placed below and to the left of the blank diagonal elements of a matrix of similarity and dissimilarity coefficients between pairs of sites (Table 17). Dissimilarity coefficients, computed as the maximum value of the similarity coefficient minus the observed value for each pair of sites, were placed above and to the right of the blank diagonal elements of the matrix. The maximum theoretical value of the similarity coefficient was 1.00. Both Beals (1960) and Jones and Thompson (1978) used maximum values less than 1.00. We saw no reason to lower the dissimilarity coefficient values and therefore used a maximum value of 1.00.

Table 19 shows high similarity of fish communities between similar habitats. Similarity coefficient values are generally proportional to structural similarity and location of sites. For example, values of the similarity coefficient were 0.892 for French and Molasses reefs, 0.888 for the Elbow and Molasses Reef, 0.846 for Carysfort and Molasses reefs, 0.844 between

Table 19. Similarity and dissimilarity coefficients based on the Bray and Curtis Index.

				Dissimilarity					
Site/ Similarity	1	2	3	4	5	6	7	8	9
1	+	0.18	0.11	0.40	0.20	0.19	0.11	0.15	0.36
2	0.82	+	0.23	0.31	0.21	0.19	0.18	0.20	0.34
3	0.89	0.77	+	0.41	0.23	0.19	0.13	0.16	0.39
4	0.60	0.69	0.59	+	0.40	0.40	0.39	0.39	0.28
5	0.80	0.78	0.77	0.60	+	0.21	0.21	0.22	0.38
6	0.81	0.82	0.81	0.60	0.79	+	0.18	0.20	0.36
7	0.89	0.82	0.87	0.61	0.79	0.83	+	0.14	0.38
8	0.85	0.80	0.84	0.62	0.78	0.80	0.86	+	0.40
9	0.64	0.66	0.61	0.72	0.62	0.64	0.62	0.60	+
10	0.71	0.77	0.71	0.69	0.76	0.70	0.73	0.71	0.69
11	0.16	0.19	0.14	0.22	0.16	0.18	0.15	0.15	0.27
12	0.18	0.19	0.17	0.24	0.17	0.19	0.20	0.18	0.21
13	0.45	0.50	0.44	0.61	0.51	0.48	0.45	0.43	0.59
14	0.35	0.39	0.34	0.57	0.37	0.37	0.34	0.32	0.51
15	0.28	0.34	0.29	0.41	0.35	0.33	0.29	0.29	0.39
16	0.26	0.22	0.26	0.41	0.29	0.29	0.28	0.26	0.36
17	0.65	0.69	0.64	0.64	0.64	0.64	0.67	0.65	0.65
18	0.83	0.85	0.79	0.67	0.84	0.83	0.83	0.82	0.65
Site/ Similarity	10	11	12	13	14	15	16	17	18
1	0.29	0.84	0.82	0.55	0.65	0.72	0.74	0.35	0.17
2	0.23	0.81	0.81	0.50	0.62	0.66	0.72	0.31	0.15
3	0.29	0.85	0.83	0.56	0.66	0.71	0.74	0.36	0.22
4	0.31	0.78	0.76	0.39	0.43	0.59	0.59	0.36	0.33
5	0.24	0.84	0.83	0.49	0.63	0.65	0.71	0.36	0.15
6	0.30	0.82	0.81	0.52	0.63	0.67	0.71	0.36	0.17
7	0.27	0.85	0.80	0.55	0.66	0.71	0.72	0.33	0.17
8	0.29	0.85	0.82	0.57	0.68	0.71	0.74	0.35	0.18
9	0.31	0.73	0.79	0.41	0.49	0.61	0.64	0.35	0.35
10	+	0.78	0.81	0.45	0.56	0.65	0.66	0.30	0.23
11	0.22	+	0.59	0.64	0.60	0.53	0.52	0.81	0.83
12	0.19	0.41	+	0.70	0.67	0.66	0.57	0.79	0.84
13	0.55	0.36	0.30	+	0.35	0.45	0.45	0.48	0.52
14	0.44	0.39	0.33	0.65	+	0.46	0.40	0.56	0.62
15	0.35	0.47	0.34	0.55	0.54	+	0.49	0.65	0.66
16	0.34	0.48	0.43	0.55	0.60	0.51	+	0.67	0.72
17	0.70	0.19	0.21	0.52	0.44	0.35	0.33	+	0.30
18	0.77	0.17	0.16	0.48	0.38	0.34	0.28	0.70	+

Carysfort and French reefs, 0.869 between the Elbow and French Reef, and so on. Similarity coefficients were not as high between less diverse habitats, but were still generally proportional to the similarity between the pair of sites. This low diversity, low similarity relationship may be due largely to the lower effectiveness of the STT in lower-diversity habitats for enumerating the species in a given area. A large proportion of the species at turtle grass sites, for example, were cryptic. Observations of many of these species during counts were chance sightings as an individual fish made a fast move or otherwise exposed itself from the cover of the turtle grass. This was the case for most gobiids, clinids, *Opsanus beta*, and syngnathids.

Two other factors contributing to lower similarities among less diverse sites were (1) the influence of random encounters with transient, non-resident species passing through the area (carangids, lutjanids, and haemulids) and (2) chance encounters with isolated structures, such as abandoned lobster traps or other artificial habitats, in otherwise monotonous environments. During the Rock Harbor census, divers found two 55-gallon steel drums and two abandoned lobster traps during the course of eight counts at this turtle grass site. No such oasis for fish fauna were found at Ocean Reef, and only one lobster trap was found at Turtle Harbor. Because juvenile pomacanthids, haemulids, carangids, lutjanids, and other fishes tended to congregate around these structures, the sites containing them were made more diverse for reasons beyond natural habitat. We contend, for example, that if we had found such structures at Ocean Reef, species numbers and scores here would likely have been more similar to other turtle grass sites. North and South channels were less similar to Point Elizabeth because a number of species were added due to the presence of a navigation marker at those two sites around which fish congregated. Also, species composition at South Channel was influenced considerably by a pile of discarded batteries (not present at North Channel or Point Elizabeth).

In general, less diverse sites were less similar than those with higher diversity because of the relatively larger influence of three factors on species composition in the less diverse areas: uneven distribution of rare, species-rich habitats, chance encounters with isolated groups of transient species, and the relative inefficiency of the STT for censusing cryptic species. An alternative sampling method should be used to replace or complement visual census techniques in future surveys at turtle grass/hardground sites. Small-mesh fish traps or isolated rotenone stations might serve this purpose. Otter trawls would effectively sample those areas, but might be too destructive for use in an underwater preserve.

Grecian Rocks had a similarity coefficient of 0.845 between years, indicating a high consistency in sampling by the STT. A number of offshore reef pairs had slightly higher similarity coefficients than did Grecian Rocks between years. However, the absolute differences between 0.845 and those values is probably negligible.

Figure 2 is the result of applying the community ordination procedure devised by Beals (1960) on the basis of the Bray and Curtis Index. Distance between communities on the two dimensional plot is proportional to dissimilarity between communities. The numbers near each point correspond to the 18 study site numbers. Study sites are positioned approximately by major habitat type, with less distance between higher-diversity locations than those with fewer species. The plot generally reflects the previously discussed lack of similarity between low-diversity sites. For example, the turtle grass sites (11, 12, and 15) are well separated from other habitat types but considerable dissimilarity is evident between the three. As discussed previously, this is probably an artifact of the sampling procedure.

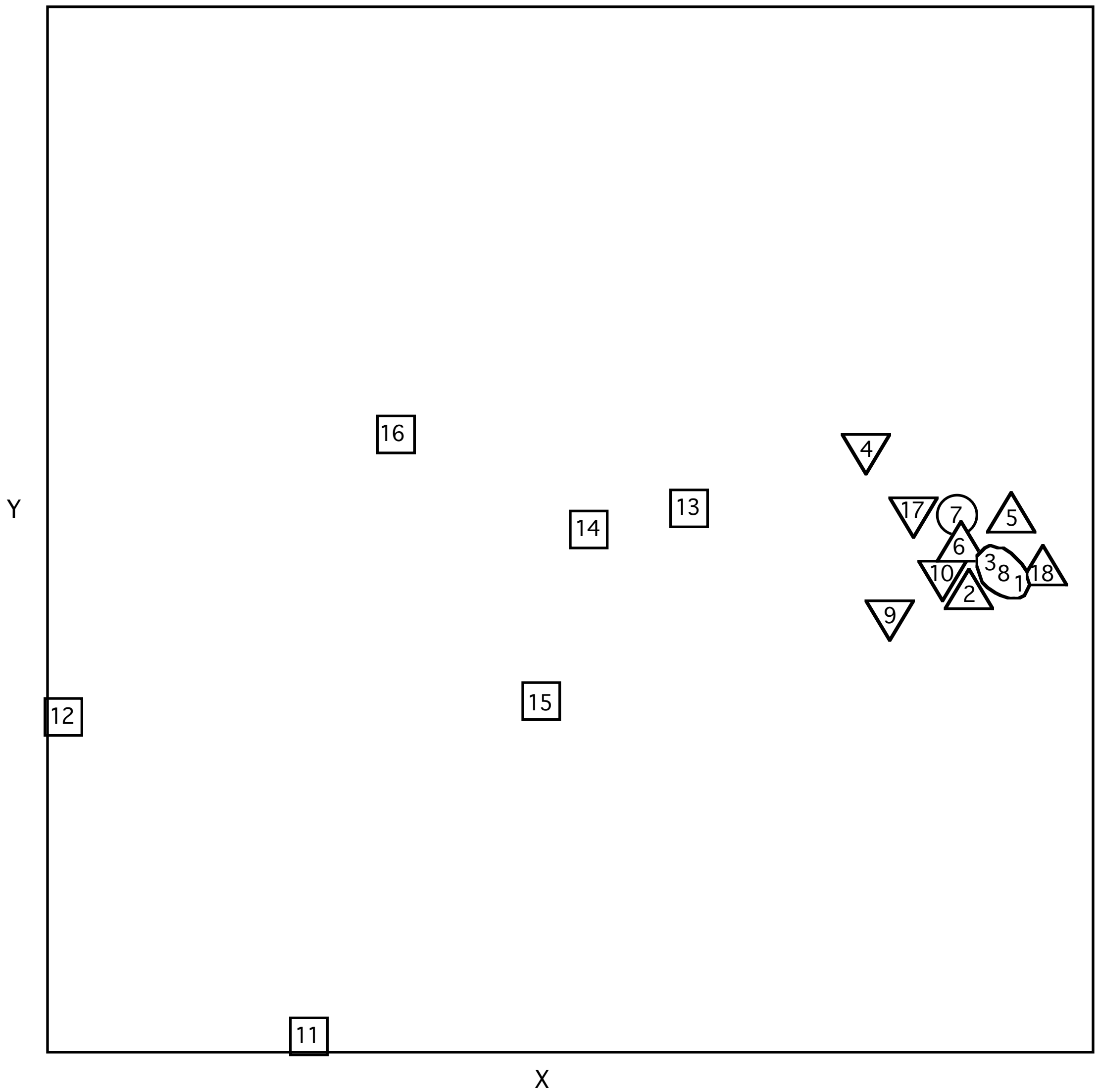

Figure 2. Two-dimensional ordination of communities based on the Bray and Curtis Index. Numbers correspond to study sites 1 through 17, with number 18 corresponding to the second (1981) census of Grecian Rocks. Numbers are enclosed by a symbol corresponding to classification of the site into one of the four major habitat types: O = offshore reef; Δ = intermediate reef; ∇ = inshore patch reef; □ = turtle grass/hardground.

12.4.5. Comments on the STT

Jones and Thompson (1978) label the STT a "random" count. However, it is not random, because the divers choose their course throughout the 50-minute counting period. We also noted that the course chosen had a large influence on which species received higher scores. For example, whether or not a count began on the back-reef or the fore-reef slope largely affected the scores assigned to the species more common to one or the other habitat. We attempted to resolve this problem by starting counts at different reef zones as equitably as possible.

Another non-random influence on individual counts is the technique used by the diver to count species. One can either swim over various habitats and zones and record species as they present themselves, or attempt to maximize time usage by developing specific search images and swimming to habitats or reef zones actively searching for species groups that have not yet been recorded. We felt that the latter approach consistently yielded higher counts than the former. This approach is relatively more demanding of diver knowledge of the systematics and life history of the fish fauna of an area, because of the increased degree of freedom of action during the STT compared to more restricted techniques such as transects.

The STT is an effective tool for rapidly enumerating species and drawing limited general conclusions about differences in species diversity between high diversity fish communities associated with coral reefs. The technique is not environmentally destructive. The technique is not as effective in low diversity environments such as turtle grass, nor is it effective for cryptic species. Also, ranking of species according to STT scores does not provide an accurate quantification of fish community structure.

We recommend that NOAA complement the STT fish survey in future monitoring studies with a more truly random and more quantitative technique in order to accurately quantify reef fish community structure at the different study sites. Species diversity at different sites is not as important as accurate quantification of the relative abundance of different species and how this relative abundance of species dominance varies over time and with user impact. We refer NOAA to a study nearing completion by James A. Bohnsack of the Cooperative Institute for Marine and Atmospheric Studies, 4600 Rickenbacker Causeway, Miami, FL 33149 (who recently accepted a position as Fishery Biologist in charge of reef fish research, National Marine Fisheries Service, Southeast Fisheries Center, Miami Laboratory). He has used a technique developed and tested by Bohnsack and Bannerot (1983) to quantify reef fish community structure using a random visual approach to study the effects of predator removal by spearfishing in several non-spearfished reefs in the Key Largo National Marine Sanctuary, Looe Key National Marine Sanctuary, and Carrie Bow Cay, Belize. We feel strongly that this technique or one similar to it would provide NOAA with data more relevant to management of the fish fauna of John Pennekamp Coral Reef State Park and Key Largo National Marine Sanctuary than techniques that sample only species diversity.

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