NOAA Technical Memorandum NMFS-SEFSC-561

Selected Reef Fish Visual Census Studies Conducted by the Miami Laboratory Reef Resources Team, 1985-2002

David B. McClellan and Douglas E. Harper
(Editors)

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center
75 Virginia Beach Drive
Miami, Florida 33149

August 2007

NOAA Technical Memorandum NMFS-SEFSC-561

Selected Reef Fish Visual Census Studies Conducted by the Miami Laboratory Reef Resources Team, 1985 - 2002

David B. McClellan and Douglas E. Harper
(Editors)

U.S. DEPARTMENT OF COMMERCE
Carlos M. Gutierrez, Secretary

National Oceanic and Atmospheric Administration
Conrad C. Lautenbacker Jr., Undersecretary for Oceans and Atmosphere

National Marine Fisheries Service
William T. Hogarth, Assistant Administrator for Fisheries

Southeast Fisheries Science Center
Miami, Florida

August 2007

This technical memorandum series is used for documentation and timely communication of preliminary results, interim reports, or special purpose information, and has not undergone external scientific review.

NOTICE

This report should be cited as follows:

McClellan, D.B., and D.E. Harper (Eds.). 2007. Selected Reef Fish Visual Census Studies Conducted by the Miami Laboratory Reef Resources Team, 1985-2002. NOAA Technical Memorandum NMFS-SEFSC-561. 104p.

Copies may be obtained by writing:

National Marine Fisheries Service
Southeast Fisheries Science Center
75 Virginia Beach Drive
Miami, Florida 33149

or

National Technical Information Service
5258 Port Royal Road
Springfield, Virginia 22161
(703) 487-4650
FAX: (703) 321-8547
Rush Orders: (800) 336-4700

PDF version available at www.sefsc.noaa.gov

Table of Contents

Foreword

G. Todd Kellison and James A. Bohnsack

This document is a compilation of unpublished reports describing six unrelated fish survey projects conducted by the NOAA Southeast Fisheries Science Center (SEFSC) Reef Resources Team during the period 1985 - 2002. The projects span the geographical range from Puerto Rico and Little Cayman in the Caribbean to the Florida middle grounds (West Florida Shelf), Dry Tortugas region, and Florida Keys. The projects described in this compilation represent early research and monitoring efforts.

The purpose of this document is to make previously unpublished research available for potential use by researchers, managers, and other parties interested in the fish communities associated with the study areas described in the studies herein. For example, researchers or managers might use data collected and summarized in this compilation as quantitative or qualitative baselines against which to assess changes over time for the study areas of interest.

In general, the reports contained in this compilation are as initially written following the original study. Thus, the report format is not consistent throughout the compilation, and with minor exceptions reports have not been edited following their original completion. For each of the reports, nomenclature was as listed in the then-current edition of the American Fisheries Society publication "Common and Scientific Names of Fishes from the United States and Canada".

For most of the reports, fish data are summarized in tabular format. For readers interested in obtaining more detailed data, inquiries should be sent to the address below.

Protected Resources and Biodiversity Division
NOAA SEFSC
75 Virginia Beach Drive
Miami, FL 33149

Chapter 1. Reef Fish Survey, Mona Island, Puerto Rico, October 1985

James A. Bohnsack and Douglas E. Harper

Purpose

The purpose of this study was to document reef fish community structure in damaged and undamaged reef areas near the grounded vessel A Regina at Mona Island, Puerto Rico (Fig. 1). The specific objectives were to quantitatively document reef fish abundances and frequencies near the grounded vessel using standard visual survey methods.

Methods

Standard visual stationary sampling methodology was used (Bohnsack and Bannerot, 1986) to assess reef fish community structure. A series of visual samples were conducted on damaged reef areas within 50 m of the vessel (inside damage stations, n =15; and adjacent to damage stations, n = 9). A series of control stations were made on reef areas showing no obvious signs of damage between 50 - 300 m away from the vessel (inshore control stations, n = 6; and offshore control stations, n = 11). The percent composition of bottom substrates was recorded at each station as viewed by the diver from one central point. All stations were taken between 11 and 15 October 1985.

Data were summarized and analyzed to provide estimates of percent frequency and mean abundance for each species for future comparisons. The mean number of individuals and species per sample were compared for damaged and control areas of Mona Island. Also the size frequency and mean abundance of the ocean surgeonfish, *Acanthurus bahianus*, were compared between damaged and control areas. The number of individuals per sample was first transformed by a $\log_{10}$ transform before analysis. Abundance of *A. bahianus* was transformed by a $\log_{10}(x + 1)$. Parametric tests were used if data appeared normally distributed and variances were approximately equal. Non-parametric U-tests were used if either of these assumptions were violated.

Three swimming transects were conducted in which all observed predators were censused in 15 min random swims (Bohnsack, 1982). Additional samples were not taken and these data were not analyzed because so few predators were observed.

Results

Bottom composition varied considerably between sample areas (Table 1). Control areas had considerably more coral coverage and damage areas had considerably more rubble coverage. The damage areas varied in morphology between offshore and inshore areas. The inshore area was primarily composed of intact coral colonies both living and dead. The dead colonies appeared to have been killed by sediments or abrasion. The offshore damage areas (seaward of the A Regina) differed in that physical damage caused by the grounded vessel had destroyed most coral colonies leaving an irregular carbonate rock and rubble substrate with little relief. Depths of stations ranged between 3 and 6 m for inside damage, 5 and 7 m for outside damage, 3 and 6 m inshore control, and 6 and 9 m for offshore control stations.

A total of 65 fish species were observed in 41 stationary samples (Table 2). The mean number of species per sample from damaged areas (mean = 15.3 ± 1 .65 95% CI, n = 24) was less than that found from control areas (mean = 18.2 ±1.69 95% CI, n = 17). The difference was highly significant ($p < 0.01$, t-test). The mean number of individuals per sample was also significantly less ($p < 0.05$, t-test) in damaged areas (transformed mean = 2.1217 ± 0.1348 95% CI, n = 24) than in undamaged control areas (transformed mean = 2.3500 ± 0.1251 95% CI, n = 17).

Statistical descriptions were made for each species observed from the four areas (Appendix A). Abundance and frequency-of occurrence patterns for each species were compared from the four sample areas (Table 3). Statistical tests for differences were not made for every species although graphical comparisons of patterns of abundance (Fig. 2) and frequency-of-occurrence (Fig. 3) were made. The abundance of grunts (Haemulidae) and snapper (Lutjanidae) were very low from all areas. Species conspicuously absent were yellowtail snapper, *Ocyurus chrysurus*, and the threespot damselfish, *Pomacentrus planifrons*. The redlip blenny *Ophioblennius atlanticus* and black durgon *Melichthys niger* were conspicuously abundant.

Differences in abundance of *A. bahianus* between damaged areas and control areas of Mona Island were significant ($p < 0.05$, one tailed t-test) with damaged sites having significantly more individuals (transformed mean = 1 .1.1778 ± 0 .2245 95% CI, n = 24) than undamaged control sites (transformed mean = 0.9036 ± 0.1278 95% CI, n = 17). The size distribution of *A. bahianus* was also significantly different between control and damaged areas ($p < 0.05$, Kolmogorov-Smirnov test) with smaller individuals observed in damaged areas (Fig. 4).

Discussion and Conclusion

The fish fauna at Mona Island was generally depauperate compared to other reefs we have examined along the North American continent from Florida to Belize. This phenomenon is most likely the result of the isolation of Mona Island from other reef habitats, the surrounding oceanic conditions, and the small amount of 1iving reef and shelf area at Mona Island. Starck (1968) observed few grunts and snapper from islands in the Caribbean with little shelf area. This is apparently the result of limited available foraging area to support fishes. The impacts of local fishing pressure on the biota are unknown but may have influenced the observed pattern.

As would be expected in a major ship grounding, bottom substrate data indicated significant differences between damage and control areas in terms of substrate composition. More coral cover was present in undamaged areas and more rubble and bare rock was present in damaged areas. The reduced habitat diversity and profile probably accounts for the observed reduced mean number of species and individuals in stations from damaged areas. Observations of the <u>Wellwood</u> grounding off Key Largo, Florida (Bohnsack, unpubl. data) indicated significant increases in numbers of the herbivores *A. bahianus* and *Scarus croicensis* on damaged areas. Also, the average size of *A. bahianus* was significantly smaller on damaged areas because of a large number of recruits. Results from damaged and undamaged areas of Mona Island show the same patterns for *A. bahianus*. Too few *S. croicensis* were present at Mona Island to support a statistical comparison. Although the mean number of all scarids were greater in damaged areas (mean = 6.25 ± 1.94 95% CI) than in control areas (5.38 ± 1.706), the difference was not statistically significant ($p > 0.05$).

The greater abundance of the herbivorous *A. bahianus* in damaged areas is probably the result of greater availability of early successional algae colonizing the newly exposed bare rock and dead coral. Smaller individuals probably occur in the damaged areas because of greater attraction for juveniles, greater recruitment of settling larvae, or better juvenile survival from reduced predation or competition. The exact mechanism has not been demonstrated.

Detailed comparisons of abundance patterns between the various sample areas were not made on a species by species basis. However, the brown chromis, *Chromis multilineatus*, showed a clear pattern of greater abundance in undamaged areas. The brown chromis, a highly mobile diurnal planktivore, normally schools around prominent outcrops and feeds on the passing plankton. Damaged areas may lack sufficient relief for brown chromis or the presence of the grounded ship may somehow alter current patterns in a way that was unfavorable for maintaining their presence.

Acknowledgements

We thank the Department of Natural Resources, Government of Puerto Rico for providing the use of the vessel Jean A, food, and logistical support for this study. Special assistance was provided by Gilberto Cintron.

Literature Cited

Bohnsack, J.A. 1982. Effects of piscivorous predator removal on coral reef fish community structure. 1981 Gutshop: Third Pacific Technical Workshop Fish Food Habits Studies. 258-267.

Bohnsack, J.A. and S.P. Bannerot. 1986. A stationary visual census technique for quantitatively assessing community structure of coral reef fishes. NOAA Technical Report 41, 15 pp.

Starck, W.A., Jr. 1968. A list of fishes of Alligator Reef, Florida with comments on the nature of the Florida reef fish fauna. Undersea Biology 1: 5-40.

Table 1. Substrate composition. Percentage of substrate viewed by a stationary diver within a 7.5 m radius.

	Sample Locations			
Bottom Type	Inshore Damage	Offshore Damage	Inshore Control	Offshore Control
Coral[1]	20.4	5.8	42.3	69.0
Sand	24.0	7.8	5.2	20.5
Rock[2]	36.6	71.4	50.8	5.5
Rubble	19.0	15.0	1.7	5.0

[1] Includes living coral colonies, intact stands of *Acropora palmata* (living and dead), gorgonians, and reef fingers dominated by macro-biota.

[2] Includes exposed bare carbonate rock or rock dominated by micro-biota.

Table 2. Alphabetical listing of fishes at the Mona Island grounding site, October 11-15, 1985, 41 samples recorded. * indicates that the species was observed during sampling, but after the initial 5 minute sampling period and no abundance estimates were recorded. Numbers identify species in Figures 1 and 2.

	SPECIES CODE	SCIENTIFIC NAME	COMMON NAME	RANDOM POINT SAMPLES Freq.	Tot. Abund.
1	ABU SAXA	Abudefduf saxatilis	Sergeant major	7	53
2	ACA BAHI	Acanthurus bahianus	Ocean surgeon	40	848
3	ACA COER	Acanthurus coeruleus	Blue tang	36	439
4	ADI VEXI	Adioryx vexillarius	Dusky squirrelfish	1	1
5	AMB PINO	Amblycirrhitus pinos	Redspotted hawkfish	1	1
6	AUL MACU	Aulostomus maculatus	Trumpetfish	1	1
7	BOD RUFU	Bodianus rufus	Spanish hogfish	21	38
8	BOT LUNA	Bothus lunatus	Peacock flounder	3	3
9	CAN PULL	Cantherhines pullus	Orangespotted filefish	1	1
10	CAR RUBE	Caranx ruber	Bar jack	18	34
11	CHA CAPI	Chaetodon capistratus	Foureye butterflyfish	3	5
12	CHA STRI	Chaetodon striatus	Banded butterflyfish	8	10
13	CHR CYAN	Chromis cyaneus	Blue chromis	1	2
14	CHR MULT	Chromis multilineatus	Brown chromis	12	322
15	EPI FULV	Epinephelus fulvus	Coney	18	65
16	GNA THOM	Gnatholepis thompsoni	Goldspot goby	1	1
17	GOB EVEL	Gobiosoma evelynae	Sharpnose goby	3	8
18	HAE AURO	Haemulon aurolineatum	Tomtate	1	15
19	HAE CARB	Haemulon carbonarium	Caesar grunt	10	12
20	HAE CHRY	Haemulon chrysargyreum	Smallmouth grunt	1	16
21	HAL BIVI	Halichoeres bivittatus	Slippery dick	31	131
22	HAL GARN	Halichoeres garnoti	Yellowhead wrasse	17	68
23	HAL MACU	Halichoeres maculipinna	Clown wrasse	29	99
24	HAL PICT	Halichoeres pictus	Rainbow wrasse	4	23
25	HAL POEY	Halichoeres poeyi	Blackear wrasse	16	44
26	HAL RADI	Halichoeres radiatus	Puddingwife	34	100
27	HOL ADSC	Holocentrus adscensionis	Squirrelfish	2	2
28	HOL RUFU	Holocentrus rufus	Longspine squirrelfish	5	6
29	HOL TRIC	Holacanthus tricolor	Rock beauty	8	14
30	KYP SECT	Kyphosus sectatrix	Bermuda chub	6	103
31	LAC BICA	Lactophrys bicaudalis	Spotted trunkfish	1	1
32	LAC POLY	Lactophrys polygonia	Honeycomb cowfish	1	1
33	LAC TRIQ	Lactophrys triqueter	Smooth trunkfish	3	3
34	LUT APOD	Lutjanus apodus	Schoolmaster	4	4
35	LUT JOCU	Lutjanus jocu	Dog snapper	2	2
36	LUT MAHO	Lutjanus mahogoni	Mahogany snapper	5	15
37	MAL AURO	Malacoctenus aurolineatus	Goldline blenny	2	3
38	MAL PLUM	Malacanthus plumieri	Sand tilefish	4	10
39	MAL SPE.	Malacoctenus sp.	Unidentified blenny	1	2
40	MAL TRIA	Malacoctenus triangulatus	Saddled blenny	12	24

Table 2 (cont.)

	SPECIES CODE	SCIENTIFIC NAME	COMMON NAME	RANDOM POINT SAMPLES Freq.	Tot. Abund.
41	MEL NIGE	Melichthys niger	Black durgon	38	575
42	MIC CHRY	Microspathodon chrysurus	Yellowtail damselfish	36	207
43	MUL MART	Mulloidichthys martinicus	Yellow goatfish	9	21
44	MYR JACO	Myripristis jacobus	Blackbar soldierfish	1	1
45	OPH ATLA	Ophioblennius atlanticus	Redlip blenny	34	355
46	POM FUSC	Pomacentrus fuscus	Dusky damselfish	34	226
47	POM PART	Pomacentrus partitus	Bicolor damselfish	11	284
48	POM PARU	Pomacanthus paru	French angelfish	1	1
49	PSE MACU	Pseudupeneus maculatus	Spotted goatfish	4	5
50	RYP SAPO	Rypticus saponaceus	Greater soapfish	1	1
51	SCA CROI	Scarus croicensis	Striped parrotfish	6	12
52	SCA TAEN	Scarus taeniopterus	Princess parrotfish	3	8
53	SCA VETU	Scarus vetula	Queen parrotfish	5	5
54	SPA AURO	Sparisoma aurofrenatum	Redband parrotfish	26	63
55	SPA CHRY	Sparisoma chrysopterum	Redtail parrotfish	9	25
56	SPA RUBR	Sparisoma rubripinne	Yellowtail parrotfish	18	65
57	SPA VIRI	Sparisoma viride	Stoplight parrotfish	28	72
58	SPH BARR	Sphyraena barracuda	Barracuda	4	4
59	SPH PICU	Sphyraena picudilla	Southern sennet	4	920
60	THA BIFA	Thalassoma bifasciatum	Bluehead	40	3,141
	(Additional species observed)				
	BAL VETU	Balistes vetula	Queen triggerfish	*	*
	CAR BART	Caranx bartholomaei	Yellow jack	*	*
	CLE PARR	Clepticus parrai	Purple reeffish	*	*
	DAS AMER	Dasyatis americana	Southern stingray	*	*
	URO JAMA	Urolophus jamaicensis	Yellow stingray	*	*

Table 3. Statistical comparison of species from four sample areas.

		REGINA DAMAGED AREA						REGINA CONTROL AREA					
		INSHORE			OUTSIDE			INSHORE			OFFSHORE		
No.	SPECIES	%FREQ (N = 15)	MEAN (N = 15)	+ or - 95% CI	%FREQ (N = 9)	MEAN (N = 9)	+ or - 95% CI	%FREQ (N = 6)	MEAN (N = 6)	+ or - 95% CI	%FREQ (N = 11)	MEAN (N = 11)	+ or - 95% CI
1	ABU SAXA	26.7%	0.47	0.53	11.1%	0.44	0	16.7%	0.50	0	9.1%	3.55	0
2	ACA BAHI	93.3%	21.13	20.43	100.0%	43.00	31.4	100.0%	7.83	8.005	100.0%	8.82	3.96
3	ACA COER	93.3%	18.80	31.98	66.7%	2.89	2.368	83.3%	6.67	6.758	100.0%	8.27	6.758
4	ADI VEXI	0.0%	0.00	0	11.1%	0.11	0	0.0%	0.00	0	0.0%	0.00	0
5	AMB PINO	0.0%	0.00	0	0.0%	0.00	0	0.0%	0.00	0	9.1%	0.09	0
6	AUL MACU	6.7%	0.07	0	0.0%	0.00	0	0.0%	0.00	0	0.0%	0.00	0
7	BOD RUFU	46.7%	0.73	0.435	44.4%	0.67	0.435	50.0%	0.67	0.605	63.6%	1.55	1.443
8	BOT LUNA	6.7%	0.07	0	0.0%	0.00	0	16.7%	0.17	0	9.1%	0.09	0
9	CAN PULL	0.0%	0.00	0	11.1%	0.11	0	0.0%	0.00	0	0.0%	0.00	0
10	CAR RUBE	40.0%	0.67	0.286	22.2%	0.33	0.533	50.0%	0.83	1.208	63.6%	1.45	1.208
11	CHA CAPI	6.7%	0.07	0	0.0%	0.00	0	0.0%	0.00	0	18.2%	0.36	0
12	CHA STRI	20.0%	0.27	0.319	11.1%	0.11	0	0.0%	0.00	.	36.4%	0.45	0.335
13	CHR CYAN	0.0%	0.00	0	0.0%	0.00	0	0.0%	0.00	0	9.1%	0.18	0
14	CHR MULT	6.7%	0.27	0	0.0%	0.00	0	33.3%	10.33	7.421	81.8%	23.27	11.91
15	EPI FULV	6.7%	0.27	0	55.6%	2.56	2.9	33.3%	0.67	0	90.9%	3.09	0.906
16	GNA THOM	6.7%	0.07	0	0.0%	0.00	0	0.0%	0.00	0	0.0%	0.00	0
17	GOB EVEL	6.7%	0.13	0	0.0%	0.00	0	16.7%	0.67	0	9.1%	0.18	0
18	HAE AURO	0.0%	0.00	0	0.0%	0.00	0	16.7%	2.50	0	0.0%	0.00	0
19	HAE CARB	53.3%	0.67	0.256	22.2%	0.22	0	0.0%	0.00	0	0.0%	0.00	0
20	HAE CHRY	6.7%	1.07	0	0.0%	0.00	0	0.0%	0.00	0	0.0%	0.00	0
21	HAL BIVI	86.7%	3.87	1.188	88.9%	4.22	2.443	66.7%	1.67	1.817	54.5%	2.27	1.303
22	HAL GARN	13.3%	0.27	0	22.2%	0.56	0.533	33.3%	0.83	2.226	100.0%	4.91	3.547
23	HAL MACU	66.7%	2.73	1.151	66.7%	3.44	3.352	66.7%	1.50	1.004	81.8%	1.64	0.671
24	HAL PICT	6.7%	0.07	0	33.3%	2.44	1.569	0.0%	0.00	0	0.0%	0.00	0
25	HAL POEY	40.0%	0.80	0.35	88.9%	3.22	1.392	16.7%	0.33	0	9.1%	0.09	0
26	HAL RADI	66.7%	1.60	0.65	100.0%	2.33	1.131	83.3%	2.83	0.938	90.9%	3.45	1.813
27	HOL ADSC	0.0%	0.00	0	11.1%	0.11	0	0.0%	0.00	0	9.1%	0.09	0
28	HOL RUFU	0.0%	0.00	0	11.1%	0.11	0	16.7%	0.17	0	27.3%	0.36	0.387
29	HOL TRIC	13.3%	0.13	0	0.0%	0.00	0	0.0%	0.00	0	54.5%	1.09	0.6
30	KYP SECT	6.7%	0.07	0	11.1%	4.44	0	50.0%	4.33	12.16	9.1%	3.27	0
31	LAC BICA	6.7%	0.07	0	0.0%	0.00	0	0.0%	0.00	0	0.0%	0.00	0
32	LAC POLY	0.0%	0.00	0	0.0%	0.00	0	0.0%	0.00	0	9.1%	0.09	0
33	LAC TRIQ	0.0%	0.00	0	0.0%	0.00	0	16.7%	0.17	0	18.2%	0.18	0
34	LUT APOD	13.3%	0.13	0	0.0%	0.00	0	33.3%	0.33	0	0.0%	0.00	0
35	LUT JOCU	0.0%	0.00	0	0.0%	0.00	0	33.3%	0.33	0	0.0%	0.00	0
36	LUT MAHO	33.3%	1.00	1.918	0.0%	0.00	0	0.0%	0.00	0	0.0%	0.00	0
37	MAL AURO	6.7%	0.07	0	0.0%	0.00	0	16.7%	0.33	0	0.0%	0.00	0
38	MAL PLUM	20.0%	0.53	0	0.0%	0.00	0	0.0%	0.00	0	9.1%	0.18	0
39	MAL SPE.	0.0%	0.00	1.152	11.1%	0.22	0	0.0%	0.00	0	0.0%	0.00	0
40	MAL TRIA	13.3%	0.13	0	22.2%	0.56	1.599	16.7%	0.17	0	63.6%	1.45	0.507
41	MEL NIGE	86.7%	13.73	19.62	88.9%	14.67	10.39	100.0%	13.00	5.593	100.0%	14.45	8.19
42	MIC CHRY	86.7%	3.40	1.184	66.7%	2.22	1.628	100.0%	7.83	4.473	100.0%	8.09	2.069
43	MUL MART	33.3%	0.67	0.553	44.4%	1.22	0.948	0.0%	0.00	0	0.0%	0.00	0
44	MYR JACO	0.0%	0.00	0	0.0%	0.00	0	0.0%	0.00	0	9.1%	0.09	0
45	OPH ATLA	60.0%	2.40	0.875	88.9%	12.22	7.833	100.0%	18.33	6.072	100.0%	9.00	4.108
46	POM FUSC	93.3%	5.07	1.813	88.9%	6.78	2.609	100.0%	9.67	4.233	54.5%	2.82	2.318
47	POM PART	6.7%	0.73	0	11.1%	0.11	0	0.0%	0.00	0	81.8%	24.73	8.115
48	POM PARU	0.0%	0.00	0	0.0%	0.00	0	0.0%	0.00	0	9.1%	0.09	0
49	PSE MACU	6.7%	0.07	0	22.2%	0.33	0.533	0.0%	0.00	0	9.1%	0.09	0
50	RYP SAPO	0.0%	0.00	0	0.0%	0.00	0	0.0%	0.00	0	9.1%	0.09	0
51	SCA CROI	33.3%	0.67	0.391	0.0%	0.00	0	0.0%	0.00	0	9.1%	0.18	0
52	SCA TAEN	6.7%	0.13	0	0.0%	0.00	0	0.0%	0.00	0	18.2%	0.55	0

Table 3 (cont.)

No.	SPECIES	REGINA DAMAGED AREA INSHORE %FREQ (N = 15)	MEAN (N = 15)	+ or - 95% CI	REGINA DAMAGED AREA OUTSIDE %FREQ (N = 9)	MEAN (N = 9)	+ or - 95% CI	REGINA CONTROL AREA INSHORE %FREQ (N = 6)	MEAN (N = 6)	+ or - 95% CI	REGINA CONTROL AREA OFFSHORE %FREQ (N = 11)	MEAN (N = 11)	+ or - 95% CI
53	SCA VETU	6.7%	0.07	0	22.2%	0.22	0	16.7%	0.17	0	9.1%	0.09	0
54	SPA AURO	66.7%	1.73	0.467	77.8%	1.56	1.056	16.7%	0.33	0	72.7%	1.91	1.562
55	SPA CHRY	20.0%	0.87	1.279	55.6%	1.11	0.754	16.7%	0.33	0	0.0%	0.00	0
56	SPA RUBR	46.7%	1.27	1.419	22.2%	1.00	3.732	100.0%	4.67	0.857	27.3%	0.82	1.163
57	SPA VIRI	73.3%	2.47	0.793	44.4%	0.78	0.721	66.7%	1.83	1.004	81.8%	1.55	0.783
58	SPH BARR	13.3%	0.13	0	0.0%	0.00	0	0.0%	0.00	0	18.2%	0.18	0
59	SPH PICU	6.7%	14.00	0	33.3%	78.89	82.71	0.0%	0.00	0	0.0%	0.00	0
60	THA BIFA	93.3%	32.20	30.29	100.0%	45.00	38.49	100.0%	86.67	111.2	100.0%	157.55	73.13

Figure 1. Location of A Regina grounding at Mona Island, Puerto Rico.

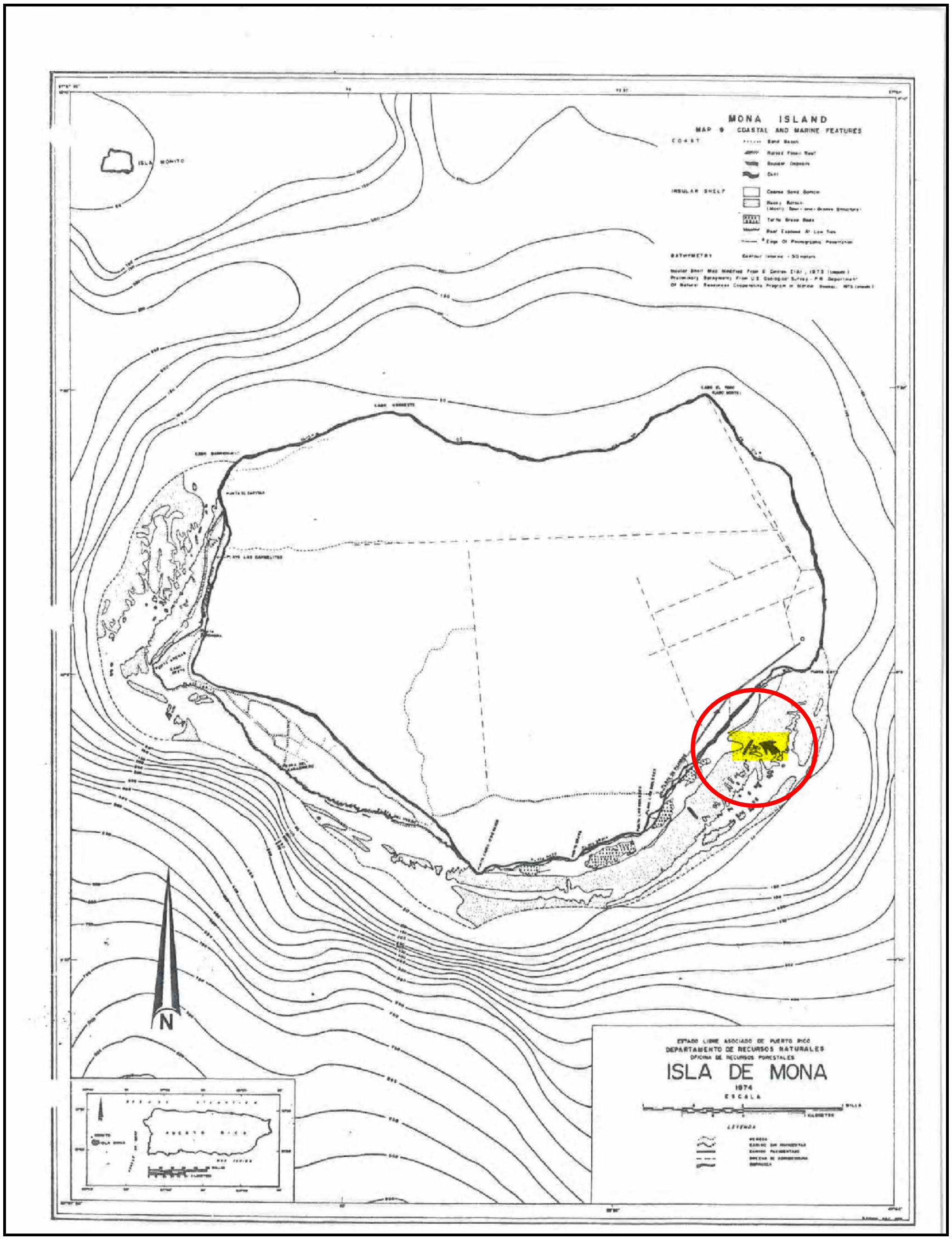


Figure 2. Comparison of mean abundance by species for the four sample locations. Species are numbered alphabetically (see Table 2).

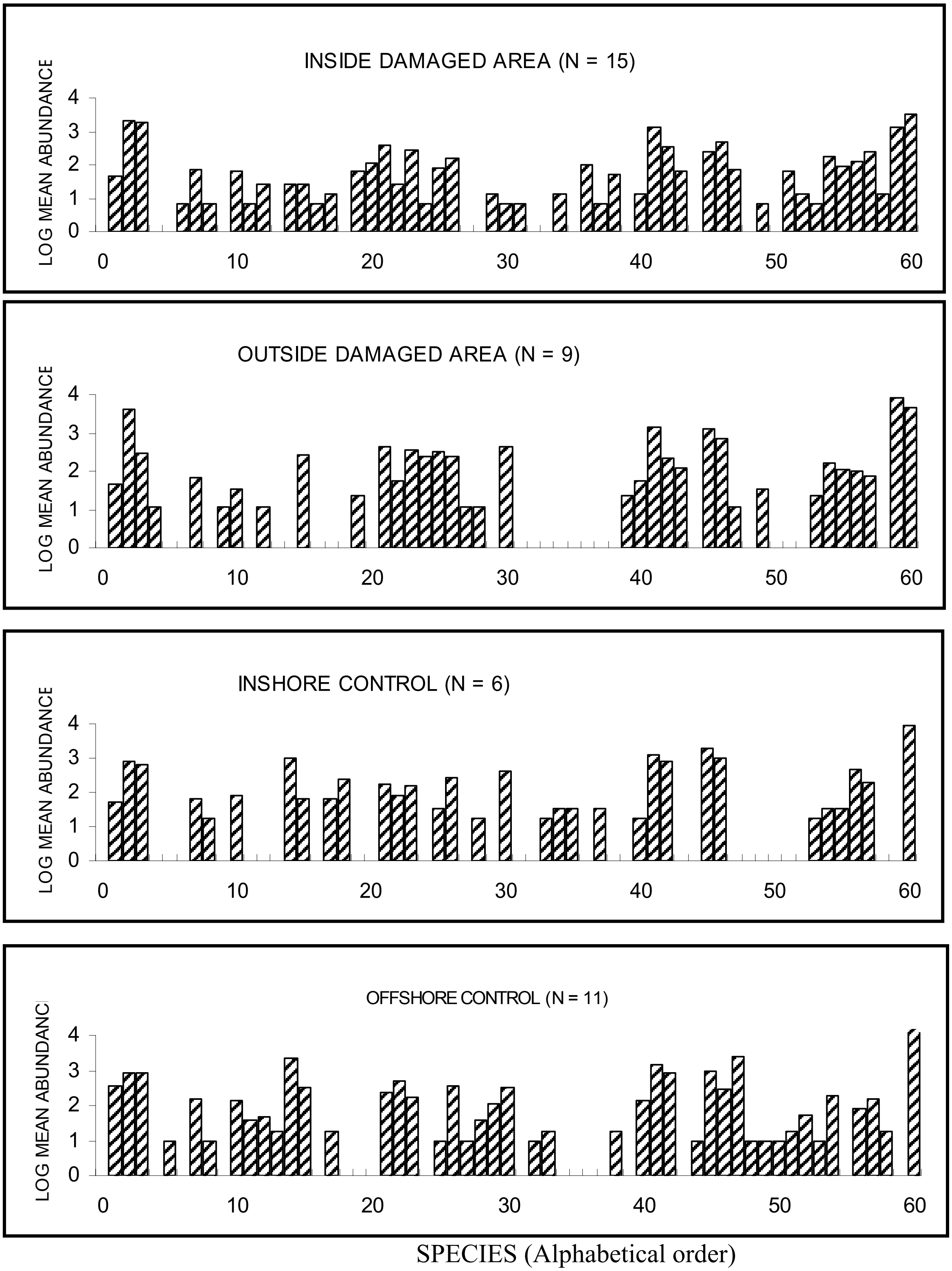


Figure 3. Comparison of frequency-of-occurrence by species for the four sample locations. Species are numbered alphabetically (see Table 2).

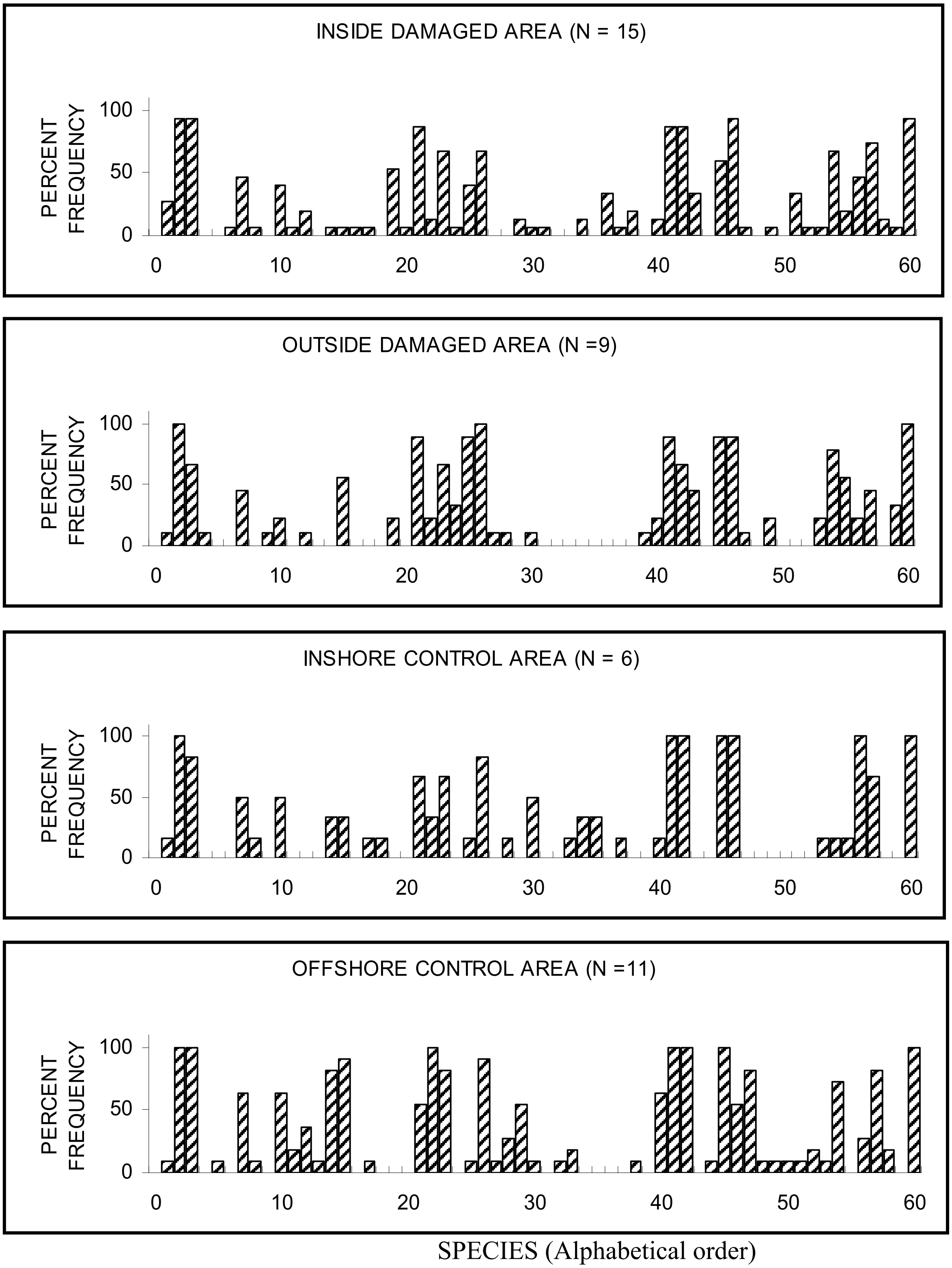
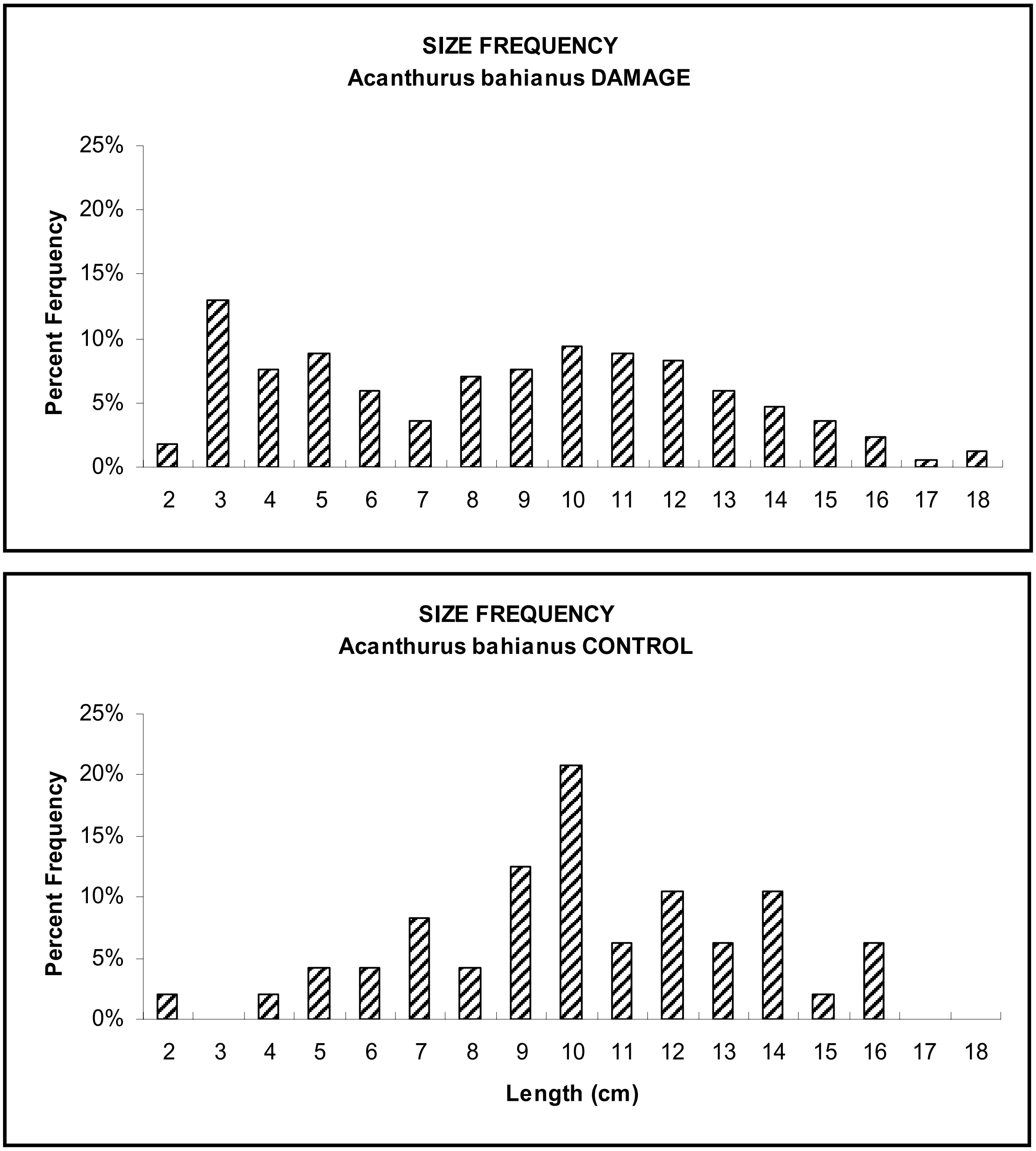


Figure 4. Comparison of size frequency distributions for *Acanthurus bahianus* from damaged (top) and control (bottom) stations.



Appendix A.1. Inside damage area, REGINA grounding, Mona Island, Puerto Rico.

No.	Species	Total Indiv.	Frequency (N=15)	%	Mean Abund.	Stand. Dev.	Range High	Low	Var/Mean Ratio
1	ABU SAXA	7	4	26.7%	0.47	0.92	3	0	1.96
2	ACA BAHI	317	14	93.3%	21.13	36.03	142	0	64.39
3	ACA COER	282	14	93.3%	18.80	55.90	220	0	177.42
4	ADI VEXI	0	0	0.0%	0.00	NA	NA	NA	NA
5	AMB PINO	0	0	0.0%	0.00	NA	NA	NA	NA
6	AUL MACU	1	1	6.7%	0.07	0.26	1	0	0.00
7	BOD RUFU	11	7	46.7%	0.73	0.96	3	0	0.84
8	BOT LUNA	1	1	6.7%	0.07	0.26	1	0	0.00
9	CAN PULL	0	0	0.0%	0.00	NA	NA	NA	NA
10	CAR RUBE	10	6	40.0%	0.67	0.90	2	0	0.40
11	CHA CAPI	1	1	6.7%	0.07	0.26	1	0	0.00
12	CHA STRI	4	3	20.0%	0.27	0.59	2	0	1.25
13	CHR CYAN	0	0	0.0%	0.00	NA	NA	NA	NA
14	CHR MULT	4	1	6.7%	0.27	1.03	4	0	0.00
15	EPI FULV	4	1	6.7%	0.27	1.03	4	0	0.00
16	GNA THOM	1	1	6.7%	0.07	0.26	1	0	0.00
17	GOB EVEL	2	1	6.7%	0.13	0.52	2	0	0.00
18	HAE AURO	0	0	0.0%	0.00	NA	NA	NA	NA
19	HAE CARB	10	8	53.3%	0.67	0.72	2	0	0.32
20	HAE CHRY	16	1	6.7%	1.07	4.13	16	0	0.00
21	HAL BIVI	58	13	86.7%	3.87	2.53	8	0	1.19
22	HAL GARN	4	2	13.3%	0.27	0.70	2	0	0.00
23	HAL MACU	41	10	66.7%	2.73	2.60	8	0	1.58
24	HAL PICT	1	1	6.7%	0.07	0.26	1	0	0.00
25	HAL POEY	12	6	40.0%	0.80	1.08	3	0	0.50
26	HAL RADI	24	10	66.7%	1.60	1.50	5	0	0.86
27	HOL ADSC	0	0	0.0%	0.00	NA	NA	NA	NA
28	HOL RUFU	0	0	0.0%	0.00	NA	NA	NA	NA
29	HOL TRIC	2	2	13.3%	0.13	0.35	1	0	0.00
30	KYP SECT	1	1	6.7%	0.07	0.26	1	0	0.00
31	LAC BICA	1	1	6.7%	0.07	0.26	1	0	0.00
32	LAC POLY	0	0	0.0%	0.00	NA	NA	NA	NA
33	LAC TRIQ	0	0	0.0%	0.00	NA	NA	NA	NA
34	LUT APOD	2	2	13.3%	0.13	0.35	1	0	0.00
35	LUT JOCU	0	0	0.0%	0.00	NA	NA	NA	NA
36	LUT MAHO	15	5	33.3%	1.00	2.36	9	0	12.00
37	MAL AURO	1	1	6.7%	0.07	0.26	1	0	0.00
38	MAL PLUM	8	3	20.0%	0.53	1.36	5	0	8.13

Appendix A.1. (cont.)

No.	Species	Total Indiv.	Frequency (N=15)	%	Mean Abund.	Stand. Dev.	Range High	Low	Var/Mean Ratio
39	MAL SPE.	0	0	0.0%	0.00	NA	NA	NA	NA
40	MAL TRIA	2	2	13.3%	0.13	0.35	1	0	0.00
41	MEL NIGE	206	13	86.7%	13.73	33.27	132	0	91.42
42	MIC CHRY	51	13	86.7%	3.40	2.41	8	0	1.35
43	MUL MART	10	5	33.3%	0.67	1.11	3	0	1.50
44	MYR JACO	0	0	0.0%	0.00	NA	NA	NA	NA
45	OPH ATLA	36	9	60.0%	2.40	2.35	6	0	1.04
46	POM FUSC	76	14	93.3%	5.07	3.45	13	0	2.12
47	POM PART	11	1	6.7%	0.73	2.84	11	0	0.00
48	POM PARU	0	0	0.0%	0.00	NA	NA	NA	NA
49	PSE MACU	1	1	6.7%	0.07	0.26	1	0	0.00
50	RYP SAPO	0	0	0.0%	0.00	NA	NA	NA	NA
51	SCA CROI	10	5	33.3%	0.67	1.05	3	0	0.75
52	SCA TAEN	2	1	6.7%	0.13	0.52	2	0	0.00
53	SCA VETU	1	1	6.7%	0.07	0.26	1	0	0.00
54	SPA AURO	26	10	66.7%	1.73	1.44	4	0	0.41
55	SPA CHRY	13	3	20.0%	0.87	2.00	7	0	6.15
56	SPA RUBR	19	7	46.7%	1.27	2.19	8	0	5.19
57	SPA VIRI	37	11	73.3%	2.47	1.96	6	0	0.83
58	SPH BARR	2	2	13.3%	0.13	0.35	1	0	0.00
59	SPH PICU	210	1	6.7%	14.00	54.22	210	0	0.00
60	THA BIFA	483	14	93.3%	32.20	53.45	220	0	92.90

NO. SAMPLES = 15
NO. SPECIES = 46
TOT.INDIVIDUALS = 2,037

Appendix A.2. Outside damage area, REGINA grounding, Mona Island, Puerto Rico.

No.	Species	Total Indiv.	Frequency (N=9)	%	Mean Abund.	Stand. Dev.	Range High	Low	Var/Mean Ratio
1	ABU SAXA	4	1	11.1%	0.44	1.33	4	0	0.00
2	ACA BAHI	387	9	100.0%	43.00	41.66	120	5	40.35
3	ACA COER	26	6	66.7%	2.89	3.30	8	0	3.42
4	ADI VEXI	1	1	11.1%	0.11	0.33	1	0	0.00
5	AMB PINO	0	0	0.0%	0.00	NA	NA	NA	NA
6	AUL MACU	0	0	0.0%	0.00	NA	NA	NA	NA
7	BOD RUFU	6	4	44.4%	0.67	0.87	2	0	0.50
8	BOT LUNA	0	0	0.0%	0.00	NA	NA	NA	NA
9	CAN PULL	1	1	11.1%	0.11	0.33	1	0	0.00
10	CAR RUBE	3	2	22.2%	0.33	0.71	2	0	1.50
11	CHA CAPI	0	0	0.0%	0.00	NA	NA	NA	NA
12	CHA STRI	1	1	11.1%	0.11	0.33	1	0	0.00
13	CHR CYAN	0	0	0.0%	0.00	NA	NA	NA	NA
14	CHR MULT	0	0	0.0%	0.00	NA	NA	NA	NA
15	EPI FULV	23	5	55.6%	2.56	3.64	11	0	5.79
16	GNA THOM	0	0	0.0%	0.00	NA	NA	NA	NA
17	GOB EVEL	0	0	0.0%	0.00	NA	NA	NA	NA
18	HAE AURO	0	0	0.0%	0.00	NA	NA	NA	NA
19	HAE CARB	2	2	22.2%	0.22	0.44	1	0	0.00
20	HAE CHRY	0	0	0.0%	0.00	NA	NA	NA	NA
21	HAL BIVI	38	8	88.9%	4.22	3.42	10	0	2.49
22	HAL GARN	5	2	22.2%	0.56	1.13	3	0	0.90
23	HAL MACU	31	6	66.7%	3.44	4.36	14	0	5.74
24	HAL PICT	22	3	33.3%	2.44	3.81	9	0	1.77
25	HAL POEY	29	8	88.9%	3.22	2.11	7	0	1.06
26	HAL RADI	21	9	100.0%	2.33	1.50	6	1	0.96
27	HOL ADSC	1	1	11.1%	0.11	0.33	1	0	0.00
28	HOL RUFU	1	1	11.1%	0.11	0.33	1	0	0.00
29	HOL TRIC	0	0	0.0%	0.00	NA	NA	NA	NA
30	KYP SECT	40	1	11.1%	4.44	13.33	40	0	0.00
31	LAC BICA	0	0	0.0%	0.00	NA	NA	NA	NA
32	LAC POLY	0	0	0.0%	0.00	NA	NA	NA	NA
33	LAC TRIQ	0	0	0.0%	0.00	NA	NA	NA	NA
34	LUT APOD	0	0	0.0%	0.00	NA	NA	NA	NA
35	LUT JOCU	0	0	0.0%	0.00	NA	NA	NA	NA
36	LUT MAHO	0	0	0.0%	0.00	NA	NA	NA	NA
37	MAL AURO	0	0	0.0%	0.00	NA	NA	NA	NA
38	MAL PLUM	0	0	0.0%	0.00	NA	NA	NA	NA

Appendix A. 2. (cont.)

No.	Species	Total Indiv.	Frequency (N=9)	%	Mean Abund.	Stand. Dev.	Range High	Low	Var/Mean Ratio
39	MAL SPE.	2	1	11.1%	0.22	0.67	2	0	0.00
40	MAL TRIA	5	2	22.2%	0.56	1.33	4	0	8.10
41	MEL NIGE	132	8	88.9%	14.67	14.02	48	0	12.95
42	MIC CHRY	20	6	66.7%	2.22	2.39	6	0	2.10
43	MUL MART	11	4	44.4%	1.22	1.64	4	0	1.30
44	MYR JACO	0	0	0.0%	0.00	NA	NA	NA	NA
45	OPH ATLA	110	8	88.9%	12.22	10.74	29	0	8.83
46	POM FUSC	61	8	88.9%	6.78	4.12	13	0	1.77
47	POM PART	1	1	11.1%	0.11	0.33	1	0	0.00
48	POM PARU	0	0	0.0%	0.00	NA	NA	NA	NA
49	PSE MACU	3	2	22.2%	0.33	0.71	2	0	1.50
50	RYP SAPO	0	0	0.0%	0.00	NA	NA	NA	NA
51	SCA CROI	0	0	0.0%	0.00	NA	NA	NA	NA
52	SCA TAEN	0	0	0.0%	0.00	NA	NA	NA	NA
53	SCA VETU	2	2	22.2%	0.22	0.44	1	0	0.00
54	SPA AURO	14	7	77.8%	1.56	1.51	4	0	1.29
55	SPA CHRY	10	5	55.6%	1.11	1.27	3	0	0.90
56	SPA RUBR	9	2	22.2%	1.00	2.65	8	0	24.50
57	SPA VIRI	7	4	44.4%	0.78	1.09	3	0	1.18
58	SPH BARR	0	0	0.0%	0.00	NA	NA	NA	NA
59	SPH PICU	710	3	33.3%	78.89	130.43	300	0	152.54
60	THA BIFA	405	9	100.0%	45.00	51.06	165	3	57.93

NO. SAMPLES = 9

NO. SPECIES = 35

TOT.INDIVIDUALS = 2,144

Appendix A.3. Inshore control area, REGINA grounding, Mona Island, Puerto Rico.

No.	Species	Total Indiv.	Frequency (N=6)	%	Mean Abund.	Stand. Dev.	Range High	Low	Var/Mean Ratio
1	ABU SAXA	3	1	16.7%	0.50	1.22	3	0	0.00
2	ACA BAHI	47	6	100.0%	7.83	7.63	23	2	7.43
3	ACA COER	40	5	83.3%	6.67	5.57	16	0	3.83
4	ADI VEXI	0	0	0.0%	0.00	NA	NA	NA	NA
5	AMB PINO	0	0	0.0%	0.00	NA	NA	NA	NA
6	AUL MACU	0	0	0.0%	0.00	NA	NA	NA	NA
7	BOD RUFU	4	3	50.0%	0.67	0.82	2	0	0.50
8	BOT LUNA	1	1	16.7%	0.17	0.41	1	0	0.00
9	CAN PULL	0	0	0.0%	0.00	NA	NA	NA	NA
10	CAR RUBE	5	3	50.0%	0.83	0.98	2	0	0.40
11	CHA CAPI	0	0	0.0%	0.00	NA	NA	NA	NA
12	CHA STRI	0	0	0.0%	0.00	NA	NA	NA	NA
13	CHR CYAN	0	0	0.0%	0.00	NA	NA	NA	NA
14	CHR MULT	62	2	33.3%	10.33	16.32	36	0	4.84
15	EPI FULV	4	2	33.3%	0.67	1.03	2	0	0.00
16	GNA THOM	0	0	0.0%	0.00	NA	NA	NA	NA
17	GOB EVEL	4	1	16.7%	0.67	1.63	4	0	0.00
18	HAE AURO	15	1	16.7%	2.50	6.12	15	0	0.00
19	HAE CARB	0	0	0.0%	0.00	NA	NA	NA	NA
20	HAE CHRY	0	0	0.0%	0.00	NA	NA	NA	NA
21	HAL BIVI	10	4	66.7%	1.67	1.86	4	0	1.80
22	HAL GARN	5	2	33.3%	0.83	1.60	4	0	5.40
23	HAL MACU	9	4	66.7%	1.50	1.38	3	0	0.61
24	HAL PICT	0	0	0.0%	0.00	NA	NA	NA	NA
25	HAL POEY	2	1	16.7%	0.33	0.82	2	0	0.00
26	HAL RADI	17	5	83.3%	2.83	1.60	4	0	0.28
27	HOL ADSC	0	0	0.0%	0.00	NA	NA	NA	NA
28	HOL RUFU	1	1	16.7%	0.17	0.41	1	0	0.00
29	HOL TRIC	0	0	0.0%	0.00	NA	NA	NA	NA
30	KYP SECT	26	3	50.0%	4.33	8.73	22	0	31.00
31	LAC BICA	0	0	0.0%	0.00	NA	NA	NA	NA
32	LAC POLY	0	0	0.0%	0.00	NA	NA	NA	NA
33	LAC TRIQ	1	1	16.7%	0.17	0.41	1	0	0.00
34	LUT APOD	2	2	33.3%	0.33	0.52	1	0	0.00
35	LUT JOCU	2	2	33.3%	0.33	0.52	1	0	0.00
36	LUT MAHO	0	0	0.0%	0.00	NA	NA	NA	NA
37	MAL AURO	2	1	16.7%	0.33	0.82	2	0	0.00
38	MAL PLUM	0	0	0.0%	0.00	NA	NA	NA	NA

Appendix A. 3. (cont.)

No.	Species	Total Indiv.	Frequency (N=6)	%	Mean Abund.	Stand. Dev.	Range High	Low	Var/Mean Ratio
39	MAL SPE.	0	0	0.0%	0.00	NA	NA	NA	NA
40	MAL TRIA	1	1	16.7%	0.17	0.41	1	0	0.00
41	MEL NIGE	78	6	100.0%	13.00	5.33	20	7	2.18
42	MIC CHRY	47	6	100.0%	7.83	4.26	14	3	2.32
43	MUL MART	0	0	0.0%	0.00	NA	NA	NA	NA
44	MYR JACO	0	0	0.0%	0.00	NA	NA	NA	NA
45	OPH ATLA	110	6	100.0%	18.33	5.79	26	12	1.83
46	POM FUSC	58	6	100.0%	9.67	4.03	16	4	1.68
47	POM PART	0	0	0.0%	0.00	NA	NA	NA	NA
48	POM PARU	0	0	0.0%	0.00	NA	NA	NA	NA
49	PSE MACU	0	0	0.0%	0.00	NA	NA	NA	NA
50	RYP SAPO	0	0	0.0%	0.00	NA	NA	NA	NA
51	SCA CROI	0	0	0.0%	0.00	NA	NA	NA	NA
52	SCA TAEN	0	0	0.0%	0.00	NA	NA	NA	NA
53	SCA VETU	1	1	16.7%	0.17	0.41	1	0	1.00
54	SPA AURO	2	1	16.7%	0.33	0.82	2	0	2.00
55	SPA CHRY	2	1	16.7%	0.33	0.82	2	0	2.00
56	SPA RUBR	28	6	100.0%	4.67	0.82	6	4	0.14
57	SPA VIRI	11	4	66.7%	1.83	1.60	4	0	1.40
58	SPH BARR	0	0	0.0%	0.00	NA	NA	NA	NA
59	SPH PICU	0	0	0.0%	0.00	NA	NA	NA	NA
60	THA BIFA	520	6	100.0%	86.67	106.03	280	7	129.73

NO. SAMPLES = 6
NO. SPECIES = 32
TOT.INDIVIDUALS = 1,120

Appendix A.4. Offshore control area, REGINA grounding, Mona Island, Puerto Rico.

No.	Species	Total Indiv.	Frequency (N=11)	%	Mean Abund.	Stand. Dev.	Range High	Low	Var/Mean Ratio
1	ABU SAXA	39	1	9.1%	3.55	11.76	39	0	0.00
2	ACA BAHI	97	11	100.0%	8.82	5.90	23	3	3.94
3	ACA COER	91	11	100.0%	8.27	10.06	36	1	12.24
4	ADI VEXI	0	0	0.0%	0.00	NA	NA	NA	NA
5	AMB PINO	1	1	9.1%	0.09	0.30	1	0	0.00
6	AUL MACU	0	0	0.0%	0.00	NA	NA	NA	NA
7	BOD RUFU	17	7	63.6%	1.55	2.07	7	0	2.99
8	BOT LUNA	1	1	9.1%	0.09	0.30	1	0	0.00
9	CAN PULL	0	0	0.0%	0.00	NA	NA	NA	NA
10	CAR RUBE	16	7	63.6%	1.45	1.81	6	0	2.23
11	CHA CAPI	4	2	18.2%	0.36	0.81	2	0	0.00
12	CHA STRI	5	4	36.4%	0.45	0.69	2	0	0.55
13	CHR CYAN	2	1	9.1%	0.18	0.60	2	0	0.00
14	CHR MULT	256	9	81.8%	23.27	19.60	60	0	13.51
15	EPI FULV	34	10	90.9%	3.09	1.64	6	0	0.59
16	GNA THOM	0	0	0.0%	0.00	NA	NA	NA	NA
17	GOB EVEL	2	1	9.1%	0.18	0.60	2	0	0.00
18	HAE AURO	0	0	0.0%	0.00	NA	NA	NA	NA
19	HAE CARB	0	0	0.0%	0.00	NA	NA	NA	NA
20	HAE CHRY	0	0	0.0%	0.00	NA	NA	NA	NA
21	HAL BIVI	25	6	54.5%	2.27	2.57	7	0	1.66
22	HAL GARN	54	11	100.0%	4.91	5.28	20	1	5.68
23	HAL MACU	18	9	81.8%	1.64	1.21	4	0	0.61
24	HAL PICT	0	0	0.0%	0.00	NA	NA	NA	NA
25	HAL POEY	1	1	9.1%	0.09	0.30	1	0	0.00
26	HAL RADI	38	10	90.9%	3.45	2.81	9	0	2.11
27	HOL ADSC	1	1	9.1%	0.09	0.30	1	0	0.00
28	HOL RUFU	4	3	27.3%	0.36	0.67	2	0	0.92
29	HOL TRIC	12	6	54.5%	1.09	1.22	3	0	0.73
30	KYP SECT	36	1	9.1%	3.27	10.85	36	0	0.00
31	LAC BICA	0	0	0.0%	0.00	NA	NA	NA	NA
32	LAC POLY	1	1	9.1%	0.09	0.30	1	0	0.00
33	LAC TRIQ	2	2	18.2%	0.18	0.40	1	0	0.00
34	LUT APOD	0	0	0.0%	0.00	NA	NA	NA	NA
35	LUT JOCU	0	0	0.0%	0.00	NA	NA	NA	NA
36	LUT MAHO	0	0	0.0%	0.00	NA	NA	NA	NA
37	MAL AURO	0	0	0.0%	0.00	NA	NA	NA	NA
38	MAL PLUM	2	1	9.1%	0.18	0.60	2	0	0.00

Appendix A. 4. (cont.)

No.	Species	Total Indiv.	Frequency (N=11)	%	Mean Abund.	Stand. Dev.	Range High	Low	Var/Mean Ratio
39	MAL SPE.	0	0	0.0%	0.00	NA	NA	NA	NA
40	MAL TRIA	16	7	63.6%	1.45	1.29	3	0	0.39
41	MEL NIGE	159	11	100.0%	14.45	12.19	37	3	10.29
42	MIC CHRY	89	11	100.0%	8.09	3.08	16	5	1.17
43	MUL MART	0	0	0.0%	0.00	NA	NA	NA	NA
44	MYR JACO	1	1	9.1%	0.09	0.30	1	0	0.00
45	OPH ATLA	99	11	100.0%	9.00	6.12	22	1	4.16
46	POM FUSC	31	6	54.5%	2.82	3.68	11	0	4.46
47	POM PART	272	9	81.8%	24.73	16.32	43	0	5.90
48	POM PARU	1	1	9.1%	0.09	0.30	1	0	0.00
49	PSE MACU	1	1	9.1%	0.09	0.30	1	0	0.00
50	RYP SAPO	1	1	9.1%	0.09	0.30	1	0	0.00
51	SCA CROI	2	1	9.1%	0.18	0.60	2	0	0.00
52	SCA TAEN	6	2	18.2%	0.55	1.21	3	0	0.00
53	SCA VETU	1	1	9.1%	0.09	0.30	1	0	0.00
54	SPA AURO	21	8	72.7%	1.91	2.30	8	0	2.83
55	SPA CHRY	0	0	0.0%	0.00	NA	NA	NA	NA
56	SPA RUBR	9	3	27.3%	0.82	1.60	4	0	3.67
57	SPA VIRI	17	9	81.8%	1.55	1.29	4	0	0.88
58	SPH BARR	2	2	18.2%	0.18	0.40	1	0	0.00
59	SPH PICU	0	0	0.0%	0.00	NA	NA	NA	NA
60	THA BIFA	1,733	11	100.0%	157.55	108.87	350	23	75.24

NO. SAMPLES = 11
NO. SPECIES = 43
TOT.INDIVIDUALS = 3,220

Chapter 2. A limited survey of reef fish abundance and species composition at the proposed Aquarius site, Conch Reef, Florida.

Douglas E. Harper, James A. Bohnsack, and Stephania Bolden

A reef fish survey of Conch Reef was conducted by members of the Reef Resources Team, Miami Laboratory, Southeast Fisheries Center on June 7, 1991. The survey utilized standardized visual sampling methods (Bohnsack and Bannerot, 1986). Fishes observed within 7.5 m of a stationary SCUBA diver were censused at randomly selected locations in the reef area adjacent to the proposed site of the Aquarius Underwater Habitat. Data collected provide fish species presence, abundance, frequency, and average size and size range. This information should be of interest to researchers desiring to conduct studies on reef fishes using the underwater habitat as a base for operations.

Six visual samples were performed by three observers at a mean depth of 53.3 feet (range = 49 to 58 feet). A summary of survey results is presented in Table 1. A total of 1,079 individual fishes representing 53 species (17 families) were recorded during the six samples. The mean number of fish per sample was 179.8 and the mean number of species per sample was 24.8. Five species were observed in all samples. These fishes along with total number observed were: bicolor damselfish, *Pomacentrus partitus* (n = 466); bluehead, *Thalassoma bifasciatum* (n = 160); blue chromis, *Chromis cyaneus* (n = 91); redband parrotfish, *Sparisoma aurofrenatum* (n = 32); and ocean surgeon, *Acanthurus bahianus* (n = 30). In addition to the fishes recorded during the regular 5 minute observational interval, two species; bluelip parrotfish, *Cryptotomus roseus* and tobaccofish, *Serranus tabacarius*; were observed during the enumeration phase of the sampling procedure.

Reef fish populations demonstrate a high degree of variability both temporally and spatially. Although limited in scope, the results of this survey indicate that the reef fish fauna near the proposed site of the Aquarius Underwater Habitat is abundant and complex. Additional studies should be conducted to further quantitatively assess the dynamics of fish populations near this site.

Acknowledgements

We thank Dave Ward, Glen Taylor, and Tom Potts at the Key Largo facility of the National Undersea Research Program for their excellent assistance and support provided during the field work involved in this study. This paper was previously unpublished Miami Laboratory Contribution MIA-90/91-60.

Literature Cited

Bohnsack, J.A. and S.P. Bannerot. 1986. A stationary visual census technique for quantitatively assessing community structure of coral reef fishes. NOAA Technical Report 41, 15 pp.

Table 1. Summary of reef fish visual censusing at Conch Reef on June 7, 1991

	Scientific name	Common name	Total Indiv.	SAMPLE FREQUENCY (N = 6)	%	Mean Abund.	Stand. Dev.	ABUNDANCE RANGE High	Low	FISH LENGTH(cm) Mean	Min.	Max.
1	*Abudefduf saxatilis*	Sergeant major	18	5	83.3%	3.00	2.19	6	0	9.6	8	12
2	*Acanthurus bahianus*	Ocean surgeon	30	6	100.0%	5.00	2.00	8	3	14.0	10	20
3	*Acanthurus chirurgus*	Doctorfish	4	1	16.7%	0.67	1.63	4	0	23.0	20	24
4	*Acanthurus coeruleus*	Blue tang	1	1	16.7%	0.17	0.41	1	0	25.0	25	25
5	*Anisotremus virginicus*	Porkfish	4	3	50.0%	0.67	0.82	2	0	22.5	20	24
6	*Aulostomus maculatus*	Trumpetfish	4	4	66.7%	0.67	0.52	1	0	20.5	15	24
7	*Bodianus rufus*	Spanish hogfish	1	1	16.7%	0.17	0.41	1	0	25.0	25	25
8	*Calamus calamus*	Saucereye porgy	1	1	16.7%	0.17	0.41	1	0	24.0	24	24
9	*Canthigaster rostrata*	Sharpnose puffer	10	4	66.7%	1.67	1.63	4	0	6.1	3	8
10	*Caranx ruber*	Bar jack	2	2	33.3%	0.33	0.52	1	0	32.0	27	37
11	*Chaetodon capistratus*	Foureye butterflyfish	9	3	50.0%	1.50	1.76	4	0	9.7	7	12
12	*Chaetodon ocellatus*	Spotfin butterflyfish	9	3	50.0%	1.50	2.35	6	0	9.7	8	12
13	*Chaetodon sedentarius*	Reef butterflyfish	10	5	83.3%	1.67	1.03	3	0	9.3	8	14
14	*Chaetodon striatus*	Banded butterflyfish	2	1	16.7%	0.33	0.82	2	0	11.0	10	12
15	*Chromis cyaneus*	Blue chromis	91	6	100.0%	15.17	11.74	36	5	7.7	2	12
16	*Chromis scotti*	Purple reeffish	1	1	16.7%	0.17	0.41	1	0	7.0	7	7
17	*Clepticus parrai*	Creole wrasse	5	2	33.3%	0.83	1.33	3	0	13.8	12	15
18	*Coryphopterus glaucofraenum*	Bridled goby	7	2	33.3%	1.17	2.04	5	0	4.4	3	5
19	*Coryphopterus personatus*	Masked goby	14	2	33.3%	2.33	4.08	10	0	2.7	1	3
20	*Epinephelus cruentatus*	Graysby	9	5	83.3%	1.50	1.22	3	0	20.2	15	27
21	*Epinephelus guttatus*	Red hind	1	1	16.7%	0.17	0.41	1	0	20.0	20	20
22	*Gnatholepis thompsoni*	Goldspot goby	1	1	16.7%	0.17	0.41	1	0	4.0	4	4
23	*Haemulon flavolineatum*	French grunt	13	4	66.7%	2.17	2.14	5	0	17.1	15	19
24	*Haemulon plumieri*	White grunt	5	5	83.3%	0.83	0.41	1	0	19.2	16	22
25	*Haemulon sciurus*	Bluestriped grunt	2	2	33.3%	0.33	0.52	1	0	21.5	17	26
26	*Haemulon striatum*	Striped grunt	7	1	16.7%	1.17	2.86	7	0	16.0	15	17
27	*Halichoeres bivittatus*	Slippery dick	4	1	16.7%	0.67	1.63	4	0	8.0	6	10
28	*Halichoeres garnoti*	Yellowhead wrasse	33	5	83.3%	5.50	3.51	9	0	6.6	4	13
29	*Halichoeres maculipinna*	Clown wrasse	3	2	33.3%	0.50	0.84	2	0	6.0	5	8
30	*Holocentrus ascensionis*	Squirrelfish	7	3	50.0%	1.17	1.94	5	0	19.0	15	30
31	*Holacanthus bermudensis*	Blue angelfish	1	1	16.7%	0.17	0.41	1	0	18.0	18	18
32	*Holacanthus ciliaris*	Queen anglefish	4	2	33.3%	0.67	1.21	3	0	20.0	15	35
33	*Holocentrus rufus*	Longspine squirrelfisl	3	1	16.7%	0.50	1.22	3	0	18.0	18	19
34	*Holacanthus tricolor*	Rock beauty	8	4	66.7%	1.33	1.21	3	0	16.0	12	26
35	*Hypoplectrus gemma #*	Blue hamlet	3	2	33.3%	0.50	0.84	2	0	10.7	9	13
36	*Hypoplectrus unicolor*	Butter hamlet	7	4	66.7%	1.17	1.17	3	0	8.9	7	11
37	*Lachnolaimus maximus*	Hogfish	2	2	33.3%	0.33	0.52	1	0	22.5	20	25
38	*Lactophrys triqueter*	Smooth trunkfish	2	2	33.3%	0.33	0.52	1	0	14.5	14	15
39	*Ocyurus chrysurus*	Yellowtail snapper	5	3	50.0%	0.83	0.98	2	0	22.0	15	30
40	*Pomacentrus fuscus*	Dusky damselfish	12	1	16.7%	2.00	4.90	12	0	11.0	9	12
41	*Pomacentrus partitus*	Bicolor damselfish	466	6	100.0%	77.67	27.90	120	53	5.2	1	9
42	*Pomacanthus paru*	French angelfish	1	1	16.7%	0.17	0.41	1	0	30.0	30	30
43	*Pomacentrus planifrons*	Three spot damselfisl	7	3	50.0%	1.17	1.33	3	0	8.6	8	10
44	*Pomacentrus variabilis*	Cocoa damselfish	6	1	16.7%	1.00	2.45	6	0	7.0	4	9
45	*Pseudupeneus maculatus*	Spotted goatfish	3	2	33.3%	0.50	0.84	2	0	17.7	17	19
46	*Scarus croicensis*	Striped parrotfish	27	4	66.7%	4.50	5.21	12	0	6.7	4	12
47	*Scarus taeniopterus*	Princess parrotfish	10	5	83.3%	1.67	1.21	3	0	19.0	12	31
48	*Scarus vetula*	Queen parrotfish	3	3	50.0%	0.50	0.55	1	0	25.0	16	30
49	*Serranus tigrinus*	Harlequin bass	4	3	50.0%	0.67	0.82	2	0	6.3	4	7
50	*Sparisoma aurofrenatum*	Redband parrotfish	32	6	100.0%	5.33	3.39	11	1	17.3	6	38
51	*Sparisoma rubripinne*	Yellowtail parrotfish	1	1	16.7%	0.17	0.41	1	0	26.0	26	26
52	*Sparisoma viride*	Stoplight parrotfish	4	3	50.0%	0.67	0.82	2	0	16.3	9	26
53	*Thalassoma bifasciatum*	Bluehead	160	6	100.0%	26.67	16.42	48	7	5.4	2	12

NUMBER OF SAMPLES -	6	SAMPLE AREA -	Conch Reef
NUMBER OF SPECIES -	53	NO. OBSERVERS -	3
TOTAL INDIVIDUALS -	1,079	SAMPLING CONDITIONS	good :U/W Visibiity 40+ feet

Chapter 3. Protected and unprotected reefs in John Pennekamp Coral Reef State Park, Florida: a comparative analysis 1992-1995.

David B. McClellan, James A. Bohnsack, Douglas E. Harper, and Stephania K. Bolden

Introduction

Coral reefs are one of the Earth's most complex ecosystems and an important resource for commercial, recreational, scientific, and educational use. In recent years these ecosystems have received increased exploitation and usage. Fishing impacts reef structure and fauna. Many reef fish stocks are fully or over exploited (Plan Development Team, 1990). The effects of fishing on reef fish populations can only be effectively evaluated by comparing areas with no fishing with fished areas. For example, rapid biomass build-up on the Caribbean Saba reef has recently been quantified following the establishment of a marine sanctuary (Roberts, 1995). Increases in size and number of fishery species in protected marine areas have been identified (reviews by Roberts and Polunin, 1991; Dugan and Davis, 1993) in many studies.

Marine reserves, areas with no consumptive usage, have been proposed as a viable management measure to protect reef fish stocks and increase net yield (Plan Development Team, 1990). The newly mandated Florida Keys National Marine Sanctuary (FKNMS) is a holistic approach to managing fisheries - one which protects the ecosystem rather than an individual species. In order to wisely manage coral reef resources and evaluate marine reserves, there is need for monitoring and comparing fish populations in areas with and without fishing activity.

The Reef Resources Team of the Southeast Fisheries Science Center, National Marine Fisheries Service, NOAA (SEFSC/NMFS/NOAA) has developed resource survey techniques to provide baseline data on reef fish abundance and composition for long-term resource monitoring. The method uses standard, non-destructive, fishery independent, visual sampling methodology (Bohnsack and Bannerot, 1986). The method has been used by the National Marine Fisheries Service, the National Park Service, and agencies of various governments. The method also has been used extensively on reefs in southeastern Florida, including Biscayne National Park, Key Largo National Marine Sanctuary, Looe Key National Marine Sanctuary, and the Dry Tortugas.

This status report is the fourth of a series which have been submitted yearly to the John Pennekamp Coral Reef State Park (JPCRSP) complying with the statement of work in the Memorandum of Understanding between the Florida Department of Environmental Protection, Division of Recreation and Parks (FDEP) and SEFSC/NMFS/NOAA.

Purpose

The ultimate purpose of this research is to evaluate the effects of fisheries on coral reef fish populations. The specific purpose of this research is to evaluate the effect of prohibiting fishing in small areas by monitoring the reef fish population at reefs "open" and "closed" to fishing. Baseline data for subsequent fluctuations in fish composition are being collected and future monitoring may determine if closing small areas affect fish size structure and abundance. This report summarizes fish populations, size structure and abundance at reefs in JPCRSP from 15 May 1992 to 27 June 1995.

Methods

This study involved monitoring of reef fishes on six small patch reefs within JPCRSP. The reef environment in JPCRSP has been described by Jaap (1984) and the study sites by Bohnsack and Harper (1992), McClellan et al. (1993), and Bolden (1994). Two patch reefs were closed to public access (protected) in August 1991 while nearby patch reefs were open to public access for fishing and diving (unprotected). Study sites included protected and unprotected patch reefs at Basin Hill Shoals (BC = closed, BO = open, and BN = new open) and Mosquito Bank (MC = closed, MO = open, and MN = new open) (Fig. 1).

Initially (May 1992, November 1992, and May 1993) the survey assessed two patch reefs per area: one "open" to fishing and one "closed." An additional "new" site which was open to fishing was added in May 1994 to equate for large areal differences between the protected and unprotected reefs. Areal coverage of censused reefs was calculated by a planimeter on aerial maps and is presented with mean depth in Table 1.

Annual sampling at each reef site was conducted during the Spring (April-June) between May 15, 1992 and June 27, 1995. A Fall survey was conducted during October-November 1992. An average 12 samples per reef (range: 11-17) were assessed (Table 2). Sampling used standardized stationary diver, non-destructive, fishery independent, visual sampling methods as described in Bohnsack and Bannerot (1986).

Two-sample t-tests were utilized to examine both the mean number of species per sample and mean abundance in 1992 and 1993. Comparisons were made between adjacent patch reefs only. Mean abundances were used to detect potential differences between study sites in 1994 and 1995. Both overall similarity and paired inter-reef differences were sought. Analysis of variance first examined mean abundance at all reefs. Second, inter-reef differences were sought by Fisher's least-significant-differences test. This comparison examines type I comparison wise error rates (not experimental).

An index of relative abundance was calculated for each species in order to provide a standard for comparison of species composition between study patch reefs (Greenfield and Johnson, 1989). This index gave equal weight to abundance and frequency-of-occurrence. The index of relative dominance (IRD), of a species, i, was calculated by:

$$IRD_i = (RA_i * RF_i)$$

where RA is relative abundance and RF is relative frequency for species i. The relative abundance (RA) of species i is the total number of individuals of species i expressed as a percentage of the sum of the total individuals censused. The relative frequency (RF) is the number of times a species was observed in a census sample expressed as a percentage of the sum of the total number of samples.

Numerical classification technique (cluster analysis) were used to compare similarity based upon species assemblages (mean species abundance) for study reefs and sampling periods. Similarity relationships were depicted using dendrograms generated by an interactive computer program which analyzes community data from ecological studies (Wolfe and Chester, 1991). Similarity was measured by the Bray-Curtis index using a flexible sorting strategy with B = -0.25 (Clifford and Stephenson, 1975). Additionally, only those species with overall IRD values greater than 0.5 were included in these analyses because rare species provide little information on the basic patterns of community structure (Ludwig and Reynolds, 1988; Sedberry and von Dolah, 1984).

Biomass estimates were calculated for each species using length-weight relationships reported by Bohnsack and Harper (1988) and unpublished data (SEFSC/NMFS/NOAA, Miami Lab). Bohnsack et al. (1994) reported that in 1992, reef fishes comprised 28% of commercial landings in the Florida Keys of which 56% were dominated by snappers, groupers, grunts and hogfish. In addition, porgies comprised an important component of recreational landings. Economically important families and groups were then examined for shifts in biomass and individual numbers as a result of fishing pressure and to identify potential differences between areas opened and closed to fishing (Figs. 3 and 4).

Results and Discussion

A total of 24,338 fishes representing 30 families, 50 genera and 109 species were observed in 298 visual censuses conducted at the six study patch reefs within JPCRSP from May 15, 1992 to June 27, 1995 (Table 3). Seven species (including one unidentified species) accounted for nearly 70% total number of fishes observed. These fishes along with percentage of total individuals censused were: white grunt, *Haemulon plumeri*, 16.9%; tomtate, *H. aurolineatum*, 14.5%; striped parrotfish, *Scarus croicensis*, 11.9%; unidentified specie, 8.8%; gray snapper, *Lutjanus griseus*, 6.4%; bluestriped grunt, *H. sciurus*, 5.6%; and yellowtail snapper, *Ocyurus chrysurus*, 5.2%. Five species accounted for nearly 60.0% of total biomass: great barracuda, *Sphyraena barracuda*, (432.5kg, 24.5%) ; gray snapper, (196.8kg, 11.2%); yellow jack, *Caranx bartholomaei*, (161.9kgf 9.2%) ; gray angelfish, *Pomacanthus arcuatus* (161.6kg, 9.2%) and white grunt, (102.0kg, 5.8%).

JPCRSP is located in close proximity to Hawk Channel which is an area of high mixing caused by wind and current, coupled with significant boat traffic. Hawk Channel probably affects water area clarity within sampling sites. Sample depths ranged from 1.2 - 3.5m with a mean of 2.3m (Table 1). Visibility ranged from 4 - 8.5m during sampling days which may have affected the number of fishes assessed.

Total abundance, mean abundance/standard deviation per sample, frequency-of-occurrence, percent frequency-of-occurrence, biomass, and mean, minimum, and maximum sizes were calculated for each species by individual study reefs (Tables 4 - 9). The total number of species for pooled samples varied by reef, ranging from 51 (BN) to 73 (BC) (Table 2). Two species, white grunt and tomtate, consistently ranked first and second by mean abundance at four of the six study reefs and no species was observed in all samples at any individual reef.

Mean number of species per sample was highest at BO (15.6, Spring 94) and lowest at MN (8.8, Spring 95) per sample for any sampling unit (site and sample) during the study (Fig. 2 and Table 2). Significant ($P>0.05$) differences in number of species per sample were identified by ANOVA during 1992 with MO greater than MC and BO greater than BC in 1993. Overall the species richness per count seemed to remain constant at Basin Hill (open > closed) with a slight decrease in 1995. At Mosquito Bank there was an increase between 1992 and 1994 (open > closed) with a decrease also in 1995.

Mean fish abundance per sampling unit (site and season) was highest for BC (246.1, Spring95) and lowest for MN (22.3 Spring 95) (Table 2 and Fig. 2). T-test comparison of mean abundances showed significant ($P>0.05$) differences per sample during 1992 with BC over BO. 1993 data revealed MO supported significantly greater mean abundances than nearby MC. ANOVA showed no reefs were significantly different from one another during 1994 but both "new open" study reefs were significantly different ($P>0.05$) from the other sites (open and closed) in 1995; BN had significantly greater mean abundance and MN had significantly less. The new open to fishing reefs was added to compensate for the areal differences between the closed and open fishing sites. One would expect them to have similar effects relative to mean abundance, but obviously other factors are influencing mean fish abundance. R^2 values accounted for less than 1% of mean abundance variability in these analyses (1994 $R^2 = 0.005$; 1995 $R^2 = 0.004$).

Fishes were combined by family (snappers, Lutjanidae; groupers, Serranidae; grunts and porgies, Haemulidae and Sparidae; surgeonfish, Acanthuridae; hogfish, Labridae; and parrotfish, Scaridae) to assess biomass changes in number/sample and biomass/sample changes per year and reef (Figs. 2 and 3). Commercially and recreationally important groups (snappers, groupers, hogfish, jacks (Carangidae), grunts and porgies, permit, *Trachinotus falcatus*, and barracuda) and herbivores (surgeonfish and parrotfish) were also combined to analyze any differences (Figs. 2 and 3). Roberts (1995) showed significant increases in fish biomass per count at the family and group level after the

Saba Bay (Caribbean) closure.

Basin Hill showed a significant increase in total biomass per sample from 1993 - 1995 for the closed site and consistently ranked higher than the open or new site except for 1993 (Fig. 2). This marked increase was also apparent in the combined commercial and the combined herbivore species groups (Fig. 2). At the family level, the snappers showed the most obvious increase. Parrotfishes had a consistently higher biomass at closed reefs but the means did not increase.

Total biomass per sample was greater at closed reefs except for 1994 at Mosquito Bank but did not show a marked increase in total biomass over the four years (Fig. 2). The commercial group showed a great increase from 1992 - 1993 at the closed site, the open sites greater in 1994 - 1995 (Fig. 3). Snappers increased dramatically from 1992-1994 at the open sites and were consistently greater than the closed sites which only differed slightly over the time period (Fig. 3).

Paired reef comparisons by year (Fisher's least-significant-differences test) revealed significant differences ($P>0.05$) in abundance between specific reefs. BN was significantly different from MO in both 1994 and 1995. In 1994, MC was significantly different from both BN and BO. 1995 censuses also revealed that MN was statistically different from both BC and BN; BN also separated from BO.

The striped parrotfish and white grunt consistently ranked among the top four IRD fishes at all Mosquito Bank study patch reefs, and at ten of twelve Basin Hill study patch reefs (Table 10). Many of the commercially and recreationally valuable foodfishes - as managed by the South Atlantic Fishery Management Council - were at some period or site ranked among the top 10 IRD species. These important fishes include: white grunt, tomtate, gray snapper, yellowtail snapper, bluestriped grunt, French grunt (*H. flavolineatum*), cottonwick (*H. melanurum*), bar jack (*Caranx ruber*), lane snapper (*Lutjanus synagris*), hogfish (*Lachnolaimus maximus*), and yellow jack (*Caranx bartholomaei*).

Bray-Curtis similarity cluster analysis showed a separation between two groups of study reefs when pooled mean abundances for 48 fishes with IRD scores greater than 0.5 were analyzed (Fig. 5). Mosquito Bank open clustered with the three Basin Hill sites (Group A), while Mosquito Bank closed and new clustered separately (Group B). When sampling efforts were further partitioned into units by season and study reef, again two group complexes could be identified (Fig. 6). Group complex A was composed of primarily Basin Hill sampling units, with two of the three 1992 Mosquito Bank sampling units (MC92s and MC92F), and represented the majority of Basin Hill sampling efforts (10 of 12, 83%). Group complex B was composed only of Mosquito Bank sampling units. This similarity analysis suggests that study reefs, and not season or open or closed to fishing/diving, plays a major role in influencing fish community structure, although the relative contribution of each factor cannot be determined based on sampling conducted to date. A longer time series of data is needed to test the persistence of these patterns impacting fish community structure relationships. Future monitoring will determine if closing small areas affect fish abundance patterns by testing the hypothesis that changes observed at closed reefs are no different than control reefs.

Summary

Reef fish were assessed at six patch reefs in 298 censuses at John Pennekamp Coral Reef State Park for the time period of May 15, 1992 to June 27, 1995. The rich ichthyofauna is comprised of 30 families, 50 genera, and 109 species of 24,338 observed fishes. It is premature to discuss community patterns. Based on these data, the mean number of species appears to be correlated with the mean number of individuals observed. Within this area, north (Basin Hill) - south (Mosquito

Bank) geographic differences, reef structure (size and openness), average visibility and usage patterns (Mosquito Bank has higher fishing/diving pressure) may impact on fish assemblages. Clearly, Basin Hill had greater mean number of individuals, mean number of species, and mean biomass than Mosquito Bank. Year class differences relative to environmental factors such as Florida Bay may have also affected the study.

Acknowledgements

We would like to thank Guy Davenport, Anne-Marie Eklund, Jack Javech, Ltjg George Konoval, and Lt Scott Sandorf for their assistance in this study. We also thank Anne Deaton, Jim Duquesnel, and Renate Skinner for their logistical help and support during sampling efforts. This paper was previously unpublished Miami Laboratory Contribution MIA-95/96-20.

Literature Cited

Bohnsack, J.A. and S.P. Bannerot. 1986. A stationary visual census technique for quantitatively assessing community structure of coral reef fishes. NOAA Technical Report NMFS 41.

Bohnsack, J.A. and D.E. Harper. 1988. Length-weight relationships of selected marine reef fishes from the southeastern United States and the Caribbean. NOAA Technical Memorandum 215. NOAA, NMFS, SEFSC, Miami, Florida. 31pp.

Bohnsack, J.A. and D.E. Harper. 1992. Quantitative visual assessment of fish community structure at protected and unprotected reefs in Pennekamp State Park, Florida: initial assessment. Miami Laboratory Contribution MIA-91/92-64. 23 p.

Bohnsack, J.A., D.E. Harper, and D.B. McClellan. 1994. Fisheries trends from Monroe county, Florida. Bull. Mar. Sci. 54 (3) : 982-1018.

Bolden, S. K. 1994. Quantitative visual assessment of fish community structure at protected and unprotected reefs in John Pennekamp Coral Reef State Park, Florida: Status report for period ending May 31, 1994. NOAA, NMFS, SEFSC, Miami Laboratory Contribution MIA-93/94-56. 17 p.

Clifford, H.T. and J.T. Stephenson. 1975. An introduction to numerical classification. Academic Press. New York, 229 p. Dugan, J.E. and G.E. Davis. 1993. Applications of marine refugia to coastal fisheries management. Can. Jour. Fish. Aquat. Sci. 50:2029-2042.

Greenfield, D.W. and R.K. Johnson. 1989. Community structure of Western Caribbean Blennioid fishes. Copeia, 1990(2):433- 448.

Jaap, W.C. 1984. The ecology of the south Florida coral reefs: A community profile. U.S. Department of the Interior, Fish and Wildlife Service FWS/OBS-82/08. 138 p. Ludwig, J.A. and J.F. Reynolds. 1988. Statistical Ecology: A Primer on Methods and Computing. John Wiley & Sons. New York, N.Y. 337 p.

McClellan, D.B., D.E. Harper, and J.A. Bohnsack. 1993. Quantitative visual assessment of fish community structure at protected and unprotected reefs in John Pennekamp Coral Reef State Park, Florida: Report for the assessment period May 1992 - May 1993. NOAA, NMFS, SEFSC, Miami Laboratory Contribution MIA-92/93-67. 24 p.

Plan Development Team. 1990. The potential of marine fishery reserves for reef fish management in the U.S. southern Atlantic. Snapper-Grouper Plan Development Team Report for the South Atlantic Fishery Management Council. NOAA Technical Memorandum NMFS-SEFC-261. 45 p.

Roberts, C.M. 1995. Rapid build-up of fish biomass in a Caribbean Marine reserve. Conserv. Bio. 9(4):815-824. Roberts, C.M. and N.V.C. Polunin. 1991. Are Marine reserves effective in management of reef fisheries? Reviews in Fish Biology and Fisheries 1:65-91.

Sedberry, G.R. and R.F. von Dolah. 1984. Demersal fish assemblages associated with hard bottom habitat in the south Atlantic Bight of the U.S.A. Environ. Biol. of Fishes 11(4):241-258. Wolfe, N.A. and A. J. Chester. 1991. Simclust: a cluster analysis program for ecological data. American Statistician 45(2):158.

Table 1. Area and mean depth (meters) of censused patch reef in Basin Hill (BH) and Mosquito Bank (MB), John Pennekamp Coral Reef State Park, Florida. Reefs are characterized by open (O) or closed (C) to fishing, with numbers designating historic (1) or recent reef addition (2) to survey.

REEF	HECTARES	X DEPTH
BH01	0.125	2.26
BHC	0.449	2.27
BHO2	0.267	2.16
MBO1	0.757	2.55
MBC	0.169	2.52
MB02	0.206	2.79

Table 2a. Comparison of species richness for open, new open, and closed study patch reefs in John Pennekamp Coral Reef State Park, Florida, May 15, 1992 – June 27, 1995.

Season	Patch Reef	Cumulative Number of Species	Number of Samples	Mean # of Species per sample	Std. Dev.	Std. Error	Two-sample t-test t-statistic	df	p
Spring 92	Basin Hill Closed	47	17	14.23	4.52	1.10			
	Basin Hill Open	41	16	12.94	2.97	0.74	0.96	31.00	ns
	Mosquito Bank Closed	39	13	9.77	2.35	0.65			
	Mosquito Bank Open	38	12	13.75	3.60	1.04	-3.25	18.70	p<.01
Fall 92									
	Basin Hill Closed	43	12	13.17	2.69	0.78			
	Basin Hill Open	38	12	14.67	2.39	0.69	-1.44	22.00	ns
	Mosquito Bank Closed	40	11	10.82	1.72	0.52			
	Mosquito Bank Open	42	12	12.17	1.95	0.56	1.75	21.00	ns
Spring 93	Basin Hill Closed	40	12	11.75	2.38	0.69			
	Basin Hill Open	41	12	14.92	2.02	0.58	-3.51	22.00	p<.01
	Mosquito Bank Closed	42	11	13.09	3.33	1.00			
	Mosquito Bank Open	40	12	14.00	1.71	0.49	0.81	14.60	ns
Spring 94	Basin Hill Closed	43	12	13.33	3.45	0.99			
	Basin Hill Open	40	12	15.58	2.57	0.74			
	Basin Hill New	37	12	14.08	3.55	1.03			
	Mosquito Bank Closed	47	12	13.33	3.45	0.99			
	Mosquito Bank Open	42	12	12.92	2.02	0.58			
	Mosquito Bank New	45	12	14.00	3.91	1.13			
Spring 95	Basin Hill Closed	48	12	11.50	3.71	1.07			
	Basin Hill Open	41	12	12.08	3.48	1.00			
	Basin Hill New	46	12	14.75	2.63	0.76			
	Mosquito Bank Closed	37	12	10.50	3.21	0.93			
	Mosquito Bank Open	38	14	9.21	3.04	0.81			
	Mosquito Bank New	38	12	8.75	2.60	0.75			
Combined (ALL POOLED)	Basin Hill Closed	73	65	12.91	3.59	0.45			
	Basin Hill Open	63	64	13.97	2.97	0.37			
	Basin Hill New	51	24	14.42	3.08	0.63			
	Mosquito Bank Closed	70	59	11.46	3.15	0.41			
	Mosquito Bank Open	69	62	10.69	5.52	0.70			
	Mosquito Bank New	56	24	11.38	4.21	0.86			

Table 2b. Comparison of fish abundance for open, new open, and closed study patch reefs in John Pennekamp Coral Reef State Park, Florida, May 15, 1992 – June 27, 1995.

Season	Patch Reef	Total Number of Individuals	Number of Samples	Mean Abundance per sample	Std. Dev.	Std. Error	Two-sample t-test: t-statistic	df	p
Spring 92	Basin Hill Closed	1905	17	112.06	66.43	16.11			
	Basin Hill Open	1171	16	73.19	28.32	7.08	2.21	21.90	p<.05
	Mosquito Bank Closed	935	13	71.92	127.20	35.28			
	Mosquito Bank Open	1404	12	117.00	152.10	43.90	0.81	23.00	ns
Fall 92	Basin Hill Closed	768	12	64.00	17.82	5.14			
	Basin Hill Open	1046	12	87.17	36.31	10.48	-1.98	16.00	ns
	Mosquito Bank Closed	599	11	54.45	27.39	8.26			
	Mosquito Bank Open	978	12	81.50	44.60	12.87	1.73	21.00	ns
Spring 93	Basin Hill Closed	913	12	67.75	15.44	4.46			
	Basin Hill Open	1076	12	89.67	35.95	10.38	-1.94	14.90	ns
	Mosquito Bank Closed	526	11	47.82	22.70	6.84			
	Mosquito Bank Open	1236	12	103.00	40.25	11.62	4.09	17.60	p<.01
Spring 94	Basin Hill Closed	907	12	75.58	43.07	12.43			
	Basin Hill Open	1158	12	96.50	55.18	15.93			
	Basin Hill New	1197	12	99.75	53.37	15.41			
	Mosquito Bank Closed	795	12	66.25	25.64	7.40			
	Mosquito Bank Open	895	12	74.08	20.33	5.87			
	Mosquito Bank New	1150	12	95.83	58.70	16.95			
Spring 95	Basin Hill Closed	2953	12	246.08	574.35	165.80			
	Basin Hill Open	526	12	43.83	14.06	4.06			
	Basin Hill New	1029	12	85.75	39.41	11.38			
	Mosquito Bank Closed	578	12	48.17	18.77	5.42			
	Mosquito Bank Open	425	14	30.36	14.33	3.83			
	Mosquito Bank New	268	12	22.33	10.52	3.04			
Combined (ALL POOLED)	Basin Hill Closed	7346	65	113.02	250.26	31.05			
	Basin Hill Open	4213	64	77.77	39.35	4.92			
	Basin Hill New	2226	24	92.75	46.43	9.48			
			59	58.19	62.10	8.09			
	Mosquito Bank Closed	3433	62	74.74	80.60	10.24			
	Mosquito Bank Open	4938	24	69.08	55.77	11.38			
	Mosquito Bank New	1418							

Table 2c. Comparison of biomass for open, new open, and closed study patch reefs in John Pennekamp Coral Reef State Park, Florida, May 15, 1992 – June 27, 1995.

Season	Patch Reef	Total Biomass (g)	Number of Samples	Mean Biomass per sample	Std. Dev.	Std. Error	Two-sample t-test t-statistic	df	p
Spring 92	Basin Hill Closed	286467.3	17	16851.02	28222.30	6844.90			
	Basin Hill Open	59538.8	16	3721.18	2792.90	677.40			
	Mosquito Bank Closed	33798.8	13	2599.91	3219.20	892.90			
	Mosquito Bank Open	26604.1	12	2217.01	2423.20	140.60			
Fall 92	Basin Hill Closed	94349	12	7862.42	6551.30	1588.90			
	Basin Hill Open	28999	12	2416.58	1614.40	391.60			
	Mosquito Bank Closed	75583	11	6871.18	10248.00	3089.90			
	Mosquito Bank Open	29504.2	12	2458.68	1415.20	150.60			
Spring 93	Basin Hill Closed	65175.7	12	5431.31	3836.00	930.40			
	Basin Hill Open	85764	12	7147.00	8316.40	2017.00			
	Mosquito Bank Closed	69602.3	11	6327.48	5797.60	1748.00			
	Mosquito Bank Open	63156.2	12	5263.02	2866.10	827.40			
Spring 94	Basin Hill Closed	106136.7	12	8844.73	6758.80	1639.20			
	Basin Hill Open	39551.7	12	3295.98	2170.60	526.50			
	Basin Hill New	98880.6	12	8240.05	5868.60	1423.30			
	Mosquito Bank Closed	25206.8	12	2100.57	1579.50	456.00			
	Mosquito Bank Open	72354.4	12	6029.53	6136.00	1771.30			
	Mosquito Bank New	109965.6	12	9163.80	7794.70	2250.10			
Spring 95	Basin Hill Closed	239945.6	12	19995.47	23315.70	5654.90			
	Basin Hill Open	52219.5	12	4351.63	4612.60	1118.70			
	Basin Hill New	65123.2	12	5426.93	4017.70	974.40			
	Mosquito Bank Closed	44640.4	12	3720.03	4287.4	1237.70			
	Mosquito Bank Open	16704.7	14	1193.19	933.80	249.60			
	Mosquito Bank New	57898.6	12	4824.88	4286.50	1237.40			
Combined (ALL POOLED)	Basin Hill Closed	792074.2	65	12185.76	18937.70	4593.10			
	Basin Hill Open	266073	64	4157.39	4766.30	1156.00			
	Basin Hill New	164003.9	24	6833.50	5222.00	1266.50			
	Mosquito Bank Closed	248831.4	59	4217.48	6004.80	781.80			
	Mosquito Bank Open	208323.5	62	3360.06	3761.50	477.70			
	Mosquito Bank New	167864.2	24	6994.34	6653.7	1658.2			

Table 3. Summary of all reef fish censused at John Pennekamp Coral Reef State Park, Florida, May 15, 1992 – June 27, 1995.

		NUMBER			Sample N=298 OCCURENCE	Number of species = 109	LENGTH (cm)			BIOMASS (gms)
SPECIES	COMMON NAME	Total Abund.	Mean Abund.	Stand. Dev.	Freq.	%	Mean	Min	Max	Total
Abudefduf saxatilis	Sergeant major	684	2.30	8.05	84	28.2%	6.0	1	15	6,714.7
Acanthurus bahianus	Ocean surgeon	100	0.34	0.78	63	21.1%	7.5	2	30	2,693.3
Acanthurus chirurgus	Doctorfish	102	0.34	0.95	57	19.1%	10.0	3	30	4,938.9
Acanthurus coeruleus	Blue tang	249	0.84	1.52	138	46.3%	13.4	2	35	31,672.5
Aluterus schoepfi	Orange filefish	2	0.01	0.12	1	0.3%	34.0	34	34	722.0
Aluterus scriptus	Scrawled filefish	3	0.01	0.10	3	1.0%	42.7	23	60	2,443.8
Anisotremus virginicus	Porkfish	256	0.86	1.90	114	38.3%	6.6	1	30	6,756.6
Archosargus rhomboidalis	Sea bream	47	0.16	1.02	12	4.0%	17.7	10	30	8,066.7
Aulostomus maculatus	Trumpetfish	4	0.01	0.12	4	1.3%	31.5	30	33	312.1
Bodianus pulchellus	Spotfin hogfish	1	0.00	0.06	1	0.3%	8.0	8	8	8.3
Bodianus rufus	Spanish hogfish	1	0.00	0.06	1	0.3%	3.0	3	3	0.4
Calamus calamus	Saucereye porgy	25	0.08	0.31	22	7.4%	19.6	6	36	5,679.8
Canthigaster rostrata	Sharpnose puffer	5	0.02	0.13	5	1.7%	5.2	4	6	13.8
Caranx bartholomaei	Yellow jack	91	0.31	2.59	9	3.0%	41.7	10	65	161,902.5
Caranx crysos	Blue runner	2	0.01	0.12	1	0.3%	20.0	20	20	331.8
Caranx ruber	Bar jack	722	2.42	16.21	49	16.4%	15.2	3	50	79,392.9
Chaetodon capistratus	Foureye butterflyfish	92	0.31	0.61	74	24.8%	5.7	3	10	641.0
Chaetodiperus faber	Atlantic spadefish	28	0.09	0.58	13	4.4%	31.3	22	42	28,387.1
Chaetodon ocellatus	Spotfin butterflyfish	18	0.06	0.34	10	3.4%	9.3	6	14	495.8
Chaetodon sedentarius	Reef butterflyfish	2	0.01	0.08	2	0.7%	5.0	4	6	8.0
Chaetodon striatus	Banded butterflyfish	2	0.01	0.12	1	0.3%	12.0	12	12	108.3
Coryphopterus dicrus	Colon goby	17	0.06	0.34	11	3.7%	4.0	2	6	15.7
Coryphopterus glaucofraenum	Bridled goby	147	0.49	1.30	58	19.5%	3.6	1	6	102.2
Coryphopterus personatus	Masked goby	16	0.05	0.37	7	2.3%	2.7	2	3	4.3
Coryphopterus species	Unknown goby	6	0.02	0.22	3	1.0%	5.3	5	7	12.0
Cryptotomus roseus	Bluelip parrotfish	8	0.03	0.37	2	0.7%	4.8	4	5	58.9
Diodon holocanthus	Balloonfish	5	0.02	0.13	5	1.7%	15.0	14	17	532.1
Diodon hystrix	Porcupinefish	3	0.01	0.13	2	0.7%	20.0	10	25	1,721.0
Diplodus holbrooki	Spottail pinfish	1	0.00	0.06	1	0.3%	16.0	16	16	85.0
Echeneis naucrates	Sharksucker	1	0.00	0.06	1	0.3%	20.0	20	20	71.1
Epinephelus adscensionis	Rock hind	1	0.00	0.06	1	0.3%	20.0	20	20	124.1
Epinephelus cruentatus	Graysby	2	0.01	0.08	2	0.7%	13.0	11	15	66.8
Epinephelus morio	Red grouper	16	0.05	0.28	13	4.4%	28.3	16	50	7,230.9
Epinephelus striatus	Nassau grouper	1	0.00	0.06	1	0.3%	38.0	38	38	820.8
Equetus punctatus	Spotted drum	1	0.00	0.06	1	0.3%	6.0	6	6	2.7
Gerres cinereus	Yellowfin mojarra	42	0.14	0.92	14	4.7%	18.9	10	47	9,461.2
Ginglymostoma cirratum	Nurse shark	1	0.00	0.06	1	0.3%	15.0	15	51	915.2
Gnatholepis thompsoni	Goldspot goby	5	0.02	0.21	2	0.7%	3.6	2	5	3.1
Gobiosoma oceanops	Neon goby	81	0.27	0.81	43	14.4%	3.0	1	5	23.0
Goby-like fish	Goby-like fish	1	0.00	0.06	1	0.3%	4.0	4	4	0.6
Gymnothorax funebris	Green moray	1	0.00	0.06	1	0.3%	8.0	8	8	1.6
Gymnothorax moringa	Spotted moray	2	0.01	0.08	2	0.7%	35.0	30	40	161.3
Haemulon aurolineatum	Tomtate	3,529	11.84	28.56	134	45.0%	6.6	1	16	21,642.9
Haemulon carbonarium	Caesar grunt	6	0.02	0.20	4	1.3%	12.8	8	20	276.4
Haemulon chrysargyreum	Smallmouth grunt	2	0.01	0.08	2	0.7%	9.0	8	10	92.2
Haemulon flavolineatum	French grunt	398	1.34	4.69	78	26.2%	8.0	3	28	8,430.2
Haemulon macrostomum	*Spanish grunt*	10	0.03	0.24	7	2.3%	13.9	4	30	1,886.4
Haemulon melanurum	Cottonwick	80	0.27	2.48	4	1.3%	13.0	10	15	3,510.9
Haemulon parra	Sailor's choice	5	0.02	0.19	3	1.0%	17.4	14	31	793.1
Haemulon plumieri	White grunt	4,102	13.77	18.13	250	83.9%	9.9	2	30	102,008.2
Haemulon sciurus	Bluestriped grunt	1,380	4.63	7.68	198	66.4%	13.1	2	30	87,828.4
Haemulon sp.	Unidentified grunt	533	1.79	20.93	10	3.4%	3.2	3	7	289.5
Halichoeres bivittatus	Slippery dick	142	0.48	1.66	54	18.1%	7.0	3	15	745.0
Halichoeres garnoti	Yellowhead wrasse	6	0.02	0.16	5	1.7%	9.0	5	15	89.5
Halichoeres maculipinna	Clown wrasse	14	0.05	0.26	11	3.7%	8.9	4	14	177.2
Halichoeres radiatus	Puddingwife	3	0.01	0.13	2	0.7%	17.3	4	40	968.7
Hemipteronotus martinicensis	Rosy razorfish	1	0.00	0.06	1	0.3%	6.0	6	6	4.5
Holacanthus bermudensis	Blue angelfish	81	0.27	0.69	62	20.8%	14.5	3	36	11,758.9
Holacanthus ciliaris	Queen anglefish	43	0.14	0.49	32	10.7%	12.7	3	30	4,171.8
Hyploplectrus nigricans	Black hamlet	2	0.01	0.08	2	0.7%	4.0	4	4	0.4
Hypoplectrus puella	Barred hamlet	2	0.01	0.08	2	0.7%	8.0	6	10	3.3

Table 3. (cont.)

SPECIES	COMMON NAME	NUMBER Total Abund.	Mean Abund.	Stand. Dev.	OCCURENCE Freq.	%	LENGTH (cm) Mean	Min	Max	BIOMASS (gms) Total
		Sample N=298			Number of species = 109					
Hypoplectrus unicolor	Butter hamlet	21	0.07	0.27	20	6.7%	6.5	4	10	18.7
Kyphosus sectatrix	Bermuda chub	66	0.22	2.48	13	4.4%	21.0	10	64	21,180.2
Lactophrys bicaudalis	Spotted trunkfish	2	0.01	0.08	2	0.7%	20.0	14	26	530.2
Lachnolaimus maximus	Hogfish	129	0.43	0.95	75	25.2%	25.7	7	51	68,340.5
Lactophrys polygonia	Honeycomb cowfish	1	0.00	0.06	1	0.3%	19.0	19	19	98.0
Lutjanus analis	Mutton snapper	30	0.10	0.35	26	8.7%	43.3	6	70	53,675.3
Lutjanus apodus	Schoolmaster	69	0.23	0.84	44	14.8%	21.5	10	42	17,226.6
Lutjanus buccanella	Blackfin snapper	1	0.00	0.06	1	0.3%	4.0	4	4	1.3
Lutjanus cyanopterus	Cubera snapper	2	0.01	0.12	1	0.3%	43.0	41	46	3,159.1
Lutjanus griseus	Gray snapper	1,553	5.21	7.43	216	72.5%	17.7	4	60	196,781.4
Lutjanus jocu	Dog snapper	1	0.00	0.06	1	0.3%	24.0	24	24	270.9
Lutjanus mahogoni	Mahogany snapper	20	0.07	0.52	6	2.0%	15.4	12	22	1,540.0
Lutjanus synagris	Lane snapper	140	0.47	2.55	24	8.1%	11.1	6	25	4,250.9
Malacoctenus macrops	Rosy blenny	3	0.01	0.10	3	1.0%	4.0	4	4	1.6
Mycteroperca bonaci	Black grouper	22	0.07	0.29	20	6.7%	29.6	16	45	9,625.2
Mycteroperca microlepis	Gag	2	0.01	0.12	1	0.3%	12.0	10	15	61.5
Mycteroperca phenax	Scamp	1	0.00	0.06	1	0.3%	16.0	16	16	57.9
Ocyurus chrysurus	Yellowtail snapper	1,271	4.27	9.17	199	66.8%	10.7	4	30	41,800.5
Odontoscion dentex	Reef crocker	7	0.02	0.15	7	2.3%	10.1	6	14	90.7
Ophioblennius atlanticus	Redlip blenny	1	0.00	0.06	1	0.3%	5.0	5	5	1.5
Pomacanthus arcuatus	Gray angelfish	305	1.02	1.37	150	50.3%	23.1	4	50	161,624.7
Pomacentrus fuscus	Dusky damselfish	74	0.25	0.99	33	11.1%	5.5	2	9	422.4
Pomacentrus leucostictus	Beaugregory	130	0.44	0.92	76	25.5%	5.0	1	10	517.5
Pomacentrus partitus	Bicolor damselfish	38	0.13	0.60	22	7.4%	4.0	3	8	68.2
Pomacanthus paru	French angelfish	41	0.14	0.45	28	9.4%	26.0	6	41	27,898.0
Pomacentrus planifrons	Three spot damselfish	629	2.11	3.58	170	57.0%	5.9	2	12	4,627.6
Pomacentrus variabilis	Cocoa damselfish	235	0.79	1.19	119	39.9%	5.9	2	10	1,346.0
Pseudupeneus maculatus	Spotted goatfish	33	0.11	0.52	20	6.7%	10.8	4	19	1,008.7
Scarus coelestinus	Midnight parrotfish	57	0.19	1.03	31	10.4%	29.3	10	50	34,842.1
Scarus coeruleus	Blue parrotfish	45	0.15	0.54	33	11.1%	19.5	3	40	9,406.4
Scarus croicensis	Striped parrotfish	2,897	9.72	8.63	236	79.2%	5.4	1	16	9,742.2
Scarus guacamaia	Rainbow parrotfish	13	0.04	0.24	11	3.7%	35.7	14	60	16,993.7
Scarus taeniopterus	Princess parrotfish	388	1.30	4.53	76	25.5%	7.1	1	30	5,452.8
Scarus vetula	Queen parrotfish	3	0.01	0.10	3	1.0%	28.3	25	30	1,256.9
Sparisoma atomarium	Greenblotch parrotfish	1	0.00	0.06	1	0.3%	4.0	4	4	0.8
Sparisoma aurofrenatum	Redband parrotfish	248	0.83	1.71	103	34.6%	7.9	3	20	2,842.5
Sparisoma chrysopterum	Redtail parrotfish	37	0.12	0.86	14	4.7%	15.3	7	26	3,080.2
Sparisoma radians	Bucktooth parrotfish	8	0.03	0.23	5	1.7%	5.8	3	10	24.2
Sparisoma rubripinne	Yellowtail parrotfish	11	0.04	0.35	4	1.3%	6.2	2	14	87.6
Sparisoma viride	Stoplight parrotfish	248	0.83	1.92	135	45.3%	10.6	2	35	16,815.2
Sphyraena barracuda	Great barracuda	150	0.50	1.40	67	22.5%	59.9	10	170	432,489.7
Sphoeroides spengleri	Bandtail puffer	3	0.01	0.10	3	1.0%	10.7	10	12	75.8
Synodus intermedius	Sand diver	1	0.00	0.06	1	0.3%	13.0	13	13	21.7
Thalassoma bifasciatum	Bluehead	111	0.37	0.70	81	27.2%	7.8	2	15	594.5
Trachinotus falcatus	Permit	1	0.00	0.06	1	0.3%	61.0	61	61	4,034.9
Tylosurus crocodilus	Houndfish	1	0.00	0.06	1	0.3%	46.0	46	46	863.0
Unidentified sp.	Unidentified species	2,151	7.22	116.01	3	1.0%	2.9	2	3	
Urolophus jamaicensis	Yellow stingray	4	0.01	0.12	4	1.3%	29.5	26	35	1,025.1
		24,338								1,763,256.0

Table 4. Summary of reef fish censused at Basin Hill (closed to fishing) in John Pennekamp Coral Reef State Park, Florida, May 15, 1992 – June 27, 1995.

		NUMBER			Sample N=65		Number of species = 73			
		Total	Mean	Stand.	OCCURENCE		LENGTH (cm)			BIOMASS (gms)
SPECIES	COMMON NAME	Abund.	Abund.	Dev.	Freq.	%	Mean	Min	Max	Total
Abudefduf saxatilis	Sergeant major	257	4.0	12.22	16	24.6%	6.5	2	11	2,364.5
Acanthurus bahianus	Ocean surgeon	27	0.4	0.92	14	21.5%	6.1	3	18	324.3
Acanthurus chirurgus	Doctorfish	27	0.4	1.20	12	18.5%	7.8	3	25	893.0
Acanthurus coeruleus	Blue tang	74	1.1	2.38	32	49.2%	18.4	4	35	21,381.8
Aluterus scriptus	Scrawled filefish	2	0.0	0.17	2	3.1%	52.5	45	60	2,201.1
Anisotremus virginicus	Porkfish	52	0.8	1.86	27	41.5%	7.4	2	24	1,164.2
Archosargus rhomboidalis	Sea bream	33	0.5	2.02	5	7.7%	18.8	10	30	6,878.4
Calamus calamus	Saucereye porgy	2	0.0	0.17	2	3.1%	27.0	25	29	887.7
Caranx bartholomaei	Yellow jack	84	1.3	5.44	6	9.2%	41.8	10	65	148,560.0
Caranx crysos	Blue runner	2	0.0	0.25	1	1.5%	20.0	20	20	331.8
Caranx ruber	Bar jack	377	5.8	31.78	13	20.0%	19.9	3	50	57,763.9
Chaetodon capistratus	Foureye butterflyfish	13	0.2	0.47	11	16.9%	6.0	4	8	94.5
Chaetodiperus faber	Atlantic spadefish	5	0.1	0.62	1	1.5%	30.0	30	30	4,257.1
Coryphopterus dicrus	Colon goby	3	0.0	0.21	3	4.6%	4.3	4	5	3.2
Coryphopterus glaucofraenum	Bridled goby	24	0.4	1.05	10	15.4%	3.1	1	5	11.8
Coryphopterus personatus	Masked goby	1	0.0	0.12	1	1.5%	3.0	3	3	0.3
Diodon holocanthus	Balloonfish	1	0.0	0.12	1	1.5%	14.0	14	14	89.4
Diodon hystrix	Porcupinefish	2	0.0	0.25	1	1.5%	25.0	25	25	1,620.3
Echeneis naucrates	Sharksucker	1	0.0	0.12	1	1.5%	20.0	20	20	71.1
Gerres cinereus	Yellowfin mojarra	13	0.2	1.25	4	6.2%	18.1	10	47	3,943.6
Ginglymostoma cirratum	Nurse shark	1	0.0	0.12	1	1.5%	200.0	200	200	47,606.3
Gobiosoma oceanops	Neon goby	24	0.4	0.78	14	21.5%	3.2	2	4	7.7
Goby-like fish	Goby-like fish	1	0.0	0.12	1	1.5%	4.0	4	4	0.6
Haemulon aurolineatum	Tomtate	477	7.3	12.69	30	46.2%	6.3	1	12	2,409.5
Haemulon carbonarium	Caesar grunt	1	0.0	0.12	1	1.5%	20.0	20	20	139.3
Haemulon flavolineatum	French grunt	123	1.9	7.77	16	24.6%	7.3	3	25	1,305.3
Haemulon macrostomum	Spanish grunt	1	0.0	0.12	1	1.5%	5.0	5	5	3.2
Haemulon parra	Sailor's choice	1	0.0	0.12	1	1.5%	14.0	14	14	53.6
Haemulon plumieri	White grunt	787	12.1	16.17	53	81.5%	10.8	4	22	22,160.6
Haemulon sciurus	Bluestriped grunt	431	6.6	11.28	44	67.7%	12.2	4	26	19,181.7
Haemulon sp.	Unidentified grunt	43	0.7	2.73	4	6.2%	3.8	3	7	56.1
Halichoeres bivittatus	Slippery dick	19	0.3	0.96	11	16.9%	8.0	5	11	134.2
Halichoeres garnoti	Yellowhead wrasse	2	0.0	0.17	2	3.1%	12.5	10	15	60.7
Halichoeres maculipinna	Clown wrasse	2	0.0	0.17	2	3.1%	10.5	7	14	50.8
Halichoeres radiatus	Puddingwife	1	0.0	0.12	1	1.5%	40.0	40	40	963.0
Holacanthus bermudensis	Blue angelfish	14	0.2	0.54	11	16.9%	13.1	4	28	1,225.7
Holacanthus ciliaris	Queen anglefish	6	0.1	0.29	6	9.2%	10.5	7	20	289.6
Kyphosus sectatrix	Bermuda chub	7	0.1	0.53	4	6.2%	25.7	15	35	3,271.8
Lachnolaimus maximus	Hogfish	14	0.2	0.80	9	13.8%	23.9	12	50	5,855.1
Lutjanus analis	Mutton snapper	10	0.2	0.48	8	12.3%	53.1	35	70	29,307.3
Lutjanus apodus	Schoolmaster	14	0.2	0.67	9	13.8%	23.6	18	30	3,431.8
Lutjanus cyanopterus	Cubera snapper	2	0.0	0.25	1	1.5%	43.0	41	46	3,159.1
Lutjanus griseus	Gray snapper	512	7.9	9.50	50	76.9%	18.3	5	60	70,791.5
Lutjanus jocu	Dog snapper	1	0.0	0.12	1	1.5%	24.0	24	24	270.9
Lutjanus synagris	Lane snapper	4	0.1	0.30	3	4.6%	10.8	7	14	106.9
Malacoctenus macrops	Rosy blenny	1	0.0	0.12	1	1.5%	4.0	4	4	0.5
Mycteroperca bonaci	Black grouper	6	0.1	0.29	6	9.2%	28.3	18	34	2,050.2
Ocyurus chrysurus	Yellowtail snapper	272	4.2	5.01	51	78.5%	11.9	4	30	13,247.3
Odontoscion dentex	Reef crocker	1	0.0	0.12	1	1.5%	6.0	6	6	2.3
Pomacanthus arcuatus	Gray angelfish	74	1.1	1.39	37	56.9%	25.2	6	35	45,606.3
Pomacentrus fuscus	Dusky damselfish	20	0.3	0.90	9	13.8%	5.9	4	8	129.0
Pomacentrus leucostictus	Beaugregory	26	0.4	0.90	15	23.1%	4.9	3	8	89.9
Pomacentrus partitus	Bicolor damselfish	7	0.1	0.53	4	6.2%	4.0	3	5	11.3
Pomacanthus paru	French angelfish	7	0.1	0.44	4	6.2%	26.3	6	36	4,982.7
Pomacentrus planifrons	Three spot damselfish	62	1.0	1.60	24	36.9%	4.7	2	9	266.9
Pomacentrus variabilis	Cocoa damselfish	40	0.6	0.93	24	36.9%	6.0	4	10	223.3
Pseudupeneus maculatus	Spotted goatfish	2	0.0	0.17	2	3.1%	12.0	12	12	58.7
Scarus coelestinus	Midnight parrotfish	27	0.4	2.02	10	15.4%	34.5	12	50	24,136.2
Scarus coeruleus	Blue parrotfish	24	0.4	0.89	15	23.1%	20.6	6	40	5,461.1
Scarus croicensis	Striped parrotfish	721	11.1	10.00	49	75.4%	6.1	3	12	3,080.3
Scarus guacamaia	Rainbow parrotfish	6	0.1	0.34	5	7.7%	28.8	14	45	3,842.9

Table 4. cont.)

SPECIES	COMMON NAME	NUMBER Total Abund.	Mean Abund.	Stand. Dev.	OCCURENCE Freq.	%	LENGTH (cm) Mean	Min	Max	BIOMASS (gms) Total
		Sample N=65			Number of species = 73					
Scarus taeniopterus	Princess parrotfish	146	2.2	7.44	13	20.0%	5.3	2	30	1,140.7
Scarus vetula	Queen parrotfish	2	0.0	0.17	2	3.1%	27.5	25	30	767.3
Sparisoma aurofrenatum	Redband parrotfish	69	1.1	2.35	26	40.0%	8.4	4	20	991.4
Sparisoma chrysopterum	Redtail parrotfish	4	0.1	0.30	3	4.6%	11.0	7	20	158.6
Sparisoma radians	Bucktooth parrotfish	6	0.1	0.46	3	4.6%	5.3	3	8	11.1
Sparisoma viride	Stoplight parrotfish	39	0.6	0.98	26	40.0%	13.1	3	32	4,537.0
Sphyraena barracuda	Barracuda	109	1.7	2.51	38	58.5%	56.9	10	152	255,699.3
Sphoeroides spengleri	Bandtail puffer	1	0.0	0.12	1	1.5%	10.0	10	10	19.9
Thalassoma bifasciatum	Bluehead	22	0.3	0.67	16	24.6%	7.9	3	13	131.0
Tylosurus crocodilus	Houndfish	1	0.0	0.12	1	1.5%	46.0	46	46	863.0
Unidentified sp.	Unidentified species	2,151	33.1	248.16	4	6.2%	2.9	2	3	
Urolophus jamaicensis	Yellow stingray	2	0.0	0.17	2	3.1%	30.5	26	35	580.7
		7,346								832,773.6

Table 5. Summary of reef fish censused at Basin Hill (open to fishing) in John Pennekamp Coral Reef State Park, Florida, May 15, 1992 – June 27, 1995.

		NUMBER			Sample N=24	Number of species = 51				
					OCCURENCE		LENGTH (cm)			BIOMASS (gms)
SPECIES	COMMON NAME	Total Abund.	Mean Abund.	Stand. Dev.	Freq.	%	Mean	Min	Max	Total
Abudefduf saxatilis	Sergeant major	38	1.6	4.90	8	33.3%	5.5	3	10	242.8
Acanthurus bahianus	Ocean surgeon	8	0.3	0.48	8	33.3%	11.8	4	30	872.0
Acanthurus chirurgus	Doctorfish	5	0.2	0.51	4	16.7%	19.6	15	25	888.7
Acanthurus coeruleus	Blue tang	29	1.2	1.06	18	75.0%	13.0	3	26	2,795.4
Anisotremus virginicus	Porkfish	23	1.0	1.37	11	45.8%	8.2	1	20	538.1
Bodianus pulchellus	Spotfin hogfish	1	0.0	0.20	1	4.2%	8.0	8	8	8.3
Calamus calamus	Saucereye porgy	7	0.3	0.46	7	29.2%	20.6	6	36	2,101.6
Caranx ruber	Bar jack	67	2.8	5.85	7	29.2%	12.9	4	30	4,622.0
Chaetodon capistratus	Foureye butterflyfish	6	0.3	0.68	4	16.7%	7.2	6	8	67.0
Chaetodipterus faber	Atlantic spadefish	2	0.1	0.28	2	8.3%	32.0	28	36	2,096.3
Chaetodon ocellatus	Spotfin butterflyfish	1	0.0	0.20	1	4.2%	6.0	6	6	6.7
Coryphopterus glaucofraenum	Bridled goby	6	0.3	0.44	6	25.0%	4.5	3	6	8.4
Coryphopterus personatus	Masked goby	2	0.1	0.41	1	4.2%	3.0	3	3	0.7
Epinephelus morio	Red grouper	8	0.3	0.76	5	20.8%	33.9	21	50	5,610.3
Gnatholepis thompsoni	Goldspot goby	5	0.2	0.72	2	8.3%	3.6	2	5	3.1
Gobiosoma oceanops	Neon goby	4	0.2	0.38	4	16.7%	3.0	2	4	1.2
Gymnothorax moringa	Spotted moray	1	0.0	0.20	1	4.2%	30.0	30	30	46.3
Haemulon aurolineatum	Tomtate	529	22.0	37.43	13	54.2%	6.4	2	9	2,593.8
Haemulon carbonarium	Caesar grunt	1	0.0	0.20	1	4.2%	8.0	8	8	8.5
Haemulon flavolineatum	French grunt	15	0.6	1.13	7	29.2%	8.6	8	9	176.7
Haemulon plumieri	White grunt	486	20.3	29.63	15	62.5%	11.1	4	29	15,350.9
Haemulon sciurus	Bluestriped grunt	162	6.8	10.57	16	66.7%	14.3	5	30	11,579.1
Halichoeres maculipinna	Clown wrasse	2	0.1	0.28	2	8.3%	8.0	8	8	11.9
Holacanthus bermudensis	Blue angelfish	11	0.5	0.66	9	37.5%	14.2	7	30	1,227.0
Holacanthus ciliaris	Queen anglefish	9	0.4	0.88	5	20.8%	12.0	6	20	538.0
Hypoplectrus puella #	Barred hamlet	1	0.0	0.20	1	4.2%	10.0	10	10	2.6
Hypoplectrus unicolor	Butter hamlet	4	0.2	0.38	4	16.7%	8.3	7	10	6.4
Lachnolaimus maximus	Hogfish	26	1.1	1.59	12	50.0%	24.9	7	51	14,578.6
Lutjanus analis	Mutton snapper	6	0.3	0.44	6	25.0%	44.5	35	53	9,403.2
Lutjanus apodus	Schoolmaster	7	0.3	0.86	4	16.7%	29.6	13	40	3,413.1
Lutjanus griseus	Gray snapper	162	6.8	7.74	19	79.2%	23.5	10	41	40,203.1
Malacoctenus macrops	Rosy blenny	1	0.0	0.20	1	4.2%	4.0	4	4	0.5
Mycteroperca bonaci	Black grouper	3	0.1	0.34	3	12.5%	26.7	20	40	1,136.2
Ocyurus chrysurus	Yellowtail snapper	152	6.3	6.18	20	83.3%	10.4	5	30	5,018.5
Pomacanthus arcuatus	Gray angelfish	43	1.8	1.59	17	70.8%	23.3	6	37	25,056.0
Pomacentrus leucostictus	Beaugregory	2	0.1	0.41	1	4.2%	5.0	5	5	6.3
Pomacentrus partitus	Bicolor damselfish	2	0.1	0.28	2	8.3%	5.5	3	8	13.4
Pomacanthus paru	French angelfish	5	0.2	0.51	4	16.7%	25.8	20	35	2,904.8
Pomacentrus planifrons	Three spot damselfish	15	0.6	0.82	11	45.8%	5.5	3	8	93.9
Pomacentrus variabilis	Cocoa damselfish	32	1.3	1.43	15	62.5%	5.8	3	8	160.0
Pseudupeneus maculatus	Spotted goatfish	2	0.1	0.41	1	4.2%	5.0	4	6	4.7
Scarus coelestinus	Midnight parrotfish	12	0.5	0.78	8	33.3%	20.5	13	35	2,476.2
Scarus coeruleus	Blue parrotfish	2	0.1	0.28	2	8.3%	18.5	15	22	243.2
Scarus croicensis	Striped parrotfish	243	10.1	7.85	20	83.3%	5.3	2	10	651.1
Scarus guacamaia	Rainbow parrotfish	1	0.0	0.20	1	4.2%	35.0	35	35	832.1
Scarus taeniopterus	Princess parrotfish	20	0.8	3.09	4	16.7%	8.1	5	25	469.3
Sparisoma aurofrenatum	Redband parrotfish	8	0.3	0.64	6	25.0%	8.9	4	16	150.5
Sparisoma chrysopterum	Redtail parrotfish	11	0.5	2.25	1	4.2%	22.0	20	23	1,944.8
Sparisoma viride	Stoplight parrotfish	26	1.1	1.21	15	62.5%	10.1	2	32	1,628.1
Sphyraena barracuda	Barracuda	7	0.3	0.62	5	20.8%	30.7	10	50	2,193.3
Thalassoma bifasciatum	Bluehead	5	0.2	0.41	5	20.8%	7.0	4	10	19.2
		2,226								164,003.9

Table 6. Summary of reef fish censused at Basin Hill (open to fishing) in John Pennekamp Coral Reef State Park, Florida, May 15, 1992 – June 27, 1995.

		NUMBER			Sample N=64		Number of species = 63			
		Total	Mean	Stand.	OCCURENCE		LENGTH (cm)			BIOMASS (gms)
SPECIES	COMMON NAME	Abund.	Abund.	Dev.	Freq.	%	Mean	Min	Max	Total
Abudefduf saxatilis	Sergeant major	210	3.3	7.98	30	46.9%	5.0	1	15	1,582.4
Acanthurus bahianus	Ocean surgeon	22	0.3	0.84	13	20.3%	8.1	3	25	872.0
Acanthurus chirurgus	Doctorfish	31	0.5	1.23	15	23.4%	8.3	3	22	812.4
Acanthurus coeruleus	Blue tang	48	0.8	0.99	30	46.9%	10.9	3	20	2,569.1
Anisotremus virginicus	Porkfish	47	0.7	0.96	31	48.4%	8.3	1	30	2,962.9
Calamus calamus	Saucereye porgy	5	0.1	0.32	4	6.3%	18.4	16	22	769.7
Canthigaster rostrata	Sharpnose puffer	2	0.0	0.18	2	3.1%	5.5	5	6	6.4
Caranx bartholomaei	Yellow jack	4	0.1	0.39	2	3.1%	26.5	22	40	1,805.9
Caranx ruber	Bar jack	68	1.1	3.61	10	15.6%	11.3	5	48	8,439.1
Chaetodon capistratus	Foureye butterflyfish	21	0.3	0.64	16	25.0%	5.0	3	7	92.7
Chaetodon ocellatus	Spotfin butterflyfish	5	0.1	0.37	3	4.7%	9.2	7	10	118.1
Coryphopterus dicrus	Colon goby	6	0.1	0.53	2	3.1%	5.0	3	6	8.9
Coryphopterus glaucofraenum	Bridled goby	70	1.1	1.81	26	40.6%	3.9	2	6	62.4
Coryphopterus personatus	Masked goby	7	0.1	0.62	2	3.1%	2.6	2	3	1.7
Coryphopterus species	Unknown goby	6	0.1	0.46	3	4.7%	5.3	5	7	12.0
Epinephelus morio	Red grouper	3	0.0	0.21	3	4.7%	28.7	20	34	1,108.2
Gerres cinereus	Yellowfin mojarra	8	0.1	0.55	4	6.3%	15.9	15	17	732.1
Gobiosoma oceanops	Neon goby	29	0.5	1.11	14	21.9%	2.9	1	5	7.9
Haemulon aurolineatum	Tomtate	1,244	19.4	27.24	40	62.5%	6.2	1	14	5,498.8
Haemulon carbonarium	Caesar grunt	3	0.0	0.38	1	1.6%	13.0	10	15	111.9
Haemulon chrysargyreum	Smallmouth grunt	1	0.0	0.13	1	1.6%	10.0	10	10	57.0
Haemulon flavolineatum	French grunt	67	1.0	3.87	18	28.1%	7.2	3	14	564.5
Haemulon macrostomum	Spanish grunt	1	0.0	0.13	1	1.6%	10.0	10	10	26.1
Haemulon parra	Sailor's choice	1	0.0	0.13	1	1.6%	31.0	31	31	578.7
Haemulon plumieri	White grunt	675	10.5	12.25	54	84.4%	9.7	3	30	16,818.1
Haemulon sciurus	Bluestriped grunt	333	5.2	6.82	52	81.3%	14.3	2	30	30,008.4
Haemulon sp.	Unidentified grunt	38	0.6	4.75	1	1.6%	3.0	3	3	14.2
Halichoeres bivittatus	Slippery dick	1	0.0	0.13	1	1.6%	9.0	9	9	8.6
Holacanthus bermudensis	Blue angelfish	32	0.5	1.14	21	32.8%	16.0	3	36	7,219.6
Holacanthus ciliaris	Queen anglefish	12	0.2	0.66	7	10.9%	10.7	3	30	1,208.7
Hypoplectrus unicolor	Butter hamlet	6	0.1	0.29	6	9.4%	6.2	4	8	4.6
Lactophrys bicaudalis	Spotted trunkfish	1	0.0	0.13	1	1.6%	14.0	14	14	113.7
Lachnolaimus maximus	Hogfish	45	0.7	1.16	22	34.4%	25.2	12	50	20,103.0
Lutjanus analis	Mutton snapper	5	0.1	0.37	3	4.7%	27.8	6	51	3,802.2
Lutjanus apodus	Schoolmaster	22	0.3	1.45	9	14.1%	16.1	10	30	2,565.8
Lutjanus griseus	Gray snapper	442	6.9	8.52	51	79.7%	16.4	4	46	46,551.6
Lutjanus synagris	Lane snapper	38	0.6	1.85	9	14.1%	11.0	7	25	1,204.5
Malacoctenus macrops	Rosy blenny	1	0.0	0.13	1	1.6%	4.0	4	4	0.5
Mycteroperca bonaci	Black grouper	2	0.0	0.18	2	3.1%	34.5	34	35	1,163.2
Mycteroperca microlepis	Gag	2	0.0	0.25	1	1.6%	12.0	10	15	61.5
Ocyurus chrysurus	Yellowtail snapper	229	3.6	5.27	42	65.6%	9.7	4	25	6,391.3
Odontoscion dentex	Reef crocker	3	0.0	0.21	3	4.7%	9.3	9	10	26.3
Ophioblennius atlanticus	Redlip blenny	1	0.0	0.13	1	1.6%	5.0	5	5	1.5
Pomacanthus arcuatus	Gray angelfish	48	0.8	1.05	28	43.8%	20.4	4	50	21,298.2
Pomacentrus fuscus	Dusky damselfish	39	0.6	1.80	13	20.3%	5.3	3	7	199.3
Pomacentrus leucostictus	Beaugregory	32	0.5	0.96	21	32.8%	4.8	1	8	115.6
Pomacentrus partitus	Bicolor damselfish	14	0.2	0.72	9	14.1%	3.6	3	5	16.2
Pomacanthus paru	French angelfish	8	0.1	0.42	6	9.4%	26.3	15	37	5,266.8
Pomacentrus planifrons	Three spot damselfish	199	3.1	5.44	39	60.9%	6.2	2	10	1,662.0
Pomacentrus variabilis	Cocoa damselfish	70	1.1	1.31	34	53.1%	5.7	2	8	376.3
Pseudupeneus maculatus	Spotted goatfish	6	0.1	0.34	5	7.8%	10.8	9	12	134.2
Scarus coelestinus	Midnight parrotfish	7	0.1	0.36	6	9.4%	31.3	26	35	4,119.6
Scarus coeruleus	Blue parrotfish	4	0.1	0.24	4	6.3%	20.0	5	32	997.7
Scarus croicensis	Striped parrotfish	543	8.5	8.47	54	84.4%	5.4	2	14	1,938.5
Scarus taeniopterus	Princess parrotfish	60	0.9	2.36	18	28.1%	10.3	4	20	1,570.6
Scarus vetula	Queen parrotfish	1	0.0	0.13	1	1.6%	30.0	30	30	489.6
Sparisoma aurofrenatum	Redband parrotfish	43	0.7	1.14	22	34.4%	6.8	3	15	259.4
Sparisoma chrysopterum	Redtail parrotfish	4	0.1	0.30	3	4.7%	17.3	11	26	441.2
Sparisoma rubripinne	Yellowtail parrotfish	2	0.0	0.25	1	1.6%	7.0	6	8	12.9
Sparisoma viride	Stoplight parrotfish	44	0.7	0.77	32	50.0%	12.3	4	35	4,045.6
Sphyraena barracuda	Barracuda	14	0.2	0.63	9	14.1%	74.9	40	120	56,760.0
Sphoeroides spengleri	Bandtail puffer	2	0.0	0.18	2	3.1%	11.0	10	12	55.9
Thalassoma bifasciatum	Bluehead	40	0.6	0.86	28	43.8%	8.3	3	15	245.5
		4,213								266,073.0

Table 7. Summary of reef fish censused at Mosquito Bank (closed to fishing) in John Pennekamp Coral Reef State Park, Florida, May 15, 1992 – June 27, 1995.

		NUMBER			Sample N=59	Number of species = 70				
		Total	Mean	Stand.	OCCURENCE		LENGTH (cm)			BIOMASS (gms)
SPECIES	COMMON NAME	Abund.	Abund.	Dev.	Freq.	%	Mean	Min	Max	Total
Abudefduf saxatilis	Sergeant major	41	0.7	2.17	9	15.3%	10.4	8	15	1,631.1
Acanthurus bahianus	Ocean surgeon	9	0.2	0.41	8	13.6%	7.8	3	12	131.0
Acanthurus chirurgus	Doctorfish	8	0.1	0.47	6	10.2%	15.8	10	22	686.9
Acanthurus coeruleus	Blue tang	30	0.5	0.84	20	33.9%	10.6	6	16	1,201.5
Aluterus schoepfi	Orange filefish	2	0.0	0.26	1	1.7%	34.0	34	34	722.0
Anisotremus virginicus	Porkfish	37	0.6	1.88	12	20.3%	5.8	2	25	1,026.9
Archosargus rhomboidalis	Sea bream	5	0.1	0.43	3	5.1%	15.6	15	17	456.1
Aulostomus maculatus	Trumpetfish	4	0.1	0.25	4	6.8%	31.5	30	33	312.1
Calamus calamus	Saucereye porgy	8	0.1	0.43	6	10.2%	15.8	6	20	864.5
Canthigaster rostrata	Sharpnose puffer	2	0.0	0.18	2	3.4%	5.0	4	6	5.2
Caranx ruber	Bar jack	92	1.6	9.20	6	10.2%	8.4	6	24	1,054.6
Chaetodon capistratus	Foureye butterflyfish	22	0.4	0.74	16	27.1%	5.4	4	9	146.1
Chaetodiperus faber	Atlantic spadefish	2	0.0	0.18	2	3.4%	26.0	22	30	1,221.8
Chaetodon striatus	Banded butterflyfish	2	0.0	0.26	1	1.7%	12.0	12	12	108.3
Coryphopterus dicrus	Colon goby	5	0.1	0.43	3	5.1%	3.0	3	3	1.7
Coryphopterus glaucofraenum	Bridled goby	15	0.3	1.04	5	8.5%	3.1	2	4	5.4
Coryphopterus personatus	Masked goby	4	0.1	0.37	2	3.4%	2.5	2	3	0.9
Cryptotomus roseus	Bluelip parrotfish	8	0.1	0.82	2	3.4%	4.8	4	5	58.9
Epinephelus cruentatus	Graysby	2	0.0	0.18	2	3.4%	13.0	11	15	66.8
Epinephelus morio	Red grouper	1	0.0	0.13	1	1.7%	24.0	24	24	189.5
Gerres cinereus	Yellowfin mojarra	3	0.1	0.29	2	3.4%	16.0	15	18	293.0
Gobiosoma oceanops	Neon goby	3	0.1	0.29	2	3.4%	2.7	2	5	1.6
Haemulon aurolineatum	Tomtate	628	10.6	45.64	24	40.7%	7.9	3	16	6,540.3
Haemulon flavolineatum	French grunt	78	1.3	3.03	18	30.5%	12.8	5	28	5,870.0
Haemulon macrostomum	Spanish grunt	3	0.1	0.22	3	5.1%	27.3	26	30	1,673.7
Haemulon melanurum	Cottonwick	80	1.4	5.48	4	6.8%	13.0	10	15	3,510.9
Haemulon plumieri	White grunt	658	11.2	12.22	55	93.2%	10.6	3	30	21,031.6
Haemulon sciurus	Bluestriped grunt	98	1.7	2.81	30	50.8%	13.7	5	30	7,623.7
Halichoeres bivittatus	Slippery dick	47	0.8	1.40	19	32.2%	6.5	3	15	228.6
Halichoeres garnoti	Yellowhead wrasse	1	0.0	0.13	1	1.7%	12.0	12	12	22.8
Halichoeres maculipinna	Clown wrasse	5	0.1	0.34	4	6.8%	10.0	8	12	79.0
Hemipteronotus martinicensis	Rosy razorfish	1	0.0	0.13	1	1.7%	6.0	6	6	4.5
Holacanthus bermudensis	Blue angelfish	3	0.1	0.22	3	5.1%	13.3	9	20	241.1
Holacanthus ciliaris	Queen anglefish	8	0.1	0.39	7	11.9%	16.5	10	25	1,221.4
Hyploplectrus nigricans	Black hamlet	1	0.0	0.13	1	1.7%	4.0	4	4	0.2
Hypoplectrus puella	Barred hamlet	1	0.0	0.13	1	1.7%	6.0	6	6	0.6
Hypoplectrus unicolor	Butter hamlet	5	0.1	0.28	5	8.5%	6.2	6	7	3.4
Kyphosus sectatrix	Bermuda chub	59	1.0	5.52	9	15.3%	20.5	10	27	11,898.8
Lachnolaimus maximus	Hogfish	15	0.3	0.58	12	20.3%	23.6	10	35	5,403.7
Lactophrys polygonia	Honeycomb cowfish	1	0.0	0.13	1	1.7%	19.0	19	19	98.0
Lutjanus analis	Mutton snapper	2	0.0	0.18	2	3.4%	47.0	45	49	3,521.4
Lutjanus apodus	Schoolmaster	11	0.2	0.43	10	16.9%	21.2	14	38	2,913.3
Lutjanus griseus	Gray snapper	71	1.2	1.69	31	52.5%	18.1	7	38	8,660.0
Lutjanus mahogoni	Mahogany snapper	5	0.1	0.53	2	3.4%	18.0	16	22	572.7
Lutjanus synagris	Lane snapper	29	0.5	3.52	3	5.1%	10.1	8	15	602.7
Mycteroperca bonaci	Black grouper	3	0.1	0.29	2	3.4%	36.7	30	45	2,341.9
Ocyurus chrysurus	Yellowtail snapper	171	2.9	5.15	31	52.5%	10.6	5	20	4,903.1
Odontoscion dentex	Reef crocker	3	0.1	0.22	3	5.1%	12.3	11	14	62.2
Pomacanthus arcuatus	Gray angelfish	73	1.2	1.63	34	57.6%	25.0	8	40	46,322.7
Pomacentrus fuscus	Dusky damselfish	3	0.1	0.29	2	3.4%	8.0	6	9	47.2
Pomacentrus leucostictus	Beaugregory	14	0.2	0.70	8	13.6%	5.4	4	10	70.8
Pomacentrus partitus	Bicolor damselfish	12	0.2	0.91	4	6.8%	4.1	3	5	19.3
Pomacanthus paru	French angelfish	10	0.2	0.53	6	10.2%	24.8	13	36	6,813.1
Pomacentrus planifrons	Three spot damselfish	168	2.8	3.59	43	72.9%	6.6	3	12	1,608.9
Pomacentrus variabilis	Cocoa damselfish	36	0.6	1.35	14	23.7%	6.8	3	10	300.3
Pseudupeneus maculatus	Spotted goatfish	16	0.3	0.98	6	10.2%	10.9	5	19	577.4
Scarus coelestinus	Midnight parrotfish	1	0.0	0.13	1	1.7%	25.0	25	25	292.1
Scarus coeruleus	Blue parrotfish	8	0.1	0.57	5	8.5%	13.8	6	24	566.2
Scarus croicensis	Striped parrotfish	536	9.1	7.82	47	79.7%	5.4	1	16	1,942.5
Scarus guacamaia	Rainbow parrotfish	5	0.1	0.34	4	6.8%	39.2	30	60	7,982.8
Scarus taeniopterus	Princess parrotfish	76	1.3	2.24	29	49.2%	8.9	3	26	1,737.8

Table 7 (cont.)

SPECIES	COMMON NAME	NUMBER Total Abund.	Mean Abund.	Stand. Dev.	OCCURENCE Freq.	%	LENGTH (cm) Mean	Min	Max	BIOMASS (gms) Total
		Sample N=59			Number of species = 70					
Sparisoma aurofrenatum	Redband parrotfish	71	1.2	2.07	24	40.7%	8.3	3	16	878.3
Sparisoma chrysopterum	Redtail parrotfish	2	0.0	0.18	2	3.4%	10.0	10	10	29.3
Sparisoma radians	Bucktooth parrotfish	1	0.0	0.13	1	1.7%	4.0	4	4	0.5
Sparisoma rubripinne	Yellowtail parrotfish	8	0.1	0.73	2	3.4%	5.0	2	8	23.9
Sparisoma viride	Stoplight parrotfish	73	1.2	3.47	27	45.8%	10.0	2	30	4,097.6
Sphyraena barracuda	Barracuda	11	0.2	0.54	8	13.6%	71.9	16	170	71,991.4
Thalassoma bifasciatum	Bluehead	15	0.3	0.63	10	16.9%	8.3	5	13	92.8
Trachinotus falcatus	Permit	1	0.0	0.13	1	1.7%	61.0	61	61	4,034.9
Urolophus jamaicensis	Yellow stingray	1	0.0	0.13	1	1.7%	27.0	27	27	186.4
		3,433								248,831.4

Table 8. Summary of reef fish censused at Mosquito Bank (open to fishing) in John Pennekamp Coral Reef State Park, Florida, May 15, 1992 – June 27, 1995.

Sample N=62 Number of species = 69

SPECIES	COMMON NAME	NUMBER Total Abund.	NUMBER Mean Abund.	NUMBER Stand. Dev.	OCCURENCE Freq.	OCCURENCE %	LENGTH (cm) Mean	LENGTH (cm) Min	LENGTH (cm) Max	BIOMASS (gms) Total
Abudefduf saxatilis	Sergeant major	122	2.0	8.35	18	29.0%	5.6	2	10	760.2
Acanthurus bahianus	Ocean surgeon	34	0.5	1.00	20	32.3%	7.0	2	14	494.0
Acanthurus chirurgus	Doctorfish	26	0.4	0.92	15	24.2%	10.2	3	30	1,376.3
Acanthurus coeruleus	Blue tang	45	0.7	1.33	26	41.9%	10.2	2	22	1,894.3
Aluterus scriptus	Scrawled filefish	1	0.0	0.13	1	1.6%	23.0	23	23	242.7
Anisotremus virginicus	Porkfish	79	1.3	2.64	27	43.5%	4.5	1	17	458.2
Archosargus rhomboidalis	Sea bream	2	0.0	0.18	2	3.2%	16.5	16	17	215.9
Bodianus rufus	Spanish hogfish	1	0.0	0.13	1	1.6%	3.0	3	3	0.4
Calamus calamus	*Saucereye porgy*	1	0.0	0.13	1	1.6%	23.0	23	23	279.4
Canthigaster rostrata	Sharpnose puffer	1	0.0	0.13	1	1.6%	5.0	5	5	2.2
Caranx bartholomaei	Yellow jack	3	0.0	0.38	1	1.6%	60.0	60	60	11,536.6
Caranx ruber	Bar jack	113	1.8	9.82	9	14.5%	8.8	6	36	6,414.3
Chaetodon capistratus	Foureye butterflyfish	24	0.4	0.58	21	33.9%	6.0	4	10	191.3
Chaetodipterus faber	Atlantic spadefish	18	0.3	1.05	7	11.3%	32.5	25	42	20,231.9
Chaetodon ocellatus	Spotfin butterflyfish	12	0.2	0.62	6	9.7%	9.7	8	14	371.1
Chaetodon sedentarius	Reef butterflyfish	2	0.0	0.18	2	3.2%	5.0	4	6	8.0
Coryphopterus dicrus	Colon goby	3	0.0	0.22	3	4.8%	3.3	2	5	2.0
Coryphopterus glaucofraenum	Bridled goby	29	0.5	1.35	10	16.1%	3.2	2	5	13.2
Diodon holocanthus	Balloonfish	3	0.0	0.22	3	4.8%	14.7	14	15	300.3
Diodon hystrix	Porcupinefish	1	0.0	0.13	1	1.6%	10.0	10	10	100.6
Diplodus holbrooki	Spottail pinfish	1	0.0	0.13	1	1.6%	16.0	16	16	85.0
Equetus punctatus	Spotted drum	1	0.0	0.13	1	1.6%	6.0	6	6	2.7
Gerres cinereus	Yellowfin mojarra	2	0.0	0.18	2	3.2%	28.0	26	30	1,087.4
Gobiosoma oceanops	Neon goby	11	0.2	0.59	6	9.7%	3.0	3	3	2.8
Gymnothorax moringa	Spotted moray	1	0.0	0.13	1	1.6%	40.0	40	40	114.9
Haemulon aurolineatum	Tomtate	338	5.5	10.59	19	30.6%	5.7	2	15	1,700.9
Haemulon flavolineatum	French grunt	84	1.4	3.76	13	21.0%	6.1	3	11	424.1
Haemulon macrostomum	*Spanish grunt*	5	0.1	0.45	2	3.2%	8.4	4	15	183.4
Haemulon parra	Sailor's choice	3	0.0	0.38	1	1.6%	14.0	14	14	160.8
Haemulon plumieri	White grunt	1,241	20.0	23.34	55	88.7%	8.7	2	25	21,365.0
Haemulon sciurus	Bluestriped grunt	318	5.1	5.72	46	74.2%	12.1	3	30	16,701.0
Haemulon sp.	Unidentified grunt	446	7.2	45.42	4	6.5%	3.2	3	4	213.5
Halichoeres bivittatus	Slippery dick	55	0.9	2.76	16	25.8%	7.1	4	12	277.6
Halichoeres garnoti	Yellowhead wrasse	2	0.0	0.25	1	1.6%	5.0	5	5	2.4
Halichoeres maculipinna	Clown wrasse	3	0.0	0.28	2	3.2%	8.7	7	11	29.0
Halichoeres radiatus	Puddingwife	2	0.0	0.25	1	1.6%	6.0	4	7	5.7
Holacanthus bermudensis	Blue angelfish	14	0.2	0.49	12	19.4%	13.5	4	25	1,360.0
Holacanthus ciliaris	Queen anglefish	5	0.1	0.27	5	8.1%	11.2	3	18	266.0
Hypoplectrus unicolor	Butter hamlet	3	0.0	0.28	2	3.2%	5.7	5	6	1.6
Lactophrys bicaudalis	Spotted trunkfish	1	0.0	0.13	1	1.6%	26.0	26	26	416.5
Lachnolaimus maximus	Hogfish	10	0.2	0.41	9	14.5%	31.6	12	50	8,812.2
Lutjanus analis	Mutton snapper	7	0.1	0.32	7	11.3%	38.4	27	55	7,641.2
Lutjanus apodus	Schoolmaster	7	0.1	0.41	5	8.1%	22.9	14	30	1,820.9
Lutjanus griseus	Gray snapper	263	4.2	6.08	45	72.6%	15.9	4	40	22,236.2
Lutjanus mahogoni	Mahogany snapper	10	0.2	0.91	2	3.2%	14.8	12	17	682.0
Lutjanus synagris	Lane snapper	69	1.1	3.93	9	14.5%	11.5	6	16	2,336.8
Mycteroperca bonaci	Black grouper	7	0.1	0.37	6	9.7%	29.1	16	40	2,861.5
Ocyurus chrysurus	Yellowtail snapper	392	6.3	17.33	43	69.4%	10.8	5	18	10,881.3
Pomacanthus arcuatus	Gray angelfish	39	0.6	1.01	24	38.7%	20.7	7	35	13,766.9
Pomacentrus fuscus	Dusky damselfish	12	0.2	0.51	9	14.5%	4.7	2	7	46.9
Pomacentrus leucostictus	Beaugregory	35	0.6	0.99	21	33.9%	4.9	2	8	130.5
Pomacentrus partitus	Bicolor damselfish	3	0.0	0.22	3	4.8%	4.7	4	6	8.0
Pomacanthus paru	French angelfish	7	0.1	0.45	4	6.5%	26.1	8	35	4,498.4
Pomacentrus planifrons	Three spot damselfish	125	2.0	3.15	37	59.7%	5.2	2	8	625.1
Pomacentrus variabilis	Cocoa damselfish	49	0.8	1.01	27	43.5%	5.7	4	10	240.3
Pseudupeneus maculatus	Spotted goatfish	7	0.1	0.37	6	9.7%	11.7	9	18	233.6
Scarus coelestinus	Midnight parrotfish	3	0.0	0.22	3	4.8%	27.3	21	39	1,508.6
Scarus coeruleus	Blue parrotfish	6	0.1	0.30	6	9.7%	21.3	3	32	1,648.5
Scarus croicensis	Striped parrotfish	678	10.9	8.12	50	80.6%	4.9	1	12	1,435.3
Scarus taeniopterus	Princess parrotfish	38	0.6	2.49	8	12.9%	6.9	1	15	340.1
Sparisoma aurofrenatum	*Redband parrotfish*	44	0.7	1.38	19	30.6%	7.3	4	16	399.5

Table 8 (cont.)

SPECIES	COMMON NAME	NUMBER Total Abund.	Mean Abund.	Stand. Dev.	OCCURENCE Freq.	%	LENGTH (cm) Mean	Min	Max	BIOMASS (gms) Total
Sparisoma chrysopterum	Redtail parrotfish	2	0.0	0.18	2	3.2%	14.0	12	16	91.2
Sparisoma radians	Bucktooth parrotfish	1	0.0	0.13	1	1.6%	10.0	10	10	12.6
Sparisoma rubripinne	Yellowtail parrotfish	1	0.0	0.13	1	1.6%	14.0	14	14	50.8
Sparisoma viride	Stoplight parrotfish	32	0.5	0.80	23	37.1%	9.7	3	30	1,424.3
Sphyraena barracuda	Barracuda	7	0.1	0.41	5	8.1%	77.1	40	120	34,936.0
Synodus intermedius	Sand diver	1	0.0	0.13	1	1.6%	13.0	13	13	21.7
Thalassoma bifasciatum	Bluehead	26	0.4	0.69	20	32.3%	6.6	2	10	81.9
Urolophus jamaicensis	Yellow stingray	1	0.0	0.13	1	1.6%	30.0	30	30	257.9
		4,938								208,323.5

Sample N=62 Number of species = 69

Table 9. Summary of reef fish censused at Mosquito Bank new (open to fishing) in John Pennekamp Coral Reef State Park, Florida, May 31, 1994 – June 27, 1995.

		NUMBER			Sample N=24		Number of species = 56			
					OCCURENCE		LENGTH (cm)			BIOMASS (gms)
SPECIES	COMMON NAME	Total Abund.	Mean Abund.	Stand. Dev.	Freq.	%	Mean	Min	Max	Total
Abudefduf saxatilis	Sergeant major	16	0.7	2.24	3	12.5%	6.1	2	10	133.7
Acanthurus chirurgus	Doctorfish	5	0.2	0.41	5	20.8%	12.6	6	20	281.6
Acanthurus coeruleus	Blue tang	23	1.0	1.68	12	50.0%	13.2	3	20	1,830.4
Anisotremus virginicus	Porkfish	18	0.8	2.11	6	25.0%	8.6	1	18	606.4
Archosargus rhomboidalis	Sea bream	7	0.3	1.00	2	8.3%	14.6	13	15	516.4
Calamus calamus	Saucereye porgy	2	0.1	0.28	2	8.3%	25.0	20	30	777.0
Caranx ruber	Bar jack	5	0.2	0.51	4	16.7%	16.2	5	38	1,099.0
Chaetodon capistratus	Foureye butterflyfish	6	0.3	0.44	6	25.0%	6.2	4	8	49.5
Chaetodiperus faber	Atlantic spadefish	1	0.0	0.20	1	4.2%	26.0	26	26	579.9
Coryphopterus glaucofraenum	Bridled goby	3	0.1	0.61	1	4.2%	3.0	3	3	1.0
Coryphopterus personatus	Masked goby	2	0.1	0.41	1	4.2%	3.0	3	3	0.7
Diodon holocanthus	Balloonfish	1	0.0	0.20	1	4.2%	17.0	17	17	142.4
Epinephelus adscensionis	Rock hind	1	0.0	0.20	1	4.2%	20.0	20	20	124.1
Epinephelus morio	Red grouper	4	0.2	0.38	4	16.7%	17.8	16	22	322.8
Epinephelus striatus	Nassau grouper	1	0.0	0.20	1	4.2%	38.0	38	38	820.8
Gerres cinereus	Yellowfin mojarra	16	0.7	2.26	2	8.3%	20.5	15	25	3,405.2
Gobiosoma oceanops	Neon goby	10	0.4	1.35	3	12.5%	2.6	1	4	1.9
Gymnothorax funebris	Green moray	1	0.0	0.20	1	4.2%	8.0	8	8	1.6
Haemulon aurolineatum	Tomtate	313	13.0	25.66	8	33.3%	8.1	4	14	2,899.6
Haemulon carbonarium	Caesar grunt	1	0.0	0.20	1	4.2%	10.0	10	10	16.7
Haemulon chrysargyreum	Smallmouth grunt	1	0.0	0.20	1	4.2%	8.0	8	8	35.2
Haemulon flavolineatum	French grunt	31	1.3	3.41	6	25.0%	5.3	4	8	89.5
Haemulon plumieri	White grunt	255	10.6	13.84	18	75.0%	8.9	4	24	5,282.1
Haemulon sciurus	Bluestriped grunt	38	1.6	3.57	10	41.7%	14.0	5	24	2,734.6
Haemulon sp.	Unidentified grunt	6	0.3	1.22	1	4.2%	4.0	4	4	5.7
Halichoeres bivittatus	Slippery dick	20	0.8	2.46	7	29.2%	7.3	3	10	96.1
Halichoeres garnoti	Yellowhead wrasse	1	0.0	0.20	1	4.2%	7.0	7	7	3.7
Halichoeres maculipinna	Clown wrasse	2	0.1	0.41	1	4.2%	6.0	4	8	6.4
Holacanthus bermudensis	Blue angelfish	7	0.3	0.55	6	25.0%	13.6	7	17	485.6
Holacanthus ciliaris	Queen anglefish	3	0.1	0.45	2	8.3%	19.3	12	24	648.2
Hyploplectrus nigricans	Black hamlet	1	0.0	0.20	1	4.2%	4.0	4	4	0.2
Hypoplectrus unicolor	Butter hamlet	3	0.1	0.34	3	12.5%	6.3	4	9	2.8
Lachnolaimus maximus	Hogfish	19	0.8	1.06	11	45.8%	27.7	10	51	13,587.9
Lutjanus apodus	Schoolmaster	8	0.3	0.56	7	29.2%	24.6	13	42	3,081.7
Lutjanus buccanella	Blackfin snapper	1	0.0	0.20	1	4.2%	4.0	4	4	1.3
Lutjanus griseus	Gray snapper	103	4.3	4.69	20	83.3%	16.0	8	30	8,339.2
Lutjanus mahogoni	Mahogany snapper	5	0.2	0.72	2	8.3%	13.8	12	15	285.3
Mycteroperca bonaci	Black grouper	1	0.0	0.20	1	4.2%	18.0	18	18	72.2
Mycteroperca phenax	Scamp	1	0.0	0.20	1	4.2%	16.0	16	16	57.9
Ocyurus chrysurus	Yellowtail snapper	55	2.3	3.42	12	50.0%	10.1	6	20	1,359.0
Pomacanthus arcuatus	Gray angelfish	28	1.2	1.55	10	41.7%	20.0	7	32	9,574.5
Pomacentrus leucostictus	Beaugregory	21	0.9	1.30	10	41.7%	5.5	3	8	104.4
Pomacanthus paru	French angelfish	4	0.2	0.38	4	16.7%	27.8	20	41	3,432.1
Pomacentrus planifrons	Three spot damselfish	60	2.5	2.65	16	66.7%	5.6	2	8	370.7
Pomacentrus variabilis	Cocoa damselfish	8	0.3	0.87	5	20.8%	6.0	4	8	45.7
Scarus coelestinus	Midnight parrotfish	7	0.3	0.91	3	12.5%	24.0	10	30	2,309.4
Scarus coeruleus	Blue parrotfish	1	0.0	0.20	1	4.2%	30.0	30	30	489.6
Scarus croicensis	Striped parrotfish	176	7.3	8.72	16	66.7%	5.6	2	14	694.5
Scarus guacamaia	Rainbow parrotfish	1	0.0	0.20	1	4.2%	60.0	60	60	4,336.0
Scarus taeniopterus	Princess parrotfish	48	2.0	7.24	4	16.7%	5.7	3	9	194.3
Sparisoma atomarium	Greenblotch parrotfish	1	0.0	0.20	1	4.2%	4.0	4	4	0.8
Sparisoma aurofrenatum	Redband parrotfish	13	0.5	1.22	6	25.0%	8.7	5	15	163.4
Sparisoma chrysopterum	Redtail parrotfish	14	0.6	1.84	3	12.5%	11.7	9	20	415.1
Sparisoma viride	Stoplight parrotfish	34	1.4	2.89	12	50.0%	8.1	3	28	1,082.5
Sphyraena barracuda	Barracuda	2	0.1	0.28	2	8.3%	90.0	80	100	10,909.8
Thalassoma bifasciatum	Bluehead	3	0.1	0.45	2	8.3%	10.0	10	10	24.2
		1,418								83,932.1

Table 10. Comparison of reef fish at patch reefs based on Index of Relative Dominance (IRD) values for the top ten species censused at John Pennekamp Coral Reef State Park, Florida, Florida, May 15, 1992 – June 27, 1995. IRD ranks are presented as overall for the park for all years and patch reef by year.

Spring 1992

IRD RANK overall	site	SPECIES	Rel. Abund.	Rel. Freq.	IRD
		MOSQUITO BANK CLOSED			
2	1	S. croicensis	16.4	92.3	1510.5
3	2	H. aurolineatum	39.4	23.1	908.3
1	3	H. plumieri	8.8	84.6	742.1
10	4	C. ruber	7.9	23.1	182.6
7	5	P. planifrons	2.8	53.8	149.7
9	6	P. arcuatus	1.9	76.9	148.1
4	7	L. griseus	1.9	53.8	103.7
17	8	S. aurofrenatum	1.8	46.2	83.9
38	9	K. sectatrix	4.6	15.4	70.8
14	10	S. taeniopterus	1.4	46.2	64.2
		MOSQUITO BANK OPEN			
1	1	H. plumieri	14.2	83.3	1181.1
2	2	S. croicensis	10.5	83.3	878.4
28	3	H. species	31.3	25.0	783.5
3	4	H. aurolineatum	9.2	58.3	536.0
5	5	H. sciurus	5.2	91.7	476.6
8	6	A. saxatilis	6.3	66.7	422.6
10	7	C. ruber	7.1	33.3	237.4
4	8	L. griseus	2.4	58.3	141.3
13	9	H. flavolineatum	2.5	50.0	124.6
11	10	A. coeruleus	1.4	75.0	101.5

Fall 1992

IRD RANK overall	site	SPECIES	Rel. Abund.	Rel. Freq.	IRD
		MOSQUITO BANK CLOSED			
1	1	H. plumieri	30.4	100.0	3038.4
2	2	S. croicensis	20.2	81.8	1652.8
6	3	O. chrysurus	12.9	63.6	818.0
7	4	P. planifrons	3.0	72.7	218.5
13	5	H. flavolineatum	3.5	54.5	191.2
3	6	H. aurolineatum	4.5	36.4	163.9
9	7	P. arcuatus	2.0	63.6	127.5
17	8	S. aurofrenatum	2.7	36.4	97.1
5	9	H. sciurus	3.2	27.3	86.5
42	10	P. maculatus	2.2	36.4	78.9
		MOSQUITO BANK OPEN			
1	1	H. plumieri	47.3	100.0	4734.2
2	2	S. croicensis	11.6	91.7	1059.1
6	3	O. chrysurus	10.0	100.0	1002.0
4	4	L. griseus	4.5	83.3	374.9
3	5	H. aurolineatum	4.9	41.7	204.5
5	6	H. sciurus	3.1	58.3	178.9
23	7	H. bivittatus	2.2	41.7	93.7
26	8	A. bahianus	1.3	66.7	88.6
13	9	H. flavolineatum	2.6	33.3	85.2
17	10	S. aurofrenatum	1.3	41.7	55.4

Spring 1993

IRD RANK overall	site	SPECIES	Rel. Abund.	Rel. Freq.	IRD
		MOSQUITO BANK CLOSED			
1	1	H. plumieri	23.6	100.0	2357.4
2	2	S. croicensis	20.9	90.9	1901.1
7	3	P. planifrons	7.6	90.9	691.3
9	4	P. arcuatus	4.9	72.7	359.5
6	5	O. chrysurus	5.3	54.5	290.4
12	6	S. viride	3.0	81.8	248.9
23	7	H. bivittatus	3.8	63.6	242.0
5	8	H. sciurus	2.7	81.8	217.8
14	9	S. taeniopterus	1.9	63.6	121.0
11	10	A. coeruleus	2.1	54.5	114.1
		MOSQUITO BANK OPEN			
1	1	H. plumieri	29.5	100.0	2953.1
6	2	O. chrysurus	18.0	100.0	1796.1
2	3	S. croicensis	15.0	100.0	1496.8
5	4	H. sciurus	10.0	100.0	1003.2
4	5	L. griseus	6.9	91.7	630.4
7	6	P. planifrons	3.6	75.0	267.0
31	7	L. synagris	4.9	50.0	242.7
17	8	S. aurofrenatum	1.1	66.7	75.5
12	9	S. viride	1.0	66.7	64.7
24	10	C. capistratus	0.7	66.7	48.5

Spring 1994

IRD RANK overall	site	SPECIES	Rel. Abund.	Rel. Freq.	IRD
		MOSQUITO BANK CLOSED			
1	1	H. plumieri	18.5	100.0	1846.2
3	2	H. aurolineatum	13.6	83.3	1136.8
2	3	S. croicensis	10.7	75.0	800.0
7	4	P. planifrons	6.4	91.7	582.9
6	5	O. chrysurus	4.8	75.0	361.5
5	6	H. sciurus	4.4	75.0	330.8
14	7	S. taeniopterus	3.9	50.0	194.9
4	8	L. griseus	2.2	75.0	161.5
17	9	S. aurofrenatum	2.3	58.3	131.6
23	10	H. bivittatus	1.5	50.0	76.9
		MOSQUITO BANK OPEN			
1	1	H. plumieri	21.5	100.0	2145.3
2	2	S. croicensis	14.9	100.0	1486.0
5	3	H. sciurus	8.8	75.0	662.0
4	4	L. griseus	8.3	75.0	620.1
6	5	O. chrysurus	6.5	75.0	486.0
3	6	H. aurolineatum	11.2	33.3	372.4
7	7	P. planifrons	4.2	75.0	318.4
15	8	A. virginicus	4.4	50.0	217.9
21	9	T. bifasciatum	1.2	58.3	71.7
22	10	C. glaucofraenum	2.0	33.3	67.0
		MOSQUITO BANK NEW			
1	1	H. plumieri	20.0	91.7	1833.3
3	2	H. aurolineatum	27.2	66.7	1814.5
2	3	S. croicensis	11.3	91.7	1036.2
4	4	L. griseus	7.0	83.3	579.7
7	5	P. planifrons	3.2	75.0	241.3
6	6	O. chrysurus	3.5	66.7	231.9
5	7	H. sciurus	2.9	50.0	143.5
13	8	H. flavolineatum	2.6	41.7	108.7
14	9	S. taeniopterus	3.7	25.0	93.5
9	10	P. arcuatus	1.6	58.3	91.3

Spring 1995

IRD RANK overall	site	SPECIES	Rel. Abund.	Rel. Freq.	IRD
		MOSQUITO BANK CLOSED			
1	1	H. plumieri	15.7	100.0	1565.5
3	2	H. aurolineatum	18.8	75.0	1406.9
2	3	S. croicensis	10.9	75.0	819.8
50	4	H. melanurum	10.8	33.3	359.9
12	5	S. viride	4.9	66.7	323.9
7	6	P. planifrons	3.6	75.0	273.3
5	7	H. sciurus	3.2	75.0	242.9
13	8	H. flavolineatum	5.5	41.7	230.5
15	9	A. virginicus	3.5	50.0	175.4
4	10	L. griseus	2.3	75.0	172.1
		MOSQUITO BANK OPEN			
2	1	S. croicensis	23.3	35.7	831.9
4	2	L. griseus	6.1	57.1	349.6
1	3	H. plumieri	5.2	64.3	332.8
14	4	S. taeniopterus	8.0	35.7	285.7
27	5	A. chirurgus	4.2	64.3	272.3
7	6	P. planifrons	4.7	50.0	235.3
16	7	P. variabilis	3.5	57.1	201.7
5	8	H. sciurus	2.8	50.0	141.2
23	9	H. bivittatus	5.2	21.4	110.9
15	10	A. virginicus	3.3	28.6	94.1
		MOSQUITO BANK NEW			
2	1	S. croicensis	17.2	41.7	715.2
4	2	L. griseus	8.6	83.3	715.2
1	3	H. plumieri	9.3	58.3	544.2
7	4	P. planifrons	8.6	58.3	500.6
12	5	S. viride	7.1	41.7	295.4
20	6	L. maximus	3.7	50.0	186.6
6	7	O. chrysurus	5.6	33.3	186.6
11	8	A. coeruleus	2.6	41.7	108.8
43	9	G. cinereus	6.0	16.7	99.5
9	10	P. arcuatus	3.7	25.0	93.3

Table 10 (cont.)

Spring 1992

IRD RANK overall	site	SPECIES	Rel. Abund.	Rel. Freq.	IRD
		BASIN HILL CLOSED			
1	1	H. plumieri	20.9	82.4	1720.5
2	2	S. croicensis	13.8	82.4	1132.6
4	3	L. griseus	9.8	82.4	804.1
3	4	H. aurolineatum	9.9	58.8	583.6
5	5	H. sciurus	6.9	58.8	407.6
8	6	A. saxatilis	7.5	29.4	220.8
7	7	P. planifrons	2.3	82.4	185.9
14	8	S. taeniopterus	5.4	17.6	94.5
9	9	P. arcuatus	1.2	64.7	74.7
11	10	A. coeruleus	1.3	58.8	74.1
		BASIN HILL OPEN			
2	1	S. croicensis	17.3	100.0	1725.0
1	2	H. plumieri	14.9	81.3	1207.3
5	3	H. sciurus	12.5	87.5	1090.9
7	4	P. planifrons	12.2	87.5	1068.5
4	5	L. griseus	8.0	68.8	551.9
3	6	H. aurolineatum	8.5	56.3	480.4
33	7	P. fuscus	2.6	50.0	128.1
16	8	P. variabilis	1.9	62.5	117.4
10	9	C. ruber	3.8	25.0	93.9
30	10	G. oceanops	1.7	43.8	74.7

Fall 1992

IRD RANK overall	site	SPECIES	Rel. Abund.	Rel. Freq.	IRD
		BASIN HILL CLOSED			
4	1	L. griseus	24.0	91.7	2196.2
2	2	S. croicensis	12.0	75.0	898.4
6	3	O. chrysurus	8.7	100.0	872.4
1	4	H. plumieri	9.5	91.7	871.3
3	5	H. aurolineatum	11.2	66.7	746.5
5	6	H. sciurus	3.9	83.3	325.5
14	7	S. taeniopterus	4.2	33.3	138.9
17	8	S. aurofrenatum	2.5	50.0	123.7
27	9	A. chirurgus	2.3	50.0	117.2
9	10	P. arcuatus	1.4	66.7	95.5
		BASIN HILL OPEN			
3	1	H. aurolineatum	41.7	100.0	4168.3
1	2	H. plumieri	14.2	91.7	1305.8
4	3	L. griseus	6.3	75.0	473.2
2	4	S. croicensis	6.2	75.0	466.1
6	5	O. chrysurus	4.3	100.0	430.2
5	6	H. sciurus	4.0	83.3	334.6
8	7	A. saxatilis	3.7	66.7	248.6
16	8	P. variabilis	1.8	83.3	151.4
22	9	C. glaucofraenu	2.0	66.7	133.8
14	10	S. taeniopterus	2.6	41.7	107.6

Spring 1993

IRD RANK overall	site	SPECIES	Rel. Abund.	Rel. Freq.	IRD
		BASIN HILL CLOSED			
3	1	H. aurolineatum	24.4	83.3	2029.5
2	2	S. croicensis	20.0	83.3	1670.8
1	3	H. plumieri	15.0	100.0	1500.6
6	4	O. chrysurus	9.3	100.0	934.8
4	5	L. griseus	10.7	83.3	891.8
5	6	H. sciurus	4.7	66.7	311.6
18	7	S. barracuda	2.5	58.3	143.5
9	8	P. arcuatus	1.6	66.7	106.6
17	9	S. aurofrenatum	1.4	58.3	78.9
12	10	S. viride	0.9	50.0	43.1
		BASIN HILL OPEN			
3	1	H. aurolineatum	50.4	100.0	5037.2
2	2	S. croicensis	9.7	91.7	886.0
1	3	H. plumieri	7.9	75.0	592.5
4	4	L. griseus	4.2	83.3	348.5
6	5	O. chrysurus	4.9	66.7	328.4
7	6	P. planifrons	1.9	75.0	139.4
31	7	L. synagris	2.8	50.0	139.4
5	8	H. sciurus	1.9	66.7	123.9
12	9	S. viride	1.3	83.3	108.4
9	10	P. arcuatus	1.2	58.3	70.5

Spring 1994

IRD RANK overall	site	SPECIES	Rel. Abund.	Rel. Freq.	IRD
		BASIN HILL CLOSED			
5	1	H. sciurus	24.9	100.0	2491.7
1	2	H. plumieri	20.9	100.0	2094.8
2	3	S. croicensis	20.6	100.0	2061.7
13	4	H. flavolineatum	7.9	25.0	198.5
4	5	L. griseus	2.9	66.7	191.1
6	6	O. chrysurus	2.0	91.7	181.9
9	7	P. arcuatus	2.4	58.3	141.5
18	8	S. barracuda	1.7	66.7	110.3
11	9	A. coeruleus	2.0	50.0	99.2
44	10	A. rhomboidalis	2.0	25.0	49.6
		BASIN HILL OPEN			
1	1	H. plumieri	21.5	100.0	2150.3
2	2	S. croicensis	11.7	100.0	1174.4
3	3	H. aurolineatum	14.3	58.3	836.2
5	4	H. sciurus	8.7	75.0	654.1
4	5	L. griseus	7.8	75.0	582.9
6	6	O. chrysurus	6.0	83.3	496.5
8	7	A. saxatilis	5.0	58.3	292.2
13	8	H. flavolineatum	3.9	58.3	226.7
7	9	P. planifrons	2.1	50.0	103.6
11	10	A. coeruleus	1.4	66.7	92.1
		BASIN HILL NEW			
1	1	H. plumieri	39.5	91.7	3622.3
2	2	S. croicensis	11.6	100.0	1161.2
5	3	H. sciurus	11.3	91.7	1033.8
6	4	O. chrysurus	7.9	83.3	654.4
4	5	L. griseus	6.9	58.3	399.6
3	6	H. aurolineatum	6.7	50.0	334.2
9	7	P. arcuatus	2.3	91.7	206.8
16	8	P. variabilis	1.3	66.7	89.1
11	9	A. coeruleus	1.2	66.7	78.0
29	10	H. bermudensis	0.9	75.0	68.9

Spring 1995

IRD RANK overall	site	SPECIES	Rel. Abund.	Rel. Freq.	IRD
		BASIN HILL CLOSED			
25	1	Unid.species	72.8	33.3	2428.0
10	2	C. ruber	11.1	50.0	553.7
6	3	O. chrysurus	3.3	83.3	270.9
18	4	S. barracuda	1.8	100.0	179.5
8	5	A. saxatilis	2.8	41.7	117.1
11	6	A. coeruleus	0.9	91.7	80.7
4	7	L. griseus	1.0	58.3	57.3
15	8	A. virginicus	0.7	50.0	33.9
40	9	C. bartholomaei	0.9	25.0	22.9
2	10	S. croicensis	0.6	33.3	19.2
		BASIN HILL OPEN			
4	1	L. griseus	27.9	100.0	2794.7
8	2	A. saxatilis	16.0	58.3	931.6
6	3	O. chrysurus	9.9	66.7	659.1
5	4	H. sciurus	4.6	91.7	418.3
2	5	S. croicensis	6.8	50.0	342.2
1	6	H. plumieri	3.4	75.0	256.7
15	7	A. virginicus	2.7	58.3	155.3
11	8	A. coeruleus	2.1	66.7	139.4
14	9	S. taeniopterus	2.9	25.0	71.3
20	10	L. maximus	2.1	33.3	69.7
		BASIN HILL NEW			
3	1	H. aurolineatum	43.6	58.3	2545.4
4	2	L. griseus	7.8	100.0	777.5
2	3	S. croicensis	10.1	66.7	673.8
6	4	O. chrysurus	5.6	83.3	469.7
10	5	C. ruber	6.5	58.3	379.8
12	6	S. viride	1.8	83.3	153.9
11	7	A. coeruleus	1.5	83.3	121.5
5	8	H. sciurus	2.6	41.7	109.3
20	9	L. maximus	1.7	58.3	96.4
16	10	P. variabilis	1.6	58.3	90.7

Figure 1. Map depicting study sites at John Pennekamp Coral Reef State Park, Florida. Mosquito Bank (MB) and Basin Hill (BH) each contain three study reefs, with reefs either open (O) or closed (C) to fishing. Numbers depict historic (1) or recent reef additions (2) to the study. Latitude and longitude are presented for each patch reef. Exclamation marks represent buoys.

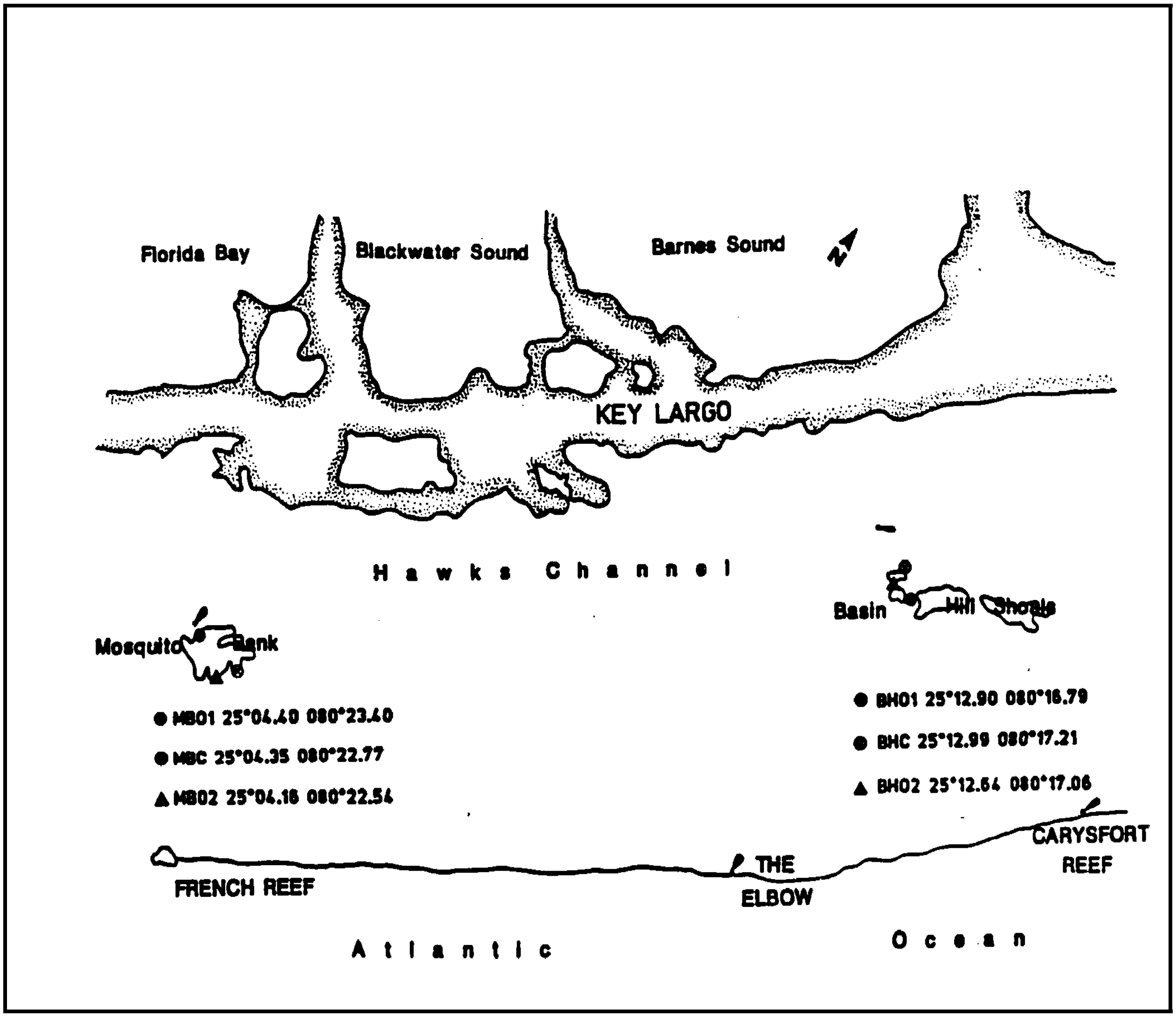


Figure 2. Mean number of censused species, individuals, (+ or – 95% CI) and biomass per sample (+ or – SE) at study reefs. Stars show significant differences between paired locations. N shows size per reef. 2,151 individuals of an unknown species was not included in SP95. N= number of samples per site.

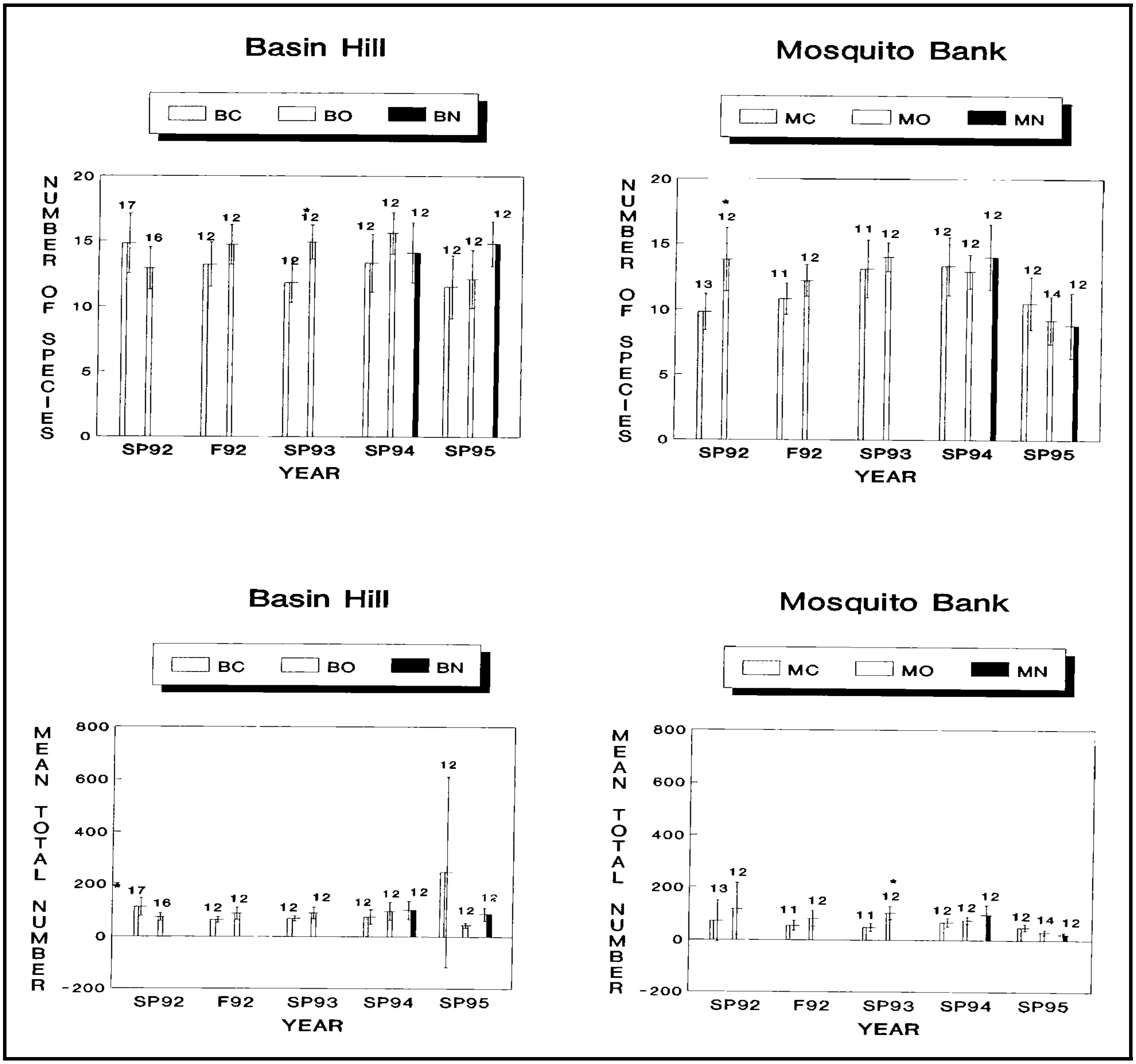


Figure 2 (cont.)

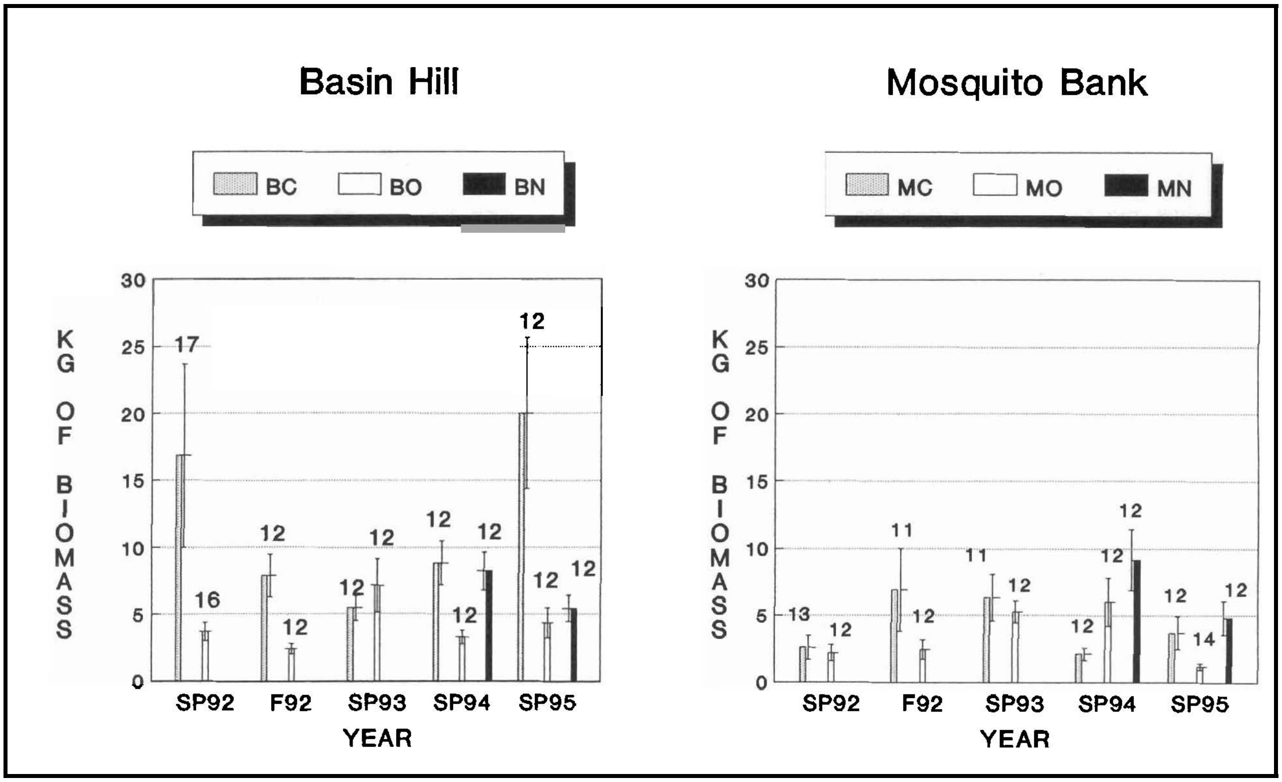


Figure 3. Mean biomass per sample of major reef fish families and groups sampled at Basin Hill reef in John Pennekamp Coral Reef State Park, Florida, May 15, 1992 – June 27, 1995. Bars indicate + or – SE.

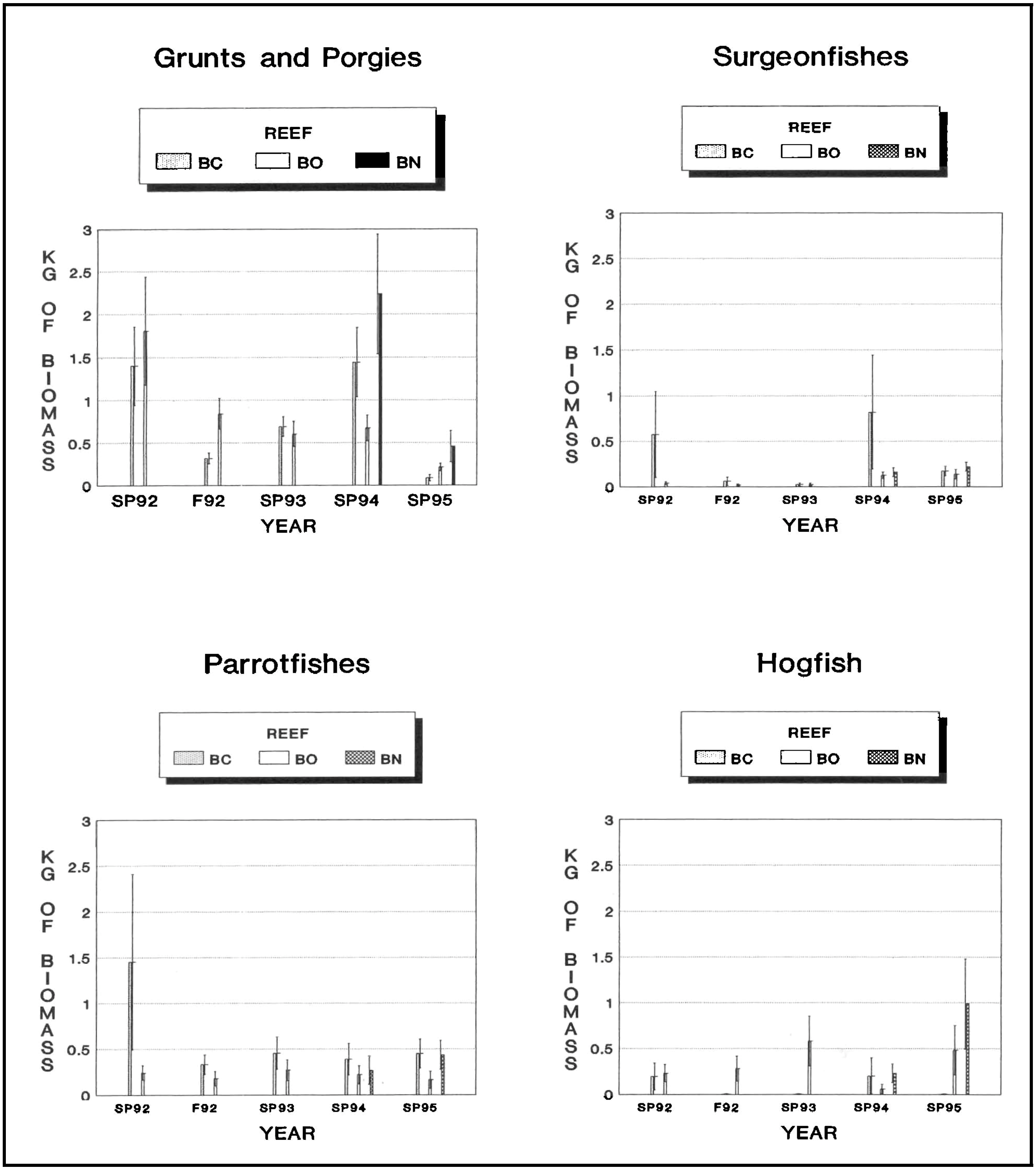


Figure 3 (cont.)

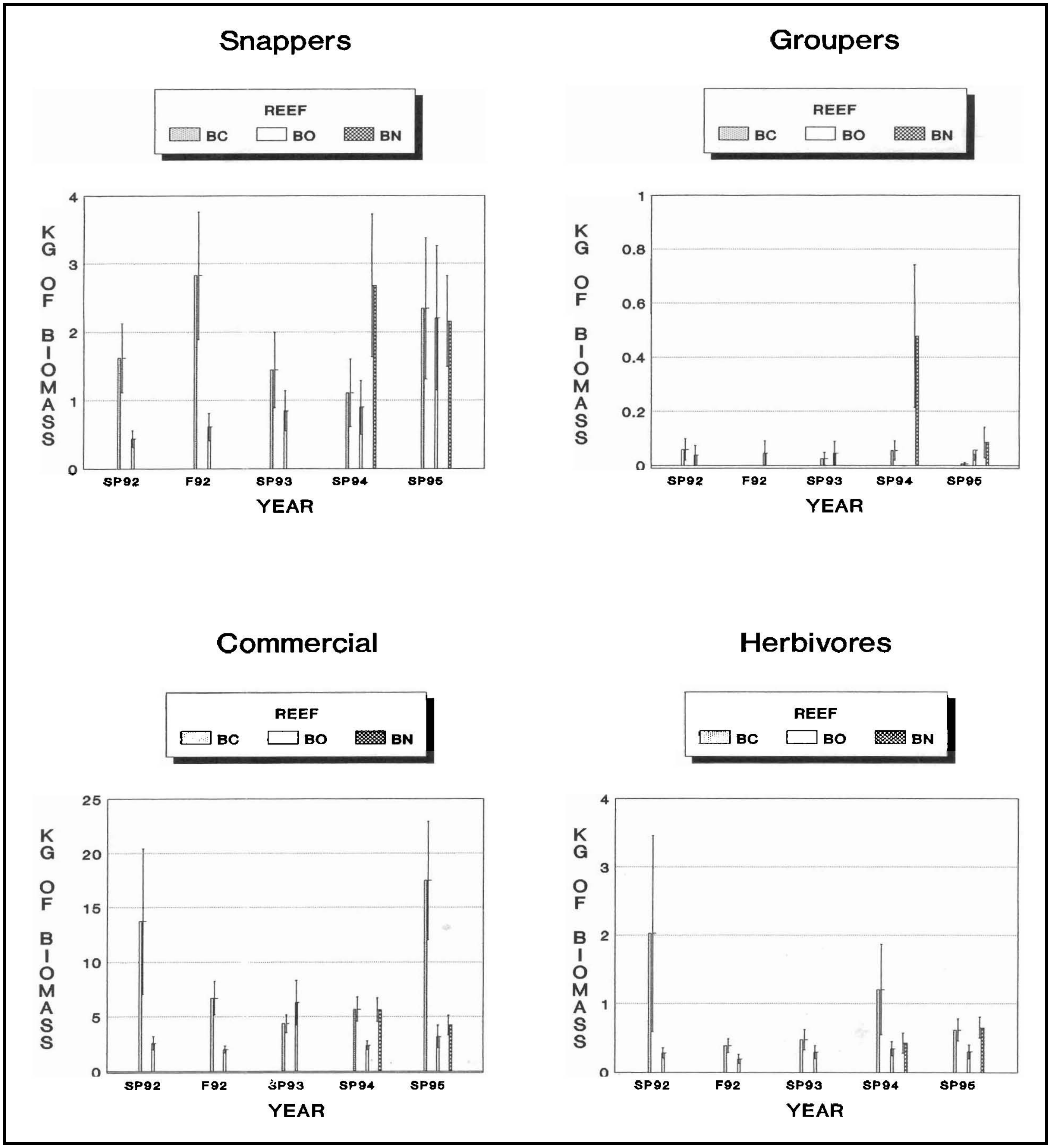


Figure 4. Mean biomass per sample of major reef fish families and groups sampled at Mosquito Bank reef in John Pennekamp Coral Reef State Park, Florida, May 15, 1992 – June 27, 1995. Bars indicate + or – SE.

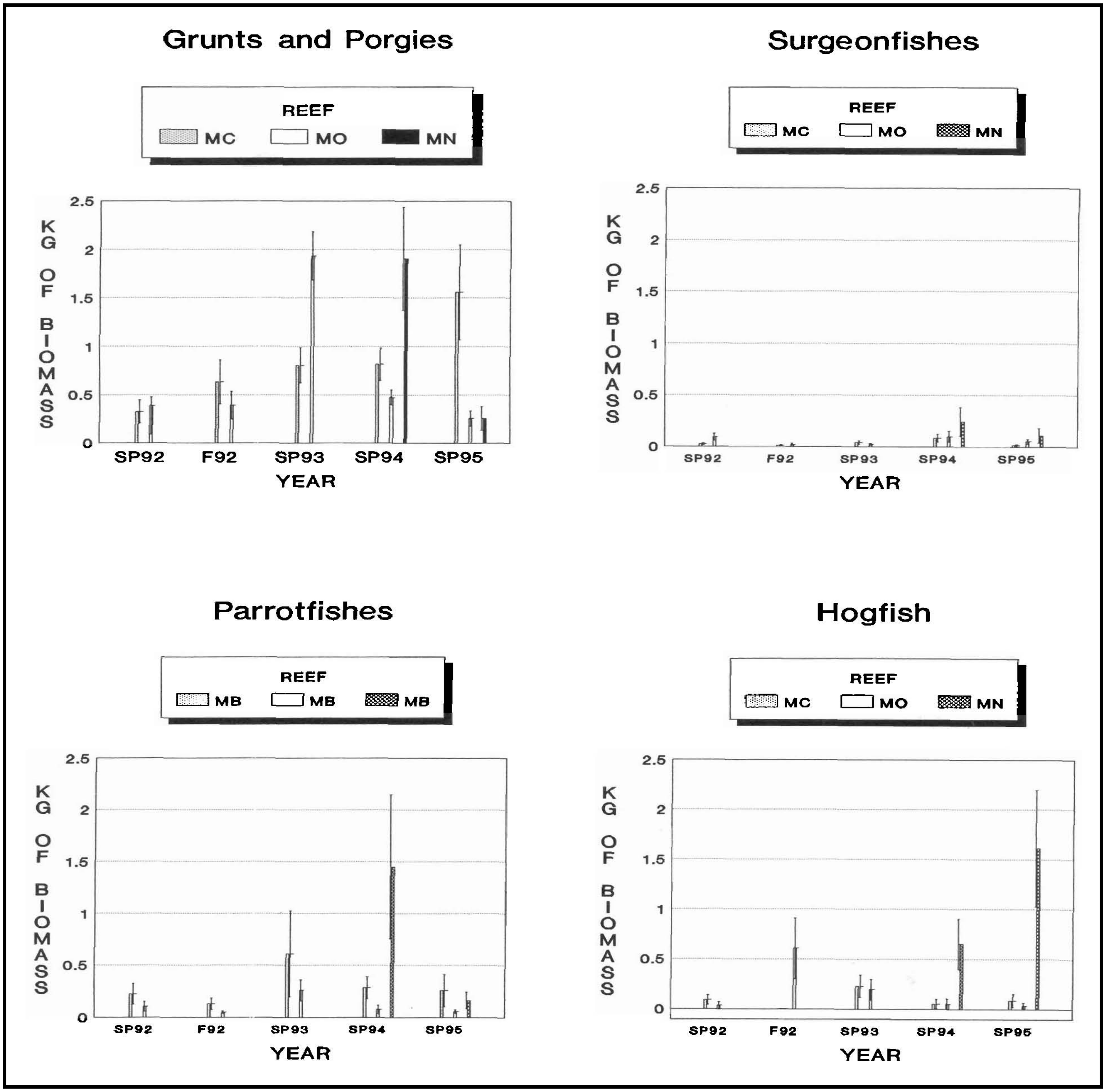


Figure 4 (cont.)

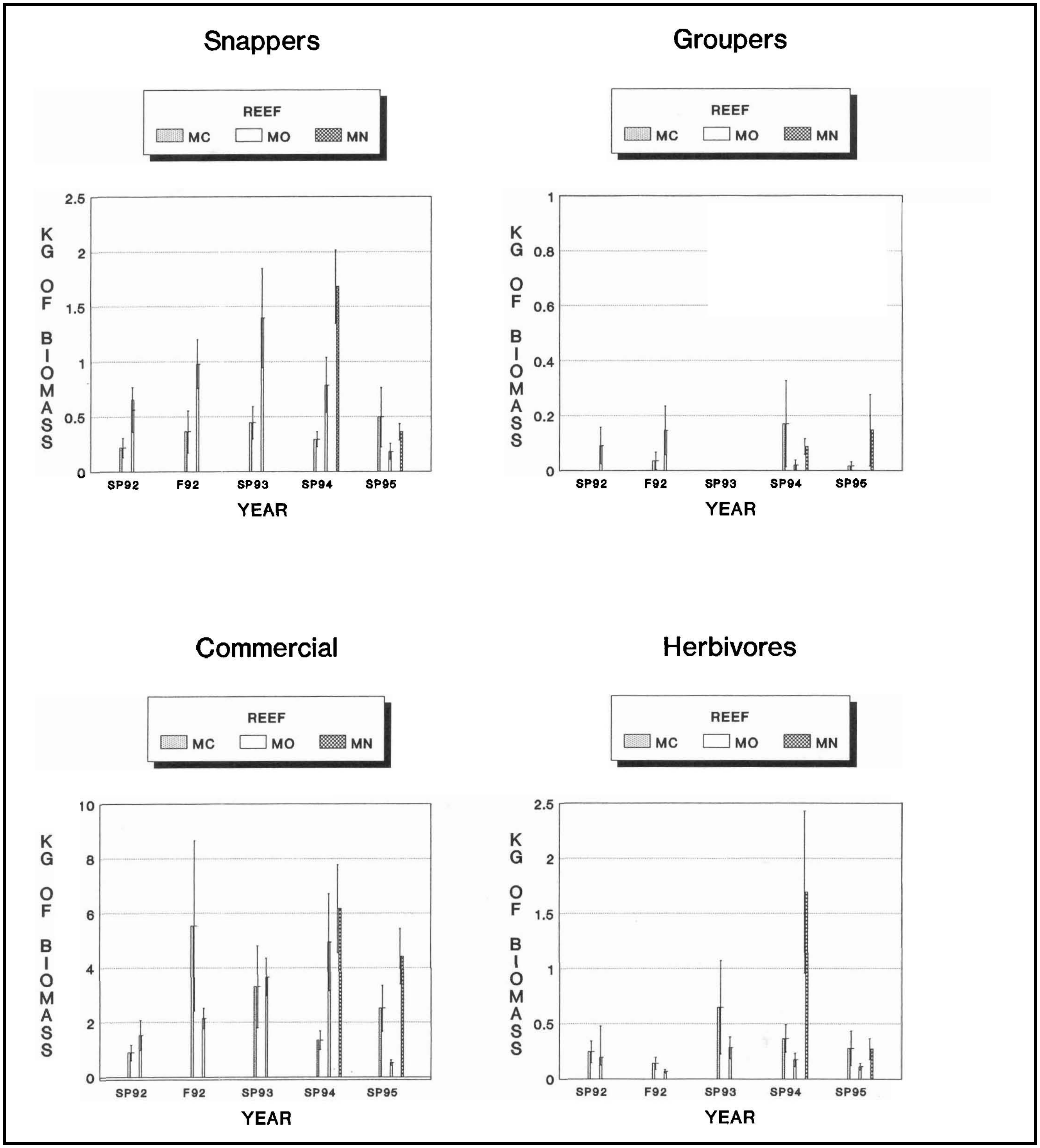


Figure 5. Dendrogram from Bray-Curtis similarity matrix of reef fish visual census samples for John Pennekamp Coral Reef State Park, Florida, May 15, 1992 – June 27, 1995. Data analyzed were pooled mean species abundance data (IRD > 0.05, n=48) for study reefs by season.

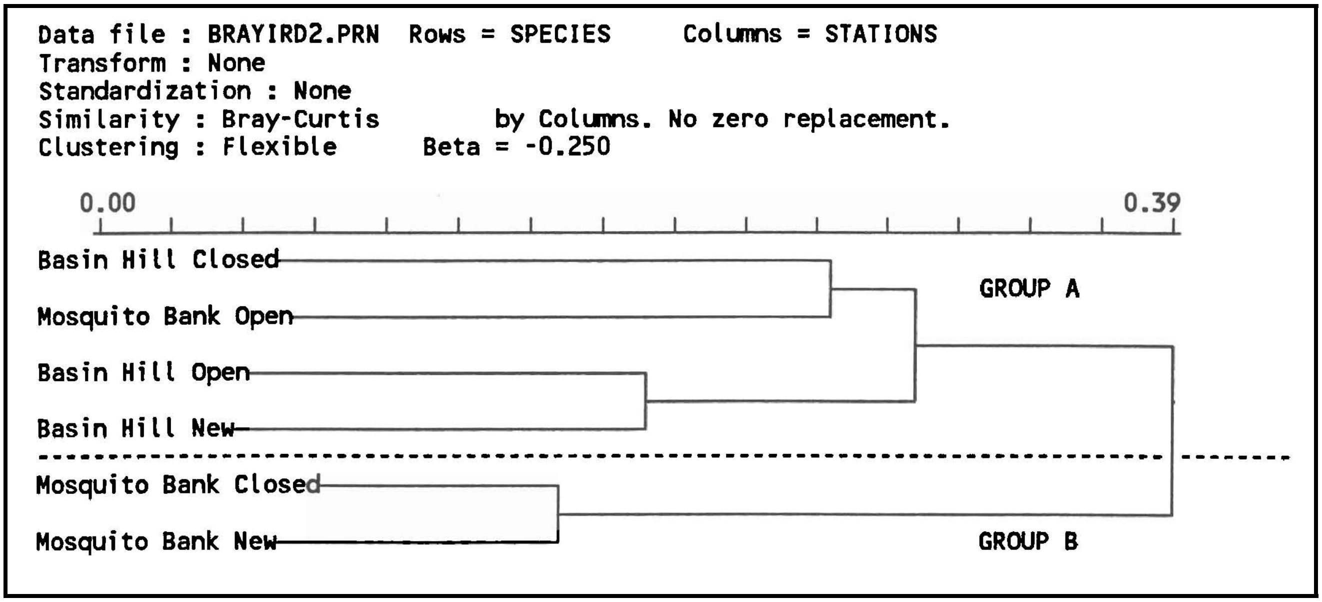
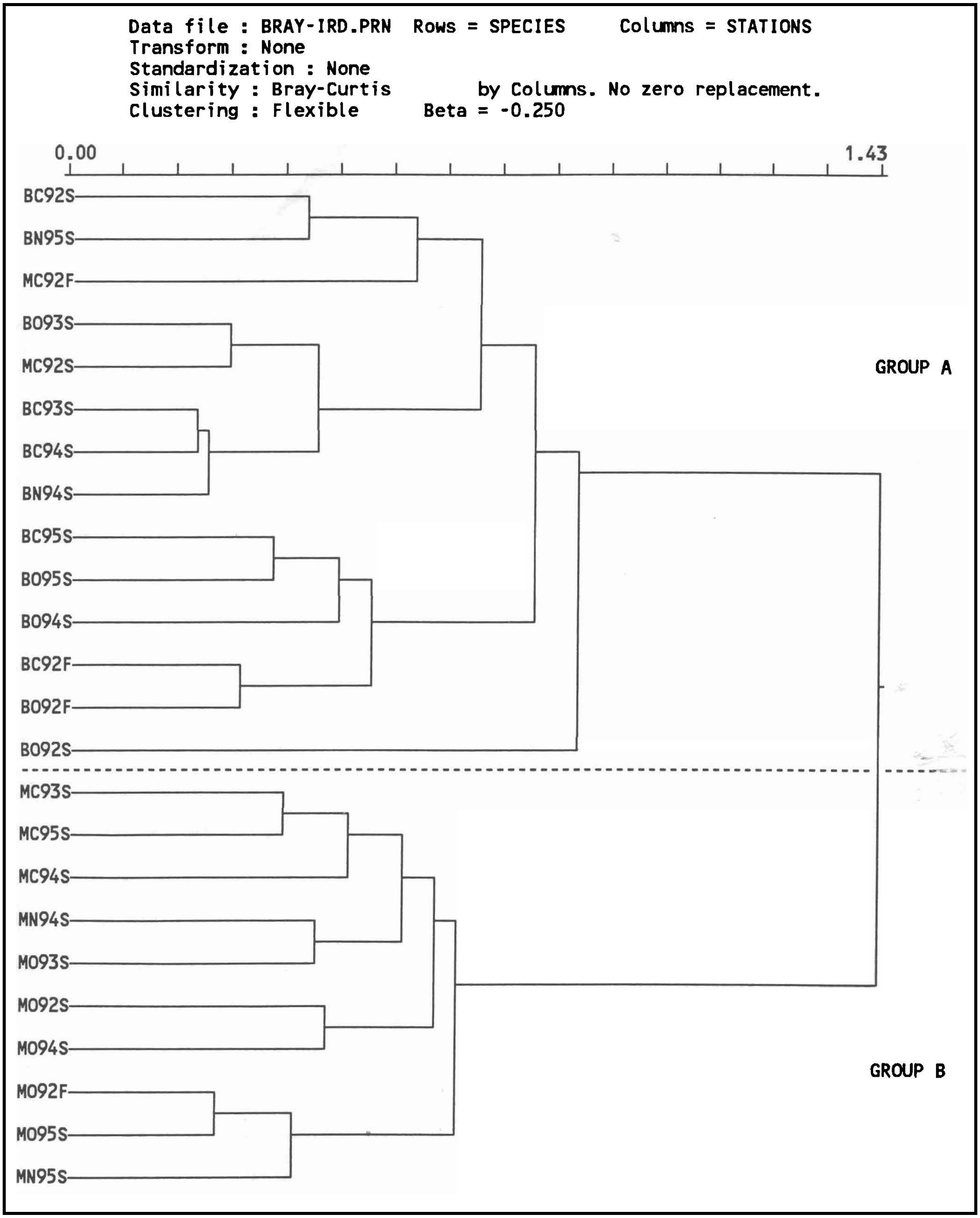


Figure 6. Dendrogram from Bray-Curtis similarity matrix of reef fish visual census samples for John Pennekamp Coral Reef State Park, Florida, May 15, 1992 – June 27, 1995. Data analyzed were pooled mean species abundance data (IRD > 0.05, n=48) for study reefs by season.



Chapter 4. Summary of Dry Tortugas Research

James A. Bohnsack and David B. McClellan

Fishery Landings Trends

In 1994 we summarized commercial and recreational fishery trends for Monroe County, including the Dry Tortugas (Bohnsack, et al., 1994). In that publication headboat landings were reported by weight (Table 3) and numbers (Table 6) from the Dry Tortugas. The Dry Tortugas accounted for 23% of the total 5.8 x 10^3 fish landed by headboats. Reef fishes accounted for 97% of Dry Tortugas headboat landings. Interestingly, between 1989 through 1991, more grouper were landed from the Dry Tortugas, despite the smaller total area, than the rest of the Florida Keys.

Visual Reef Fish Assessments

In 1978, data were collected on fish assemblages on isolated coral heads and observations made on the effects of a severe cold snap on corals in the Dry Tortugas (Bohnsack 1983).

With support from NOAA, NURC, and BRD of USGS, we have been involved in various cruises conducted annually in the Dry Tortugas between 1994 and 1997 where data were collected to assess reef fish community structure on 30 reef sites inside and outside the Dry Tortugas National Park (DTNP) (Fig. 1). Data were collected using a stationary point sampling technique (Bohnsack and Bannerot 1986) and a 15 min swimming predator search (Bohnsack 1982). A total of 518 stationary samples were collected from 9 reefs in DTNP, 20 reefs in FKNMS, and 1 reef, Sherwood Forest, outside the FKNMS boundary in the Gulf of Mexico (Table 1). A total of 162 species (76,408 individual fish) were observed in this effort (Table 2) and are statistically summarized in Table 3.

A total of 129 predator searches were also conducted on 11 reefs in DTNP and 6 reefs in FKNMS between 1994 and 1997 (Table 4). During these surveys, 39 piscivorous predatory species were observed (Table 5), including 11,794 individuals. Surveys are statistically summarized in Table 6.

In 1998, divers observed 88 species (6,961 individuals) in 80 visual point samples from seven reefs. During 12 predator searches, NMFS divers observed 20 predatory species (367 individuals) on 3 reefs.

Comparison of Reef Fish Assemblages inside DTNP and outside DTNP

Cluster analysis was used to distinguish fish assemblages between reefs inside versus outside Dry Tortugas National Park boundaries (Fig. 2). A comparison was made of fishes on reefs inside and outside DTNP with data collected through1997 (Table 7, Fig. 3). There were obvious habitat differences between sites inside and outside DTNP. Sites inside DTNP tended to be shallower (Fig. 4), more turbid, and more likely to have sand substrate and seagrasses. The substrate had higher cover of coral or 'rock' outside DTNP (Fig. 4). Performance of various parameters were analyzed by reef and compared between sites inside and outside DTNP. Reefs outside DTNP tended to have a higher average number of individuals (mostly planktivorous damselfishes, Fig. 3), species, total biomass (Fig. 5) as well as being deeper and with more hard substrate (Table 8, Fig, 4). Performance analyses showed total snapper were more variable outside DTNP (Fig. 6A) primarily because of large schools of yellowtail snapper (*Ocyurus chryurus*) (Fig. 8C). Mean total grouper varied similarly inside and outside DTNP (Fig. 6B). Hogfish (*Lachnolaimus maximus*) were more consistently observed and less variable inside DTNP but at lower abundances (Fig. 6C). Among individual species, black grouper (*Mycteroperca bonaci*) were more frequently seen in DTNP than outside (Fig. 7C). As with yellowtail, the mean abundance of mutton snapper (*Lutjanus apodus*) was more variable outside DTNP (Fig. 7B).

Literature Cited

Bohnsack, J.A. 1982. The effects of piscivorous predator removal on coral reef fish community structure. 1981 Gutshop: Third Pacific Technical Workshop Fish Food Habits Studies. Washington Sea Grant Publication. pp 258-267.

Bohnsack, J.A. 1983. Resiliency of reef fish communities in the Florida Keys following a January 1977 hypothermal fish kill. Env. Biol. Fish 9: 41-53.

Bohnsack, J.A., and S.P. Bannerot. 1986. A stationary visual census technique for quantitatively assessing community structure of coral reef fishes. NOAA Tech. Rep. NMFS 41:1-15.

Bohnsack, J.A., D.E. Harper, and D.B. McClellan. 1994. Fisheries trends from Monroe County, Florida. Bull. Mar. Sci. 54:982-1018.

Table 1. Summary of Dry Tortugas stationary point sampling effort (1994 - 1997).

Geog. Posit. Reef	Sq Km	Log Area m2	Reef code	POINTSAMPLES 1994 APR	MAY	JUN	JUL	AUG	SEP	OCT	1995 APR	MAY	JUN	JUL	AUG	SEP	OCT	1996 APR	MAY	JUN	JUL	AUG	SEP	OCT	1997 MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
Dry Tortugas	466.17	8.67																															518
Inside Park																																	
55 Pulaski Shoal			PS			14										11				12					12					12			61
57 Long/Bird Key			LB			28										12				12										22			74
58 White Shoal			WS			14														12					9					22			57
59 Loggerhead Key			LG			21														12										10			43
60 Texas Rock			TX			11														12										14			37
64 Twin Peaks			TP			10																											10
67 Little Africa			LA			26														12					13								51
68 ReplenishZone			RZ			8																											8
89 Guys Grotto			GG																											12			12
FKNMS																																	
54 Cecilys Hump			CC																									3					3
61 Tortugas Bank			TB			12									9																		21
65 Hangover Reef			HO			12																											12
66 Joe's Hump			JH			16														16													32
86 Crosby's Hump			CZ																	12								7					19
91 EightFathom Bank			EF																						8								8
92 Black Coral Bank			BL																						8								8
101 Hump 1			H1																									5					5
102 Hump 2			H2																									3					3
103 Hump 3			H3																									6					6
104 Garys Anchor			GA																									6					6
105 Tortugas Flat			TF																									5					5
112 Sherwood Forest			SF																											8			8
113 Marker H			MH																											4			4
114 Mauro Vetaric			MV																											9			9
115 Devils Reef			DV																											8			8
93 Little Bank			LB																						8								8

Table 2. Cumulative species listing for all 1994-1997 stationary point sampling. SPCODE is species code derived from first 3 letters of genera and first four letters from species. NUM is number of individuals observed.

	SPCODE	NUM	SPECIES	COMMON NAME	FAMILY	FAMILY NAME
1	ABU SAXA	10	Abudefduf saxatilis	Sergeant major	POMACENTRIDAE	Damselfishes
2	ACA BAHI	30	Acanthurus bahianus	Ocean surgeon	ACANTHURIDAE	Surgeonfishes
3	ACA CHIR	50	Acanthurus chirurgus	Doctorfish	ACANTHURIDAE	Surgeonfishes
4	ACA COER	60	Acanthurus coeruleus	Blue tang	ACANTHURIDAE	Surgeonfishes
5	AET NARI	66	Aetobatus narinari	Spotted eagle ray	MYLIOBATIDAE	Eagle rays
6	ALE CILI	70	Alectis ciliaris	African pompano	CARANGIDAE	Jacks
7	ALU SCRI	90	Aluterus scriptus	Scrawled filefish	BALISTIDAE	Leatherjackets
8	ANI VIRG	120	Anisotremus virginicus	Porkfish	HAEMULIDAE	Grunts
9	APO BINO	125	Apogon binotatus	Barred cardinalfish	APOGONIDAE	Cardinalfishes
10	AUL MACU	180	Aulostomus maculatus	Trumpetfish	AULOSTOMIDAE	Trumpetfishes
11	BAL VETU	200	Balistes vetula	Queen triggerfish	BALISTIDAE	Leatherjackets
12	BLE CRIS	210	Blennius cristata	Molly miller	BLENNIIDAE	Combtooth blennies
13	BOD RUFU	220	Bodianus rufus	Spanish hogfish	LABRIDAE	Wrasses
14	CAL BAJO	240	Calamus bajonado	Jolthead porgy	SPARIDAE	Porgies
15	CAL CALA	260	Calamus calamus	Saucereye porgy	SPARIDAE	Porgies
16	CAN MACR	280	Cantherhines macrocerus	Whitespotted filefish	BALISTIDAE	Leatherjackets
17	CAN PULL	290	Cantherhines pullus	Orangespotted filefish	BALISTIDAE	Leatherjackets
18	CAN ROST	300	Canthigaster rostrata	Sharpnose puffer	TETRAODONTIDAE	Puffers
19	CAN SUFF	310	Canthidermis sufflamen	Ocean triggerfish	BALISTIDAE	Leatherjackets
20	CAR BART	320	Caranx bartholomaei	Yellow jack	CARANGIDAE	Jacks
21	CAR CRYS	330	Caranx crysos	Blue runner	CARANGIDAE	Jacks
22	CAR HIPP	340	Caranx hippos	Crevalle jack	CARANGIDAE	Jacks
23	CAR RUBE	350	Caranx ruber	Bar jack	CARANGIDAE	Jacks
24	CHA CAPI	370	Chaetodon capistratus	Foureye butterflyfish	CHAETODONTIDAE	Butterflyfishes
25	CHA OCEL	390	Chaetodon ocellatus	Spotfin butterflyfish	CHAETODONTIDAE	Butterflyfishes
26	CHA SEDE	400	Chaetodon sedentarius	Reef butterflyfish	CHAETODONTIDAE	Butterflyfishes
27	CHA STRI	410	Chaetodon striatus	Banded butterflyfish	CHAETODONTIDAE	Butterflyfishes
28	CHR CYAN	430	Chromis cyaneus	Blue chromis	POMACENTRIDAE	Damselfishes
29	CHR ENCH	435	Chromis enchrysurus	Yellowtail reeffish	POMACENTRIDAE	Damselfishes
30	CHR INSO	440	Chromis insolatus	Sunshinefish	POMACENTRIDAE	Damselfishes
31	CHR MULT	450	Chromis multilineatus	Brown chromis	POMACENTRIDAE	Damselfishes
32	CHR SCOT	460	Chromis scotti	Purple reeffish	POMACENTRIDAE	Damselfishes
33	CLE PARR	470	Clepticus parrai	Creole wrasse	LABRIDAE	Wrasses
34	COR DICR	480	Coryphopterus dicrus	Colon goby	GOBIIDAE	Gobies
35	COR EIDO	485	Coryphopterus eidolon	Pallid goby	GOBIIDAE	Gobies
36	COR GLAU	490	Coryphopterus glaucofraenum	Bridled goby	GOBIIDAE	Gobies
37	COR PERS	493	Coryphopterus personatus	Masked goby	GOBIIDAE	Gobies
38	COR SPE.	495	Coryphopterus species	Unknown goby	GOBIIDAE	Gobies
39	CRY ROSE	510	Cryptotomus roseus	Bluelip parrotfish	SCARIDAE	Parrotfishes
40	DAS AMER	530	Dasyatis americana	Southern stingray	DASYATIDAE	Stingrays
41	DEC MACA	540	Decapterus macarellus	Mackerel scad	CARANGIDAE	Jacks
42	DIO HYST	570	Diodon hystrix	Porcupinefish	DIODONTIDAE	Porcupinefishes
43	DIP ARGE	577	Diplodus argenteus	Silver porgy	SPARIDAE	Porgies
44	ECH NAUC	590	Echeneis naucrates	Sharksucker	ECHENEIDAE	Remoras
45	EPI ADSC	650	Epinephelus adscensionis	Rock hind	SERRANIDAE	Sea basses
46	EPI CRUE	660	Epinephelus cruentatus	Graysby	SERRANIDAE	Sea basses
47	EPI FULV	675	Epinephelus fulvus	Coney	SERRANIDAE	Sea basses
48	EPI GUTT	680	Epinephelus guttatus	Red hind	SERRANIDAE	Sea basses
49	EPI ITAJ	685	Epinephelus itajara	Jewfish	SERRANIDAE	Sea basses
50	EPI MORI	690	Epinephelus morio	Red grouper	SERRANIDAE	Sea basses
51	EPI STRI	710	Epinephelus striatus	Nassau grouper	SERRANIDAE	Sea basses
52	EQU ACUM	720	Equetus acuminatus	High-hat	SCIAENIDAE	Drums
53	GIN CIRR	760	Ginglymostoma cirratum	Nurse shark	ORECTOLOBIDAE	Carpet sharks
54	GNA THOM	770	Gnatholepis thompsoni	Goldspot goby	GOBIIDAE	Gobies
55	GOB OCEA	790	Gobiosoma oceanops	Neon goby	GOBIIDAE	Gobies
56	GOB RAND	793	Gobiosoma randalli	Yellownose goby	GOBIIDAE	Gobies
57	GOB SPE.	795	Goby-like fish	Goby-like fish	GOBIIDAE	Gobies
58	GYM MORI	830	Gymnothorax moringa	Spotted moray	MURAENIDAE	Morays
59	HAE AURO	870	Haemulon aurolineatum	Tomtate	HAEMULIDAE	Grunts
60	HAE CARB	880	Haemulon carbonarium	Caesar grunt	HAEMULIDAE	Grunts
61	HAE CHRY	890	Haemulon chrysargyreum	Smallmouth grunt	HAEMULIDAE	Grunts

Table 2 (cont.)

	SPCODE	NUM	SPECIES	COMMON NAME	FAMILY	FAMILY NAME
62	HAE FLAV	900	Haemulon flavolineatum	French grunt	HAEMULIDAE	Grunts
63	HAE MACR	910	Haemulon macrostomum	Spanish grunt	HAEMULIDAE	Grunts
64	HAE MELA	920	Haemulon melanurum	Cottonwick	HAEMULIDAE	Grunts
65	HAE PARR	930	Haemulon parrai	Sailor's choice	HAEMULIDAE	Grunts
66	HAE PLUM	940	Haemulon plumieri	White grunt	HAEMULIDAE	Grunts
67	HAE SCIU	950	Haemulon sciurus	Bluestriped grunt	HAEMULIDAE	Grunts
68	HAE SPE.	955	Haemulon sp.	Unidentified grunt	HAEMULIDAE	Grunts
69	HAE STRI	960	Haemulon striatum	Striped grunt	HAEMULIDAE	Grunts
70	HAL BIVI	970	Halichoeres bivittatus	Slippery dick	LABRIDAE	Wrasses
71	HAL CYAN	975	Halichoeres cyanocephalus	Yellowcheek wrasse	LABRIDAE	Wrasses
72	HAL GARN	980	Halichoeres garnoti	Yellowhead wrasse	LABRIDAE	Wrasses
73	HAL MACU	990	Halichoeres maculipinna	Clown wrasse	LABRIDAE	Wrasses
74	HAL POEY	1010	Halichoeres poeyi	Blackear wrasse	LABRIDAE	Wrasses
75	HAL RADI	1020	Halichoeres radiatus	Puddingwife	LABRIDAE	Wrasses
76	HEM BRAS	1030	Hemiramphus brasiliensis	Ballyhoo	EXOCETIDAE	Flyingfishes/Halfbeaks
77	HEM MART	1035	Hemipteronotus martinicensis	Rosy razorfish	LABRIDAE	Wrasses
78	HEM SIMU	1050	Hemiemblemaria simulus	Wrasse blenny	CLINIDAE	Clinids
79	HOL ADSC	1070	Holocentrus adscensionis	Squirrelfish	HOLOCENTRIDAE	Squirrelfishes
80	HOL BERM	1080	Holacanthus bermudensis	Blue angelfish	POMACANTHIDAE	Angelfishes
81	HOL CILI	1090	Holacanthus ciliaris	Queen angelfish	POMACANTHIDAE	Angelfishes
82	HOL RUFU	1120	Holocentrus rufus	Longspine squirrelfish	HOLOCENTRIDAE	Squirrelfishes
83	HOL TOWN	1128	Holacanthus (bermudensis x ciliaris)	Townsend angelfish	POMACANTHIDAE	Angelfishes
84	HOL TRIC	1130	Holacanthus tricolor	Rock beauty	POMACANTHIDAE	Angelfishes
85	HOL VEXI	1140	Holocentrus vexillarius	Dusky squirrelfish	HOLOCENTRIDAE	Squirrelfishes
86	HYP BERM	1150	Hypleurochilus bermudensis	Barred blenny	BLENNIIDAE	Combtooth blennies
87	HYP GEMM	1160	Hypoplectrus gemma #	Blue hamlet	SERRANIDAE	Sea basses
88	HYP GUTT	1162	Hypoplectrus guttavarius #	Shy hamlet	SERRANIDAE	Sea basses
89	HYP HYBR	1165	Hypoplectrus (hybrid) #	Hybrid hamlet	SERRANIDAE	Sea basses
90	HYP INDI	1166	Hypoplectrus indigo #	Indigo hamlet	SERRANIDAE	Sea basses
91	HYP NIGR	1170	Hyploplectrus nigricans #	Black hamlet	SERRANIDAE	Sea basses
92	HYP PUEL	1180	Hypoplectrus puella #	Barred hamlet	SERRANIDAE	Sea basses
93	HYP TANN	1195	Hypoplectrus (tan) #	Tan hamlet	SERRANIDAE	Sea basses
94	HYP UNIC	1190	Hypoplectrus unicolor	Butter hamlet	SERRANIDAE	Sea basses
95	INE VITT	1200	Inermia vittata	Boga	EMMELICHTHYIDAE	Bonnetmouths
96	IOG CALL	1210	Ioglossus calliurus	Blue goby	GOBIIDAE	Gobies
97	IOG HELE	1215	Ioglossus helenae	Hovering goby	GOBIIDAE	Gobies
98	KYP SECT	1230	Kyphosus sectatrix	Bermuda chub	KYPHOSIDAE	Sea chubs
99	LAC BICA	1240	Lactophrys bicaudalis	Spotted trunkfish	OSTRACIIDAE	Boxfishes
100	LAC MAXI	1250	Lachnolaimus maximus	Hogfish	LABRIDAE	Wrasses
101	LAC TRIQ	1290	Lactophrys triqueter	Smooth trunkfish	OSTRACIIDAE	Boxfishes
102	LUT ANAL	1310	Lutjanus analis	Mutton snapper	LUTJANIDAE	Snappers
103	LUT APOD	1320	Lutjanus apodus	Schoolmaster	LUTJANIDAE	Snappers
104	LUT GRIS	1350	Lutjanus griseus	Gray snapper	LUTJANIDAE	Snappers
105	LUT JOCU	1360	Lutjanus jocu	Dog snapper	LUTJANIDAE	Snappers
106	LUT MAHO	1370	Lutjanus mahogoni	Mahogany snapper	LUTJANIDAE	Snappers
107	LUT SYNA	1385	Lutjanus synagris	Lane snapper	LUTJANIDAE	Snappers
108	MAL MACR	1410	Malacoctenus macrops	Rosy blenny	CLINIDAE	Clinids
109	MAL PLUM	1420	Malacanthus plumieri	Sand tilefish	MALACANTHIDAE	Tilefishes
110	MAL TRIA	1430	Malacoctenus triangulatus	Saddled blenny	CLINIDAE	Clinids
111	MAL VERS	1440	Malacoctenus versicolor	Barfin blenny	CLINIDAE	Clinids
112	MEG ATLA	1460	Megalops atlanticus	Tarpon	ELOPIDAE	Tarpons
113	MIC CHRY	1480	Microspathodon chrysurus	Yellowtail damselfish	POMACENTRIDAE	Damselfishes
114	MON TUCK	1500	Monacanthus tuckeri	Slender filefish	BALISTIDAE	Leatherjackets
115	MUL MART	1510	Mulloidichthys martinicus	Yellow goatfish	MULLIDAE	Goatfishes
116	MYC BONA	1540	Mycteroperca bonaci	Black grouper	SERRANIDAE	Sea basses
117	MYC MICR	1550	Mycteroperca microlepis	Gag	SERRANIDAE	Sea basses
118	MYC PHEN	1560	Mycteroperca phenax	Scamp	SERRANIDAE	Sea basses
119	OCY CHRY	1600	Ocyurus chrysurus	Yellowtail snapper	LUTJANIDAE	Snappers
120	ODO DENT	1610	Odontoscion dentex	Reef crocker	SCIAENIDAE	Drums
121	OPH ATLA	1630	Ophioblennius atlanticus	Redlip blenny	BLENNIIDAE	Combtooth blennies
122	OPI AURI	1650	Opistognathus aurifrons	Yellowhead jawfish	OPISTOGNATHIDAE	Jawfishes

Table 2 (cont.)

	SPCODE	NUM	SPECIES	COMMON NAME	FAMILY	FAMILY NAME
	=========	=======	============================	==================	=================	================
123	PAR FURC	1695	Paranthias furcifer	Creole-fish	SERRANIDAE	Sea basses
124	PAR MARM	1700	Paraclinus marmoratus	Marbled blenny	CLINIDAE	Clinids
125	POM ARCU	1740	Pomacanthus arcuatus	Gray angelfish	POMACANTHIDAE	Angelfishes
126	POM DIEN	1750	Pomacentrus diencaeus	Longfin damselfish	POMACENTRIDAE	Damselfishes
127	POM FUSC	1760	Pomacentrus fuscus	Dusky damselfish	POMACENTRIDAE	Damselfishes
128	POM LEUC	1770	Pomacentrus leucostictus	Beaugregory	POMACENTRIDAE	Damselfishes
129	POM PART	1780	Pomacentrus partitus	Bicolor damselfish	POMACENTRIDAE	Damselfishes
130	POM PARU	1790	Pomacanthus paru	French angelfish	POMACANTHIDAE	Angelfishes
131	POM PLAN	1800	Pomacentrus planifrons	Three spot damselfish	POMACENTRIDAE	Damselfishes
132	POM VARI	1810	Pomacentrus variabilis	Cocoa damselfish	POMACENTRIDAE	Damselfishes
133	PRI AREN	1820	Priacanthus arenatus	Bigeye	PRIACANTHIDAE	Bigeyes
134	PSE MACU	1840	Pseudupeneus maculatus	Spotted goatfish	MULLIDAE	Goatfishes
135	SCA COEL	1870	Scarus coelestinus	Midnight parrotfish	SCARIDAE	Parrotfishes
136	SCA COER	1880	Scarus coeruleus	Blue parrotfish	SCARIDAE	Parrotfishes
137	SCA CRIS	1885	Scartella cristata	Molly miller	BLENNIIDAE	Combtooth blennies
138	SCA CROI	1890	Scarus croicensis	Striped parrotfish	SCARIDAE	Parrotfishes
139	SCA GUAC	1900	Scarus guacamaia	Rainbow parrotfish	SCARIDAE	Parrotfishes
140	SCA TAEN	1910	Scarus taeniopterus	Princess parrotfish	SCARIDAE	Parrotfishes
141	SCA VETU	1920	Scarus vetula	Queen parrotfish	SCARIDAE	Parrotfishes
142	SCO CAVA	1930	Scomberomorus cavalla	King mackerel	SCOMBRIDAE	Mackerels/Tunas
143	SCO MACU	1940	Scomberomorus maculatus	Spanish mackerel	SCOMBRIDAE	Mackerels/Tunas
144	SCO REGA	1960	Scomberomorus regalis	Cero mackerel	SCOMBRIDAE	Mackerels/Tunas
145	SER BALD	1980	Serranus baldwini	Lanternfish	SERRANIDAE	Sea basses
146	SER DUME	1990	Seriola dumerili	Greater amberjack	CARANGIDAE	Jacks
147	SER RIVO	2000	Seriola rivoliana	Almaco jack	CARANGIDAE	Jacks
148	SER TABA	2010	Serranus tabacarius	Tobaccofish	SERRANIDAE	Sea basses
149	SER TIGR	2020	Serranus tigrinus	Harlequin bass	SERRANIDAE	Sea basses
150	SER TORT	2030	Serranus tortugarum	Chalk bass	SERRANIDAE	Sea basses
151	SPA ATOM	2040	Sparisoma atomarium	Greenblotch parrotfish	SCARIDAE	Parrotfishes
152	SPA AURO	2050	Sparisoma aurofrenatum	Redband parrotfish	SCARIDAE	Parrotfishes
153	SPA CHRY	2060	Sparisoma chrysopterum	Redtail parrotfish	SCARIDAE	Parrotfishes
154	SPA RADI	2070	Sparisoma radians	Bucktooth parrotfish	SCARIDAE	Parrotfishes
155	SPA RUBR	2080	Sparisoma rubripinne	Yellowtail parrotfish	SCARIDAE	Parrotfishes
156	SPA VIRI	2090	Sparisoma viride	Stoplight parrotfish	SCARIDAE	Parrotfishes
157	SPH BARR	2095	Sphyraena barracuda	Barracuda	SPHYRAENIDAE	Barracudas
158	SPH SPEN	2120	Sphoeroides spengleri	Bandtail puffer	TETRAODONTIDAE	Puffers
159	SYN INTE	2180	Synodus intermedius	Sand diver	SYNODONTIDAE	Lizardfishes
160	THA BIFA	2190	Thalassoma bifasciatum	Bluehead	LABRIDAE	Wrasses
161	TRA FALC	2200	Trachinotus falcatus	Permit	CARANGIDAE	Jacks
162	URO JAMA	2800	Urolophus jamaicensis	Yellow stingray	DASYATIDAE	Stingrays

Table 3. Statistical summary of Dry Tortugas reef fish visual censuses (1994 - 1997).

			SAMPLE FREQUENCY				SAMP. FREQ. RANGE		FISH LENGTH (cm)			BIOMASS
	Species	Total Indiv.	(N = 518)	%	Mean Abund.	Stand. Dev.	High	Low	Mean	Min.	Max.	Total (gms)
1	ABU SAXA	1,426	122	23.6%	2.8	8.33	56	0	9.3	2	13	41,321.6
2	ACA BAHI	434	160	30.9%	0.8	1.95	18	0	10.9	3	23	17,062.2
3	ACA CHIR	257	100	19.3%	0.5	1.50	17	0	12.2	2	35	18,471.4
4	ACA COER	879	340	65.6%	1.7	2.87	45	0	12.7	2	33	82,459.2
5	AET NARI	1	1	0.2%	0.0	0.04	1	0	90.0	90	90	238.1
6	ALE CILI	9	3	0.6%	0.0	0.25	5	0	82.2	70	100	92,523.9
7	ALU SCRI	4	4	0.8%	0.0	0.09	1	0	39.3	22	55	2,788.9
8	ANI VIRG	82	60	11.6%	0.2	0.51	5	0	14.6	4	36	12,445.1
9	APO BINO	1	1	0.2%	0.0	0.04	1	0	5.0	5	5	2.2
10	AUL MACU	19	18	3.5%	0.0	0.20	2	0	36.1	16	60	2,738.1
11	BAL VETU	2	2	0.4%	0.0	0.06	1	0	32.5	30	35	1,803.2
12	BLE CRIS	4	2	0.4%	0.0	0.14	3	0	4.8	4	5	4.9
13	BOD RUFU	60	51	9.8%	0.1	0.38	3	0	19.5	3	36	12,068.6
14	CAL BAJO	5	3	0.6%	0.0	0.15	3	0	28.8	12	38	3,585.7
15	CAL CALA	204	141	27.2%	0.4	0.75	4	0	17.3	3	39	36,644.5
16	CAN MACR	3	3	0.6%	0.0	0.08	1	0	24.7	15	30	967.8
17	CAN PULL	11	9	1.7%	0.0	0.17	2	0	10.9	6	16	407.3
18	CAN ROST	122	86	16.6%	0.2	0.65	8	0	5.4	2	10	568.0
19	CAN SUFF	11	9	1.7%	0.0	0.17	2	0	41.6	26	60	19,919.6
20	CAR BART	105	19	3.7%	0.2	2.31	50	0	33.2	18	65	86,514.6
21	CAR CRYS	82	12	2.3%	0.2	1.53	25	0	20.4	15	40	17,251.3
22	CAR HIPP	1	1	0.2%	0.0	0.04	1	0	75.0	75	75	6,944.5
23	CAR RUBE	1,002	78	15.1%	1.9	14.27	300	0	20.2	2	70	181,564.1
24	CHA CAPI	295	152	29.3%	0.6	1.02	6	0	7.6	2	12	4,625.3
25	CHA OCEL	238	135	26.1%	0.5	0.88	6	0	10.0	3	16	7,919.0
26	CHA SEDE	116	64	12.4%	0.2	0.70	7	0	8.1	2	13	2,190.2
27	CHA STRI	19	14	2.7%	0.0	0.23	2	0	8.7	2	12	500.1
28	CHR CYAN	1,192	136	26.3%	2.3	7.27	75	0	5.6	1	15	9,030.8
29	CHR ENCH	38	8	1.5%	0.1	0.80	11	0	2.3	1	4	13.2
30	CHR INSO	5	5	1.0%	0.0	0.10	1	0	4.2	2	6	11.1
31	CHR MULT	907	34	6.6%	1.8	13.09	195	0	8.9	4	12	19,775.6
32	CHR SCOT	4,288	189	36.5%	8.3	24.87	350	0	4.2	1	10	11,156.8
33	CLE PARR	1,135	46	8.9%	2.2	12.61	200	0	12.9	2	30	65,402.9
34	COR DICR	61	31	6.0%	0.1	0.64	9	0	3.4	2	6	39.6
35	COR EIDO	4	3	0.6%	0.0	0.11	2	0	2.3	2	3	0.7
36	COR GLAU	1,093	212	40.9%	2.1	4.40	35	0	3.2	1	8	602.2
37	COR PERS	12,437	212	40.9%	24.0	55.70	600	0	2.6	1	6	3,345.4
38	COR SPE.	50	1	0.2%	0.1	2.20	50	0	2.0	2	3	5.4
39	CRY ROSE	4	3	0.6%	0.0	0.11	2	0	4.8	3	8	47.6
40	DAS AMER	9	8	1.5%	0.0	0.14	2	0	153.3	80	200	210,638.3
41	DEC MACA	20	1	0.2%	0.0	0.88	20	0	8.0	6	9	116.6
42	DIO HYST	2	2	0.4%	0.0	0.06	1	0	30.5	26	35	2,628.4
43	DIP ARGE	2	2	0.4%	0.0	0.06	1	0	13.0	9	17	116.6
44	ECH NAUC	4	4	0.8%	0.0	0.09	1	0	10.0	9	12	66.9
45	EPI ADSC	7	6	1.2%	0.0	0.13	2	0	26.3	15	35	2,449.0
46	EPI CRUE	128	82	15.8%	0.2	1.14	23	0	19.6	5	35	19,255.9
47	EPI FULV	1	1	0.2%	0.0	0.04	1	0	26.0	26	26	270.6
48	EPI GUTT	15	14	2.7%	0.0	0.18	2	0	23.9	12	43	5,005.0
49	EPI ITAJ	3	3	0.6%	0.0	0.08	1	0	135.3	6	200	320,814.3
50	EPI MORI	88	74	14.3%	0.2	0.45	3	0	40.2	7	75	102,876.8
51	EPI STRI	3	3	0.6%	0.0	0.08	1	0	48.3	40	60	5,972.9
52	EQU ACUM	6	3	0.6%	0.0	0.19	4	0	9.2	3	12	84.4
53	GIN CIRR	1	1	0.2%	0.0	0.04	1	0	100.0	100	100	6,414.4
54	GNA THOM	103	20	3.9%	0.2	1.35	17	0	3.1	2	5	31.1
55	GOB OCEA	356	140	27.0%	0.7	1.58	16	0	2.6	1	5	70.9
56	GOB RAND	1	1	0.2%	0.0	0.04	1	0	3.0	3	3	0.3
57	GOB SPE.	4	1	0.2%	0.0	0.18	4	0	3.0	2	3	0.8
58	GYM MORI	1	1	0.2%	0.0	0.04	1	0	40.0	40	40	114.9
59	HAE AURO	5,648	68	13.1%	10.9	48.19	500	0	5.0	1	15	14,407.4
60	HAE CARB	44	12	2.3%	0.1	0.80	12	0	19.8	4	30	8,849.9
61	HAE CHRY	1	1	0.2%	0.0	0.04	1	0	16.0	16	16	157.0
62	HAE FLAV	1,099	109	21.0%	2.1	11.09	150	0	10.7	3	25	41,152.6
63	HAE MACR	28	10	1.9%	0.1	0.64	13	0	14.0	5	40	4,907.0
64	HAE MELA	6	2	0.4%	0.0	0.20	4	0	6.0	5	6	25.0
65	HAE PARR	9	3	0.6%	0.0	0.23	3	0	28.3	25	34	4,226.4
66	HAE PLUM	1,487	305	58.9%	2.9	5.83	55	0	13.1	2	40	147,127.9
67	HAE SCIU	109	35	6.8%	0.2	1.78	37	0	20.8	6	38	23,689.7

Table 3. (cont.)

			SAMPLE FREQUENCY				SAMP. FREQ. RANGE		FISH LENGTH (cm)			BIOMASS
	Species	Total Indiv.	(N = 518)	%	Mean Abund.	Stand. Dev.	High	Low	Mean	Min.	Max.	Total (gms)
68	HAE SPE.	1,132	17	3.3%	2.2	20.35	400	0	2.5	1	5	376.1
69	HAE STRI	4	1	0.2%	0.0	0.18	4	0	22.0	17	25	994.2
70	HAL BIVI	3,345	298	57.5%	6.5	10.37	80	0	5.7	1	15	9,465.6
71	HAL CYAN	6	4	0.8%	0.0	0.15	3	0	5.3	3	8	12.0
72	HAL GARN	1,026	253	48.8%	2.0	3.22	24	0	6.7	1	15	5,100.7
73	HAL MACU	469	132	25.5%	0.9	2.09	15	0	6.0	2	22	1,680.2
74	HAL POEY	6	4	0.8%	0.0	0.14	2	0	6.3	4	9	22.1
75	HAL RADI	39	34	6.6%	0.1	0.30	3	0	7.1	2	40	1,797.3
76	HEM BRAS	30	1	0.2%	0.1	1.32	30	0	14.0	14	14	1,571.1
77	HEM MART	2	2	0.4%	0.0	0.06	1	0	9.5	6	13	52.9
78	HEM SIMU	29	4	0.8%	0.1	1.14	26	0	3.1	3	4	16.9
79	HOL ADSC	113	27	5.2%	0.2	2.30	37	0	15.8	12	27	12,472.6
80	HOL BERM	342	197	38.0%	0.7	1.09	6	0	21.3	3	42	110,445.9
81	HOL CILI	70	49	9.5%	0.1	0.50	4	0	18.0	4	38	17,439.0
82	HOL RUFU	79	31	6.0%	0.2	0.81	9	0	20.8	7	35	17,683.9
83	HOL TOWN	1	1	0.2%	0.0	0.04	1	0	15.0	15	15	82.1
84	HOL TRIC	57	39	7.5%	0.1	0.42	3	0	14.2	4	24	5,761.2
85	HOL VEXI	4	3	0.6%	0.0	0.11	2	0	10.0	9	12	129.6
86	HYP BERM	5	5	1.0%	0.0	0.10	1	0	3.0	2	4	2.0
87	HYP GEMM	326	159	30.7%	0.6	1.51	21	0	6.4	3	13	1,619.4
88	HYP GUTT	3	1	0.2%	0.0	0.13	3	0	7.0	5	10	23.9
89	HYP HYBR	1	1	0.2%	0.0	0.04	1	0	8.0	8	8	8.2
90	HYP INDI	4	4	0.8%	0.0	0.09	1	0	7.3	6	9	25.9
91	HYP NIGR	42	36	6.9%	0.1	0.32	3	0	6.1	3	11	197.9
92	HYP PUEL	156	119	23.0%	0.3	0.62	3	0	6.2	3	11	724.8
93	HYP TANN	29	25	4.8%	0.1	0.27	3	0	5.8	3	11	121.1
94	HYP UNIC	466	253	48.8%	0.9	1.23	10	0	6.1	2	12	2,090.4
95	INE VITT	514	5	1.0%	1.0	21.97	500	0	9.2	8	20	5,013.1
96	IOG CALL	22	9	1.7%	0.0	0.37	6	0	7.8	2	10	113.6
97	IOG HELE	5	2	0.4%	0.0	0.18	4	0	5.2	4	10	11.3
98	KYP SECT	274	30	5.8%	0.5	3.31	40	0	28.3	10	70	201,319.3
99	LAC BICA	3	3	0.6%	0.0	0.08	1	0	16.0	7	21	532.9
100	LAC MAXI	91	60	11.6%	0.2	0.61	8	0	34.2	2	60	94,072.2
101	LAC TRIQ	11	9	1.7%	0.0	0.17	2	0	16.7	11	22	1,934.8
102	LUT ANAL	75	44	8.5%	0.1	0.65	10	0	49.8	30	75	176,636.3
103	LUT APOD	22	10	1.9%	0.0	0.37	6	0	22.6	12	35	6,634.0
104	LUT GRIS	657	121	23.4%	1.3	3.76	31	0	26.6	8	50	268,226.0
105	LUT JOCU	2	2	0.4%	0.0	0.06	1	0	42.5	35	50	3,002.3
106	LUT MAHO	2	2	0.4%	0.0	0.06	1	0	25.5	24	27	576.5
107	LUT SYNA	21	3	0.6%	0.0	0.68	15	0	26.7	12	30	6,757.6
108	MAL MACR	157	57	11.0%	0.3	1.13	9	0	3.6	2	6	68.5
109	MAL PLUM	4	2	0.4%	0.0	0.12	2	0	9.5	6	15	54.1
110	MAL TRIA	321	135	26.1%	0.6	1.94	33	0	3.9	1	8	202.4
111	MAL VERS	5	2	0.4%	0.0	0.16	3	0	5.0	4	5	7.0
112	MEG ATLA	3	3	0.6%	0.0	0.08	1	0	161.7	135	200	148,902.3
113	MIC CHRY	64	41	7.9%	0.1	0.49	4	0	9.8	4	14	2,104.1
114	MON TUCK	4	4	0.8%	0.0	0.09	1	0	5.5	4	7	18.8
115	MUL MART	151	29	5.6%	0.3	2.25	40	0	19.7	3	42	38,792.5
116	MYC BONA	43	37	7.1%	0.1	0.32	2	0	48.0	12	100	112,387.0
117	MYC MICR	1	1	0.2%	0.0	0.04	1	0	30.0	30	30	389.0
118	MYC PHEN	33	20	3.9%	0.1	0.39	6	0	28.3	4	50	15,817.4
119	OCY CHRY	3,213	317	61.2%	6.2	18.02	250	0	16.9	2	50	369,271.1
120	ODO DENT	6	4	0.8%	0.0	0.14	2	0	15.0	11	18	235.5
121	OPH ATLA	16	9	1.7%	0.0	0.28	5	0	3.4	3	4	9.7
122	OPI AURI	593	109	21.0%	1.1	3.28	31	0	6.5	2	10	1,687.6
123	PAR FURC	25	1	0.2%	0.0	1.10	25	0	15.0	10	20	1,314.5
124	PAR MARM	52	20	3.9%	0.1	0.60	6	0	3.3	1	7	50.4
125	POM ARCU	214	145	28.0%	0.4	0.78	6	0	23.3	8	45	108,845.4
126	POM DIEN	16	6	1.2%	0.0	0.35	6	0	4.7	2	8	63.2
127	POM FUSC	805	108	20.8%	1.6	4.71	43	0	5.1	2	8	3,487.1
128	POM LEUC	807	190	36.7%	1.6	3.23	35	0	4.0	1	8	1,670.1
129	POM PART	3,358	237	45.8%	6.5	11.14	62	0	4.5	1	10	8,356.2
130	POM PARU	49	37	7.1%	0.1	0.39	4	0	26.7	4	50	38,894.6
131	POM PLAN	1,631	234	45.2%	3.1	5.78	54	0	5.6	2	10	9,418.7
132	POM VARI	1,992	382	73.7%	3.8	4.70	40	0	4.8	1	10	6,517.1
133	PRI AREN	11	2	0.4%	0.0	0.40	9	0	30.2	21	35	4,779.9
134	PSE MACU	151	78	15.1%	0.3	1.16	15	0	9.7	3	25	4,748.3
135	SCA COEL	19	9	1.7%	0.0	0.34	5	0	28.8	11	45	11,251.2

Table 3. (cont.)

	Species	Total Indiv.	SAMPLE FREQUENCY (N = 518)	%	Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE High	Low	FISH LENGTH (cm) Mean	Min.	Max.	BIOMASS Total (gms)
136	SCA COER	25	12	2.3%	0.0	0.45	8	0	18.0	4	45	8,732.0
137	SCA CRIS	13	4	0.8%	0.0	0.45	10	0	4.7	3	5	17.3
138	SCA CROI	7,936	473	91.3%	15.3	20.54	240	0	5.5	1	26	28,769.7
139	SCA GUAC	10	1	0.2%	0.0	0.44	10	0	40.0	30	50	13,019.8
140	SCA TAEN	373	80	15.4%	0.7	2.54	23	0	7.2	2	23	3,862.8
141	SCA VETU	19	13	2.5%	0.0	0.31	6	0	20.3	6	38	4,415.4
142	SCO CAVA	1	1	0.2%	0.0	0.04	1	0	110.0	110	110	9,737.9
143	SCO MACU	1	1	0.2%	0.0	0.04	1	0	70.0	70	70	2,812.2
144	SCO REGA	35	19	3.7%	0.1	0.53	10	0	42.0	29	80	23,844.6
145	SER BALD	8	5	1.0%	0.0	0.20	4	0	5.0	3	7	15.2
146	SER DUME	5	5	1.0%	0.0	0.10	1	0	88.0	35	120	60,204.3
147	SER RIVO	1	1	0.2%	0.0	0.04	1	0	50.0	50	50	2,259.4
148	SER TABA	71	43	8.3%	0.1	0.55	5	0	7.7	2	14	683.9
149	SER TIGR	56	43	8.3%	0.1	0.38	2	0	6.8	3	12	348.0
150	SER TORT	46	9	1.7%	0.1	1.00	20	0	4.7	2	10	101.5
151	SPA ATOM	312	86	16.6%	0.6	2.02	17	0	4.6	2	10	482.6
152	SPA AURO	1,344	366	70.7%	2.6	3.36	30	0	11.2	2	35	59,446.7
153	SPA CHRY	98	47	9.1%	0.2	0.95	16	0	16.6	4	32	13,451.0
154	SPA RADI	24	8	1.5%	0.0	0.46	8	0	5.9	4	14	112.6
155	SPA RUBR	61	31	6.0%	0.1	0.63	10	0	23.1	7	40	19,959.3
156	SPA VIRI	575	260	50.2%	1.1	1.57	10	0	18.8	2	45	138,962.9
157	SPH BARR	61	56	10.8%	0.1	0.35	2	0	90.2	33	190	496,031.0
158	SPH SPEN	5	5	1.0%	0.0	0.10	1	0	11.4	6	15	188.5
159	SYN INTE	7	7	1.4%	0.0	0.12	1	0	11.0	7	17	114.4
160	THA BIFA	6,298	419	80.9%	12.2	20.58	230	0	5.5	1	15	12,071.6
161	TRA FALC	1	1	0.2%	0.0	0.04	1	0	80.0	80	80	8,878.6
162	URO JAMA	2	2	0.4%	0.0	0.06	1	0	17.5	17	18	98.2

NO. SAMPLES = 518
NO. SPECIES = 162
TOT.INDIVIDUALS = 76,408
TOT. BIOMASS = 4437143.05

SAMPLE AREA - ALL DRY TORTUGAS SAMPLES
NO. OBSERVERS -
SAMPLING CONDITIONS -

Table 4. Summary of Dry Tortugas predator count effort (1994 - 1997).

Geog. Posit.	Reef	Sq Km	Log Area m2	Reef code	POINTSAMPLES 1994							1995							1996							1997								
					APR	MAY	JUN	JUL	AUG	SEP	OCT	APR	MAY	JUN	JUL	AUG	SEP	OCT	APR	MAY	JUN	JUL	AUG	SEP	OCT	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
					Number of Predator Searches																													
Dry Tortugas		466.17	8.67																															129
Inside Park																																		116
	955 Pulaski Shoal			PS			8														4					3					4			19
	956 French Wreck			FW			3														4					4								11
	957 Long/Bird Key			LB			10														4										8			22
	958 White Shoal			WS			4														4					3					8			19
	959 Loggerhead Key			LG																	4										1			5
	960 Texas Rock			TX			3														4										6			13
	967 Little Africa			LA			2														4					1								7
	987 Dave's Dive Site			DD																	4													4
	988 George's Gorge			GO																	4													4
	989 Guy's Grotto			GG																	4										4			8
	990 Joe's Crack			JC																	4													4
FKNMS																																		13
	961 Tortugas Bank			TB			4																											4
	964 Twin Peaks			TP			2																											2
	965 Hangover Reef			HO			2																											2
	1013 Marker H			MH																											1			1
	1014 Mauro Velaric			MV																											4			4
	1015 Devil's Reef			DV																											4			4

Table 5. Species listing for all 1994-1997 predator searches.

	SPCODE	NUM	SPECIES	COMMON NAME	FAMILY	FAMILY NAME
1	ALE CILI	70	Alectis ciliaris	African pompano	CARANGIDAE	Jacks
2	AUL MACU	180	Aulostomus maculatus	Trumpetfish	AULOSTOMIDAE	Trumpetfishes
3	CAR BART	320	Caranx bartholomaei	Yellow jack	CARANGIDAE	Jacks
4	CAR CRYS	330	Caranx crysos	Blue runner	CARANGIDAE	Jacks
5	CAR HIPP	340	Caranx hippos	Crevalle jack	CARANGIDAE	Jacks
6	CAR LATU	345	Caranx latus	Horse-eye jack	CARANGIDAE	Jacks
7	CAR RUBE	350	Caranx ruber	Bar jack	CARANGIDAE	Jacks
8	DAS AMER	530	Dasyatis americana	Southern stingray	DASYATIDAE	Stingrays
9	EPI ADSC	650	Epinephelus adscensionis	Rock hind	SERRANIDAE	Sea basses
10	EPI CRUE	660	Epinephelus cruentatus	Graysby	SERRANIDAE	Sea basses
11	EPI FULV	670	Epinephelus fulvus	Coney	SERRANIDAE	Sea basses
12	EPI GUTT	680	Epinephelus guttatus	Red hind	SERRANIDAE	Sea basses
13	EPI ITAJ	685	Epinephelus itajara	Jewfish	SERRANIDAE	Sea basses
14	EPI MORI	690	Epinephelus morio	Red grouper	SERRANIDAE	Sea basses
15	EPI STRI	710	Epinephelus striatus	Nassau grouper	SERRANIDAE	Sea basses
16	GIN CIRR	760	Ginglymostoma cirratum	Nurse shark	ORECTOLOBIDAE	Carpet sharks
17	GYM MORI	830	Gymnothorax moringa	Spotted moray	MURAENIDAE	Morays
18	GYM SAXI	840	Gymnothorax saxicola	Ocellated moray	MURAENIDAE	Morays
19	HYP GEMM	1160	Hypoplectrus gemma #	Blue hamlet	SERRANIDAE	Sea basses
20	HYP NIGR	1170	Hyploplectrus nigricans #	Black hamlet	SERRANIDAE	Sea basses
21	HYP PUEL	1190	Hypoplectrus puella #	Barred hamlet	SERRANIDAE	Sea basses
22	HYP TANN	1180	Hypoplectrus (tan)	Tan hamlet	SERRANIDAE	Sea basses
23	HYP UNIC	1200	Hypoplectrus unicolor	Butter hamlet	SERRANIDAE	Sea basses
24	LAC MAXI	1260	Lachnolaimus maximus	Hogfish	LABRIDAE	Wrasses
25	LUT ANAL	1320	Lutjanus analis	Mutton snapper	LUTJANIDAE	Snappers
26	LUT APOD	1330	Lutjanus apodus	Schoolmaster	LUTJANIDAE	Snappers
27	LUT GRIS	1360	Lutjanus griseus	Gray snapper	LUTJANIDAE	Snappers
28	LUT JOCU	1370	Lutjanus jocu	Dog snapper	LUTJANIDAE	Snappers
29	LUT MAHO	1380	Lutjanus mahogoni	Mahogany snapper	LUTJANIDAE	Snappers
30	LUT SYNA	1385	Lutjanus synagris	Lane snapper	LUTJANIDAE	Snappers
31	MEG ATLA	1465	Megalops atlanticus	Tarpon	ELOPIDAE	Tarpons
32	MYC BONA	1545	Mycteroperca bonaci	Black grouper	SERRANIDAE	Sea basses
33	MYC MICR	1560	Mycteroperca microlepis	Gag	SERRANIDAE	Sea basses
34	MYC PHEN	1570	Mycteroperca phenax	Scamp	SERRANIDAE	Sea basses
35	OCY CHRY	1610	Ocyurus chrysurus	Yellowtail snapper	LUTJANIDAE	Snappers
36	SCO REGA	1970	Scomberomorus regalis	Cero mackerel	SCOMBRIDAE	Mackerels/Tunas
37	SPH BARR	2097	Sphyraena barracuda	Barracuda	SPHYRAENIDAE	Barracudas
38	SYN INTE	2190	Synodus intermedius	Sand diver	SYNODONTIDAE	Lizardfishes
39	TRA FALC	2203	Trachinotus falcatus	Permit	CARANGIDAE	Jacks

Table 6a. Statistical summary of Dry Tortugas predator searches (1994-1997).

			SAMPLE FREQUENCY				SAMP. FREQ. RANG		FISH LENGTH (cm)			BIOMASS
	Species	Total Indiv.	(N = 126)	%	Mean Abund.	Stand. Dev.	High	Low	Mean	Min.	Max.	Total (gms)
1	ALE CILI	2	1	0.8%	0.0	0.18	2	0	100.0	100	100	33,981.0
2	AUL MACU	20	14	11.1%	0.2	0.53	4	0	41.1	20	60	3,976.8
3	CAR BART	61	5	4.0%	0.5	3.53	30	0	25.7	15	70	32,081.2
4	CAR CRYS	141	7	5.6%	1.1	9.20	101	0	20.9	15	40	30,125.1
5	CAR HIPP	20	1	0.8%	0.2	1.78	20	0	34.0	32	36	15,977.8
6	CAR LATU	10	3	2.4%	0.1	0.57	5	0	53.5	35	100	41,157.9
7	CAR RUBE	1,211	50	39.7%	9.6	25.58	165	0	20.5	3	40	205,862.5
8	DAS AMER	5	5	4.0%	0.0	0.20	1	0	92.0	60	110	19,029.6
9	EPI ADSC	1	1	0.8%	0.0	0.09	1	0	28.0	28	28	353.6
10	EPI CRUE	49	27	21.4%	0.4	0.87	4	0	20.0	7	31	8,248.5
11	EPI FULV	3	2	1.6%	0.0	0.20	2	0	21.7	18	25	498.9
12	EPI GUTT	1	1	0.8%	0.0	0.09	1	0	25.0	25	25	248.5
13	EPI ITAJ	4	3	2.4%	0.0	0.22	2	0	185.0	170	200	525,085.8
14	EPI MORI	92	49	38.9%	0.7	1.34	8	0	35.6	9	75	79,500.6
15	EPI STRI	1	1	0.8%	0.0	0.09	1	0	32.0	32	32	471.2
16	GIN CIRR	9	7	5.6%	0.1	0.31	2	0	179.6	125	230	334,261.1
17	GYM MORI	3	3	2.4%	0.0	0.15	1	0	46.0	30	60	664.3
18	GYM SAXI	1	1	0.8%	0.0	0.09	1	0	50.0	50	50	232.5
19	HYP GEMM	25	14	11.1%	0.2	0.69	5	0	6.4	4	9	112.0
20	HYP NIGR	4	3	2.4%	0.0	0.22	2	0	6.8	6	7	17.3
21	HYP PUEL	11	9	7.1%	0.1	0.34	2	0	6.3	5	9	46.6
22	HYP TANN	1	1	0.8%	0.0	0.09	1	0	5.0	5	5	1.8
23	HYP UNIC	29	14	11.1%	0.2	0.74	4	0	6.3	3	14	184.9
24	LAC MAXI	179	69	54.8%	1.4	2.03	11	0	32.5	10	75	184,452.3
25	LUT ANAL	24	16	12.7%	0.2	0.58	3	0	50.8	22	70	65,649.6
26	LUT APOD	357	30	23.8%	2.8	8.30	53	0	23.5	10	55	103,713.9
27	LUT GRIS	2,952	80	63.5%	23.4	37.05	170	0	25.5	10	55	906,632.0
28	LUT JOCU	6	4	3.2%	0.0	0.28	2	0	54.3	22	65	19,475.5
29	LUT MAHO	161	12	9.5%	1.3	7.02	53	0	20.4	10	40	34,088.9
30	LUT SYNA	21	2	1.6%	0.2	1.32	11	0	32.4	20	35	11,140.5
31	MEG ATLA	7	7	5.6%	0.1	0.23	1	0	155.0	70	250	371,842.5
32	MYC BONA	113	55	43.7%	0.9	1.45	9	0	46.1	15	150	406,213.8
33	MYC MICR	5	5	4.0%	0.0	0.20	1	0	33.6	22	60	4,463.0
34	MYC PHEN	37	20	15.9%	0.3	0.78	4	0	27.2	10	50	15,304.7
35	OCY CHRY	6,114	115	91.3%	48.5	84.22	524	0	19.7	4	50	993,487.7
36	SCO REGA	12	9	7.1%	0.1	0.43	4	0	44.3	20	96	14,528.1
37	SPH BARR	100	51	40.5%	0.8	2.03	20	0	69.2	17	150	495,262.5
38	SYN INTE	1	1	0.8%	0.0	0.09	1	0	18.0	18	18	57.7
39	TRA FALC	1	1	0.8%	0.0	0.09	1	0	60.0	60	60	3,845.5

NO. SAMPLES = 126 SAMPLE AREA - ALL PRED SEARCES
NO. SPECIES = 39 NO. OBSERVERS - 4
TOT.INDIVIDUALS = 11,794 SAMPLING CONDITIONS - 3-5, 15-25 e winds
TOT. BIOMASS (g) = 4,962,278.1

Table 6b. Statistical summary of Dry Tortugas predator searches (1998).

			SAMPLE FREQUENCY				SAMP. FREQ. RANGE		FISH LENGTH (cm)			BIOMASS
	Species	Total Indiv.	(N = 12)	%	Mean Abund.	Stand. Dev.	High	Low	Mean	Min.	Max.	Total (gms)
1	AUL MACU	1	1	8.3%	0.1	0.29	1	0	38.0	38	38	133.1
2	CAR BART	1	1	8.3%	0.1	0.29	1	0	45.0	45	45	1,665.6
3	CAR RUBE	6	2	16.7%	0.5	1.17	3	0	28.0	25	40	2,781.7
4	EPI CRUE	7	4	33.3%	0.6	1.16	4	0	22.9	12	30	1,525.1
5	EPI MORI	21	9	75.0%	1.8	1.66	6	0	42.1	21	65	26,773.1
6	HYP GEMM	15	4	33.3%	1.3	2.18	6	0	8.3	3	14	237.6
7	HYP NIGR	2	1	8.3%	0.2	0.58	2	0	6.0	6	6	6.6
8	HYP PUEL	7	4	33.3%	0.6	0.90	2	0	8.4	5	12	83.1
9	HYP UNIC	18	7	58.3%	1.5	1.68	4	0	5.9	4	10	72.6
10	LAC MAXI	11	3	25.0%	0.9	1.88	6	0	33.1	20	45	8,855.3
11	LUT ANAL	3	2	16.7%	0.3	0.62	2	0	42.0	36	50	3,971.8
12	LUT GRIS	125	8	66.7%	10.4	11.65	35	0	32.2	17	55	73,520.3
13	LUT JOCU	3	2	16.7%	0.3	0.62	2	0	32.7	24	40	2,110.0
14	LUT MAHO	6	2	16.7%	0.5	1.24	4	0	25.7	17	35	1,870.0
15	MYC BONA	12	6	50.0%	1.0	1.35	4	0	43.8	35	70	18,336.1
16	MYC MICR	2	2	16.7%	0.2	0.39	1	0	56.0	42	70	6,149.6
17	MYC PHEN	9	4	33.3%	0.8	1.36	4	0	27.2	19	45	3,634.5
18	MYC VENE	1	1	8.3%	0.1	0.29	1	0	28.0	28	28	315.6
19	OCY CHRY	116	8	66.7%	9.7	14.24	41	0	21.6	6	45	21,811.3
20	SPH BARR	1	1	8.3%	0.1	0.29	1	0	130.0	130	130	16,299.8

NO. SAMPLES = 12 SAMPLE AREA - DRY TORTUGAS
NO. SPECIES = 20 NO. OBSERVERS - 4
TOT.INDIVIDUALS = 367 SAMPLING CONDITIONS - 3-5, 15-25 e winds
TOT. BIOMASS (g) = 190,152.6

Table 7. Summary comparison of fishes inside and outside DTNP based on stationary sample data.

	Sanctuary	Park		Sanctuary	Park
DATE	1994-1997	1994-1997		1994-1997	1994-1997
Total samples	183	335			
Total species	135	140			
Mean species/sample	20.10	17.68			
Total individuals	33,302	43,106			
Mean individuals/sample	181.98	128.67			
Total biomass (g)	2,109,001.2	2,328,141.9			
Mean biomass (g)/sample	11524.60	6949.68			
INDIVIDUALS	Mean	Mean		%	%
Barracuda	0.14	0.10		0.08%	0.08%
Damselfishes	57.26	18.06		31.47%	14.04%
Grunts and Porgies	8.03	25.04		4.41%	19.46%
Other	54.06	25.12		29.71%	25.14%
Parrotfishes	15.31	23.87		8.41%	18.55%
Serranids	3.55	2.63		1.95%	2.04%
Lutjanids	9.78	6.58		5.37%	5.11%
Surgeonfishes	2.67	3.23		1.47%	2.51%
Wrasses	31.17	16.82		17.13%	13.07%
BIOMASS	Mean (g)	Mean (g)		%	%
Barracuda	705.49	1095.30		6.12%	15.76%
Damselfishes	360.28	140.28		3.13%	2.02%
Grunts and Porgies	519.00	607.80		4.50%	8.75%
Other	4113.35	2381.36		35.69%	34.27%
Parrotfishes	525.14	616.16		4.56%	8.87%
Serranids	2261.57	529.34		19.62%	7.62%
Lutjanids	2511.31	1109.06		21.79%	15.96%
Surgeonfishes	177.99	254.99		1.54%	3.67%
Wrasses	350.46	215.39		3.04%	3.10%
TOTAL NUMBER OF SPECIES	OUTSIDE	INSIDE	TOTAL		
Barracuda	1	1	1		
Damselfishes	12	13	13		
Grunts and Porgies	11	13	14		
Other	62	63	80		
Parrotfishes	13	12	13		
Serranids	19	19	22		
Snappers	6	7	7		
Surgeonfishes	3	3	3		
Wrasses	8	9	9		
TOTAL	135	140	162		

Table 8. Reef characteristics and summaries for DTNP and FKNMS study sites.

	Mean Total Individuals	Mean Total Species	Mean Total Biomass	Average Depth	Average Percent Coral	Mean Total Snapper	Mean Total Grouper	Mean Total Hogfish
GG (12)	108.83	18.00	2217.96	33.50	51.66%	2.90	4.72	
LA (51)	103.45	17.06	7642.28	13.04	36.75%	3.88	3.22	0.14
LB (74)	128.14	17.73	7924.97	30.88	43.28%	6.23	1.49	0.04
LG (43)	122.81	17.00	4898.15	25.91	21.44%	5.95	1.65	0.30
PS (61)	146.93	20.75	11228.31	38.77	38.62%	15.84	3.11	0.30
TX (37)	151.03	18.54	4826.30	33.81	72.59%	9.00	0.57	0.05
WS (57)	126.49	14.74	4407.05	15.26	18.68%	6.92	4.50	0.14
Inside (335)	**128.67**	**17.68**	**6949.68**	**26.72**	**37.99%**	**6.58**	**2.63**	**0.15**
Outside (183)	**181.98**	**20.10**	**11524.60**	**56.74**	**61.26%**	**9.78**	**3.55**	**0.23**
BL (8)	250.38	18.88	50464.13	66.25	86.88%	17.75	5.25	0.13
CC (3)	190.67	18.33	2024.87	48.67	83.33%	3.00	2.33	
CZ (19)	78.53	15.63	1767.86	55.84	44.74%	0.47	1.42	0.11
DV (8)	126.00	18.75	10750.875	46.50	43.38%	6.00	3.75	
EF (8)	222.88	20.88	23144.68	61.88	82.50%	21.13	2.75	
GA (6)	248.17	19.33	14910.70	56.50	84.17%	1.67	1.33	0.50
H1 (5)	223.20	19.80	5671.22	51.40	88.00%	11.17	3.33	
H2 (3)	519.33	17.33	3352.80	56.67	68.33%	1.60	2.20	
H3 (6)	409.83	22.50	20165.75	52.17	95.83%	1.67	1.33	
HO (12)	245.75	25.75	7246.33	47.67	59.08%	47.83	2.83	
JH (32)	106.50	19.63	8442.73	62.88	51.81%	3.09	3.88	0.47
LI (8)	150.75	23.00	22529.20	58.88	67.50%	35.50	5.75	1.38
MH (4)	159.50	14.25	925.33	64.75	42.50%	0.00	3.75	
MV (9)	207.11	21.44	6706.88	27.00	23.89%	11.00	2.89	0.44
RZ (8)	121.50	21.25	6383.81	65.00	60.00%	1.25	3.25	0.25
SF (8)	362.63	18.63	10294.05	80.63	92.50%	2.00	4.75	
TB (21)	157.38	21.62	9320.30	55.05	75.67%	25.00	0.46	0.05
TF (5)	97.40	16.40	3315.00	65.20	18.00%	0.00	1.60	0.20
TP (10)	209.20	23.00	19844.24	44.00	69.30%	10.00	5.14	

Table 9. Summary comparison of fishes inside and outside DTNP based on predator search data.

	Sanctuary	Park		Sanctuary	Park
DATE	1994-1997	1994-1997		1994-1997	1994-1997
Total samples	21	105			
Total species	22	37			
Mean species/sample	5.67	5.52			
Total individuals	3,166	8,628			
Mean individuals/sample	150.76	82.17			
Total biomass (g)	1000386.08	3961892.04			
Mean biomass (g)/sample	47637.43	37732.31			
INDIVIDUALS	Mean	Mean		%	%
Barracuda	0.8	0.8		0.51%	0.97%
Serranids	3.6	2.8		2.46%	3.45%
Other	37.8	6.8		25.05%	8.24%
Lutjanids	106.2	70.5		70.47%	85.81%
Hogfish	2.3	1.2		1.52%	1.52%
BIOMASS	Mean (g)	Mean (g)		%	%
Barracuda	4274.31	3861.92		8.97%	10.24%
Serranids	6443.99	8623.12		13.53%	22.85%
Other	13724.90	7803.82		28.81%	20.68%
Lutjanids	20585.23	16208.56		43.21%	42.96%
Hogfish	2609.00	1234.89		5.48%	3.27%
TOTAL NUMBER OF SPECIES	OUTSIDE	INSIDE	TOTAL		
Barracuda	1	1	1		
Serranids	8	14	15		
Other	8	14	15		
Lutjanids	4	7	7		
Hogfish	1	1	1		
TOTAL	22	37	39		

Figure 1. Summary or reef sites sampled.

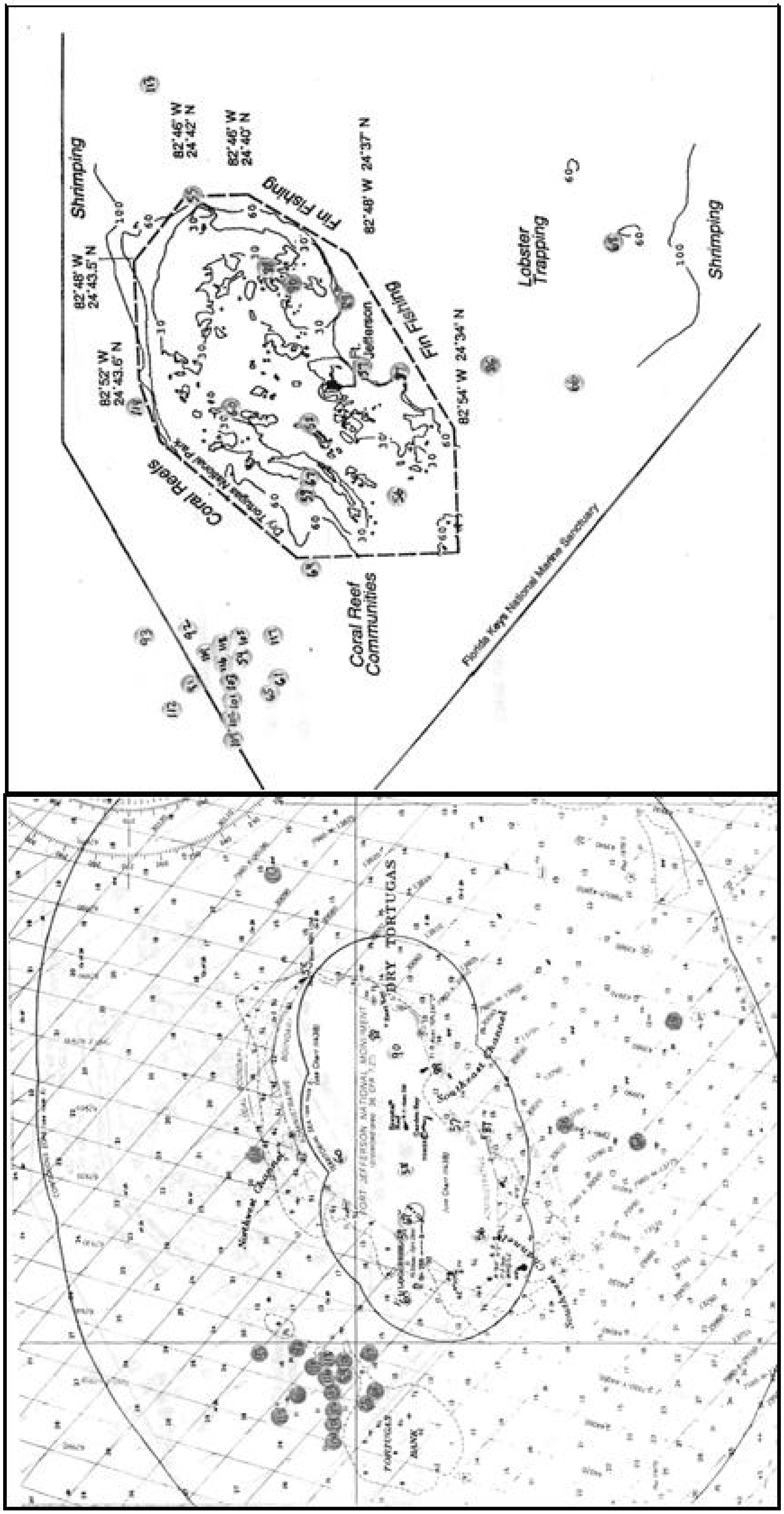


Figure 2. Cluster analysis of fish assemblage similarity from Dry Tortugas Reefs.

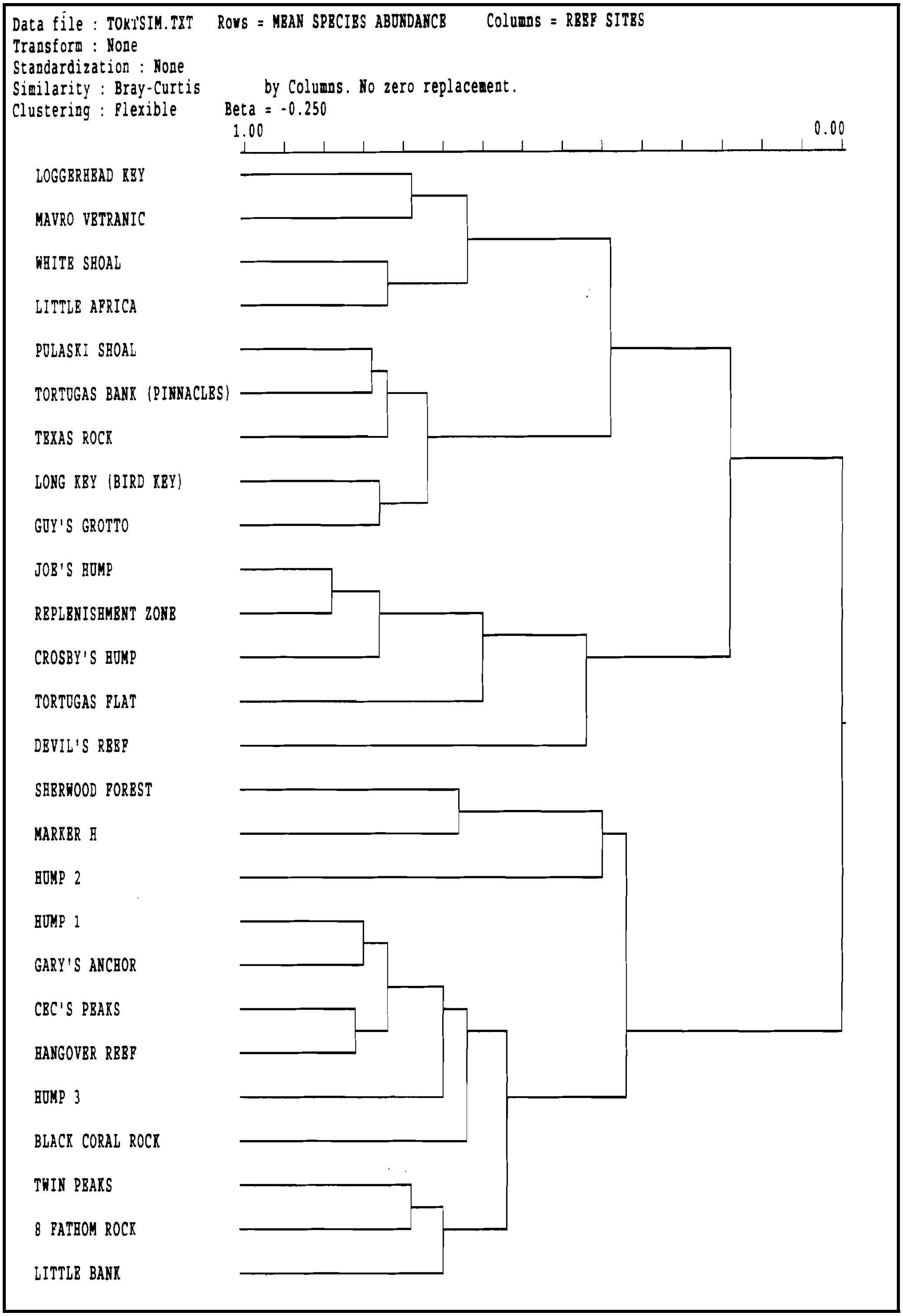


Figure 3. Family comparisons of fishes observed in stationary point samples inside and outside DTNP.

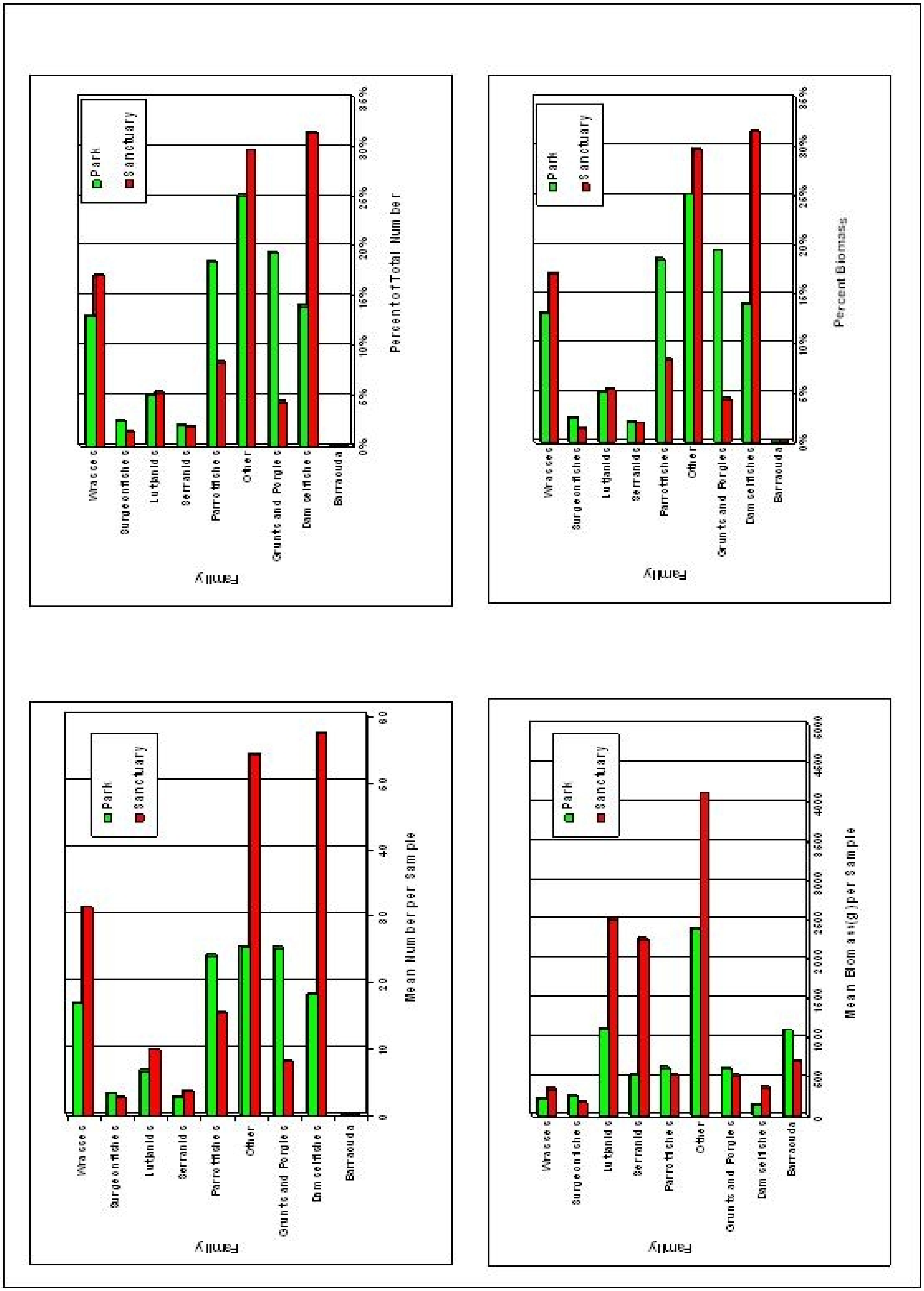


Figure 4. Average depth and percentage or coral and rock substrate at reef sites inside and outside DTNP.

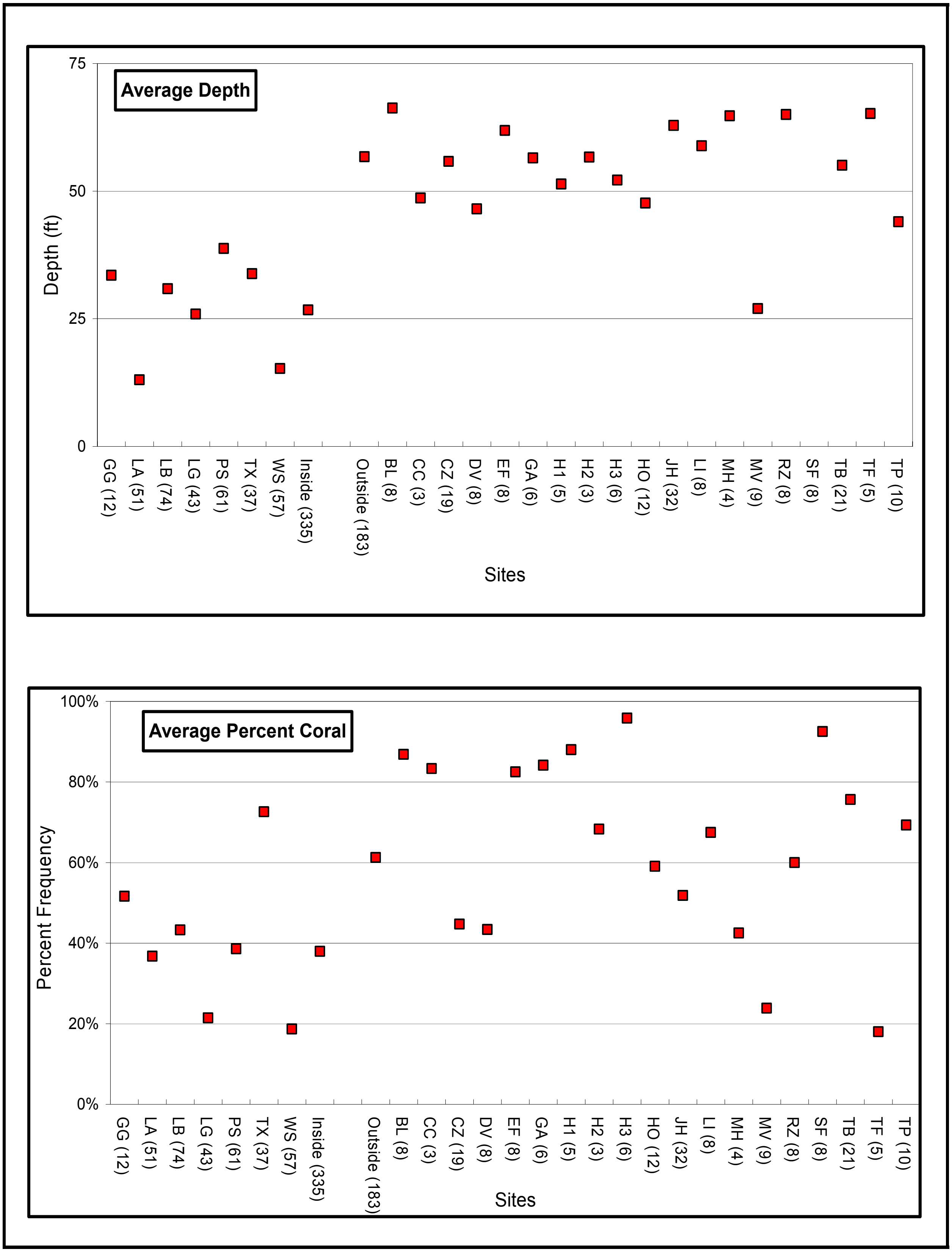


Figure 5. Scattergrams showing performance of mean total individuals, mean total species, and mean total biomass from individual reef sites.

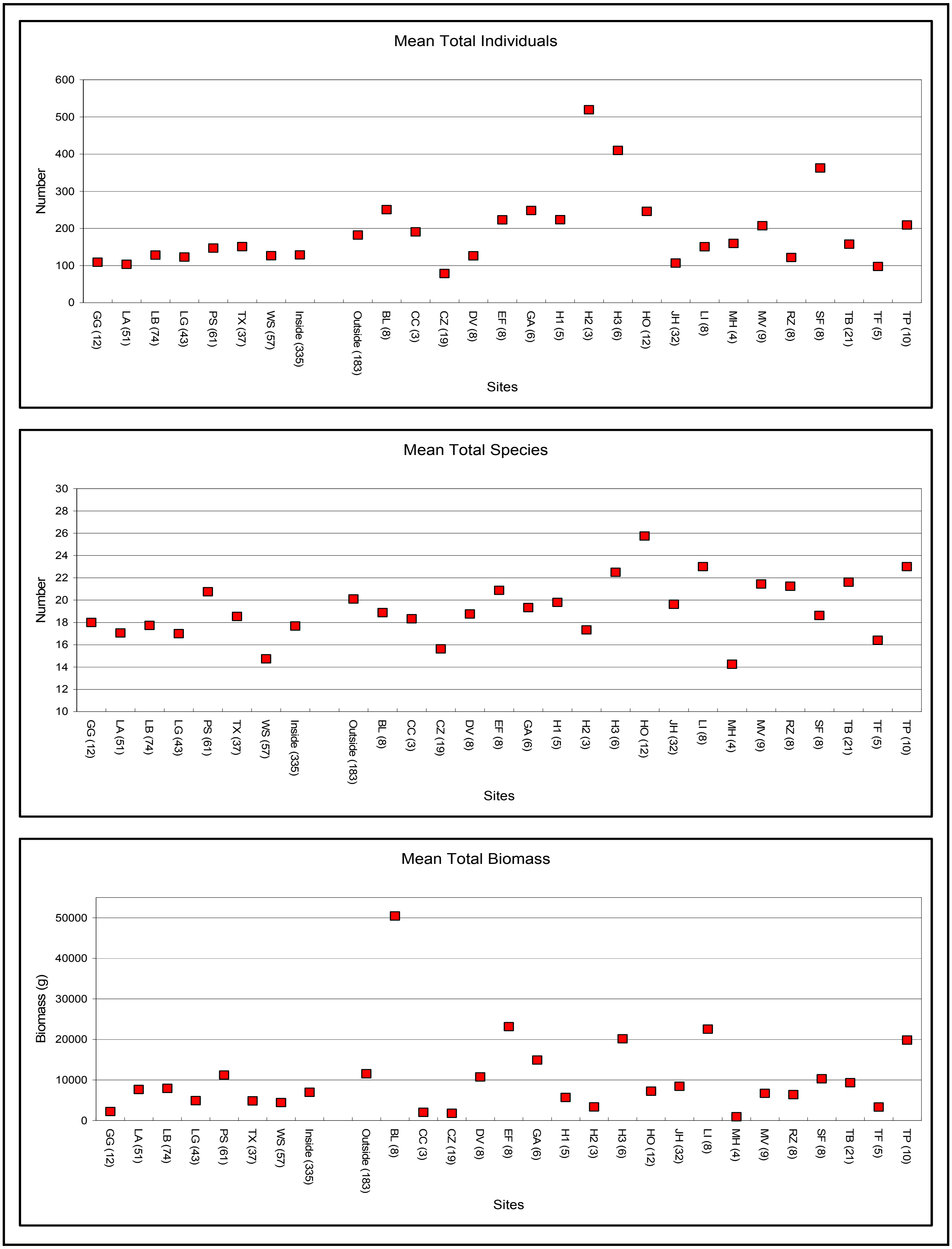


Figure 6. Scattergrams showing performance of mean total snapper (lutjanids), grouper (serranids), and hogfish from individual reef sites.

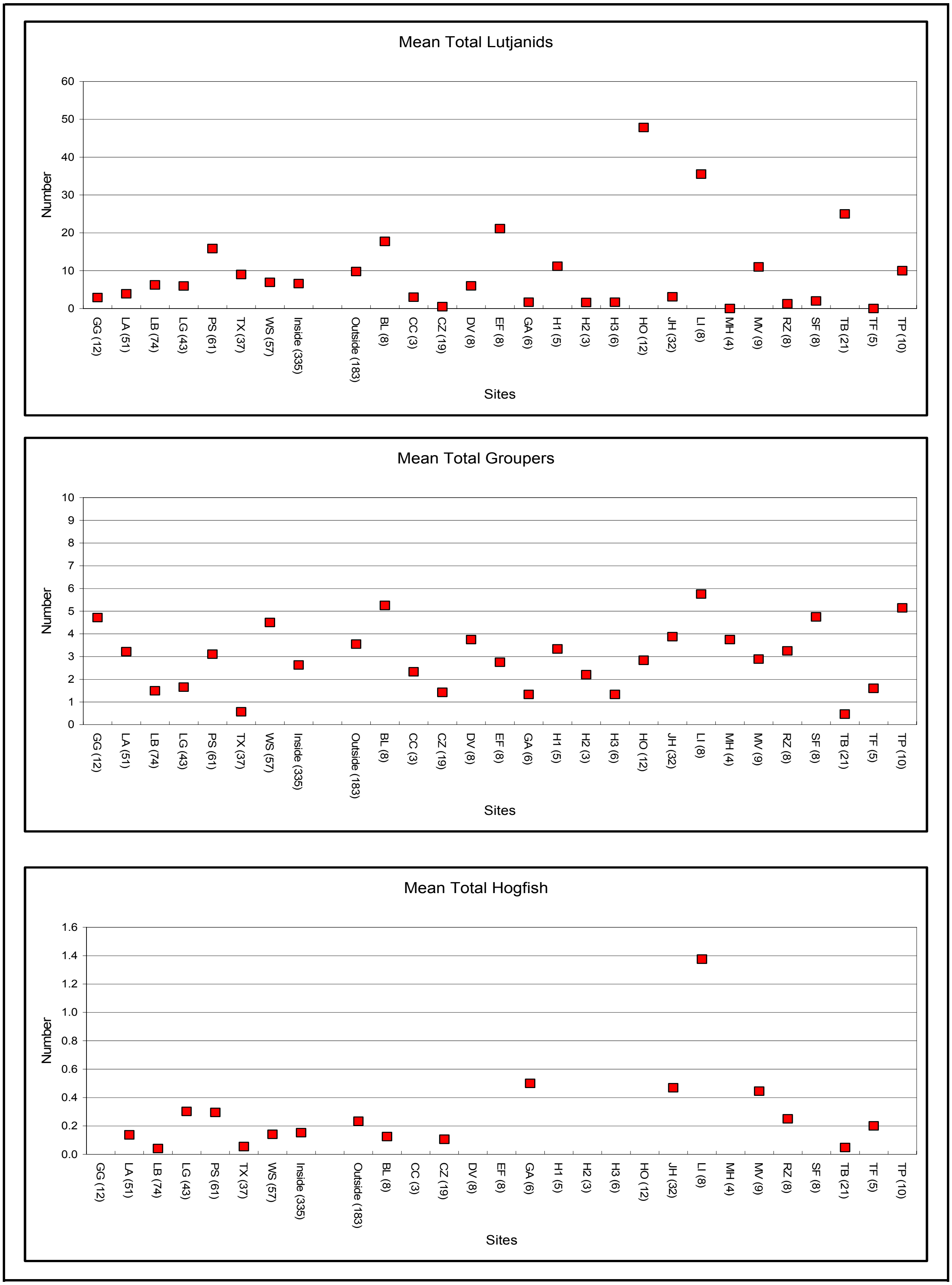


Figure 7. Scattergrams showing performance of mean total abundances of hogfish, mutton snapper, black grouper and yellowtail from individual reef sites.

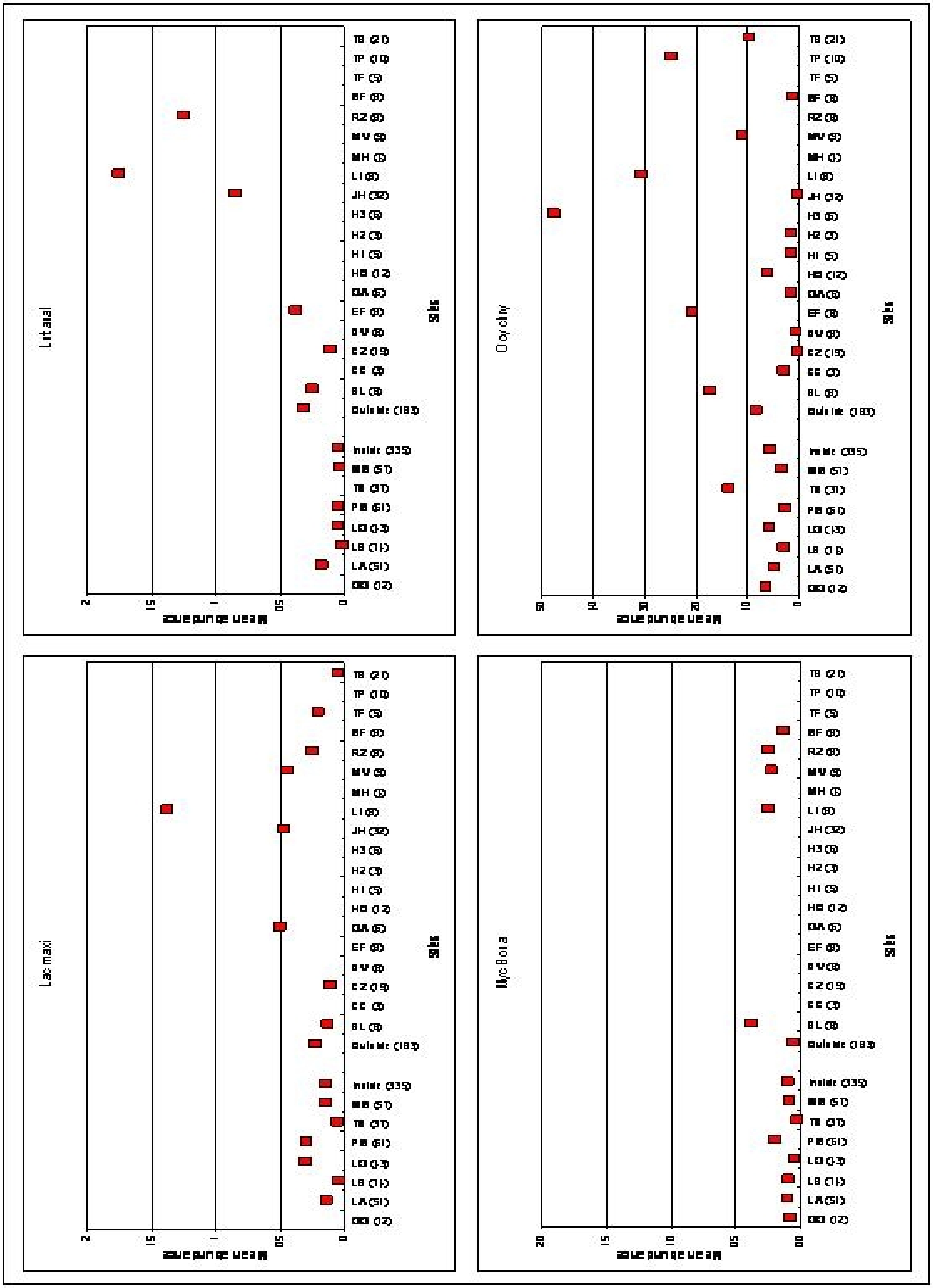
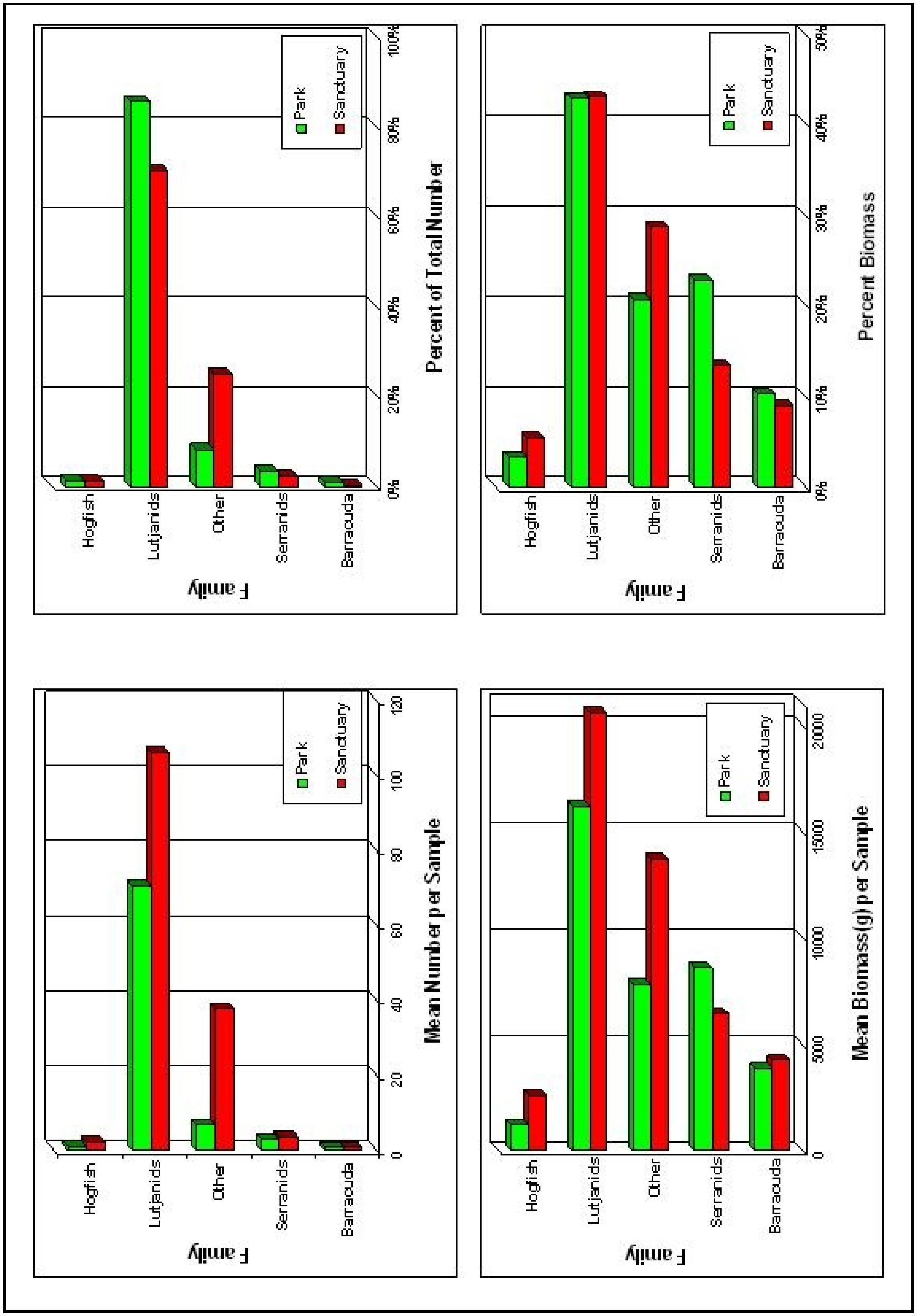


Figure 8. Family comparisons of fishes observed in predator samples inside and outside DTNP.



Chapter 5. Reef fish abundance and species composition from the Florida Middle Grounds: R/V Suncoaster cruise August 18-23, 2000.

David B. McClellan and Michael T. Judge

Introduction

A limited reef fish survey of the proposed Habitat Area of Particular Concern (HAPC) in the Florida Middle Ground (FMG) was conducted by two members of the Rapid Fish Assessment Team, Reef Resources Team, Protected Resources and Biodiversity Division, SEFSC, NOAA Fisheries, from August 18-23, 2000. The primary purpose of this R/V Suncoaster cruise, PI Dr. David Mallison, was to map the bottom of the area utilizing side-scan sonar and multibeam bathymetry survey methods. At sites selected by bottom features on the sonar, dives were conducted to collect sediment samples and videotape of the habitat, as well as survey the fish fauna (Figure 1).

Results and Discussion

Data were collected using a stationary point sampling technique (Bohnsack and Bannerot 1986) which utilizes standard visual sampling methods. Twelve stationary samples were collected from six sites (two samples per site) at a mean depth of 92 feet (range 79 to 100 feet). Only one count per diver could be finished per dive because of depth and bottom time constraints. Data collected provide fish species presence, abundance, frequency, biomass, average size, and size range. This information is important for accessing fish composition of the Florida Middle Ground and for management of the proposed HAPC.

Summary information of the August 18-23, 2000 FMG cruise data are provided in Tables 1 and 2. A total of 4,340 fishes representing 54 species (19 families) were recorded from the 12 samples. The mean number of fish observed per sample was 362 (range 87 to 1167) and the mean number of species per sample was 21 (range 14 to 25). Five species were observed from all samples; the purple reef fish *Chromis scottii* (n=2,988), striped parrotfish *Scarus croiscensis* (n=196), scamp *Mycteroperca phenax* (n=145), three unknown porgies *Calamus sp.* n=96), and blue angelfish *Holocanthus bermudensis* (n=59).

The purple reef fish was the most prevalent species seen from all the sites (n=2,988), followed by the striped parrotfish (n=196), scamp (n=145), clown wrasse *Halichoere*s *maculipinna* (n=135), and cocoa damselfish *Pomacentrus variabilis* (n=131). The most common predator species seen was the scamp grouper (n=145) which also had the highest biomass (47.5 kg total, average weight 1.1 kg). The mangrove snapper *Lutjanus griseus* (n=68, 45.2 kg total, average weight 0.67 kg) had the next highest biomass, followed by the red grouper *Epinephelus morio* (n=25, 26.8 kg, average weight 1.1 kg), and combined porgy species *Calamus sp.* (n=96, 27.5 kg total, 0.29 kg). Only three gag grouper *Mycteroperca microlepis* and two Gulf red snapper *Lutjanus campechanus* were observed during the counts. An additional 10 species were recorded after five minutes; the two-spot cardinalfish *Apogon pseudomaculatus*, trumpetfish *Aulostomus maculatus*, smooth puffer *Canthigaster rostrata*, bar jack *Caranx ruber*, sunshine fish *Chromis insolatus*, goldspot goby *Gnatholepis thompsoni*, spotted moray *Gymnothorax moringa*, red porgy *Pagrus pagrus*, spotted goatfish *Pseudopeneus maculatus*, and almaco jack *Seriola rivolina*.

Habitat information was collected from each site using the criteria developed by the Rapid Assessment Team (Smith et al. 2000). Five of the six sites were prominent outcrops dominated by the blade fire coral *Millepora sp.* and unidentified gorgonian species. The FMG region is characterized by steep-profile limestone escarpments and knolls rising 10-15 meters above the surrounding sand, sand-shell substrate (Smith et al. 1975), with a zone of minor reef building on some banks in the *Millepora* zone (18-52 meters) (Rezak et al. 1990).

The reef fish census conducted during this cruise, although limited in scope, demonstrates the complexity and abundance of the reef fish fauna associated with the Florida Middle Ground. Smith et al. (1975) recorded 128 fish species representing 49 families from all habitats in the FMG using numerous census methods. The 54 species from 19 families observed during our censuses represent species associated with a single type reef habitat. Species such as the purple reef fish, the porgies, the red grouper, and the scamp were considered abundant in the 1970's (Smith et al. 1975), as they are today. The red snapper and gag grouper, considered common in the 1970's (Smith et al. 1975), were rare during our study. An average of 12.1 scamp per count (range four to 30) were recorded, representing a much higher number than seen elsewhere in waters of the Florida Keys and Dry Tortugas (Bohnsack et al. 2000). A 16 inch (41 centimeter) total length commercial and recreational size limit presently occurs for the scamp in Federal waters of the Gulf of Mexico, and most of the scamp observed during this study fall below this size. Additional reef fish censusing is needed to establish a more precise baseline, as well as supply data for future assessments of the reef fish complex in the Florida Middle Ground Habitat Area of Particular Concern.

Literature Cited

Bohnsack, J.A. and S.P. Bannerot. 1986. A stationary visual census technique for quantitatively assessing community structure of coral reef fishes. NOAA Tech. Rept. 41, 15p.

Bohnsack, J.A., D.B. McClellan, D.E. Harper, G.S. Davenport, G.J. Konoval, A.M. Eklund, J.P. Contillo, S.K. Bolden, P.C. Fischel, G.S. Sandorf, J.C. Javech, M.W. White, M.H. Pickett, M.W. Hulsbeck, J.L. Tobias, J.S. Ault, G.A. Meester, S.G. Smith, and J. Luo. 1999. Baseline Data for Evaluating Reef Fish Populations in the Florida Keys, 1979-1998. NOAA Tech. Memo. NMFS-SEFSC-427. 61 p.

Rezak, R., S.R. Gittings, and T.J. Bright. 1990. Biotic assemblages and ecological controls on reefs and banks of the northwest Gulf of Mexico. Amer. Zool. 30:23-35.

Smith, G.B., H. M. Austin, S.A. Bortone, R.W. Hastings, and L.H. Ogren. 1975. Fishes of the Florida middle Ground with comments on ecology and zone geography. Fla. Mar. Res. Publ. No. 9. 14p.

Smith, S., J. Ault, G. Meester, J. Bohnsack, D. McClellan, D. Harper, M. Chiappone, D. Swanson, and S. Miller. 2000. (Unpubl.) Habitat characterization for reef fish censuses in the Florida Keys, May 18, 2000. 3pp.

Table 1. Analysis of reef fish visual sampling during the R/V Suncoaster cruise to the Florida Middle Ground Habitat Area of Particular Concern, August 18-23, 2000.

			SAMPLE FREQUENCY				SAMP. FREQ. RANGE		FISH LENGTH (cm)			BIOMASS
	Species	Total Indiv.	Frequency	% Freq.	Mean Abund.	Stand. Dev.	High	Low	Mean	Min.	Max.	Total(gms)
1	ACA BAHI	40	7	58.3%	3.3	5.96	20	0	14.3	8	22	3,062.3
2	ACA CHIR	24	9	75.0%	2.0	1.91	6	0	17.8	2	30	3,877.4
3	ACA COER	13	3	25.0%	1.1	2.31	6	0	14.7	6	25	1,794.9
4	ADI VEXI	8	1	8.3%	0.7	2.31	8	0	15.0	12	18	724.0
5	APO MACU	1	1	8.3%	0.1	0.29	1	0	6.0	6	6	3.9
6	BAL CAPR	2	2	16.7%	0.2	0.39	1	0	42.5	40	45	3,049.5
7	CAL SPE1	8	3	25.0%	0.7	1.30	4	0	21.3	10	30	2,748.3
8	CAL SPE2	71	12	100.0%	5.9	5.65	20	1	17.1	5	35	11,990.7
9	CAL SPE3	17	6	50.0%	1.4	1.73	5	0	32.8	15	40	13,475.4
10	CAN SUFF	2	2	16.7%	0.2	0.39	1	0	35.0	30	40	1,956.9
11	CAR BART	1	1	8.3%	0.1	0.29	1	0	30.0	30	30	512.2
12	CHA CAPI	3	1	8.3%	0.3	0.87	3	0	10.0	8	12	111.6
13	CHA OCEL	24	10	83.3%	2.0	2.04	8	0	10.9	8	20	1,113.2
14	CHA SEDE	17	6	50.0%	1.4	2.27	8	0	9.6	6	12	507.1
15	CHR SCOT	2,988	12	100.0%	249.0	357.10	1000	25	3.5	1	11	4,016.8
16	COR GLAU	4	2	16.7%	0.3	0.89	3	0	2.3	1	3	0.6
17	CRY ROSE	3	2	16.7%	0.3	0.62	2	0	5.3	5	6	31.9
18	EPI ADSC	5	4	33.3%	0.4	0.67	2	0	28.0	15	40	2,518.9
19	EPI CRUE	27	8	66.7%	2.3	3.52	11	0	19.0	10	30	3,572.3
20	EPI MORI	25	10	83.3%	2.1	1.44	5	0	39.3	15	60	26,752.1
21	EQU ACUM	4	1	8.3%	0.3	1.15	4	0	17.0	15	20	329.5
22	GNA THOM	6	1	8.3%	0.5	1.73	6	0	2.0	2	2	0.3
23	GOB OCEA	12	3	25.0%	1.0	2.34	8	0	2.0	2	3	1.0
24	HAE PLUM	2	2	16.7%	0.2	0.39	1	0	29.0	28	30	1,020.6
25	HAL BIVI	40	6	50.0%	3.3	6.10	18	0	5.5	2	10	90.2
26	HAL GARN	1	1	8.3%	0.1	0.29	1	0	5.0	5	5	1.2
27	HAL MACU	135	11	91.7%	11.3	10.23	25	0	5.5	2	12	352.7
28	HOL ADSC	3	2	16.7%	0.3	0.62	2	0	23.3	20	25	841.4
29	HOL BERM	59	12	100.0%	4.9	1.98	9	3	22.9	6	40	20,461.8
30	HOL CILI	1	1	8.3%	0.1	0.29	1	0	15.0	15	15	86.8
31	HOL MARI	2	1	8.3%	0.2	0.58	2	0	15.0	15	15	177.5
32	HOL RUFU	9	3	25.0%	0.8	1.76	6	0	20.2	10	45	2,941.6
33	HYP PUEL	24	10	83.3%	2.0	1.81	6	0	7.4	4	10	193.5
34	IOG CALL	4	1	8.3%	0.3	1.15	4	0	3.0	3	3	1.1
35	LAC MAXI	6	5	41.7%	0.5	0.67	2	0	27.5	15	45	3,919.7
36	LUT CAMP	2	2	16.7%	0.2	0.39	1	0	52.5	50	55	4,920.8
37	LUT GRIS	68	6	50.0%	5.7	10.01	35	0	33.0	15	55	45,191.9
38	MYC MICR	3	3	25.0%	0.3	0.45	1	0	75.0	50	100	23,025.8
39	MYC PHEN	145	12	100.0%	12.1	6.80	30	4	25.9	6	50	47,445.2
40	OPI AURI	21	3	25.0%	1.8	3.96	13	0	2.4	2	6	5.3
41	POM ARCU	2	2	16.7%	0.2	0.39	1	0	35.0	30	40	2,790.9
42	POM DIEN	8	1	8.3%	0.7	2.31	8	0	4.0	3	5	16.6
43	POM PART	60	5	41.7%	5.0	11.55	40	0	4.8	2	8	179.7
44	POM PLAN	1	1	8.3%	0.1	0.29	1	0	8.0	8	8	14.4
45	POM VARI	131	11	91.7%	10.9	13.57	50	0	4.9	2	12	446.2
46	PRI AREN	1	1	8.3%	0.1	0.29	1	0	30.0	30	30	401.7
47	PSE MACU	13	2	16.7%	1.1	2.61	8	0	14.2	7	30	1,399.4
48	SCA CROI	196	12	100.0%	16.3	17.91	60	1	4.6	2	15	481.4
49	SER PHOE	1	1	8.3%	0.1	0.29	1	0	8.0	8	8	7.1
50	SER DUME	3	2	16.7%	0.3	0.62	2	0	36.7	30	40	2,508.8
51	SPA ATOM	3	2	16.7%	0.3	0.62	2	0	5.0	5	6	5.9
52	SPA AURO	11	5	41.7%	0.9	1.51	4	0	17.6	10	25	1,210.7
53	SPA RADI	20	1	8.3%	1.7	5.77	20	0	3.0	2	4	4.2
54	THA BIFA	60	9	75.0%	5.0	8.53	30	0	6.4	4	15	203.9

NO. SAMPLES = 12
NO. SPECIES = 54
TOT.INDIVIDUALS = 4,340
BIOMASS (grams) = 239,436

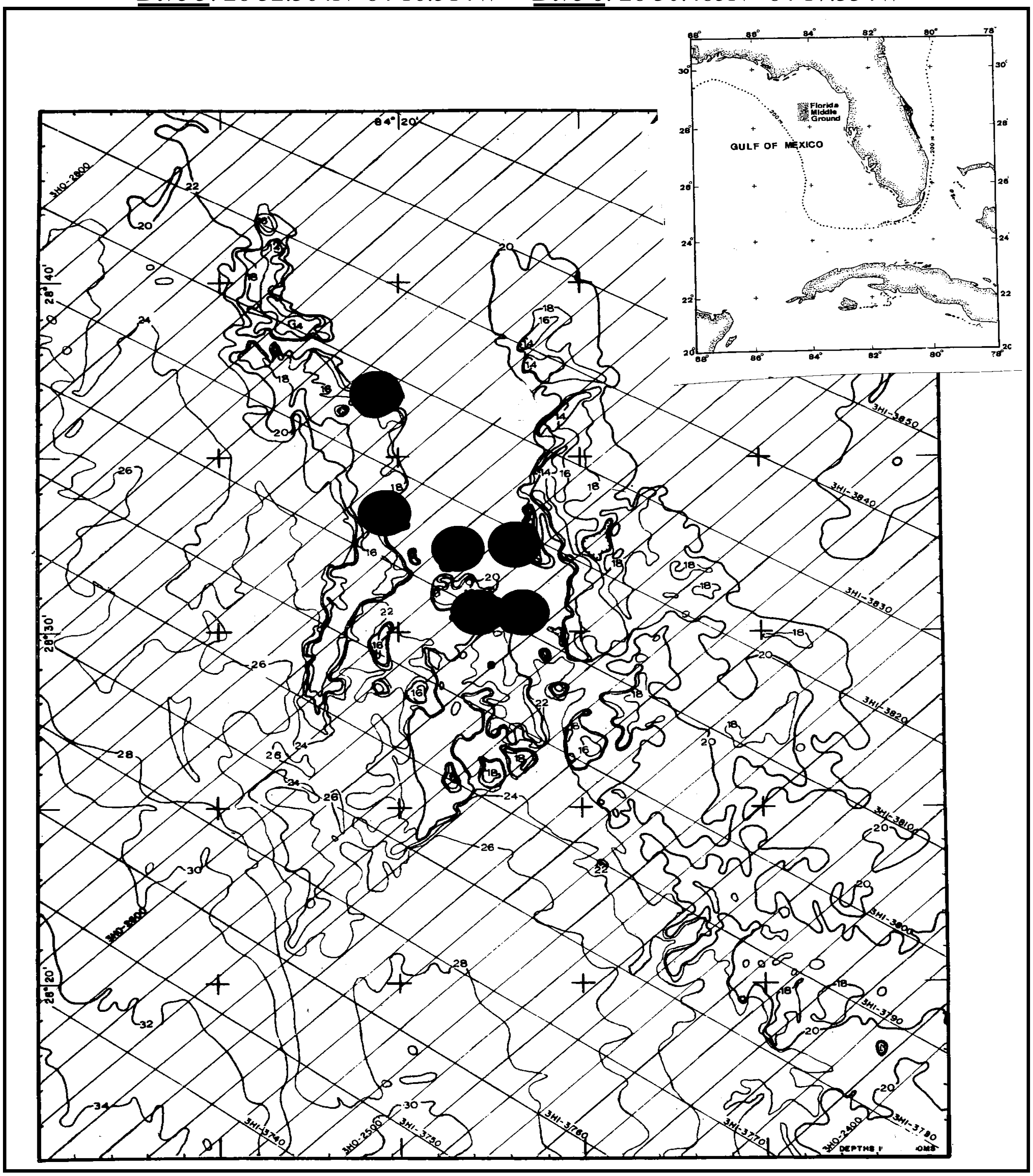
Table 2. Analysis of reef fish visual sampling during the R/V Suncoaster cruise to the Florida Middle Ground Habitat Area of Particular Concern, August 18-23, 2000.

	SPCODE	NUM	SPECIES	COMMON NAME	FAMILY	FAMILY NAME
1	ACA BAHI	30	Acanthurus bahianus	Ocean surgeon	ACANTHURIDAE	Surgeonfishes
2	ACA CHIR	50	Acanthurus chirurgus	Doctorfish	ACANTHURIDAE	Surgeonfishes
3	ACA COER	60	Acanthurus coeruleus	Blue tang	ACANTHURIDAE	Surgeonfishes
4	ADI VEXI	63	Adioryx vexillarius	Dusky squirrelfish	HOLOCENTRIDAE	Squirrelfishes
5	APO MACU	130	Apogon maculatus	Flamefish	APOGONIDAE	Cardinalfishes
6	BAL CAPR	190	Balistes capriscus	Gray triggerfish	BALISTIDAE	Leatherjackets
7	CAL BAJO	240	Calamus bajonado	Jolthead porgy	SPARIDAE	Porgies
8	CAL CALA	260	Calamus calamus	Saucereye porgy	SPARIDAE	Porgies
9	CAL SPE.	276	Calamus spe.	Unknown porgy	SPARIDAE	Porgies
10	CAN SUFF	310	Canthidermis sufflamen	Ocean triggerfish	BALISTIDAE	Leatherjackets
11	CAR BART	320	Caranx bartholomaei	Yellow jack	CARANGIDAE	Jacks
12	CHA CAPI	370	Chaetodon capistratus	Foureye butterflyfish	CHAETODONTIDAE	Butterflyfishes
13	CHA OCEL	390	Chaetodon ocellatus	Spotfin butterflyfish	CHAETODONTIDAE	Butterflyfishes
14	CHA SEDE	400	Chaetodon sedentarius	Reef butterflyfish	CHAETODONTIDAE	Butterflyfishes
15	CHR SCOT	460	Chromis scotti	Purple reeffish	POMACENTRIDAE	Damselfishes
16	COR GLAU	490	Coryphopterus glaucofraenum	Bridled goby	GOBIIDAE	Gobies
17	CRY ROSE	510	Cryptotomus roseus	Bluelip parrotfish	SCARIDAE	Parrotfishes
18	EPI ADSC	650	Epinephelus adscensionis	Rock hind	SERRANIDAE	Sea basses
19	EPI CRUE	660	Epinephelus cruentatus	Graysby	SERRANIDAE	Sea basses
20	EPI MORI	690	Epinephelus morio	Red grouper	SERRANIDAE	Sea basses
21	EQU ACUM	720	Equetus acuminatus	High-hat	SCIAENIDAE	Drums
22	GNA THOM	770	Gnatholepis thompsoni	Goldspot goby	GOBIIDAE	Gobies
23	GOB OCEA	790	Gobiosoma oceanops	Neon goby	GOBIIDAE	Gobies
24	HAE PLUM	940	Haemulon plumieri	White grunt	HAEMULIDAE	Grunts
25	HAL BIVI	970	Halichoeres bivittatus	Slippery dick	LABRIDAE	Wrasses
26	HAL GARN	980	Halichoeres garnoti	Yellowhead wrasse	LABRIDAE	Wrasses
27	HAL MACU	990	Halichoeres maculipinna	Clown wrasse	LABRIDAE	Wrasses
28	HOL ADSC	1070	Holocentrus adscensionis	Squirrelfish	HOLOCENTRIDAE	Squirrelfishes
29	HOL BERM	1080	Holacanthus bermudensis	Blue angelfish	POMACANTHIDAE	Angelfishes
30	HOL CILI	1090	Holacanthus ciliaris	Queen anglefish	POMACANTHIDAE	Angelfishes
31	HOL MARI	1110	Holocentrus marianus	Longjaw squirrelfish	HOLOCENTRIDAE	Squirrelfishes
32	HOL RUFU	1120	Holocentrus rufus	Longspine squirrelfish	HOLOCENTRIDAE	Squirrelfishes
33	HYP PUEL	1190	Hypoplectrus puella #	Barred hamlet	SERRANIDAE	Sea basses
34	IOG CALL	1215	Ioglossus calliurus	Blue goby	GOBIIDAE	Gobies
35	LAC MAXI	1260	Lachnolaimus maximus	Hogfish	LABRIDAE	Wrasses
36	LUT CAMP	1340	Lutjanus campechanus	Red snapper	LUTJANIDAE	Snappers
37	LUT GRIS	1360	Lutjanus griseus	Gray snapper	LUTJANIDAE	Snappers
38	MYC MICR	1560	Mycteroperca microlepis	Gag	SERRANIDAE	Sea basses
39	MYC PHEN	1570	Mycteroperca phenax	Scamp	SERRANIDAE	Sea basses
40	OPI AURI	1680	Opistognathus aurifrons	Yellowhead jawfish	OPISTOGNATHIDAE	Jawfishes
41	POM ARCU	1745	Pomacanthus arcuatus	Gray angelfish	POMACANTHIDAE	Angelfishes
42	POM DIEN	1760	Pomacentrus diencaeus	Longfin damselfish	POMACENTRIDAE	Damselfishes
43	POM PART	1790	Pomacentrus partitus	Bicolor damselfish	POMACENTRIDAE	Damselfishes
44	POM PLAN	1810	Pomacentrus planifrons	Three spot damselfish	POMACENTRIDAE	Damselfishes
45	POM VARI	1815	Pomacentrus variabilis	Cocoa damselfish	POMACENTRIDAE	Damselfishes
46	PRI AREN	1830	Priacanthus arenatus	Bigeye	PRIACANTHIDAE	Bigeyes
47	PSE MACU	1850	Pseudupeneus maculatus	Spotted goatfish	MULLIDAE	Goatfishes
48	SCA CROI	1900	Scarus croicensis	Striped parrotfish	SCARIDAE	Parrotfishes
49	SER PHOE	1950	Seriola phoebe	Tattler bass	SERRANIDAE	Sea basses
50	SER DUME	2000	Seriola dumerili	Greater amberjack	CARANGIDAE	Jacks
51	SPA ATOM	2050	Sparisoma atomarium	Greenblotch parrotfish	SCARIDAE	Parrotfishes
52	SPA AURO	2060	Sparisoma aurofrenatum	Redband parrotfish	SCARIDAE	Parrotfishes
53	SPA RADI	2080	Sparisoma radians	Bucktooth parrotfish	SCARIDAE	Parrotfishes
54	THA BIFA	2200	Thalassoma bifasciatum	Bluehead	LABRIDAE	Wrasses

Figure 1: Area of reef fish sampling in the Florida Middle Ground Habitat of Particular Concern, August 18-23, 2000. (Adapted from Smith et al. 1975)

Sampling Sites

Dive 1: 28 32.353N 84 18.422W ***Dive 4***: 28 33.270N 84 20.343W
Dive 2: 28 36.366N 84 20.966W ***Dive 5***: 28 30.350N 84 17.280W
Dive 3: 28 32.364N 84 16.514W ***Dive 6***: 28 30.485N 84 17.334W



Chapter 6. Nassau grouper distribution and habitat characteristics at Little Cayman, Cayman Islands, British West Indies, December 2002.

Jennifer Schull, David B. McClellan, Anne Marie Eklund, Michael Judge, L. Alan Collins, Michael Feeley

Introduction

Surveys made by the Reef Environmental Education Foundation (REEF) in January 2002 revealed a large spawning aggregation (SPAG) of Nassau grouper at the southwest corner of Little Cayman, Cayman Islands, BWI (Whaylen et al., 2004). Approximately 5,200 Nassau grouper, exhibiting courtship behavior and color change, were present at the spawning site and significant spawning events were witnessed and documented. Since there was an active fishery at the time, 1,934 groupers were captured from this aggregation, with fishers and divers vying for propriety of the aggregation site. The previous year, when the aggregation was discovered, fishers harvested approximately 2,000 Nassau groupers from this site (Whaylen et al., 2004). Nassau grouper SPAGs are particularly susceptible to overfishing with very low incidence of recovery or reformation (Olsen and LaPlace, 1979; Sadovy, 1994).

A team from the NOAA Fisheries, Southeast Fisheries Science Center (NOAA SEFSC) traveled to Little Cayman to observe spawning activity of Nassau grouper during the period surrounding the December full moon of 2002 (12/19/02). The objectives for this research trip were to (1) document, if present, spawning behavior of Nassau grouper at Little Cayman Island spawning sites, (2) take fishery dependent samples from Nassau grouper landed during the SPAG to determine sex ratio, fecundity, and age and (3) characterize the associated fish assemblage and habitat. Sampling of fishes were conducted in December because of a pending government mandate to close fishing at spawning aggregation sites every other year, beginning in January 2003.

Methods

We conducted underwater visual censuses by both roving and stationary techniques. Research methodologies represented an evolution of various census techniques used by the Reef Fish Research Team at NOAA SEFSC. Our research team of four was divided into two dive pairs. Each pair conducted Reef Visual Census (RVC) point counts at specific locations on the reef, and/or conducted focused predator counts during exploratory drift dives along the edge of the wall. Twenty one paired research dives were conducted during the five day research trip, resulting in sixteen RVC point counts and eleven predator counts. Almost all diving activity was done adjacent to the Cayman Island Shelf, an area commonly referred to as “the wall” (Figure 1).

The RVC technique, a standardized stationary point count method, was the dominant research tool utilized (Bohnsack and Bannerot, 1986). A diver attempts to count all individuals and species within five minutes in an imaginary, 7.5 meter (24 ft.) radius cylinder extending from the seafloor to the water’s surface. New species are enumerated while rotating in ones cylinder. After the initial five minutes, divers systematically record data for each species seen (numbers and sizes) working from last to first observed. This method is highly versatile and is useful in both large scale and small scale surveys. Information collected provides a quantitative snapshot for future research on fish assemblages and spawning aggregations in this region. Prior research in Little Cayman (Pattengill-Semmens and Semmens, 2002; Whaylen et al., 2004) relied on the REEF Roving Diver Technique which, while more accessible and inclusive of both divers engaged and species observed, is less quantitative than the RVC technique (Bohnsack, 1996). The RVC technique was augmented by the additional recording of benthic habitat information (McClellan and Miller, 2003). RVC research dives were conducted on a Cayman Island Department of Environment research vessel or a recreational SCUBA diving vessel provided by and run by the Southern Cross Club.

Alternatively, the predator counts allowed researchers to quantitatively scan the underwater landscape for conspicuous piscivores, particularly groupers (Eklund et al., 2000). Predator counts consisted of paired SCUBA divers swimming along a transect adjacent to the shelf edge, usually drifting with the prevailing current. The depth and length of these transects varied depending on the depth of the shelf edge and current speed and direction. One diver recorded numbers and sizes of conspicuous predatory fish, including time seen, while a second diver documented the habitat, fish assemblage, and fish behavior using digital photography or videography. Notable behaviors, color patterns, interactions, and physical conditions were additionally recorded. Surface support recorded starting and ending positions and times using a handheld GPS unit. These locations were later downloaded into a Geographic Information System (GIS) software package (Arcview 3.1) for mapping of diver effort in relation to aggregation sites (Figure 1). Information on the exact time each fish was seen helped map locations of these fish along the transect.

These quantitative samples characterized the distribution and abundance of grouper populations, species specific spawning activities, underlying habitat, and baseline fish assemblage information. Dives were conducted throughout the day and often included early evening or dusk dives. Nassau grouper spawning activities have been previously and almost exclusively documented at dusk. Extensive photographs and video were taken to help characterize habitat and document behaviors during these dives. Data collected during all research dives was entered into a computer software package designed by NOAA SEFSC and the University of Miami Rosenstiel School of Marine and Atmospheric Science (RSMAS). Summary statistics were produced using a bio-analysis program. Metadata descriptions of the Cayman Island research trip is in FGDC format and stored at the SEFSC clearinghouse (www.sefsc.noaa.gov).

Fishery dependent sampling was also to occur using Nassau grouper landed by local fishermen. They were to be weighed and measured, otoliths and dorsal fin spines and rays kept for age and growth analysis, and gonads extracted and preserved using a 10% formalin solution to determine sex, reproductive stage, and fecundity.

Results and Discussion

a. Fish Censuses

Overall, 100 fish species representing 30 families were observed in Little Cayman waters. All species had been previously reported at Little Cayman by Pattengill-Semmens and Semmens (2002). Hawksbill sea turtles, *Eretmochelys imbricate*; spiny lobster, *Panulirus argus*; and queen conch, *Strombus gigas* were also observed. Additional observations of almaco jack, *Seriola rivoliana*, and the tripletail, *Lobotes surinamensis*, observed floating with a piece of flotsam beyond the edge of the shelf was not included in our species list.

The predator count methodology is a search technique that allows for a quantitative scan of underwater habitats and can be used to cover long distances in a short period of time. It is useful when looking for a particular or conspicuous group of predatory fish, Nassau grouper in our case (Eklund et al., 2000). Our team conducted eleven predator counts along the Cayman Island shelf edge. We observed 23 predator species, 10 of which had not been documented during RVC point counts (Tables 1 and 5). While we did not locate a spawning aggregation, Nassau grouper were present in 100% of our predator searches (along with the schoolmaster snapper, *Lutjanus apodus*). Several species of jacks (*Carangidae*) were also conspicuous in predator counts since these fast moving fish tend to travel along or over the edge of the wall. Our RVC counts were done adjacent to or on top of this habitat, and therefore, tended to underestimate the numbers of jacks present.

Predator counts are similar in technique to REEF Roving Diver Surveys (RDT). In 2002, REEF reported sighting frequencies for four grouper species: tiger grouper (79.1%), Nassau grouper (62.6%), yellowfin grouper (*Mycteroperca venenosa*; 41.7%), and black grouper (*M. bonaci*; 13.4%) (Whaylen et al., in press). Our counts reported sighting frequencies of 72.3%, 100%, 36.36%, and 72.73% respectively. Additionally, we also observed yellowmouth grouper (*M. interstitalis*; 27.27%), graysby (*E. cruentatus*; 45.45%), coney (*E. fulvus*; 36.36%), and red hind (*E. guttatus*; 18.18%).

A total of 16 RVC samples were accomplished and 68 species representing 21 families and 4,636 individuals were observed (Tables 1 and 2). The creole wrasse, C*lepticus parrai* (N=1,324, 28.6% of total) was the most abundant species observed followed by the fairy basslet, *Gramma loreto* (N=524, 11.3% of total); blue chromis, *Chromis cyanea* (N=401, 8.6% of total); and masked goby, *Coryphoptrus personatus* (N=351, 7.6% of total). These four planktivorous species represented over 56.1% of the total number observed. Creole wrasse; fairy basslet; black durgon, *Melichthys niger;* and bicolor damselfish, *Pomacentrus partitus,* were observed in 100% of the samples. Biomass estimates were derived for all species using length-to-weight comparisons compiled in Bohnsack and Harper (1988). Yellowtail snapper, *Ocyurus chrysurus*, represented the most biomass (69.5 kg, 23.2% of total) followed by Bermuda chub, *Kyphosus sectatrix* (41.9 kg, 14.0% of total), Nassau grouper, *E. striatus* (25.9 kg, 8.6% of total), and tiger grouper, *Mycteroperca tigris* (20.3 kg, 6.8% of total). Yellowtail snapper, Nassau grouper, and tiger grouper are conspicuous higher trophic level predators and important commercial species. Large grouper species appear at high densities and biomass, paralleling results by Chaippone et al. (2000) showing that areas experiencing light or no fishing have higher densities, biomass and species diversity of large groupers than areas with heavy fishing and no protection. The large biomass of Bermuda chub, an herbivore, is notable because these fish are occasionally observed in large numbers at Nassau grouper spawning sites in the Bahamas ([1]D.B. Eggleston, pers. comm.; Figure 4b).

Descriptive habitat data was collected in conjunction with the fish assemblage information during RVC fish counts. Habitat was consistent across sampling areas since all diving activity was conducted adjacent to the Cayman Island Shelf. Figure 2 depicts the benthic habitat composition for sites near the grouper aggregation site and compares it to a composite of sites along the wall. Habitat composition appears to be similar; however, additional samples must be collected in order to determine the degree of similarity. Figure 3 displays some images of typical habitat encountered during our research dives at Little Cayman.

Colin (1992) wrote, "differences in some physical or biological factors would be expected between spawning and other non-spawning locations, if indeed spawning sites were measurably superior locations". Domeier and Colin (1997) proposed objective criteria for characterizing spawning aggregations and their discrete locations in specific terms, rather than simply describing SPAGS as "spectacularly high densities of spawning size fish". They also called for a quantitative comparison of densities of aggregating fish between non-reproductive and reproductive periods. We feel, by using the RVC methodology, we can make an important contribution to this classification. Although we did not witness spawning, we can characterize the fish assemblage at a particular site using the RVC methodology and compare it to other sites over time. Tables 3 and 4 summarize the RVC data collected from both the Nassau grouper aggregation site and other sites along the wall. Table 6 compares summary data from these two groups of data to the total. While our research only presents a snapshot of this idea, hypothetically, if the sites were continuously censused, one would

[1] Eggleston, David B. 2002. North Carolina State University, Dept. of MEAS, Raleigh, NC 27695-7840. Personal commun.

expect to see significant differences such as a spike in the numbers of spawning fish at a spawning site versus a non-spawning site during a particular spawning season. Additionally, one might document the utilization of the site by other species during other times of the year. Due to limited time and personnel, we could not conduct enough samples to adequately analyze the differences in fish assemblages between the grouper aggregation site and other reference points along the Little Cayman Shelf. Continuing this data comparison over time could lead to better understandings of spawning aggregation site dynamics.

b. Characterization of SPAG Location

The environmental characteristics common to spawning aggregation sites generally include a description of lunar cycle, light conditions, geomorphology, water temperature, currents, learned behavior, and geography. Reef promontories near drop off and near the most seaward point of islands can be preferred habitat for spawning (Colin 1992, Colin et al. 1987). The Little Cayman spawning aggregation site was in approximately 30 m of water on the edge of the Cayman Shelf. Here, high relief spur and groove formations run perpendicular to the wall edge as it curves around the contour of the southwest point of the island. While we did not experience the high currents common to this area, anecdotal reports indicate that currents between 1 and 3 knots are often present here. Dives were conducted during the appropriate lunar phase (full moon) for Nassau grouper spawning, however, Nassau grouper prefer water temperatures of about 26^{o}C for spawning to occur (Tucker et al. 1993; Colin 1992; Carter et al. 1994), and water temperatures were consistently between 26.7^{o}C and 28.3^{o}C.; a further indicator of less-than-optimal spawning conditions.

During diving activities, we noted uncharacteristically bold behavior by dog snapper and ocean triggerfish and high incidences of tiger and yellowfin groupers (no courtship behavior or coloration was documented). The physical and oceanographic conditions that make a site ideal for grouper spawning are also probably suitable for a suite of other gregarious spawners (Heyman, 2001). Whaylen et al. (2004) reported on the presence of ten additional species demonstrating courtship behavior and/or spawning at the Nassau grouper spawning site in January 2002: tiger grouper; yellowfin grouper; black grouper; horse-eye jack, *Caranx latus*; bar jack, *C. rubber*; black jack, *C. lugubris;* yellow jack, *C. bartholomaei;* mackerel scad, *Decapterus macarellus*; dog snapper, *Lutjanus jocu*; and ocean triggerfish, *Canthidermis sufflamen*. Eggleston (pers. com.) described spawning by the smooth trunkfish*, Lactophrys triqueter*, and horse-eye jacks, and high abundances of yellowtail snapper, Bermuda chub, and creole wrasse during the January 2003 spawning event. Carter et al. (1994) noted at a single site the presence of courting or spawning dog snapper, black grouper, yellowfin grouper, and coneys in Belize. The presence and behavior of these fishes (especially the non-fished ones) could indicate undiscovered or previously exploited spawning aggregation sites.

Notably, Nassau grouper were not present in sufficient numbers (nor were they exhibiting characteristic behavior or coloration) to define a spawning aggregation. The Nassau grouper observed along the wall both during RVC point counts (N=9) and predator searches (N=31) ranged in size from 15 to 72 cm (mean = 43.3 cm). Nassau grouper are thought to reach maturity between 40-45 cm, which corresponds to 4 - 7 years of age (Sadovy and Eklund 1999). Colin (1992) describes four color phases for spawning Nassau grouper: white belly, bicolor, dark, and barred (normal). The Nassau groupers observed were generally solitary and were not exhibiting any courtship behavior or color changes. Only two Nassau groupers were observed with a very faint white belly color pattern (see Figure 4a), and two very small Nassau groupers (<40 cm) were observed exhibiting some sort of mock territoriality or courtship behavior, blanching white over the white sand as they circled each other tightly. However, several of the larger fish appeared to have somewhat distended abdomens.

c. Fishery Dependent Sampling

Ripe Nassau grouper are collected from December through February (Sadovy and Eklund, 1999). However, most spawning activity for Nassau grouper in Cayman Islands occurs between the months of November and February, with the greatest activity during January and February (Tucker et al., 1993). If the full moon occurs late in the month (as in the case with 2002), spawning could be in December and January (Tucker et al., 1993; Colin et al., 2003). Because of the impending fishery closure, our team sampled the aggregation site on the full moon in mid-December to capitalize on the opportunity to take biological samples from fish caught at the aggregation site. The legislation enacted by the Cayman Islands Government in February 2002 protects Nassau grouper by closing all spawning aggregations to fishing in alternate years (i.e. closed 2003, open 2004 etc..), limiting the size and number of fish that can be taken in the open years (size limit of >12 inches (30.48 cm), maximum of 12 fish per boat per day), and prohibiting traps within one nautical mile of any designated grouper spawning area ([2]Phillipe Bush, pers comm.)

Phillipe Bush, research manager at the Cayman Islands Department of Environment, has been working with the government to institute fishing closure for Nassau grouper aggregation sites during the spawning season. Last January's successful Grouper Moon project, lead by REEF, brought tremendous media attention to not only the fascinating ecology of these groupers, but also the imminent threat they face from overfishing. Pressure on the Cayman Island Government lead to the aggregation closures, effective in January 2003. Phillipe Bush hosted an informational forum for fishermen during the December 2002 full moon to explain the rationale and the rules for the closure, listening to their concerns, misconceptions and answering their questions.

Our research team expected to work with local fishermen to obtain reproductive and age and growth samples from fish captured during the last month of open Nassau grouper fishing prior to the January 2003 closure. In January 2002, approximately 1,934 Nassau grouper were landed at Little Cayman, many of which were captured at the spawning aggregation site (in the previous year, an estimated 2000 fish were taken). Cayman Island Department of the Environment scientists reported an average size of 61.9 cm for landed fish, and a female to male sex ratio of 1:1.6 (Whaylen et al., 2004, based on 275 fish measured, and 431 fish sexed). Other fished aggregation sites in the Caribbean indicates sex ratios skewed to females, which generally indicates the overharvesting of spawning fish (Colin et al., 1987; Colin, 1992; Carter et al., 1994). Thus, this Little Cayman aggregation may be relatively healthy in comparison to other historically fished aggregations in the Caribbean, despite the two years of take from this recently discovered site.

Most of the fishermen targeting the aggregation were from a visiting island, Cayman Brac, and many were insensitive to the impact that large groupers have on the recreational dive community on Little Cayman. Many Little Caymanians decided to boycott grouper meat during that time, and the harvested meat was either exported to Grand Cayman or consumed on Cayman Brac. Some locals reported that some of the harvested meat spoiled before it could be sold. Because of this incident and because of the pending legislation, Nassau grouper fishing in December 2002 was greatly curtailed, and we were unable to collect any fishery dependent samples. However, L. Alan Collins, a fishery biologist and reproductive histology expert from NOAA Fisheries' Panama City Laboratory, presented a talk to fisheries officers from Grand Cayman on the importance of collecting

---

[2] Bush, Phillipe. 2003. Cayman Island Department of Environment P.O. Box 486 GT. Grand Cayman, BWI. Personal commun.

age and growth and fecundity data, and our group will hopefully return to Grand Cayman in January of 2004 to collaboratively conduct this work. Very significant contacts were made during our visit to Little Cayman, and we will be able to capitalize on these relationships during future research opportunities.

Conclusion

Little Cayman displays a very healthy, dynamic reef environment, with only artisanal level fishing pressure. However, with Nassau grouper SPAGs consistently under attack from these fishers, it is imperative to continue to monitor the health of these reefs and their ability, or more probably, their inability to sustain this level of take. Of the five Nassau grouper SPAGs documented in the Cayman Islands, three have disappeared or are commercially extinct (Whaylen et al., 2004). Since it is widely believed that Cayman Island aggregations are self-recruiting because of the expanse of deep water separating the islands, protection of these aggregations is paramount (Colin et al.,1987). Furthermore, Little Cayman's aggregations appear to be more resilient and larger than aggregations in other areas of the Caribbean (Whaylen et al., 2004) and may provide an exceptional opportunity for conservation and research. Unfortunately, the size limit enacted by the Cayman Island Department of Environment may be insufficient to ensure sub-adult Nassau grouper have an opportunity to reach maturity as immature fish will recruit into the fishery well before attaining sexual maturity. This has been a common theme throughout the Caribbean (Sadovy et al., 2000).

While these aggregations have been the focus of research efforts by the Cayman Island Department of the Environment, the surrounding habitat and fish assemblage must be characterized as well in order to provide a robust assessment of changes to the landscape. In 2002, Cayman Island Fisheries Officers visited Little Cayman monthly to monitor the spawning site. However, these reconnaissance dives did not quantify the conditions or species present. Use of the RVC

Methodology may provide a cost effective, efficient way to census the fish biota at spawning aggregation sites during and beyond the spawning season. The RVC and predator count methodologies are standardized and fairly easy to learn, and may offer an efficient, cost effective way for Caribbean fisheries managers to begin collecting statistically sound baseline data on overall reef health (Bohnsack, 1996). During the winter full moons of 2004, when the fishery is open, we hope to conduct similar surveys in conjunction with sampling landed fish from the region to further characterize the islands' fish fauna, habitat, and spawning aggregation dynamics; and to compare these results with prior studies both in the Cayman Islands and the greater Caribbean.

Acknowledgments

This was previously unpublished Protected Resources Division Contribution PRD-01/02-15. Sincere thanks to Cayman Islands Department of the Environment biologists for their expertise, hospitality and collaboration: Phillippe Bush, Kirsten Luke, Bradley Johnson, and Croy McCoy; David Eggleston, North Carolina State University, for his leadership and support of Nassau grouper research and editorial comments; REEF Grouper Moon Biologist Leslie Whaylen for her contacts and field insights; and The Southern Cross Club for logistical support.

Literature Cited

Bohnsack, J.A., McClellan, D.B., Harper, D.E., Davenport, G.S., Konoval, G.J., Eklund, A.M., Contillo, J.P., Bolden, S.K., Fischel, P.C., Sandorf, G.S., Javech, J.C., White, M.W., Pickett, M.H., Hulsbeck, M.W., Tobias, J.L., Ault, J.S., Meester, G.A., Smith, S.G., and Luo, J. 1999. Baseline data for evaluating reef fish populations in the Florida Keys, 1979-1998. NOAA Tech. Memo. NMFS-SEFSC-427. 61 p.

Bohnsack, J.A. 1996. Two visually based methods for monitoring coral reef fishes. *in* Crosby, M.P., G.R. Gibson, and K.W. Potts (eds). *A coral reef symposium on practical, reliable, low cost monitoring methods for assessing the biota and habitat conditions of coral reefs, January 26-27, 1995.* Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration, Silver Springs, MD. pp 31-35.

Bohnsack, J. and S. Bannerot. 1986. A stationary visual census technique for quantitatively assessing community structure of coral reef fishes. NOAA Tech. Rep., NMFS 41, 15 p.

Bohnsack, J. and D. Harper. 1988. Length-weight relationships of selected marine reef fishes from the Caribbean. NOAA Tech. Memo. NMFS-SEFSC-215. 31 p.

Carter, J.G., G. Marrow, and V. Pryor. 1994. Aspects of the ecology and reproduction of Nassau grouper, *Epinephelus striatus*, off the coast of Belize, Central America. Proc. Gulf Carib. Fish. Inst. 43:65-111.

Chiappone, M., R. Sluka and K. Sullivan Sealey. 2000. Groupers (Pisces: Serranidae) in fished and protected areas of the Florida Keys, Bahamas and northern Caribbean. Mar. Ecol. Prog. Ser. 198: 261-272.

Colin, P.L., D.Y. Shapiro, and D. Weiler. 1987. Aspects of the reproduction of two species of groupers, *Epinephelus guttatus* and *E. striatus* in the West Indes. Bul. Mar. Sci. 40(2):220:230.

Colin, P.L. 1992. Reproduction of the Nassau grouper, *Epinephelus striatus* (Pisces: Serranidae) and its relationship to environmental conditions. Envir. Biol. Fish 34:357-377.

Colin, P.L., Y.J. Sadovy, and M.L. Domeier. 2003. Manual for the study and conservation of reef fish spawning aggregations. Society for the Conservation of Reef Fish Aggregations Special Publication Number 1 (Version 1.0). pp 1-98+iii.

Domeier, M.L., and P.L. Colin. 1997. Tropical reef fish spawning aggregations defined and reviewed. Bul. Mar. Sci. 60(3):698-726.

Eklund, A.M., D.B. McClellan, and D.E. Harper. 2000. Black grouper aggregations in relation to protected areas within the Florida Keys National Marine Sanctuary. Bul. Mar. Sci. 66(3):721-728.

Heyman, W. 2001. Session introduction: Conservation of multi-species reef fish spawning aggregations. Proc. Gulf. Carib. Fish. Inst. 54:650-651.

McClellan, D.B. and G. M. Miller. 2003. Reef fish abundance, biomass, species composition and habitat characterization of Navassa Island. *in* Miller, M.W. (Ed.) Status of reef resources of Navassa Island: Cruise report Nov. 2002. pp 24-33. NOAA Technical Memorandum NMFS SEFSC-501m 118 pp.

Olsen, D.A., and J.A. LaPlace. 1979. A study of a Virgin Islands grouper fishery based on a breeding aggregation. Proc. Gulf Carib. Fish. Inst. 3:130-144.

Pattengill-Semmens, C.V. and B.X. Semmens. 2002. Status of coral reefs of Little Cayman and Grand Cayman, British West Indies, in 1999. Atoll Research Bulletin.

Sadovy, Y. 1994. Grouper stocks of the Western Central Atlantic: the need for management and management needs. Proc. Gulf Carib. Fish. Inst. 43:43-64.

Sadovy, Y. and A.M. Eklund. 1999. Synopsis of biological data on the Nassau grouper, *Epinephelus striatus* (Bloch, 1792), and the jewfish, *E. itajara* (Lichtenstein, 1822). NOAA Techn. Rpt. NMFS 146.65 p.

Tucker, J.W., P.G. Bush, and S. Slaybaugh. 1993. Reproductive patterns of Cayman Islands Nassau grouper (*Epinephelus striatus*) populations. Bull. Mar. Sci. 52 (3):961-969.

Whaylen, L., C.V. Pattengill-Semmens, B.X. Semmens, P.G. Bush, and M.R. Boardman. 2004. Observations of a Nassau grouper (*Epinephelus striatus*) spawning aggregation site in Little Cayman, including multi-species spawning information. Environmental Biology of Fishes 70(3):305-313.

Table 1. Phylogenic listing of families and species observed in visual samples from Little Cayman Island, December 2002. Names are according to Robins et al. (1991), with the exception that *Hypoplectrus* species (denoted by #) which were listed as *H. unicolor*. The species codes were derived from the first three and four letters, respectively, of the genus and trivial species name. Trophic level codes: B browser, F piscivore, H herbivore, Ma macroinvertivore, Mi microinvertivoore, P planktivore. Predominate adult trophic mode indicated in bold (Bohnsack et al. 1999). *=seen in predator searches only. **=seen at other times.

FAMILY NAME	*Scientific name*	**Family common name**	Species common name	Trophic Level	Species Code
RHINCODONTIDAE		**Carpet sharks**			
	Ginglymostoma cirratum		Nurse shark	**Ma**,F	GIN CIRR **
MYLIOBATIDAE		**Eagle rays**			
	Aetobatus narinari		Spotted eagle ray	**Ma**	AET NARI **
MURAENIDAE		**Morays**			
	Gymnothorax funebris		Green moray	**F**,Ma	GYM FUNE *
HOLOCENTRIDAE		**Squirrelfishes**			
	Holocentrus adscensionis		Squirrelfish	**Ma**,Mi	HOL ADSC
	Holocentrus marianus		Longjaw squirrelfish	**Ma**,Mi	HOL MARI
	Holocentrus rufus		Longspine squirrelfish	**Ma**,Mi	HOL RUFU
	Myripristis jacobus		Blackbar soldierfish	**P**	MYR JACO
AULOSTOMIDAE		**Trumpetfishes**			
	Aulostomus maculatus		Trumpetfish	**F**	AUL MACU
SERRANIDAE		**Sea basses**			
	Epinephelus cruentatus		Graysby	**F**,Ma	EPI CRUE
	Epinephelus fulvus		Coney	**F**,Ma	EPI FULV
	Epinephelus guttatus		Red hind	**Ma**,F	EPI GUTT
	Epinephelus striatus		Nassau grouper	**F**,Ma	EPI STRI
	Hypoplectrus puella #		Barred hamlet	**Mi**	HYP PUEL
	Hypoplectrus unicolor #		Butter hamlet	**Mi**	HYP UNIC
	Liopropoma mowbrayi		Cave basslet	**Mi**	LIO MOWB **
	Liopropoma rubre		Peppermint bass	**Mi**	LIO RUBE
	Mycteroperca bonaci		Black grouper	**F**,Ma	MYC BONA *,**
	Mycteroperca interstitialis		Yellowmouth grouper	**F**,Ma	MYC INTE *,**
	Mycteroperca tigris		Tiger grouper	**F**,Ma	MYC TIGR
	Mycteroperca venenosa		Yellowfin grouper	**F**,Ma	MYC VENE
	Rypticus saponaceus		Greater soapfish	**F**,Ma	RYP SAPO **
	Serranus tabacarius		Tobaccofish	**Mi**	SER TABA **
	Serranus tigrinus		Harlequin bass	**Mi**	SER TIGR
GRAMMATIDAE		**Basslets**			
	Gramma loreto		Fairy basslet	**Mi**	GRA LORE
	Gramma melacara		Blackcap basslet	**Mi**	GRA MELA

Table 1 (cont.)

FAMILY NAME	*Scientific name*	***Family common name***	Species common name	Trophic Level	Species Code
POMACANTHIDAE		***Angelfishes***			
	Holacanthus ciliaris		Queen angelfish	**B**	HOL CILI
	Holacanthus tricolor		Rock beauty	**B**	HOL TRIC
	Pomacanthus arcuatus		Gray angelfish	**B**	POM ARCU
	Pomacanthus paru		French angelfish	**B**	POM PARU
POMACENTRIDAE		***Damselfishes***			
	Chromis cyanea		Blue chromis	**P**	CHR CYAN
	Chromis insolata		Sunshinefish	**P**	CHR INSO
	Chromis multilineata		Brown chromis	**P**	CHR MULT
	Pomacentrus fuscus		Dusky damselfish	**H**	POM FUSC
	Pomacentrus leucostictus		Cocoa damselfish	**H**	POM LEUC **
	Pomacentrus partitus		Bicolor damselfish	**P**	POM PART
	Pomacentrus planifrons		Three spot damselfish	**H**	POM PLAN
CIRRHITIDAE		***Hawkfishes***			
	Amblycirrhitus pinos		Redspotted hawkfish	**Mi**	AMB PINO
LABRIDAE		***Wrasses***			
	Clepticus parrae		Creole wrasse	**P**	CLE PARR
	Halichoeres garnoti		Yellowhead wrasse	**Ma**,Mi	HAL GARN
	Halichoeres maculipinna		Clown wrasse	**Mi**,Ma	HAL MACU
	Lachnolaimus maximus		Hogfish	**Ma**	LAC MAXI
	Thalassoma bifasciatum		Bluehead	**P**,Mi,Ma	THA BIFA
SPHYRAENIDAE		***Barracudas***			
	Sphyraena barracuda		Great barracuda	**F**,Ma	SPH BARR *
SCARIDAE		***Parrotfishes***			
	Scarus croicensis		Striped parrotfish	**H**	SCA CROI
	Scarus taeniopterus		Princess parrotfish	**H**	SCA TAEN
	Scarus vetula		Queen parrotfish	**H**	SCA VETU
	Sparisoma aurofrenatum		Redband parrotfish	**H**	SPA AURO
	Sparisoma chrysopterum		Redtail parrotfish	**H**	SPA CHRY
	Sparisoma rubripinne		Redfin parrotfish	**H**	SPA RUBR **
	Sparisoma viride		Stoplight parrotfish	**H**	SPA VIRI
OPISTOGNATHIDAE		***Jawfishes***			
	Opistognathus aurifrons		Yellowhead jawfish	**P**	OPI AURI
CLINIDAE		***Clinids***			
	Malacoctenus boehlkei		Diamond blenny	**Mi**,P	MAL BOEH **
	Malacoctenus triangulatus		Saddled blenny	**Mi**,P	MAL TRIA **

Table 1 (cont.)

FAMILY NAME	Scientific name	Family common name	Species common name	Trophic Level	Species Code
GOBIIDAE		***Gobies***			
	Coryphopterus glaucofraenum		Bridled goby	**H**	COR GLAU **
	Coryphopterus personatus		Masked goby	**P**	COR PERS
	Gobiosoma evelynae		Sharknose goby	**Mi**,	GOB EVEL **
	Gobiosoma genie		Cleaning goby	**Mi**,	GOB GENI **
	Goby-like fish		Goby-like fish	**Mi**,H	GOB SPE./COR SPE. **
	Priolepis hipoliti		Rusty goby	**P**	PRI HIPO **
ACANTHURIDAE		***Surgeonfishes***			
	Acanthurus bahianus		Ocean surgeon	**H**	ACA BAHI
	Acanthurus chirurgus		Doctorfish	**H**	ACA CHIR
	Acanthurus coeruleus		Blue tang	**H**	ACA COER
BALISTIDAE		***Leatherjackets***			
	Aluterus scriptus		Scrawled filefish	**H,**B	ALU SCRI **
	Balistes vetula		Queen triggerfish	**Ma**	BAL VETU **
	Canthidermis sufflamen		Ocean triggerfish	**Ma**,P	CAN SUFF
	Melichthys niger		Black durgon	**P**	MEL NIGE
MONACANTHIDAE		***Filefishes***			
	Cantherhines macrocerus		Whitespotted filefish	**B,**H	CAN MACR **
OSTRACIIDAE		***Boxfishes***			
	Lactophrys quadricornis		Scrawled cowfish	**B**	LAC QUAD
	Lactophrys triqueter		Smooth trunkfish	**B**	LAC TRIQ **
TETRAODONTIDAE		***Puffers***			
	Canthigaster rostrata		Sharpnose puffer	**H**,B,Mi	CAN ROST
	Diodon holocanthus		Balloonfish	**Ma**	DIO HOLO

Table 2. Statistical summary by species at Little Cayman Island, December 2002. Species are listed alphabetically by species code. Scientific names for codes are given in Table 1.

Species	Total Indiv.	Sample Frequency (N=16)	Mean Abund.	SAMP. FREQ. RANGE High	Low	FISH LENGTH (cm) Mean	Min.	Max.	BIOMASS Total(gms)
ACA BAHI	20	37.5%	1.3	8	0	12.9	8	20	1,207.9
ACA CHIR	5	12.5%	0.3	3	0	17.6	14	25	761.7
ACA COER	32	93.8%	2.0	6	0	11.7	6	15	1,536.8
AMB PINO	1	6.3%	0.1	1	0	10.0	10	10	6.9
AUL MACU	3	18.8%	0.2	1	0	38.3	35	40	413.6
CAN ROST	10	31.3%	0.6	3	0	5.4	2	10	52.3
CAN SUFF	20	31.3%	1.3	8	0	29.0	20	40	11,822.1
CAR LUGU	5	31.3%	0.3	1	0	36.6	30	40	4,406.3
CAR RUBE	8	25.0%	0.5	4	0	17.3	7	40	1,779.0
CHA ACUL	4	12.5%	0.3	3	0	8.0	6	8	51.6
CHA CAPI	16	56.3%	1.0	2	0	8.4	6	12	389.9
CHA OCEL	7	25.0%	0.4	2	0	9.4	8	12	175.1
CHA SEDE	10	6.3%	0.6	10	0	6.0	4	15	156.1
CHA STRI	4	18.8%	0.3	2	0	9.5	8	10	106.8
CHR CYAN	401	93.8%	25.1	50	0	6.1	3	10	2,536.0
CHR INSO	2	6.3%	0.1	2	0	2.0	2	2	0.3
CHR MULT	65	25.0%	4.1	27	0	5.2	3	7	233.1
CLE PARR	1,324	100.0%	82.8	250	5	8.1	4	17	11,182.8
COR PERS	351	37.5%	21.9	120	0	1.9	1	4	40.2
DIO HOLO	1	6.3%	0.1	1	0	18.0	18	18	163.3
EPI CRUE	17	50.0%	1.1	6	0	15.6	8	30	1,373.5
EPI FULV	5	18.8%	0.3	2	0	13.2	12	16	193.2
EPI GUTT	1	6.3%	0.1	1	0	24.0	24	24	218.9
EPI STRI	9	37.5%	0.6	3	0	50.4	30	72	25,861.3
GOB SPE.	1	6.3%	0.1	1	0	4.0	4	4	0.8
GRA LORE	524	100.0%	32.8	150	2	5.9	2	8	1,426.3
GRA MELA	210	25.0%	11.9	100	0	6.9	3	10	650.0
HAE CARB	50	6.3%	3.1	50	0	23.0	20	25	10,662.9
HAE FLAV	26	43.8%	1.6	12	0	11.4	10	30	1,186.0
HAE PARR	25	6.3%	1.6	25	0	25.0	20	30	7,671.6
HAE PLUM	23	18.8%	1.4	15	0	21.6	12	30	5,411.4
HAE SCIU	55	31.3%	3.4	25	0	21.6	14	30	11,614.6
HAL GARN	32	75.0%	2.0	6	0	7.7	4	15	326.4
HAL MACU	2	12.5%	0.1	1	0	6.0	6	6	4.1
HOL ADSC	15	25.0%	0.9	6	0	15.7	10	22	1,649.4
HOL CILI	1	6.3%	0.1	1	0	18.0	18	18	147.3
HOL MARI	7	25.0%	0.4	3	0	8.9	6	12	174.7
HOL RUFU	9	31.3%	0.6	3	0	16.0	14	20	722.3
HOL TRIC	3	18.8%	0.2	1	0	12.3	10	15	181.1
HYP PUEL	6	25.0%	0.4	2	0	7.7	6	10	47.0
HYP UNIC	1	6.3%	0.1	1	0	8.0	8	8	8.2
KYP SECT	77	62.5%	4.8	25	0	26.4	12	50	41,949.7
LAC MAXI	2	12.5%	0.1	1	0	57.5	55	60	7,400.3
LAC QUAD	1	6.3%	0.1	1	0	35.0	35	35	546.4
LIO RUBE	3	6.3%	0.2	3	0	2.0	2	2	27.0
LUT APOD	78	50.0%	4.9	44	0	17.2	10	40	9,528.5
LUT JOCU	2	12.5%	0.1	1	0	45.0	30	60	4,226.9
LUT MAHO	70	18.8%	4.4	35	0	16.6	10	25	6,950.5
MEL NIGE	108	100.0%	6.8	17	1	14.3	8	25	7,634.1
MUL MART	4	18.8%	0.3	2	0	17.8	15	20	334.0
MYC TIGR	15	43.8%	0.9	7	0	37.3	12	80	20,342.4
MYC VENE	2	12.5%	0.1	1	0	30.0	30	30	778.0
MYR JACO	19	18.8%	1.2	16	0	18.3	8	20	3,045.3
OCY CHRY	230	93.8%	14.4	50	0	25.2	14	50	69,536.8
OPI AURI	20	6.3%	1.3	20	0	6.0	6	6	39.4

Table 2 (cont.)

Species	Total Indiv.	Sample Frequency (N=16)	Mean Abund.	SAMP. FREQ. RANGE High	Low	FISH LENGTH (cm) Mean	Min.	Max.	BIOMASS Total(gms)
POM ARCU	4	18.8%	0.3	2	0	26.5	20	35	2,650.8
POM FUSC	12	18.8%	0.8	8	0	5.7	4	10	77.4
POM PART	238	100.0%	14.9	34	1	4.7	2	10	827.9
POM PARU	4	18.8%	0.3	2	0	31.3	20	35	4,335.8
POM PLAN	20	37.5%	1.3	7	0	6.4	4	12	202.3
SCA CROI	70	93.8%	4.4	20	0	8.8	4	20	1,125.9
SCA TAEN	33	56.3%	2.1	6	0	11.6	4	34	1,483.0
SCA VETU	1	6.3%	0.1	1	0	28.0	28	28	395.0
SER TIGR	5	31.3%	0.3	1	0	8.0	6	10	47.4
SPA AURO	23	56.3%	1.4	6	0	9.5	4	20	745.1
SPA CHRY	2	12.5%	0.1	1	0	24.5	24	25	503.1
SPA VIRI	27	62.5%	1.7	8	0	20.6	5	40	8,104.8
THA BIFA	255	87.5%	15.9	32	0	5.6	1	15	570.4

NO. SAMPLES =	16
NO. SPECIES =	68
TOT.INDIVIDUALS =	4,636
TOT. BIOMASS (g) =	299,961.10

Table 3. Analysis of RVC samples taken at the Little Cayman Island Nassau grouper SPAG, December 2002.

Species	Total Indiv.	SAMPLE FREQ (N = 4)	Mean Abund.	SAMP. FREQ. RANGE High	Low	FISH LENGTH (cm) Mean	Min.	Max.	BIOMASS Total(gms)
ACA BAHI	13	75.0%	3.3	8	0	13.0	10	20	750.7
ACA CHIR	5	50.0%	1.3	3	0	17.6	14	25	761.7
ACA COER	17	125.0%	4.3	6	0	11.6	8	15	763.9
AMB PINO	1	25.0%	0.3	1	0	10.0	10	10	6.9
CAN ROST	1	25.0%	0.3	1	0	5.0	5	5	2.2
CAN SUFF	15	75.0%	3.8	8	0	32.0	20	40	10,990.4
CAR LUGU	3	75.0%	0.8	1	0	34.3	30	38	2,140.9
CAR RUBE	2	50.0%	0.5	1	0	35.0	30	40	1,579.0
CHA CAPI	6	75.0%	1.5	2	0	8.3	6	12	156.9
CHR CYAN	83	100.0%	20.8	25	13	5.1	3	8	286.5
CLE PARR	475	100.0%	118.8	250	5	8.6	6	17	4,845.4
EPI CRUE	4	50.0%	1.0	3	0	25.5	10	30	958.3
EPI FULV	2	25.0%	0.5	2	0	13.0	12	14	72.0
EPI GUTT	1	25.0%	0.3	1	0	24.0	24	24	218.9
GRA LORE	54	100.0%	13.5	27	4	4.6	3	6	49.7
HAE FLAV	16	75.0%	4.0	12	0	10.4	10	12	344.1
HAE PLUM	3	25.0%	0.8	3	0	14.0	12	16	159.6
HAE SCIU	21	50.0%	5.3	20	0	20.0	20	20	3,258.2
HAL GARN	17	100.0%	4.3	6	3	7.2	4	15	140.3
HAL MACU	1	25.0%	0.3	1	0	6.0	6	6	2.1
HOL RUFU	1	25.0%	0.3	1	0	16.0	16	16	72.6
HOL TRIC	1	25.0%	0.3	1	0	12.0	12	12	51.9
HYP PUEL	1	25.0%	0.3	1	0	8.0	8	8	8.2
KYP SECT	19	100.0%	4.8	10	1	18.5	12	34	4,123.2
LAC QUAD	1	25.0%	0.3	1	0	35.0	35	35	546.4
LUT APOD	6	75.0%	1.5	3	0	25.3	14	35	2,378.2
LUT JOCU	2	50.0%	0.5	1	0	45.0	30	60	4,226.9
MEL NIGE	35	100.0%	8.8	12	2	13.5	8	25	2,276.3
MYC TIGR	2	50.0%	0.5	1	0	52.0	24	80	9,225.2
MYC VENE	1	25.0%	0.3	1	0	30.0	30	30	389.0
MYR JACO	18	50.0%	4.5	16	0	18.9	10	20	3,027.6
OCY CHRY	70	100.0%	17.5	43	3	22.8	15	45	16,047.5
OPI AURI	20	25.0%	5.0	20	0	6.0	6	6	39.4
POM ARCU	1	25.0%	0.3	1	0	20.0	20	20	250.2
POM FUSC	1	25.0%	0.3	1	0	10.0	10	10	27.8
POM PART	70	100.0%	17.5	34	1	4.8	3	10	222.9
POM PARU	3	50.0%	0.8	2	0	35.0	35	35	4,098.3
SCA CROI	13	75.0%	3.3	5	0	10.7	6	16	378.4
SCA TAEN	8	50.0%	2.0	6	0	9.0	5	14	122.3
SER TIGR	3	75.0%	0.8	1	0	8.0	6	10	27.8
SPA AURO	8	75.0%	2.0	5	0	9.3	4	20	284.4
SPA VIRI	5	50.0%	1.3	4	0	29.8	25	35	2,681.3
THA BIFA	86	100.0%	21.5	32	14	5.6	3	10	151.5

NO. SAMPLES =	4
NO. SPECIES =	43
TOT.INDIVIDUALS =	1,115
BIOMASS (g) =	78,144.90

Table 4. Analysis of RVC samples taken at the Little Cayman Island Bloody Wall site, December 2002.

	Total	SAMPLE FREQ	Mean	SAMP. FREQ. RANGE		FISH LENGTH (cm)			BIOMASS
Species	Indiv.	(N = 12)	Abund.	High	Low	Mean	Min.	Max.	Total(gms)
ACA BAHI	7	25.0%	0.6	4	0	12.6	8	20	457.2
ACA COER	15	83.3%	1.3	3	0	11.8	6	15	772.9
AUL MACU	3	25.0%	0.3	1	0	38.3	35	40	413.6
CAN ROST	9	33.3%	0.8	3	0	5.4	2	10	50.1
CAN SUFF	5	16.7%	0.4	3	0	20.0	20	20	831.7
CAR LUGU	2	16.7%	0.2	1	0	40.0	40	40	2,265.4
CAR RUBE	6	16.7%	0.5	4	0	11.3	7	18	200.0
CHA ACUL	4	16.7%	0.3	3	0	8.0	6	8	51.6
CHA CAPI	10	50.0%	0.8	2	0	8.4	6	12	233.1
CHA OCEL	7	33.3%	0.6	2	0	9.4	8	12	175.1
CHA SEDE	10	8.3%	0.8	10	0	6.0	4	15	156.1
CHA STRI	4	25.0%	0.3	2	0	9.5	8	10	106.8
CHR CYAN	318	91.7%	26.5	50	0	6.3	4	10	2,249.5
CHR INSO	2	8.3%	0.2	2	0	2.0	2	2	0.3
CHR MULT	65	33.3%	5.4	27	0	5.2	3	7	233.1
CLE PARR	849	100.0%	70.8	150	5	7.8	4	15	6,337.5
COR PERS	351	50.0%	29.3	120	0	1.9	1	4	40.2
DIO HOLO	1	8.3%	0.1	1	0	18.0	18	18	163.3
EPI CRUE	13	50.0%	1.1	6	0	12.5	8	18	415.2
EPI FULV	3	16.7%	0.3	2	0	13.3	12	16	121.2
EPI STRI	9	50.0%	0.8	3	0	50.4	30	72	25,861.3
GOB SPE.	1	8.3%	0.1	1	0	4.0	4	4	0.8
GRA LORE	470	100.0%	39.2	150	2	6.1	2	8	1,376.6
GRA MELA	210	33.3%	15.8	100	0	6.9	3	10	650.0
HAE CARB	50	8.3%	4.2	50	0	23.0	20	25	10,662.9
HAE FLAV	10	33.3%	0.8	5	0	13.0	10	30	841.9
HAE PARR	25	8.3%	2.1	25	0	25.0	20	30	7,671.6
HAE PLUM	20	16.7%	1.7	15	0	22.8	14	30	5,251.8
HAE SCIU	34	25.0%	2.8	25	0	22.6	14	30	8,356.4
HAL GARN	15	66.7%	1.3	4	0	8.2	4	15	186.1
HAL MACU	1	8.3%	0.1	1	0	6.0	6	6	2.1
HOL ADSC	15	33.3%	1.3	6	0	15.7	10	22	1,649.4
HOL CILI	1	8.3%	0.1	1	0	18.0	18	18	147.3
HOL MARI	7	33.3%	0.6	3	0	8.9	6	12	174.7
HOL RUFU	8	33.3%	0.7	3	0	16.0	14	20	649.8
HOL TRIC	2	16.7%	0.2	1	0	12.5	10	15	129.1
HYP PUEL	5	25.0%	0.4	2	0	7.6	6	10	38.9
HYP UNIC	1	8.3%	0.1	1	0	8.0	8	8	8.2
KYP SECT	58	50.0%	4.8	25	0	28.9	18	50	37,826.5
LAC MAXI	2	16.7%	0.2	1	0	57.5	55	60	7,400.3
LIO RUBE	3	8.3%	0.3	3	0	2.0	2	2	27.0
LUT APOD	72	41.7%	6.0	44	0	16.5	10	40	7,150.4
LUT MAHO	70	25.0%	5.8	35	0	16.6	10	25	6,950.5
MEL NIGE	73	100.0%	6.1	17	1	14.6	10	20	5,357.9
MUL MART	4	25.0%	0.3	2	0	17.8	15	20	334.0
MYC TIGR	13	41.7%	1.1	7	0	35.1	12	55	11,117.1
MYC VENE	1	8.3%	0.1	1	0	30.0	30	30	389.0
MYR JACO	1	8.3%	0.1	1	0	8.0	8	8	17.8
OCY CHRY	160	91.7%	13.3	50	0	26.2	14	50	53,489.3
POM ARCU	3	16.7%	0.3	2	0	28.7	20	35	2,400.6
POM FUSC	11	16.7%	0.9	8	0	5.3	4	6	49.6
POM PART	168	100.0%	14.0	25	6	4.7	2	10	605.0

Table 4 (cont.)

Species	Total Indiv.	SAMPLE FREQ (N = 12)	Mean Abund.	SAMP. FREQ. RANGE High	Low	FISH LENGTH (cm) Mean	Min.	Max.	BIOMASS Total(gms)
POM PARU	1	8.3%	0.1	1	0	20.0	20	20	237.5
POM PLAN	20	50.0%	1.7	7	0	6.4	4	12	202.3
SCA CROI	57	100.0%	4.8	20	1	8.4	4	20	747.4
SCA TAEN	25	58.3%	2.1	6	0	12.4	4	34	1,360.7
SCA VETU	1	8.3%	0.1	1	0	28.0	28	28	395.0
SER TIGR	2	16.7%	0.2	1	0	8.0	6	10	19.6
SPA AURO	15	50.0%	1.3	6	0	9.7	5	20	460.7
SPA CHRY	2	16.7%	0.2	1	0	24.5	24	25	503.1
SPA VIRI	22	66.7%	1.8	8	0	18.5	5	40	5,423.5
THA BIFA	169	83.3%	14.1	32	0	5.6	1	15	419.0

NO. SAMPLES =	12
NO. SPECIES =	62
TOT.INDIVIDUALS =	3,521
BIOMASS (g) =	221,816.20

Table 5. Alphabetical summary of piscivores observed during drift predator counts along the Little Cayman Island's shelf edge. Table 1 defines species code.

Species	Number of Individuals	Sample Frequency	FISH LENGTH (cm) Mean	Min	Max
CAR BART	115	18.18%	26.5	18	35
CAR HIPP	2	9.09%	67.5	65	70
CAR LATU	1361	54.55%	47.4	30	80
CAR LUGU	10	54.55%	43.3	30	60
CAR RUBE	256	54.55%	16.3	12	40
ELA BIPI	31	18.18%	32	20	50
EPI CRUE	15	45.45%	11.2	5	18
EPI FULV	8	36.36%	19.8	14	35
EPI GUTT	2	18.18%	37.5	35	40
EPI STRI	31	100.00%	41.3	15	70
GYM FUNE	1	9.09%	nd	nd	nd
LAC MAXI	1	9.09%	30	30	30
LUT ANAL	5	27.27%	31.8	19	40
LUT APOD	347	100.00%	26.2	12	40
LUT JOCU	4	9.09%	57.5	50	60
LUT MAHO	205	54.55%	16.8	12	25
MYC BONA	12	72.73%	57.9	30	100
MYC INTE	4	27.27%	35	20	45
MYC TIGR	18	72.73%	37.4	25	48
MYC VENE	9	36.36%	52.5	30	75
OCY CHRY	1322	81.82%	27.5	14	45
SPH BARR	11	72.73%	63.4	30	120
TRA FALC	15	9.09%	50	45	55

Table 6. Comparison of fish fauna between the southwest Little Cayman Island Nassau grouper SPAG and similar sites along the little Cayman Island shelf.

	Overall	Aggregation Site	Little Cayman Island Shelf
Number of RVC Counts	16	4	12
Total Number of Species Observed	68	43	62
Mean Biomass (grams/individual)	64.7	70.1	63.0
Most Abundand 5 species in declining order	Creole Wrasse, Fairy Basslet, Blue Chromis, Masked Goby, Bluehead Wrasse	Creole Wrasse, Bluehead Wrasse, Blue Chromis, Yellowtail Snapper (tie), Bicolored Damselfish (tie), Fairy Basslet	Creole Wrasse, Fairy Basslet, Masked Goby, Blue Chromis, Blackcap Basslet
Species Present in 100% of Samples	Creole Wrasse, Fairy Basslet, Black Durgon, Bicolored Damselfish,	Blue Chromis, Blue Tang, Creole Wrasse, Fairy Basslet, Yellowhead Wrasse, Bermuda Chub, Black Durgon, Yellowtail Snapper, Bicolored Damselfish, Bluehead Wrasse	Creole Wrasse, Fairy Basslet, Black Durgon, Bicolored Damsel, Striped Parrotfish
Five species representing the most biomass in declining order	Yellowtail Snapper (23.2%), Bermuda Chub (14.0%), Nassau Grouper (8.6%), Tiger Grouper (6.8%), Ocean Trigger (3.9%)	Yellowtail Snapper (20.5%), Ocean Trigger (14.1%), Tiger Grouper (11.8%), Creole Wrasse (6.2%), Bermuda Chub (5.3%)	Yellowtail Snapper (24.1%), Bermuda Chub (30.8%), Nassau Grouper (21.1%), Caesar Grunt (8.7%)

Figure 1. Little Cayman Island, Cayman Islands, British West Indies. Triangles represent predator counts and Red circles represent RVC point counts. The aggregation site was located at the southwest point of the island.

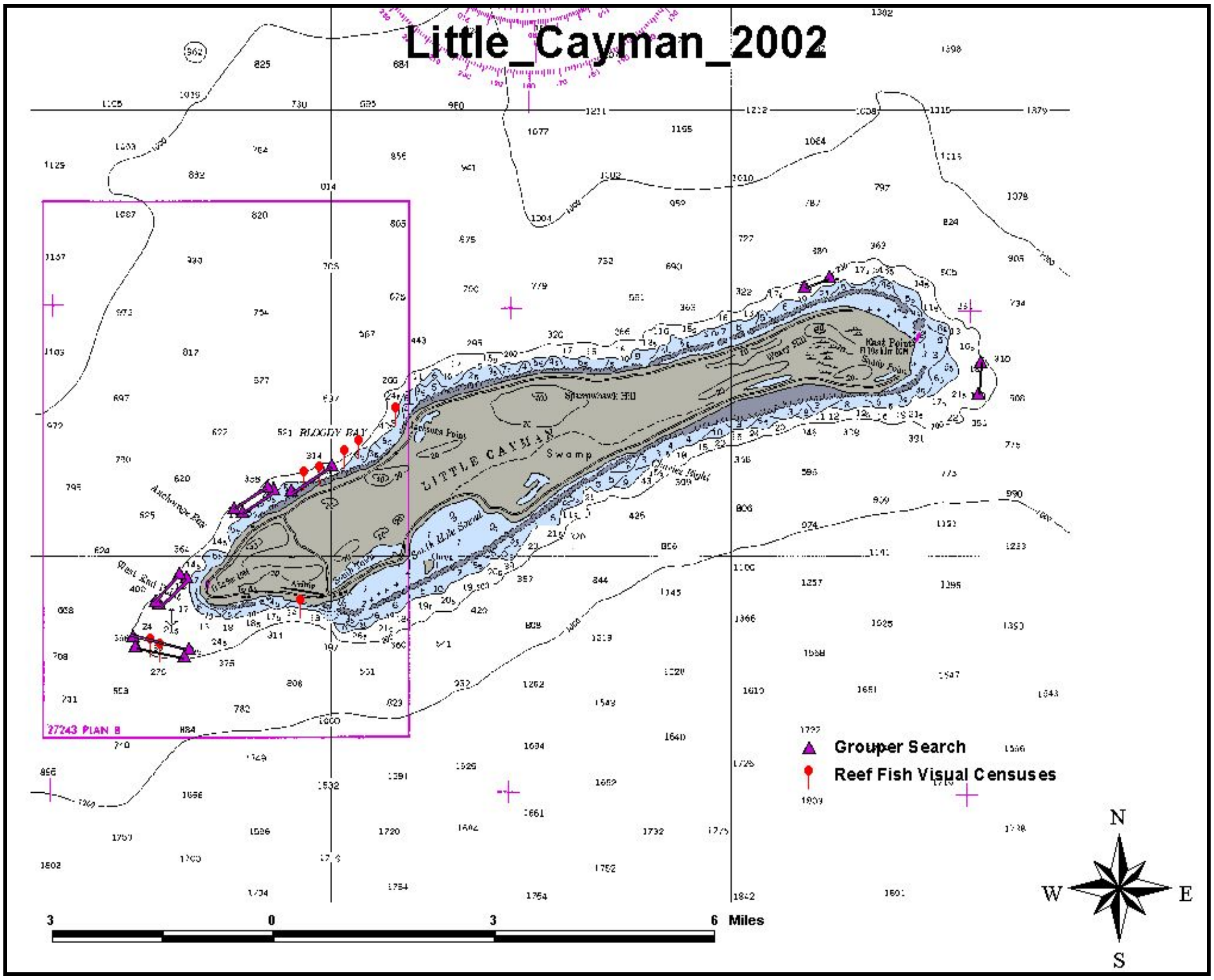


Figure 2. Habitat analysis of Little Cayman RVC sampling sites, December 2002.

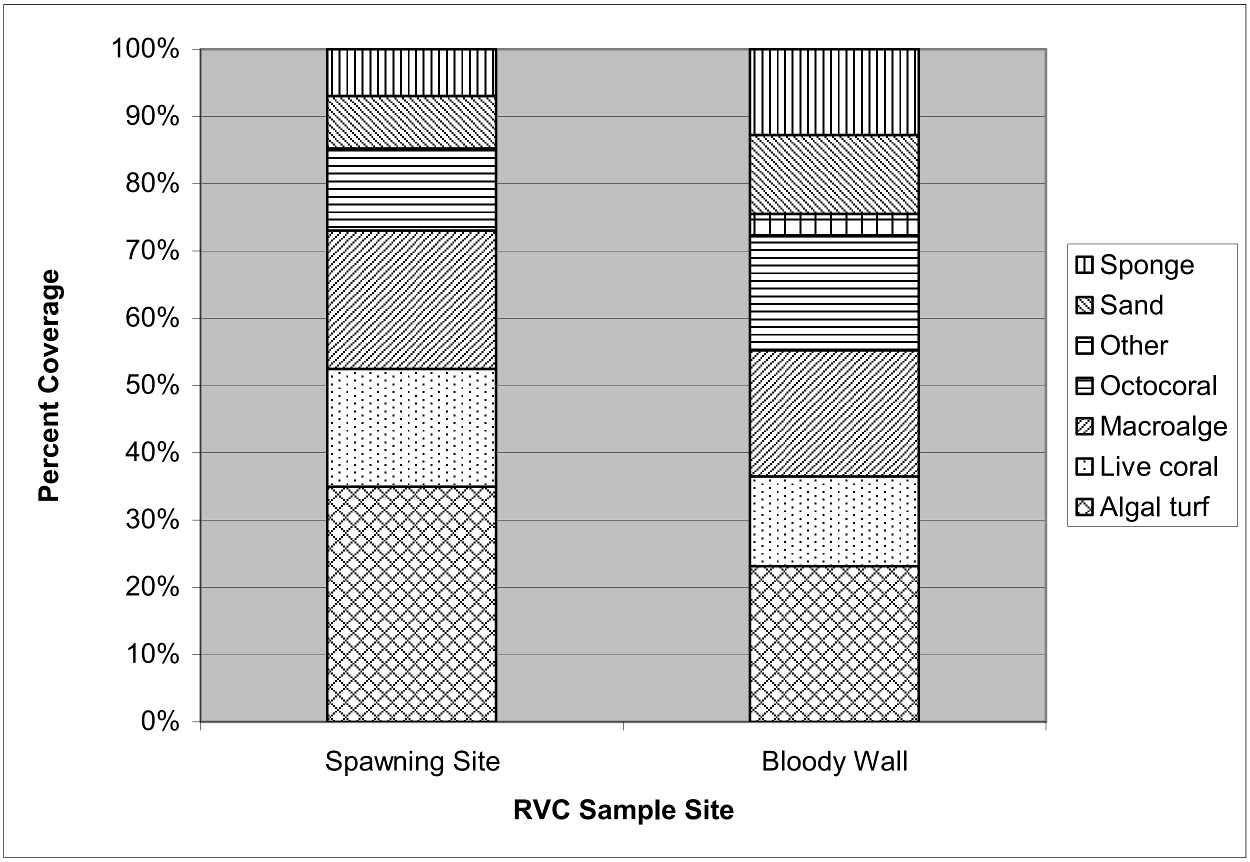
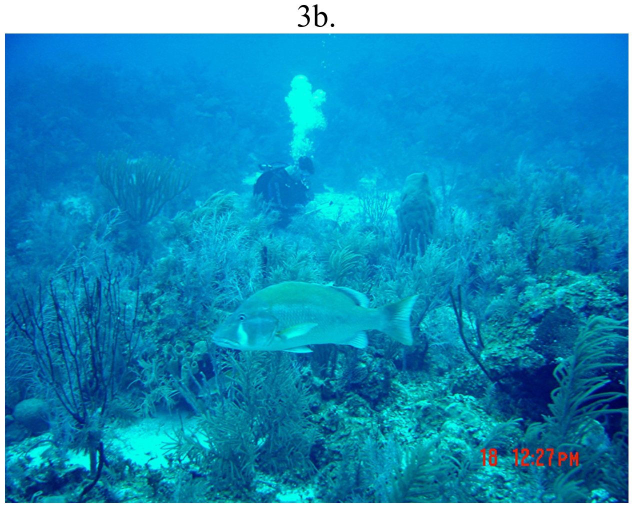


Figure 3. Representative photographs of habitat sampled at Little Cayman Island. All habitats are adjacent to the shelf edge. 3a – Nassau grouper aggregation site located adjacent to the shelf edge on the southwest corner of Little Cayman Island. The visible mooring line and float were installed by the Cayman Island Department of Environment during our research trip. 3b – Diver conducting RVC point count. A dog snapper swims in the foreground. 3c – Diver conducting roving predator search along the edge of the wall.

3a.

3b.



3c

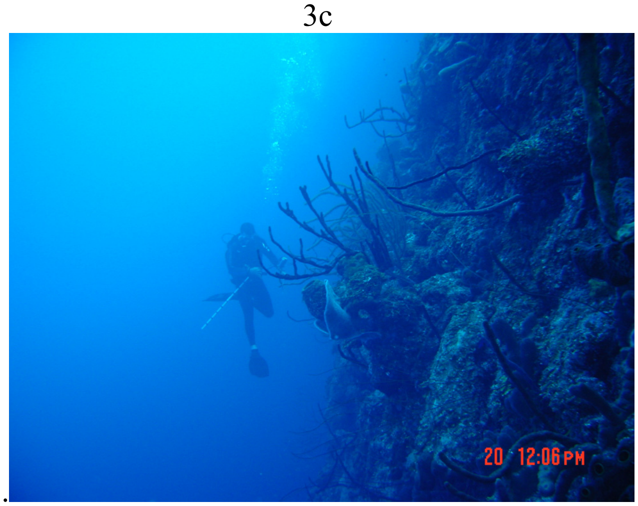


Figure 4. Representative photographs of fauna encountered during research dives on Little Cayman Island. 4a – Solitary Nassau grouper, exhibiting faint "white belly" coloration, swimming adjacent to the wall; note distended abdomen. 4b – Large aggregation of Bermuda chub encountered during predator search. 4c – Typical assemblage of fish swarming above the reef consisting of predominantly of black durgon, creole wrasse, and blue chromis.

4a.

4b.

4c.