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Baseline Data for Evaluating Reef Fish Populations in the Florida Keys, 1979-1998

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EXECUTIVE SUMMARY

Reef fishes are an essential and conspicuous component of the South Florida Marine Ecosystem that support important commercial, recreational, and aesthetic fisheries. Fishes are the ultimate downstream integrators of environmental conditions and human activities. Factors that increase mortality, such as fishing, loss of habitat, and pollution are eventually reflected in adult population abundance, individual size and condition. Over the last two decades, the Florida reef tract ecosystems and Florida Bay have undergone dramatic environmental changes from human and natural forces. These changes are a general concern and the focus of an intensive effort to restore the ecosystem by altering the hydrology to a more natural condition. Fishes are a direct public concern and obvious measure of restoration success. Success of restoration and management changes should be reflected in reef fish communities in terms of the species composition, the size/age structure of fishes, and in fisheries. Fishery resources are regulated by several state and federal agencies under different levels of spatial protection. Understanding and modeling the dynamics of physical and biological processes of Florida Bay and the Florida reef tract requires a good database on fish composition by habitat.

The Florida Keys National Marine Sanctuary (FKNMS) final management plan became effective on 1 July 1997 creating the first planned network of 'no-take' marine reserves in North America. These reserves included 18 'no-take' Sanctuary Protected Areas (SPAs) and one large 'no-take' ecological reserve. This action provides a unique research opportunity to examine the processes and effects of reserve protection at replicated sites of different size. An important goal of the FKNMS management plan is to evaluate changes resulting from establishing no-take marine reserves five

years after they became established. In addition, new ecological reserves are being proposed for the Tortugas region.

Biological data on reef fish biodiversity have been collected continuously since 1979 by highly trained and experienced divers using open circuit SCUBA and visual methods. Visual methods are ideal for assessing reef fishes in the Florida Keys because of prevailing good visibility and management concerns requiring the use of nondestructive assessment methods. Data were collected from randomly selected 7.5 m radius plots using a standard fishery-independent, stationary plot method (Bohnsack and Bannerot 1986). Data collected show reef fish species composition, abundance (density per plot), frequency-of-occurrence, and individual sizes of fishes at reef sites extending from Miami through the Tortugas. These data can be used to assess changes in reef fish communities in the Florida Keys as the result of changes in zoning, regional fishery management practices, and restoration efforts in Florida Bay.

This report provides a summary of a 20 year historical data base that will form the baseline for assessing future changes in reef fish communities in the FKNMS. A total of 263 fish taxa from 54 families were observed from 118 sites in the Florida Keys from 6,673 visual stationary plot samples from 1979 through 1998. The ten most abundant species accounted for 59% of all individuals observed. Ten species had a frequency-of-occurrence in samples greater than 50% and only ten species accounted for 55% of the total observed biomass.

Bray-Curtis similarity analysis of 90 reef sites was conducted to analyze spatial distribution patterns. The analysis showed that reef sites clustered primarily between inshore patch reefs and offshore reefs irrespective of region. Within offshore reefs, Tortugas deeper reefs were distinguished from

sites in the rest of the Florida Keys. In the main Keys, offshore reefs clustered into high relief forereef and low relief hard bottom habitats. Within habitat types, reef sites clustered primarily by geographical region.

Trophic composition of fishes differed greatly in terms of number of individuals and total biomass. Fishes were numerically dominated by planktivores (44%) followed by macroinvertebrates (26%), herbivores (17%), piscivores (8%), microinvertebrates (3%), and browsers (1%). In terms of biomass, piscivores (42%) dominated, followed by macroinvertebrates (25%), herbivores (21%), planktivores (5%), browsers (4%), and microinvertebrates (3%).

Data collected from 1994-1997 form a baseline for assessing changes at study sites during the first five years of protection under the FKNMS management plan. Annual mean density (number of fish observed per plot sample) with 95% confidence intervals were calculated for selected species and projected through 2002 as a prediction of future performance based on the assumption of no changes in population parameters over time.

Since only one full year of data were available following the establishment of no-take zones, it is premature to make conclusion about the impacts of marine reserves on changes in abundance or sizes of multispecies reef fish stocks. It is encouraging, however, that after only one year of no-take protection, the annual mean densities of exploited species in no-take sites were the highest observed for yellowtail snapper, combined grouper, and hogfish and the second highest for gray snapper compared to the baseline period. In comparison, similar uniform responses were not observed for the same species at fished sites nor for two species without direct economic importance (striped and stoplight parrotfish).

Size of reef fishes are also being monitored to assess population changes. Mean fish size in exploitable and non-

exploitable phases for stocks of economically important species were examined as baseline statistics for evaluating future community changes in response to management actions. Because adult growth rates are relatively slow, size changes were unlikely to change much after only one year of protection and may lag other parameters.

The 20 year data set provides an excellent long-term baseline for assessing future changes in reef fish biodiversity, population abundance, and average sizes in the Florida Keys resulting from changes in Florida Keys National Marine Sanctuary zoning, regional fishery management practices, and restoration efforts involving Florida Bay.

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INTRODUCTION

Reef fishes are an essential and conspicuous component of the South Florida Marine Ecosystem. They support important commercial, recreational, and aesthetic fisheries and are the ultimate downstream integrators of environmental conditions and human activities. Factors that increase mortality, such as pollution, fishing, and loss of habitat, are eventually reflected in adult population abundance, individual size and condition. The Caribbean and the Florida Keys have experienced increased human use and resource degradation from coastal development, increased diving, and expanding recreational and commercial fishing related to a growing resident and tourist population (Richards and Bohnsack 1990). In response to these growing threats, the U.S. Congress established the Florida Keys National Marine Sanctuary (FKNMS) in 1990. The final management plan (FMP) became effective on July 1, 1997. An important change is the use of spatial protection in the FKNMS including the establishment of the first planned network of 'no-take' marine reserves. These included 18 'no-take' Sanctuary Protected Areas (SPAs) and one large 'no-take' ecological reserve. This action provides a unique research opportunity to examine the processes and effects of reserve protection on restoring reef fish populations (e.g. PDT 1990, Bohnsack 1996). An important goal of the FKNMS management plan is to evaluate changes resulting from establishing no-take marine reserves five years after establishment.

Many reef species use inshore habitats and Florida Bay as nursery and forage areas for part of their life history before moving out to reef habitats as adults. Examples include barracuda, hogfish, spiny lobster, most snapper and grouper, and many grunts. Florida Bay is a critical nursery habitat for pink shrimp, spiny lobster and many fish species in the Florida Keys. Over the last two decades, Florida Bay has undergone dramatic

environmental changes which are the focus of an intensive effort to restore the ecosystem by altering the hydrology to a more natural condition¹. This restoration program includes a comprehensive effort to understand and model the physical and biological processes of Florida Bay. Success of restoration and management changes should be reflected in reef fish communities in terms of the species composition, the size/age structure of fishes, and in fisheries. Fishes are a direct public concern and obvious measure of restoration success. Understanding and modeling the dynamics of physical and biological processes of Florida Bay and the reef tract requires a good database on fish composition by habitat.

Visual methods are ideal for assessing reef fishes in the Florida Keys because of the prevailing clear water conditions on coral reefs and general management concerns requiring the use of non-destructive assessment methods. This report describes the 20 year Southeast Fisheries Science Center (SEFSC) visual database consisting of non-destructive, fishery-independent, stationary plot data on reef fish composition, abundance, and sizes from reefs in the Florida Keys from Miami through the Tortugas. These data form a historical baseline for assessing future changes in reef fish communities in the Florida Keys as the result of zoning changes in the FKNMS management plan, regional fishery management practices, and restoration efforts in Florida Bay. This research is a cooperative effort between investigators at the SEFSC under the direction of Dr. James Bohnsack and at the University of Miami under the direction of Dr. Jerald Ault. Support was provided by the NOAA South Florida

¹Armentano, T.V., J. Hunt, D. Rudnick, N. Thompson, P. Ortner, M. Robblee, and R. Halley. 1997. Strategic Plan for the Interagency Florida Bay Science Program. Florida Bay Program Management Committee. 42p.

Ecosystem Restoration Prediction and Modeling (SFERPM) program.

BACKGROUND

The distribution and ecology of southern Florida reef ecosystems (Fig. 1) has been described in terms of geological history (Shinn 1963, Hoffmeister 1974), habitat (Japp 1984), and oceanographic processes (Lee et al. 1992, 1994). The complex geology, hydrography, and marine ecology of the Keys and surrounding areas were described in several reviews (Jaap 1984; Continental Shelf Associates, Inc. 1990; NOAA 1996).

Robins (1971) described the regional distribution and ecological patterns of fishes. Starck (1968) listed a total of 517 fish species in the Florida Keys of which 389 were considered primary or secondary reef species. Limouzy-Paris et al. (1994) described the diversity of fish larvae in the Florida Keys. Other studies have examined fish populations in mangrove prop roots (Thayer et al. 1987) and among basin and channel habitats in Florida Bay (Thayer and Chester 1989). Fish and fisheries have been reviewed for southern Florida (Bannerot, 1990), the Florida Keys (Chiappone and Sluka 1996), and the Tortugas (Longley and Hildebrand 1941, McKenna 1997, Schmidt et al., in prep). Bohnsack et al. (1994) described total fish landings in the Florida Keys. McClellan (1996) used aerial surveys to describe boating activity patterns in the Keys.

Database History. In response to limitations of existing sampling methods, Bohnsack and Bannerot (1983, 1986) developed a stationary plot technique as a new, objective, and reliable method for assessing reef fish community structure in any habitat. Bohnsack and Harper (1988) later developed length-to-weight conversion formulae for estimating biomass of individual species. Procedures were later developed to

objectively distinguish length-frequency distributions for exploitable and non-exploitable phases of individual species for use in multispecies fishery assessments (Ault et al. 1998; Meester et al., in press). Other reports discussed applications for coral reefs (Bohnsack 1997), passive assessments (Bohnsack 1995), and artificial reefs (Bortone and Bohnsack 1991)².

The reef fish visual census sampling database described in this report was first used to assess the effects of spearfishing on reef fish community structure at reefs protected from and exposed to spearfishing (Bohnsack 1982). Later, reef fish assemblages were assessed in different habitats of Looe Key National Marine Sanctuary (Bohnsack et al. 1987). Preliminary changes in community structure in response to management changes at Looe Key Reef were reported by Clark et al. (1989). The database contributed to the development and location of protection zones in the FMP for Florida Keys National Marine Sanctuary (DOC 1996; Bohnsack 1997, 1998). With the creation of the FKNMS, the number of sampling sites was expanded to assess regional reef fish biodiversity (Smith-Vanix et al. 1995; Bohnsack and Ault, 1996). Ault et al. (1997, 1998) demonstrated that visual estimates of fish sizes agreed closely with measurements obtained independently from fishery dependent samples of headboat landings in the Florida Keys. The database was also used to assess condition and retrospective changes in reef fish stocks in the Florida Keys (Ault et al. 1997, 1998). They showed that a total of 13 of 16 groupers, 7 of 13 snappers, and 2 of 5 grunts were found to

²Bohnsack, J.A. 1995. Visually based methods for monitoring coral reef fishes. Pages 45-47 in *Proceedings of the reef fish workshop for the southeast area monitoring and assessment program (Seamap)*. SEAMAP Reef Fish Work Group. Gulf States Marine Fisheries Commission. 76 p.

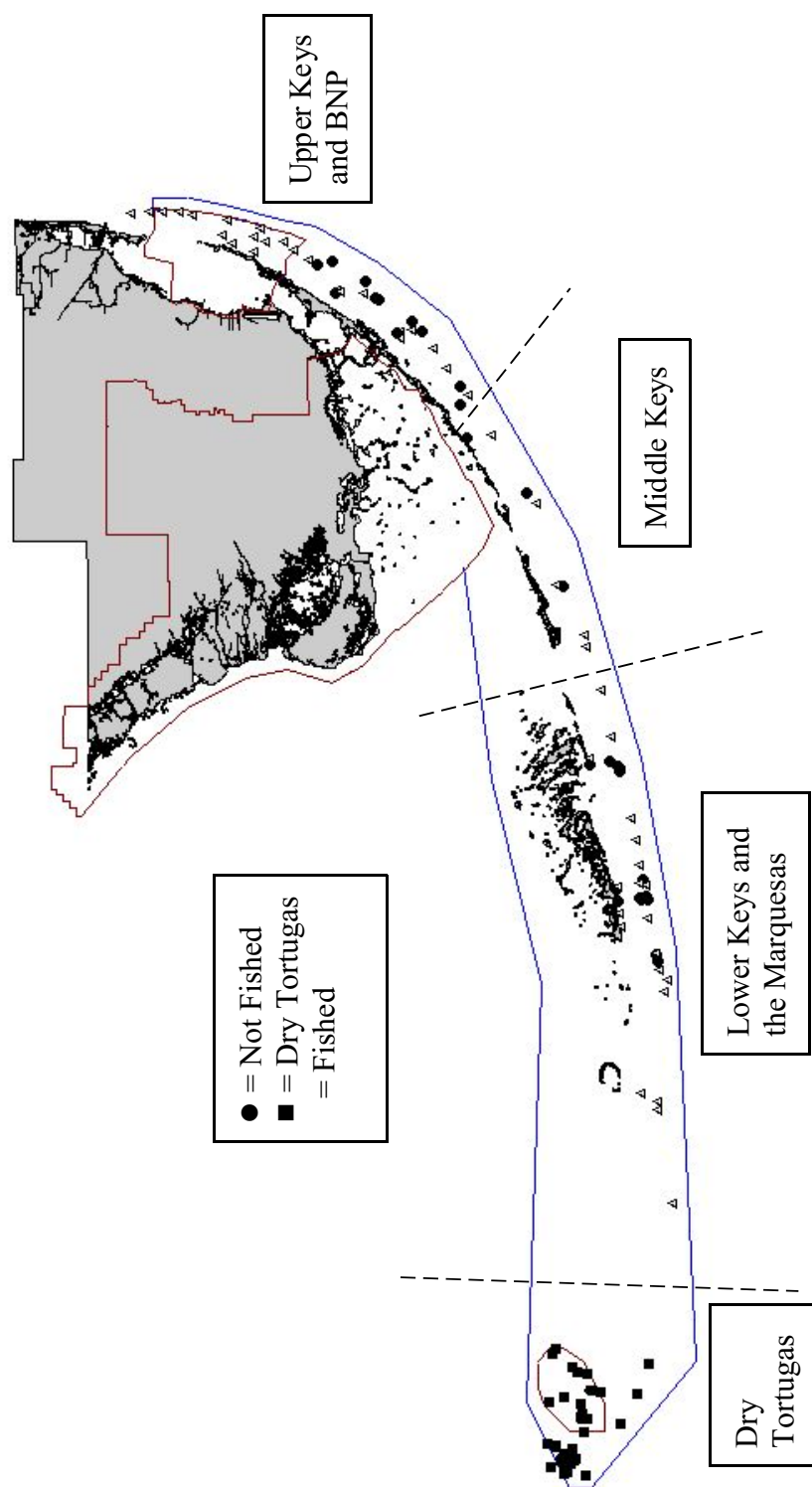


Figure 1. Map of the Florida Keys showing regional subdivisions and sampled reef sites (1979-1998). No fishing zones were established July 1, 1997 as part of the Florida Keys National Marine Sanctuary final management plan.

be below the 30% spawning potential ratio (SPR) federal definition of overfishing and that some stocks appeared to have been chronically overfished since the late 1970's. The visual database most recently was used to facilitate site locations for marine reserves in the Tortugas region (Schmidt et al. 1999, in prep.) and to assess reef fishes in Biscayne National Park³.

The stationary plot method also has been used to assess reef fishes in Broward County, Florida⁴, the Dry Tortugas (McKenna 1997), the U.S. Virgin Islands (Beets 1993), and other locations (e.g. Bortone et al. 1986). Additional visual monitoring of reef fishes in the Florida Keys is being conducted by the Reef Environmental Education Foundation (REEF) using volunteer divers and a rover diver technique (Schmitt and Sullivan 1996, Pattengill-Semmens and Semmens 1999)^{5,6,7,8}.

³Harper, D.E., J.A. Bohnsack and B. Lockwood. (in review) Recreational Fisheries in Biscayne National Park, Florida, 1976-1991.

⁴Spieler, R.E. 1999. The marine fishes of Broward County, Florida: Report of 1998-99 Survey Results. Unpublished Progress Report to the Southeast Fisheries Science Center (NOAA/NMFS Order # 40GEN800140). 14 p.

⁵Bohnsack, J.A. 1996. Two visually based methods for monitoring coral reef fishes. Pages 31-36 in M.P. Crosby, G.R. Gibson, Jr., 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 Spring, MD. 80 p.

⁶Schmitt, E. (Compiler). 1996. Status of reef fishes in the Florida Keys National Marine Sanctuary. The Nature Conservancy, Marine Science Conservation Center, U. of Miami, Coral

Ongoing Activities

This report describes data collected from 1979 through 1998 which will provide a baseline for testing multiple hypotheses concerning no-take marine reserves. Current monitoring is targeted to provide a 5-year review of the FKNMS Management Plan and to eventually evaluate changes in fish communities as the result of Florida Bay restoration efforts. Spatial effects will be directly tested by comparing fish communities in similar habitats inside and outside of different management zones and areas impacted by different water quality. Current research under funding from the South Florida Ecosystem Restoration Program (SFERP) is monitoring marine reserves and surrounding reference areas in the Florida Keys.

METHODS

Study Area

The Florida reef tract extends approximately 370 km from Key Biscayne to the Dry Tortugas (Fig. 1). The Florida Keys are situated parallel to the Straits of Florida and the Florida current to the south and Florida Bay to the north. This coastal ecosystem encompasses many varied habitats

Gables, FL. 90 p.

⁷Schmitt, E., D.W. Feeley, and K.M. Sullivan. 1998. Surveying coral reef fishes: A manual for data collection, processing, and interpretation of fish survey information for the tropical northwest Atlantic. The Nature Conservancy, Marine Science Conservation Center, U. of Miami, Coral Gables, FL. 139 p.

⁸Pattengill-Semmens, C.V. and B.X. Semmens. 1999b. Assessment and monitoring applications of a community-based monitoring program: The Reef Environmental Education Foundation. A poster presented at the National Coral Reef Institute Meeting, April 1999, Ft. Lauderdale. Reef Environmental Education Foundation, P.O. Box 246, Key Largo, FL. 13 p.

including freshwater marshes, estuaries, lagoons, mangrove stands, coral islands, sea grass beds, and coral reefs. Florida Bay and adjacent coastal estuaries serve as nursery areas for spiny lobster and many juvenile fishes that migrate to reefs as adults. For reporting purposes, study sites were divided into four regions: Upper, Middle, and Lower Keys, and the Tortugas (Table 1, Fig. 1).

Protected areas in the Florida Keys were described by Smith-Vaniz et al. (1995) and the U.S. Department of Commerce⁹. The Florida Keys National Marine Sanctuary (FKNMS) covers the largest total area, 9,515 km² (3,673 mi²), and extends from Miami in the east to beyond the Dry Tortugas in the west. Other protected areas, moving approximately east to west, include Biscayne National Park (BNP), Key Largo National Marine Sanctuary, John Pennekamp Coral Reef State Park, Biscayne Bay and Card Sound Aquatic Preserve, and Lignumvitae Aquatic Preserve in the Upper Keys. The Lower and Middle Keys include the National Key Deer Refuge, Coupon Bight Aquatic Preserve, Looe Key National Marine Sanctuary, the Great White Heron National Refuge, and the Key West Wildlife Refuge. Further west is Dry Tortugas National Park (DTNP). Everglades National Park (ENP) includes aquatic areas in Florida Bay north of the Keys.

Fisheries are regulated by state and federal agencies. The state of Florida is responsible for managing fisheries within state waters which include areas 3 nmi offshore on the Atlantic side and 9 nmi offshore on the Gulf of Mexico side of the Keys. The federal government has

responsibility outside state waters to the 200 mi limit of the Exclusive Economic Zone (EEZ). In 1976, the U.S. Congress passed the Magnuson Fishery Conservation and Management Act that established regional Fishery Management Councils (FMCs) to regulate fisheries in federal waters. The South Atlantic FMC regulates federal waters on the Atlantic side of the Florida Keys while the Gulf of Mexico FMC regulates federal waters on the Gulf side.

Levels of protection for individual reef sites in the Florida Keys have varied in space and time. Before July 1, 1997 five levels of protection existed (Tables 1 and 2). Since the 1960's the most protected sites in the upper Keys were within Pennekamp Coral Reef State Park and the Key Largo National Marine Sanctuary which prohibited spearfishing and tropical collecting (level 3). Biscayne National Park prohibited spearfishing (level 2). The lower and middle Keys were only managed solely by regional fishery regulations (level 1). During this time Dry Tortugas National Park offered the highest level of protection (level 5) by allowing only recreational hook-and-line. Looe Key Reef in the lower Keys moved from level 1 to level 3 (no spearfishing) in 1981 with the establishment of the Looe Key National Marine Sanctuary.

On July 1, 1997, the FKNMS FMP became effective resulting in 8 levels of protection with the addition of three zone types that further limited extractive usage (Table 2). Catch-and-release trolling (level 6) was the only extractive activity allowed at Alligator, Conch, Sombrero, and Sand Key reefs. Two kinds of 'no-take' zones were also added. Level 7 'no-take' zones included one large (79 km²) marine ecological reserve (MER) in the Sambo region of the Lower Keys and 19 small (range 0.16 - 4 km²) Sanctuary Preservation Areas (SPAs) scattered throughout the Keys. Level 8 protection does not allow any extraction or

⁹USDOC (U.S. Department of Commerce). 1996. Florida Keys National Marine Sanctuary: Final Management Plan/Environmental Impact Statement, Vol 1. Sanctuaries and Reserves Division, National Oceanic and Atmospheric Administration. 319 p.

Table 1. Annual distribution of sampling effort by region and study site. Levels of protection are described in Table 2 and apply before and after 1 July 1997 when the FKNMS final management plan became effective. Boxed areas denote the protected sites. Locations are given in Appendix B.

Geog. Posit.	Site	Pre-Protection Level	Post-Protection Level	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Total		
Number of Point Samples																										
Outside Sanctuary																										
1	GROUPE SITE	1	1					36	4	6	8	40	40	21							12		7	134		
2	KEY BISCAYNE SITE	1	1					36	4	6	8	40	40	21	0	0	0	0	0	0	0	12	0	7	40	
Total Outside Samples																										
Biscayne National Park (BNP)																										
3	BNP: NE CORNER REEF	2	2										31	29	25	12	22			12		12	9	152		
4	FOWEY ROCKS	2	2										20	51	29	12	24			8		12	9	29		
5	BNP: BREWSTER REEF	2	2										20	51	29	12	24			12		12	12	172		
6	BACHE SHOAL	2	2																		12	12	9	33		
7	BNP: TRIUMPH REEF	2	2											26	30	13	32			24	12	12	12	161		
8	BNP: MARKER 14	2	2										22	46	30		20			11		13	9	151		
9	BNP: PETREL POINT	2	2										12	28						11		12	9	72		
10	BNP: STAR CORAL	2	2										22		16					13		12	10	73		
11	BNP: AJAX REEF	2	2										10	16	32	12	28			24	12	12	12	158		
12	BNP: ALINA'S	2	2										32	31	31					12	12	12	12	142		
13	BNP: IGW TRUST	2	2										31	30	30	16				8		12	6	133		
14	BNP: BALL BUOY	2	2										19	56	31	16				8	12	12	6	160		
Total BNP																										
				0	0	0	0	0	0	0	0	0	187	297	282	81	126	0	0	143	60	145	115	1436		
Upper Keys (FKNMS) and John Pennecamp Coral Reef State Park (JPSP)																										
15	TURTLE REEF	3	3															28	16		12		12	6	46	
16	BASIN HILL - OPEN	3	3															28	12		12		12	9	85	
17	BASIN HILL - CLOSED	8	8															29	12		12		12		86	
18	BASIN HILL - OPEN (NEW)	3	3																		12		12	9	45	
19	CARYSPORT REEF	3	7															16	9	24	11			15	103	
20	CARYSPORT SOUTH REEF	3	7																		12	13		9	43	
21	GARDEN COVE	3	3																						12	36
22	THE ELBOW	3	7																						12	82
23	KEY LARGO DRY ROCKS	3	7															4	10					12	44	
24	GRECIAN ROCKS	3	7																						12	49
25	MOSQUITO BANK - OPEN	3	3																						12	84
26	MOSQUITO BANK - OPEN (NEW)	3	3																						12	48
27	MOSQUITO BANK - CLOSED	8	8																						12	83
28	FRENCH REEF	3	7																						11	130
29	WHITE BANK	3	3																						15	15
30	MOLASSES REEF	3	7																						12	467
31	TRIANGLES	1	3																						11	17
32	PICKLES REEF	1	3																						11	39
33	CONCH REEF	1	6																						6	61
34	DAVIS REEF	1	7																						12	39
35	CROCKER REEF	1	3																						12	50
Total Upper Keys (FKNMS) and JPSP																										
				4	47	116	71	43	69	52	12	9	6	0	0	91	105	111	207	209	156	165	179	1652		
Middle Keys (FKNMS)																										
36	HEN AND CHICKENS	1	7																						12	36
37	CHEECA ROCKS	1	7																						19	31
38	ALLIGATOR REEF	1	6																						12	53
39	TENNESSEE REEF (RESEARCH)	1	8																						28	50
40	TENNESSEE REEF (FISHED)	1	1																						29	56
41	COFFIN PATCH	1	7																						12	24
42	WEST TURTLE SHOAL	1	1																						12	24
43	DELTA SHOAL	1	1																						12	54
44	SOMBREIRO KEY	1	6																						12	109
Total Middle Keys (FKNMS)																										
				0	0	0	23	0	55	0	0	0	0	0	0	13	0	12	24	66	0	148	96	437		

Table 1 (cont.)

Geog. Postl.	Site	Pre-Protection Level	Post-Protection Level	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Total
Number of Point Samples																								
Lower Keys (FKNMS)																								
45	NO NAME REEF	1	1															3		9	12	12	12	9
46	LOOE KEY - EAST	3	7															3	28		13	12	12	39
47	LOOE KEY - WEST	3	7															3						68
48	LOOE KEY - OTHER	3	7	9	98	87	95	426	101	66	13	24	30			95	25	18		12				1099
49	LOOE KEY RESEARCH	1	8																					26
50	BIG PINE SHOAL	1	1																			14	12	21
51	NEWFOUND HARBOR KEY (SPA E)	1	7															16				12	9	38
52	NEWFOUND HARBOR KEY (SPA W)	1	7			6												4				13	9	34
53	NEWFOUND HARBOR KEY (FISHED)	1	1															16		20		12	9	37
54	AMERICAN SHOAL	1	1																		12	12	12	44
55	MARYLAND SHOAL	1	1																					12
56	PELICAN SHOAL	1	1																	10		12	12	22
57	EASTERN SAMBO	1	8															19		8	12	12	28	79
58	MIDDLE SAMBO	1	1															20		9	12	12	24	77
59	WESTERN SAMBO - EAST	1	7															19		21		21	24	97
60	15-13 SAMBOS	1	7																			12	12	24
61	12-12 SAMBOS	1	1																			12	15	27
62	14 SAMBOS	1	7																			12	12	24
63	PETE'S PINNACLE	1	1																			12	12	24
64	WESTERN SAMBO - WEST	1	7															18		40	12	21	24	115
65	EASTERN DRY ROCKS	1	7																	12		12	13	37
66	EASTERN DRY ROCKS (FISHED)	1	1																			12	12	24
67	ROCK KEY	1	7																	12	12	12	13	49
68	MARKER 56	1	7																	19		12	17	48
69	KEY WEST (INSHORE FISHED)	1	1																	8				8
70	KEY WEST (WESTERN FISHED)	1	1																			12	12	12
71	KEY WEST (EASTERN FISHED)	1	1																	8		12	14	34
72	ANNE'S ANCHORAGE	1	7																			12	15	27
73	DOUG'S DEN	1	1																			12	12	24
74	SAND KEY	1	6															12		23	12	12	12	71
75	WESTERN DRY ROCKS	1	1																			12	12	24
Total Lower Keys (FKNMS)				9	98	93	95	426	101	66	13	24	30	0	0	95	25	136	40	211	97	321	394	2274
Marquesas Keys (FKNMS)																								
76	COSGROVE SHOAL	1	1																11	22				33
77	MARQUESAS ROCKS	1	1																	9				9
78	28 FOOT SHOAL	1	1																	12				12
79	DEVIL'S REEF	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	43		8		8
Total Marquesas Keys (FKNMS)				13	145	209	189	505	229	124	33	73	263	318	282	280	256	259	282	672	325	787	791	6035
Total FKNMS, BNP, JPSP																								

Table 1 (cont.)

Geog Posit.	Site	Pre- Protection Level	Post- Protection Level	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Total
Tortugas Area (FKNMS) and Dry Tortugas National Park (DTNP)																								
Inside DTNP																								
	80 PULASKI SHOAL	5	5																14	11	12	24		61
	81 TEXAS ROCK	5	5																11		12	14		37
	82 LOGGERHEAD KEY	5	5																21		12	10	12	55
	83 LONG KEY (BIRD KEY)	5	5																28	12	12	22	12	86
	84 TWIN PEAKS	5	5																10					10
	85 LITTLE AFRICA	5	5																26		12	13		51
	86 REPLENISHMENT ZONE	5	5																8					8
	87 WHITE SHOAL	5	5																14		12	31		57
	88 MARKER H	5	5																		4			4
	89 MAVRO VETRANIC	5	5																					
	90 GUY'S GROTTTO	5	5																		9			9
	91 DAVE'S FINAL FRONTIER	5	5																		12			12
	92 JOE'S CRACK	5	5																			12		12
	93 GEORGE'S GORGE	5	5																					0
	94 FRENCH WRECK	5	5																					0
	Total Inside DTNP			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	132	23	72	139	36	402
Outside DTNP (FKNMS)																								
	95 TORTUGAS BANK (PINNACLES)	1	1																12	9				21
	96 JOE'S HUMP	1	1																16		16			32
	97 HANGOVER REEF	1	1																					12
	98 8 FATHOM ROCK	1	1																			8		8
	99 BLACK CORAL ROCK	1	1																			8		8
	100 HUMP 1	1	1																			5		5
	101 CROSBY'S HUMP	1	1																		12	7		19
	102 HUMP 2	1	1																					3
	103 TORTUGAS FLAT	1	1																		5			5
	104 GARY'S ANCHOR	1	1																		6			6
	105 HUMP 3	1	1																					6
	106 CECILY'S SITE	1	1																		6			6
	107 LITTLE BANK	1	1																		3			9
	108 SHERWOOD FOREST	1	1																		8			8
	109 FANTOM REEF	1	1																		8			14
	110 GEORGE'S ROCK	1	1																			10		10
	111 RALPH'S RIDGE	1	1																			12		12
	112 POTT'S PEAK	1	1																			12		12
	113 TORTUGAS BANK SITE11	1	1																					6
	114 TORTUGAS BANK SITE18	1	1																					6
	115 TORTUGAS BANK SITE25	1	1																					6
	116 TORTUGAS BANK SITE51	1	1																					6
	117 TORTUGAS PARK SITE52	1	1																					6
	118 TORTUGAS PARK SITE82	1	1																					6
	Total Outside DTNP (FKNMS)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	9	28	67	92	236
	Total Tortugas Area (FKNMS) and DTNP			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	172	32	100	206	128	638
	Total All Sites			13	145	209	189	65	229	124	33	73	263	318	282	280	26	29	48	704	425	983	919	6673

Table 2. Summary of protection levels spatially applied to extractive activities in the Florida Keys. Protection levels range from a low of 1 to 8, the highest.

PL 1. Open access under regional regulations. This is the lowest level of protection and encompasses the largest area. It includes all areas under current state and federal fisheries and resource regulations. These include general size limits, bag limits, and gear restrictions established by Florida and the South Atlantic Fishery Management Council for the region. These area are open to commercial and recreational fishing for spearfishing, lobster diving and fishing, hook-and-line fishing, tropical fish collecting, etc.

PL 2. No marine life collecting. Biscayne National Park. All other extractive activities permitted under regional regulations.

PL 3. No spearfishing. Florida waters in the Upper Keys have banned spearfishing since the 1960s.

PL 4. No spearfishing or marine life collecting. These are historically protected areas that include John Pennekamp Coral Reef State Park and the former Key Largo National Marine Sanctuary since the 1960s. The former Looe Key National Marine Sanctuary (fore reef excluded, see PL5) was included in 1981. These area are open to commercial and recreational fishing with hook-and-line, and lobster fishing with traps or by diving.

PL 5. No spearfishing, lobster harvesting, collecting, or commercial fishing. This is the area inside of the Dry Tortugas National Park. Recreational hook-and-line fishing and 'no-take' diving are allowed. The Looe Key fore reef area is included due to the protection it received between 1981 and 1997 (it is now a SPA under PL 7).

PL 6. Catch-and-release fishing only. This includes four experimental "Sanctuary Protected Areas" [sic] which are 'no-take' except for catch-and-release troll fishing. All other take is prohibited. Skin and SCUBA diving are allowed. These areas are: Conch Reef (shallow), Alligator Reef, Sombrero Reef, and Sand Key.

PL 7. No extractive removals "no-take". This includes 19 Sanctuary Protected Areas (SPAs) and the Sambos Ecological Reserve (ER). No fishing or other taking are allowed. Skin and SCUBA diving are allowed.

PL 8. Permitted research only. No extractive activities and no skin or SCUBA diving allowed. In the FKNMS three of these zones are intended to examine the impacts of divers on reefs: Looe Key Research, Eastern Sambo, Tennessee Reef. One zone (Conch Reef, deep) is the site of the NURC Aquarius project. Two additional small, no entry, patch reef sites were established in 1992 in John Pennekamp Coral Reef State Park at Mosquito Banks and Basin Hill Shoals.

entry except for permitted research at Conch Reef, Tennessee, Looe Key Research, and Eastern Sambo Reefs.

Table 1 shows the classification changes for each sampled site by level of protection before and after 1 July 1997. Four reefs moved from level 1 to level 6 and were distributed in the upper (1), middle (2), and lower (1) Keys. Seven reefs moved from level 3 to level 7 protection; six in the upper and one in the lower Keys. Eleven reef sites moved from level 1 to level 7 protection; three in the middle Keys and eight in the lower Keys. Dry Tortugas National Park is classified at level 5 protection although the level of protection changed by prohibiting recreational lobster harvesting and later by prohibiting headboat fishing within Park boundaries.

Field Methods

Biological data on reef fish biodiversity were collected continuously since 1979 using visual methods by highly trained and experienced divers using open circuit SCUBA. Visual methods are ideal for assessing reef fishes in the Florida Keys because of prevailing good visibility and management concerns requiring the use of non-destructive assessment methods. Data were collected by a stationary diver centered in a randomly selected 7.5 m radius circular plot using a standard fishery-independent, stationary plot method (Bohnsack and Bannerot 1986). The plot method is non-destructive and provides reliable quantitative estimates of species composition, abundance (density per plot), frequency-of-occurrence, and individual size composition for the reef fish community. Management concerns required non-destructive sampling methods wherever possible. Reef sites were sampled from Miami through the Tortugas region.

At study sites, divers first recorded the species observed in five min within randomly selected 7.5 m radius circular plots. Then

data were collected for each species on their abundance in the plot and the minimum, mean and maximum lengths of each species. Divers attempted to record all fish observed within each imaginary cylinder extending from the bottom to the limits of vertical visibility (usually the surface). Depth, bottom composition, and estimated percentage cover were recorded for each plot from the polar perspective of the centrally located observer. A ruler held out perpendicularly at the end of a meter stick aided in making size estimates by reducing apparent magnification errors. Obtaining accurate and precise visual estimates of fish length underwater requires well-trained and experienced observers because objects in water appear magnified and closer than their actual range (Bell et al. 1985; Bellwood and Alcala 1988, Harvey and Shortis 1996). To improve accuracy, divers continuously calibrated their length estimates using the 30 cm ruler and meter-stick. Divers with calibration sticks have been shown to obtain a mean accuracy of 86% for length estimates (St. John et al., 1990).

A rigorous sampling regime was used to avoid bias and prevent counting the same individuals more than once. Divers began each sample by facing in one direction and listing all species within the field of view inside the sample radius. When no new species were noted, new sectors were scanned by rotating in one direction. New species were listed as observed and rotations continued for five min. Several complete rotations were usually made for each plot. Divers periodically calibrated their estimates of the sample radius with the meter stick or fiberglass tape. Species with few individuals (e.g. angelfish, barracuda, hogfish) were counted and size estimated immediately. Species that were highly mobile and unlikely to remain in the area (e.g. sharks, carangids, *Clepticus parrai*) were tabulated when first observed and then ignored. Common species that were reliably always in the sample area

(e.g. damselfish, wrasses, etc.) were initially listed only and later tabulated after the initial 5 min sample period when divers would make one 360° rotation for each species by working back up the list in reverse order of recording. This procedure eliminated potential bias in selecting to count a species when they were particularly abundant or obvious. The time required to record each sample averaged 15-20 min (range 5 - 30), depending on the plot.

Experimental Design

Sampling was conducted at inshore and offshore reef sites along the Florida reef tract from Miami to the Dry Tortugas (Fig. 2). Different areas of the reef track have had different levels of protection and different historical management policies (Table 2). Sampling has been concentrated in the spring and summer when sea conditions are generally calm and water conditions most suitable for visual sampling (Bohnsack and Bannerot 1986, Bohnsack et al., 1987). Actual sampling intensity has varied on a yearly basis as determined by weather, logistics, funding, scheduling, and personnel consideration. In recent years we have been investigating modifications in the survey design to increase the precision in the estimates.

This report describes baseline estimates of the abundance and size distributions of all observable reef fish populations based on samples taken continuously from 1979 to 30 June 1996, before the FKNMS FMP became effective. The years 1997 and 1998 are considered transition years following changes in management actions for the FKNMS. The experimental design was established to test factors in time and space. Time comparisons can be made at all sites before and after zoning changes (increased protection) became effective in 1997. Also, spatial comparisons can be made between sites with different levels of protection. The ultimate goal is to

examine the effectiveness of different levels of management protection along the Keys. Eventually the effectiveness of different sized protected areas will be examined.

The null hypotheses is no change for specific parameters in space or over time. The geographical distribution, sizes, types, and numbers of protected areas in the FKNMS provide opportunities to evaluate types and sizes of zone protection. Zones provide different treatments in terms of the levels of protection and often include replicated sites of different size. Specific hypotheses and alternatives can then be tested to evaluate various levels and spatial scales of protection. In order for no-take marine reserves to be effective, for example, it is necessary (but not sufficient) to show that reserves increase spawning potential and protect biodiversity. Spawning potential can be increased by increasing abundance and size structure through differential mortality inside versus outside reserves.

Paired reef sites that differed in level of protection were selected for monitoring purposes. Where possible, the two sites were chosen to be in close proximity and as similar in terms of habitat structure and size as possible. Newly protected SPAs were approximately paired (where possible) with a level 1 or 2 protected site. SPAs are considered replicates because they are similar in size. Both SPAs and MER can be considered as "controls" for assessing impacts of fishing because they have minimum direct human extractive impacts even though we expect them to change over the short and intermediate term. Sites with different levels of fishing and other extractive activities can be considered "treatment" sites.

Analytical Methods

Statistical descriptions were made for each observed species showing mean, total and standard deviation of abundance; absolute, range, and percent frequency-of-

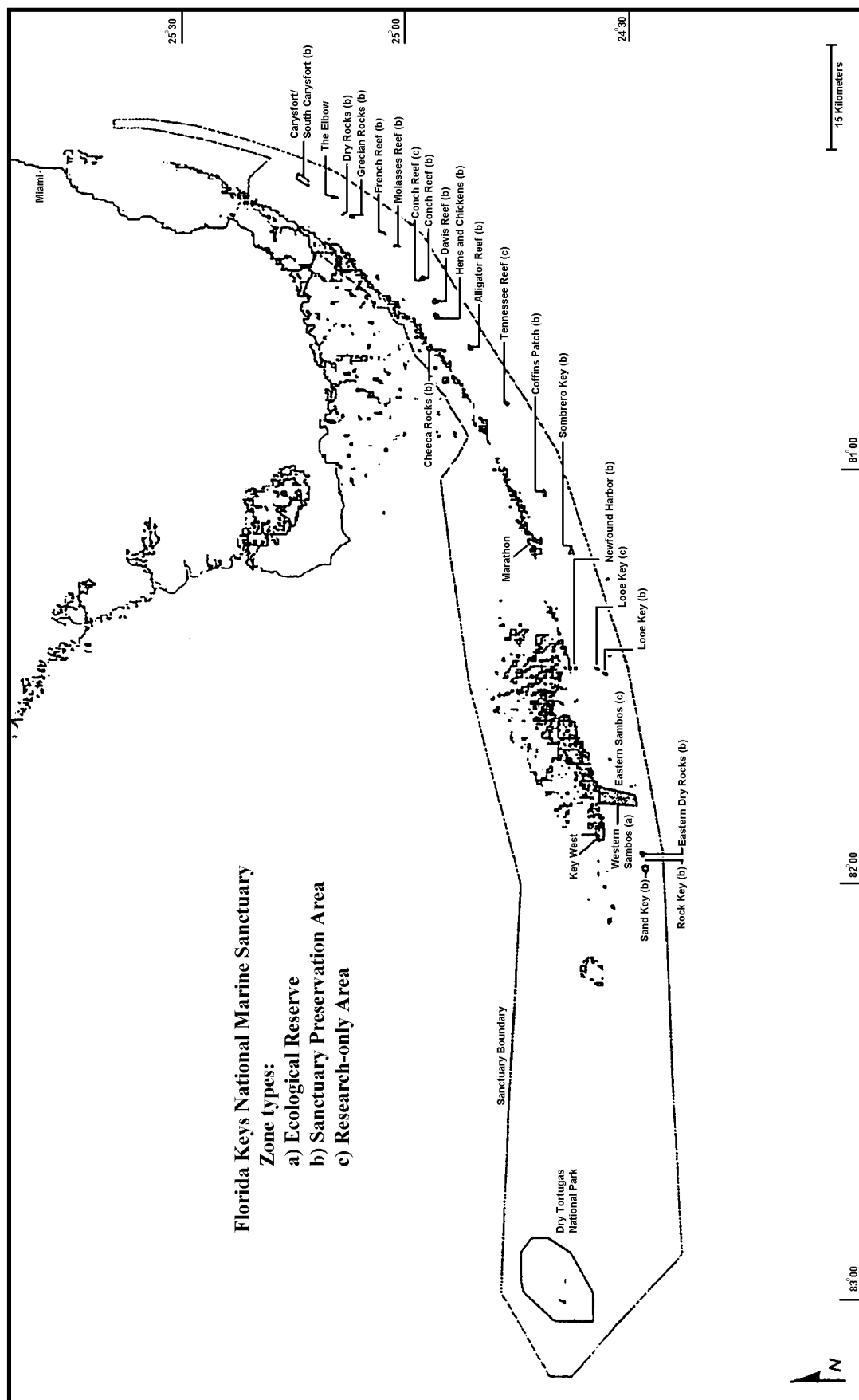


Figure 2. Location of reefs and no-take management zones in the Florida Keys National Marine Sanctuary. Source: Zone Performance Update: First Year Report 1998. Florida Keys National Marine Sanctuary.

occurrence; mean, minimum, and maximum length; and total biomass (Sokal and Rohlf 1981). Lengths of individual fish were converted into estimated biomass based on length-weight formulae developed and updated by Bohnsack and Harper (1988). Data summarized here are based on raw uncalibrated data. The power of the method is based in part on the large number of samples and reef sites included in the study. Maximum power and utilization of the visual survey data requires statistical intercalibration of the relative sampling efficiency of each diver (Ault et al. 1998) but is beyond the descriptive purpose of this report.

Community structure was evaluated in terms of species richness (total number of species) abundance, frequency-of-occurrence, individual size, and total biomass for observed species. Rank order total abundance and frequency were plotted for all samples. Confidence intervals for percent frequency were calculated according to Sokal and Rohlf (1981).

Spatial patterns among study sites were examined in terms of Bray-Curtis community similarity (Bray and Curtis 1957) using mean species abundance of 87 frequently occurring species. Flexible clustering (Beta = 0.25) was used and included 90 reef sites sampled from 1 January 1988 through 30 June 1997 (n = 3,679 samples). Data were not transformed or standardized. Species occurring in less than 2.5% of the total samples were excluded. Data collected before 1988 were excluded because they contained only a few study sites. No zero replacement was applied.

Species were classified into trophic categories according to primary adult feeding patterns based on published literature about each species or closely related species (e.g. Hiatt and Strasburg 1960, Randall 1967, Hobson 1974, Hobson and Chess 1976, Harmelin-Vivien 1981). Trophic structure was then examined in terms of total

individuals and biomass for combined data and for different reef types in the four regions of the Keys.

Trends in annual mean density (number of individuals per sample) were examined for selected representative taxa. Annual mean density, 95% CI, and ± 1 SE were calculated for each species. These annual mean density values were then used to evaluate performance trends over the baseline study period (1979 - 1997). A performance band was plotted for each taxa showing the long-term annual mean density ($\pm 95\%$ CI). The same procedures were used to compare baseline performance for combined data from no-take sites with fished and Tortugas sites. Baseline performance for no-take and fished sites was based on 4 year of data collected immediately prior to implementation of the FKNMS FMP (1994-1997). Average performance bands for each category of reef site were projected for five years into the future as a prediction of future values assuming no change in performance.

Size data were analyzed separately for exploitable and non-exploitable phase fishes according to procedures developed by Ault et al. (1998) and Meester et al. (in press) where exploitable phase fishes were defined as individuals equal to or larger than the length at first capture (L').

RESULTS AND DISCUSSION

Sampling Summary

From 1979 through 1998 a total of 263 fish taxa from 54 families were observed from 118 sites in the Florida Keys from 6,673 visual stationary plot samples. A phylogenetic listing and trophic classification of species observed during the study is shown in Table 3. Ten families that had over 10 identified species accounted for 59% of all observed fish taxa: Serranidae (32 species), Labridae (16), Gobiidae (14), Scaridae (14), Haemulidae

(13), Pomacentridae (13), Carangidae (12), Lutjanidae (11), Balistidae (11) and Clinidae (11).

A total of 118 reef sites were sampled through 1998. The distribution of sample effort by study site and year is shown in [Table 1](#). Larger and fragmented reefs were divided into multiple sites (e.g. Carysfort, Looe Key, Newfound Harbor, and Western Sambo). Prior to 1987 most samples were collected from Molasses Reef in the Upper Keys and Looe Key Reef in the Lower Keys. Sampling in the Tortugas began in 1994. Sampling effort was most intense in recent years with over 650 samples being collected annually in 1995, 1997, and 1998.

Community Structure

Statistical descriptions of individual species and unidentified taxa for all 6,673 samples are provided in [Table 4](#). Descriptive statistics include the total number of observed individuals; frequency and percent occurrence; abundance mean, standard deviation, and range; mean, minimum, and maximum observed length, and estimated total biomass for each species. Plots of rank order total abundance versus log abundance for all species and samples ([Fig. 3](#)) show a classic linear pattern of community structure characteristic of highly diverse ecosystems (Hubbell, 1979).

Rank order frequency-of-occurrence by species for all samples shows that most species rarely occur and that 95% confidence intervals are well defined ([Fig. 4](#)). Because the stationary plot technique provides large sample sizes, percent frequency becomes a useful statistic for detecting changes in frequency-of-occurrence. It should be especially sensitive and useful for detecting any increased occurrence of rare species.

The ten most abundant species accounted for 59% of all individuals observed ([Table 4](#)). These include in decreasing order: bluehead (*Thalassoma bifasciatum*, 188,037),

bicolor damselfish (*Pomacentrus partitus*, 151,266), tomtate (*Haemulon aurolineatum*, 115,696), sergeant major (*Abudefduf saxatilis*, 68,357), striped parrotfish (*Scarus croicensis*, 45,114), yellowtail snapper (*Ocyurus chrysurus*, 43,967), bluestriped grunt (*H. sciurus*, 33,268), white grunt (*H. plumieri*, 31,577), masked goby (*Coryphopterus personatus*, 27,726), and French grunt (*H. flavolineatum*, 27,342).

Ten species had greater than 50% frequency-of-occurrence in plot samples ([Table 4](#)) and are listed below in decreasing order. The five species underlined were also among the ten most abundant species: bluehead (81.0%), redband parrotfish (*Sparisoma aurofrenatum*, 69.4%), blue tang (*Acanthurus coeruleus*, 67.7%), striped parrotfish (65.3%), stoplight parrotfish (*S. viride*, 62.8%), ocean surgeon (*A. bahianus*, 62.2%), yellowtail snapper (60.7%), yellowhead wrasse (*Halichoeres garnoti*, 55.0%), French grunt (52.0%), and white grunt (51.7%).

Ten species accounted for 55% of the total observed biomass ([Table 4](#)) and are listed below in decreasing order. The three species underlined were also among the ten most abundant species observed: tarpon (*Megalops atlanticus*, 8,869 kg), barracuda (*Sphyrna barracuda*, 7,641 kg), yellowtail snapper (6,253 kg), bluestriped grunt (4,556 kg), gray snapper (*Lutjanus griseus*, 4,287 kg), Bermuda chub (*Kyphosus sectatrix*, 3,392 kg), tomtate (3,205 kg), stoplight parrotfish (2,832 kg), smallmouth grunt (*H. chrysargyreum*, 2,755 kg), and yellow goatfish (*Mulloidichthys martinicus* 2,596 kg).

Site Comparisons

A dendrogram shows the Bray-Curtis similarity analysis for 90 reef sites sampled between 1 January 1988 and 30 June 1997 (n = 3,679 samples) ([Fig. 5](#)). Reef sites clustered primarily between inshore patch

Table 3. Phylogenetic listing of families and species observed in visual samples from the Florida Keys (1979-1998). Names are according to Robins et al. (1986, 1991) with the exception that Hypoplectrus species (denoted by #) which were all listed as H. unicolor in Robins et al. (1991) and are named according to Stokes (1980). The species codes was 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, macroinvertevore; Mi, microinvertevore; P, planktivore. Predominate adult trophic mode indicated in bold.

FAMILY NAME	<i>Scientific name</i>	<u>Family common name</u>	Species common name	Trophic Level	Species Code
RHINCODONTIDAE		<u>Carpet sharks</u>			
	<i>Ginglymostoma cirratum</i>		nurse shark	Ma,F	GIN CIRR
CARCHARHINIDAE		<u>Requiem sharks</u>			
	<i>Carcharhinus limbatus</i>		blacktip shark	F	CAR LIMB
SPHYRNIDAE		<u>Hammerhead sharks</u>			
	<i>Sphyrna lewini</i>		scalloped hammerhead	F,Ma	SPH LEWI
	<i>Sphyrna mokarran</i>		great hammerhead	F,Ma	SPH MOKA
DASYATIDAE		<u>Stingrays</u>			
	<i>Dasyatis americana</i>		southern stingray	Ma	DAS AMER
UROLOPHIDAE		<u>Round stingrays</u>			
	<i>Urolophus jamaicensis</i>		yellow stingray	Ma,Mi	URO JAMA
MYLIOBATIDAE		<u>Eagle rays</u>			
	<i>Aetobatus narinari</i>		spotted eagle ray	Ma	AET NARI
MOBULIDAE		<u>Mantas</u>			
	<i>Manta birostris</i>		manta	P	MAN BIRO
ELOPIDAE		<u>Tarpons</u>			
	<i>Megalops atlanticus</i>		tarpon	F	MEG ATLA
MURAENIDAE		<u>Morays</u>			
	<i>Gymnothorax funebris</i>		green moray	F,Ma	GYM FUNE
	<i>Gymnothorax miliaris</i>		goldentail moray	F,Ma	GYM MILI
	<i>Gymnothorax moringa</i>		spotted moray	F	GYM MORI
	<i>Gymnothorax saxicola</i>		honeycomb moray	F,Ma	GYM SAXI
	<i>Gymnothorax vicinus</i>		purplemouth moray	F,Ma	GYM VICI

Table 3. (cont.)

FAMILY NAME	<i>Scientific name</i>	<u>Family common name</u>	Species common name	Trophic Level	Species Code
CLUPEIDAE		<u>Herrings</u>			
	<i>Harengula jaguana</i>		scaled sardine	P	HAR JAGU
	<i>Jenkinsia lamprotaenia</i>		dwarf herring	P	JEN LAMP
	<i>Jenkinsia species</i>		unknown herring	P	JEN SPE.
OGCOCEPHALIDAE		<u>Batfishes</u>			
	<i>Ogcocephalus species</i>		unknown batfish	Ma,F	OGC SPE.
EXOCETIDAE		<u>Flyingfishes</u>			
	<i>Hemiramphus brasiliensis</i>		ballyhoo	F	HEM BRAS
BELONIDAE		<u>Needlefishes</u>			
	<i>Tylosurus crocodilus</i>		houndfish	F	TYL CROC
ATHERINIDAE		<u>Silversides</u>			
	<i>Atherinomorus stipes</i>		hardhead silverside	P	ATH STIP
	<i>Hypoatherina harringtonensis</i>		reef silverside	P	HYP HARR
HOLOCENTRIDAE		<u>Squirrelfishes</u>			
	<i>Holocentrus adscensionis</i>		squirrelfish	Ma,Mi	HOL ADSC
	<i>Holocentrus coruscus</i>		reef squirrelfish	Ma,Mi	HOL CORU
	<i>Holocentrus marianus</i>		longjaw squirrelfish	Ma,Mi	HOL MARI
	<i>Holocentrus rufus</i>		longspine squirrelfish	Ma,Mi	HOL RUFU
	<i>Holocentrus spe.</i>		unidentified squirrelfish	Ma,Mi	HOL SPE.
	<i>Holocentrus vexillarius</i>		dusky squirrelfish	Ma,Mi	HOL VEXI
	<i>Myripristis jacobus</i>		blackbar soldierfish	P	MYR JACO
	<i>Ostichthys trachypoma</i>		bigeye soldierfish	Mi,P	OST TRAC
AULOSTOMIDAE		<u>Trumpetfishes</u>			
	<i>Aulostomus maculatus</i>		trumpetfish	F	AUL MACU
SCORPAENIDAE		<u>Scorpionfishes</u>			
	<i>Scorpaena plumieri</i>		spotted scorpion fish	F	SCO PLUM
FISTULARIIDAE		<u>Cornetfishes</u>			
	<i>Fistularia tabacaria</i>		bluespotted cornetfish	F	FIS TABA

Table 3. (cont.)

FAMILY NAME	<i>Scientific name</i>	<u>Family common name</u>	Species common name	Trophic Level	Species Code
CENTROPOMIDAE		<u>Snooks</u>			
	<i>Centropomus undecimalis</i>		common snook	F, Ma	CEN UNDE
SERRANIDAE		<u>Sea basses</u>			
	<i>Diplectrum formosum</i>		sand perch	Ma, Mi	DIP FORM
	<i>Epinephelus adscensionis</i>		rock hind	Ma, F	EPI ADSC
	<i>Epinephelus cruentatus</i>		graysby	F, Ma	EPI CRUE
	<i>Epinephelus fulvus</i>		coney	F, Ma	EPI FULV
	<i>Epinephelus guttatus</i>		red hind	Ma, F	EPI GUTT
	<i>Epinephelus inermis</i>		marbled grouper	F, Ma	EPI INER
	<i>Epinephelus itajara</i>		jewfish	Ma, F	EPI ITAJ
	<i>Epinephelus morio</i>		red grouper	F, Ma	EPI MORI
	<i>Epinephelus striatus</i>		Nassau grouper	F, Ma	EPI STRI
	<i>Hypoplectrus chlorurus</i> #		yellowtail hamlet	Mi	HYP CHLO
	<i>Hypoplectrus gemma</i> #		blue hamlet	Mi	HYP INDI
	<i>Hypoplectrus guttavarius</i> #		shy hamlet	Mi	HYP GEMM
	<i>Hypoplectrus (hybrid)</i> #		hybrid hamlet	Mi	HYP HYBR
	<i>Hypoplectrus indigo</i> #		indigo hamlet	Mi	HYP GUTT
	<i>Hypoplectrus nigricans</i> #		black hamlet	Mi	HYP NIGR
	<i>Hypoplectrus puella</i> #		barred hamlet	Mi	HYP PUEL
	<i>Hypoplectrus sp.</i> #		unidentified hamlet	Mi	HYP SPE.
	<i>Hypoplectrus (tan)</i> #		tan hamlet	Mi	HYP TANN
	<i>Hypoplectrus unicolor</i> #		butter hamlet	Mi	HYP UNIC
	<i>Liopropoma eukrines</i>		wrasse bass	Ma	LIO EUKR
	<i>Mycteroperca bonaci</i>		black grouper	F, Ma	MYC BONA
	<i>Mycteroperca interstitialis</i>		yellowmouth grouper	F, Ma	MYC INTE
	<i>Mycteroperca microlepis</i>		gag	F, Ma	MYC MICR
	<i>Mycteroperca phenax</i>		scamp	F, Ma	MYC PHEN
	<i>Mycteroperca tigris</i>		tiger grouper	F, Ma	MYC TIGR
	<i>Mycteroperca venenosa</i>		yellowfin grouper	F, Ma	MYC VENE
	<i>Paranthias furcifer</i>		creole-fish	P, F	PAR FURC
	<i>Rypticus saponaceus</i>		greater soapfish	F, Ma	RYP SAPO
	<i>Serranus baldwini</i>		lanternfish	Mi	SER BALD
	<i>Serranus tabacarius</i>		tobaccofish	Mi	SER TABA
	<i>Serranus tigrinus</i>		harlequin bass	Mi	SER TIGR
	<i>Serranus tortugarum</i>		chalk bass	Mi	SER TORT
PRIACANTHIDAE		<u>Bigeyes</u>			
	<i>Priacanthus arenatus</i>		bigeye	F, Ma, P	PRI AREN
	<i>Priacanthus cruentatus</i>		glasseye snapper	Ma, P	PRI CRUE
APOGONIDAE		<u>Cardinalfishes</u>			
	<i>Apogon binotatus</i>		barred cardinalfish	P	APO BINO
	<i>Apogon pseudomaculatus</i>		twospot cardinalfish	P	APO PSEU

Table 3. (cont.)

FAMILY NAME	<i>Scientific name</i>	<i>Family common name</i>	Species common name	Trophic Level	Species Code
MALACANTHIDAE		<u>Tilefishes</u>			
	<i>Malacanthus plumieri</i>		sand tilefish	Mi, Ma	MAL PLUM
ECHENEIDAE		<u>Remoras</u>			
	<i>Echeneis naucrates</i>		sharksucker	F, Ma	ECH NAUC
CARANGIDAE		<u>Jacks</u>			
	<i>Alectis ciliaris</i>		African pompano	Ma	ALE CILI
	<i>Caranx bartholomaei</i>		yellow jack	F	CAR BART
	<i>Caranx crysos</i>		blue runner	F	CAR CRYC
	<i>Caranx hippos</i>		crevalle jack	F	CAR HIP
	<i>Caranx latus</i>		horse-eye jack	F, Ma	CAR LATU
	<i>Caranx ruber</i>		bar jack	F, Ma	CAR RUBE
	<i>Caranx spe.</i>		unidentified jack	F, Ma	CAR SPE.
	<i>Decapterus macarellus</i>		mackerel scad	P	DEC MACA
	<i>Decapterus punctatus</i>		round scad	P	DEC PUNC
	<i>Elagatis bipinnulata</i>		rainbow runner	P	ELA BIPI
	<i>Seriola dumerili</i>		greater amberjack	F	SER DUME
	<i>Seriola rivoliana</i>		almaco jack	F	SER RIVO
	<i>Trachinotus falcatus</i>		permit	Ma	TRA FALC
LUTJANIDAE		<u>Snappers</u>			
	<i>Lutjanus analis</i>		mutton snapper	Ma, F	LUT ANAL
	<i>Lutjanus apodus</i>		schoolmaster	F, Ma	LUT APOD
	<i>Lutjanus buccanella</i>		blackfin snapper	F, Ma	LUT BUCC
	<i>Lutjanus cyanopterus</i>		cupera snapper	F, Ma	LUT CYAN
	<i>Lutjanus griseus</i>		gray snapper	F, Ma	LUT GRIS
	<i>Lutjanus jocu</i>		dog snapper	F, Ma	LUT JOCU
	<i>Lutjanus mahogoni</i>		mahogany snapper	F, Ma	LUT MAHO
	<i>Lutjanus spe.</i>		unidentified snapper	F, Ma	LUT SPE.
	<i>Lutjanus synagris</i>		lane snapper	Ma, F	LUT SYNA
	<i>Ocyurus chrysurus</i>		yellowtail snapper	F, Ma, Mi, P	OCY CHRY
	<i>Pristipomoides aquilonaris</i>		wenchman	F, Ma, P	PRI AQU
	<i>Rhomboplites aurorubens</i>		vermillion snapper	P, F	RHO AURO
GERREIDAE		<u>Mojarras</u>			
	<i>Eucinostomus argenteus</i>		spotfin mojarra	Mi, Ma	EUC ARGE
	<i>Gerres cinereus</i>		yellowfin mojarra	Ma, Mi	GER CINE

Table 3. (cont.)

FAMILY NAME	<i>Scientific name</i>	<u>Family common name</u>	Species common name	Trophic Level	Species Code
HAEMULIDAE		<u>Grunts</u>			
	<i>Anisotremus surinamensis</i>		black margate	Ma	ANI SURI
	<i>Anisotremus virginicus</i>		porkfish	Ma	ANI VIRG
	<i>Haemulon album</i>		margate	Ma	HAE ALBU
	<i>Haemulon aurolineatum</i>		tomtate	Ma	HAE AURO
	<i>Haemulon carbonarium</i>		caesar grunt	Ma	HAE CARB
	<i>Haemulon chrysargyreum</i>		smallmouth grunt	Ma	HAE CHRY
	<i>Haemulon flavolineatum</i>		French grunt	Ma	HAE FLAV
	<i>Haemulon macrostomum</i>		Spanish grunt	Ma	HAE MACR
	<i>Haemulon melanurum</i>		cottonwick	Ma	HAE MELA
	<i>Haemulon parra</i>		sailors choice	Ma	HAE PARR
	<i>Haemulon plumieri</i>		white grunt	Ma	HAE PLUM
	<i>Haemulon sciurus</i>		bluestriped grunt	Ma	HAE SCIU
	<i>Haemulon sp.</i>		unidentified grunt	Ma	HAE SPE.
	<i>Haemulon striatum</i>		striped grunt	Ma	HAE STRI
INERMIIIDAE		<u>Bonnetmouths</u>			
	<i>Inermia vittata</i>		boga	P	INE VITT
SPARIDAE		<u>Porgies</u>			
	<i>Archosargus probatocephalus</i>		sheepshead	Ma	ARC PROB
	<i>Archosargus rhomboidalis</i>		sea bream	H	ARC RHOM
	<i>Calamus bajonado</i>		jolthead porgy	Ma	CAL BAJO
	<i>Calamus calamus</i>		saucereye porgy	Ma	CAL CALA
	<i>Calamus penna</i>		sheepshead porgy	Ma	CAL PENN
	<i>Calamus proridens</i>		littlehead porgy	Ma	CAL PROR
	<i>Calamus spe.</i>		unknown porgy	Ma	CAL SPE.
	<i>Diplodus argenteus</i>		silver porgy	H,B	DIP ARGE
	<i>Diplodus holbrookii</i>		spottail pinfish	H,B	DIP HOLB
	<i>Lagodon rhomboides</i>		pinfish	B,H	LAG RHOM
SCIAENIDAE		<u>Drums</u>			
	<i>Equetus acuminatus</i>		high-hat	Ma,Mi	EQU ACUM
	<i>Equetus lanceolatus</i>		jackknife-fish	Ma	EQU LANC
	<i>Equetus punctatus</i>		spotted drum	Ma	EQU PUNC
	<i>Equetus umbrosus</i>		cubbyu	Mi,Ma	EQU UMBR
	<i>Odontoscion dentex</i>		reef crocker	Ma	ODO DENT
MULLIDAE		<u>Goatfishes</u>			
	<i>Mulloidichthys martinicus</i>		yellow goatfish	Mi	MUL MART
	<i>Pseudupeneus maculatus</i>		spotted goatfish	Mi	PSE MACU

Table 3. (cont.)

FAMILY NAME	<i>Scientific name</i>	<i>Family common name</i>	Species common name	Trophic Level	Species Code
PEMPHERIDAE		<u>Sweepers</u>			
	<i>Pempheris schomburgki</i>		glassy sweeper	P,Mi	PEM SCHO
KYPHOSIDAE		<u>Sea chubs</u>			
	<i>Kyphosus sectatrix</i>		Bermuda chub	H	KYP SECT
EPHIPPIDAE		<u>Spadefishes</u>			
	<i>Chaetodiperus faber</i>		Atlantic spadefish	Ma	CHA FABE
CHAETODONTIDAE		<u>Butterflyfishes</u>			
	<i>Chaetodon capistratus</i>		four-eye butterflyfish	B	CHA CAPI
	<i>Chaetodon ocellatus</i>		spotfin butterflyfish	B	CHA OCEL
	<i>Chaetodon sedentarius</i>		reef butterflyfish	Mi	CHA SEDE
	<i>Chaetodon striatus</i>		banded butterflyfish	B	CHA STRI
POMACANTHIDAE		<u>Angelfishes</u>			
	<i>Centropyge argi</i>		cherubfish	B	CEN ARG1
	<i>Holacanthus bermudensis</i>		blue angelfish	B	HOL BERM
	<i>Holacanthus ciliaris</i>		queen angelfish	B	HOL CILI
	<i>Holacanthus (bermudensis x ciliaris)</i>		Townsend angelfish	B	HOL TOWN
	<i>Holacanthus tricolor</i>		rock beauty	B	HOL TRIC
	<i>Pomacanthus arcuatus</i>		gray angelfish	B	POM ARCU
	<i>Pomacanthus paru</i>		French angelfish	B	POM PARU
POMACENTRIDAE		<u>Damselfishes</u>			
	<i>Abudefduf saxatilis</i>		sergeant major	P	ABU SAXA
	<i>Chromis cyanea</i>		blue chromis	P	CHR CYAN
	<i>Chromis enchrysurus</i>		yellowtail reeffish	P	CHR ENCH
	<i>Chromis insolata</i>		sunshinefish	P	CHR INSO
	<i>Chromis multilineata</i>		brown chromis	P	CHR MULT
	<i>Chromis scotti</i>		purple reeffish	P	CHR SCOT
	<i>Microspathodon chrysurus</i>		yellowtail damselfish	B,H	MIC MICR
	<i>Pomacentrus dieneae</i>		longfin damselfish	H	POM DIEN
	<i>Pomacentrus fuscus</i>		dusky damselfish	H	POM FUSC
	<i>Pomacentrus leucostictus</i>		beaugregory	H	POM LEUC
	<i>Pomacentrus partitus</i>		bicolor damselfish	P	POM PART
	<i>Pomacentrus planifrons</i>		three spot damselfish	H	POM PLAN
	<i>Pomacentrus variabilis</i>		cocoa damselfish	H	POM VARI
CIRRHITIDAE		<u>Hawkfishes</u>			
	<i>Amblycirrhitus pinos</i>		redspotted hawkfish	Mi	AMB PINO

Table 3. (cont.)

FAMILY NAME	<i>Scientific name</i>	<u>Family common name</u>	Species common name	Trophic Level	Species Code
SPHYRAENIDAE		<u>Barracudas</u>			
	<i>Sphyraena barracuda</i>		great barracuda	F,Ma	SPH BARR
	<i>Sphyraena picudilla</i>		southern sennet	F	SPH PICU
LABRIDAE		<u>Wrasses</u>			
	<i>Bodianus pulchellus</i>		spotfin hogfish	Ma,Mi	BOD PULC
	<i>Bodianus rufus</i>		Spanish hogfish	Ma,Mi	BOD RUFU
	<i>Clepticus parrae</i>		creole wrasse	P	CLE PARR
	<i>Doratonotus megalepis</i>		dwarf wrasse	Mi	DOR MEGA
	<i>Halichoeres bivittatus</i>		slippery dick	Ma,Mi	HAL BIVI
	<i>Halichoeres cyanocephalus</i>		yellowcheek wrasse	Mi,Ma	HAL CYAN
	<i>Halichoeres garnoti</i>		yellowhead wrasse	Ma,Mi	HAL GARN
	<i>Halichoeres maculipinna</i>		clown wrasse	Mi,Ma	HAL MACU
	<i>Halichoeres pictus</i>		rainbow wrasse	P	HAL PICT
	<i>Halichoeres poeyi</i>		blackear wrasse	Mi,Ma	HAL POEY
	<i>Halichoeres radiatus</i>		puddingwife	Mi,Ma	HAL RAD
	<i>Hemipteronotus martinicensis</i>		rosy razorfish	Ma,Mi	HEM MART
	<i>Hemipteronotus novacula</i>		pearly razorfish	Ma,Mi	HEM NOVA
	<i>Hemipteronotus sp.</i>		unidentified razorfish	Ma,Mi	HEM SPE.
	<i>Hemipteronotus splendens</i>		green razorfish	Ma,Mi	HEM SPLE
	<i>Lachnolaimus maximus</i>		hogfish	Ma	LAC MAXI
	<i>Thalassoma bifasciatum</i>		bluehead	P,Mi,Ma	THA BIFA
SCARIDAE		<u>Parrotfishes</u>			
	<i>Cryptotomus roseus</i>		bluelip parrotfish	H	CRY ROSE
	<i>Nicholsina usta</i>		emerald parrotfish	B	NIC USTA
	<i>Scarus coelestinus</i>		midnight parrotfish	H	SCA COEL
	<i>Scarus coeruleus</i>		blue parrotfish	H	SCA COER
	<i>Scarus croicensis</i>		striped parrotfish	H	SCA CROI
	<i>Scarus guacamaia</i>		rainbow parrotfish	H	SCA GUAC
	<i>Scarus spe.</i>		unidentified parrotfish	H	SCA SPE.
	<i>Scarus taeniopterus</i>		princess parrotfish	H	SCA TAEN
	<i>Scarus vetula</i>		queen parrotfish	H	SCA VETU
	<i>Sparisoma atomarium</i>		greenblotch parrotfish	H	SPA ATOM
	<i>Sparisoma aurofrenatum</i>		redband parrotfish	H	SPA AURO
	<i>Sparisoma chrysotermum</i>		redtail parrotfish	H	SPA CHRY
	<i>Sparisoma radians</i>		bucktooth parrotfish	H	SPA RAD
	<i>Sparisoma rubripinne</i>		redfin parrotfish	H	SPA RUBR
	<i>Sparisoma spe.</i>		unidentified parrotfish	H	SPA SPE.
	<i>Sparisoma viride</i>		stoplight parrotfish	H	SPA VIRI
OPISTOGNATHIDAE		<u>Jawfishes</u>			
	<i>Opistognathus aurifrons</i>		yellowhead jawfish	P	OPI AURI
	<i>Opistognathus whitehursti</i>		dusky jawfish	P	OPI WHIT

Table 3. (cont.)

FAMILY NAME	<i>Scientific name</i>	<u>Family common name</u>	Species common name	Trophic Level	Species Code
CLINIDAE		<u>Clinids</u>			
	<i>Acanthemblemaria aspera</i>		roughhead blenny	P	ACA ASPE
	<i>Acanthemblemaria chaplini</i>		papillose blenny	P	ACA CHAP
	<i>Emblemaria pandionis</i>		sailfin blenny	H	EMB PAND
	<i>Hemiemblemaria simulus</i>		wrasse blenny	Mi,P	HEM SIMU
	<i>Labrisiomus nuchipinnis</i>		hairy blenny	H	LAB NUCH
	<i>Malacoctenus gilli</i>		dusky blenny	Mi,P	MAL GILL
	<i>Malacoctenus macrops</i>		rosy blenny	Mi,P	MAL MACR
	<i>Malacoctenus sp.</i>		unidentified blenny	Mi,P	MAL SPE.
	<i>Malacoctenus triangulatus</i>		saddled blenny	Mi,P	MAL TRIA
	<i>Malacoctenus versicolor</i>		barfin blenny	Mi,P	MAL VERS
	<i>Paraclinus marmoratus</i>		marbled blenny	P,Mi	PAR MARM
	<i>Paraclinus nigripinnis</i>		blackfin goby	P,Mi	PAR NIGR
BLENNIIDAE		<u>Combtooth blennies</u>			
	<i>Unidentified blenny</i>		unidentified blenny	H	BLE SPE.
	<i>Hypleurochilus bermudensis</i>		barred blenny	H	HYP BERM
	<i>Ophioblennius atlanticus</i>		redlip blenny	H	OPH ATLA
	<i>Scartella cristata</i>		molly miller	H	SCA CRIS
CALLIONYMIDAE		<u>Dragonets</u>			
	<i>Paradiplogrammus bairdi</i>		lancer dragonet	Ma	PAR BAIR
GOBIIDAE		<u>Gobies</u>			
	<i>Coryphopterus dicrus</i>		colon goby	H	COR DICR
	<i>Coryphopterus eidolon</i>		pallid goby	H	COR EIDO
	<i>Coryphopterus glaucofraenum</i>		bridled goby	H	COR GLAU
	<i>Coryphopterus personatus</i>		masked goby	P	COR PERS
	<i>Coryphopterus species</i>		unknown goby	H,P	COR SPE.
	<i>Gnatholepis thompsoni</i>		goldspot goby	H	GNA THOM
	<i>Gobiosoma evelynae</i>		sharknose goby	Mi	GOB EVEL
	<i>Gobiosoma macrodon</i>		tiger goby	Mi	GOB MACR
	<i>Gobiosoma oceanops</i>		neon goby	Mi	GOB OCEA
	<i>Gobiosoma randalli</i>		yellownose goby	Mi	GOB RAND
	<i>Goby-like fish</i>		goby-like fish	Mi,H	GOB SPE.
	<i>Ioglossus calliurus</i>		blue goby	P	IOG CALL
	<i>Ioglossus helenae</i>		hovering goby	P	IOG HELE
	<i>Microgobius carri</i>		Seminole goby	P	MIC CARR
	<i>Microgobius microlepis</i>		banner goby	H	MIC CHRY

Table 3. (cont.)

FAMILY NAME	<i>Scientific name</i>	<u>Family common name</u>	Species common name	Trophic Level	Species Code
ACANTHURIDAE		<u>Surgeonfishes</u>			
	<i>Acanthurus bahianus</i>		ocean surgeon	H	ACA BAH1
	<i>Acanthurus chirurgus</i>		doctorfish	H	ACA CHIR
	<i>Acanthurus coeruleus</i>		blue tang	H	ACA COER
	<i>Acanthurus spe.</i>		unidentified Acanthurid	H	ACA SPE.
SCOMBRIDAE		<u>Mackerels/Tunas</u>			
	<i>Scomberomorus cavalla</i>		king mackerel	F,Ma	SCO CAVA
	<i>Scomberomorus maculatus</i>		Spanish mackerel	F,Ma	SCO MACU
	<i>Scomberomorus regalis</i>		cero	F,Ma	SCO REGA
BOTHIDAE		<u>Lefteye flounders</u>			
	<i>Bothus lunatus</i>		peacock flounder	F,Ma	BOT LUNA
	<i>Bothus ocellatus</i>		eyed flounder	F,Ma	BOT OCEL
BALISTIDAE		<u>Leatherjackets</u>			
	<i>Aluterus monoceros</i>		unicorn filefish	H	ALU MONO
	<i>Aluterus schoepfi</i>		orange filefish	H	ALU SCHO
	<i>Aluterus scriptus</i>		scrawled filefish	H,B	ALU SCR1
	<i>Balistes capriscus</i>		gray triggerfish	Ma	BAL CAPR
	<i>Balistes vetula</i>		queen triggerfish	Ma	BAL VETU
	<i>Cantherhines macrocerus</i>		whitespotted filefish	B,H	CAN MACR
	<i>Cantherhines pullus</i>		orangespotted filefish	B,H	CAN PULL
	<i>Canthidermis sufflamen</i>		ocean triggerfish	Ma,P	CAN SUFF
	<i>Melichthys niger</i>		black durgon	P	MEL NIGE
	<i>Monacanthus hispidus</i>		planehead filefish	Mi	MON HISP
	<i>Monacanthus tuckeri</i>		slender filefish	Mi	MON TUCK
OSTRACIIDAE		<u>Boxfishes</u>			
	<i>Lactophrys bicaudalis</i>		spotted trunkfish	B	LAC BICA
	<i>Lactophrys polygonia</i>		honeycomb cowfish	B	LAC POLY
	<i>Lactophrys quadricornis</i>		scrawled cowfish	B	LAC QUAD
	<i>Lactophrys trigonius</i>		trunkfish	B	LAC TRIG
	<i>Lactophrys triqueter</i>		smooth trunkfish	B	LAC TRIQ
TETRAODONTIDAE		<u>Puffers</u>			
	<i>Canthigaster rostrata</i>		sharpnose puffer	H,B,Mi	CAN ROST
	<i>Chilomycterus antennatus</i>		bridled burrfish	Ma	CHI ANTE
	<i>Chilomycterus schoepfi</i>		striped burrfish	Ma	CHI SCHO
	<i>Diodon holocanthus</i>		balloonfish	Ma	DIO HOLO
	<i>Diodon hystrix</i>		porcupinefish	Ma	DIO HYST
	<i>Diodon species</i>		unknown porcupinefish	Ma	DIO SPE.
	<i>Sphoeroides spengleri</i>		bandtail puffer	Mi,B	SPH SPEN
UNKNOWN		<u>Unknown</u>			
	<i>Unidentified sp.</i>		unidentified species		UNK SPE.

Table 4. Statistical summary by species of Florida Keys visual sampling, 1979 - 1998. Species are listed alphabetically by species code. Scientific names for codes are given in Table 1.

Species Code	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMPLE ABUNDANCE RANGE			FISH LENGTH (cm)			BIOMASS (gms)
		N	%			High	Low		Mean	Min.	Max.	
1 ABU SAXA	68,357	2,969	44.49	9.923	29.62	550	0		9.7	1	15	2,267,284.2
2 ACA ASPE	14	6	0.09	0.002	0.08	5	0		2.9	2	3	2.5
3 ACA BAH1	20,710	4,147	62.15	3.006	6.41	220	0		11.1	1	38	891,588.5
4 ACA CHAP	7	7	0.10	0.001	0.03	1	0		2.4	2	4	2.8
5 ACA CHIR	5,541	1,585	23.75	0.804	3.21	120	0		14.3	1	38	616,922.8
6 ACA COER	19,744	4,520	67.74	2.866	12.38	450	0		14.2	1	40	2,196,928.4
7 ACA SPE.	1	1	0.01	<0.001	0.01	1	0		3	3	3	0.9
8 AET NARI	8	8	0.12	0.001	0.03	1	0		143.5	65	200	7,980.3
9 ALE CILI	20	5	0.07	0.003	0.12	8	0		42.7	9	100	92,785.1
10 ALU MONO	1	1	0.01	<0.001	0.01	1	0		14	14	14	45.1
11 ALU SCHO	32	24	0.36	0.005	0.09	3	0		31	7	60	11,590.6
12 ALU SCRI	318	253	3.79	0.046	0.26	6	0		40.4	12	75	221,722.4
13 AMB PINO	30	27	0.40	0.004	0.07	3	0		6.6	4	9	56.8
14 ANI SUR1	124	80	1.20	0.018	0.22	8	0		32.1	12	53	118,636.6
15 ANI VIRG	3,446	1,399	20.97	0.500	2.35	110	0		14.4	1	40	526,032.7
16 APO BINO	1	1	0.01	<0.001	0.01	1	0		5	5	5	2.2
17 APO PSEU	2	1	0.01	<0.001	0.02	2	0		3	3	3	1.0
18 ARC PROB	5	5	0.07	0.001	0.03	1	0		29.4	18	48	4,814.7
19 ARC RHOM	166	21	0.31	0.024	0.86	60	0		16.4	10	30	19,699.4
20 ATH STIP	22,712	7	0.10	3.297	153.66	9812	0		3.3	2	6	10,691.8
21 AUL MACU	967	769	11.52	0.140	0.44	5	0		33.7	10	104	133,167.4
22 BAL CAPR	27	23	0.34	0.004	0.07	2	0		23.7	12	35	8,925.8
23 BAL VETU	47	41	0.61	0.007	0.09	3	0		27.2	14	40	29,259.8
24 BLE SPE.	11	10	0.15	0.002	0.04	2	0		5.3	3	12	34.1
25 BOD PULC	5	3	0.04	0.001	0.04	2	0		5.2	4	8	16.7
26 BOD RUFU	1,546	1,099	16.47	0.224	0.60	8	0		16.9	1	43	216,974.7
27 BOT LUNA	5	3	0.04	0.001	0.04	3	0		6.4	6	8	19.4
28 BOT OCEL	3	3	0.04	<0.001	0.02	1	0		9	6	12	41.0
29 CAL BAJO	116	94	1.41	0.017	0.16	4	0		28.5	8	50	90,786.8
30 CAL CALA	825	597	8.95	0.120	0.47	9	0		18.3	2	50	167,643.3
31 CAL PENN	4	3	0.04	0.001	0.03	2	0		24.3	23	25	1,509.7
32 CAL PROR	7	5	0.07	0.001	0.04	3	0		27.3	17	35	3,083.3
33 CAL SPE.	2	2	0.03	<0.001	0.02	1	0		28	18	38	1,280.8
34 CAN MACR	28	25	0.37	0.004	0.07	3	0		18.3	4	40	5,878.0
35 CAN PULL	225	199	2.98	0.033	0.20	3	0		11.6	3	25	10,769.5
36 CAN ROST	1,879	1,257	18.84	0.273	0.70	11	0		4.6	1	10	4,470.1
37 CAN SUFF	94	72	1.08	0.014	0.15	4	0		40	16	69	153,449.1
38 CAR BART	1,286	227	3.40	0.187	2.97	175	0		33.5	8	100	1,346,127.8
39 CAR CRY5	2,672	82	1.23	0.388	8.89	350	0		23.5	6	45	773,287.6
40 CAR HIPPI	1	1	0.01	<0.001	0.01	1	0		75	75	75	6,944.5
41 CAR LATU	215	4	0.06	0.031	1.35	80	0		27	20	40	106,024.8
42 CAR LIMB	1	1	0.01	<0.001	0.01	1	0		152	152	152	22,092.0
43 CAR RUBE	16,631	1,486	22.27	2.414	13.21	500	0		15	2	70	1,655,218.3
44 CAR SPE.	1	1	0.01	<0.001	0.01	1	0		120	120	120	10,553.2
45 CEN ARG1	5	3	0.04	0.001	0.04	3	0		4.2	3	5	11.1
46 CEN UNDE	37	20	0.30	0.005	0.16	12	0		73.8	36	122	163,420.2
47 CHA CAPI	5,230	2,484	37.22	0.759	1.21	12	0		8.1	1	15	103,418.4
48 CHA FABE	398	66	0.99	0.058	1.39	75	0		32.2	8	50	469,194.9
49 CHA OCEL	2,033	1,186	17.77	0.295	0.74	12	0		10.6	3	20	81,980.1
50 CHA SEDE	793	469	7.03	0.115	0.52	17	0		8.7	2	15	19,491.4
51 CHA STRI	734	458	6.86	0.107	0.43	6	0		10.1	2	16	25,686.1
52 CHI ANTE	2	2	0.03	<0.001	0.02	1	0		18.5	18	19	430.9
53 CHI SCHO	2	2	0.03	<0.001	0.02	1	0		14.5	14	15	201.6
54 CHR CYAN	9,877	1,795	26.90	1.434	4.99	130	0		6.3	1	15	83,667.5
55 CHR ENCH	44	13	0.19	0.006	0.22	11	0		2.5	1	5	19.0
56 CHR INSO	52	16	0.24	0.008	0.22	13	0		5.9	2	10	437.3
57 CHR MULT	10,337	755	11.31	1.501	8.88	280	0		7.6	1	17	144,297.8
58 CHR SCOT	5,094	360	5.39	0.739	7.24	350	0		4.4	1	11	15,426.5
59 CLE PARR	13,355	495	7.42	1.939	14.44	500	0		11.1	1	30	503,242.4
60 COR DICR	430	227	3.40	0.062	0.46	13	0		3.1	1	6	202.0
61 COR EIDO	4	3	0.04	0.001	0.03	2	0		2.3	2	3	0.7
62 COR GLAU	6,549	1,653	24.77	0.951	3.09	100	0		3.1	1	8	3,239.2
63 COR PERS	27,726	620	9.29	4.025	26.55	800	0		2.4	1	6	6,205.7
64 COR SPE.	57	5	0.07	0.008	0.60	50	0		2.4	2	7	17.7

Table 4 (cont.)

Species Code	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMPLE ABUNDANCE RANGE			FISH LENGTH (cm)			BIOMASS (gms)
		N	%			High	Low		Mean	Min.	Max.	
65 CRY ROSE	315	83	1.24	0.046	0.58	23	0		4.5	2	11	2,847.6
66 DAS AMER	40	38	0.57	0.006	0.08	2	0		121	25	200	523,663.4
67 DEC MACA	91	3	0.04	0.013	0.88	70	0		12.5	2	14	2,272.1
68 DEC PUNC	236	4	0.06	0.034	2.05	150	0		10.4	7	17	3,937.9
69 DIO HOLO	46	45	0.67	0.007	0.08	2	0		15.7	11	23	5,716.8
70 DIO HYST	35	32	0.48	0.005	0.08	2	0		33.4	5	76	77,178.8
71 DIO SPE.	1	1	0.01	<0.001	0.01	1	0		10	10	10	100.6
72 DIP ARGE	15	3	0.04	0.002	0.16	13	0		12.1	8	17	561.3
73 DIP FORM	62	16	0.24	0.009	0.26	16	0		3.9	2	12	73.9
74 DIP HOLB	78	18	0.27	0.011	0.37	24	0		14.6	4	26	5,829.1
75 DOR MEGA	1	1	0.01	<0.001	0.01	1	0		4	4	4	0.9
76 ECH NAUC	105	98	1.47	0.015	0.13	3	0		13.1	4	61	5,579.1
77 ELA BIPI	10	4	0.06	0.001	0.06	4	0		23	15	30	1,550.8
78 EMB PAND	2	1	0.01	<0.001	0.02	2	0		8	7	8	8.3
79 EPI ADSC	42	40	0.60	0.006	0.08	2	0		21.6	7	35	9,326.8
80 EPI CRUE	1,790	1,296	19.42	0.260	0.70	23	0		15.9	3	40	148,966.9
81 EPI FULV	42	35	0.52	0.006	0.09	4	0		17.5	5	35	5,813.9
82 EPI GUTT	78	71	1.06	0.011	0.12	2	0		19.7	6	43	14,742.4
83 EPI INER	1	1	0.01	<0.001	0.01	1	0		24	24	24	186.1
84 EPI ITAJ	3	3	0.04	<0.001	0.02	1	0		135.3	6	200	320,814.3
85 EPI MORI	292	235	3.52	0.042	0.25	5	0		35.5	6	75	246,820.7
86 EPI STRI	55	51	0.76	0.008	0.10	2	0		41.6	13	70	82,293.1
87 EQU ACUM	239	101	1.51	0.035	0.52	29	0		9.1	1	17	3,050.7
88 EQU LANC	3	3	0.04	<0.001	0.02	1	0		3.7	2	5	0.8
89 EQU PUNC	34	29	0.43	0.005	0.09	4	0		11.4	1	24	1,283.4
90 EQU UMBR	31	19	0.28	0.004	0.14	10	0		9.5	3	15	473.3
91 EUC ARGE	1	1	0.01	<0.001	0.01	1	0		15	15	15	78.0
92 FIS TABA	1	1	0.01	<0.001	0.01	1	0		60	60	60	492.8
93 GER CINE	1,357	121	1.81	0.197	4.04	210	0		18.2	2	47	226,429.6
94 GIN CIRR	33	30	0.45	0.005	0.08	3	0		135.5	27	350	847,626.5
95 GNA THOM	1,263	410	6.14	0.183	1.09	29	0		3.5	1	7	792.0
96 GOB EVEL	2	2	0.03	<0.001	0.02	1	0		1.5	1	2	0.1
97 GOB MACR	3	1	0.01	<0.001	0.04	3	0		4	4	4	1.9
98 GOB OCEA	1,591	647	9.70	0.231	1.04	21	0		2.7	1	6	372.5
99 GOB RAND	1	1	0.01	<0.001	0.01	1	0		3	3	3	0.3
100 GOB SPE.	22	11	0.16	0.003	0.10	6	0		3.6	1	9	20.2
101 GYM FUNE	32	32	0.48	0.005	0.07	1	0		101.9	8	200	122,820.5
102 GYM MILI	26	24	0.36	0.004	0.07	2	0		32.5	19	60	2,587.7
103 GYM MORI	30	30	0.45	0.004	0.07	1	0		49.7	12	100	10,897.1
104 GYM SAXI	3	3	0.04	<0.001	0.02	1	0		39.7	30	50	385.0
105 GYM VICI	3	3	0.04	<0.001	0.02	1	0		50.7	16	90	1,673.0
106 HAE ALBU	64	19	0.28	0.009	0.34	25	0		19.6	4	60	23,899.3
107 HAE AURO	115,696	1,391	20.85	16.794	97.55	5000	0		9.2	1	30	3,205,014.1
108 HAE CARB	3,511	527	7.90	0.510	5.07	225	0		16.8	2	30	366,017.7
109 HAE CHRY	26,169	526	7.88	3.799	24.33	600	0		12.9	2	25	2,755,339.3
110 HAE FLAV	27,342	3,472	52.03	3.969	13.84	400	0		12.4	2	30	1,509,196.5
111 HAE MACR	865	425	6.37	0.126	1.42	100	0		18.9	2	53	288,376.2
112 HAE MELA	844	53	0.79	0.123	3.88	233	0		14.9	3	22	70,286.0
113 HAE PARR	1,179	250	3.75	0.171	2.13	94	0		20.1	4	45	225,747.2
114 HAE PLUM	31,577	3,450	51.70	4.584	15.89	500	0		12.3	1	40	1,955,794.3
115 HAE SCIU	33,268	2,593	38.86	4.829	18.35	450	0		17.4	1	40	4,556,407.8
116 HAE SPE.	22,572	132	1.98	3.277	114.53	9000	0		1.9	1	14	7,726.1
117 HAE STRI	837	37	0.55	0.121	2.50	95	0		11.3	3	25	33,364.9
118 HAL BM	22,235	3,161	47.37	3.228	7.16	100	0		6	1	18	78,608.1
119 HAL CYAN	13	10	0.15	0.002	0.06	3	0		7.5	3	15	120.0
120 HAL GARN	16,809	3,667	54.95	2.440	4.01	90	0		6.6	1	21	94,476.4
121 HAL MACU	12,726	2,913	43.65	1.847	3.60	75	0		6.1	1	25	49,045.2
122 HAL PICT	20	11	0.16	0.003	0.09	5	0		6.4	3	12	86.8
123 HAL POEY	140	54	0.81	0.020	0.38	25	0		7.2	3	14	809.7
124 HAL RADJ	1,990	1,318	19.75	0.289	0.74	8	0		8.1	1	66	79,708.2
125 HAR JAGU	12,100	6	0.09	1.756	63.42	3000	0		5.5	3	8	33,376.9
126 HEM BRAS	656	14	0.21	0.095	3.43	175	0		16.9	7	30	58,060.0
127 HEM MART	243	24	0.36	0.035	1.25	79	0		5.9	2	30	2,164.7
128 HEM NOVA	17	9	0.13	0.002	0.09	6	0		6.1	5	10	50.4
129 HEM SIMU	37	9	0.13	0.005	0.32	26	0		3.5	3	8	46.8
130 HEM SPE.	161	5	0.07	0.023	1.11	60	0		2	1	5	48.0

Table 4 (cont.)

Species Code	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMPLE ABUNDANCE RANGE		FISH LENGTH (cm)			BIOMASS (gms)
		N	%			High	Low	Mean	Min.	Max.	
131 HEM SPLE	391	101	1.51	0.057	0.85	34	0	7.1	2	15	2,117.1
132 HOL ADSC	1,075	361	5.41	0.156	2.13	150	0	19.9	8	35	222,562.3
133 HOL BERM	930	667	10.00	0.135	0.49	8	0	22.9	3	45	373,407.4
134 HOL CILI	676	544	8.15	0.098	0.41	16	0	17.9	3	45	156,588.4
135 HOL CORU	4	3	0.04	0.001	0.03	2	0	11	10	12	104.3
136 HOL MARI	15	11	0.16	0.002	0.06	2	0	16.4	12	25	1,861.5
137 HOL RUFU	814	356	5.33	0.118	0.73	24	0	17.6	4	35	97,152.2
138 HOL SPE.	1	1	0.01	<0.001	0.01	1	0	2	2	2	0.5
139 HOL TOWN	1	1	0.01	<0.001	0.01	1	0	15	15	15	82.1
140 HOL TRIC	1,884	1,265	18.96	0.273	0.68	8	0	12.2	1	25	137,522.3
141 HOL VEXI	85	40	0.60	0.012	0.26	17	0	13.9	7	22	7,749.5
142 HYP BERM	8	8	0.12	0.001	0.03	1	0	3.1	2	4	3.5
143 HYP CHLO	1	1	0.01	<0.001	0.01	1	0	9	9	9	2.0
144 HYP GEMM	757	494	7.40	0.110	0.54	21	0	7	3	14	5,471.0
145 HYP GUTT	10	8	0.12	0.001	0.05	3	0	7.1	4	10	73.2
146 HYP HARR	17,500	5	0.07	2.540	111.25	7000	0	2.7	1	4	5,687.9
147 HYP HYBR	1	1	0.01	<0.001	0.01	1	0	8	8	8	8.2
148 HYP INDI	29	27	0.40	0.004	0.07	2	0	9.4	5	15	498.4
149 HYP NIGR	90	80	1.20	0.013	0.13	3	0	6.9	3	15	642.1
150 HYP PUEL	307	258	3.87	0.045	0.25	4	0	6.9	3	14	2,276.7
151 HYP SPE.	4	4	0.06	0.001	0.02	1	0	10.5	7	13	90.2
152 HYP TANN	57	47	0.70	0.008	0.11	4	0	6.3	3	12	338.2
153 HYP UNIC	1,480	996	14.93	0.215	0.63	10	0	6.6	1	15	9,334.3
154 INE VITT	1,981	39	0.58	0.288	7.87	500	0	15.6	4	35	152,368.3
155 IOG CALL	278	60	0.90	0.040	0.62	29	0	4.4	1	10	375.1
156 IOG HELE	10	6	0.09	0.001	0.06	4	0	4.2	1	10	13.9
157 JEN LAMP	50	1	0.01	0.007	0.60	50	0	5	5	5	98.1
158 JEN SPE.	13,000	6	0.09	1.887	122.12	9999	0	1.5	1	5	1,916.9
159 KYP SECT	9,140	831	12.45	1.327	7.48	220	0	23.1	3	70	3,391,860.3
160 LAB NUCH	1	1	0.01	<0.001	0.01	1	0	7	7	7	4.2
161 LAC BICA	61	59	0.88	0.009	0.10	2	0	14.5	5	37	9,124.2
162 LAC MAXI	1,288	892	13.37	0.187	0.62	15	0	24.5	2	60	532,490.2
163 LAC POLY	9	9	0.13	0.001	0.04	1	0	22	13	35	2,116.0
164 LAC QUAD	67	65	0.97	0.010	0.10	2	0	23.5	10	40	16,688.1
165 LAC TRIG	14	13	0.19	0.002	0.05	2	0	16.5	7	37	2,425.6
166 LAC TRIQ	338	307	4.60	0.049	0.24	4	0	13.4	4	30	39,998.8
167 LAG RHOM	37	4	0.06	0.005	0.29	20	0	12.5	10	17	1,464.3
168 LJO EUKR	1	1	0.01	<0.001	0.01	1	0	8	8	8	8.2
169 LUT ANAL	230	186	2.79	0.033	0.24	10	0	44.5	6	85	434,726.6
170 LUT APOD	7,798	1,111	16.65	1.132	6.32	220	0	21.9	2	50	1,888,807.2
171 LUT BUCC	1	1	0.01	<0.001	0.01	1	0	4	4	4	1.3
172 LUT CYAN	4	3	0.04	0.001	0.03	2	0	41.8	39	46	5,682.4
173 LUT GRIS	19,510	1,612	24.16	2.832	14.33	508	0	22.3	4	60	4,286,995.0
174 LUT JOCU	100	62	0.93	0.015	0.20	8	0	33.5	4	90	113,247.5
175 LUT MAHO	1,243	334	5.01	0.180	1.52	47	0	25.1	1	60	395,949.9
176 LUT SPE.	3	2	0.03	<0.001	0.03	2	0	14	2	20	270.9
177 LUT SYNA	2,386	185	2.77	0.346	3.83	134	0	16.9	5	40	238,913.2
178 MAL GILL	6	2	0.03	0.001	0.05	4	0	4.7	4	6	8.2
179 MAL MACR	196	87	1.30	0.028	0.33	9	0	3.6	2	6	88.1
180 MAL PLUM	214	130	1.95	0.031	0.30	10	0	12.8	2	40	8,809.2
181 MAL SPE.	1	1	0.01	<0.001	0.01	1	0	5	5	5	1.1
182 MAL TRIA	449	244	3.66	0.065	0.58	33	0	4	1	8	312.1
183 MAL VERS	5	2	0.03	0.001	0.04	3	0	5	4	5	7.0
184 MAN BIRO	5	2	0.03	0.001	0.05	4	0	112	90	200	523,224.3
185 MEG ATLA	284	91	1.36	0.041	1.17	60	0	137.5	50	200	8,869,484.3
186 MEL NIGE	3	3	0.04	<0.001	0.02	1	0	30.7	28	32	1,756.6
187 MIC CARR	9	6	0.09	0.001	0.05	2	0	6.3	3	11	28.5
188 MIC CHRY	11,636	2,698	40.43	1.689	3.17	40	0	10.4	1	20	445,190.2
189 MIC MICR	3	2	0.03	<0.001	0.03	2	0	9.3	6	11	35.0
190 MON HISP	18	14	0.21	0.003	0.06	2	0	15.4	3	22	1,368.3
191 MON TUCK	38	32	0.48	0.006	0.09	3	0	6.3	3	9	250.9
192 MUL MART	10,351	974	14.60	1.503	8.71	380	0	21.9	3	45	2,595,961.4
193 MYC BONA	309	268	4.02	0.045	0.24	4	0	38.9	6	100	437,330.2
194 MYC INTE	3	3	0.04	<0.001	0.02	1	0	16.7	15	20	209.1
195 MYC MICR	22	20	0.30	0.003	0.06	2	0	36	10	90	30,298.1
196 MYC PHEN	45	30	0.45	0.007	0.12	6	0	27.4	4	50	19,266.8
197 MYC TIGR	2	2	0.03	<0.001	0.02	1	0	30	30	30	778.0
198 MYC VENE	3	3	0.04	<0.001	0.02	1	0	21.7	17	26	473.7

Table 4 (cont.)

Species Code	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMPLE ABUNDANCE RANGE		FISH LENGTH (cm)			BIOMASS (gms)
		N	%			High	Low	Mean	Min.	Max.	
199 MYR JACO	45	21	0.31	0.007	0.17	9	0	13.8	10	27	3,495.6
200 NIC USTA	1	1	0.01	<0.001	0.01	1	0	6	6	6	2.2
201 OCY CHRY	43,967	4,051	60.71	6.382	34.67	2000	0	18.6	1	60	6,252,521.5
202 ODO DENT	1,192	357	5.35	0.173	1.89	80	0	10.6	4	24	18,538.0
203 OGC SPE.	1	1	0.01	<0.001	0.01	1	0	16	16	16	75.1
204 OPH ATLA	224	116	1.74	0.033	0.32	11	0	6.2	2	14	645.8
205 OPI AURI	921	224	3.36	0.134	1.08	31	0	6.2	2	10	2,447.4
206 OPI WHIT	1	1	0.01	<0.001	0.01	1	0	14	14	14	24.8
207 OST TRAC	2	2	0.03	<0.001	0.02	1	0	10	8	12	38.8
208 PAR BAIR	5	3	0.04	0.001	0.01	1	0	4	1	3	0.2
209 PAR FURC	103	5	0.07	0.015	0.90	70	0	10.6	6	20	2,217.3
210 PAR MARM	62	25	0.37	0.009	0.18	6	0	3.4	1	7	60.0
211 PAR NIGR	1	1	0.01	<0.001	0.01	1	0	4	4	4	0.6
212 PEM SCHO	4,924	214	3.21	0.715	11.97	650	0	7.6	1	20	49,269.3
213 POM ARCU	2,654	1,699	25.46	0.385	0.84	12	0	25.6	2	50	1,734,586.8
214 POM DIEN	1,295	372	5.57	0.188	1.07	29	0	7.7	1	13	20,087.5
215 POM FUSC	9,320	1,544	23.14	1.353	4.37	73	0	6	1	14	68,908.1
216 POM LEUC	2,614	954	14.30	0.379	1.56	35	0	4.7	1	12	9,166.8
217 POM PART	151,266	4,966	74.42	21.958	31.94	400	0	4.1	1	10	283,535.2
218 POM PARU	755	577	8.65	0.110	0.54	27	0	25.1	3	50	497,272.6
219 POM PLAN	19,204	2,599	38.95	2.788	7.30	120	0	6.6	1	15	181,824.6
220 POM VARI	5,259	1,694	25.39	0.763	2.20	40	0	5.4	1	14	25,523.7
221 PRI AQUI	3	1	0.01	<0.001	0.04	3	0	5	4	6	14.5
222 PRI AREN	20	11	0.16	0.003	0.12	9	0	23.3	8	35	5,402.0
223 PRI CRUE	78	48	0.72	0.011	0.20	10	0	14.9	7	25	11,021.4
224 PSE MACU	1,244	704	10.55	0.181	0.97	50	0	13.5	3	35	82,098.5
225 RHO AURO	3	1	0.01	<0.001	0.04	3	0	20	15	25	1,027.4
226 RYP SAPO	7	7	0.10	0.001	0.03	1	0	17.3	10	23	642.0
227 SCA COEL	1,376	398	5.96	0.200	1.91	75	0	38.2	6	91	1,779,889.7
228 SCA COER	983	516	7.73	0.143	0.97	42	0	29.1	3	75	757,273.9
229 SCA CRIS	40	21	0.31	0.006	0.12	10	0	4.5	1	7	48.9
230 SCA CROI	45,114	4,359	65.32	6.549	11.00	240	0	6.1	1	30	271,402.0
231 SCA GUAC	585	323	4.84	0.085	0.63	22	0	37.6	3	75	766,313.1
232 SCA SPE.	7	2	0.03	0.001	0.06	4	0	20.3	10	28	1,557.4
233 SCA TAEN	7,829	1,760	26.37	1.136	4.01	118	0	8.2	1	35	179,622.0
234 SCA VETU	2,531	1,328	19.90	0.367	0.99	18	0	24.4	2	60	937,976.5
235 SCO CAVA	4	4	0.06	0.001	0.02	1	0	80.5	45	120	23,811.0
236 SCO MACU	8	8	0.12	0.001	0.03	1	0	47.1	35	70	8,853.1
237 SCO PLUM	14	14	0.21	0.002	0.05	1	0	24.2	15	32	4,773.2
238 SCO REGA	191	138	2.07	0.028	0.27	10	0	44.2	15	100	168,879.3
239 SER BALD	66	43	0.64	0.010	0.14	5	0	4.5	2	8	94.1
240 SER DUME	9	7	0.10	0.001	0.04	2	0	95.6	35	183	179,367.9
241 SER RIVO	4	2	0.03	0.001	0.04	3	0	32	24	50	3,190.3
242 SER TABA	403	276	4.14	0.058	0.36	12	0	7.1	1	18	3,870.2
243 SER TIGR	1,914	1,293	19.38	0.278	0.69	8	0	6.8	1	18	11,620.2
244 SER TORT	151	20	0.30	0.022	0.61	29	0	4.7	1	10	321.7
245 SPA ATOM	1,612	411	6.16	0.234	1.41	36	0	4.3	1	12	2,181.2
246 SPA AURO	21,090	4,632	69.41	3.061	4.04	42	0	11.2	1	40	909,186.5
247 SPA CHRY	2,069	772	11.57	0.300	1.68	75	0	18.6	2	45	353,831.3
248 SPA RAD1	589	156	2.34	0.085	1.07	52	0	6	1	23	4,345.2
249 SPA RUBR	3,135	1,252	18.76	0.455	1.75	40	0	22.6	2	70	1,013,156.5
250 SPA SPE.	2	2	0.03	0.000	0.02	1	0	16.5	5	28	385.3
251 SPA VIRI	12,574	4,193	62.84	1.825	2.51	35	0	17.4	1	50	2,831,744.8
252 SPH BARR	1,848	1,012	15.17	0.268	1.06	35	0	68.8	6	200	7,641,148.5
253 SPH LEWI	1	1	0.01	<0.001	0.01	1	0	190	190	190	45,748.2
254 SPH MOKA	1	1	0.01	<0.001	0.01	1	0	245	245	245	65,672.4
255 SPH PICU	55	1	0.01	0.008	0.66	55	0	40	38	42	18,989.3
256 SPH SPEN	32	30	0.45	0.005	0.07	2	0	9.8	3	16	849.5
257 SYN FOET	2	2	0.03	<0.001	0.02	1	0	13.5	10	17	48.2
258 SYN INTE	35	35	0.52	0.005	0.07	1	0	15.3	4	35	2,803.7
259 THA BIFA	188,037	5,402	80.95	27.295	43.59	800	0	4.9	1	16	258,589.9
260 TRA FALC	59	24	0.36	0.009	0.31	24	0	58.3	35	90	227,315.1
261 TYL CROC	54	15	0.22	0.008	0.30	19	0	54.6	30	75	79,721.6
262 UNK SPE.	6,563	11	0.16	0.953	45.19	3000	0	1.6	1	3	741.1
263 URO JAMA	158	153	2.29	0.023	0.15	2	0	30	10	50	46,644.6
NO. SAMPLES = 6,673											
NO. SPECIES = 263											
TOT. INDIVIDUALS = 1,241,270											
TOT. BIOMASS (g) = 84,752,393.3 (some Biomass values are estimates)											

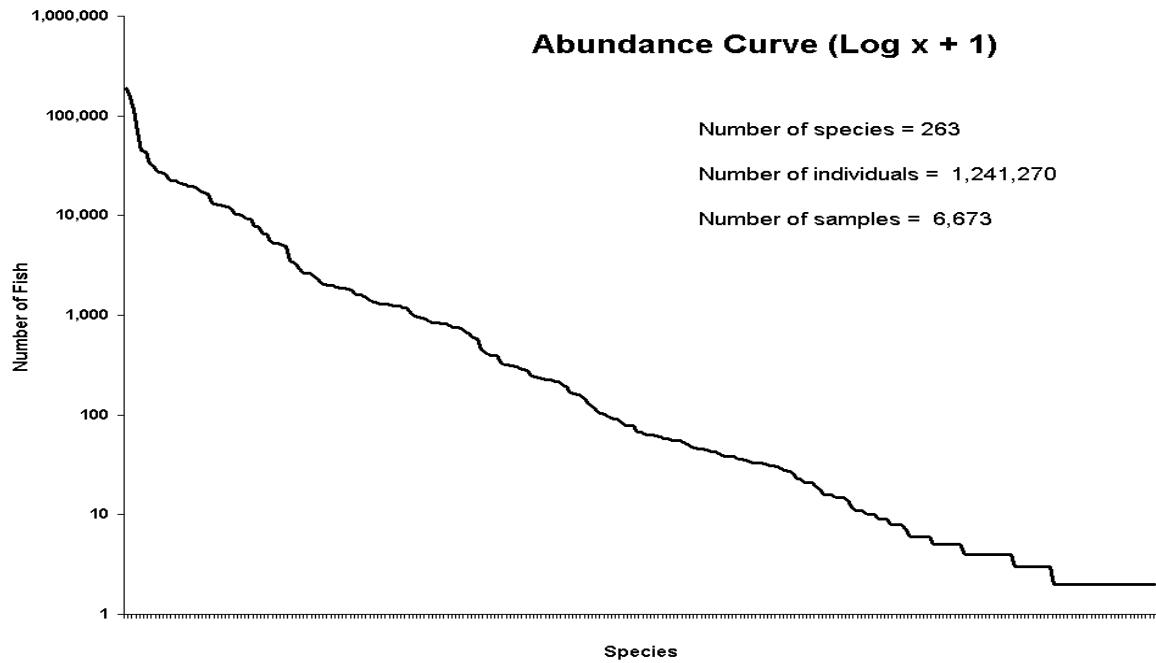


Figure 3. Rank order total log abundance for all species in 6,673 samples. Table 4 provides abundance data for individual species.

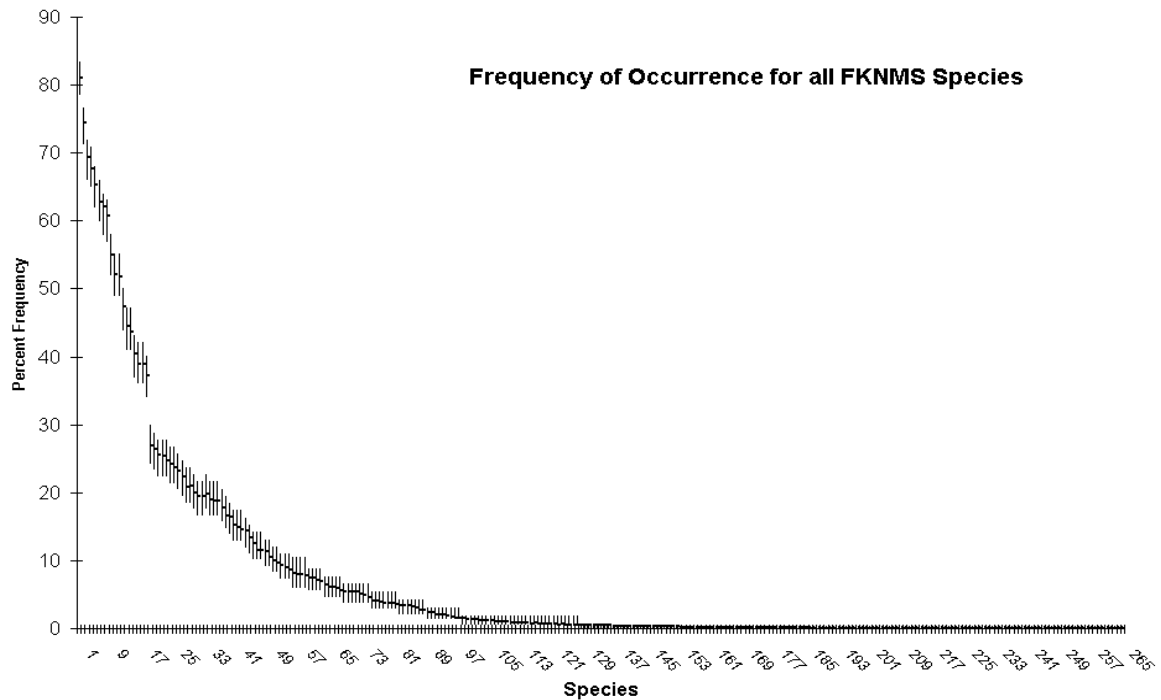


Figure 4. Rank order mean frequency-of-occurrence (\pm 95% C.I.) for all species in 6,673 samples. Table 4 shows frequency data for individual species.

reefs and offshore reefs irrespective of geographical region. Within offshore reefs, Tortugas deeper reefs were distinguished from sites in the rest of the Florida Keys. In the main Keys, offshore reefs clustered into high relief forereef and low relief hard bottom habitats. Within habitat types, reefs sites clustered primarily by geographical region (Fig 5.).

Trophic Structure

Each observed species was classified according to primary trophic level based on adult feeding patterns (Bohnsack et al. 1987, Table 1). Fishes were numerically dominated by planktivores (44 %), followed by macroinverteviores (26 %), herbivores (17 %), piscivores (8 %), microinverteviores (3 %), and browsers (1 %) (Fig. 6a). The pattern was quite different for biomass (Fig. 6b) in which piscivores (42%) dominated, followed by macroinverteviores (25%), herbivores (21%), planktivores (5%), browsers (4%), and microinverteviores (3%). The pattern of dominance by predators is classic for coral reef fish communities (Talbot and Goldman 1973, Goldman and Talbot 1976).

Trophic classification was further analyzed according to region and reef type. In terms of numbers, the proportion of planktivores was higher at offshore reefs in all regions except the upper Keys (Fig. 7). The pattern for the upper Keys, however, may be anomalous because an unusual occurrence of large numbers of midwater planktivores occurred at one inshore reef and dominated the total numbers. The proportion of planktivores was lower in the middle Keys than in other regions. Macroinverteviores were especially abundant on inshore reefs in the lower Keys.

In terms of biomass, trophic structure across regions and reef types was remarkably consistent (Fig. 8). In all four regions biomass by reef type tended to be dominated by macroinverteviores and piscivores, followed

by herbivores, browsers, planktivores, and macroinverteviores. Offshore reefs tended to have fewer browsers, but more planktivores and microinverteviores than mid-channel and inshore patch reefs.

Spatial Density Patterns

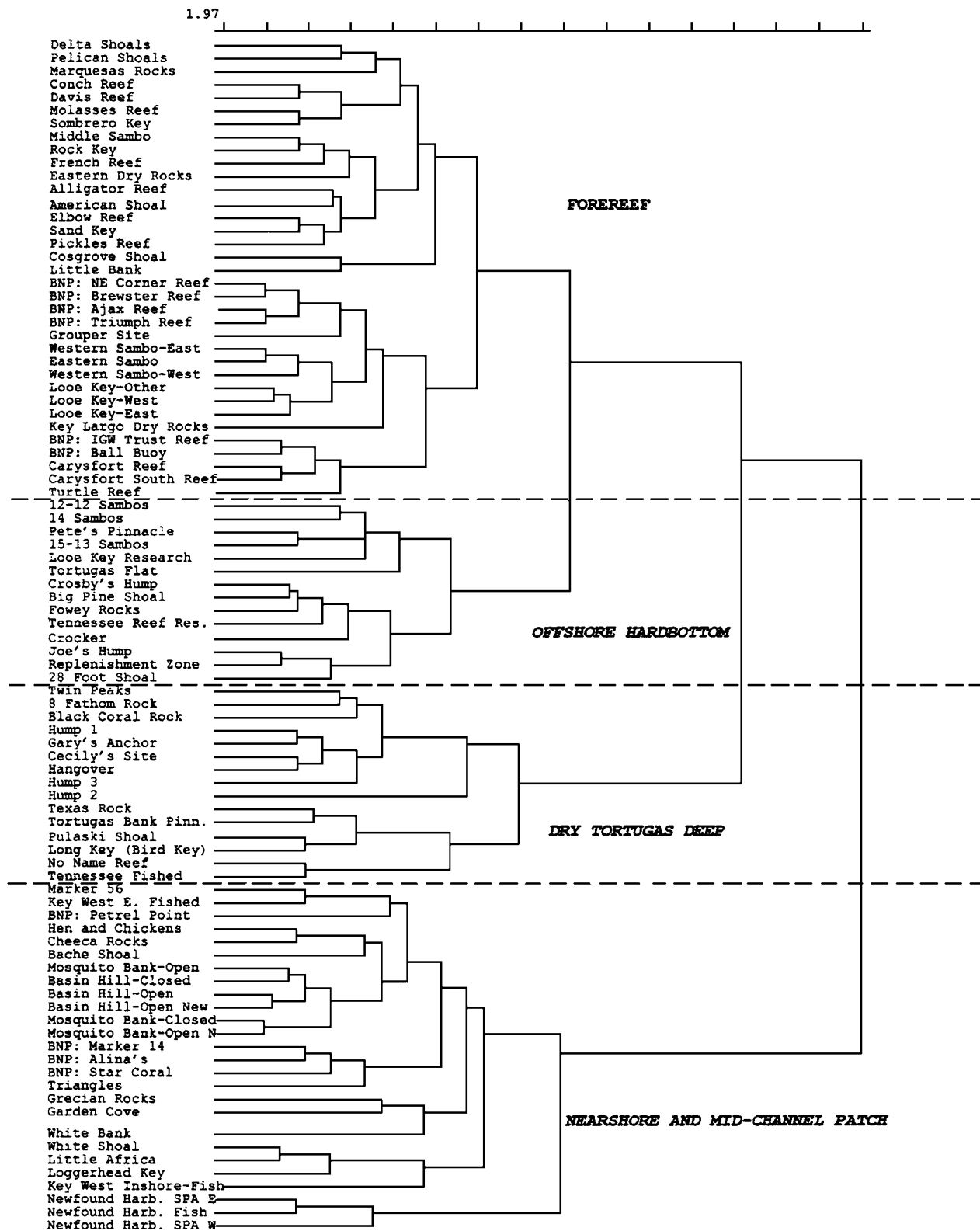
Spatial patterns of density (number of individuals observed per sample) can be determined for individual species using the database. Schmidt et al. (1999) plotted distributions for exploitable and non-exploitable phases of mutton snapper, gray snapper, yellowtail snapper, and red grouper in the Florida Keys and the Tortugas. In most cases relatively few exploitable phase individuals were observed. The highest occurrence of exploitable phase fishes tended to be in the Tortugas region, presumably because overall fishing mortality was lower. To avoid redundancy, these figures are not replicated here.

Density Trends

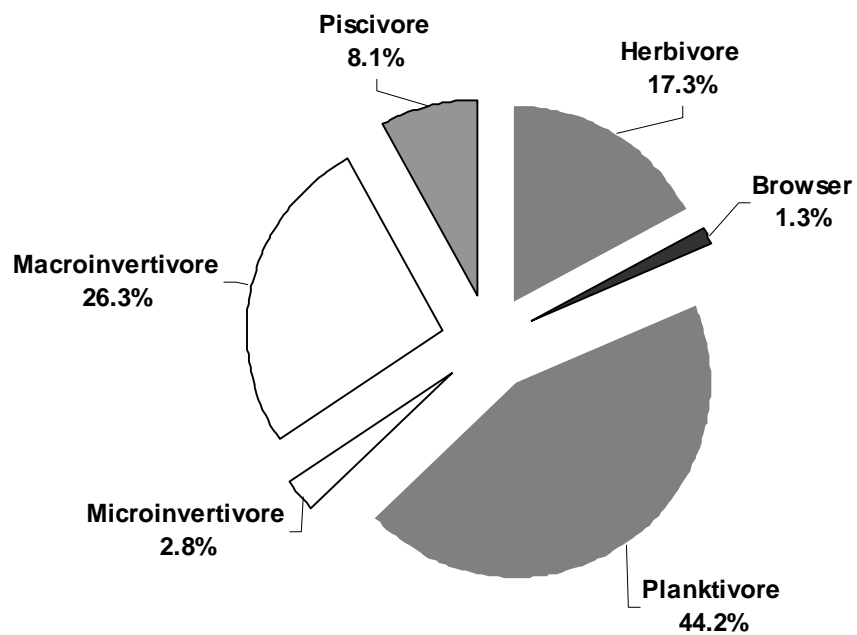
Density changes in number of individuals observed per sample were examined for selected species. Taxa selected with economic importance are gray snapper, yellowtail snapper, combined exploited grouper, and hogfish. Exploited grouper excluded graysby and coney. For comparison purposes, two taxa without direct economic importance were also analyzed in the same manner. Stoplight parrotfish represented a large species while striped parrotfish represented a small abundant species.

Four plots show trends for selected taxa: the first shows all data and the second includes only Tortugas data. Data from the rest of the Keys are included in the remaining two plots that show either sites that became no-take zones in 1997 or sites that continued to be fished. Trends showing all data should be interpreted cautiously because of variation in annual sample size and in the distribution of sites among regions (Table 1). The

Figure 5. Bray-Curtis similarity dendrogram of 90 reef sites sampled between 1 January 1988 and 30 June 1997 (n = 3,679 samples). Major reef types for major groupings are noted. Transform = none, standardization = none, no zero replacement, and $\beta = 0.25$.



a)



b)

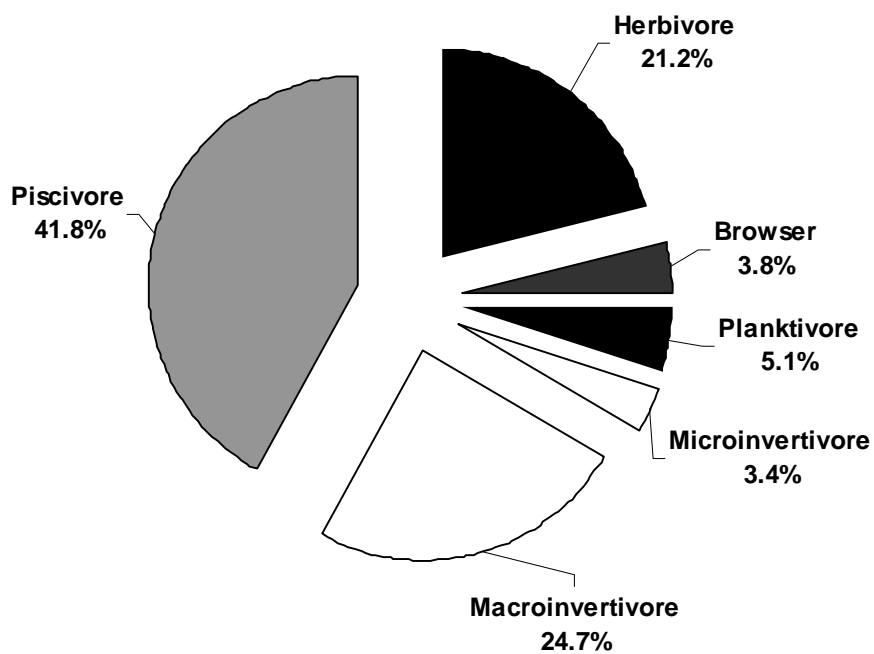


Figure 6. Mean trophic structure of reef fishes in the Florida Keys as percentage of total individuals (a) and biomass (b). N = 1,241,270 individuals, 6,673 samples, and 118 reef sites. Data were collected from 1979 - 98.

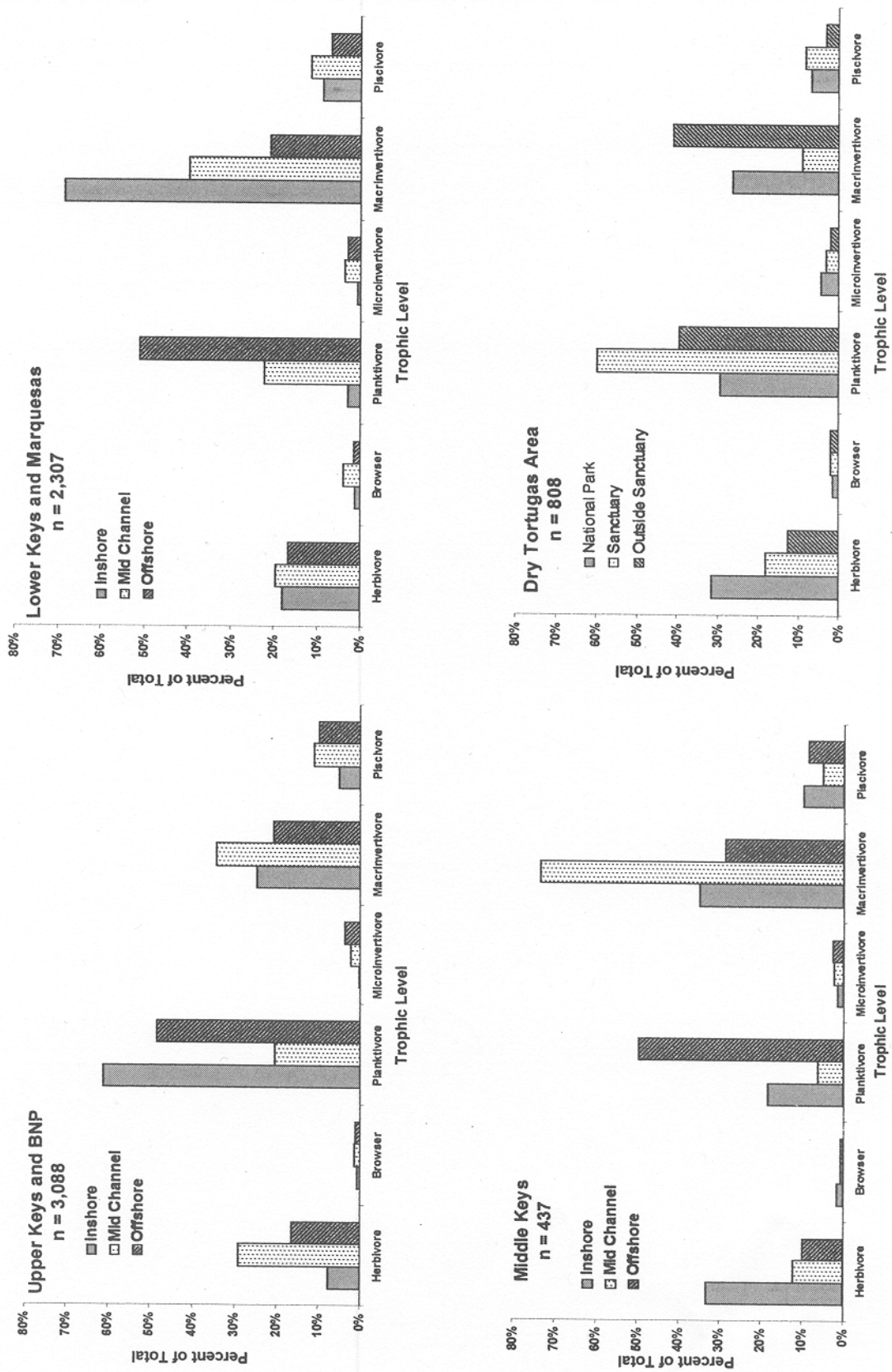


Figure 7. Reef fish trophic composition in numbers of individuals by reef type and region.

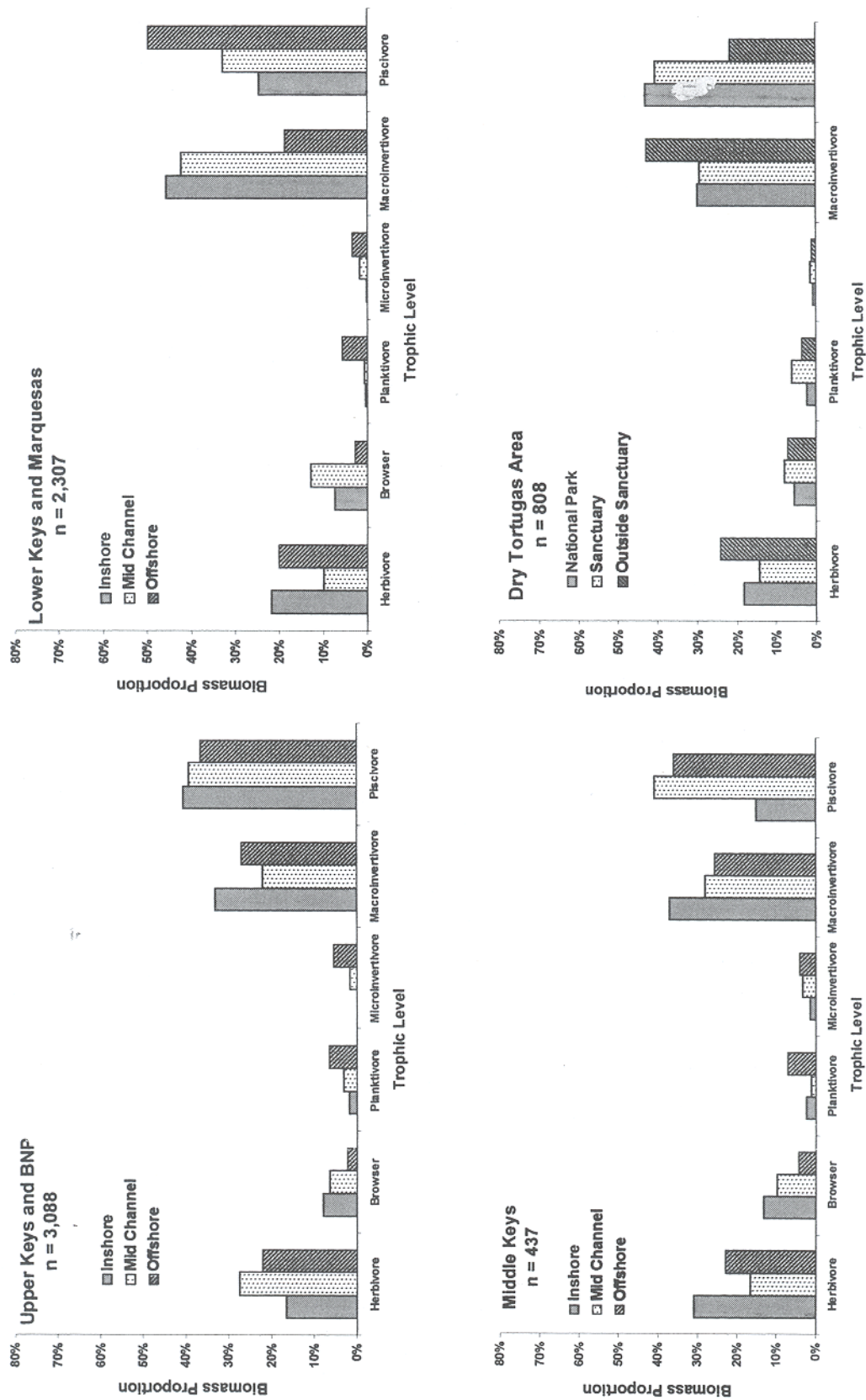


Figure 8. Reef fish trophic composition in biomass by reef type and region.

Tortugas region, for example, was not sampled until after 1994 while samples in 1979 through 1986 were primarily from Looe Key Reef and the Upper Keys. Also, changes in general regional fishery regulations may have influenced observed fish densities and sizes. In 1980, fish traps were banned in Florida waters. In 1983, fish traps were prohibited in federal waters less than 100 ft (30.5 m) deep by the SAFMC Snapper-Grouper Fishery Management Plan. In 1990, the SAFMC prohibited all fish traps in federal waters on the Atlantic side of the Florida Keys west to 83° N Longitude as part of Amendment 4 to the Snapper-Grouper Plan. In December 1986, Florida established bag limits of 10 snapper and 5 grouper/angler/day.

Gray Snapper (*L. griseus*) (Fig. 9, Table 5). Mean density (Fig. 9a) tended to decline through the early and middle 1980s before recovering somewhat in the early 1990s. The high density and variance in 1979 was most likely the result of a very small sample size ($n = 2$) collected only at Molasses Reef. Mean density at unfished sites (Fig. 9c) was slightly higher than at fished sites (Fig. 9d) during the baseline period, however, the 95% confidence intervals overlapped the fished sites. Mean density in the Tortugas (Fig. 9c) was similar to fished sites in the rest of the Keys. Changes in regional fishing regulations may have influenced observed densities. On July 1, 1985, Florida established a minimum size limit of 10" (25.4 cm) for state waters (< 3 nmi from land). In 1991, Amendment 4 of the SAFMC Snapper-Grouper Plan established a minimum size limit of 12 in (30.5 cm) for federal waters (> 3 nmi from land).

Yellowtail Snapper (*Ocyurus chrysurus*) (Fig. 10, Table 5). Mean density (Fig. 10a) was reasonably consistent through the 1980s but tended to increase in the early 1990s. Mean density and confidence intervals were similar at unfished (Fig. 10c) and fished sites (Fig.

10d) during the baseline period. Mean densities in the Tortugas (Fig. 10b) was slightly lower than the rest of the Keys. Changes in regional fishing regulations may have influenced observed densities. Minimum size limits of 12" (30.5 cm) were established in federal waters (>3 nm from land) by the SAFMC in September 1983 and in Florida waters (< 3 nm from shore) in February 1990.

Combined Exploited Grouper (Serranidae) (Fig. 11, Table 5). Because of low grouper density Keys-wide, data for the larger exploited species were combined for analysis. Graysby (*Epinephelus guttatus*) and coney (*E. fulvus*) were excluded because of their small maximum adult size. Mean grouper density (Fig. 11a) increased over the study period, perhaps in response to the prohibition in fish traps, the establishment of minimum size limits, and increased sampling in the Tortugas. Mean grouper density was similar and low at fished (Fig. 11d) and unfished (Fig. 11c) sites during the baseline period. Mean densities were much higher in the Tortugas (Fig. 11b) than in the rest of the Keys, an observation consistent with Bohnsack et al. (1994) who showed that grouper fishery landings were higher from the Tortugas region than the rest of the Keys.

Changes in regional fishing regulations may have influenced observed densities. In September 1983 minimum size limits of 12" (30.5 cm) were established for black grouper (*Mycteroperca bonaci*) by the SAFMC. On July 1, 1985, Florida established new minimum size limits of 18" (45.7 cm) for gag (*M. microlepis*), black (*M. bonaci*), red (*Epinephelus morio*), and yellowfin (*M. venenosa*) grouper. In February 1990, Florida added or increased minimum size limits to 20" (50.8 cm) for scamp (*M. phenax*) and black, gag, red, yellowfin, and yellowmouth grouper (*M.*

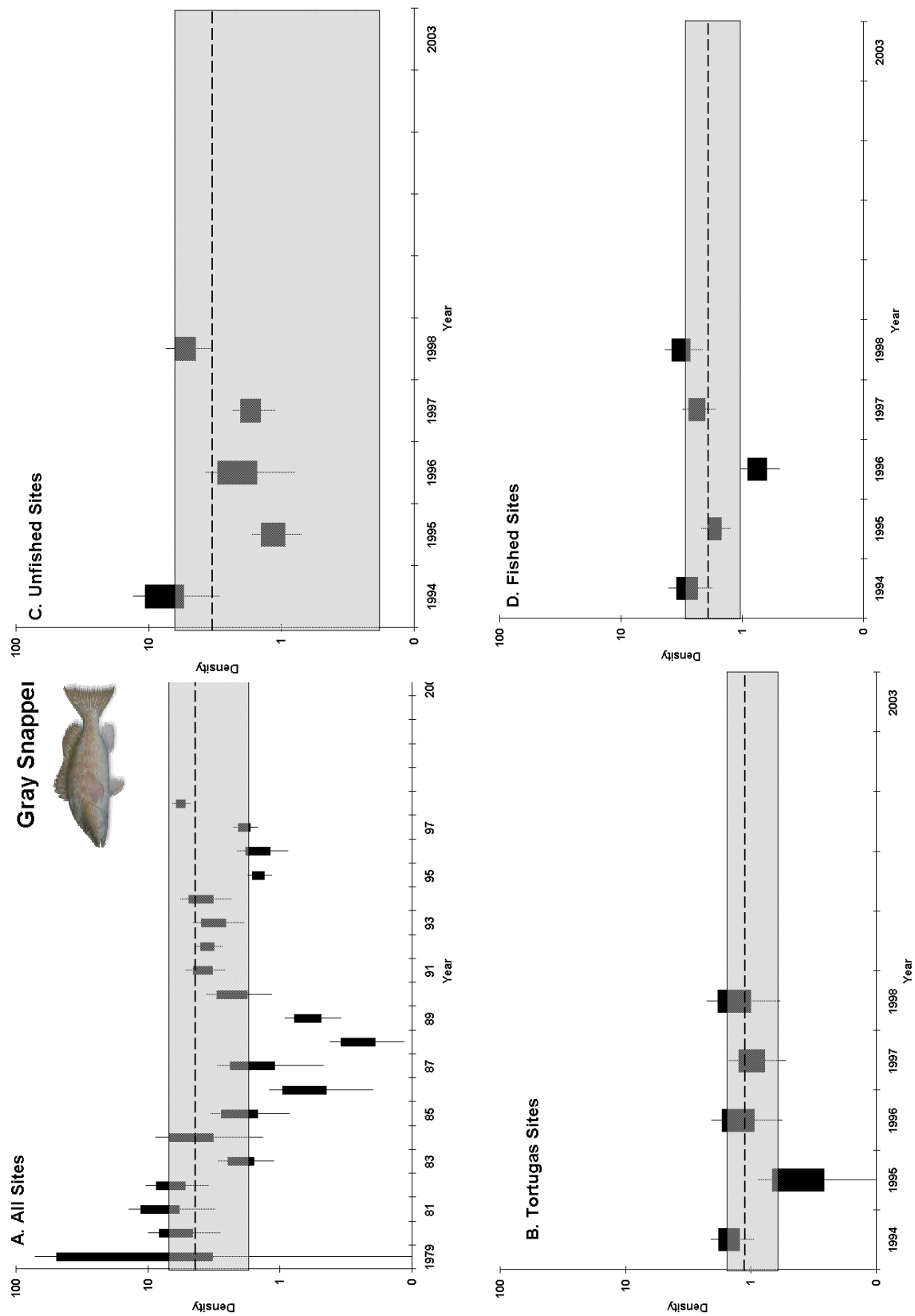


Figure 9. Changes in gray snapper mean density (total number of individuals per sample). (A) all sites; (B) Tortugas sites; (C) unfished sites with no take protection beginning 1 July 1997; (D) fished sites excluding the Tortugas. Vertical lines show annual mean \pm 95% CI. Bars show annual mean \pm 1 SE. Shaded areas show 95% CI for annual means through 1997 in Fig A and for 1994 -1997 in Figs. B, C, and D. Shaded areas are projected beyond 1997 to show predicted performance ranges after 1997. Table 1 shows annual sample size.

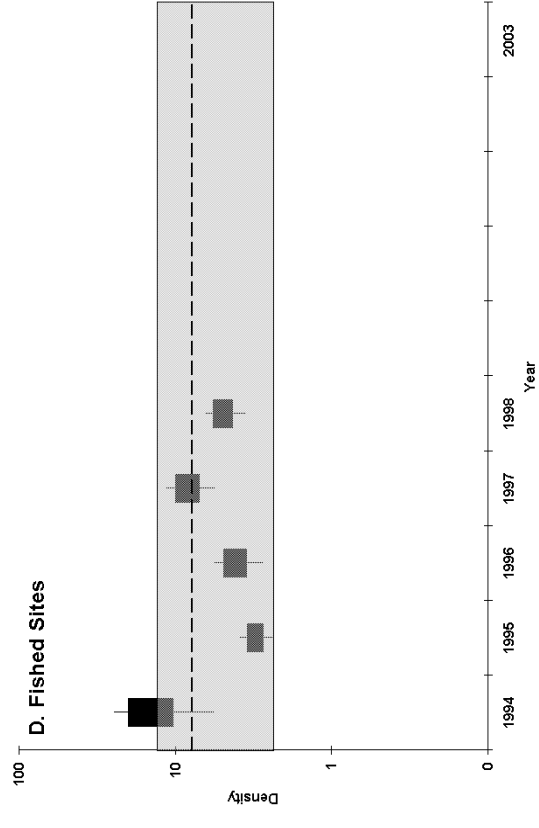
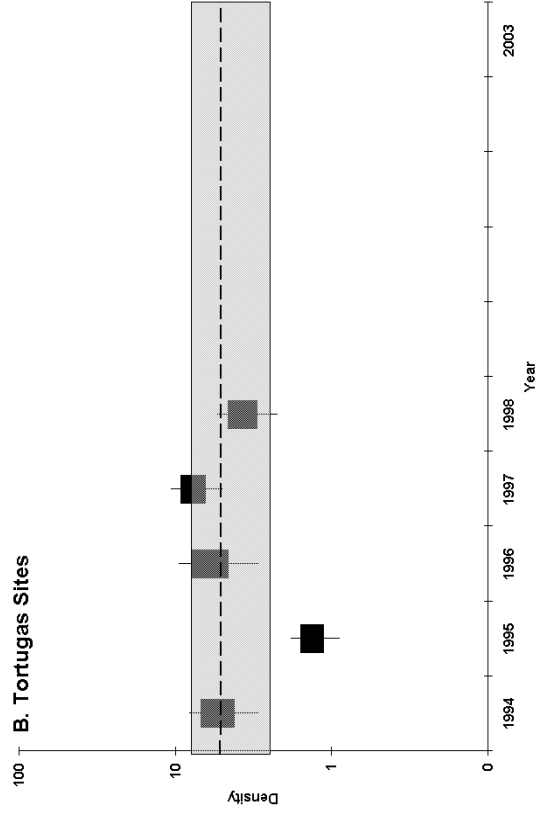
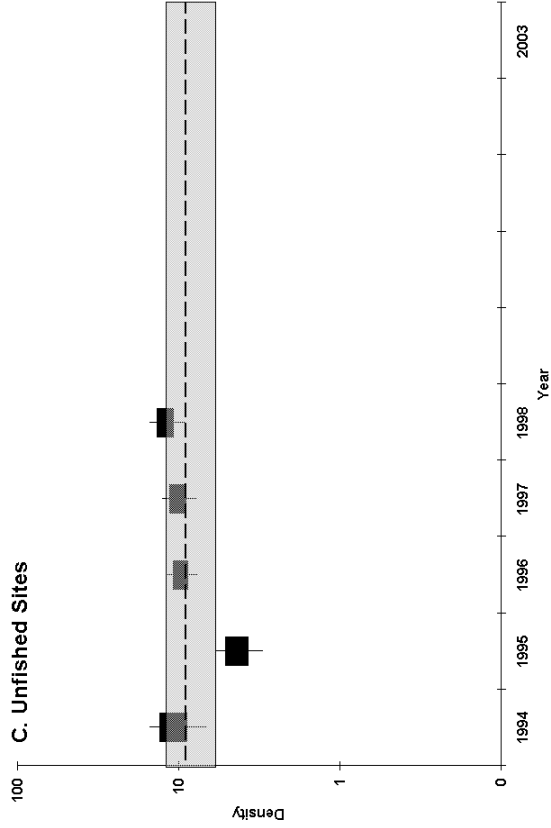
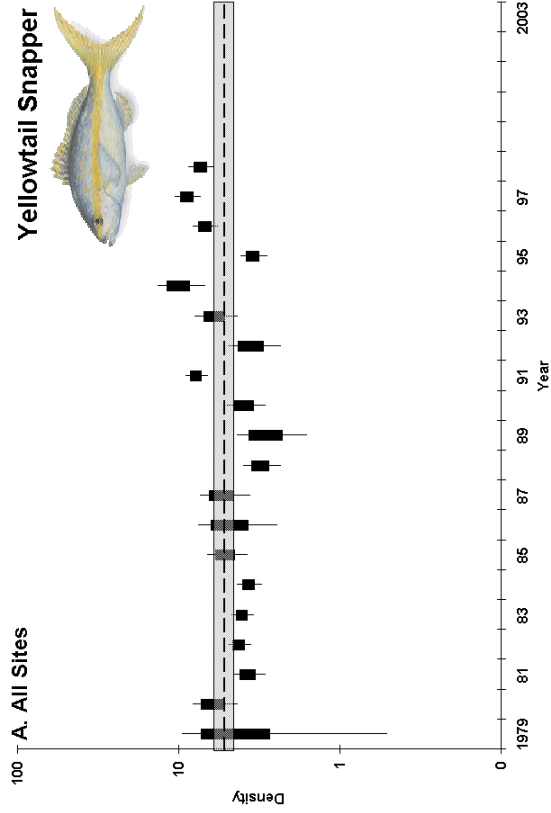


Figure 10. Changes in yellowtail snapper mean density (total number of individuals per sample). (A) all sites; (B) Tortugas sites; (C) unfished sites with no-take protection beginning 1 July 1997; (D) fished sites excluding the Tortugas. Vertical lines show annual mean \pm 95% CI. Bars show annual mean \pm 1 SE. Shaded areas show 95% CI for annual means through 1997 in Fig A and for 1994 -1997 in Figs. B, C, and D. Shaded areas are projected beyond 1997 to show predicted performance ranges after 1997. Table1 shows annual sample size.

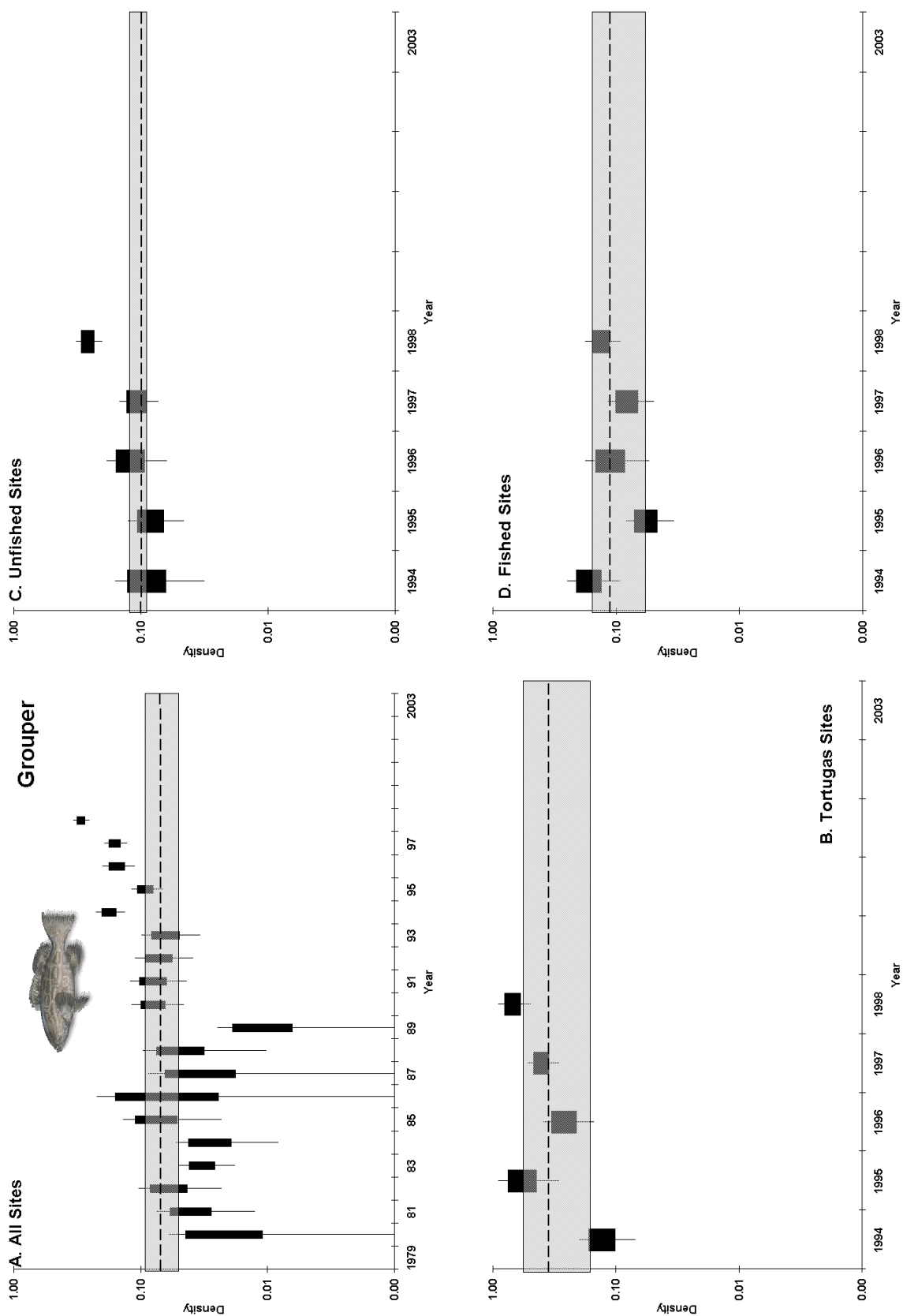


Figure 11. Changes in combined grouper mean density (total number of individuals per sample). (A) all sites; (B) Tortugas sites; (C) unfished sites with no-take protection beginning 1 July 1997; (D) fished sites excluding the Tortugas. Vertical lines show annual mean \pm 95% CI. Bars show annual mean \pm 1 SE. Shaded areas show 95% CI for annual means through 1997 in Fig A and for 1994 -1997 in Figs. B, C, and D. Shaded areas are projected beyond 1997 to show predicted performance ranges after 1997. Table 1 shows annual sample size.

interstitialis).

Hogfish (*Lachnolaimus maximus*) (Fig. 12, Table 5). Mean density (Fig. 12a) increased over the study period, perhaps in response to the prohibition of fish traps; the establishment of minimum 12" (30.5 cm) size limits by Florida in July 1994 and by the SAFMC in 1994; and the 5 fish daily bag limits by Florida in July, 1994. Mean hogfish density was higher in fished sites (Fig. 12d) than in unfished (Fig. 12c) sites during the baseline period. Mean densities in the Tortugas (Fig. 12b) were similar to fished sites in the rest of the Keys but had wider confidence intervals.

Stoplight Parrotfish (*Sparisoma viride*) (Fig. 13, Table 5). Mean density (Fig. 13a) varied over the study period. Densities were low relative to the base period in 1998 in both fished (Fig. 13d) and unfished (Fig. 13c) sites. Although larger individuals are occasionally landed, this species is medium sized and has little direct economic value. Thus, effects of no-take protection were expected to be minimal in terms of protection from direct exploitation. Average density of stoplight parrotfish was much lower in the Tortugas than in the rest of the Keys (Fig. 13b). This observation may be the result of the fact that sites in the Tortugas tended to be deeper than the rest of the Keys. Deeper sites have lower light levels and fewer algal food resources which may be reflected in lower parrotfish density.

Striped Parrotfish (*Scarus croicensis*) (Fig. 14, Table 5). No-take protection is predicted to have no direct impact on this species because it is small, has no direct economic value, and would rarely be caught by fishing. Mean annual densities at fished (Fig. 14d) and unfished (Fig. 14c) sites were consistent. The fact that the high observed annual mean densities came from both fished and unfished sites in 1998 suggests that protection level

was not responsible for the observed changes.

A comparison of fish density for exploited species at no-take sites and fished reference sites shows very similar patterns between species (Table 5). It is premature, however, to make conclusions about the impacts of no-take zones on reef fishes since only one full year of data are available following zoning changes in the FKNMS. It is encouraging, however, that after only one year of no-take protection, the annual mean densities of exploited species in no-take sites were the highest observed for yellowtail snapper, combined grouper, and hogfish and the second highest for gray snapper compared to the baseline period. In comparison, a similar uniform responses were not observed for these species at fished sites nor for two species examined without direct economic importance (striped and stoplight parrotfish). These patterns suggest that no-take protection is having some positive impact on density of exploited species. Despite the increased density of exploited grouper in no-take zones, grouper density was still much higher in the Tortugas than in the rest of the Keys. This difference suggests that a potential exists for a much greater response in the future.

Density of Size Phases

Trends in mean annual density of larger exploitable and smaller non-exploitable phase fishes were plotted for gray snapper, yellowtail snapper, combined grouper and hogfish. Because of relatively slow adult growth rates, changes in mean fish size were considered unlikely to change significantly after only one year protection.

Gray Snapper. Density of exploitable phase gray snapper (Fig. 15a) tended to decline slightly over the study period. The 95% confidence interval shows wide variation in density to very low values. The low density of exploitable sized gray snapper in 1998 and 1989 probably reflect intensive sampling in

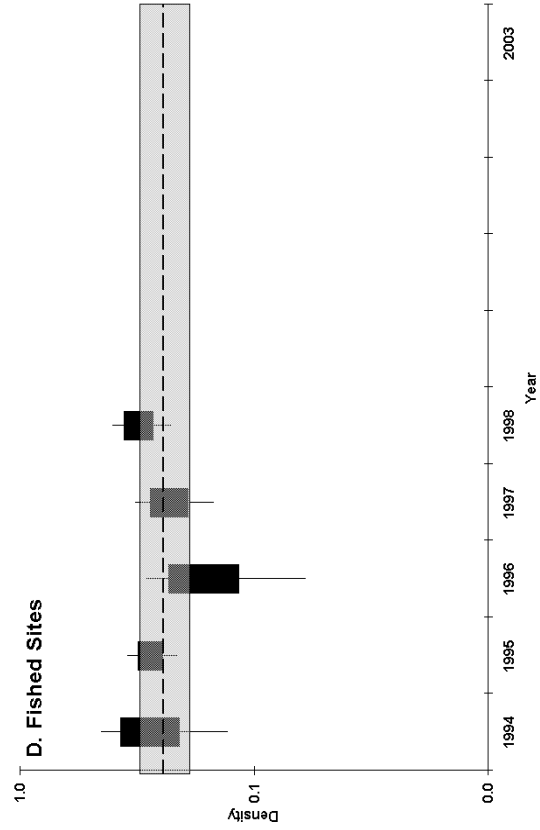
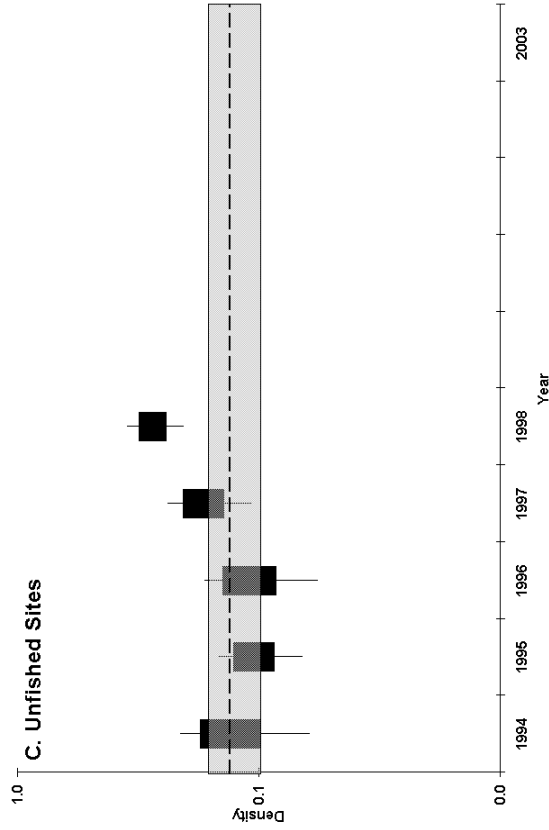
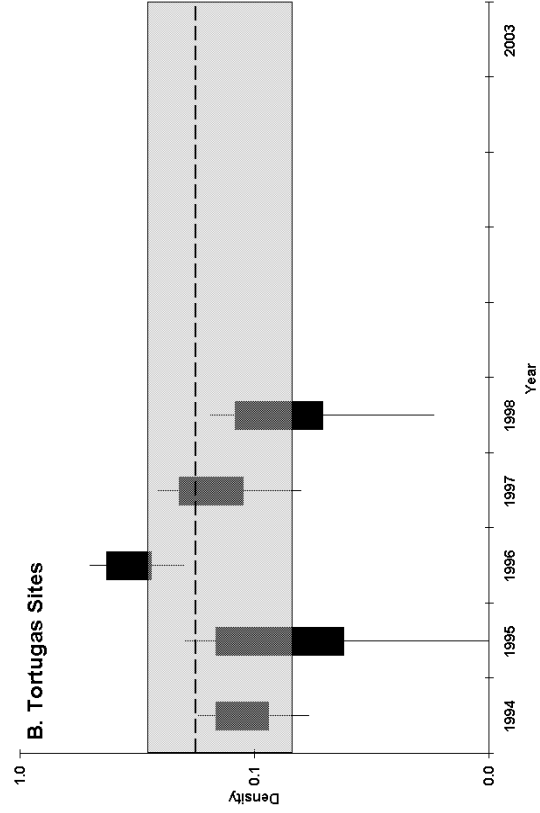
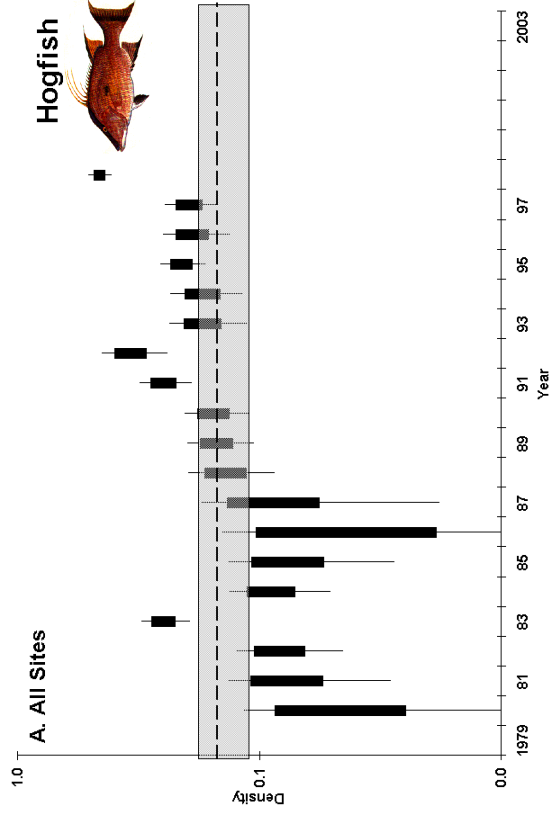


Figure 12. Changes in hogfish mean density (total number of individuals per sample). (A) all sites; (B) Tortugas sites; (C) unfished sites with no-take protection beginning 1 July 1997; (D) fished sites excluding the Tortugas. Vertical lines show annual mean \pm 95% CI. Bars show annual mean \pm 1 SE. Shaded areas show 95% CI for annual means through 1997 in Fig A and for 1994 -1997 in Figs. B, C, and D. Shaded areas are projected beyond 1997 to show predicted performance ranges after 1997. Table 1 shows annual sample size.

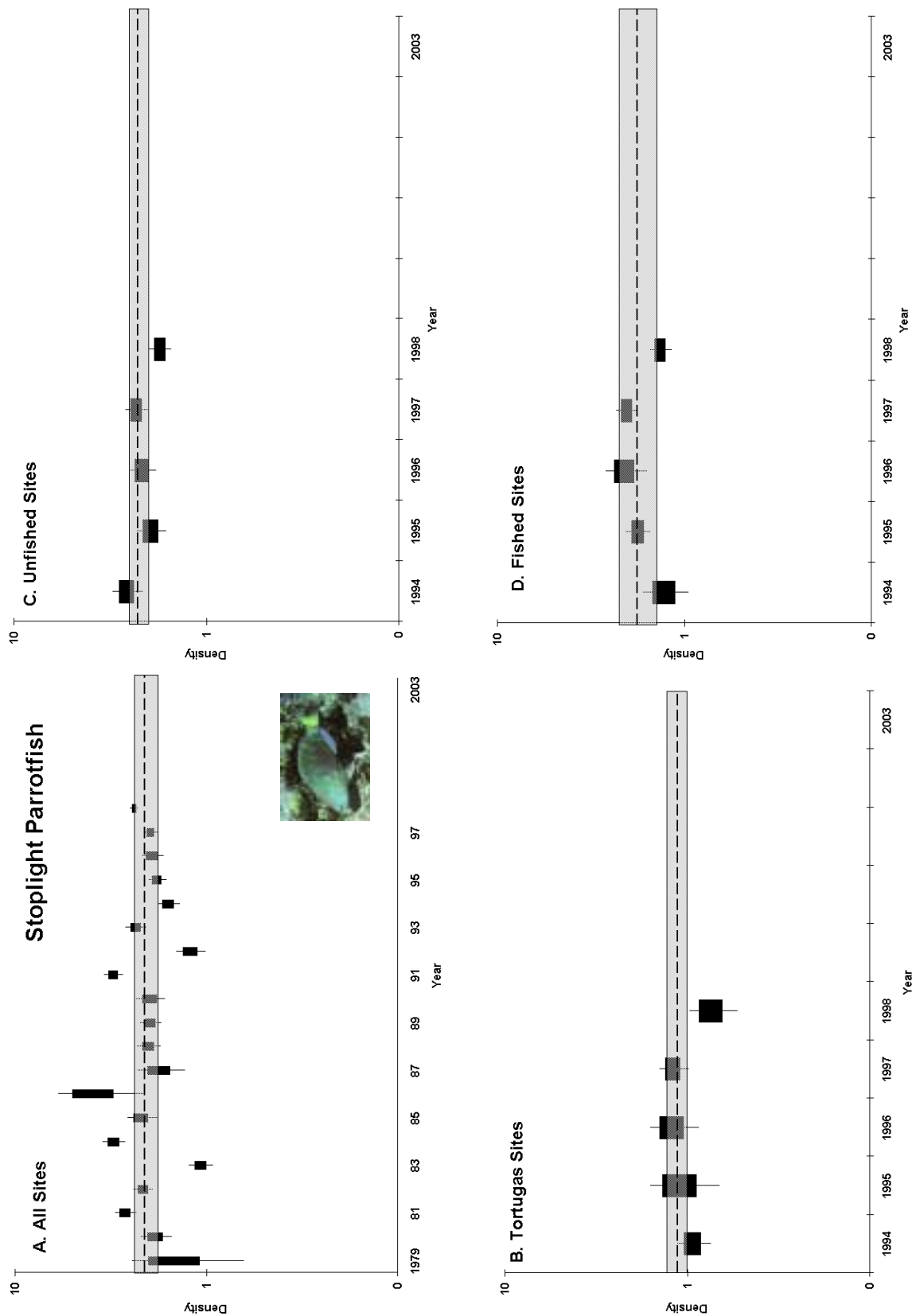


Figure 13. Changes in stoplight parrotfish mean density (total number of individuals per sample). (A) all sites; (B) Tortugas sites; (C) unfished sites with no-take protection beginning 1 July 1997; (D) fished sites excluding the Tortugas. Vertical lines show annual mean \pm 95% CI. Bars show annual mean \pm 1 SE. Shaded areas show 95% CI for annual means through 1997 in Fig A and for 1994 - 1997 in Figs. B, C, and D. Shaded areas are projected beyond 1997 to show predicted performance ranges after 1997. Table 1 shows annual sample size.

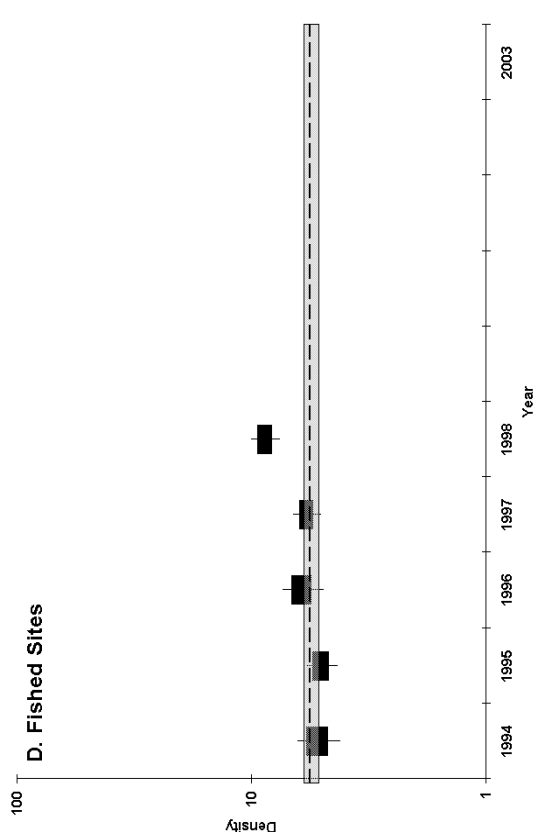
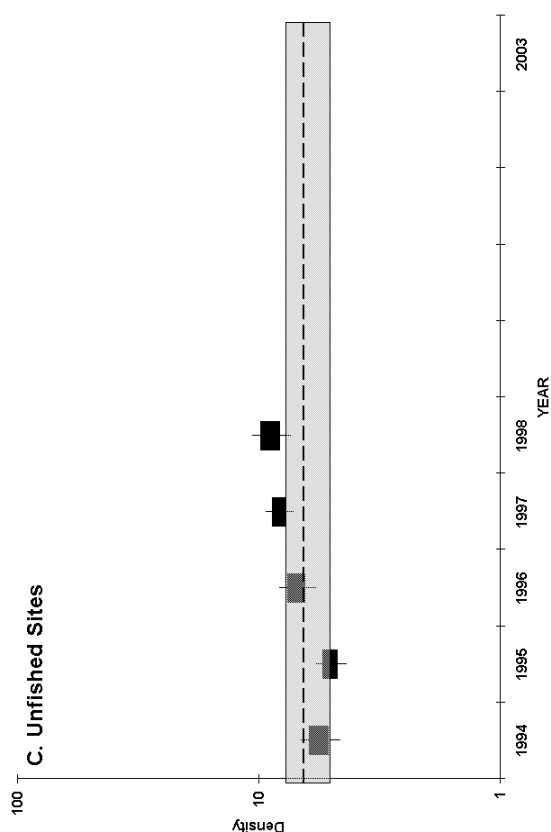
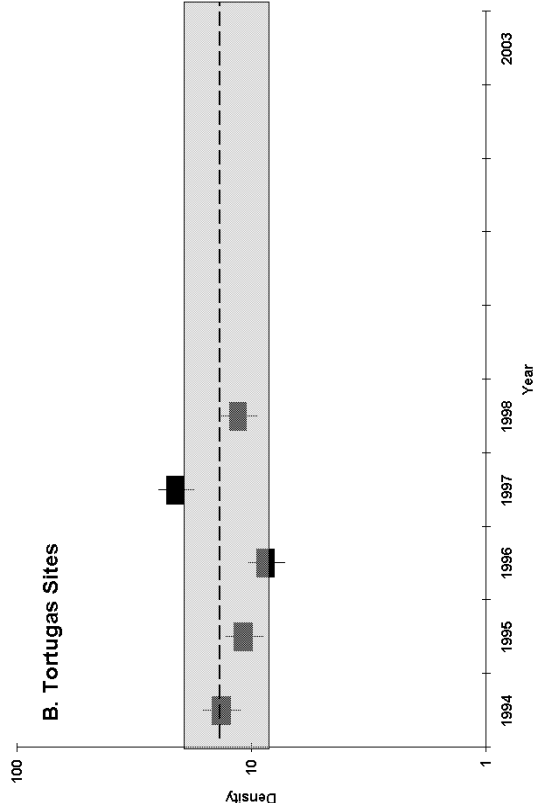
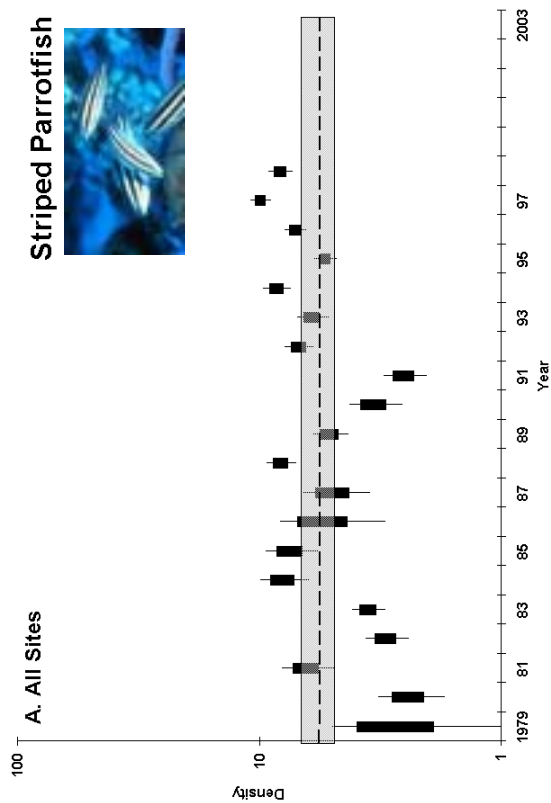


Figure 14. Changes in striped parrotfish mean density (total number of individuals per sample). (A) all sites; (B) Tortugas sites; (C) unfished sites with no-take protection beginning 1 July 1997; (D) fished sites excluding the Tortugas. Vertical lines show annual mean \pm 95% CI. Bars show annual mean \pm 1 SE. Shaded areas show 95% CI for annual means through 1997 in Fig A and for 1994 -1997 in Figs. B, C, and D. Shaded areas are projected beyond 1997 to show predicted performance ranges after 1997. Table 1 shows annual sample size.

Table 5. Summary statistics for selected species for Figures 9 - 14. SD = standard deviation; CI = confidence interval.

Protection Level																
Species	Not Fished				Fished				Tortugas				All			
	Mean #	SD	Lower 95% CI	Upper 95% CI	Mean #	SD	Lower 95% CI	Upper 95% CI	Mean #	SD	Lower 95% CI	Upper 95% CI	Mean #	SD	Lower 95% CI	Upper 95% CI
Gray snapper	3.282	3.159	0.186	6.377	1.933	0.922	1.029	2.837	1.075	0.454	0.630	1.520	4.333	5.760	1.743	6.923
Yellowtail snapper	8.817	2.984	5.893	11.741	7.691	5.438	2.362	13.020	5.203	2.741	2.516	7.889	5.234	2.004	4.333	6.135
Combined grouper	0.104	0.017	0.087	0.120	0.107	0.048	0.060	0.154	0.351	0.197	0.159	0.544	0.072	0.049	0.050	0.094
Hogfish	0.132	0.030	0.102	0.161	0.244	0.053	0.192	0.295	0.180	0.117	0.066	0.294	0.147	0.084	0.109	0.184
Stoplight parrotfish	2.259	0.271	1.993	2.525	1.803	0.365	1.445	2.160	1.124	0.129	0.997	1.251	2.115	0.696	1.802	2.428
Striped parrotfish	6.482	1.409	5.102	7.863	5.570	0.501	5.079	6.061	13.568	5.444	8.233	18.903	5.659	2.243	4.651	6.668

Biscayne National Park at sites dominated by juveniles. Non-exploitable juvenile snapper (Fig. 15ab) showed a narrower confidence interval and cyclic pattern in density with two peaks of abundance in the early 1980s and 1990s. The density changes in the mid 1980s is highly correlated with a similar decline and recovery in commercial pink shrimp landings from the Tortugas (Nance and Patella 1989). This pattern may be a spurious correlation or may possibly reflect a period of poor recruitment in response to problems or changes in Florida Bay, a habitat used by both pink shrimp and gray snapper.

Yellowtail Snapper. Annual mean density of exploitable phase yellowtail snapper varied greatly over the study period (Fig. 16a) in comparisons to juveniles which were more consistent over time (Fig. 16b). Mean annual density of juveniles was an order of magnitude higher than adults.

Grouper. Annual mean densities of exploitable phase grouper were low and varied greatly over the study period (Fig. 17a) in comparisons to juveniles which were more consistent over time (Fig. 17b). Mean annual density of juveniles was an order of magnitude higher than adults.

Hogfish. Mean density of observed exploitable (Fig 18a) and non-exploitable hogfish (Fig. 18b) was low but has tended to increase over the study period most likely in response to the implementation of several conservation measures discussed earlier.

CONCLUSIONS

Fishery-independent visual sampling is a cost-effective method to obtain high precision spatial estimates and to non-destructively monitor reef fish biodiversity, abundance, and size trends in the Florida Keys. A 20 year data set, beginning in 1979, provides a basis for evaluating short and long term changes in the Florida Keys resulting from different management practices and

environmental changes. Since only one full year of data are available following the establishment of no-take zones, it is premature to make conclusion about the impacts of marine reserves on reef fishes. It is encouraging, however, that after only one year of no-take protection, the annual mean densities of exploited species in no-take sites were the highest observed for yellowtail snapper, combined grouper, and hogfish and the second highest for gray snapper compared to the baseline period. In comparison, similar uniform responses were not observed for the same species at fished sites nor for two species without direct economic importance (striped and stoplight parrotfish). Over time, the average exploitable phase size of exploited species is expected to increase in no-take protect areas.

ACKNOWLEDGMENTS

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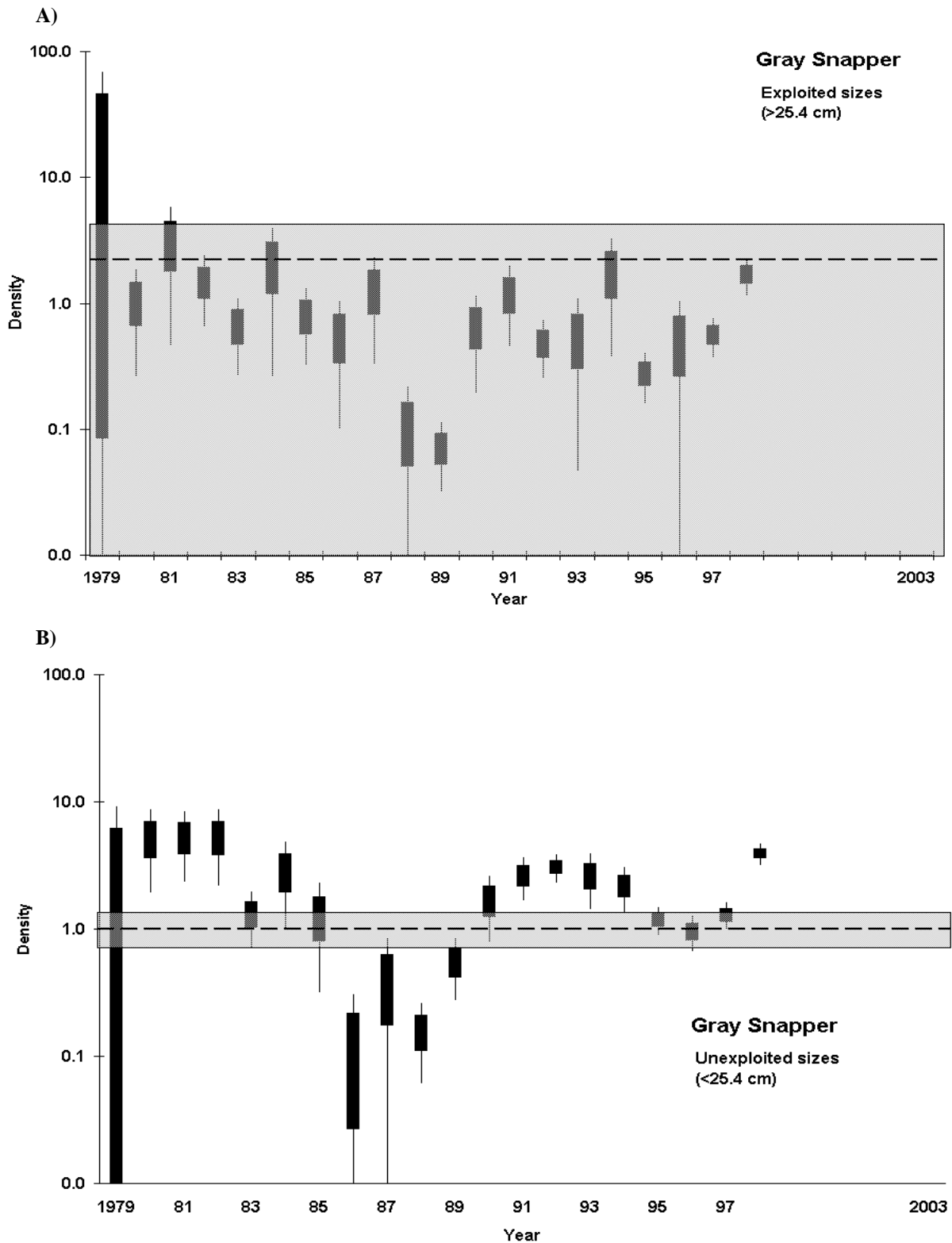


Figure15. Changes in gray snapper mean density (total number of individuals per sample) for (A) exploitable (≥ 25.4 cm FL) and (B) un-exploitable sizes (< 25.4 cm FL) from all sites (1979-1998). Vertical lines show annual mean $\pm 95\%$ CI. Bars show annual mean ± 1 SE. Shaded areas show 95% CI for annual means through 1997. Shaded areas are projected beyond 1997 to show predicted performance ranges assuming no changes. Table 1 shows annual sample size.

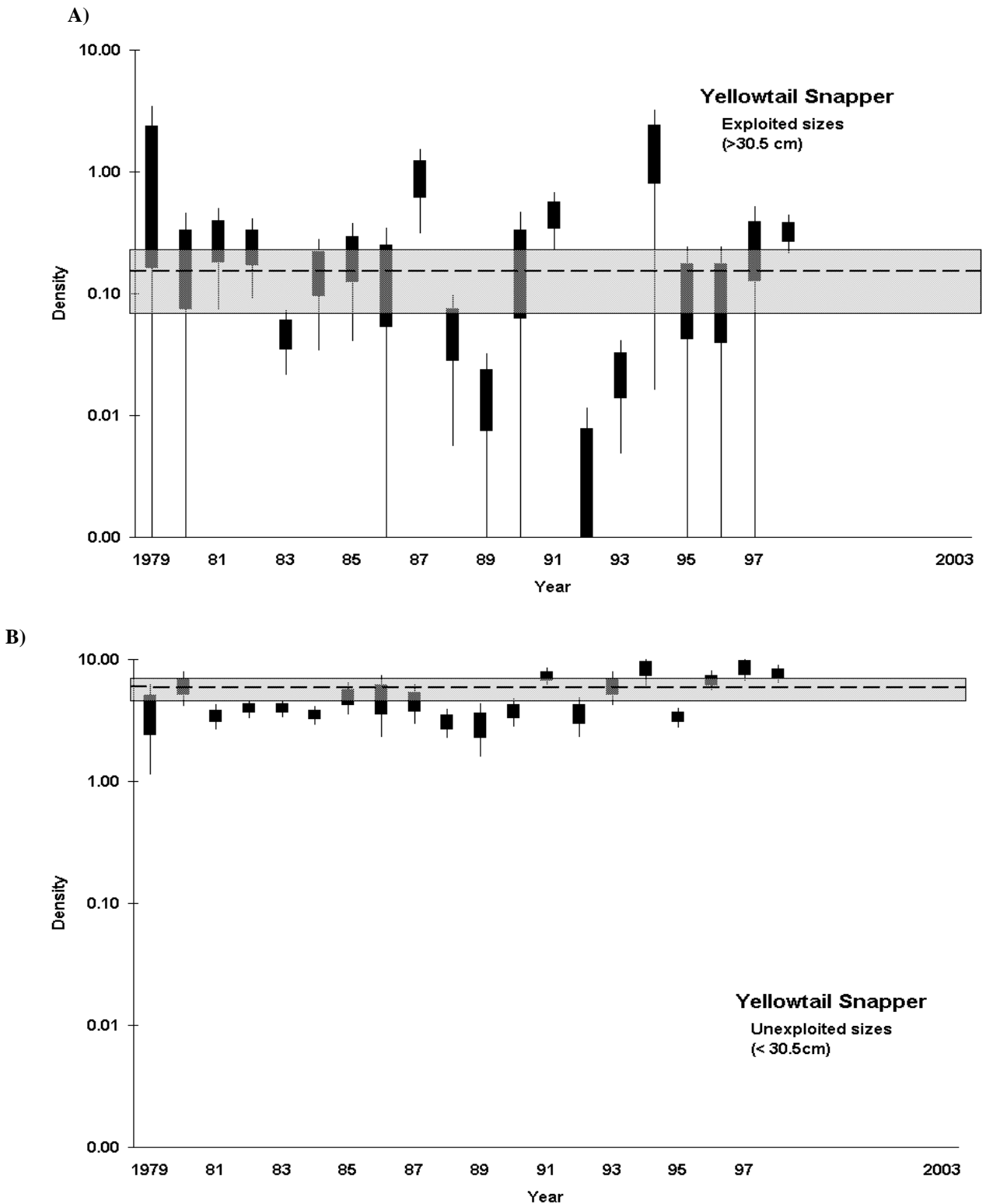


Figure 16. Changes in yellowtail snapper mean density (total number of individuals per sample) for (A) exploitable sizes (≥ 30.5 cm FL) and (B) unexploitable sizes (< 30.5 cm FL) from all sites (1979 - 1998). Vertical lines show annual mean \pm 95% CI. Bars show annual mean \pm 1 SE. Shaded areas show 95% CI for annual means through 1997. Shaded areas are projected beyond 1997 to show predicted performance assuming no changes. Table 1 gives annual sample size.

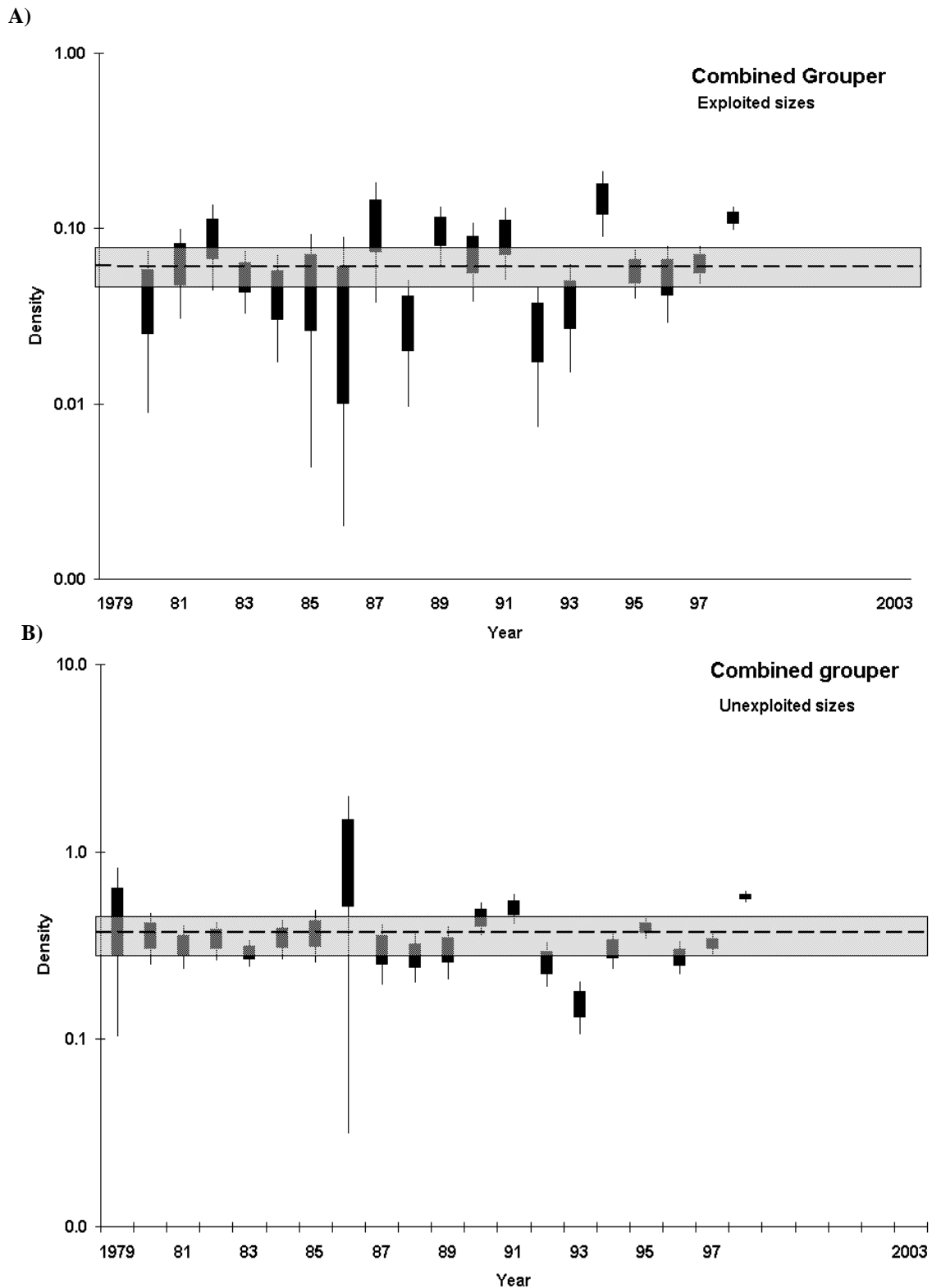


Figure17. Changes in combined grouper mean density (total number of individuals per sample) for (A) exploitable and (B) unexploitable sizes from all sites (1979-1998). Size at first capture varies between species. Vertical lines show annual mean \pm 95% CI. Bars show annual mean \pm 1 SE. Shaded areas show 95% CI for annual means through 1997. Shaded areas are projected beyond 1997 to show predicted performance ranges assuming no changes. Table1 shows annual sample size.

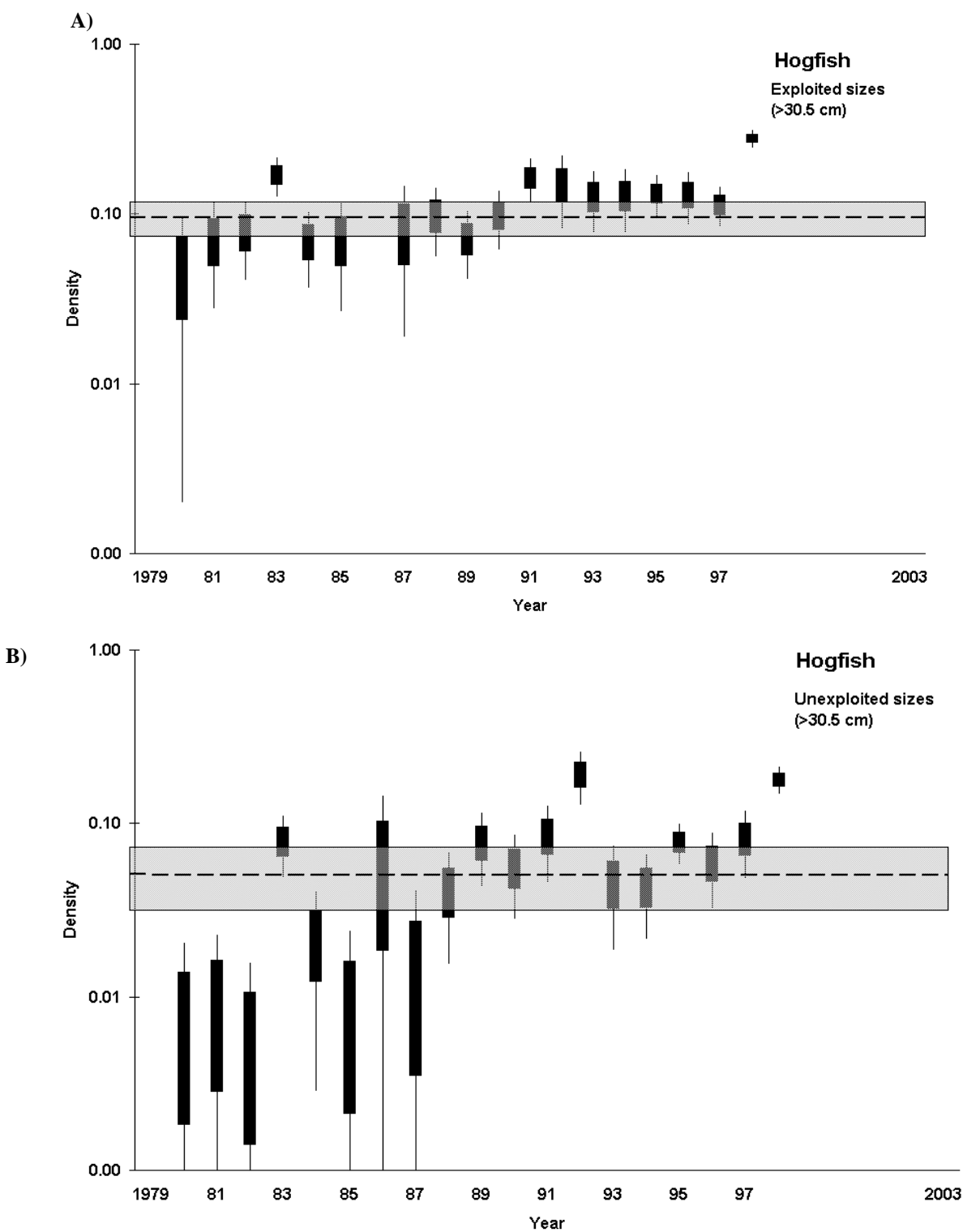


Figure18. Changes in hogfish mean density (total number of individuals per sample) for (A) exploitable sizes (≥ 30.5 cm FL) and (B) unexploitable sizes (< 30.5 cm FL) from all sites (1979 - 1998). Vertical lines show annual mean \pm 95% CI. Bars show annual mean \pm 1 SE. Shaded areas show 95% CI for annual means through 1997. Shaded areas are projected beyond 1997 to show predicted performance ranges assuming no changes. Table 1 gives annual sample size.

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APPENDIX A: List of Abbreviations

BNP	Biscayne National Park
CI	Confidence Interval
DTNP	Dry Tortugas National Park
EEZ	Exclusive Economic Zone
ENP	Everglades National Park
FKNMS	Florida Keys National Marine Sanctuary
FMC	Fishery Management Council
GMFMC	Gulf of Mexico Fishery Management Council
JPSP	John Pennekamp Coral Reef State Park
MER	Marine Ecological Reserve
NURC	National Undersea Research Center
PDT	Plan Development Team (Snapper-Grouper Plan, SAFMC))
SAFMC	South Atlantic Fishery Management Council
SD	Standard Deviation
SE	Standard Error
SFERP	South Florida Ecosystem Restoration Program
USDOC	U.S. Department of Commerce.

Appendix B. Locations of sampled reef site in the FKNMS.

Reef Name	LATITUDE	LONGITUDE
12-12 SAMBOS	24-30.16 N	081-40.37 W
14 SAMBOS	24-29.61 N	081-42.82 W
15-13 SAMBOS	24-29.81 N	081-42.38 W
8 FATHOM ROCK	24-41.98 N	082-59.92 W
ALLIGATOR REEF	24-51.13 N	080-37.11 W
AMERICAN SHOAL	24-31.39 N	081-31.10 W
ANNE'S ANCHORAGE	24-33.03 N	081-42.85 W
BACHE SHOAL	25-29.20 N	080-09.00 W
BASIN HILL - CLOSED	25-12.99 N	080-17.21 W
BASIN HILL - OPEN	25-12.90 N	080-16.79 W
BASIN HILL - OPEN (NEW)	25-12.40 N	080-17.06 W
BIG PINE SHOAL	24-34.21 N	081-19.63 W
BLACK CORAL ROCK	24-41.95 N	083-00.12 W
BNP: AJAX REEF	25-23.70 N	080-07.90 W
BNP: ALINA'S	25-23.10 N	080-09.90 W
BNP: BALL BUOY	25-19.10 N	080-11.00 W
BNP: BREWSTER REEF	25-33.40 N	080-06.10 W
BNP: IGW TRUST	25-20.40 N	080-09.90 W
BNP: MARKER 14	25-27.80 N	080-10.10 W
BNP: NE CORNER REEF	25-37.60 N	080-05.50 W
BNP: PETREL POINT	25-24.70 N	080-11.20 W
BNP: STAR CORAL	25-24.60 N	080-09.10 W
BNP: TRIUMPH REEF	25-28.50 N	080-06.80 W
CARYSFORT REEF	25-13.49 N	080-12.70 W
CARYSFORT SOUTH REEF	25-12.66 N	080-13.20 W
CECILY'S SITE	24-40.43 N	083-01.29 W
CHEECA ROCKS	24-54.30 N	080-37.50 W
COFFIN PATCH	24-40.80 N	080-58.40 W
CONCH REEF	24-57.49 N	080-27.68 W
COSGROVE SHOAL	24-27.51 N	082-11.29 W
CROCKER REEF	24-54.49 N	080-31.51 W
CROSBY'S HUMP	24-32.63 N	082-56.92 W
DAVE'S FINAL FRONTIER	24-35.60 N	082-52.40 W
DAVIS REEF	24-55.36 N	080-30.34 W
DELTA SHOAL	24-37.94 N	081-05.38 W
DEVIL'S REEF	24-26.19 N	081-54.04 W
DOUG'S DEN	24-32.94 N	081-44.61 W
EASTERN DRY ROCKS (FISHED)	24-27.89 N	081-50.25 W
EASTERN DRY ROCKS	24-27.52 N	081-50.67 W
EASTERN SAMBO	24-29.48 N	081-39.84 W
THE ELBOW	25-08.69 N	080-15.53 W
FANTOM REEF	24-40.57 N	083-01.40 W
FOWEY ROCKS	25-35.20 N	080-05.53 W
FRENCH REEF	25-02.17 N	080-21.05 W
FRENCH WRECK	24-37.57 N	082-56.12 W
GARDEN COVE	25-09.27 N	080-17.29 W
GARY'S ANCHOR	24-40.70 N	083-03.83 W
GEORGE'S GORGE	24-39.50 N	082-48.80 W
GEORGE'S ROCK	24-39.62 N	083-00.34 W
GRECIAN ROCKS	25-06.71 N	080-18.18 W
GROUPE SITE	25-42.15 N	080-05.88 W
GUY'S GROTTO	24-37.50 N	082-49.80 W
HANGOVER REEF	24-39.39 N	083-01.92 W
HEN AND CHICKENS	24-55.36 N	080-32.90 W
HUMP 1	24-40.76 N	083-03.50 W
HUMP 2	24-40.76 N	083-03.05 W
HUMP 3	24-40.85 N	083-01.70 W
JOE'S CRACK	24-38.80 N	082-49.60 W
JOE'S HUMP	24-30.46 N	082-52.65 W

Appendix B (cont.)

KEY BISCAYNE SITE	25-39.50 N	080-05.60 W
KEY LARGO DRY ROCKS	25-07.40 N	080-17.85 W
KEY WEST (EASTERN FISHED)	24-33.25 N	081-40.88 W
KEY WEST (INSHORE FISHED)	24-32.15 N	081-47.90 W
KEY WEST (WESTERN FISHED)	24-32.62 N	081-46.56 W
LITTLE AFRICA	24-38.25 N	082-55.33 W
LITTLE BANK	24-43.05 N	082-59.52 W
LOGGERHEAD KEY	24-38.37 N	082-55.93 W
LONG KEY (BIRD KEY)	24-36.71 N	082-52.18 W
LOOE KEY - EAST	24-32.81 N	081-24.26 W
LOOE KEY - WEST	24-32.78 N	081-24.50 W
LOOE KEY - OTHER	24-33.00 N	081-24.00 W
LOOE KEY RESEARCH	24-34.09 N	081-23.11 W
MARKER 56	24-33.23 N	081-41.23 W
MARKER H	24-44.00 N	082-54.00 W
MARQUESAS ROCKS	24-27.53 N	082-12.39 W
MARYLAND SHOAL	24-30.53 N	081-34.42 W
MAVRO VETRANIC	24-42.32 N	082-46.95 W
MIDDLE SAMBO	24-29.27 N	081-40.53 W
MOLASSES REEF	25-00.72 N	080-22.60 W
MOSQUITO BANK - CLOSED	25-04.35 N	080-22.77 W
MOSQUITO BANK - OPEN	25-04.04 N	080-23.40 W
MOSQUITO BANK - OPEN (NEW)	25-04.16 N	080-22.54 W
NEWFOUND HARBOR KEY (FISHED)	24-37.16 N	081-22.87 W
NEWFOUND HARBOR KEY (SPA E)	24-36.90 N	081-23.64 W
NEWFOUND HARBOR KEY (SPA W)	24-36.90 N	081-23.73 W
NO NAME REEF	24-35.55 N	081-13.05 W
PELICAN SHOAL	24-30.10 N	081-37.90 W
PETE'S PINNACLE	24-29.06 N	081-45.41 W
PICKLES REEF	24-59.40 N	080-24.92 W
POTT'S PEAK	24-40.78 N	083-01.06 W
PULASKI SHOAL	24-41.78 N	082-46.23 W
RALPH'S RIDGE	24-40.65 N	083-01.23 W
REPLENISHMENT ZONE	24-28.82 N	082-48.24 W
ROCK KEY	24-27.24 N	081-51.43 W
SAND KEY	24-27.26 N	081-52.65 W
SHERWOOD FOREST	24-42.52 N	083-02.81 W
SOMBRERO KEY	24-37.68 N	081-06.60 W
TENNESSEE REEF (FISHED)	24-44.66 N	080-46.82 W
TENNESSEE REEF (RESEARCH)	24-45.93 N	080-45.39 W
TEXAS ROCK	24-40.87 N	082-53.06 W
TORTUGAS BANK (PINNACLES)	24-39.17 N	083-01.81 W
TORTUGAS BANK SITE11	24-40.20 N	083-03.70 W
TORTUGAS BANK SITE18	24-39.70 N	083-02.50 W
TORTUGAS BANK SITE25	24-37.60 N	083-04.00 W
TORTUGAS BANK SITE51	24-41.06 N	083-01.90 W
TORTUGAS FLAT	24-40.43 N	083-01.29 W
TORTUGAS PARK SITE52	24-38.20 N	082-56.20 W
TORTUGAS PARK SITE82	24-38.10 N	082-55.30 W
TRIANGLES	25-07.07 N	080-24.47 W
TURTLE REEF	25-17.03 N	080-12.36 W
28 FOOT SHOAL	24-25.30 N	082-25.30 W
TWIN PEAKS	24-37.98 N	082-58.01 W
WEST TURTLE SHOAL	24-41.86 N	080-58.17 W
WESTERN DRY ROCKS	24-26.68 N	081-55.57 W
WESTERN SAMBO - EAST	24-28.91 N	081-42.36 W
WESTERN SAMBO - WEST	24-28.86 N	081-42.74 W
WHITE BANK	25-02.38 N	080-22.28 W
WHITE SHOAL	24-38.46 N	082-53.91 W