Essential Fish Habitat and Marine Reserves for Groupers in the Turks & Caicos Islands

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ABSTRACT

There has been much interest recently in the use of marine reserves to conserve fish stocks, particularly those species such as groupers, which are long-lived and slow growing and in many cases aggregate to spawn. Marine reserves may benefit fish stocks in several ways, including protection of spawning stock biomass and the maintenance of undisturbed fish habitat. Studies on the habitat preferences of Turks & Caicos grouper indicate that grouper occupy a wide range of habitats. Coney (*Epinephelus fulvus*) and adult Nassau grouper (*E. striatus*) were most abundant on high-relief shelf-edge bank reefs. Studies of the effects of protection on grouper in the Bahamas, Barbados, Belize, Cuba, the Dominican Republic, and the Florida Keys have shown increased density and biomass of groupers in protected areas. However, recent research in the Turks & Caicos Islands shows no effect of marine reserves on grouper abundance or distribution. Fishing pressure on grouper in the Turks & Caicos Islands may be insufficient to cause differences in density or biomass between fished and protected areas. Several species of grouper, such as Nassau grouper and gag (*Mycteroperca microlepis*) undertake seasonal spawning migrations of up to several hundred kilometers. During these migrations, grouper may leave the boundaries of marine reserves and may be subject to fishing mortality. More information is needed on the habitat preferences and migratory habits of groupers in order to design more effective reserves.

KEY WORDS: Essential fish habitat, grouper, marine reserves

INTRODUCTION

Groupers (Serranidae) are important to both commercial and recreational fisheries. They occur worldwide in warm-temperate to tropical waters, generally associated with hard bottom habitats. The larger groupers (those most targeted by fisheries) are slow-growing, long-lived species with delayed reproduction and reduced spawning periods (Chiappone et al. 2000). Many species are protogynous hermaphrodites that aggregate to spawn (Domeier and Colin 1997). These life history traits render groupers particularly susceptible to overexploitation (Huntsman and Schaaf 1994). Groupers are subject to intense fishing pressure, particularly in

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ii) Sampling effort greatly exceeds the effort scientists and resource agencies would be able to contribute to field research.

Furthermore, the spatial coverage of the volunteer sampling effort is often greater than that of scientists. Volunteer or "citizen" science allows all those who are interested in the resource to contribute to its understanding. Beyond providing valuable data, the increased stewardship that comes from participation is vital to the protection of a resource.

The Reef Environmental Education Foundation (REEF) is a nonprofit organization that educates the public about marine resources and enables divers to participate in long-term monitoring. REEF accomplishes this through its Fish Survey Project, which was developed by REEF with support from The Nature Conservancy (TNC) and guidance by the National Marine Fisheries Service Southeast Fisheries Science Center. The REEF/TNC Fish Survey Project allows volunteer divers and snorkelers to collect and report information on marine fish populations in the tropical western Atlantic and the west coast of the United States and Canada. Volunteers conduct fish surveys during their regular diving and snorkeling activities, and then submit their data to REEF on specially designed computer scantron data sheets. These data sheets are then scanned, and the information is subsequently entered into a database managed by REEF. This database is publicly-accessible via REEF's Website (<http://www.reef.org>), and as of October 1999, contains over 19,000 surveys. A variety of summary reports can be generated from the database over the Internet. REEF also provides datafiles to researchers and agencies upon request.

The REEF/TNC Fish Survey Project and its database are an important source of information for many resource agencies and marine parks, including the Bonaire Marine Park (BMP). Since 1993, the BMP has been the focus of seven REEF field surveys and individual survey effort there has been large. These surveys provide a useful reef fish species inventory, as well as a baseline of information that the BMP can use to enhance park management. In addition, site-specific data provide a tool to evaluate relationships between sites with different physical characteristics and levels of use.

Bonaire, the second largest island of the Netherlands Antilles, is located 100km off the coast of Venezuela. The island is approximately 56km long and 11km wide, and boasts a semi-arid climate. Klein Bonaire is a small, uninhabited island off the leeward (western) coast of Bonaire. The entire coasts of both Bonaire and Klein Bonaire are lined by narrow fringing coral reefs, and a double reef complex is present in most of the southern sites on Bonaire's leeward side (Van Veghel 1997). A sand/coral rubble shelf is present from shore out to the reef crest. Besides salt production and oil storage, tourism related to SCUBA diving is the third largest industry on Bonarie (Dixon et al. 1993). In response to increased use, the BMP was created in the early 1980s to protect the waters surrounding Bonaire and Klein Bonaire from the high water mark to the 200 foot contour. Collecting of any kind while on SCUBA or snorkel is prohibited. Approximately seventy mooring buoys have been installed to minimize anchor damage and an admission use fee for diving

was implemented in 1992. Two marine reserve areas, one adjacent to the Karpata Ecological Centre and one south of Washington Slagbaai National Park, were established as research only sites.

The fishes of Bonaire have not been systematically studied, but J.M. van Rooij and others have conducted a prolific amount of research on parrotfishes (Scaridae). Other reef fish research conducted on Bonaire includes Velde et al. (1990), Nemtzov et al. (1993), Nemtzov (1997), and Wicksten (1998).

This paper presents a description of the fish assemblage of the BMP with preliminary analyses to examine relationships among sites on Bonaire and Klein Bonaire. The utility of REEF as a community-based monitoring program to enhance the management of the BMP is also discussed.

METHODS

Volunteers conduct REEF surveys during organized field surveys or on their own. REEF surveys are conducted using the Roving Diver Technique (RDT) (Schmitt and Sullivan, 1996), a visual survey method developed specifically for volunteer data collection. During RDT surveys, divers swim freely throughout a dive site and record every observed species using waterproof slates and underwater checklists. At the conclusion of each survey, divers assign each recorded species one of four $\log_{10}$ abundance categories [single (1); few (2-10); many (11-100); and abundant (> 100)]. The species data along with survey time, depth, temperature, and other environmental information are then transferred to a REEF scansheet. These sheets are returned to REEF and optically scanned into the database.

The RDT survey data provide species lists, frequency of occurrence, and relative abundance data. Percent sighting frequency (%SF) for each species is the percentage of all dives in which the species was recorded. An estimate of abundance is calculated as:

$$\text{Abundance Score} = D \times \%SF$$

where the density score (D) for each species is a weighted average index based on the frequency of observations in different abundance categories. Density score is calculated as:

$$D = ((n_S x1)+(n_F x2)+(n_M x3)+(n_A x4)) / (n_S + n_F + n_M + n_A),$$

where n_S, n_F, n_M, and n_A represent the number of times each abundance category was assigned for a given species. Data are categorized as expert or novice according to the surveyor's survey experience and performance on a series of identification exams.

A cumulative species list for the BMP was compiled using the expert survey data. However, to capitalize on the power of the large dataset, the %SF and D for each species was calculated using all surveys (expert and novice). Expert sightings

were used to reduce mis-identifications. To compare sites and areas (Bonaire and Klein Bonaire), a two-dimensional MDS ordination plot was produced using Pearson's similarity index. The similarity analysis dataset included sites with more than 20 RDT surveys (37 sites, Figure 1) and was calculated using the log of abundance score for species seen in at least 5% of all surveys (135 species). The species cutoff was used in order to minimize the effect of including rare species in a similarity analysis (Grossman et al. 1982). Analyses were completed with SYSTAT 7.01.

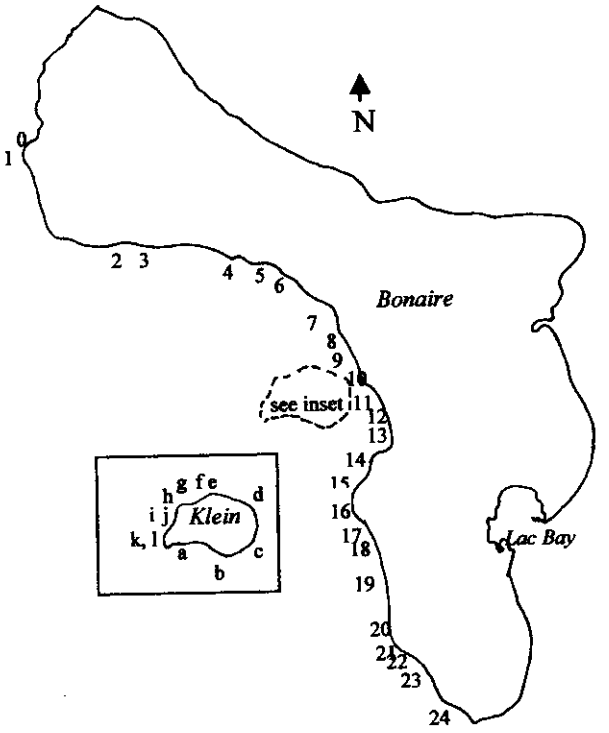

Figure 1. Map of Bonaire with sites used in the similarity analysis shown. 0- Twin Rocks; 1- North Reserve; 2- Karpata Reserve; 3- Karpata Non-Reserve; 4- Ol' Blue; 5- 1000 Steps; 6- Weber's Joy; 7- Small Wall; 8- Cliff; 9- La Machaca; 10- Bari Reef; 11- Something Special; 12- Town Pier; 13- Calabas Reef; 14- 18th Palm; 15- Bachelor's Beach; 16- The Lake; 17- Angel City; 18- Alice in Wonderland; 19- Salt Pier; 20- Invisibles; 21- Tori's Reef; 22- Pink Beach; 23- Margate Bay; 24- Red Slave; a- Forest; b- Bonaventure; c- Just a Nice Dive; d- No Name; e- Sampler; f- Knife; g- Ebo's Special; h- Carl's Hill; i- Carl's Hill Annex; j- Sharon's Serenity; k- Southwest Corner; l- Munk's Haven.

RESULTS

Between December 1993 and July 1999, REEF volunteers conducted 1,557 novice and 457 expert RDT surveys on the reefs of Bonaire and Klein Bonaire, representing 1,937 hours of survey time at 58 sites. A total of 362 species were reported, with 286 of those species reported by REEF experts (Appendix). Volunteers reported 270 species on Bari Reef, the highest species richness of all sites in the REEF database, locally and Caribbean-wide.

The composition of the fish assemblage on Bonaire reefs was similar to that found throughout the southern Caribbean. The five most frequent species sighted were blue tang (*Acanthurus coeruleus*), bicolor damsel (*Stegastes partitus*), stoplight parrotfish (*Sparisoma viride*), brown chromis (*Chromis multilineata*), and bluehead wrasse (*Thalassoma bifasciatum*). The diversity of grunts (Haemulidae) was lower than other Caribbean areas.

According to the MDS plot (Figure 2), the fish assemblages of Bonaire sites were relatively distinct from those on Klein. One notable exception was the grouping of the Karpata Reserve site with the Klein Bonaire sites and the two northern reserve sites as outliers. The Town Pier and La Machaca wreck were also outliers.

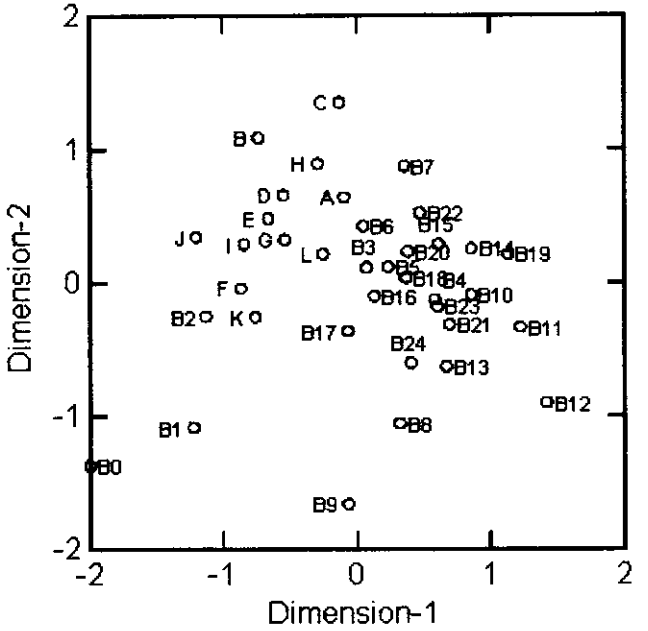

Figure 2. MDS Ordination Plot. Site labels given in Figure 1. Two distinct clusters were revealed, with Klein sites (A-K) in one and most of the Bonaire sites in the other. The Karpata Reserve site (B2) grouped with the Klein cluster. The two northern reserve sites (B0 and B1), La Machaca Wreck (B9) and Town Pier (B12) were outliers.

The overall species composition between Bonaire sites and Klein sites was the same. Species that were the most different by abundance score between Klein and Bonaire included bluestriped grunt (*Haemulon sciurus*), smallmouth grunt (*Haemulon chrysargyreum*), spotted goatfish (*Pseudupeneus maculatus*), and yellowfin mojarra (*Gerres cinereus*), with lower abundance for all species on Klein sites. The reserve sites were characterized by similarly low abundance of these species and slightly higher abundance of the planktivores blue chromis (*Chromis cyanea*), brown chromis (*Chromis multilineata*), and creole wrasse (*Clepticus parrae*). The slippery dick wrasse (*Halichoeres bivittatus*), a species commonly encountered on other Bonaire sites, was rarely seen at the reserve sites.

DISCUSSION

The reefs of Bonaire and Klein Bonaire support a rich fish assemblage, with a diverse array of species. The wide sand shelf, reef ledge, wall, and occasional rocky structures such as jetties and breakwaters provide a wide variety of habitats for reef fish species. Submerged vegetated habitat such as grassbeds and mangroves are only found within Lac Bay. The Bay is an important nursery area, and helps maintain the park's reef fish diversity (Velde et al. 1990). The lack of grassbeds adjacent to the reefs, however, has led to a lower diversity and abundance of grunts (Haemulidae) in the BMP as compared with other Caribbean reefs, and this is due to the use of grassbeds by grunts during nocturnal feeding.

Results of the ordination analysis suggest that the composition of fish assemblages of Bonaire and Klein Bonaire are distinct from each other. It is clear that the overall fish assemblage composition is similar, and that certain components of the assemblage are driving the ordination pattern. The low average abundance of bluestriped grunt and smallmouth grunt on Klein sites is most likely an important factor. It is assumed that this is also responsible for the separation of the reserve sites from other Bonaire sites. Another distinction between Klein and reserve sites from Bonaire sites is their lack of a wide sand shelf, and this was reflected in the low abundance of spotted goat, yellowfin mojarra, and slippery dick, all species that primarily utilize the sand habitat. The reserve sites are further distinguished by high wave action and currents, leading to large schools of planktivores.

The two outliers, Town Pier and La Machaca wreck, are both artificial structures and the pier is mostly surveyed during dusk. Given these factors, their distinction from the main groupings is obvious.

The MDS analysis is a useful tool to graphically examine the overall similarity among sites and identify major groups. However, to compare sites within the groups, further analysis is needed to generate sufficient resolution. It is expected that differences between sites in each group is the result of a variety of factors. The double reef system present at many of the sites on the southern end of Bonaire most likely influences the local fish assemblage. The distance of B17 (Angel City), which has a double reef, from the main Bonaire grouping (Figure 2) suggests that this is the case. A site's location in reference to prevailing current and wind regimes

should also affect the resident fishes. The level of use a site gets and its proximity to resorts and other development should be considered. For example, fish feeding by divers is illegal within the BMP, but many seaside restaurants discard leftovers in the water. Additional factors that may drive differences between sites include the width of the sand shelf and the presence and density of octocorals in the shallow area of a reef. The factors listed above can be used in concert with REEF data in a multi-variate analysis to further investigate site-specific differences in fish assemblage composition.

The large survey effort by volunteers on the reefs of the BMP is undeniably a valuable resource to park management. The question is how to use this information. As illustrated here, a large number of volunteer surveys can produce a relatively complete taxonomic list for an area. Survey data collected in a consistent manor at a number of sites can also provide a means for site characterization. Beyond similarity analyses, trophic patterns and fish-habitat interactions can also be investigated (Jeffrey and Pattengill-Semmens, in prep.). The continual nature of volunteer data can also provide a valuable dataset to document change over time. In addition to long-term monitoring, REEF data can be used in management decisions, such as in siting algorithms for marine reserves (Schmitt et al. in press) or to assess the impact of disturbance events or management strategies such as harvest restrictions (Pattengill-Semmens and Semmens 1999).

One issue of particular concern for the BMP is the level of use by divers and how that use affects the overall condition of the reef. The reserves, which restrict recreational SCUBA diving, can be a way to look at this. The dissimilarity of the Bonaire reserve sites from other areas on Bonaire suggests that either the sites are different or that the level of use at other Bonaire sites has influenced their structure. The location of both reserves on the northern portion of the leeward side, an area subject to greater wind and waves, could be one factor driving this difference. Further analysis and research, along with historical data, will be needed to more fully understand the differences.

The use of volunteer-generated data requires that consideration be given to the wide variety of surveyor skill levels. It has been shown that for a given number of surveys, experts generate more precise data (Pattengill-Semmens and Semmens 1998). However, it is also important to note that the power of non-expert data often exceeds expert data at survey sites, because of differences in sampling effort. The statistical power to detect change increases as sample size increases, and the power of non-expert data has been shown to be comparable to or better than that generated by a smaller group of experts for most species (Pattengill-Semmens and Semmens 1998). Confidence in data used from the REEF database can be increased by selecting a sighting frequency cut-off (i.e. only using information for species seen in more than a given percentage of surveys) or by selectively using data from REEF members with more experience and skill.

The use of REEF Fish Survey Project data to describe the fish assemblages of the BMP is a significant step toward better understanding the park's resources. The species list generated here is the most complete set of information to date at the fish

assemblage level. Further analyses on the data should be initiated to investigate site-specific differences. Additionally, the dataset can complement scientific research and other park monitoring efforts. Volunteer-generated data such as those in the REEF program are a valuable element to resource managers, and can enhance the management and protection of a marine resource.

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Appendix. Species list for REEF surveys from Bonaire and Klein Bonaire. Species reported by experts were used to compile the list, but values given are based on all REEF surveys (novice and expert). Data given are sighting frequency (%SF) and density score (den).

Common Name	Species	%SF	Den
Angelfishes	*Pomacanthidae*		
Cherubfish	*Centropyge argi*	7%	1.6
Flameback Angelfish	*Centropyge aurantonotus*	0%	1.7
Blue Angelfish	*Holacanthus bermudensis*	1%	1.8
Queen Angelfish	*Holacanthus ciliaris*	42%	1.5
Rock Beauty	*Holacanthus tricolor*	86%	2.1
Gray Angelfish	*Pomacanthus arcuatus*	3%	1.4
French Angelfish	*Pomacanthus paru*	57%	1.6
Barracudas	*Sphyraenidae*		
Great Barracuda	*Sphyraena barracuda*	21%	1.4
Southern Sennet	*Sphyraena picudilla*	1%	1.9
Bigeyes	*Priacanthidae*		
Bigeye	*Priacanthus arenatus*	1%	1.5
Glasseye Snapper	*Priacanthus cruentatus*	10%	1.3
Blennies (Clinids)	*Clinidae*		
Roughhead Blenny	*Acanthemblemaria aspera*	1%	1.8
Secretary Blenny	*Acanthemblemaria maria*	29%	2.2
Spinyhead Blenny	*Acanthemblemaria spinosa*	10%	1.9
Yellowface Pikeblenny	*Chaenopsis limbaughi*	1%	1.3
Blackhead Blenny	*Coralliozetus bahamensis*	7%	1.5
Sailfin Blenny	*Emblemaria pandionis*	6%	1.5
Lofty Triplefin	*Enneanectes altivelis*	3%	1.3
Blackedge Triplefin	*Enneanectes atrorus*	0%	1
Mimic Triplefin	*Enneanectes jordani*	0%	2
Redeye Triplefin	*Enneanectes pectoralis*	1%	1.4
Puffcheek Blenny	*Labrisomus bucciferus*	0%	1
Downy Blenny	*Labrisomus kalisherae*	0%	1
Hairy Blenny	*Labrisomus nuchipinnis*	3%	1.2
Goldline Blenny	*Malacoctenus aurolineatus*	1%	1.6
Dusky Blenny	*Malacoctenus gilli*	1%	1.2
Rosy Blenny	*Malacoctenus macropus*	1%	1.8
Saddled Blenny	*Malacoctenus triangulatus*	13%	1.8
Ringed Blenny	*Starksia hassi*	0%	1.1
Dwarf Blenny	*Starksia nanodes*	3%	1.2
Blennies (Combtooth)	*Blenniidae*		
Barred Blenny	*Hypleurochilus bermudensis*	1%	1.6
Tesselated Blenny	*Hypsoblennius invemar*	0%	1
Redlip Blenny	*Ophioblennius atlanticus*	41%	2.2
Seaweed Blenny	*Parablennius marmoreus*	3%	1.8
Molly Miller	*Scartella cristata*	1%	1.8
Bonefish	*Albulidae*		
Bonefish	*Albula vulpes*	12%	2.2
Bonnetmouths	*Inermiidae*		
Boga	*Inermia vittata*	18%	3.5
Bonnetmouth	*Emmelichthyops atlanticus*	2%	3
Boxfishes	*Ostraciontidae*		
Spotted Trunkfish	*Lactophrys bicaudalis*	47%	1.6
Honeycomb Cowfish	*Lactophrys polygonia*	47%	1.4

Appendix. Continued.

Common Name	Species	%SF (%)	Den
Scrawled Cowfish	Lactophrys quadricornis	4%	1.3
Trunkfish	Lactophrys trigonus	1%	2
Smooth Trunkfish	Lactophrys triqueter	80%	2
Brotula	Bythitidae		
Black Brotula	Stygnobrotula latebricola	0%	1
Butterflyfishes	Chaetondontidae		
Longsnout Butterflyfish	Chaetodon aculeatus	27%	1.4
Foureye Butterflyfish	Chaetodon capistratus	91%	2.3
Spotfin Butterflyfish	Chaetodon ocellatus	10%	1.9
Reef Butterflyfish	Chaetodon sedentarius	2%	1.7
Banded Butterflyfish	Chaetodon striatus	66%	2
Cardinalfishes	Apogonidae		
Bigtooth Cardinalfish	Apogon affinis	0%	2.3
Barred Cardinalfish	Apogon binotatus	18%	2.1
Whitestar Cardinalfish	Apogon lachneri	16%	1.9
Flamefish	Apogon maculatus	12%	1.8
Pale Cardinalfish	Apogon planifrons	2%	1.8
Twospot Cardinalfish	Apogon pseudomaculatus	2%	1.8
Sawcheek Cardinalfish	Apogon quadrisquamatus	0%	1.6
Belted Cardinalfish	Apogon townsendi	25%	2.1
Dusky Cardinalfish	Phaeoptyx pigmentaria	3%	1.9
Sponge Cardinalfish	Phaeoptyx xenus	9%	1.6
Clingfish	Gobiesocidae		
Barred Clingfish	Tomicodon fasciatus	0%	1
Red Clingfish	Arcos rubiginosus	2%	1.6
Cornetfishes	Fistulariidae		
Bluespotted Cornetfish	Fistularia tabacaria	4%	1.2
Chubs	Kyphosidae		
Bermuda/Yellow Chub	Kyphosus sectatrix/incisor	23%	1.9
Damselfishes	Pomacentridae		
Sergeant Major	Abudefduf saxatilis	86%	2.8
Night Sergeant	Abudefduf taurus	5%	1.8
Blue Chromis	Chromis cyanea	91%	3.6
Sunshinefish	Chromis insolata	5%	1.8
Brown Chromis	Chromis multilineata	91%	3.8
Yellowtail Damselfish	Microspathodon chrysurus	83%	2.4
Longfin Damselfish	Stegastes diencaeus	48%	2.5
Dusky Damselfish	Stegastes fuscus	41%	2.3
Beaugregory	Stegastes leucostictus	15%	2
Bicolor Damselfish	Stegastes partitus	93%	3.6
Threespot Damselfish	Stegastes planifrons	77%	3
Cocoa Damselfish	Stegastes variabilis	26%	2.3
Drums	Sciaenidae		
Highhat	Equetus acuminatus	2%	1.2
Jackknife-Fish	Equetus lanceolatus	1%	1.1
Spotted Drum	Equetus punctatus	46%	1.5
Reef Croaker	Odontoscion dentex	0%	2
Eels (Conger)	Congridae		
Brown Garden Eel	Heteroconger halis	6%	3.1
Eels (Moray)	Muranidae		
Chain Moray	Echidna catenata	6%	1.2
Chestnut Moray	Enchelycore carychroa	1%	1

Appendix. Continued.

Common Name	Species	%SF (%)	Den
Viper Moray	*Enchelycore nigricans*	1%	1.1
Green Moray	*Gymnothorax funebris*	5%	1.1
Goldentail Moray	*Gymnothorax miliaris*	22%	1.3
Spotted Moray	*Gymnothorax moringa*	35%	1.4
Purplemouth Moray	*Gymnothorax vicinus*	2%	1.1
Reticulate Moray	*Muraena retifera*	0%	1
Eels (Snake)	*Ophichthidae*		
Spotted Spoon-nose Eel	*Echiophis intertinctus*	0%	1
Sharptail Eel	*Myrichthys breviceps*	16%	1.2
Goldspotted Eel	*Myrichthys ocellatus*	1%	1.3
Spotted Snake Eel	*Ophichthus ophis*	1%	1.1
Frogfishes	*Antennariidae*		
Longlure Frogfish	*Antennarius multiocellatus*	3%	1.2
Goatfishes	*Mullidae*		
Yellow Goatfish	*Mulloidichthys martinicus*	88%	2.9
Spotted Goatfish	*Pseudupeneus maculatus*	37%	2
Gobies	*Gobiidae*		
Colon Goby	*Coryphopterus dicrus*	14%	2
Pallid Goby	*Coryphopterus eidolon*	27%	2.2
Bridled Goby	*Coryphopterus glaucofraenum*	60%	3.1
Peppermint Goby	*Coryphopterus lipernes*	45%	2.4
Masked Goby/Glass Goby	*Coryphopterus personatus/hyalinus*	60%	3.7
Spotted Goby	*Coryphopterus punctipectophorus*	0%	2
Nineline Goby	*Ginsburgellus novemlineatus*	0%	1.5
Goldspot Goby	*Gnatholepis thompsoni*	35%	2.5
Dash Goby	*Gobionellus saepepallens*	2%	1.8
Shortstripe Goby	*Gobiosoma chancei*	8%	1.9
Orangesided Goby	*Gobiosoma dilepsis*	10%	1.4
Sharknose Goby	*Gobiosoma evelynae*	24%	2
Cleaning Goby	*Gobiosoma genie*	5%	2
Yellowline Goby	*Gobiosoma horsti*	20%	2
Spotlight Goby	*Gobiosoma louisae*	7%	1.7
Tiger Goby	*Gobiosoma macrodon*	1%	1.3
Broadstripe Goby	*Gobiosoma prochilos*	1%	1.8
Yellownose Goby	*Gobiosoma randalli*	24%	2
Slaty Goby	*Gobiosoma tenox*	0%	1.2
Yellowprow Goby	*Gobiosoma xanthiprora*	1%	1.7
Hovering Goby	*Ioglossus helenae*	1%	1.8
Island Goby	*Lythrypnus nesiotes*	1%	1.5
Orangespotted Goby	*Nes longus*	0%	2
Rusty Goby	*Priolepis hipoliti*	4%	1.2
Grunts	*Haemulidae*		
Black Margate	*Anisotremus surinamensis*	17%	1.6
Tomtate	*Haemulon aurolineatum*	2%	2.4
Caesar Grunt	*Haemulon carbonarium*	22%	1.6
Smallmouth Grunt	*Haemulon chrysargyreum*	34%	2.7
French Grunt	*Haemulon flavolineatum*	88%	2.4
Spanish Grunt	*Haemulon macrostomum*	5%	1.6
Cottonwick	*Haemulon melanurum*	1%	2.2
Sailors Choice	*Haemulon parra*	6%	1.8
Bluestriped Grunt	*Haemulon sciurus*	53%	1.9

Appendix. Continued.

Common Name	Species	%SF (%)	Den
Striped Grunt	*Haemulon striatum*	2%	2.5
Hawkfishes	*Cirrhitidae*		
Redspotted Hawkfish	*Amblycirrhitus pinos*	32%	1.7
Jacks	*Carangidae*		
Yellow Jack	*Caranx bartholomaei*	2%	2.1
Blue Runner	*Caranx crysos*	0%	2
Crevalle Jack	*Caranx hippos*	2%	1.7
Horse-Eye Jack	*Caranx latus*	25%	2.1
Black Jack	*Caranx lugubris*	1%	1.6
Bar Jack	*Caranx ruber*	80%	2.2
Mackerel Scad	*Decapterus macarellus*	3%	3.3
Round Scad	*Decapterus punctatus*	1%	3.4
Irish Pompano	*Diapterus olisthostomus*	0%	1.6
Rainbow Runner	*Elagatis bipinnulata*	1%	1.8
Spanish Mackerel	*Scomberomorus maculatus*	0%	2
Cero	*Scomberomorus regalis*	2%	1.7
Bigeye Scad	*Selar crumenophthalmus*	0%	3.6
Permit	*Trachinotus falcatus*	2%	1.5
Palometa	*Trachinotus goodei*	6%	2.1
Jawfishes	*Opistognathidae*		
Yellowhead Jawfish	*Opistognathus aurifrons*	11%	1.7
Leatherjackets	*Balistidae*		
Orange Filefish	*Aluterus schoepfi*	2%	1.7
Scrawled Filefish	*Aluterus scriptus*	20%	1.3
Queen Triggerfish	*Balistes vetula*	3%	1.3
Whitespotted Filefish	*Cantherhines macrocerus*	43%	1.5
Orangespotted Filefish	*Cantherhines pullus*	46%	1.6
Ocean Triggerfish	*Canthidermis sufflamen*	2%	1.5
Black Durgon	*Melichthys niger*	37%	2.3
Pygmy Filefish	*Monacanthus setifer*	0%	1.7
Slender Filefish	*Monacanthus tuckeri*	13%	1.4
Lefteye Flounders	*Bothidae*		
Peacock Flounder	*Bothus lunatus*	24%	1.3
Eyed Flounder	*Bothus ocellatus*	4%	1.3
Lizzardfishes	*Synodotidae*		
Sand Diver	*Synodus intermedius*	37%	1.5
Bluestriped Lizardfish	*Synodus saurus*	1%	1.4
Red Lizardfish	*Synodus synodus*	1%	1.3
Snakefish	*Trachinocephalus myops*	0%	1.2
Mojarra	*Gerreidae*		
Spotfin Mojarra	*Eucinostomus argenteus*	0%	1.3
Slender Mojarra	*Eucinostomus jonesi*	2%	2.1
Mottled Mojarra	*Eucinostomus lefroyi*	9%	2.1
Flagfin Mojarra	*Eucinostomus melanopterus*	4%	2
Yellowfin Mojarra	*Gerres cinereus*	45%	2.1
Mullets	*Mugilidae*		
White Mullet	*Mugil curema*	7%	2.2
Needlefishes	*Belonidae*		
Flat Needlefish	*Ablennes hians*	1%	1.8
Keeltail Needlefish	*Platybelone argalus*	3%	2.3
Atlantic Needlefish	*Strongylura marina*	0%	3
Redfin Needlefish	*Strongylura notata*	0%	2.5

Appendix. Continued.

Common Name	Species	%SF (%)	Den
Houndfish	*Tylosurus crocodilus*	4%	2.3
Parrotfishes	*Scaridae*		
Midnight Parrotfish	*Scarus coelestinus*	9%	1.4
Blue Parrotfish	*Scarus coeruleus*	7%	1.5
Striped Parrotfish	*Scarus croicensis*	45%	2.2
Rainbow Parrotfish	*Scarus guacamaia*	13%	1.7
Princess Parrotfish	*Scarus taeniopterus*	82%	2.5
Queen Parrotfish	*Scarus vetula*	77%	2.5
Greenblotch Parrotfish	*Sparisoma atomarium*	2%	1.6
Redband Parrotfish	*Sparisoma aurofrenatum*	72%	2.4
Redtail Parrotfish	*Sparisoma chrysopterum*	28%	1.8
Bucktooth Parrotfish	*Sparisoma radians*	2%	2.2
Redfin Parrotfish	*Sparisoma rubripinne*	28%	1.8
Stoplight Parrotfish	*Sparisoma viride*	93%	2.7
Pipefishes	*Syngnathidae*		
Harlequin Pipefish	*Micrognathus ensenadae*	1%	1
Longsnout Seahorse	*Hippocampus reidi*	3%	1.3
Shortfin Pipefish	*Cosmocampus elucens*	0%	1
Porgies	*Sparidae*		
Jolthead Porgy	*Calamus bajonado*	5%	1.2
Saucereye Porgy	*Calamus calamus*	7%	1.4
Sheepshead Porgy	*Calamus penna*	0%	1
Silver Porgy	*Diplodus argenteus*	2%	1
Puffers	*Tetradontidae*		
Sharpnose Puffer	*Canthigaster rostrata*	76%	2.3
Bridled Burrfish	*Chilomycterus antennatus*	0%	1.9
Web Burrfish	*Chilomycterus antillarum*	1%	1.2
Balloonfish	*Diodon holocanthus*	40%	1.8
Porcupinefish	*Diodon hystrix*	16%	1.2
Bandtail Puffer	*Sphoeroides spengleri*	3%	1.9
Rays (Eagle)	*Myliobatidae*		
Spotted Eagle Ray	*Aetobatus narinari*	1%	1.1
Rays (Stingray)	*Dasyatidae*		
Southern Stingray	*Dasyatis americana*	2%	1.1
Remoras	*Echeneididae*		
Sharksucker	*Echeneis naucrates*	1%	1.3
Sea Basses	*Serranidae*		
Sand Perch	*Diplectrum formosum*	0%	2
Rock Hind	*Epinephelus adscensionis*	22%	1.4
Graysby	*Epinephelus cruentatus*	82%	2.2
Coney	*Epinephelus fulvus*	59%	2
Red Hind	*Epinephelus guttatus*	15%	1.6
Marbled Grouper	*Epinephelus inermis*	0%	4
Red Grouper	*Epinephelus morio*	0%	1.6
Nassau Grouper	*Epinephelus striatus*	2%	1.3
Yellowcheek Basslet	*Gramma linki*	0%	2.5
Fairy Basslet	*Gramma loreto*	83%	3.1
Blackcap Basslet	*Gramma melacara*	2%	2.8
Hybrid Hamlet	*Hypoplectrus (Hybrid)*	6%	1.2
Yellowbelly Hamlet	*Hypoplectrus aberrans*	2%	1.1
Yellowtail Hamlet	*Hypoplectrus chlorurus*	44%	1.7
Blue Hamlet	*Hypoplectrus gemma*	0%	2

Appendix. Continued.

Common Name	Species	%SF (%)	Den
Golden Hamlet	*Hypoplectrus gummigutta*	0%	1.3
Shy Hamlet	*Hypoplectrus guttavarius*	0%	1.2
Black Hamlet	*Hypoplectrus nigricans*	5%	1.3
Barred Hamlet	*Hypoplectrus puella*	45%	1.6
Masked Hamlet	*Hypoplectrus sp.*	0%	1.8
Tan Hamlet	*Hypoplectrus sp.*	1%	1.2
Butter Hamlet	*Hypoplectrus unicolor*	38%	1.5
Threeline Basslet	*Lipogramma trilineatum*	4%	1.4
Candy Bass	*Liopropoma carmabi*	1%	1.1
Cave Bass	*Liopropoma mowbrayi*	0%	1.1
Peppermint Bass	*Liopropoma rubre*	14%	1.5
Black Grouper	*Mycteroperca bonaci*	4%	1.5
Yellowmouth Grouper	*Mycteroperca interstitialis*	6%	1.2
Comb Grouper	*Mycteroperca rubra*	5%	1.2
Tiger Grouper	*Mycteroperca tigris*	55%	1.6
Yellowfin Grouper	*Mycteroperca venenosa*	4%	1.1
Creole-fish	*Paranthias furcifer*	63%	2.8
Lantern Bass	*Serranus baldwini*	10%	1.6
Tobaccofish	*Serranus tabacarius*	16%	1.7
Harlequin Bass	*Serranus tigrinus*	80%	2.3
School Bass	*Shultzea beta*	4%	2.9
Scorpionfishes	*Scorpionidae*		
Reef Scorpionfish	*Scorpaenodes caribbaeus*	3%	1.4
Spotted Scorpionfish	*Scorpaena plumieri*	19%	1.2
Mushroom Scorpionfish	*Scorpaena inermis*	0%	1
Sharks (Requeim)	*Carcharhinidae*		
Reef Shark	*Carcharhinus perezi*	0%	1
Blackfin Snapper	*Lutjanus buccanella*	1%	2.7
Sharks (Nurse)	*Orectolobidae*		
Nurse Shark	*Ginglymostoma cirratum*	1%	1.2
Snappers	*Lutjanidae*		
Mutton Snapper	*Lutjanus analis*	3%	1.6
Schoolmaster	*Lutjanus apodus*	83%	2.3
Cubera Snapper	*Lutjanus cyanopterus*	4%	1.5
Gray Snapper	*Lutjanus griseus*	21%	2.3
Dog Snapper	*Lutjanus jocu*	2%	1.8
Mahogany Snapper	*Lutjanus mahogoni*	69%	2.2
Lane Snapper	*Lutjanus synagris*	1%	2.3
Yellowtail Snapper	*Ocyurus chrysurus*	83%	2.6
Snook	*Centropomidae*		
Common Snook	*Centropomus undecimalis*	4%	1.7
Soapfishes	*Grammistidae*		
Whitespotted Soapfish	*Rypticus maculatus*	0%	1
Greater Soapfish	*Rypticus saponaceus*	31%	1.5
Spotted Soapfish	*Rypticus subbifrenatus*	3%	1.4
Squirrelfishes	*Holocentridae*		
Squirrelfish	*Holocentrus adscensionis*	26%	1.7
Reef Squirrelfish	*Holocentrus coruscum*	5%	1.7
Longjaw Squirrelfish	*Holocentrus marianus*	38%	1.7
Longspine Squirrelfish	*Holocentrus rufus*	34%	1.7
Dusky Squirrelfish	*Holocentrus vexillarius*	14%	1.7
Blackbar Soldierfish	*Myripristis jacobus*	82%	2.5

Appendix. Continued.

Common Name	Species	%SF (%)	Den
Cardinal Soldierfish	*Plectrypops retrospinis*	4%	1.2
Surgonfishes	*Acanthuridae*		
Ocean Surgeonfish	*Acanthurus bahianus*	75%	2.6
Doctorfish	*Acanthurus chirurgus*	45%	2.1
Blue Tang	*Acanthurus coeruleus*	93%	2.9
Sweepers	*Pempheridae*		
Shortfin Sweeper	*Pempheris poeyi*	1%	2.9
Glassy Sweeper	*Pempheris schomburgki*	3%	2.2
Tarpon	*Elopidae*		
Tarpon	*Megalops atlanticus*	8%	1.7
Tilefishes	*Matacanthidae*		
Sand Tilefish	*Malacanthus plumieri*	3%	1.5
Trumpetfishes	*Aulostomidae*		
Trumpetfish	*Aulostomus maculatus*	92%	2.2
Wrassess	*Labridae*		
Spotfin Hogfish	*Bodianus pulchellus*	2%	2
Spanish Hogfish	*Bodianus rufus*	81%	2.2
Creole Wrasse	*Clepticus parrae*	77%	3.4
Slippery Dick	*Halichoeres bivittatus*	51%	2.8
Yellowhead Wrasse	*Halichoeres garnoti*	85%	3
Clown Wrasse	*Halichoeres maculipinna*	40%	2.3
Rainbow Wrasse	*Halichoeres pictus*	29%	2.4
Blackear Wrasse	*Halichoeres poeyi*	1%	2.1
Puddingwife	*Halichoeres radiatus*	40%	1.9
Rosy Razorfish	*Hemipteronotus martinicensis*	6%	2.1
Pearly Razorfish	*Hemipteronotus novacula*	2%	1.8
Green Razorfish	*Hemipteronotus splendens*	7%	1.6
Hogfish	*Lachnolaimus maximus*	5%	1.9
Bluehead	*Thalassoma bifasciatum*	89%	3.2
TOTAL # SPECIES	284		