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Distribution and Sighting Frequency of Reef Fishes in the Florida Keys National Marine Sanctuary

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DISTRIBUTION AND SIGHTING FREQUENCY OF REEF FISHES IN THE FLORIDA KEYS NATIONAL MARINE SANCTUARY

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ABSTRACT

This study analyzed species richness, distribution, and sighting frequency of selected reef fishes to describe species assemblage composition, abundance, and spatial distribution patterns among sites and regions (Upper Keys, Middle Keys, Lower Keys, and Dry Tortugas) within the Florida Keys National Marine Sanctuary (FKNMS) barrier reef ecosystem. Data were obtained from the Reef Environmental Education Foundation (REEF) Fish Survey Project, a volunteer fish-monitoring program. A total of 4,324 visual fish surveys conducted at 112 sites throughout the FKNMS were used in these analyses. The data set contained sighting information on 341 fish species comprising 68 families. Species richness was generally highest in the Upper Keys sites (maximum was 220 species at Molasses Reef) and lowest in the Dry Tortugas sites. Encounter rates differed among regions, with the Dry Tortugas having the highest rate, potentially a result of differences in the evenness in fishes and the lower diversity of habitat types in the Dry Tortugas region. Geographic coverage maps were developed for 29 frequently observed species. Fourteen of these species showed significant regional variation in mean sighting frequency (%SF). Six species had significantly lower mean %SF and eight species had significantly higher mean %SF in the Dry Tortugas compared with other regions. Hierarchical clustering based on species composition (presence-absence) and species % SF revealed interesting patterns of similarities among sites that varied across spatial scales. Results presented here indicate that phenomena affecting reef fish composition in the FKNMS operate at multiple spatial scales, including a biogeographic scale that defines the character of the region as a whole, a reef scale (~50-100 km) that include meso-scale physical oceanographic processes and regional variation in reef structure and associated reef habitats, and a local scale that includes level of protection, cross-shelf location and a suite of physical characteristics of a given reef. It is likely that at both regional and local scales, species habitat requirements strongly influence the patterns revealed in this study, and are particularly limiting for species that are less frequently observed in the Dry Tortugas. The results of this report serve as a benchmark for the current status of the reef fishes in the FKNMS. In addition, these data provide the basis for analyses on reserve effects and the biogeographic coupling of benthic habitats and fish assemblages that are currently underway.

Key Words: Florida Keys National Marine Sanctuary, biogeography, distribution, reef fish, volunteer data, Reef Environmental Education Foundation

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Reef fish communities are a major component of tropical and sub tropical fish faunas. Fishes dominate the top of coral reef food webs and play an important role as herbivores, and their presence and abundance reflect the overall condition of an area (Ogden and Lobel, 1978). Reef fishes also support important commercial and recreational fisheries, and because these fishes represent a large proportion of the biomass in coastal environments, intense fishing pressure may have significant effects on ecosystem processes (Richards and Lindeman, 1987).

It is generally accepted that reef fishery resources of the Florida Keys are highly stressed, and increased documentation of declining fisheries and marine environments has prompted the use of no-take marine reserves to protect these important resources (Bohnsack and Ault, 1996; NOAA, 1996; Allison et al., 1998; Ault et al., 1998). Additionally, the 1990 amendment of the Magnuson Fishery Conservation and Management Act (H.R. 2061) has increased focus on habitat protection within the United States coastal waters.

Implementing marine protected areas to enhance fishery resources (e.g. increase biomass) requires an understanding of the complex interactions among several physical and biological factors (e.g., ocean currents, habitat distribution, and reproductive behavior) that determine broad-scale patterns of fish abundance and distribution. Specifically, resource managers need a better understanding of the natural spatial and temporal variability exhibited by marine populations as well as the ecological relationships among ecosystems, habitats, and the living resources they contain. Reef fish populations and assemblages often vary greatly among habitat patches at varying scales such as physiographic reef zones or reef types (Williams, 1991). Thus, designing effective monitoring or resource management programs requires an understanding of a population's spatial and temporal patterns of distribution.

This report describes the reef fish assemblage composition, abundance, and spatial distribution patterns within the Florida Keys National Marine Sanctuary (FKNMS) barrier reef ecosystem. It is the first part of a larger project, and provides the basis for future analyses of reserve effects and biogeographic coupling of benthic habitats and fish assemblages. Data were obtained from the Reef Environmental Education Foundation (REEF) Fish Survey Project, a volunteer fish-monitoring program (REEF 2000).

The specific objectives of this report are as follows:

1. Provide fish species composition of the FKNMS;
2. Describe the diversity and distribution of reef fishes in the FKNMS; and
3. Compare the species richness, distribution, and relative abundance of selected species and families among sites and regions in the FKNMS.

PROJECT OVERVIEW

In 1999, the Biogeography Program of the National Oceanic and Atmospheric Administration (NOAA) initiated a joint project with the NOAA's Marine Sanctuaries Division (MSD) and the Reef Environmental Education Foundation (REEF). The project's goal was to describe the distribution and abundance of reef fishes in the FKNMS, and to use that information to evaluate fish-habitat interactions and the performance of management zones.

The Biogeography Program within the Center for Coastal Monitoring and Assessment (CCMA) was established to develop a knowledge base of living marine resource distributions and ecology throughout the Nation's estuarine and coastal environments and to provide resource managers with an improved ecosystem basis for decision-making. The program integrates information on the distribution and abundance of species, distribution of habitats, and defines the strength of species-habitat associations using a suite of technologies including GIS and modeling tools. The program's goal is to provide resource managers with a variety of tools to successfully manage living resources.

In November 1990, the United States Congress passed the Florida Keys National Marine Sanctuary and Protection Act (HR 5909) that designated the FKNMS. The Act authorized NOAA to develop and implement a comprehensive management plan to manage and protect Sanctuary resources for the enjoyment of present and future generations. The FKNMS comprises approximately 9,500 km^2 of coastal and oceanic water and submerged lands organized into five management areas: Wildlife Management Areas (WMA), Ecological Reserves (ER), Sanctuary Preservation Areas (SPA), Existing Management Areas (EMA), and Special Use/Research Only Areas (SA/RO). On July 1, 1997, the FKNMS Management Plan, which included a large-scale marine zoning plan became effective and closed 23 areas (eighteen SPAs, four SAs, and one ER) to all extractive use (NOAA, 1996). These zones aim to protect the biological diversity and integrity of the marine environment in the Keys. In addition to providing areas that are limited to non-extractive recreation, these no-take zones are intended to act as replenishment zones where the total abundance of fishes, their average size, and their overall egg production may increase. In the year 2002, State and Federal managers will reevaluate the use of zones as a management tool. Therefore, the FKNMS and NOAA's South Florida Restoration Fund are supporting a wide-scale, three-tiered monitoring program to evaluate the effects of the zones on biodiversity and human activities. Monitoring projects include research on coral, algae, fish, lobster, and human values, and focus on three levels: ecosystem, human/ecosystem interface, and volunteer monitoring of ecosystem health.

In 1997, REEF's Advanced Assessment Team (AAT), made up of highly trained and active volunteers, was contracted to annually monitor reef fish populations at 31 sites within the FKNMS as part of the Sanctuary's zone monitoring program. REEF is a nonprofit organization founded in 1990 that educates the public about marine resources and enables divers and snorkelers 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 from the National Marine Fisheries Service (NMFS) Southeast Fisheries

Science Center. The Fish Survey Project is now in place in the tropical western Atlantic, the west coast of the US and Canada, and in the tropical eastern Pacific (Gulf of California to the Galapagos Islands). Participants conduct standardized surveys as part of their regular diving activities, and the data collected are input into REEF's database. Data summaries are available on the REEF Website (http://www.reef.org) and data files are available to the research, conservation, and management communities. REEF has been monitoring fishes in the Florida Keys since 1993, and to date its members have completed more than 6,387 fish surveys in Florida. This extensive data set has become an important source of information on reef fishes for the FKNMS.

METHODS

Study area: the Florida Keys

The Florida Keys comprise an island archipelago that extends 320 km southwest from Soldier Key in Biscayne Bay to the Dry Tortugas (Figure 1). To the north and west, the Keys are bounded by Biscayne Bay and the Gulf of Mexico; to the east and south, they are bounded the Straits of Florida. Submerged aquatic habitats include extensive seagrass beds and an extensive coral reef tract that extends 8 km off-shore toward the Atlantic Ocean. For this study, the FKNMS was divided into four regions reflecting geomorphological differences (FMRI, 1998). The regions were the Upper Keys (Key Largo to Upper Matecumbe Key), Middle Keys (Upper Matecumbe Key to Pigeon Key), Lower Keys (Little Duck Key to Marquesas Key), and the Dry Tortugas (Figure 1). Hereafter, the term "Florida Keys" will be used to collectively describe the Upper, Middle and Lower Keys excluding the Dry Tortugas region.

Field data collection

Data on fish presence and relative abundance were collected between Feb 7, 1994 and August 9, 1999, by REEF volunteers using a visual survey method called the Roving Diver Technique (RDT; Schmitt and Sullivan, 1996). The RDT involves divers swimming freely about a dive site (within a 100-m radius of the starting point) and recording every fish species that can be positively identified. The survey begins as soon as the diver enters the water. At the conclusion of each survey, the diver assigns each recorded species to one of four $\log_{10}$ abundance categories [single (1); few (2-10); many (11-100); and abundant (>100)] based on the approximate number of individuals seen. Survey location, survey time, depth, temperature, and other environmental data pertinent to the survey are also noted. All data are recorded on REEF survey sheets printed on underwater paper and are transferred to standardized data scan sheets, which are returned to REEF and optically scanned into a database (REEF, 2000).

Data processing

RDT survey data files obtained from REEF were imported into JMP statistical software (Version 3.2.2, SAS Institute Inc.) for processing and analysis. Each survey was assigned a unique identification number and was used as a replicate within survey sites. Site (point sample) locations were identified by unique geographic zone codes and by latitude and longitude.

Five hundred and eighteen REEF divers conducted 4,431 surveys at 119 sites in the Florida Keys and Dry Tortugas from July 1993 to August 1999 (Appendix 1). Recorded survey time varied significantly, ranging from 10 minutes to 245 minutes (4.75 hr), and were normally distributed around a mean of 59.4 min ± 0.2 min (Figure 3). Approximately 96% (4,331) of the surveys ranged between 30 and 100 minutes (Figure 3). Because species richness data may be influenced by observation time, surveys shorter than 30 minutes or greater than 100 minutes were considered outliers, and data from these surveys were not used in statistical analyses. Additionally, sites with fewer than three replicate surveys were excluded, resulting in 4,324 surveys from 112 sites being used for analysis of species richness and sighting frequency.

Species richness (R), defined as the total number of species documented, was calculated for each survey, site, and region. Three parameters, percent sighting frequency (%SF), density score (D), and abundance score (A), were calculated for each species by site and by region (after Schmitt and Sullivan 1996). Percent sighting frequency was the percentage of all survey dives in which the particular species or family was recorded. The density score for each species, a weighted average index based on the frequency of observations in different abundance categories, was calculated as:

$$D = [(n_S \times 1)+(n_F \times 2) + (n_M \times 3) + (n_A \times 4)] / (n_S + n_F + n_M + n_A),$$

where n_S, n_F, n_M, and n_A represent the number of times each abundance category was assigned for a given species. An abundance score (where A = D x %SF) was calculated to account for zero observations.

Statistical analysis and development of species distribution maps

A series of N-way ANOVA or Kruskal-Wallis non-parametric Rank Sums tests was conducted with JMP statistical software (Ver. 3.2.6, SAS Institute, 1999) to determine the important factors that may be influencing two parameters of reef fishes in the Florida Keys: species richness and sighting frequency. Raw data and estimated variables were checked for normality to determine whether parametric or non-parametric statistical procedures should be used. Surveys were considered replicates, whereas location, region and other factors (e.g., diver experience and habitat types) were considered treatment effects. Statistical analyses (including comparisons of means among treatments) were done with $\alpha = 0.05$ to test for significant differences.

Distribution maps for the most frequently observed species were created using four equal %SF quartiles (Figure 2). Data were imported into Arc View GIS software (ver. 3.1.1, ESRI Inc., 1999) and geographic coverages were created with base maps of the FKNMS region.

Similarity in species assemblage composition among sites and regions was determined by hierarchical clustering (Ward's minimum variance) and correspondence analysis. Hierarchical clustering was used to group sites based on species composition (presence-absence) and species %SF such that sites that were most similar clustered more closely than sites that were more dissimilar. The clustering analysis included only sites with at least five surveys and all species

were included. Resulting clusters were plotted as dendograms so that regional patterns of assemblage composition could be detected more easily. Correspondence analysis was used to determine if any significant associations existed between the resulting clusters and the four geographic regions of the FKNMS.

RESULTS

Survey effort

Survey effort varied substantially among regions and between diver types (Figures 4 and 5). The Upper Keys sites were most intensely surveyed (2,595 surveys) and Dry Tortugas sites were the least surveyed (411 surveys; Figure 4). REEF volunteer divers are classified into two groups, novice and expert. Expert divers, those with at least 35 surveys and a score of 90% or greater on the REEF Advanced Exam, conducted about half as many surveys as novice divers in all regions. The pattern of decreasing survey effort from the Upper Keys to the Dry Tortugas was similar for both diver types (Figure 5).

Patterns of species richness

The Florida Keys and Dry Tortugas REEF data set contained sighting information on 341 fish species comprising 68 families (Appendix 2). The Molasses Reef site in the Upper Keys (25.009° N, 87.3737° W) had 220 species, the highest number of species observed per location. Molasses Reef also had the greatest number of surveys (277 surveys; approximately 261hr.).

To determine the relationship between species richness and survey effort, the cumulative number of species was plotted against cumulative survey time for each location (Figure 6). Cumulative species richness at survey sites varied strongly with total survey time ($R^2 = 0.82$, $P < 0.0001$; Figure 6). The cumulative number of species observed at survey sites increased log-linearly with increasing cumulative survey time, such that log-linear model accounted for 82% of the observed variation in cumulative species richness. Approximately 75% of the species richness was observed after 50 hr., and 90% of the species richness was observed after 130 hr. of survey time (Figure 6).

Cumulative species richness also varied strongly with cumulative survey time within and among regions (Figure 7). Within regions, observed species richness increased log-linearly with cumulative survey time. Observed species richness was strongly correlated with cumulative survey time at sites in the Upper, Middle, and Lower Keys, with the model accounting for 81-94 % of the observed variation in species richness in those regions (see R^2 values in Figure 7). Species richness was not as strongly correlated with survey time in the Dry Tortugas (Figure 7). The species encounter rate also varied among regions such that the encounter rate relative to the total number of species present was faster in the Dry Tortugas than in other regions of the Florida Keys (Figure 8). Approximately 95% of the species seen in the Dry Tortugas were observed within 50 hr compared with 85% for the Middle and Lower Keys and 75% for the Upper Keys within the same period.

Significant patterns were observed when mean species richness was compared among regions. Chi-square comparisons of mean richness among regions showed significantly fewer species in the Dry Tortugas compared with other regions, $P < 0.0001$ (Figure 9). The number of species observed per survey were similar among the Upper, Middle, and Lower Keys but was significantly lower in the Dry Tortugas, $P < 0.0001$ (Figure 10). Patterns of species richness were similar between novice and expert divers using the RDT method. Family richness did not vary significantly among regions or diver types (Figure 11).

Regional patterns in species distribution

Geographic coverages were developed for the twenty most frequently observed species in the Florida Keys and the Dry Tortugas (Table 1). Blue tang (*Acanthurus coeruleus*) was the most frequently seen fish and had a sighting frequency of 91%. Other frequently observed species included the stoplight parrotfish (*Sparisoma viride*), yellowtail snapper (*Ocyurus chrysurus*), sergeant major (*Abudefduf saxatilis*), bluehead (*Thalassoma bifasciatum*), and the french grunt (*Haemulon flavolineatum*). Grunts (Haemulidae) and damselfishes (Pomacentridae) were more highly represented among the top twenty species than other reef fish families (Table 2). No groupers (Serranidae) were ranked among the top twenty most frequently observed species. Several of the most frequently observed species in the Dry Tortugas did not rank among the twenty most frequently observed species overall (Table 3); distribution maps were developed for those nine species.

A series of non-parametric analyses and Tukey HSD tests showed significant regional variation in the mean % SF of fourteen of the 29 species whose distributions were mapped (Table 4). Six species had significantly lower mean % SF, and eight species had significantly higher mean % SF in the Dry Tortugas compared with other regions (Tukey HSD, $P < 0.05$; Table 4). Bluestriped grunt (*Haemulon sciurus*) was significantly less frequent at Dry Tortugas sites (38.0 % ± 8.2) compared with the Lower (81.2 % ± 3.2), Middle (87.1% ± 4.3), and Upper Keys (86.1 % ± 2.6) but differences among the Lower, Middle, and Lower Keys were not significant (Tukey HSD, $P < 0.05$; Figure 12). Yellowtail damselfish (*Microspathodon chrysurus*), sergeant major (*A. saxatilis*), and porkfish (*Anisotremus virginicus*) had distribution patterns similar to that of the bluestriped grunts (Figures 13-15), all having significantly greater %SF in the Upper, Middle, and Lower Keys than in the Dry Tortugas.

Mean sharpnose puffer (*Canthigaster rostrata*) % SF was less variable among regions (Figure 16). Comparisons showed that the mean % SF of the Dry Tortugas region (48.5% ± 7.9) was significantly lower than the mean of the Upper Keys (71.8% ± 3.4) but was not different from the means of the Lower and Middle Keys (58.0% ± 6.0 and 56% ± 5.1). Results also showed that the Lower and Middle Keys were not significantly different from the Upper Keys (Tukey HSD, $P > 0.05$).

The mean % SF of foureye butterflyfish (*Chaetodon capistratus*) was lowest in the Dry Tortugas region (55.1 % ± 7.7) and highest in the Lower and Middle Keys (81.4 % ± 5.5 and 85.6% ± 5.4 SF); this difference was significant (Tukey HSD, $P < 0.05$; Figure 17). Mean % SF in the Upper Keys was not significantly different from that of other regions (73.5% ± 4.4).

Eight species were consistently more frequently observed in the Dry Tortugas than other regions of the Keys (Table 4). Barred hamlets (*Hypoplectrus puella*) occurred almost twice as often at Dry Tortugas sites than at sites in other regions, and were not observed at 47% and 20% of sampled sites in the Middle and Upper Keys, respectively (Figure 18). The distribution of blue hamlets (*Hypoplectrus gemma*) was similar. In the Dry Tortugas, the mean % SF of blue hamlets was 59.7% (±5.9), whereas it ranged from 25.4% ± 6.3 to 30.0% ± 3.9 in the rest of the Keys (Figure 19). Blue hamlets were not observed in 16-20% of the Florida Keys sites compared with 8% of sampled sites in the Dry Tortugas (Figure 19). These differences were significant ($q^* = 2.609$, $P < 0.05$, Tukey HSD).

Butter hamlets (*Hypoplectrus unicolor*) were observed in 78% of sampled sites in the Middle, Lower Keys and the Dry Tortugas region compared with 67% in Upper Keys sites. Butter hamlets had a mean % SF of 70.5% ± 5.5 in the Dry Tortugas region, which was significantly different from that of the Upper Keys (55.6% ± 3.8), the Middle Keys (40.5% ± 6.2), and Lower Keys (38.6% ± 6.0), ($q^* = 2.609$, $P < 0.05$, Tukey HSD; Figure 20). The mean % SF of butter hamlets in the Upper Keys was significantly different from that of the Lower and Middle Keys but differences between Middle and Lower Keys were not significant ($P > 0.05$).

The cocoa damselfish (*Stegastes variabilis*) had significantly higher mean % SF in the Dry Tortugas region (69.8 ± 5.0%) than the rest of the Florida Keys (50.1% ± 5.5 to 53.1% ± 5.6; $P = 0.0046$; Figure 21). Differences among mean % SF means for the Upper, Middle, and Lower Keys were small and not significant (Figure 21). Threespot damelfish (*Stegastes planifrons*) distribution (Figure 22) was different from that seen in the cocoa damselfish in that the Dry Tortugas and the Upper Keys had significantly higher mean % SF (70.9% ± 5.8 and 62.7% ± 4.1) than the Middle Keys (43.2% ± 6.5). Other pairwise comparisons of threespot damselfish mean % SF among regions were not significant ($P > 0.05$).

Other species with significant variation among regions included the blue angelfish (*Holacanthus bermudensis*), striped parrotfish (*Scarus croicensis*), and the neon goby (*Gobiosoma oceanops*). Blue angelfish were sighted significantly more frequently in the Dry Tortugas (66.7% ± 5.2) than in the Lower (30.6% ± 5.7), Middle (36.6% ± 5.8), and Upper Keys (22.9% ± 3.6) (Figure 23). Differences in blue angelfish mean % SF among the Lower, Middle, and Upper Keys were not significant ($P > 0.05$). Striped parrotfish %SF was highest in the Dry Tortugas (70.9% ± 4.8) and decreased eastward through the Florida Keys (Figure 24). Significant differences in striped parrotfish mean %SF occurred between the Dry Tortugas region and the Upper Keys only ($P < 0.05$). Neon goby %SF was high in the Dry Tortugas and Lower Keys (66.7% ± 5.5 and 64.1% ± 6.0) but significantly lower in the Middle and Upper Keys (39.6% ± 6.1 and 43.7% ± 3.8; $P < 0.05$; Figure 25).

Patterns in species composition

Hierarchical clustering based on species composition (presence-absence) and species %SF revealed interesting patterns of similarities among sites that varied across spatial scales (Figures 26-28). Clustering based on species presence-absence data revealed 6 main site clusters within the Florida Keys and Dry Tortugas (Figure 26). Similar patterns were observed in

clustering based on species sighting frequency data. For most clusters (e.g., Cluster 1), sites within regions tended to cluster together more closely than with sites from other regions. For example, sites in the Dry Tortugas clustered together and separately from other sites, as did several Upper Key sites (Figures 26 and 27). However, several sub-clusters did not necessarily follow geographical location, suggesting that much of the variation in species composition and sighting frequency cannot be explained solely by regional differences or geographic variation. These sub-clusters may have resulted from cross-shelf location of sites. For example, inshore patch reef sites (e.g., Hens and Chickens and Cheeca Rocks) tended to cluster together, even though they were located in different regions. Similarly, offshore bank reef sites tended to cluster together (Figure 26). Correspondence analysis revealed highly significant associations between regions and cluster groups (Figure 28, $P < 0.0001$).

DISCUSSION

Critical to the design of effective monitoring programs is a preliminary understanding of the populations of interest. Estimates of parameters such as species encounter rates and levels of sample variance each provide researchers with information that can be used to determine the effort required to test specific hypotheses or to detect changes of varying magnitude. This study is intended, in part, to provide such background, and utilizes a database generated by a large, volunteer-based survey effort to accomplish this. In addition, the study extends the effort to ascertain regional patterns of diversity and abundance.

The species/effort curves (Figure 7) suggested that encounter rate was inversely proportional to richness for each of the four regions, with the Tortugas region having the highest rate. Higher encounter rates would generally be expected in populations with higher evenness, that is, in populations with individuals apportioned more equally among species. This may be the case for the Tortugas. However, it is not clear whether the lower richness estimates for the Tortugas are real or due to reduced survey effort. If they are real, the likely explanations relate to the limited geographic extent of the area relative to the rest of the Florida Keys, as well as the more limited variety and extent of habitats in the Dry Tortugas region. The other regions of the Florida Keys contain considerably more areas of seagrass and mangrove, both important nursery and early life habitats for reef fishes.

The sighting frequency data confirmed the uniqueness of the Tortugas reefs relative to other regions of the Florida Keys. Among the 14 species (of the 29 most frequently observed in the data set) with significant differences between regions, eight were more frequently observed in the Tortugas (barred, blue and butter hamlets, cocoa and threespot damselfish, blue angelfish, neon goby, and striped parrotfish) than in most or all the other regions. The six others were less frequently encountered in the Tortugas (bluestriped grunt, yellowtail damselfish, sergeant major, porkfish, foureye butterflyfish, and sharpnose puffer).

Beyond the regional differences revealed in the study, site differences were identified in the cluster analysis. Most sites clustered according to region, supporting other analyses, but

others did not. Probable reasons for this vary, and are likely to be related to reef size and structure, proximity between sites, distance from shore, stochastic events, and other factors.

Thus, it is clear that phenomena affecting reef fish composition in the FKNMS operate at multiple spatial scales. Beyond the biogeographic scale that defines the character of the region as a whole (the reefs contain tropical species of the Caribbean Province), processes operating on a scale of the order of ~50-100 km account for differences between the Tortugas and the rest of the Florida Keys. These are likely to include meso-scale physical oceanographic processes such as those recently identified by Lee et al. (1992, 1994), which may localize recruitment, to an extent, within several areas of the Keys. Regional variation in reef structure may also contribute to differences at this scale. Upper Keys reefs tend to be more complex than those in the Middle and Lower Keys. The influence of Florida Bay may operate at similar scales, as passes are not common in the Upper Keys, but are numerous in the Middle and Lower Keys. Finally, submerged aquatic vegetation, habitat utilized by species during portions of their life, is abundant in the Upper Keys, less so in the Middle and Lower Keys, and is rare by comparison in the Tortugas.

It is likely that at both regional and local scales, habitat requirements strongly influence the patterns revealed in this study, and are particularly limiting for species that are less frequently observed in the Tortugas. This is because of constraints imposed by the reduced variety and extent of habitats in that region. The importance of specific characteristics of habitats in controlling fish populations indicates the need to investigate sub-regional scale phenomena, such as the proximity of reefs to seagrass beds and to shore-associated habitats (e.g. mangroves). Also, the extent of reef habitats themselves at each sample site should be evaluated against reef fish community composition, as this factor is also likely to limit community development. Currently, we are using the REEF data set to analyze these relationships. Ongoing analyses include testing hypotheses of non-uniform fish distribution among benthic habitats and management zones, and analyzing spatial trends and correlations between fish community structure and benthic habitat parameters (e.g., diversity and reef proximity to submerged aquatic vegetation) within the Florida Keys National Marine Sanctuary.

The results of this report serve as a benchmark for the current status of the reef fishes in the FKNMS. These data provide the basis for analyses on reserve effects and the biogeographic coupling of benthic habitats and fish assemblages, and ultimately, may be useful in developing future management zones.

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TABLES

Table 1. Most frequently observed species in the Florida Keys based on sighting frequency (%SF). Data are from REEF (2000).

Rank	Common Name	Scientific Name	Family	SF (%)
1	Blue tang	*Acanthurus coeruleus*	Acanthuridae	91.1
2	Stoplight parrotfish	*Sparisoma viride*	Scaridae	87.7
3	Yellowtail snapper	*Ocyurus chrysurus*	Lutjanidae	84.1
4	Sergeant major	*Abudefduf saxatilis*	Pomacentridae	83.4
5	Bluehead	*Thalassoma bifasciatum*	Labridae	83.4
6	French grunt	*Haemulon flavolineatum*	Haemulidae	82.4
7	Bicolor damselfish	*Stegastes partitus*	Pomacentridae	81.6
8	Ocean surgeonfish	*Acanthurus bahianus*	Acanthuridae	77.5
9	Bluestriped grunt	*Haemulon sciurus*	Haemulidae	77.3
10	Yellowtail damselfish	*Microspathodon chrysurus*	Pomacentridae	74.8
11	Porkfish	*Anisotremus virginicus*	Haemulidae	74.2
12	Foureye butterflyfish	*Chaetodon capistratus*	Chaetodontidae	73.9
13	White grunt	*Haemulon plumieri*	Haemulidae	73.9
14	Redband parrotfish	*Sparisoma aurofrenatum*	Scaridae	71.1
15	Spotfin butterflyfish	*Chaetodon ocellatus*	Chaetodontidae	70.5
16	Yellowhead wrasse	*Halichoeres garnoti*	Labridae	70.1
17	Great barracuda	*Sphyraena barracuda*	Sphyraenidae	68.5
18	Gray angelfish	*Pomacanthus arcuatus*	Pomacanthidae	68.0
19	Bar jack (Skipjack)	*Caranx ruber*	Carangidae	66.4
20	Sharpnose puffer	*Canthigaster rostrata*	Tetraodontidae	62.4

Table 2. The number of species per family ranked among the twenty most frequently observed species in the Florida Keys and Dry Tortugas.

Family		# of species
Haemulidae	Grunts	4
Pomacentridae	Damselfishes	3
Scaridae	Parrotfishes	2
Labridae	Wrasses	2
Chaetodontidae	Butterflyfish	2
Acanthuridae	Surgeonfishes	2
Tetradontidae	Puffers	1
Sphyraenidae	Barracuda	1
Pomacanthidae	Angelfishes	1
Lutjanidae	Snappers	1
Carangidae	Jacks	1

Table 3. Twenty most common species found in the Dry Tortugas sites ranked by sighting frequency (%SF). Asterisks denote species that were not ranked among the twenty most frequently observed species in the Florida Keys.

Rank	Common name	Species	Family	SF (%)
1	Blue tang	*Acanthurus coeruleus*	Acanthuridae	93.4
2	Bluehead	*Thalassoma bifasciatum*	Labridae	89.5
3	Stoplight parrotfish	*Sparisoma viride*	Scaridae	83.9
4	Gray angelfish	*Pomacanthus arcuatus*	Pomacanthidae	83.7
5	Yellowtail snapper	*Ocyurus chrysurus*	Lutjanidae	83.2
6	White grunt	*Haemulon plumieri*	Haemulidae	78.8
7	Cocoa damselfish*	*Stegastes variabilis*	Pomacentridae	78.1
8	Spotfin butterflyfish	*Chaetodon ocellatus*	Chaetodontidae	77.1
9	Threespot damselfish*	*Stegastes planifrons*	Pomacentridae	75.9
10	Neon goby*	*Gobiosoma oceanops*	Gobiidae	74.9
11	Redband parrotfish	*Sparisoma aurofrenatum*	Scaridae	69.6
12	Butter hamlet*	*Hypoplectrus unicolor*	Serranidae	68.6
13	Blue angelfish*	*Holacanthus bermudensis*	Pomacanthidae	68.4
14	French grunt	*Haemulon flavolineatum*	Haemulidae	64.0
15	Striped parrotfish*	*Scarus croicensis*	Scaridae	63.8
16	Bicolor damselfish	*Stegastes partitus*	Pomacentridae	63.5
17	Blue hamlet*	*Hypoplectrus gemma*	Serranidae	63.0
18	Yellowhead wrasse	*Halichoeres garnoti*	Labridae	61.6
19	Slippery dick*	*Halichoeres bivittatus*	Labridae	59.9
20	Barred hamlet*	*Hypoplectrus puella*	Serranidae	57.4

Table 4. Results of Wilcoxon / Kruskal-Wallis non-parametric (Rank Sums) and Tukey HSD tests of no significant difference in mean percent sighting frequency among regions, for twenty-nine frequently sighted species in the Florida Keys and the Dry Tortugas (alpha = 0.05, df = 3). Asterisks indicate species ranked in the Dry Tortugas but not among the twenty most observed species in the Florida Keys. Frequency classes are based on equal quantiles determined from the distribution of the mean sighting frequencies (n = 112 site means). DT = Dry Tortugas, UK = Upper Keys, MK = Middle Keys, LK = Lower Keys. A positive (+) sign indicates significant results.

Species		Family	Chi-Sq	P(Chi-Sq)	Sig.	Average Frequency			
						DT	LK	MK	UK
Bluestriped grunt	*Haemulon sciurus*	Haemulidae	21.00	0.00	+	C	HF	HF	HF
Yellowtail damselfish	*Microspathodon chrysurus*	Pomacentridae	20.52	0.00	+	C	F	HF	F
Sergeant major	*Abudefduf saxatilis*	Pomacentridae	18.42	0.00	+	C	HF	HF	HF
Porkfish	*Anisotremus virginicus*	Haemulidae	14.85	0.00	+	C	HF	HF	HF
Sharpnose puffer	*Canthigaster rostrata*	Tetradontidae	11.29	0.01	+	C	F	F	F
Foureye butterflyfish	*Chaetodon capistratus*	Chaetodontidae	7.86	0.05	+	F	HF	HF	F
Barred hamlet*	*Hypoplectrus puella*	Serranidae	23.57	0.00	+	C	UC	UC	UC
Blue angelfish*	*Holacanthus bermudensis*	Pomacanthidae	29.65	0.00	+	F	C	C	UC
Neon goby*	*Gobiosoma oceanops*	Gobiidae	19.41	0.00	+	F	F	C	C
Butter hamlet*	*Hypoplectrus unicolor*	Serranidae	18.72	0.00	+	F	C	C	F
Blue hamlet*	*Hypoplectrus gemma*	Serranidae	15.66	0.00	+	F	C	C	C
Cocoa damselfish*	*Stegastes variabilis*	Pomacentridae	13.03	0.00	+	F	F	F	F
Threespot damselfish*	*Stegastes planifrons*	Pomacentridae	11.49	0.01	+	F	F	C	F
Striped parrotfish*	*Scarus croicensis*	Scaridae	9.48	0.02	+	F	F	F	F
Redband parrotfish	*Sparisoma aurofrenatum*	Scaridae	7.68	0.05		F	F	F	HF
Bar jack	*Caranx ruber*	Carangidae	7.35	0.06		F	F	HF	F
Ocean surgeonfish	*Acanthurus bahianus*	Acanthuridae	6.77	0.08		F	HF	HF	HF
French grunt	*Haemulon flavolineatum*	Haemulidae	6.50	0.09		F	HF	HF	HF
Bluehead	*Thalassoma bifasciatum*	Labridae	6.34	0.10		HF	F	HF	HF
Gray angelfish	*Pomacanthus arcuatus*	Pomacanthidae	6.12	0.11		HF	F	HF	F
Yellowhead wrasse	*Halichoeres garnoti*	Labridae	5.05	0.17		F	F	HF	HF
Spotfin butterflyfish	*Chaetodon ocellatus*	Chaetodontidae	4.87	0.18		HF	F	HF	F
Yellowtail snapper	*Ocyurus chrysurus*	Lutjanidae	4.63	0.20		HF	HF	F	HF
Bicolor damselfish	*Stegastes partitus*	Pomacentridae	4.40	0.22		F	F	HF	HF
Great barracuda	*Sphyraena barracuda*	Sphyraenidae	3.05	0.38		F	F	F	F
Blue tang	*Acanthurus coeruleus*	Acanthuridae	1.68	0.64		HF	HF	HF	HF
White grunt	*Haemulon plumieri*	Haemulidae	1.28	0.73		HF	HF	HF	HF
Stoplight parrotfish	*Sparisoma viride*	Scaridae	1.17	0.76		HF	HF	HF	HF
Slippery dick*	*Halichoeres bivittatus*	Labridae	1.31	0.73		F	F	F	F

HF Highly frequent F Frequent C Common UC Uncommon

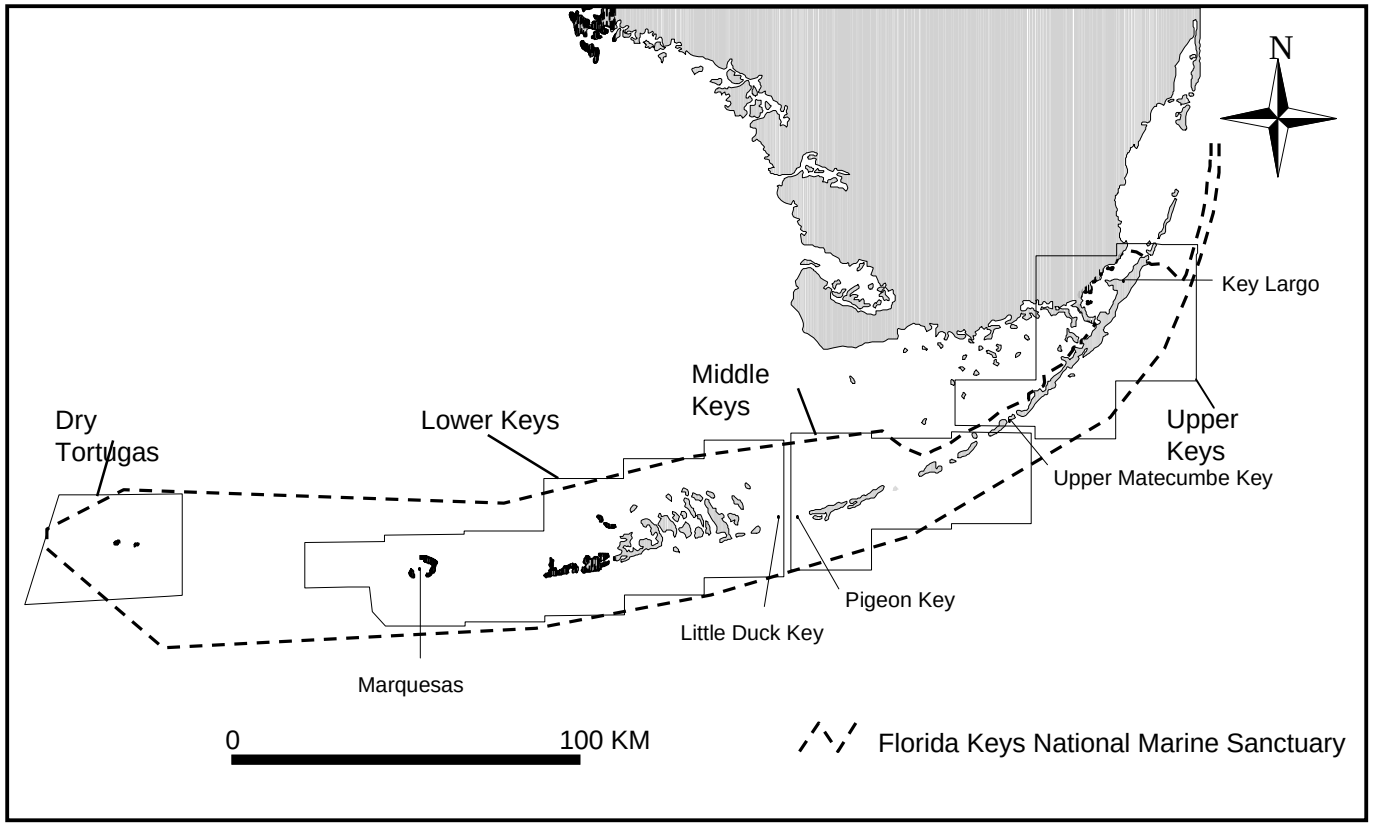


Figure 1. Map of the Florida Keys showing geographic boundaries among four regions.

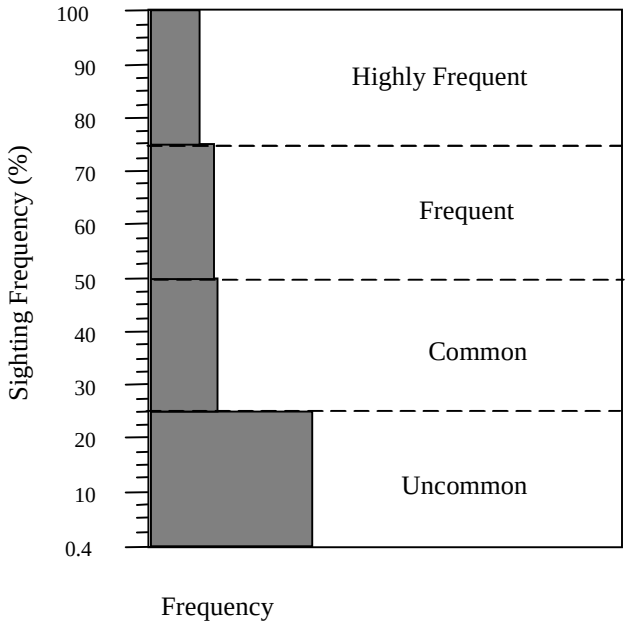
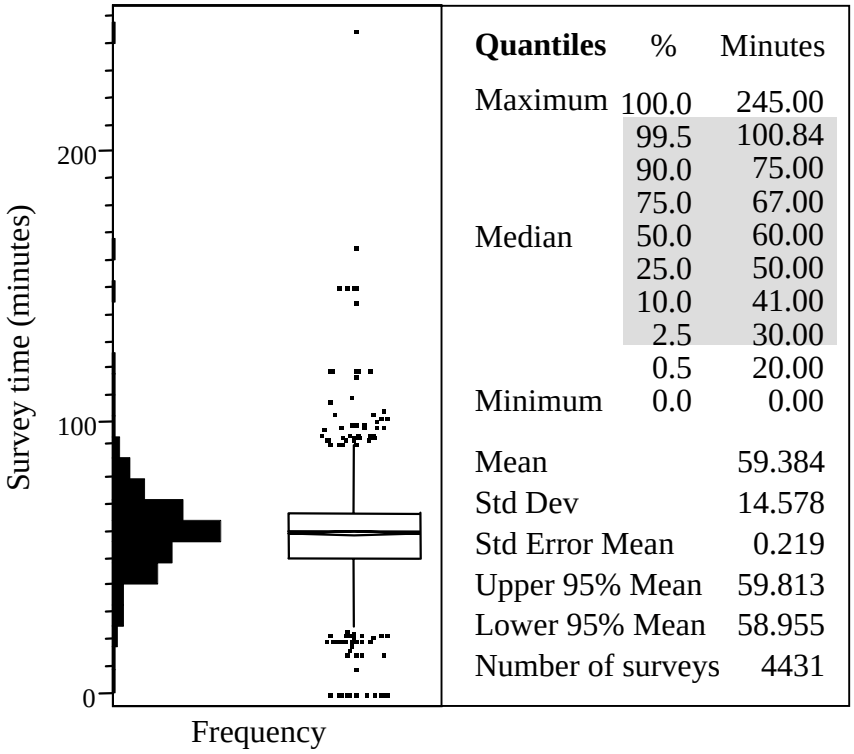


Figure 2. Classification scheme used in mapping fish abundance and summary statistics for fish data obtained from the Reef Environmental Education Foundation (REEF, 2000).



Quantiles	%	Minutes
Maximum	100.0	245.00
	99.5	100.84
	90.0	75.00
	75.0	67.00
Median	50.0	60.00
	25.0	50.00
	10.0	41.00
	2.5	30.00
	0.5	20.00
Minimum	0.0	0.00

Mean	59.384
Std Dev	14.578
Std Error Mean	0.219
Upper 95% Mean	59.813
Lower 95% Mean	58.955
Number of surveys	4431

Figure 3. The frequency distribution and summary statistics for time spent by REEF divers while surveying fishes in the Florida Keys. Only data from surveys with time ranging between 30 –100 minutes (in shaded box) were included for analysis.

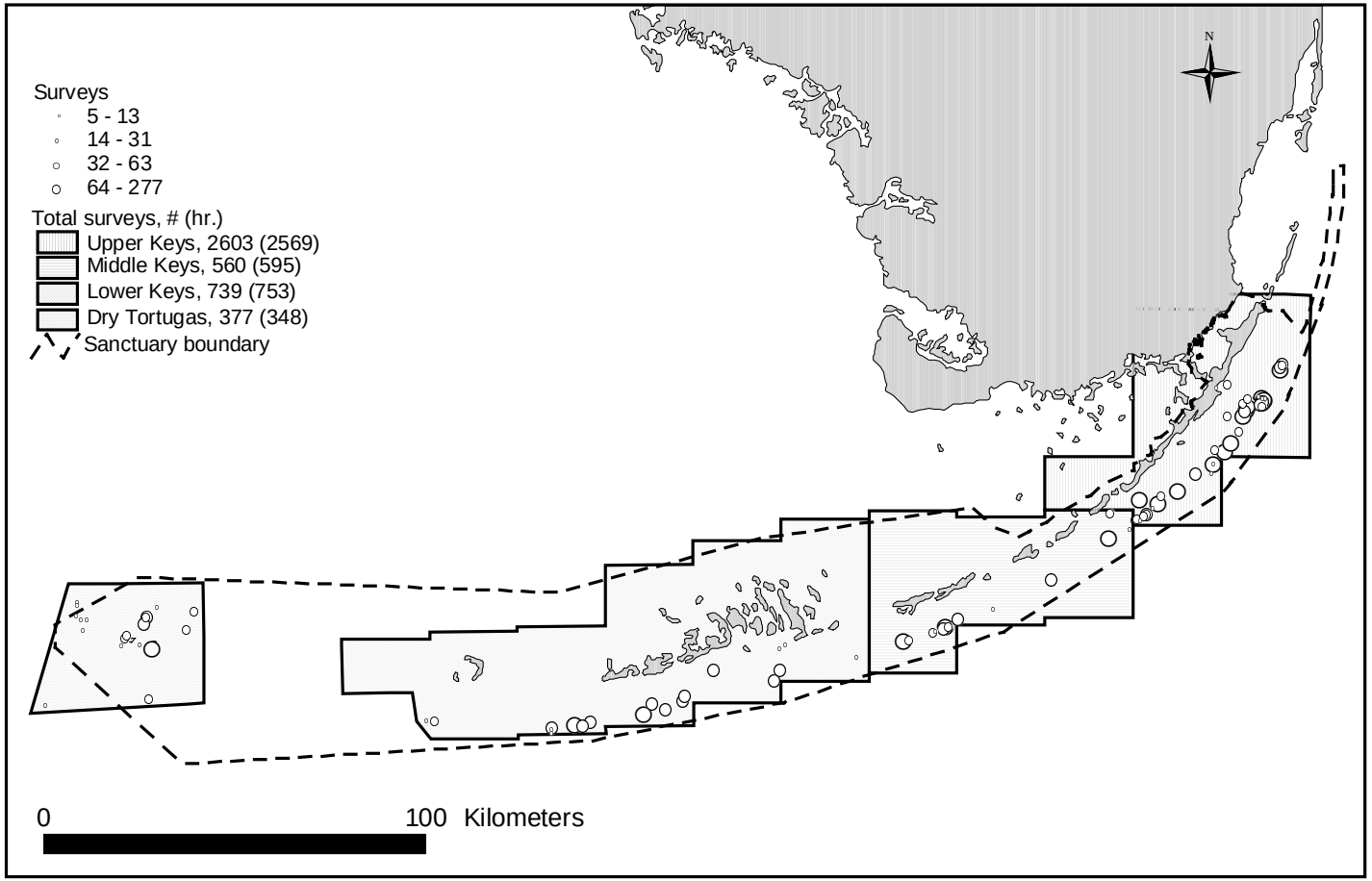


Figure 4. Distribution map of visual surveys done by Reef Environmental Education Foundation (REEF) volunteers using the Roving Diver Technique (RDT).

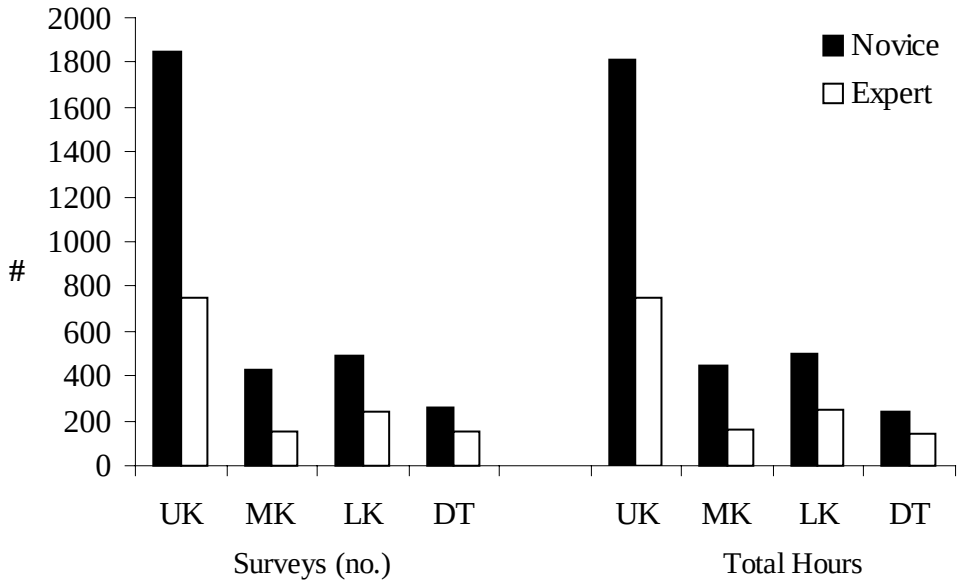
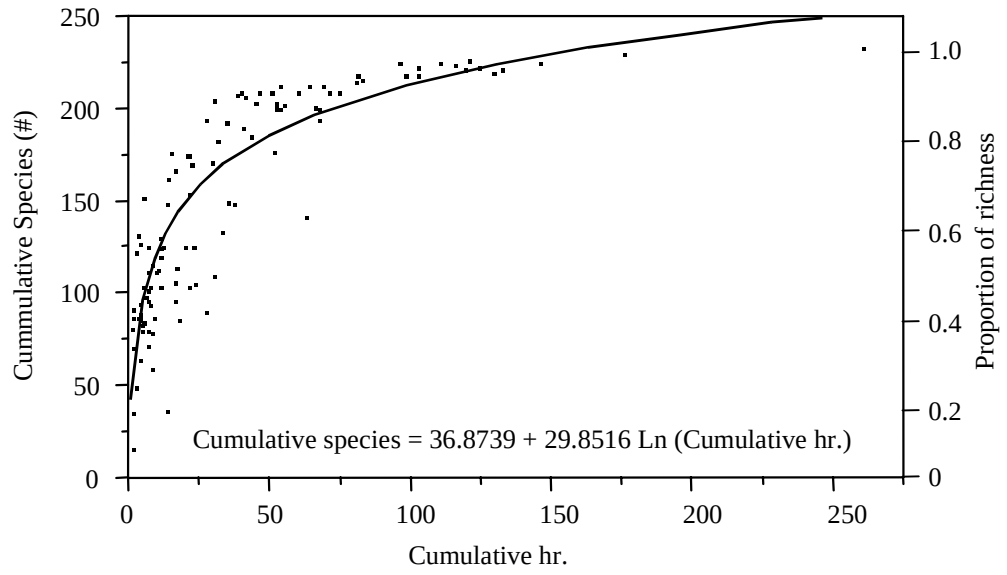


Figure 5. Level of survey effort compared among expert and novice divers stratified by region (UK = Upper Keys, MK = Middle Keys, LK = Lower Keys, DT = Dry Tortugas).

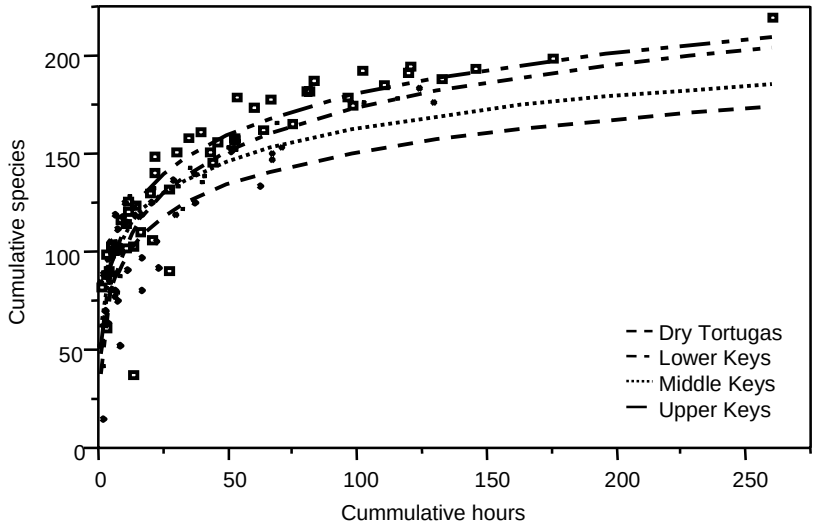


Source	DF	Sum of Squares	Mean square	F Ratio	Prob> F
Model	1	156350.56	156351	487.1304	<.0001
Error	110	35305.87	321		
Total	111	191656.43			

Summary of Fit

R^2	Root Mean Square Error	Mean	SE	N
0.82	17.91542	125.8214	3.92637	112

Figure 6. Cumulative species-time curve for reef fishes observed in the Florida Keys with summary of fit and analysis of variance results for the fitted curve.



Region	Source	DF	Type 1 SS	F	R^2	Prob>F
Dry Tortugas	Model	1	11916.702	26.832	0.549	0.0001
	Error	22	9770.631			
	Total	23	21687.333			
Lower Keys	Model	1	27195.207	297.804	0.943	0.0001
	Error	18	1643.743			
	Total	19	28838.950			
Middle Keys	Model	1	20412.881	191.293	0.918	0.0001
	Error	17	1814.067			
	Total	18	2226.947			
Upper Keys	Model	1	66422.296	205.955	0.814	0.0001
	Error	47	15157.949			
	Total	48	81580.245			

Figure 7. Regional cumulative species richness and analysis of variance results for fitted curves for sites among four regions of the Florida Keys.

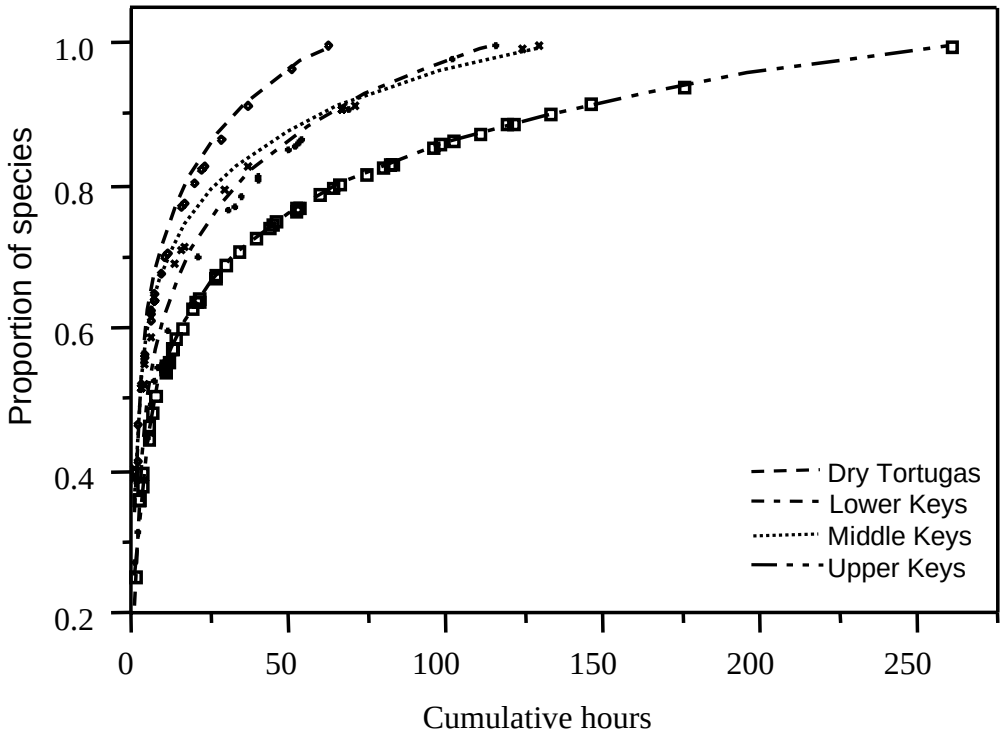


Figure 8. Proportion of species richness for regions of the Florida Keys. Data are predicted estimates from fitted curves in Figure 6.

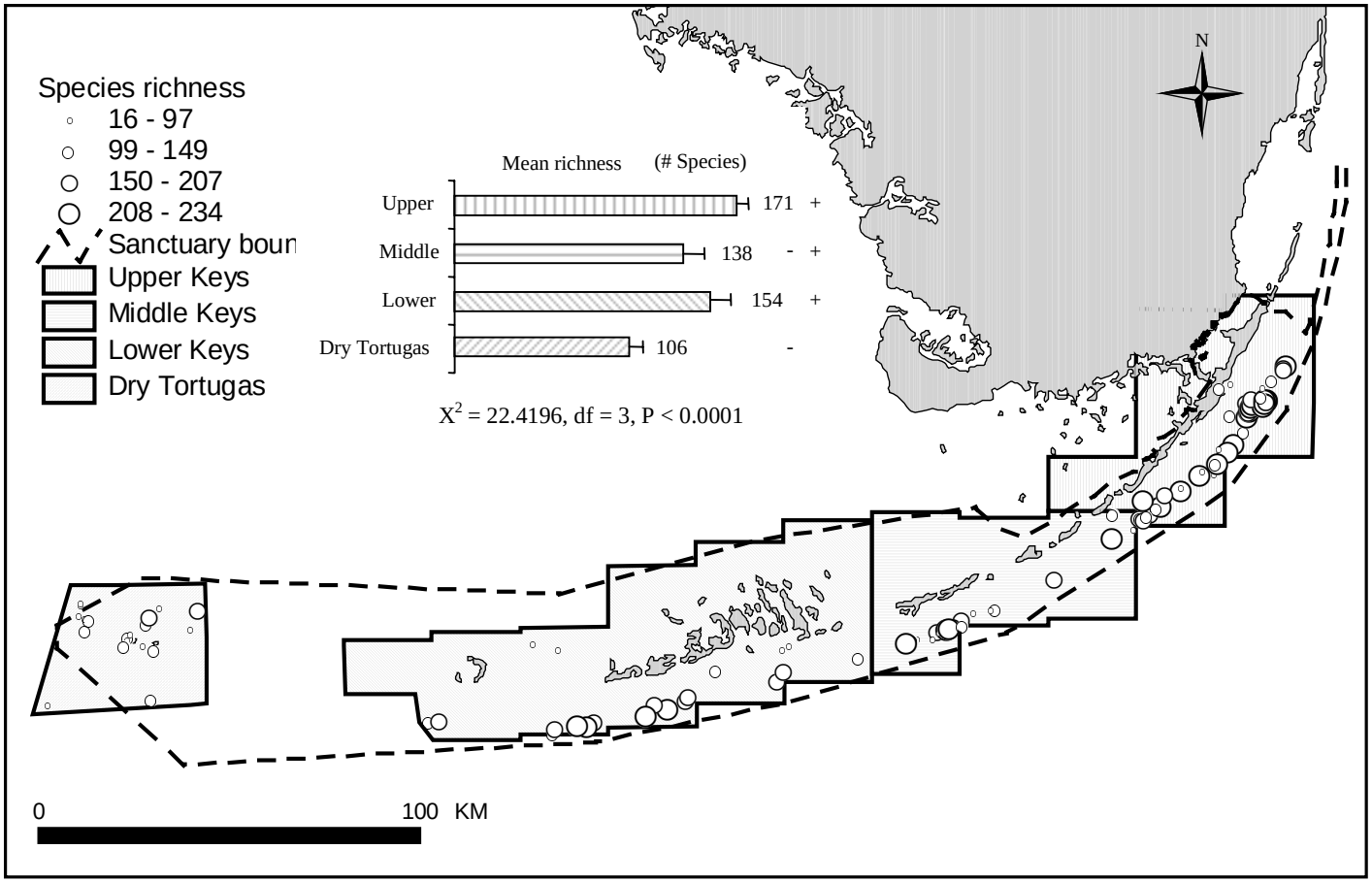
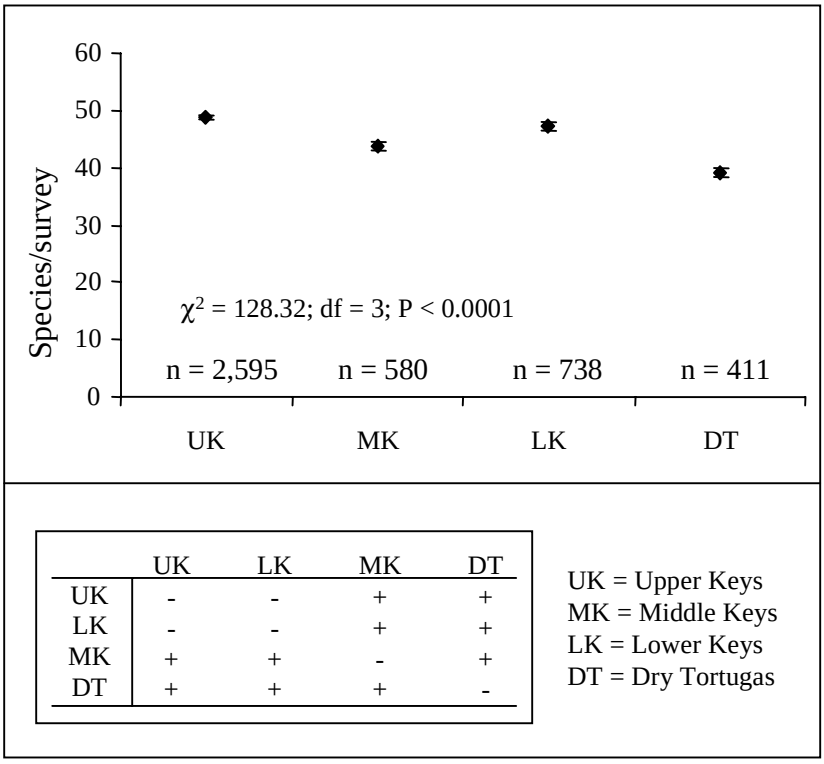


Figure 9. Distribution map of species richness for four regions of the Florida Keys. The bar graph shows regional differences in the mean number of species and tests for significant differences among regional means (Kruskal-Wallis Chi-Squared [χ^2] test, $\alpha = 0.05$; Tukey-Kramer HSD test, $\alpha = 0.05$). Means with the same symbols (+ or -) were not significantly different.



	UK	LK	MK	DT
UK	-	-	+	+
LK	-	-	+	+
MK	+	+	-	+
DT	+	+	+	-

UK = Upper Keys
MK = Middle Keys
LK = Lower Keys
DT = Dry Tortugas

Figure 10. Mean species richness per diver survey for four regions of the Florida Keys. Differences between means are significant. Means were tested with a Wilcoxon / Kruskal-Wallis one-way Chi-Squared (Rank Sums) test. The table shows the results of pairwise comparisons among regions using Tukey-Kramer HSD test ($\alpha = 0.05$; $q^* = 2.57003$). A '+' indicates significant differences among paired means; a '-' shows no significant differences among paired means.

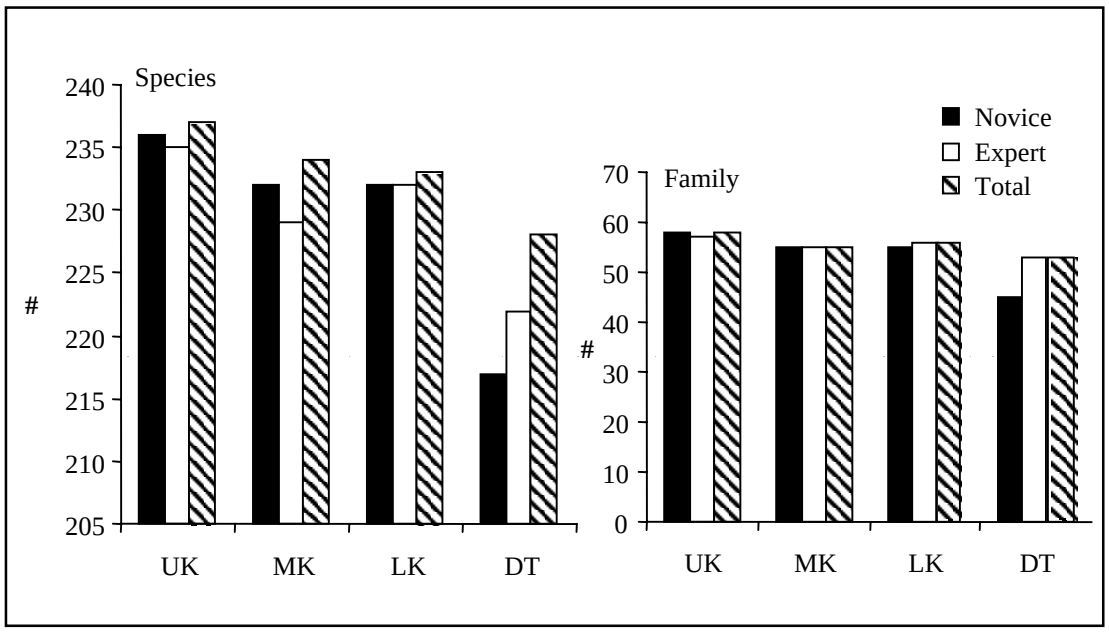


Figure 11. Species and family richness among expert and novice divers in the Florida Keys.

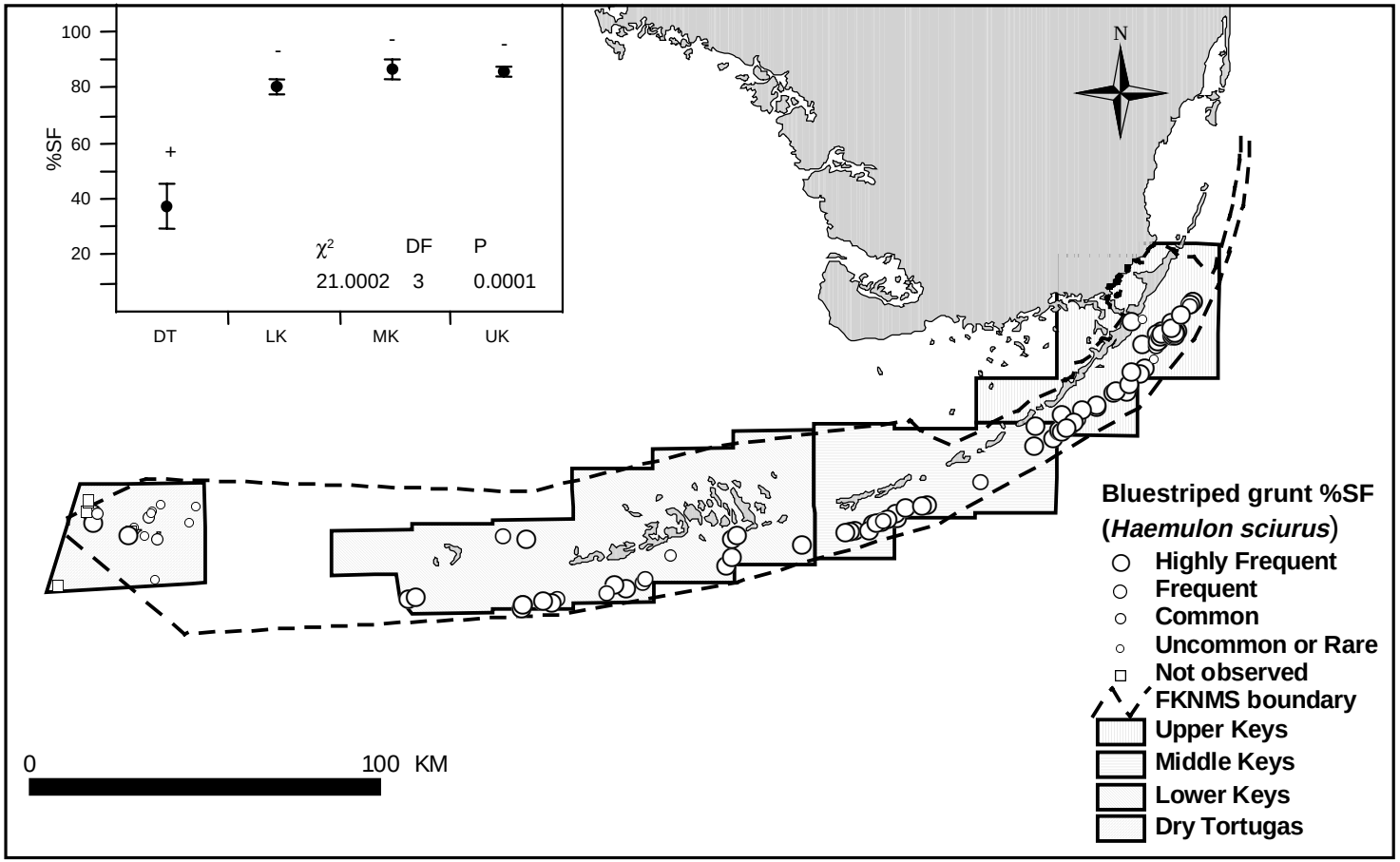


Figure 12. Spatial distribution and relative %SF of bluestriped grunt among regions of the Florida Keys. The scatter plot shows regional differences in mean %SF and tests for significant differences among means (Kruskal-Wallis Chi-Squared [χ^2] test, $\alpha = 0.05$; Tukey-Kramer HSD test, $\alpha = 0.05$). Means with the same symbols (+ or -) were not significantly different.

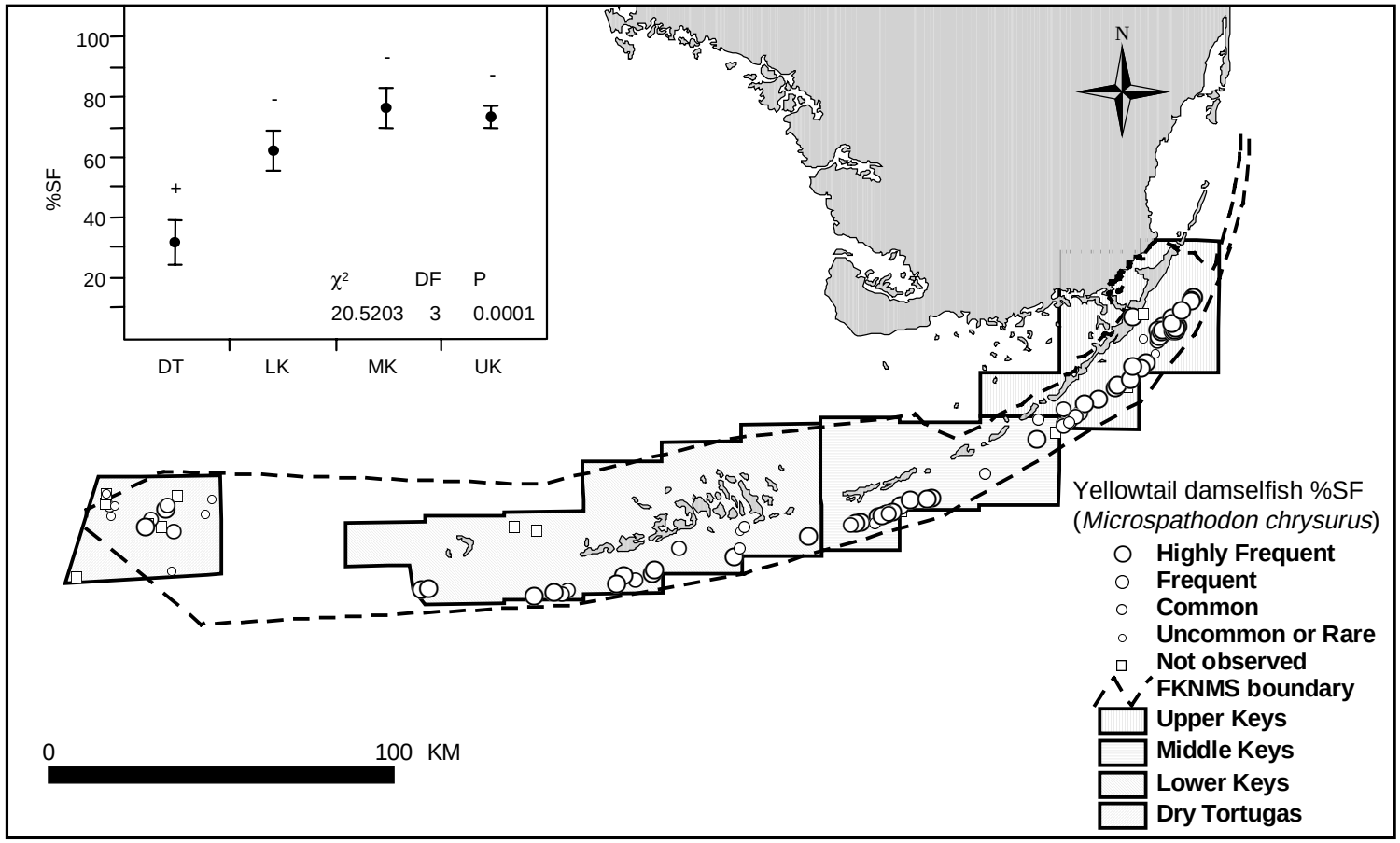


Figure 13. Spatial distribution and relative %SF of yellowtail damselfish among regions of the Florida Keys. The scatterplot shows regional differences in mean %SF and tests for significant differences among means (Kruskal-Wallis Chi-Squared [χ^2] test, $\alpha = 0.05$; Tukey-Kramer HSD test, $\alpha = 0.05$). Means with the same symbols (+ or -) were not significantly different.

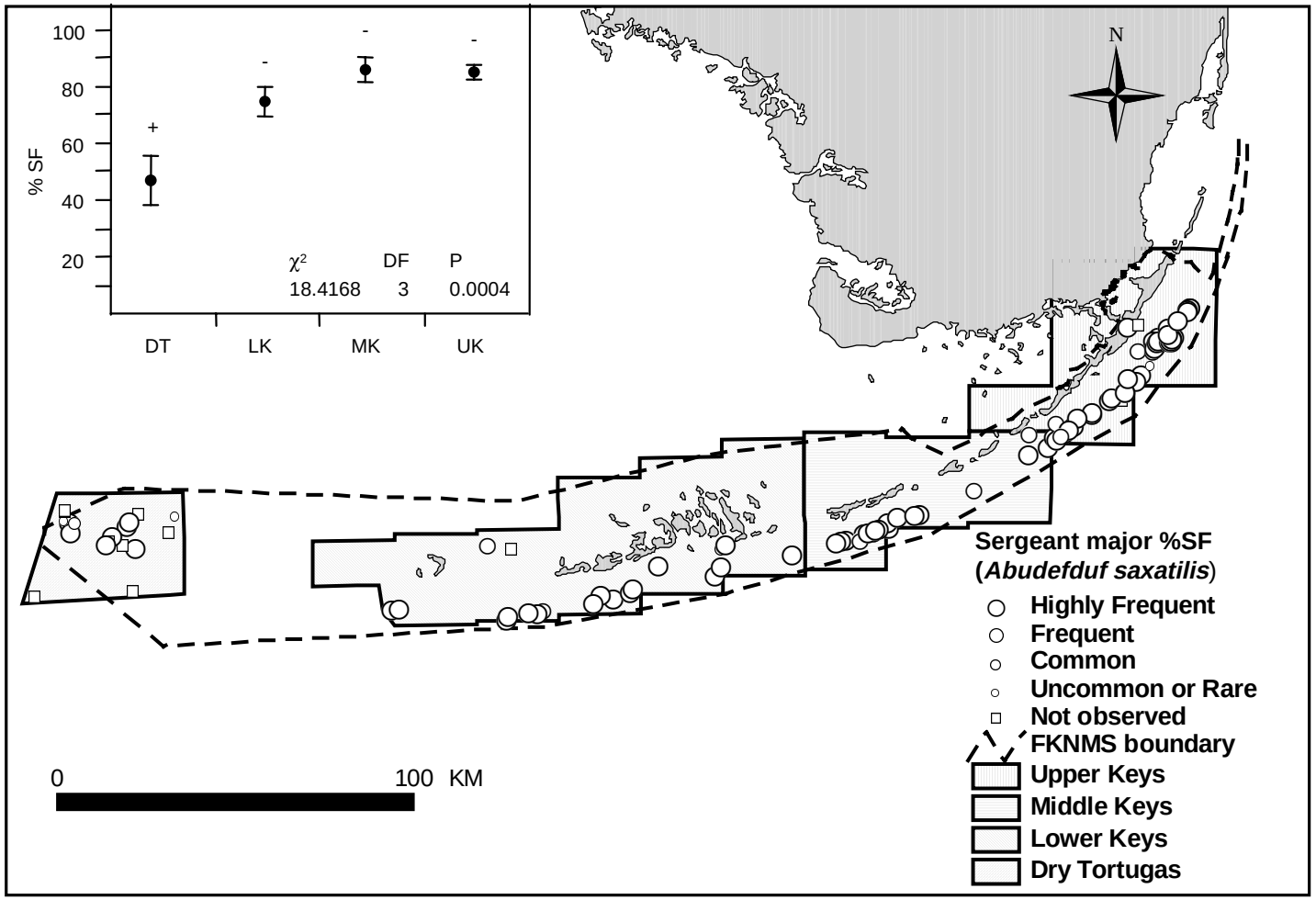


Figure 14. Spatial distribution and relative %SF of sergeant major among regions of the Florida Keys. The scatterplot shows regional differences in mean %SF and tests for significant differences among means (Kruskal-Wallis Chi-Squared [χ^2] test, $\alpha = 0.05$; Tukey-Kramer HSD test, $\alpha = 0.05$). Means with the same symbols (+ or -) were not significantly different.

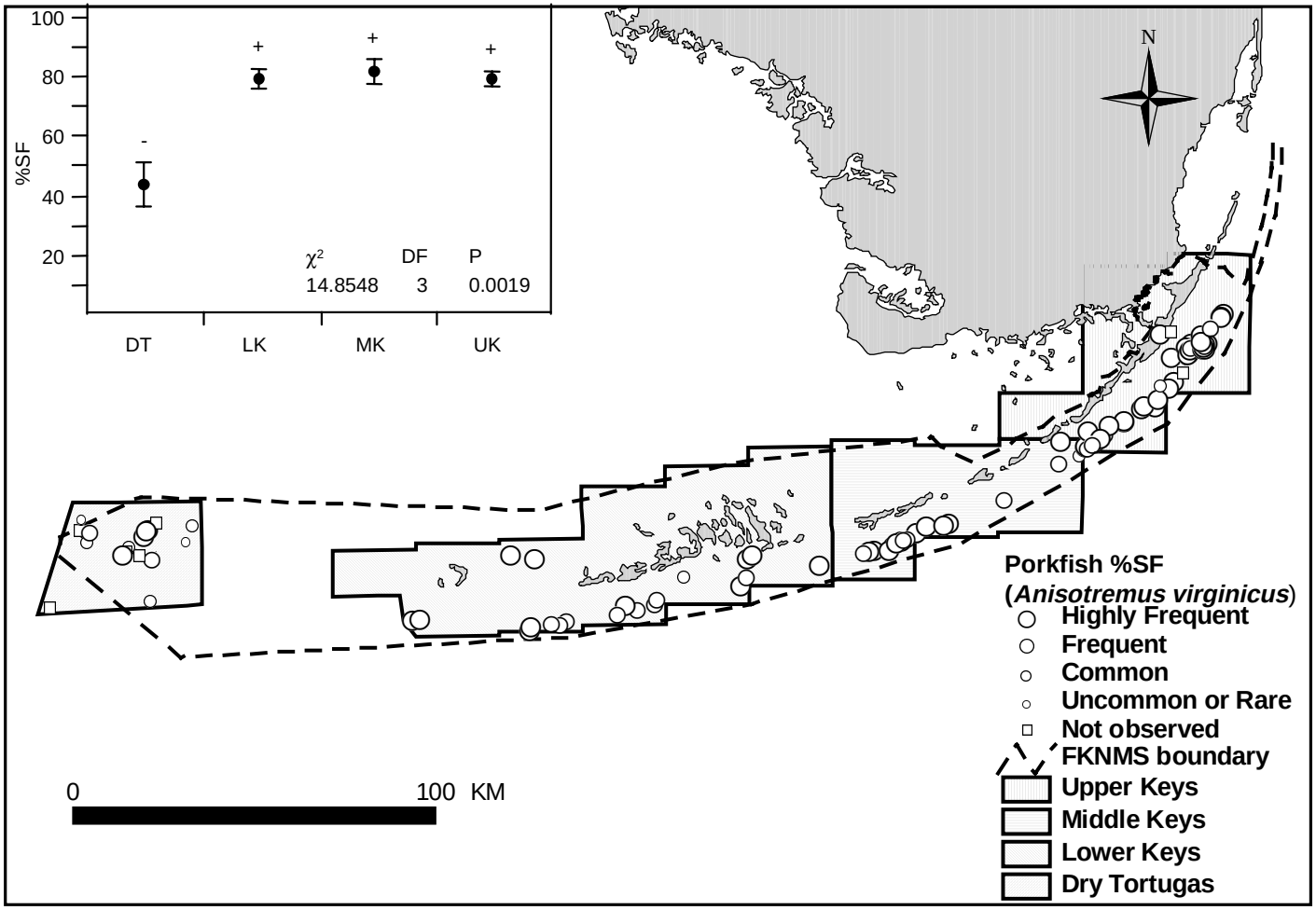


Figure 15. Spatial distribution and relative %SF of porkfish among regions of the Florida Keys. The scatterplot shows regional differences in mean %SF and tests for significant differences among means (Kruskal-Wallis Chi-Squared [χ^2] test, $\alpha = 0.05$; Tukey-Kramer HSD test, $\alpha = 0.05$). Means with the same symbols (+ or -) were not significantly different.

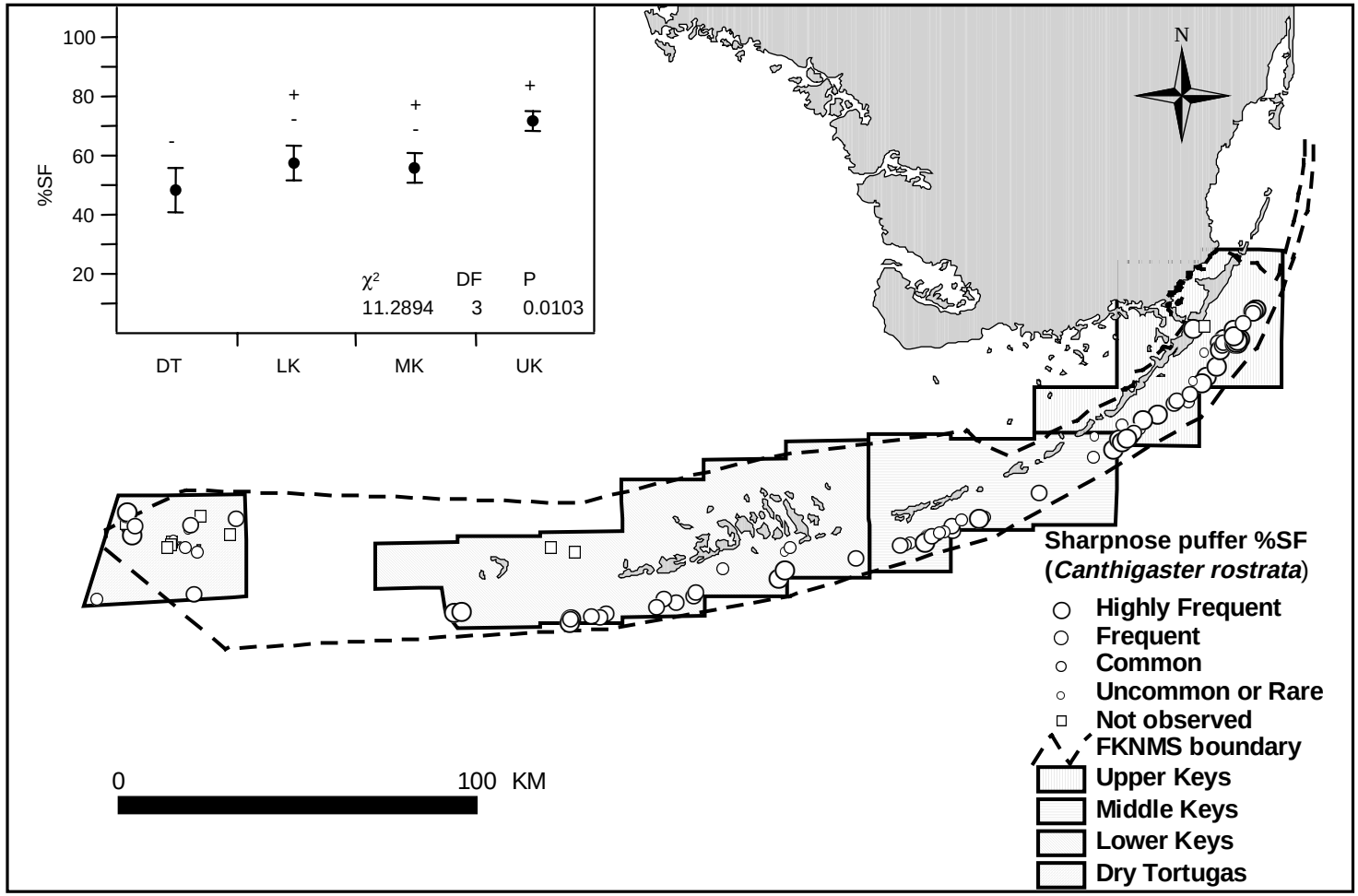


Figure 16. Spatial distribution and relative %SF of sharpnose puffer among regions of the Florida Keys. The scatterplot shows regional differences in mean %SF and tests for significant differences among means (Kruskal-Wallis Chi-Squared [χ^2] test, $\alpha = 0.05$; Tukey-Kramer HSD test, $\alpha = 0.05$). Means with the same symbols (+ or -) were not significantly different.

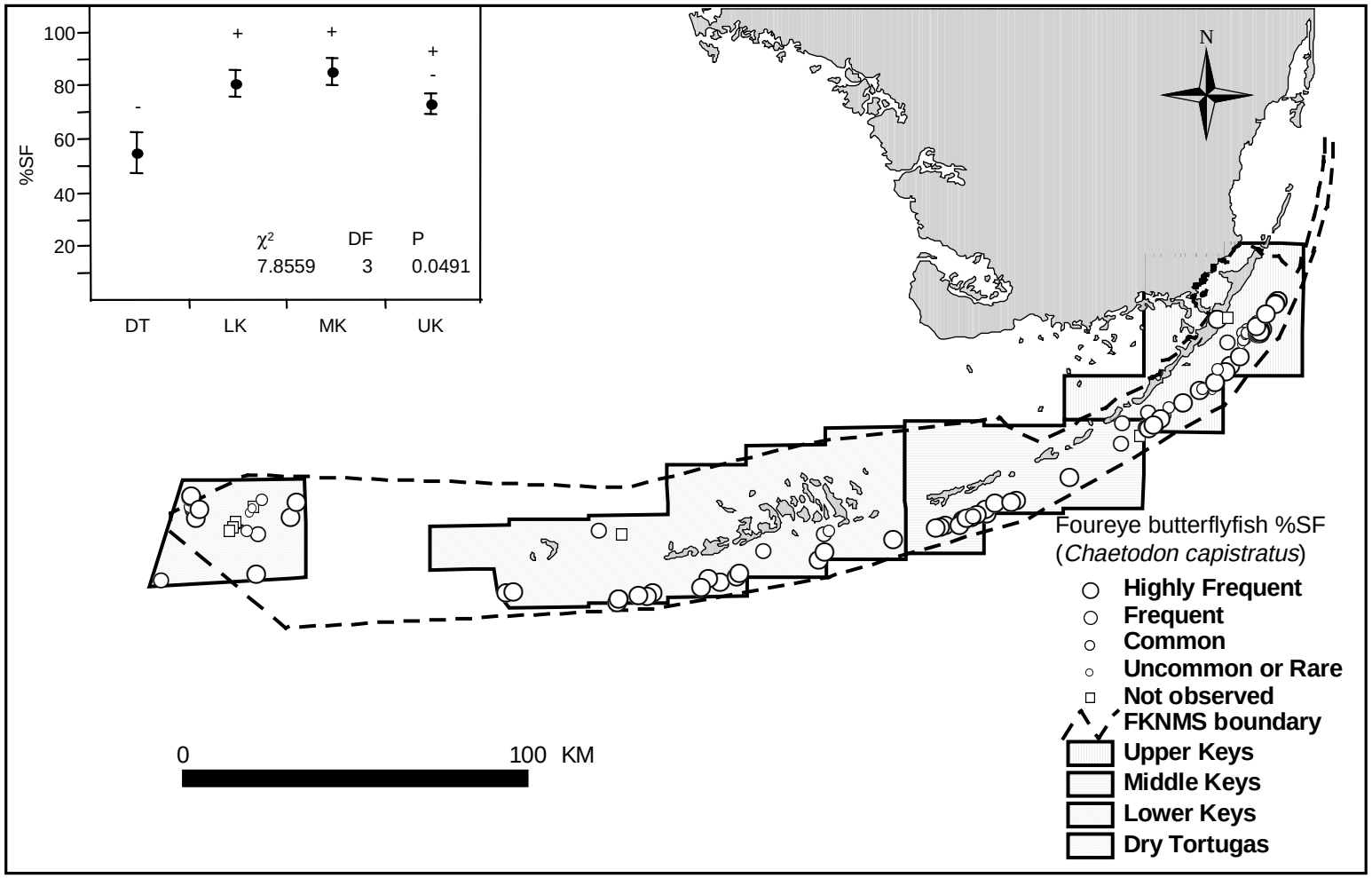


Figure 17. Spatial distribution and relative %SF of foureye butterflyfish among regions of the Florida Keys. The scatterplot shows regional differences in mean %SF and tests for significant differences among means (Kruskal-Wallis Chi-Squared [χ^2] test, $\alpha = 0.05$; Tukey-Kramer HSD test, $\alpha = 0.05$). Means with the same symbols (+ or -) were not significantly different.

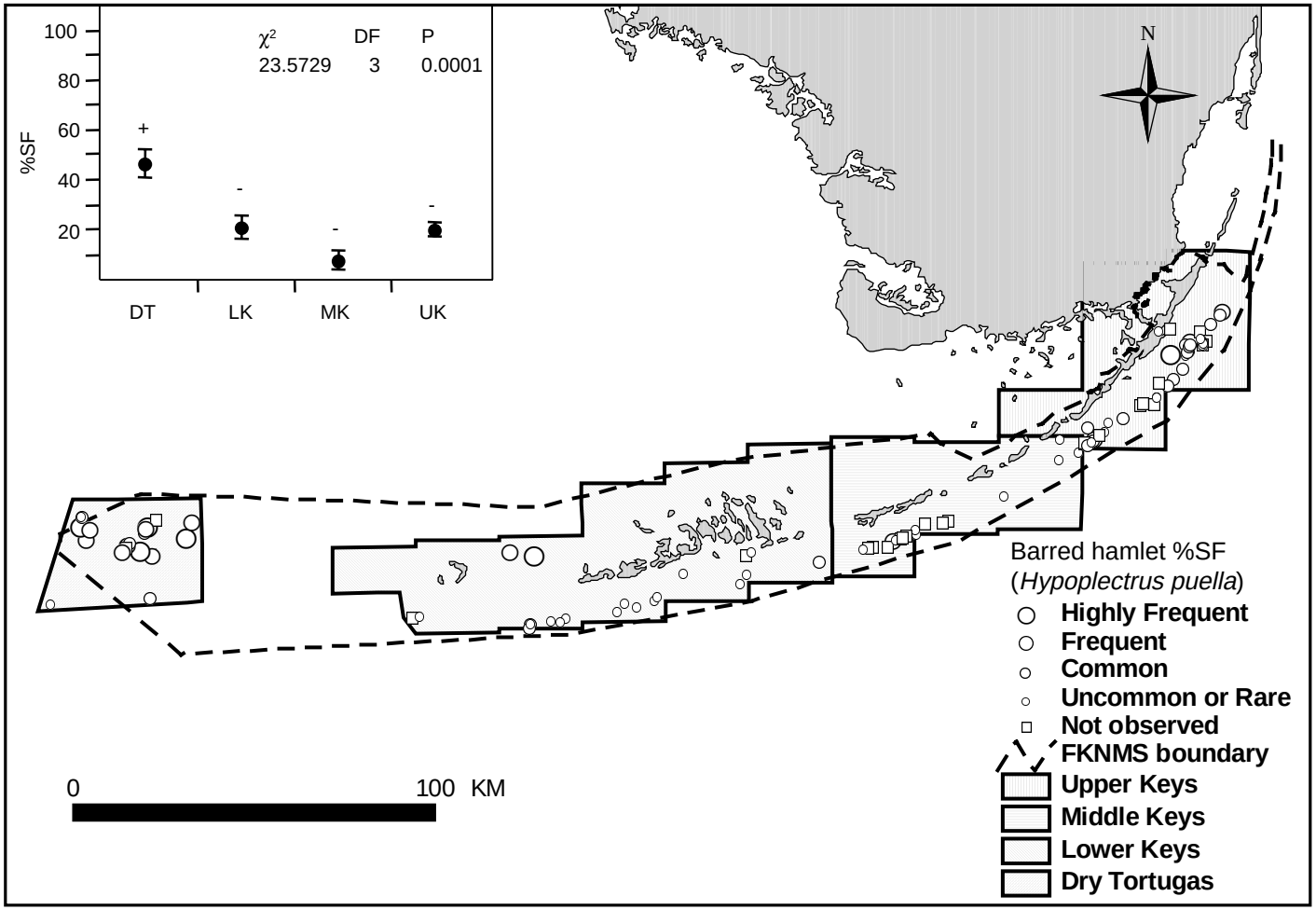


Figure 18. Spatial distribution and relative %SF of barred hamlet among regions of the Florida Keys. The scatterplot shows regional differences in mean %SF and tests for significant differences among means (Kruskal-Wallis Chi-Squared [χ^2] test, $\alpha = 0.05$; Tukey-Kramer HSD test, $\alpha = 0.05$). Means with the same symbols (+ or -) were not significantly different.

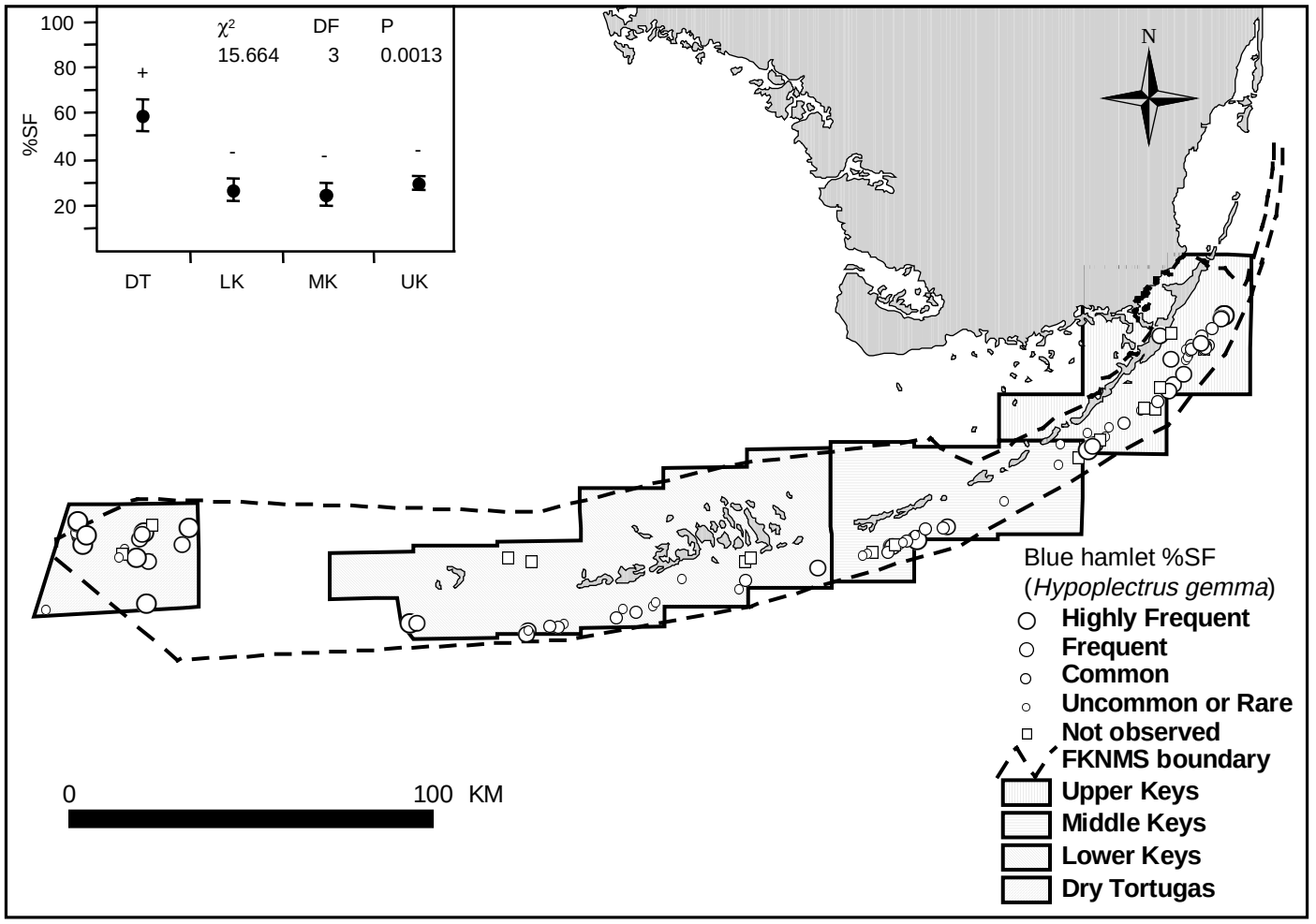


Figure 19. Spatial distribution and relative %SF of blue hamlet among regions of the Florida Keys. The scatterplot shows regional differences in mean %SF and tests for significant differences among means (Kruskal-Wallis Chi-Squared [χ^2] test, $\alpha = 0.05$; Tukey-Kramer HSD test, $\alpha = 0.05$). Means with the same symbols (+ or -) were not significantly different.

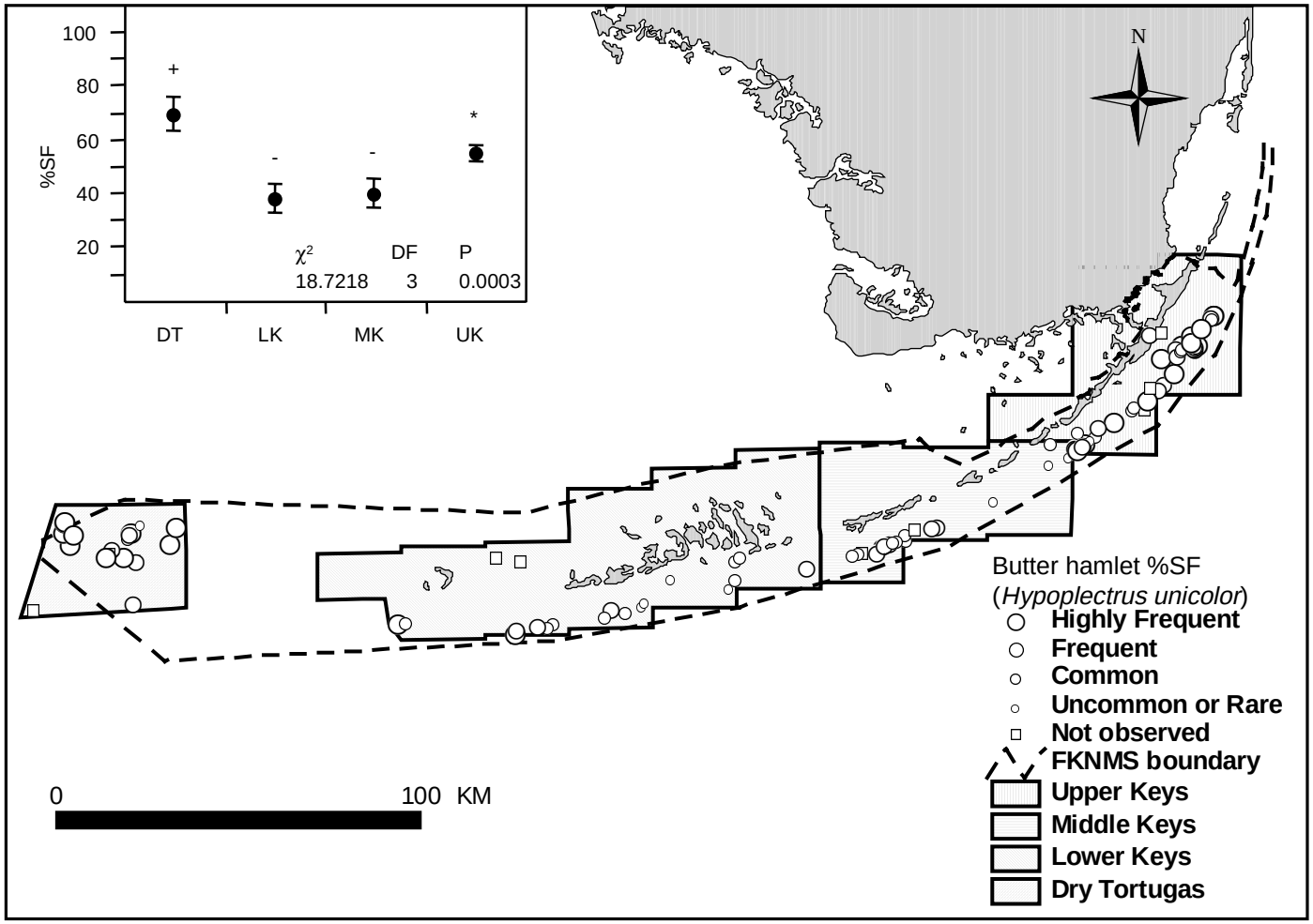


Figure 20. Spatial distribution and relative %SF of butter hamlet among regions of the Florida Keys. The scatterplot shows regional differences in mean %SF and tests for significant differences among means (Kruskal-Wallis Chi-Squared [χ^2] test, $\alpha = 0.05$; Tukey-Kramer HSD test, $\alpha = 0.05$). Means with the same symbols (+, -, or *) were not significantly different.

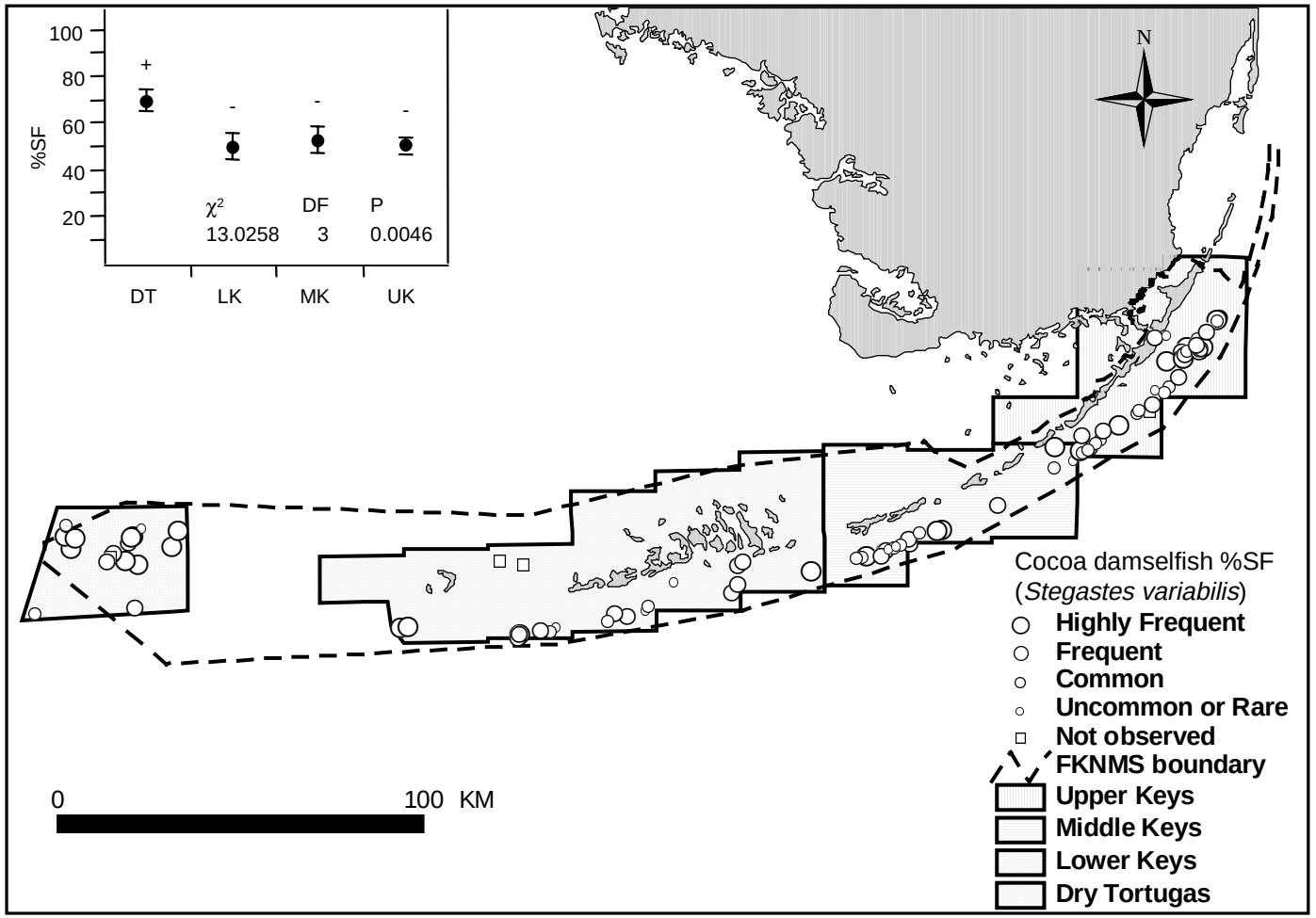


Figure 21. Spatial distribution and relative %SF of cocoa damselfish among regions of the Florida Keys. The scatterplot shows regional differences in mean %SF and tests for significant differences among means (Kruskal-Wallis Chi-Squared [χ^2] test, $\alpha = 0.05$; Tukey-Kramer HSD test, $\alpha = 0.05$). Means with the same symbols (+ or -) were not significantly different.

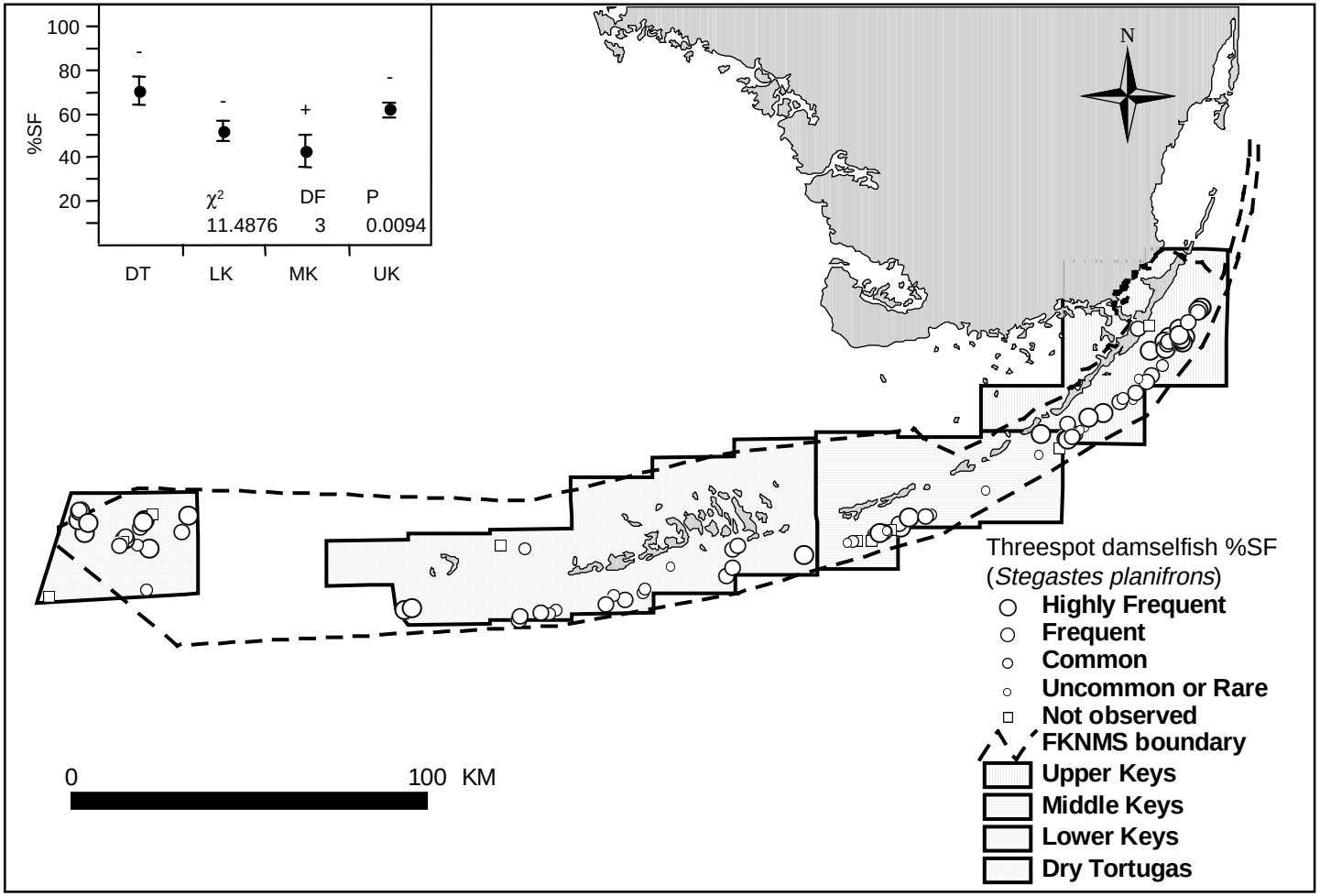


Figure 22. Spatial distribution and relative %SF threespot damselfish among regions of the Florida Keys. The scatterplot shows regional differences in mean %SF and tests for significant differences among means (Kruskal-Wallis Chi-Squared [χ^2] test, $\alpha = 0.05$; Tukey-Kramer HSD test, $\alpha = 0.05$). Means with the same symbols (+ or -) were not significantly different.

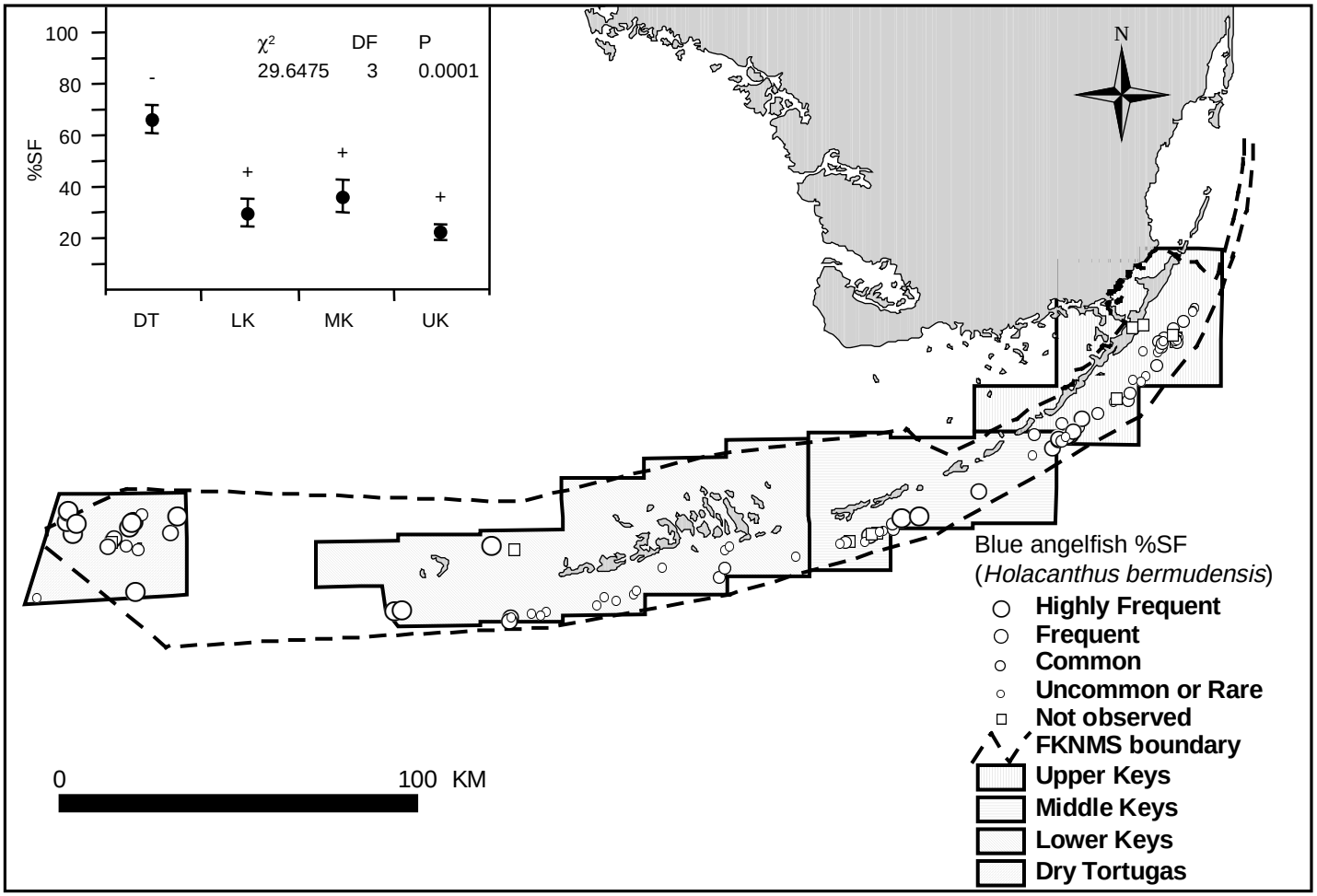


Figure 23. Spatial distribution and relative %SF of blue angelfish among regions of the Florida Keys. The scatterplot shows regional differences in mean %SF and tests for significant differences among means (Kruskal-Wallis Chi-Squared [χ^2] test, $\alpha = 0.05$; Tukey-Kramer HSD test, $\alpha = 0.05$). Means with the same symbols (+ or -) were not significantly different.

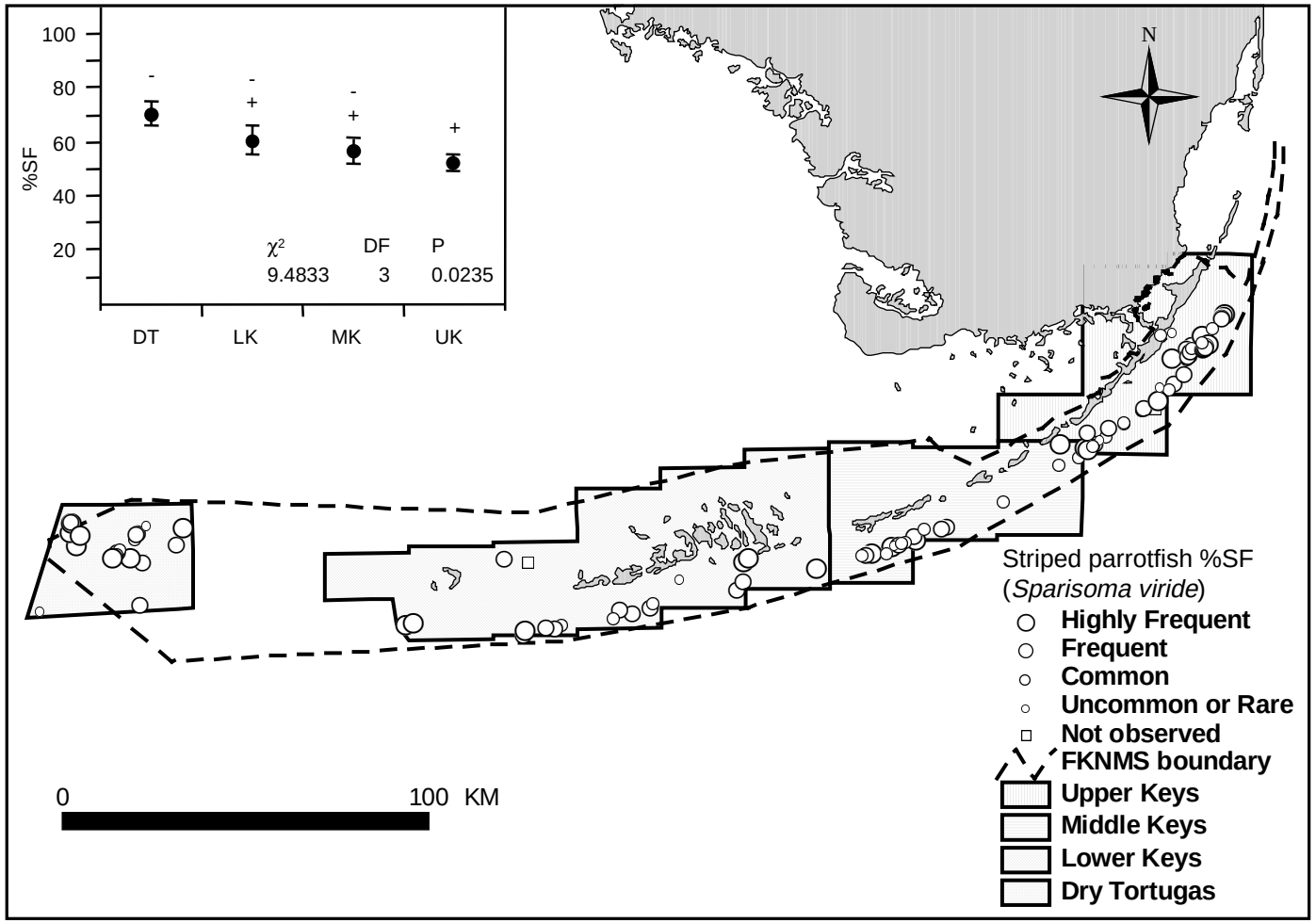


Figure 24. Spatial distribution and relative %SF of striped parrotfish among regions of the Florida Keys. The scatterplot shows regional differences in mean %SF and tests for significant differences among means (Kruskal-Wallis Chi-Squared [χ^2] test, $\alpha = 0.05$; Tukey-Kramer HSD test, $\alpha = 0.05$). Means with the same symbols (+ or -) were not significantly different.

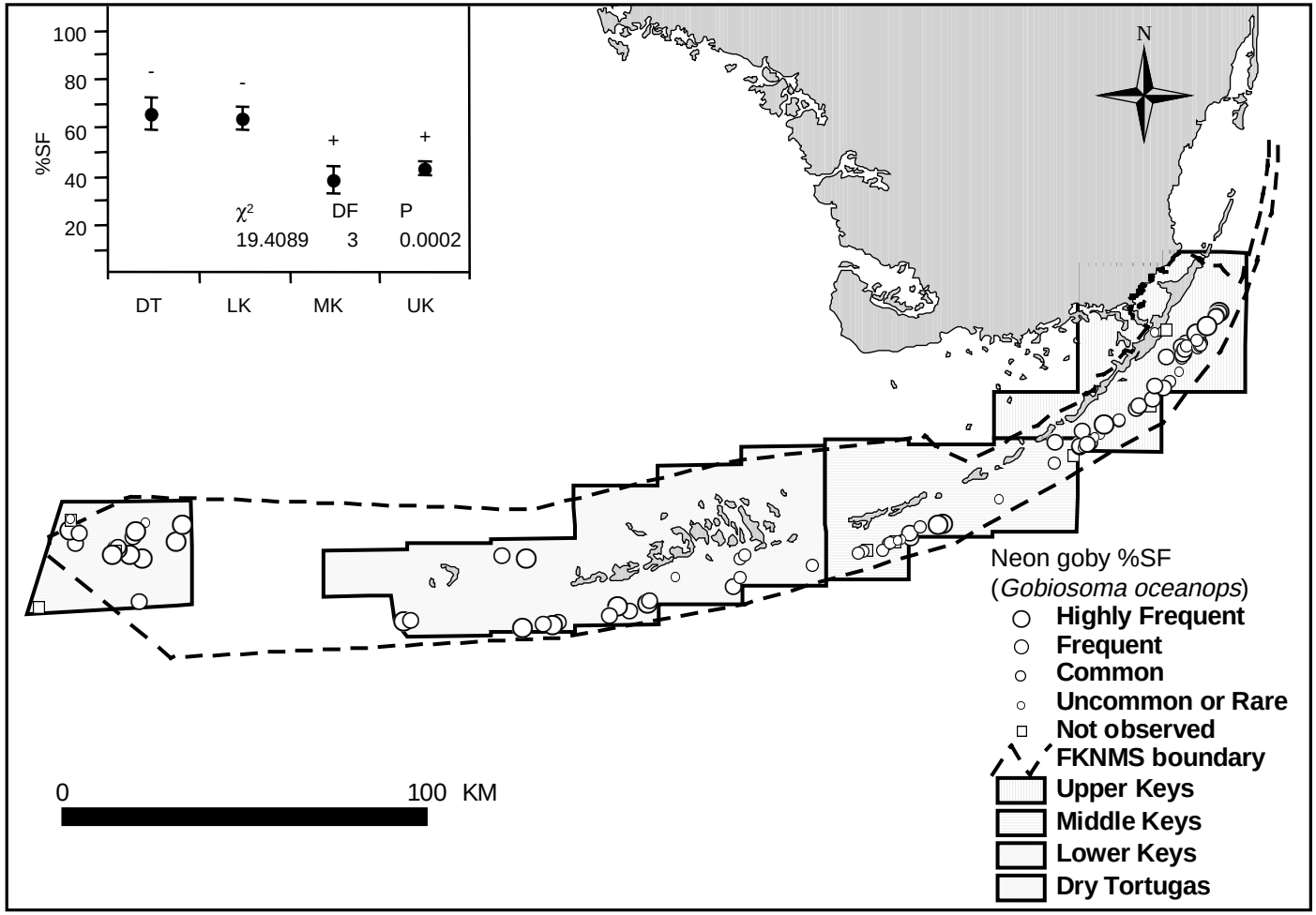


Figure 25. Spatial distribution and relative %SF of neon goby among regions of the Florida Keys. The scatterplot shows regional differences in mean %SF and tests for significant differences among means (Kruskal-Wallis Chi-Squared [χ^2] test, $\alpha = 0.05$; Tukey-Kramer HSD test, $\alpha = 0.05$). Means with the same symbols (+ or -) were not significantly different.

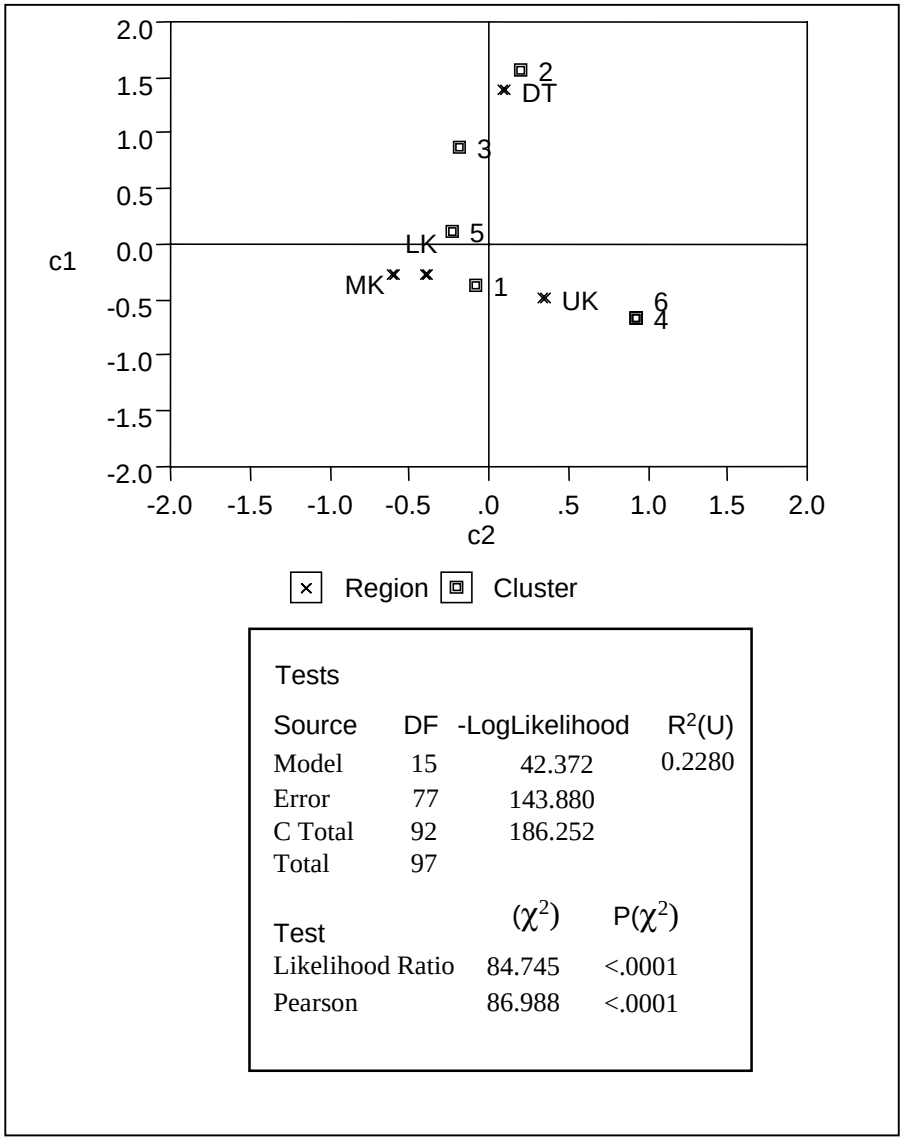
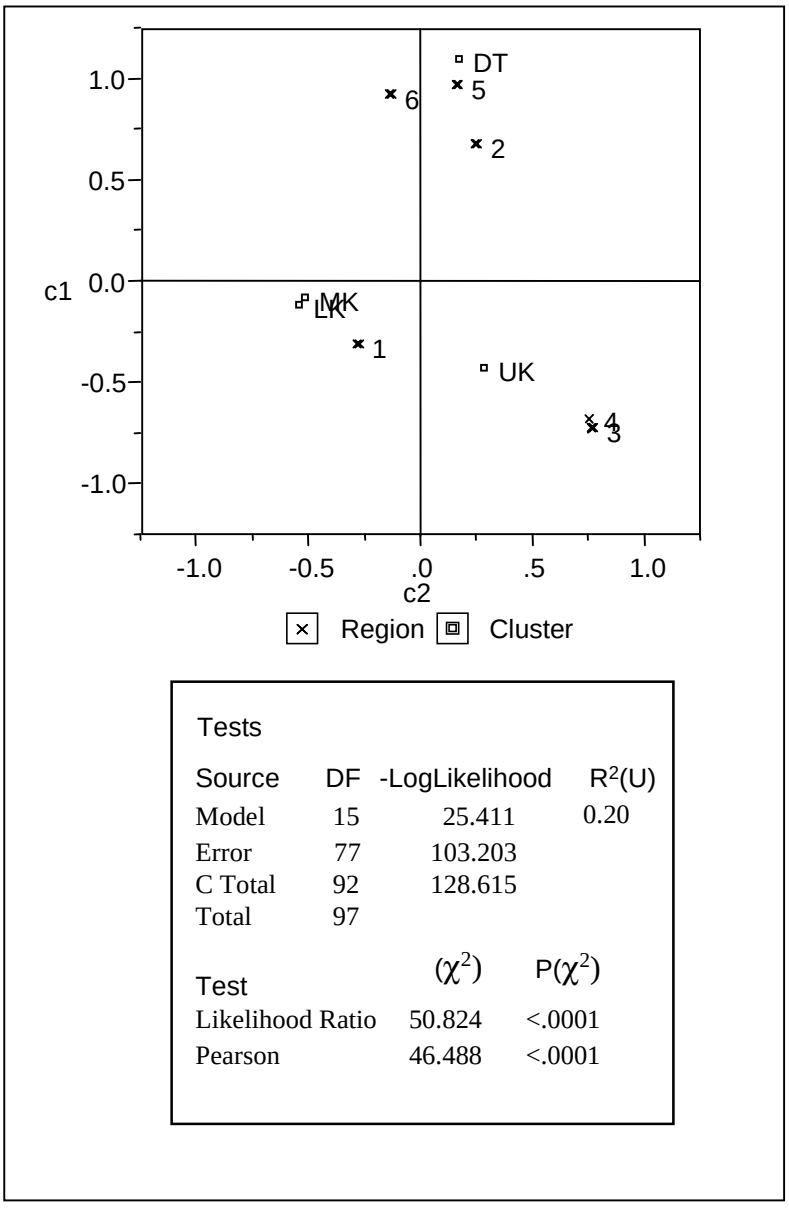


Figure 26. Correspondence analysis plot of associations among site clusters and regions of the FKNMS. Site clusters were identified from hierarchical clustering (Ward's minimum variance technique) of species composition (i.e. the presence or absence of a species at a given site). The table shows Chi-square (χ^2) and - log-likelihood tests of significant correlation among cluster groups and regions.



Tests

Source	DF	-LogLikelihood	$R^2(U)$
Model	15	25.411	0.20
Error	77	103.203	
C Total	92	128.615	
Total	97		

Test	(χ^2)	$P(\chi^2)$
Likelihood Ratio	50.824	<.0001
Pearson	46.488	<.0001

Figure 27. Correspondence analysis plot of associations among site clusters and regions of the FKNMS. Site clusters were identified from hierarchical clustering (Ward's minimum variance technique) of species frequency (%SF). The table shows Chi-square (χ^2) and - log-likelihood tests of significant correlation among cluster groups and regions.

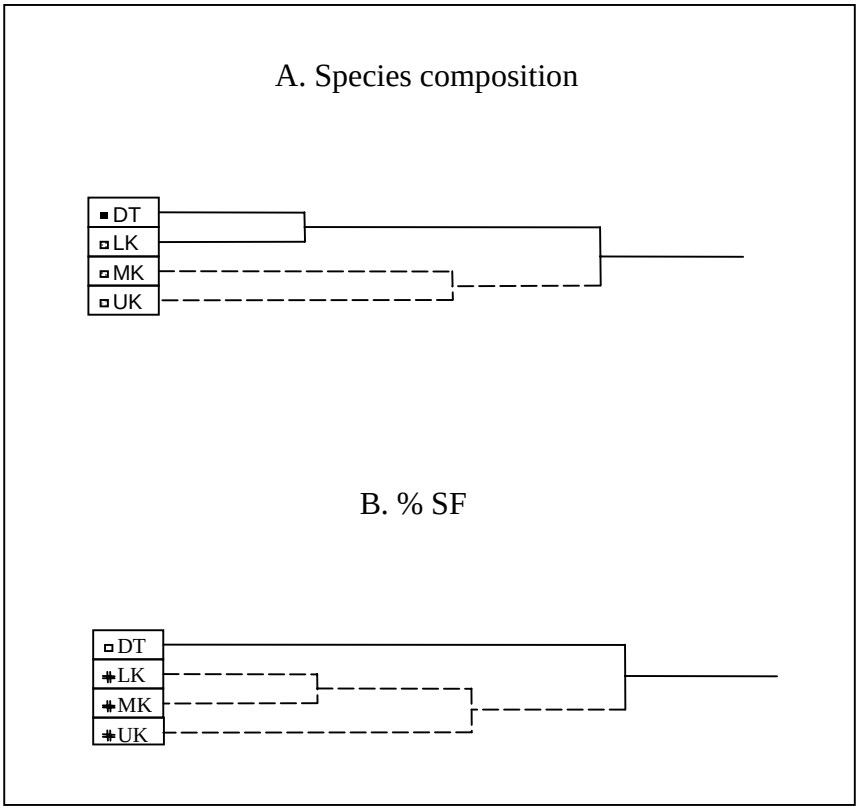


Figure 28. Dendograms from hierarchical clustering (Figures 26 and 27) showing similarities in (A) species composition and (B) species sighting frequency (%SF) among regions of the Florida Keys. Symbols (▫ or +) indicates regions which were most similar and clustered together.

Appendix 1. List of sites in the Florida Keys and Dry Tortugas surveyed by the Reef Environmental Education Foundation (REEF) volunteers between 1993 and 1999.

Location	Lat. (° N)	Long. (° W)	Surveys (no.)	Hours (tot.)	Species (tot.)
Upper Keys					
Carysfort Reef	25.2200	80.2123	63	60.2	209
Carysfort Deep Ledge	25.2200	80.2112	26	21.5	175
Carysfort Reef Johnny's Spot	25.2135	80.2168	49	52.5	200
South Carysfort Reef	25.2105	80.2172	65	66.6	202
Watson's Reef	25.1860	80.2425	3	3.0	132
Toadfish Flats (Hawks Ch.)	25.1792	80.3403	15	13.5	37
N. Carysfort - Fishbowl	25.1707	80.3680	12	11.7	120
Triple North (off Elbow)	25.1525	80.2673	7	7.1	102
Elpis Grounding Site	25.1483	80.2525	8	8.4	116
South-South Ledges E1	25.1473	80.2610	89	96.2	225
Civil War Wreck (Elbow)	25.1473	80.2577	8	6.3	99
City of Washington-E7/8	25.1460	80.2558	84	81.9	219
Anchor Chain E6	25.1450	80.2563	141	145.7	225
Mike's Wreck E4/5	25.1447	80.2568	87	83.3	216
The Fingers E3	25.1423	80.2577	46	44.7	204
Train Wheel E2	25.1420	80.2578	44	43.6	186
South Ledges E9	25.1403	80.2590	94	98.5	219
The Elbow	25.1388	80.2610	56	53.6	213
Horseshoe Reef	25.1387	80.3050	31	30.6	205
Spanish Anchor (Elbow)	25.1382	80.2600	4	4.0	127
NN Dry Rocks	25.1363	80.2903	84	80.5	215
Pecks Place / Cap Happy's	25.1343	80.2638	37	40.1	210
Spikes Ridge (off Elbow)	25.1333	80.2585	19	19.9	126
Minnow Caves/North Dry Rocks	25.1307	80.2943	64	64.1	213
Key Largo Dry Rocks	25.1225	80.2975	177	175.7	230
Little Grecian	25.1190	80.3002	48	52.6	201
Cannon Patch/Garret's Reef	25.1118	80.3417	22	21.3	104
Grecian Rocks	25.1098	80.3042	123	119.6	222
Dixie Ledge	25.0773	80.3110	16	11.1	131
Benwood Wreck	25.0527	80.3337	114	110.9	226
White Banks	25.0417	80.3700	29	27.2	91
French Reef	25.0353	80.3473	123	121.2	227
Molasses Reef	25.0090	80.3737	277	261.0	234
Wellwood Grounding Site	25.0083	80.3750	11	11.4	125
The Pillars	24.9922	80.4085	3	3.1	87
Duane	24.9880	80.3805	7	3.6	87
Pickles Reef	24.9862	80.4157	52	46.5	209
Horseshoe (Near Conch)	24.9567	80.4570	2	1.4	82
Conch Reef	24.9518	80.4595	106	102.5	219
Mutton Snapper Reef	24.9435	80.4953	26	27.3	195
Hens and Chickens	24.9317	80.5483	72	75.3	210
Davis Reef	24.9220	80.5060	123	132.9	222
Pleasure Reef	24.9135	80.5158	11	10.7	114
Crocker Ridges	24.9032	80.5302	15	14.7	176
Crockers Wall	24.9002	80.5313	47	34.6	193
Pocket, The	24.8982	80.5363	14	13.5	149
Fish Bowl	24.8933	80.5527	15	16.1	107
Aquarium Reef	24.8912	80.5555	20	22.3	171
Hammerhead Reef	24.8888	80.5468	6	5.5	152

Appendix 1 continued

Location	Lat. (° N)	Long. (° W)	Surveys (no.)	Hours (tot.)	Species (tot.)
Middle Keys					
Cheeca Rocks	24.9045	80.6155	28	30.5	110
Wreck of the Eagle	24.8695	80.5702	12	7.0	97
Alligator Reef	24.8512	80.6202	108	129.9	220
Tennessee Reef	24.7617	80.7550	57	67.6	195
Porkfish	24.7002	80.8938	5	5.3	104
Rusty's	24.6953	80.9058	4	4.3	89
Donut Reef	24.6918	80.9478	2	1.9	92
Coffins Patch	24.6767	80.9750	63	68.0	200
Horseshoe	24.6612	80.9942	14	14.5	163
Samantha's Ledge	24.6592	81.0040	66	71.3	210
Joanie's Reef	24.6563	81.0095	36	38.2	208
Joanie's Rock	24.6560	81.0098	4	4.3	95
Pot Holes	24.6517	81.0247	4	4.2	89
Hermans Behind	24.6510	81.0290	7	4.4	90
Herman's Hole	24.6505	81.0313	16	16.7	167
Boom Ledge	24.6353	81.0793	2	1.7	71
Lucille's Reef	24.6348	81.0415	4	4.2	86
Delta Shoals	24.6327	81.0900	18	17.2	115
Sombrero Reef	24.6283	81.1050	130	124.5	223
Lower Keys					
The Alexander	24.6232	81.9822	3	2.5	50
Newfound Open/Captain's Coral	24.6215	81.3805	12	8.3	79
Newfound Harbor Spa	24.6138	81.3953	12	9.2	87
Cottrel (Stingray)	24.6137	81.9213	2	2.0	36
No Name Reef	24.5965	81.2140	12	12.5	126
Nine Foot Stake	24.5683	81.5517	32	33.0	134
Looe Key - Research	24.5667	81.3933	32	31.6	183
Looe Key - East	24.5450	81.4083	48	52.4	204
Widow Fingers	24.5117	81.6172	38	40.5	190
Pelican Shoals	24.5020	81.6230	39	41.2	207
Middle Sambo	24.4952	81.6965	50	53.8	200
Eastern Sambo	24.4848	81.6648	63	69.4	213
Western Sambo	24.4730	81.7143	114	116.1	224
Research Site #1	24.4612	82.2047	18	21.8	155
Eastern Dry Rocks	24.4583	81.8407	57	55.1	203
Sand Key	24.4508	81.8778	100	102.8	223
Rock Key	24.4490	81.8563	51	50.5	210
Western Dry Rocks	24.4443	81.9305	39	35.5	150
Lost Reef	24.4433	81.9325	7	5.4	85
Trinity Cove	24.4338	81.9330	9	6.9	126

Appendix 1 continued

Location	Lat. (° N)	Long. (° W)	Surveys (no.)	Hours (tot.)	Species (tot.)
Dry Tortugas					
The Wall (before Carysfort)	25.1693	80.2663	2	2.2	87
Shark's Reef	25.1475	80.2927	20	20.7	175
Sherwood Forest	24.7115	83.0468	8	5.1	80
Robins Hood	24.7072	83.0475	7	4.0	64
Squid Row	24.7030	82.8593	10	8.5	60
Pulaski	24.6955	82.7713	31	29.4	172
Big Johnson	24.6843	82.8832	21	22.7	126
Oklahoma	24.6840	83.0505	7	6.8	81
Texas Rock	24.6817	82.8847	54	51.7	177
Cessies Peak (aka Bird In Hand)	24.6782	83.0375	6	5.0	84
Wreck Reef (Tortugas Banks)	24.6765	83.0242	13	9.9	113
Juanita's Reef	24.6672	82.8920	37	38.0	149
The Gap	24.6660	80.9718	4	2.9	123
Blenny flats	24.6553	82.7877	16	17.7	86
G-Spot (near Pinnacles)	24.6538	83.0333	13	11.2	120
Oasis	24.6442	82.9295	18	16.8	97
Loggerhead Nursery	24.6385	82.9320	20	23.4	106
SW Loggerhead	24.6318	82.9362	2	2.0	16
Garlic Gardens (near Bird Key)	24.6217	82.9005	6	7.2	73
Windjammer Site	24.6212	82.9430	7	8.0	105
Bird Key	24.6128	82.8713	72	63.2	142
Simon's Hump	24.5077	82.8775	18	11.7	105
Riley's hump	24.4937	83.1218	13	7.9	94
Cuda Reef/Marquesas Rock	24.4593	82.2245	6	7.1	113

Appendix 2. Species list for the Flordia Keys and Dry Tortugas.

Family	Common family	Species	Common species
Acanthuridae	Surgeonfish	*Acanthurus coeruleus*	Blue Tang
Acanthuridae	Surgeonfish	*Acanthurus chirurgus*	Doctorfish
Acanthuridae	Surgeonfish	*Acanthurus bahianus*	Ocean Surgeonfish
Antennariidae	Frogfish	*Antennarius multiocellatus*	Longlure Frogfish
Apogonidae	Cardinalfish	*Apogon binotatus*	Barred Cardinalfish
Apogonidae	Cardinalfish	*Apogon townsendi*	Belted Cardinalfish
Apogonidae	Cardinalfish	*Apogon affinis*	Bigtooth Cardinalfish
Apogonidae	Cardinalfish	*Apogon aurolineatus*	Bridle Cardinalfish
Apogonidae	Cardinalfish	*Apogon maculatus*	Flamefish
Apogonidae	Cardinalfish	*Apogon planifrons*	Pale Cardinalfish
Apogonidae	Cardinalfish	*Apogon robinsi*	Roughlip Cardinalfish
Apogonidae	Cardinalfish	*Apogon quadrisquamatus*	Sawcheek Cardinalfish
Apogonidae	Cardinalfish	*Apogon pseudomaculatus*	Twospot Cardinalfish
Apogonidae	Cardinalfish	*Apogon lachneri*	Whitestar Cardinalfish
Apogonidae	Cardinalfish	*Astrapogon puncticulatus*	Blackfin Cardinalfish
Apogonidae	Cardinalfish	*Astrapogon stellatus*	Conchfish
Apogonidae	Cardinalfish	*Phaeoptyx pigmentaria*	Dusky Cardinalfish
Apogonidae	Cardinalfish	*Phaeoptyx xenus*	Sponge Cardinalfish
Atherinidae/ Clupeidae/ Engraulidae	Silversides, Herrings, Anchovies		
Aulostomidae	Trumpetfish	*Aulostomus maculatus*	Trumpetfish
Balistidae	Leatherjacket	*Aluterus schoepfi*	Orange Filefish
Balistidae	Leatherjacket	*Aluterus scriptus*	Scrawled Filefish
Balistidae	Leatherjacket	*Balistes capriscus*	Gray Triggerfish
Balistidae	Leatherjacket	*Balistes vetula*	Queen Triggerfish
Balistidae	Leatherjacket	*Cantherhines pullus*	Orangespotted Filefish
Balistidae	Leatherjacket	*Cantherhines macrocerus*	Whitespotted Filefish
Balistidae	Leatherjacket	*Canthidermis sufflamen*	Ocean Triggerfish
Balistidae	Leatherjacket	*Canthidermis maculata*	Rough Triggerfish
Balistidae	Leatherjacket	*Melichthys niger*	Black Durgon
Balistidae	Leatherjacket	*Monacanthus ciliatus*	Fringed Filefish
Balistidae	Leatherjacket	*Monacanthus hispidus*	Planehead Filefish
Balistidae	Leatherjacket	*Monacanthus setifer*	Pygmy Filefish
Balistidae	Leatherjacket	*Monacanthus tuckeri*	Slender Filefish
Batrachoididae	Toadfish	*Opsanus tau*	Oyster Toadfish
Belonidae	Needlefish	*Playbelone argalus*	Keeltail Needlefish
Belonidae	Needlefish	*Strongylura marina*	Atlantic Needlefish
Belonidae	Needlefish	*Strongylura notata*	Redfin Needlefish
Belonidae	Needlefish	*Tylosurus crocodilus*	Houndfish
Blenniidae	Blenny	*Hypleurochilus bermudensis*	Barred Blenny
Blenniidae	Blenny	*Ophioblennius atlanticus*	Redlip Blenny
Blenniidae	Blenny	*Parablennius marmoreus*	Seaweed Blenny
Blenniidae	Blenny	*Scartella cristata*	Molly Miller
Bothidae	Flounder	*Bothus ocellatus*	Eyed Flounder
Bothidae	Flounder	*Bothus lunatus*	Peacock Flounder
Bothidae	Flounder	*Paralichthys albigutta*	Gulf Flounder
Bothidae	Flounder	*Syacium micrurum*	Channel Flounder
Callionymidae	Dragonet	*Diplogrammus pauciradiatus*	Spotted Dragonet
Callionymidae	Dragonet	*Paradiplogrammus bairdi*	Lancer (coral) Dragonet
Carangidae	Jack	*Alectis ciliaris*	African Pompano (Threadfin/threadfish)
Carangidae	Jack	*Caranx ruber*	Bar Jack (Skipjack)
Carangidae	Jack	*Caranx lugubris*	Black Jack
Carangidae	Jack	*Caranx crysos*	Blue Runner (Hard-tailed Jack)
Carangidae	Jack	*Caranx hippos*	Crevalle Jack
Carangidae	Jack	*Caranx latus*	Horse-Eye Jack
Carangidae	Jack	*Caranx bartholomaei*	Yellow Jack
Carangidae	Jack	*Decapterus macarellus*	Mackerel Scad
Carangidae	Jack	*Elagatis bipinnulata*	Rainbow Runner
Carangidae	Jack	*Seriola rivoliana*	Almaco Jack
Carangidae	Jack	*Seriola dumerili*	Greater Amberjack
Carangidae	Jack	*Trachinotus goodei*	Palometa (Gaftopsail Pompano/Longfin Pompano)
Carangidae	Jack	*Trachinotus falcatus*	Permit (Round Pompano)
Carcharhinidae	Requiem Shark	*Carcharhinus limbatus*	Blacktip Shark

Appendix 2 continued

Family	Common family	Species	Common species
Carcharhinidae	Requiem Shark	*Carcharhinus perezi*	Reef Shark
Centropomidae	Snook	*Centropomus undecimalis*	Common Snook
Chaetodontidae	Butterflyfish	*Chaetodon striatus*	Banded Butterflyfish
Chaetodontidae	Butterflyfish	*Chaetodon capistratus*	Foureye Butterflyfish
Chaetodontidae	Butterflyfish	*Chaetodon aculeatus*	Longsnout Butterflyfish
Chaetodontidae	Butterflyfish	*Chaetodon sedentarius*	Reef Butterflyfish
Chaetodontidae	Butterflyfish	*Chaetodon ocellatus*	Spotfin Butterflyfish
Cirrhitidae	Hawkfish	*Amblycirrhitus pinos*	Redspotted Hawkfish
Clinidae	Blenny	*Acanthemblemaria chaplini*	Papillose Blenny
Clinidae	Blenny	*Acanthemblemaria aspera*	Roughhead Blenny
Clinidae	Blenny	*Acanthemblemaria maria*	Secretary Blenny
Clinidae	Blenny	*Acanthemblemaria spinosa*	Spinyhead Blenny
Clinidae	Blenny	*Chaenopsis limbaughi*	Yellowface Pikeblenny
Clinidae	Blenny	*Coralliozetus bahamensis*	Blackhead Blenny
Clinidae	Blenny	*Emblemaria pandionis*	Sailfin Blenny
Clinidae	Blenny	*Hemiemblemaria simulus*	Wrasse Blenny
Congridae	Conger	*Heteroconger halis*	Brown Garden Eel
Coryphanidae	Dolphin	*Coryphaena hippurus*	Dolphin (Mahi-Mahi)
Dasyatidae	Stingray	*Dasyatis americana*	Southern Stingray
Echeneidae	Remora	*Echeneis naucrates*	Sharksucker
Echeneidae	Remora	*Echeneis neucratoides*	Whitefin Sharksucker
Echeneidae	Remora	*Remora remora*	Remora
Elopidae	Tarpon	*Megalops atlanticus*	Tarpon
Ephippidae	Spadefish	*Chaetodipterus faber*	Atlantic Spadefish
Exocoetidae	Flyingfish/Halfbeak	*Hemiramphus brasiliensis*	Ballyhoo
Exocoetidae	Flyingfish/Halfbeak	*Hirundichthys speculiger*	Mirrorwing Flyingfish
Fistulariidae	Cornetfish	*Fistularia tabacaria*	Bluespotted Cornetfish
Gerreidae	Mojarra	*Eucinostomus jonesi*	Slender Mojarra
Gerreidae	Mojarra	*Gerres cinereus*	Yellowfin Mojarra
Gobiidae	Goby	*Bollmannia boqueronensis*	White-eye Goby
Gobiidae	Goby	*Coryphopterus glaucofraenum*	Bridled Goby
Gobiidae	Goby	*Coryphopterus dicrus*	Colon Goby
Gobiidae	Goby	*Coryphopterus personatus/hyalinus*	Masked Goby/Glass Goby
Gobiidae	Goby	*Coryphopterus eidolon*	Pallid Goby
Gobiidae	Goby	*Coryphopterus lipernes*	Peppermint Goby
Gobiidae	Goby	*Coryphopterus punctipectophorus*	Spotted Goby
Gobiidae	Goby	*Gnatholepis thompsoni*	Goldspot Goby
Gobiidae	Goby	*Gobionellus saepepallens*	Dash Goby
Gobiidae	Goby	*Gobionellus stigmalophius*	Spotfin Goby
Gobiidae	Goby	*Gobiosoma illecebrosum*	Barsnout Goby
Gobiidae	Goby	*Gobiosoma prochilos*	Broadstripe Goby
Gobiidae	Goby	*Gobiosoma genie*	Cleaning Goby
Gobiidae	Goby	*Gobiosoma saucrum*	Leopard Goby
Gobiidae	Goby	*Gobiosoma oceanops*	Neon Goby
Gobiidae	Goby	*Gobiosoma dilepsis*	Orangesided Goby
Gobiidae	Goby	*Gobiosoma grosvenori*	Rockcut Goby
Gobiidae	Goby	*Gobiosoma evelynae*	Sharknose Goby
Gobiidae	Goby	*Gobiosoma louisae*	Spotlight Goby
Gobiidae	Goby	*Gobiosoma macrodon*	Tiger Goby
Gobiidae	Goby	*Gobiosoma horsti*	Yellowline Goby
Gobiidae	Goby	*Gobiosoma randalli*	Yellownose Goby
Gobiidae	Goby	*Gobiosoma xanthiprora*	Yellowprow Goby
Gobiidae	Goby	*Ioglossus calliuris*	Blue Goby
Gobiidae	Goby	*Ioglossus helenae*	Hovering Goby
Gobiidae	Goby	*Lophogobius cyprinoides*	Crested Goby
Gobiidae	Goby	*Microgobius microlepis*	Banner Goby
Gobiidae	Goby	*Microgobius carri*	Seminole Goby
Gobiidae	Goby	*Nes longus*	Orangespotted Goby
Gobiidae	Goby	*Priolepis hipoliti*	Rusty Goby
Gobiidae	Goby	*Risor ruber*	Tusked Goby
Grammatidae	Basslet	*Gramma melacara*	Blackcap Basslet
Grammatidae	Basslet	*Gramma loreto*	Fairy Basslet (Royal gramma)
Haemulidae	Grunt	*Anisotremus surinamensis*	Black Margate
Haemulidae	Grunt	*Anisotremus virginicus*	Porkfish

Appendix 2 continued

Family	Common family	Species	Common species
Haemulidae	Grunt	*Haemulon bonariense*	Black Grunt
Haemulidae	Grunt	*Haemulon sciurus*	Bluestriped Grunt
Haemulidae	Grunt	*Haemulon carbonarium*	Caesar Grunt
Haemulidae	Grunt	*Haemulon melanurum*	Cottonwick
Haemulidae	Grunt	*Haemulon flavolineatum*	French Grunt
Haemulidae	Grunt	*Haemulon parra*	Sailors Choice
Haemulidae	Grunt	*Haemulon chrysargyreum*	Smallmouth Grunt
Haemulidae	Grunt	*Haemulon macrostomum*	Spanish Grunt
Haemulidae	Grunt	*Haemulon striatum*	Striped Grunt
Haemulidae	Grunt	*Haemulon aurolineatum*	Tomtate
Haemulidae	Grunt	*Haemulon plumieri*	White Grunt
Haemulidae	Grunt	*Haemulon album*	White Margate
Haemulidae	Grunt	*Orthopristis chrysoptera*	Pigfish
Holocentridae	Squirrelfish	*Holocentrus vexillarius*	Dusky Squirrelfish
Holocentridae	Squirrelfish	*Holocentrus marianus*	Longjaw Squirrelfish
Holocentridae	Squirrelfish	*Holocentrus rufus*	Longspine Squirrelfish
Holocentridae	Squirrelfish	*Holocentrus coruscum*	Reef Squirrelfish
Holocentridae	Squirrelfish	*Holocentrus adscensionis*	Squirrelfish
Holocentridae	Squirrelfish	*Myripristis jacobus*	Blackbar Soldierfish
Holocentridae	Squirrelfish	*Plectrypops retrospinis*	Cardinal Soldierfish
Inermiidae	Bonnetmouth	*Emmelichthyops atlanticus*	Bonnetmouth
Inermiidae	Bonnetmouth	*Inermia vittata*	Boga
Kyphosidae	Chub	*Kyphosus sectatrix/incisor*	Bermuda Chub/Yellow Chub
Labridae	Wrasse	*Bodianus rufus*	Spanish Hogfish
Labridae	Wrasse	*Bodianus pulchellus*	Spotfin Hogfish
Labridae	Wrasse	*Clepticus parrae*	Creole Wrasse
Labridae	Wrasse	*Doratonotus megalepis*	Dwarf Wrasse
Labridae	Wrasse	*Halichoeres poeyi*	Blackear Wrasse
Labridae	Wrasse	*Halichoeres maculipinna*	Clown Wrasse
Labridae	Wrasse	*Halichoeres radiatus*	Puddingwife
Labridae	Wrasse	*Halichoeres pictus*	Rainbow (painted) Wrasse
Labridae	Wrasse	*Halichoeres bivittatus*	Slippery Dick
Labridae	Wrasse	*Halichoeres cyanocephalus*	Yellowcheek Wrasse
Labridae	Wrasse	*Halichoeres garnoti*	Yellowhead Wrasse
Labridae	Wrasse	*Hemipteronotus splendens*	Green Razorfish
Labridae	Wrasse	*Hemipteronotus novacula*	Pearly Razorfish
Labridae	Wrasse	*Hemipteronotus martinicensis*	Rosy Razorfish
Labridae	Wrasse	*Lachnolaimus maximus*	Hogfish
Labridae	Wrasse	*Thalassoma bifasciatum*	Bluehead
Lutjanidae	Snapper	*Lutjanus buccanella*	Blackfin Snapper
Lutjanidae	Snapper	*Lutjanus cyanopterus*	Cubera Snapper
Lutjanidae	Snapper	*Lutjanus jocu*	Dog Snapper
Lutjanidae	Snapper	*Lutjanus griseus*	Gray (mangrove) Snapper
Lutjanidae	Snapper	*Lutjanus synagris*	Lane Snapper
Lutjanidae	Snapper	*Lutjanus mahogoni*	Mahogany Snapper
Lutjanidae	Snapper	*Lutjanus analis*	Mutton Snapper
Lutjanidae	Snapper	*Lutjanus apodus*	Schoolmaster
Lutjanidae	Snapper	*Ocyurus chrysurus*	Yellowtail Snapper
Malacanthidae	Tilefish	*Malacanthus plumieri*	Sand Tilefish
Mugilidae	Mullet	*Mugil cephalus*	Striped Mullet
Mullidae	Goatfish	*Mulloidichthys martinicus*	Yellow Goatfish
Mullidae	Goatfish	*Mullus auratus*	Red Goatfish
Mullidae	Goatfish	*Pseudupeneus maculatus*	Spotted Goatfish
Muraenidae	Moray	*Echidna catenata*	Chain Moray
Muraenidae	Moray	*Enchelycore carychroa*	Chestnut Moray
Muraenidae	Moray	*Enchelycore nigricans*	Viper Moray
Muraenidae	Moray	*Gymnothorax miliaris*	Goldentail Moray
Muraenidae	Moray	*Gymnothorax funebris*	Green Moray
Muraenidae	Moray	*Gymnothorax vicinus*	Purplemouth Moray
Muraenidae	Moray	*Gymnothorax moringa*	Spotted Moray
Myliobatidae	Eagle Ray	*Aetobatus narinari*	Spotted Eagle Ray
Ogcocephalidae	Batfish	*Ogcocephalus radiatus*	Polka-dot Batfish
Ophichthidae	Snake Eel	*Myrichthys ocellatus*	Goldspotted Eel
Opistognathidae	Jawfish	*Opistognathus macrognathus*	Banded Jawfish

Appendix 2 continued

Family	Common family	Species	Common species
Opistognathidae	Jawfish	*Opistognathus whitehursti*	Dusky Jawfish
Opistognathidae	Jawfish	*Opistognathus aurifrons*	Yellowhead Jawfish
Ostraciidae	Boxfish	*Lactophrys trigonus*	BuffaloTrunkfish
Ostraciidae	Boxfish	*Lactophrys polygonia*	Honeycomb Cowfish
Ostraciidae	Boxfish	*Lactophrys quadricornis*	Scrawled Cowfish
Ostraciidae	Boxfish	*Lactophrys triqueter*	Smooth Trunkfish
Ostraciidae	Boxfish	*Lactophrys bicaudalis*	Spotted Trunkfish
Pempheridae	Sweeper	*Pempheris schomburgki*	Glassy Sweeper (Copper Sweeper/Hatchetfish)
Pomacanthidae	Angelfish	*Centropyge argi*	Cherubfish
Pomacanthidae	Angelfish	*Holacanthus bermudensis*	Blue Angelfish
Pomacanthidae	Angelfish	*Holacanthus ciliaris*	Queen Angelfish
Pomacanthidae	Angelfish	*Holacanthus tricolor*	Rock Beauty
Pomacanthidae	Angelfish	*Holacanthus sp. (Hybrid)*	Townsend Angelfish
Pomacanthidae	Angelfish	*Pomacanthus paru*	French Angelfish
Pomacanthidae	Angelfish	*Pomacanthus arcuatus*	Gray Angelfish
Pomacentridae	Damselfish	*Abudefduf taurus*	Night Sergeant
Pomacentridae	Damselfish	*Abudefduf saxatilis*	Sergeant Major
Pomacentridae	Damselfish	*Chromis cyanea*	Blue Chromis
Pomacentridae	Damselfish	*Chromis multilineata*	Brown Chromis
Pomacentridae	Damselfish	*Chromis scotti*	Purple Reeffish
Pomacentridae	Damselfish	*Chromis insolata*	Sunshinefish
Pomacentridae	Damselfish	*Chromis enchrysura*	Yellowtail Reeffish
Pomacentridae	Damselfish	*Microspathodon chrysurus*	Yellowtail Damselfish
Pomacentridae	Damselfish	*Stegastes leucostictus*	Beaugregory
Pomacentridae	Damselfish	*Stegastes partitus*	Bicolor Damselfish
Pomacentridae	Damselfish	*Stegastes variabilis*	Cocoa Damselfish
Pomacentridae	Damselfish	*Stegastes fuscus*	Dusky Damselfish
Pomacentridae	Damselfish	*Stegastes diencaeus*	Longfin Damselfish
Pomacentridae	Damselfish	*Stegastes planifrons*	Threespot Damselfish
Priacanthidae	Bigeye	*Priacanthus arenatus*	Bigeye
Priacanthidae	Bigeye	*Priacanthus cruentatus*	Glasseye Snapper
Rachycentridae	Cobia	*Rachycentron canadum*	Cobia
Rhincodontidae	Carpet Shark	*Ginglymostoma cirratum*	Nurse Shark
Rhinobatidae	Guitarfish	*Rhinobatos lentiginosus*	Atlantic Guitarfish
Rhinobatidae	Guitarfish	*Rhinobatos percellens*	Southern Guitarfish
Scaridae	Parrotfish	*Cryptotomus roseus*	Bluelip Parrotfish (Rosy Parrotfish/Slender Parrotfish)
Scaridae	Parrotfish	*Nicholsina usta*	Emerald Parrotfish
Scaridae	Parrotfish	*Scarus coeruleus*	Blue Parrotfish
Scaridae	Parrotfish	*Scarus coelestinus*	Midnight Parrotfish
Scaridae	Parrotfish	*Scarus taeniopterus*	Princess Parrotfish
Scaridae	Parrotfish	*Scarus vetula*	Queen Parrotfish
Scaridae	Parrotfish	*Scarus guacamaia*	Rainbow Parrotfish
Scaridae	Parrotfish	*Scarus croicensis*	Striped Parrotfish
Scaridae	Parrotfish	*Sparisoma radians*	Bucktooth Parrotfish
Scaridae	Parrotfish	*Sparisoma atomarium*	Greenblotch Parrotfish
Scaridae	Parrotfish	*Sparisoma aurofrenatum*	Redband Parrotfish
Scaridae	Parrotfish	*Sparisoma rubripinne*	Redfin (yellowtail) Parrotfish
Scaridae	Parrotfish	*Sparisoma chrysopterum*	Redtail Parrotfish
Scaridae	Parrotfish	*Sparisoma viride*	Stoplight Parrotfish
Sciaenidae	Drum	*Bairdiella sanctaeluciae*	Striped Croaker
Sciaenidae	Drum	*Equetus umbrosus*	Cubbyu
Sciaenidae	Drum	*Equetus acuminatus*	Highhat
Sciaenidae	Drum	*Equetus lanceolatus*	Jackknife-Fish
Sciaenidae	Drum	*Equetus punctatus*	Spotted Drum
Sciaenidae	Drum	*Odontoscion dentex*	Reef Croaker
Scombridae	Mackerel	*Acanthocybium solandri*	Wahoo
Scombridae	Mackerel	*Scomberomorus regalis*	Cero
Scombridae	Mackerel	*Scomberomorus maculatus*	Spanish Mackerel
Scorpaenidae	Scorpionfish	*Scorpaena plumieri*	Spotted Scorpionfish
Scorpaenidae	Scorpionfish	*Scorpaenodes caribbaeus*	Reef Scorpionfish
Serranidae	Seabass	*Alphestes afer*	Mutton Hamlet
Serranidae	Seabass	*Diplectrum bivittatum*	Dwarf Sand Perch

Appendix 2 continued

Family	Common family	Species	Common species
Serranidae	Seabass	*Diplectrum formosum*	Sand Perch
Serranidae	Seabass	*Epinephelus fulvus*	Coney
Serranidae	Seabass	*Epinephelus cruentatus*	Graysby (Kitty Mitchell)
Serranidae	Seabass	*Epinephelus itajara*	Jewfish
Serranidae	Seabass	*Epinephelus striatus*	Nassau Grouper
Serranidae	Seabass	*Epinephelus morio*	Red Grouper
Serranidae	Seabass	*Epinephelus guttatus*	Red Hind (Speckled Hind/Strawberry Grouper)
Serranidae	Seabass	*Epinephelus adscensionis*	Rock Hind
Serranidae	Seabass	*Epinephelus nigritus*	Warsaw Grouper
Serranidae	Seabass	*Hypoplectrus puella*	Barred Hamlet
Serranidae	Seabass	*Hypoplectrus nigricans*	Black Hamlet
Serranidae	Seabass	*Hypoplectrus gemma*	Blue Hamlet
Serranidae	Seabass	*Hypoplectrus unicolor*	Butter Hamlet
Serranidae	Seabass	*Hypoplectrus gummigutta*	Golden Hamlet
Serranidae	Seabass	*Hypoplectrus (Hybrid)*	Hybrid Hamlet
Serranidae	Seabass	*Hypoplectrus indigo*	Indigo Hamlet
Serranidae	Seabass	*Hypoplectrus sp.*	Masked Hamlet
Serranidae	Seabass	*Hypoplectrus guttavarius*	Shy Hamlet
Serranidae	Seabass	*Hypoplectrus sp.*	Tan Hamlet
Serranidae	Seabass	*Hypoplectrus aberrans*	Yellowbelly Hamlet
Serranidae	Seabass	*Hypoplectrus chlorurus*	Yellowtail Hamlet
Serranidae	Seabass	*Liopropoma carmabi*	Candy Bass
Serranidae	Seabass	*Liopropoma rubre*	Peppermint Bass
Serranidae	Seabass	*Mycteroperca bonaci*	Black Grouper
Serranidae	Seabass	*Mycteroperca rubra*	Comb Grouper
Serranidae	Seabass	*Mycteroperca microlepis*	Gag
Serranidae	Seabass	*Mycteroperca phenax*	Scamp (Salmon Rockfish)
Serranidae	Seabass	*Mycteroperca tigris*	Tiger Grouper
Serranidae	Seabass	*Mycteroperca venenosa*	Yellowfin Grouper
Serranidae	Seabass	*Mycteroperca interstitialis*	Yellowmouth Grouper
Serranidae	Seabass	*Paranthias furcifer*	Creole-fish
Serranidae	Seabass	*Rypticus bistrispinus*	Freckled Soapfish
Serranidae	Seabass	*Rypticus saponaceus*	Greater Soapfish
Serranidae	Seabass	*Rypticus subbifrenatus*	Spotted Soapfish
Serranidae	Seabass	*Rypticus maculatus*	Whitespotted Soapfish
Serranidae	Seabass	*Serranus subligarius*	Belted Sandfish (Belted Sand Bass)
Serranidae	Seabass	*Serranus tortugarum*	Chalk Bass
Serranidae	Seabass	*Serranus tigrinus*	Harlequin Bass
Serranidae	Seabass	*Serranus baldwini*	Lantern Bass
Serranidae	Seabass	*Serranus annularis*	Orangeback Bass
Serranidae	Seabass	*Serranus tabacarius*	Tobaccofish
Sparidae	Porgy	*Archosargus rhomboidalis*	Sea Bream
Sparidae	Porgy	*Archosargus probatocephalus*	Sheepshead
Sparidae	Porgy	*Calamus bajonado*	Jolthead Porgy
Sparidae	Porgy	*Calamus nodosus*	Knobbed Porgy
Sparidae	Porgy	*Calamus proridens*	Littlehead Porgy
Sparidae	Porgy	*Calamus pennatula*	Pluma
Sparidae	Porgy	*Calamus calamus*	Saucereye Porgy
Sparidae	Porgy	*Calamus penna*	Sheepshead Porgy
Sparidae	Porgy	*Diplodus argenteus*	Silver Porgy
Sparidae	Porgy	*Diplodus holbrooki*	Spottail Pinfish
Sparidae	Porgy	*Lagodon rhomboides*	Pinfish
Sphyraenidae	Barracuda	*Sphyraena barracuda*	Great Barracuda
Sphyraenidae	Barracuda	*Sphyraena picudilla*	Southern Sennet
Sphyrnidae	Hammerhead Shark	*Sphyrna tiburo*	Bonnethead
Sphyrnidae	Hammerhead Shark	*Sphyrna mokarran*	Great Hammerhead
Sphyrnidae	Hammerhead Shark	*Sphyrna lewini*	Scalloped Hammerhead
Syngnathidae	Pipefish & Seahorse	*Cosmocampus elucens*	Shortfin Pipefish
Syngnathidae	Pipefish & Seahorse	*Micrognathus ensenadae*	Harlequin Pipefish
Synodontidae	Lizardfish	*Synodus saurus*	Bluestriped Lizardfish
Synodontidae	Lizardfish	*Synodus foetens*	Inshore Lizardfish
Synodontidae	Lizardfish	*Synodus synodus*	Red Lizardfish (Rockspear)
Synodontidae	Lizardfish	*Synodus intermedius*	Sand Diver

Appendix 2 continued

Family	Common family	Species	Common species
Tetraodontidae	Puffer	*Canthigaster rostrata*	Sharpnose Puffer
Tetraodontidae	Puffer	*Chilomycterus antennatus*	Bridled Burrfish
Tetraodontidae	Puffer	*Chilomycterus schoepfi*	Striped Burrfish
Tetraodontidae	Puffer	*Chilomycterus antillarum*	Web Burrfish
Tetraodontidae	Puffer	*Diodon holocanthus*	Balloonfish (Spiny Puffer)
Tetraodontidae	Puffer	*Diodon hystrix*	Porcupinefish (Spotted Spiny Puffer)
Tetraodontidae	Puffer	*Sphoeroides spengleri*	Bandtail Puffer
Tetraodontidae	Puffer	*Sphoeroides greeleyi*	Caribbean Puffer
Tetraodontidae	Puffer	*Sphoeroides testudineus*	Checkered Puffer
Tetraodontidae	Puffer	*Sphoeroides nephelus*	Southern Puffer
Torpedinidae	Electric Ray	*Narcine brasiliensis*	Lesser Electric Ray
Tripterygiidae	Triplefins	*Enneanectes altivelis*	Lofty Triplefin
Tripterygiidae	Triplefins	*Enneanectes pectoralis*	Redeye Triplefin
Urolophidae	Round Stingrays	*Urolophus jamaicensis*	Yellow Stingray
Stromateidae	Butterfishes	*Nomeus gronovii*	Man-of-war Fish
Carapidae	Carapuds	*Carapus bermudensis*	Pearlfish
Labrisomidae	Labrisomids	*Labrisomus kalisherae*	Downy Blenny
Labrisomidae	Labrisomids	*Labrisomus nuchipinnis*	Hairy Blenny
Labrisomidae	Labrisomids	*Labrisomus gobio*	Palehead Blenny
Labrisomidae	Labrisomids	*Labrisomus bucciferus*	Puffcheek Blenny
Labrisomidae	Labrisomids	*Malacoctenus versicolor*	Barfin Blenny
Labrisomidae	Labrisomids	*Malacoctenus boehlkei*	Diamond Blenny
Labrisomidae	Labrisomids	*Malacoctenus macropus*	Rosy Blenny
Labrisomidae	Labrisomids	*Malacoctenus triangulatus*	Saddled Blenny
Labrisomidae	Labrisomids	*Starksia hassi*	Ringed Blenny
Istiophoridae	Billfishes	*Makaira nigricans*	Blue Marlin