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Juvenile and small resident fishes of Florida Bay, a critical habitat in the Everglades National Park, Florida

Allyn B. Powell
Gordon Thayer
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CONTENTS

Abstract—This compendium presents information on the life history, diet, and abundance and distribution of 46 of the more abundant juvenile and small resident fish species, and data on three species of seagrasses in Florida Bay, Everglades National Park. Abundance and distribution of fish data were derived from three sampling schemes: (1) an otter trawl in basins (1984–1985, 1994–2001), (2) a surface trawl in basins (1984–1985), and (3) a surface trawl in channels (1984–1985). Results from surface trawling only included pelagic species. Collections made with an otter trawl in basins on a bi-monthly basis were emphasized. Nonparametric statistics were used to test spatial and temporal differences in the abundance of species and seagrasses. Fish species accounts were presented in four sections – **Life history, Diet, Abundance and distribution,** and **Length-frequency distributions.** Although Florida Bay is a subtropical estuary, the majority of fish species (76%) had warm-temperate affinities; i.e., only 24% were solely tropical species. The five most abundant species collected, in descending order, by (1) otter trawl in basins were: *Eucinostomus gula*, *Lucania parva*, *Anchoa mitchilli*, *Lagodon rhomboides*, and *Syngnathus scovelli*; (2) surface trawl in basins were: *Hyporhamphus unifasciatus*, *Strongylura notata*, *Chriodorus atherinoides*, *Anchoa hepsetus*, and *Atherinomorus stipes*; (3) surface trawl in channels were: *Hypoatherina harringtonensis*, *A. stipes*, *A. mitchelli*, *H. unifasciatus*, and *C. atherinoides*.

Juvenile and small resident fishes of Florida Bay, a critical habitat in the Everglades National Park, Florida

Allyn B. Powell
Gordon Thayer[1]
Michael Lacroix
Robin Cheshire

Center for Coastal Fisheries and Habitat Research
National Oceanic and Atmospheric Administration
101 Pivers Island Road
Beaufort, North Carolina 28516

e-mail address: Allyn.Powell@noaa.gov

[1]Current address: I. M. Systems Group Incorporated
3401 Blexhill Place
Kensington, MD 20895

Chapter 1. Introduction

The importance of estuaries as nursery areas for fishes has been well documented, and there is ample evidence that many commercial and recreational fisheries target those species that utilize estuaries. Estuaries provide abundant food resources and relatively fewer predators than coastal waters. They provide a variety of habitats that include the water column, grass beds, marshes, mangroves, and hard/soft bottoms. Potential impacts on these habitats include fishing, development, chemical spills, and freshwater input and diversion. Of recent concern has been the impact of man-induced activities in the Kissimmee-Okeechobee-Everglades drainage basin on estuarine systems within Everglades National Park. The hydrology of this drainage basin has been altered by water management policies to reclaim wetlands and furnish irrigation for agriculture, and provide flood control for the sprawling population of the Miami area. These alterations of the drainage, along with natural causes, have had an impact on the downstream estuary—Florida Bay (Thayer and Chester, 1989; Hoss and Thayer, 1993; Boesch, 1996; Able and Fahay, 1998; Schofield, 2003).

Florida Bay is a shallow lagoon roughly encompassed on the north by the mainland of the Florida peninsula, on the east and south by the Florida Keys, and to the west by the Gulf of Mexico (Fig.1.1). The precise boundaries of Florida Bay vary because of the open connection of the Bay with the Gulf of Mexico. Here, we define Florida Bay as that portion which is situated within the boundaries of Everglades National Park, covering an area of approximately 1700 km^2 (FMRI[1]). An excellent summary of the description of the Florida Bay ecosystem is given by Fourqurean and Robblee (1999), which is a source of information for this introduction.

A latticework of carbonate mud banks and shallow basins (1–3 m deep) connected by channels is characteristic of the Bay. Approximately 200 small mangrove-lined islands, or keys, occur in the Bay. The carbonate mud banks restrict tidal flow from the Gulf of Mexico on the west while the Florida Keys isolate all but the south-

[1] FMRI. 1995. Fisheries-independent monitoring program, 1994 annual data summary report. Florida Marine Research Institute, Florida Department of Environmental Protection, St. Petersburg, FL, 451 p.

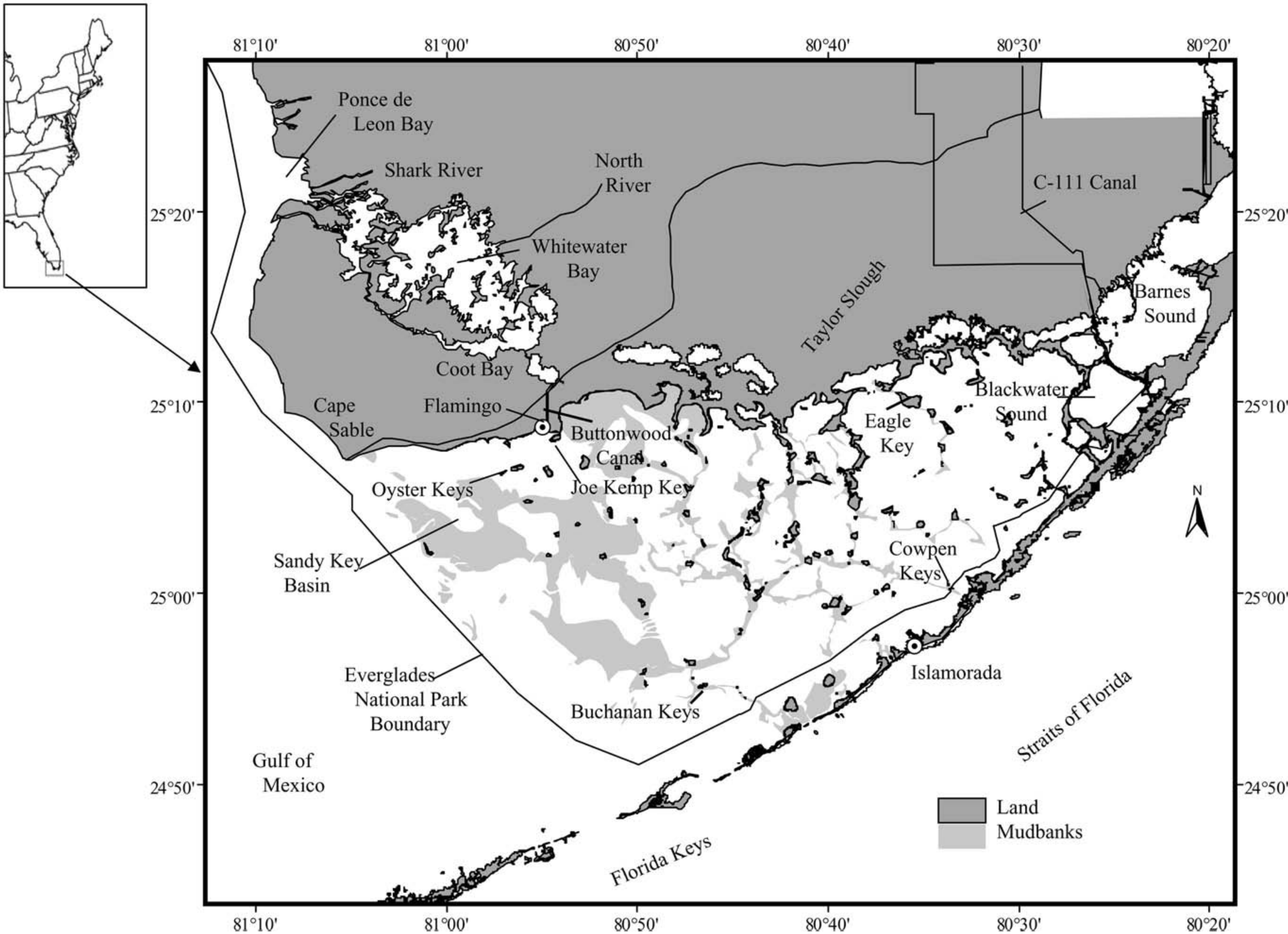


Figure 1.1
Florida Bay and location of geographic names used in text.

ern portion of the Bay from tidal cycles of the Atlantic Ocean. Tides along the western margin of the bay range 61 cm; whereas on the east, adjacent to the Florida Keys, tides range 17 cm. Within most of the central and northeastern portions of the Bay, tides are generally wind driven. Southwest winds produce relatively higher tides, while northeast winds, which are dominant in winter, produce relatively lower tides (Fourqurean and Robblee, 1999; FMRI[1]). Lack of strong tidal circulation in the central and northeastern portion of the bay could restrict the recruitment of early-stage, planktonic fish larvae into those areas.

Weather in Florida Bay is subtropical and is characterized by a warm, wet season from May to October and a cooler, dry season from November to April. The majority of rainfall (75%) occurs during the wet season, and annual evaporation and precipitation are similar. Freshwater run-off into Florida Bay is mainly through Taylor Slough. Natural freshwater flow into the Bay has been disrupted since the late 1800s as a result of managed agriculture, water supply, and flood control on the Florida mainland (Fourqurean and Robblee, 1999).

Florida Bay is generally oligotrophic with low phytoplankton biomass throughout. Western Florida Bay has relatively stable marine conditions with near Redfield N:P ratios for seston, which are good indicators of nitrogen or phosphate limitations to phytoplankton. The central portion of the bay is occasionally hyperhaline, with high N:P ratios for seston, and high concentrations of dissolved inorganic matter. The eastern portion of the Bay has highly variable salinities and N:P ratios. Phosphate is a limiting factor for phytoplankton productivity in this eastern part of the Bay (Boyer et al., 1999; Fourqurean and Robblee, 1999).

The organic content of the surface sediment, which is linked to overall hydrology, deposition, and the plant community, is generally low in eastern Florida Bay and highest in western and northwestern Florida Bay. The western Bay also has greater sediment depths which generally correspond to a high seagrass standing crop (Thayer and Chester, 1989).

Basins, banks, and channels in Florida Bay are dominated by the seagrass *Thalassia testudinum*, followed by *Halodule wrightii*, and *Syringodium filiforme*. The distribution and abundance of seagrasses within the Bay is not uniform. Generally higher seagrass standing crop, higher seagrass short-shoot densities, and higher seagrass species diversity are found in western Florida Bay and channels throughout the Bay. The highest mean densities of fishes also are found there. Eastern Florida Bay has a relatively low standing crop of seagrasses, and the lowest mean density of fishes (Thayer and Chester, 1989).

In the late 1980s environmental changes occurred in Florida Bay. Dense stands of *Thalassia* experienced major die-offs. Turbidity increased and subsequent algal blooms further reduced the penetration of light into the water column (Fourqurean and Robblee, 1999). Prior to the die-off of seagrasses, three species of fish (*Lucania parva*, *Lagodon rhomboides*, and *Eucinostomus gula*) were dominant in Florida Bay (Thayer and Chester, 1989; Thayer et al., 1999). A decade later while the die-off was still in progress the bay anchovy (*Anchoa mitchilli*), a zooplanktivore, increased dramatically in abundance (Thayer et al., 1999). Although the fish community was still dominated by a few species (*L. parva*, *L. rhomboides*, and *E. gula*), the major presence of *A. mitchilli* signaled a shift from a fish community associated with seagasses (i.e., canopy dwellers), to one dominated by a zooplanktivorus species.

This habitat change occurred rapidly, and may have been a consequence of long-term stressors, including chronic hyperhaline conditions, overdevelopment of seagrass beds, silting of the Bay due to lack of hurricanes, and abnormally warm summer and fall temperatures (Fourqurean and Robblee, 1999). For a detailed account of the changes in seagrass distribution and abundance prior to and after the die-off of seagrasses, and a conceptual model of seagrass die-off in Florida Bay, see Hall et al. (1999), Thayer et al. (1999), and Zieman et al. (1999).

These environmental changes have resulted in modifications of aspects of the ecology of the Bay beyond seagrass and fish. Some resident populations of sponges, which provide nursery habitat for spiny lobster, have also experienced die-offs. Landings of pink shrimp, which use seagrass beds in Florida Bay as a nursery area, have also declined. Thus, modifications in the Bay's ecology can have far reaching impacts on its fishery resources since various life history stages utilize Florida Bay as a nursery area or as a transient or permanent residence. This compendium of life history information for the fishes and invertebrates, which we collected throughout the bay between 1984–2001, will provide future researchers and managers with information needed to evaluate changes in life history structures that may occur as a result of natural or anthropogenic environmental changes.

Biological information is provided for 46 fish species. Included for each species is brief life history information, diet, spatial and temporal abundance and distribution data, and length-frequency distributions to infer spawning, recruitment, and growth. Also included are temporal and spatial analyses of temperature, salinity, and seagrass composition and abundance.

Chapter 2. Methods

Field and laboratory methods

Sampling strategy Two methods of stratifying Florida Bay were employed. For the first, sampling occurred in basins and channels in three strata. During the periods May 1984–June 1985 and July 1994–January 1999, sampling during each trip was conducted at 18 basin stations equally divided among three strata – East, Central, and West (Fig. 2.1). Also, six random samples per trip were taken in channels during 1984–1985. The samples in channels were not stratified by strata, and sampling at channels was done at fixed sites because of the limited trawling area. Sampling locations in the basin strata were determined using a grid system. Each grid cell was approximately 1800 m on a side. Six cells were randomly chosen for each basin strata and samples were taken at approximately the center of the cell where possible.

For the second method, we modified our sampling beginning in March 1999 to conform with the South Florida Ecosystem Restoration Prediction and Modeling (SFERPM) Program Management Committee's (PMC) subdivision designations. Florida Bay was stratified into six subdivisions (Fig. 2.1). Sampling locations in the basin strata were determined using a grid system. Each grid cell was 1800 m on a side. Because the number of trawlable squares in each subdivision was not equal, the number of stations to be sampled was weighted by trawlable area. Thirty-six stations were randomly chosen (Gulf: 4; Western: 3; Central: 10; Atlantic: 7; Northern: 3; Eastern: 9). Samples were taken at approximately the center of the cell where possible. For latitude and longitude demarcations see Fig. 2.1; for location of geographic locations referred to in the text, see Fig. 1.1. Because of the change in the stratified design in 1999, caution should be used when comparisons are made between May 1984–January 1999 and March 1999–January 2001 as more extensive sampling from 1999 through 2001 may result in biased comparisons.

Collection methods: 1984–2001 [A summary of sampling in Florida Bay by month, habitat, and gear is presented in Table 1.] From the initial sampling trip in May 1984 through January 1999, a two-boat (5-m long), otter trawl was employed. In March 1999, the two boats were replaced with one 5.5 m boat for safety reasons. This required re-calibrating the opening of the mouth of the otter trawl to calculate area sampled. The otter trawl had a 3.4 m head rope, 3.8 m foot rope equipped with a 3 mm galvanized tickler chain, 6 mm mesh in the body, and a 3 mm tailbag.

A surface trawl was employed only in 1984–1985. The surface trawl measured 6.6 m at the head rope, 6.2 m at the foot rope, was 0.7 m deep, had 6 mm mesh in the body and 3 mm mesh in the tailbag. The surface trawl, without doors to open the net, was pulled by two boats each angled about 45° away from the intended trawl path.

The surface and otter trawls were towed at a speed of approximately 2.0 m^{-sec} for 2 min, unless the net was clogged with detritus. A floating marker was deployed at the beginning and end of each tow and the distance

Table 1

Summary of sampling in Florida Bay by month, habitat, and gear. The symbol X indicates sampling occurred. Shaded areas indicate annual periods of bi-monthly, otter trawl collections in basins. Periods are separated by variable shading. For example, the first annual period is from July 1984 through May 1985, the second from July 1994 through May 1995.

	Month[1]							Habitat		Gear	
Year	Jan	Mar	May	Jun	Jul	Sep	Nov	Channels[2]	Basins	Otter trawl	Surface trawl
1984				X	X	X	X	X	X	X	X
1985	X	X	X	X				X	X	X	X
1994					X	X	X	X	X	X	
1995	X	X	X	X				X	X	X	
1996	X	X	X	X	X	X	X	X	X	X	
1997					X	X	X		X	X	
1998	X	X	X	X	X		X		X	X	
1999		X	X		X	X	X		X	X	
2000	X	X	X		X	X	X		X	X	
2001	X								X	X	

[1] Sampling did not occur in February, April, August, October, and November.
[2] Data from samples taken in channels in 1984–1985 were only used to depict the distribution and abundance of pelagic species collected by surface trawl. Sampling in channels with an otter trawl occurred in 1984–1985 and 1994–1996, but data were only used for length-frequency distributions.

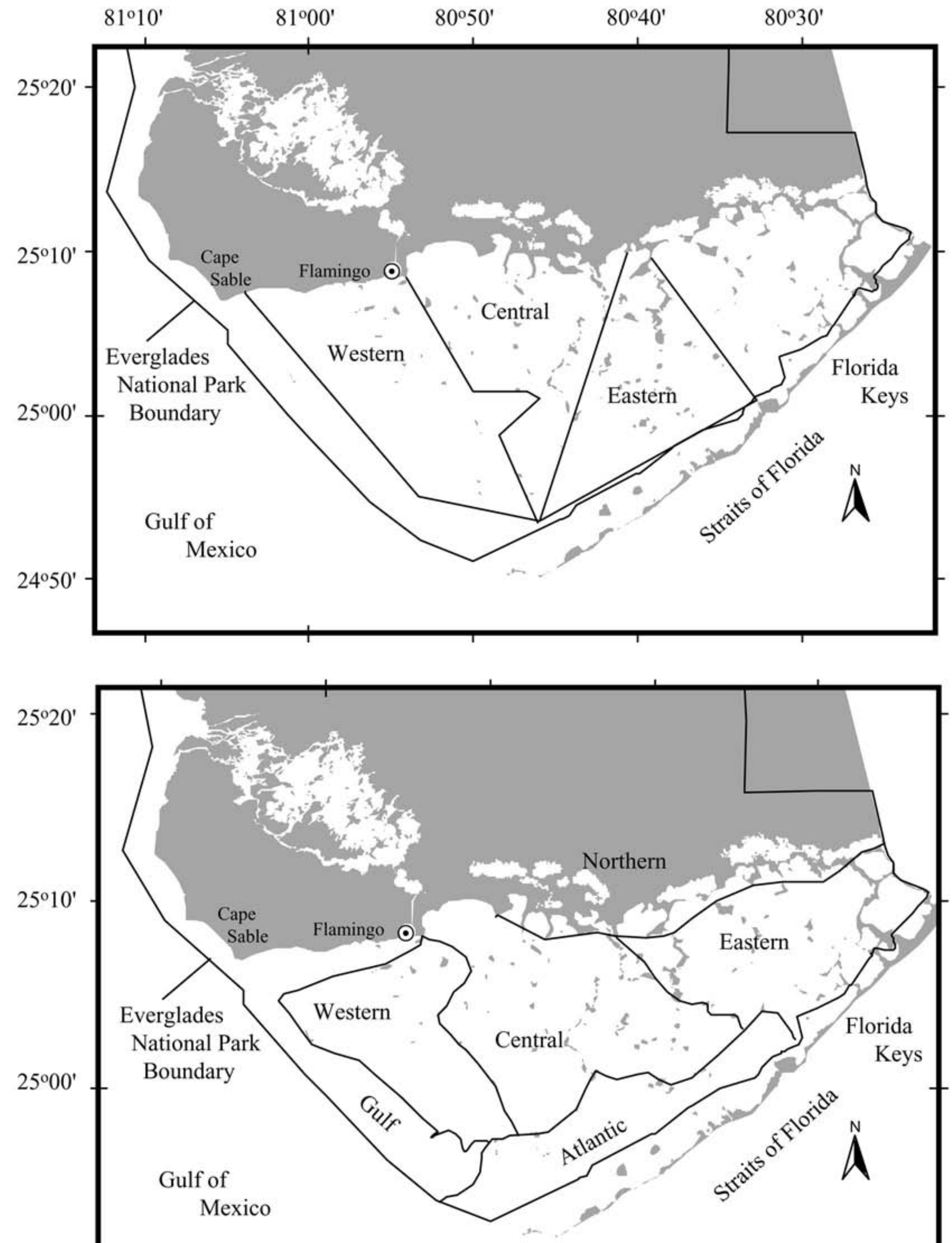


Figure 2.1
Location of Florida Bay strata (top) and subdivisions (bottom).

between buoys was measured with an optical range finder. The area covered by each trawl transect was calculated knowing the distance towed and the mouth opening of the net. Densities (number of fish 1000 m^{-2}) were used as an index of abundance.

Temperature was measured at the surface with a standard hand-held thermometer, and salinity measured at the surface with a refractometer.

For seagrass we measured short-shoot density, aboveground standing crop, blade length, and species composition. In 1984–1985 we collected three 100 cm^2 replicates of seagrass at the beginning, middle, and end of each trawl line, but in July 1994 through November 1995, we used a 1 m^2 quadrate subdivided into sixteen 0.062 m^2 subsections as described by Thayer et al. (1994). Three random samples were taken at each location when vegetation was present. If shoots exceeded 40 per subsection, a 0.01 m^2 quadrate was used. In January 1996, a 0.01 m^2 core was used to collect seagrass.

Processing of specimens Fishes and selected invertebrates were preserved in 10% formalin, transferred to 95% ethyl alcohol, identified to species in the laboratory, and then weighed. Measurements of fishes were in standard length (SL), except for seahorses (*Hippocampus*) where the tip of the tail (outstretched body) was measured to the corona (Ginsburg, 1937). Fish lengths reported from the literature are in notochord length (NL) for preflexion and flexion stage larvae, standard length (SL), total length (TL), and fork length (FL).

Plants were removed at the sediment surface, placed in a labeled bag on ice, and returned to the laboratory for density and biomass measures. At the laboratory, individual short shoots of each seagrass species were sorted by species. Individual short shoots of each species were counted and separated from any below ground materials. Carbonates and epiphytes were removed by soaking seagrasses in 10% phosphoric acid until effervescence ceased, and then re-washed in seawater. Seagrasses were dried at 80° C to a constant weight and weighed to the nearest 0.001 g. Data were averaged at each site for each species.

Data analysis and presentation

Temperature and salinity Regression models (SAS Institute, 1997; PROC REG) were used to depict patterns of temperature and salinity in Florida Bay. We tested for significant differences (α=0.05) among stratum and subdivision (Fig. 2.1), year, and month. Only bi-monthly data (January, March, May, July, September, and November) for six annual periods were included as only these months were consistently sampled throughout the period 1984–2001 (Table 1).

Seagrasses A non-parametric Kruskal-Wallis test (Sokal and Rohlf, 1981) with α=0.05 was used to test differences in seagrass short-shoot densities (number m^{-2}) and seagrass above-ground biomass (g dry weight m^{-2}) among stratum and subdivision (Fig. 2.1), year, and month. As detailed above, only bi-monthly samples for six annual periods were included (Table 1).

Seagrass distribution data were presented in GIS generated, six-panel figures by stratum, subdivision, and year for individual species (e.g., see Figs. 3.7 and 3.8). In addition, we included a three-panel figure depicting mean seagrass densities, and standing crop by year, month, stratum, and subdivision (e.g., see Figs. 3.5 and 3.6). Seagrass composition and short-shoot density data from 1984–1985 and 1994–1996 were a major part of a data set that was used to evaluate the composition and density of seagrasses relative to changes in environmental conditions in Florida Bay (Thayer et al., 1999).

Fishes A species was included when the total number collected was ≥50. There were fourteen pelagics and 32 non-pelagics included (Table 2). A non-parametric Kruskal-Wallis test (Sokal and Rohlf, 1981) with α=0.05 was used to test differences in mean densities (numbers 1000 m^{-2}) of a given species (all non-pelagics, and those pelagics that numbered ≥50) among years, months, stratum, and subdivision for otter trawl bi-monthly basin collections (1984–2001; see Table 1 for the designation of sampling periods). For surface trawl data (1984–1985), the same test was used to test differences in mean densities of only pelagic species, among months, stratum, and basins and channels. For surface trawl collections all months in 1984–1985 were included.

Mean Wilcoxon scores (rank sums) were used to estimate the frequency (i.e., the percentage of stations) a species occurred. Levels of species abundance were arbitrarily assigned to the following categories: very abundant, ≥10,000 total fish collected; abundant, <10,000 and ≥1,000; common, <1,000 and ≥100; uncommon, <100. Fish species accounts are presented by family, with each family constituting a chapter. However, the families Atherinidae and Atherinopsidae, Fundulidae, and Cyprinodontidae were combined to avoid confusion. For a summary of sampling by year, month, habitat, and gear, see Table 1.

Fish species data are presented in four sections. The sections on **Life history** and **Diet** were derived from the literature. The section on **Abundance and distribution** consists of data from bi-monthly otter trawl collections (1984–2001), and/or surface trawl collections of pelagic species in basins and channels (1984–1985). Data from these two gears are presented separately. In addition, comparisons with other studies are included here typically following our results. The section on **Length-frequency** distributions consists of length measurements

Table 2

Summary of selected ecological characteristics of juvenile and small resident fishes in Florida Bay reported in this study. Transient species spend only a portion of their life history in Florida Bay and spawn outside the Bay.

Family	Species	Tropical	Warm temperate	Resident	Transient	Benthic/ demersal	Pelagic	Canopy dweller
Clupeidae	*Brevoortia smithi*		X		X		X	
	Harengula jaguana		X		X		X	
	Opisthonema oglinum	X	X		X		X	
	Sardinella aurita	X	X		X		X	
Engraulidae	*Anchoa hepsetus*		X	X			X	
	A. mitchilli		X	X			X	
Ariidae	*Arius felis*		X	X		X		
Synodontidae	*Synodus foetens*	X	X		X	X		
Batrachoididae	*Opsanus beta*		X	X		X		
Hemiramphidae	*Chriodorus atherinoides*	X		X (?)			X	
	Hemiramphus brasiliensis	X	X	X			X	
	Hyporhamphus unifasciatus	X		X (?)			X	
Belonidae	*Strongylura notata*	X		X			X	
	S. timucu	X	X	X			X	
Cyprinodontidae	*Floridichthys carpio*		X	X				X
Fundulidae	*Lucania parva*		X	X				X
Atherinidae	*Atherinomorus stipes*	X		X			X	
	Hypoatherina harringtonensis	X		X			X	
Atherinopsidae	*Membras martinica*		X	X			X	
Syngnathidae	*Anarchopterus criniger*	X	X	X				X
	Syngnathus floridae	X	X	X				X
	S. scovelli	X	X	X				X
	Hippocampus erectus	X	X	X				X
	H. zosterae	X	X	X				X
Lutjanidae	*Lutjanus griseus*	X			X			X
	L. synagris	X			X			X
Gerreidae[1]	*Eucinostomus gula*		X		X			X
Haemulidae	*Haemulon plumieri*	X	X		X			X
	H. sciurus	X			X			X
	Orthopristis chrysoptera		X		X			X
Sparidae	*Archosargus probatocephalus*		X		X			X
	Calamus arctifrons		X		X			X
	Lagodon rhomboides		X		X			X
Sciaenidae	*Bairdiella chrysoura*		X		X			X
	Cynoscion nebulosus		X	X				X
Sphyraenidae	*Sphyraena barracuda*	X	X		X			X
Scaridae	*Nicholsina usta*	X	X		X			X
Callionymidae	*Diplogrammus pauciradiatus*	X		X		X		
Gobiidae	*Gobiosoma robustum*		X	X		X		
	Microgobius gulosus		X	X		X		
	M. microlepis	X		X		X		
Monacanthidae	*Monacanthus ciliatus*	X	X		X			X
	M. hispidus		X		X			
Ostraciidae	*Lactophrys quadricornis*	X	X	X (?)		X		
Tetraodontidae	*Sphoeroides nephelus*	X			X	X		
Diodontidae	*Chilomycterus schoepfi*		X		X	X		

[1] *Eucinostomus argenteus* was also identified, but most were mis-identified and were most likely *E. harengulus*.

from all collections, except 1984–1985 when no measurements were taken. Length-frequency distributions were used, when possible, to estimate life stage captured, spawning times, recruitment into Florida Bay for those species which spawn outside the Bay, and growth. Additional material from the literature was added when appropriate.

For each fish species an un-numbered table is presented that depicts the raw numbers collected and overall rank of the species by gear and habitat. For surface trawl collections in basins and channels, a total of 14 pelagic species (Table 2) in each habitat were ranked. For otter trawl collections in basin habitats, 39 species were ranked.

The graphic presentation of data was dependent on gear and raw numbers of fish collected. Pelagic fish species collected by surface trawl in 1984–1985 were presented in one-panel GIS generated figures depicting their distribution in basins and channels by stratum (e.g., Fig. 4.1). Also included were figures (bar graphs) depicting the mean densities (numbers 1000 m^{-2}) by month and strata (e.g., Fig. 4.2). However, when a pelagic species was collected by otter trawl in basins, and sample size was >50 fish, GIS generated two-panel (<100 total fish; e.g., Fig. 4.10) or six-panel (≥100 total fish) figures were included (e.g., Fig. 4.5). Also included for this gear were figures (bar graphs) depicting the mean densities (numbers 1000 m^{-2}) by year, month, and strata/subdivision (e.g., Fig. 4.6). For all other species (i.e., canopy dwellers and benthics that made up the majority of species) that totaled >50 fish, we included GIS generated two-panel (<100 total fish; e.g., Fig. 6.4) or six-panel figures (≥100 total fish; e.g., Fig.6.1) depicting their distribution. Also included for these species were figures (bar graphs) depicting the mean densities (numbers 1000 m^{-2}) by year, month, and strata/subdivision (e.g., Fig. 6.2).

Juvenile and small resident fish data from 1984–1985 and 1994–1996 were a major part of a data set that was used in a manuscript to evaluate the composition of ichthyofauna relative to changes in environmental conditions in Florida Bay (Thayer et al., 1999).

Chapter 3. Environmental variables

Temperature

Mean annual water temperatures for Florida Bay ranged from 25.4°C in 1999–2000 to 27.2°C in 1997–1998 (Fig. 3.1A). Mean temperatures among strata (1984–1985, 1994–1998) were similar and ranged from 25.9°C in the Central stratum to 26.9°C in the West stratum. Mean temperatures were similar among subdivisions (1999–2001) and ranged from 25.2°C in the Eastern subdivision to 25.8°C in the Atlantic subdivision (Fig. 3.1B). Generally, coldest temperatures occurred in January, followed by March; warmest temperatures occurred from May through September (Fig. 3.2). Our observations support those of Boyer et al. (1999), who concluded that water temperatures in Florida Bay showed pronounced seasonal patterns, but no interannual trends.

Salinity

Overall, mean monthly salinities were highest in July and May. High salinities during this wet period are a result of high water temperatures, high evaporation rates, and long water residence times (Sogard et al., 1987; Boyer et al., 1999). Salinities were similar among strata (Fig. 3.3), but differed among subdivisions (Fig. 3.4). Salinities were similar and highest in the Atlantic, Central, Western, and Gulf subdivisions. Moderate salinities were observed in the Eastern subdivision; whereas salinities were low and variable in the Northern subdivision (Fig. 3.4), the latter an area influenced by freshwater inputs from Taylor Slough (Fig. 1.1; Boyer et al., 1999).

Our findings of yearly trends in salinity differ from Boyer et al. (1999). From a robust data set, they found a 38% decrease is salinity during the period 1991–1997 in the eastern area of the Bay, a 29% decrease in the central area, and a 15% decrease in the western area. These declines were linked to wetter than normal conditions in 1994–1996. Although we did not find any significant differences among years, the pattern we observed suggested a decline in salinities from 1984–1985, while salinities remained relatively low during the last three annual sampling periods (Fig. 3.1A).

A comprehensive study of salinity trends in Florida Bay is given by Orlando et al. (1997), who depicted salinity characteristics by salinity contours using 40 years (1955–1995) of data. They observed three persistent features which included a hypersaline "bull's-eye" area in the north-central area of the Bay, brackish salinities in the northeast, and near-ocean salinities along the western and southern boundaries. They noted that long-term changes might include decreasing salinities in the northeastern area of the Bay, while the hypersaline "bull's eye" area might be intensifying.

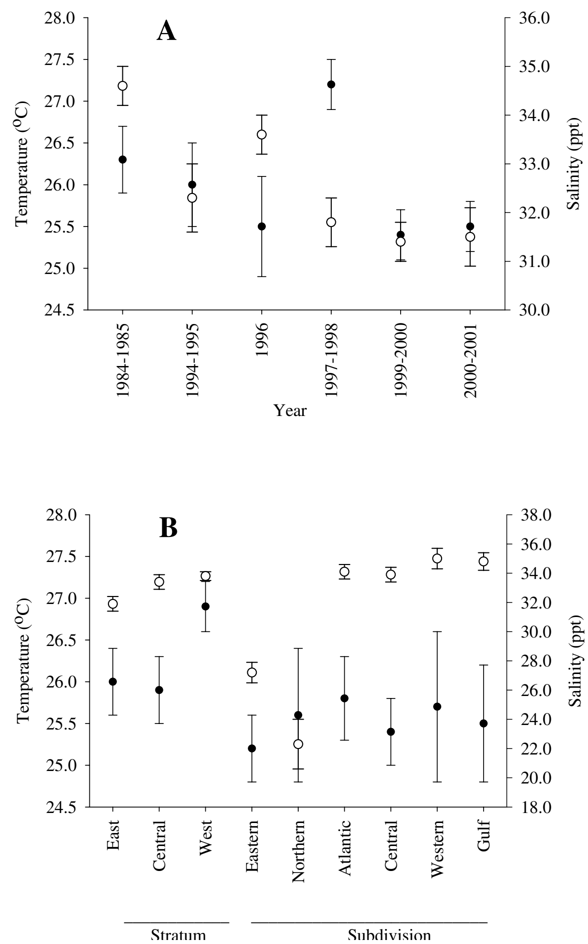


Figure 3.1

Mean temperature and salinity by (A) year and (B) stratum and subdivision. Error bars are one standard deviation from the mean. Solid circles represent temperature, open circles represent salinity. For location of strata and subdivisions see Fig. 2.1.

Seagrasses

***Thalassia testudinum* (turtle grass)** Turtle grass, a member of the Caribbean flora, is the dominant seagrass in Florida Bay both in spatial distribution and biomass (Zieman et al., 1989; Hemminga and Duarte, 2000).

We observed a distinct temporal trend in short-shoot densities of turtle grass. Densities declined Bay-wide from 722 short-shoots m^{-2} in 1984–1985 to 12 short-shoots m^{-2} in 1996. Some recovery in short-shoot densi-

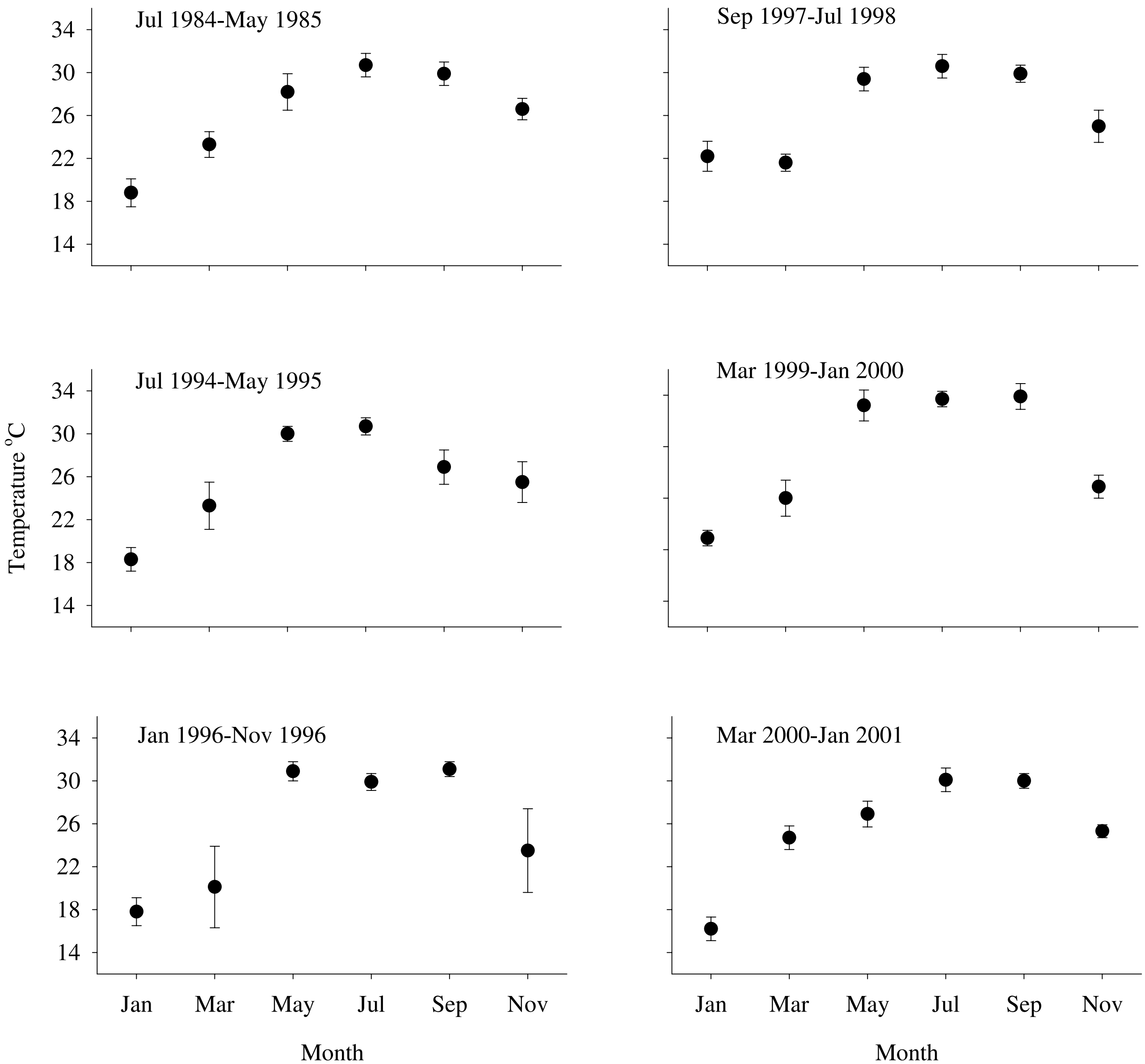


Figure 3.2

Mean monthly temperatures by year. Error bars are one standard deviation from the mean.

ties has occurred since 1996, but densities are well below 1984–1985 levels (Figs. 3.5 and 3.7). No significant differences in monthly densities were observed.

Short-shoot densities of turtle grass differed among subdivisions, but not strata. Unexpectedly, short-shoot densities were relatively low in the Western subdivision (Fig. 3.5). Our original sampling design (Fig. 2.1) was based on the premise that there is a general increase in standing crop of turtle grass from the northeastern area of Florida Bay to the western part of the Bay (Thayer and Chester, 1989). Furthermore, short-shoot densities have been shown to be positively associated with standing crop in Florida Bay (Hall et al., 1999).

Differences in standing crop mirrored our observations for turtle grass short-shoot densities (Figs. 3.6 and 3.8 vs. 3.5 and 3.7), but standing crop of turtle grass was not positively associated with short-shoot densities. However, standing crop generally increased from east to west and was highest in western Florida Bay (Figs. 3.6 and 3.8). Disparity between short-shoot densities and standing crop is related to spatial differences in blade length. Mean blade lengths (cm) of turtle grass were

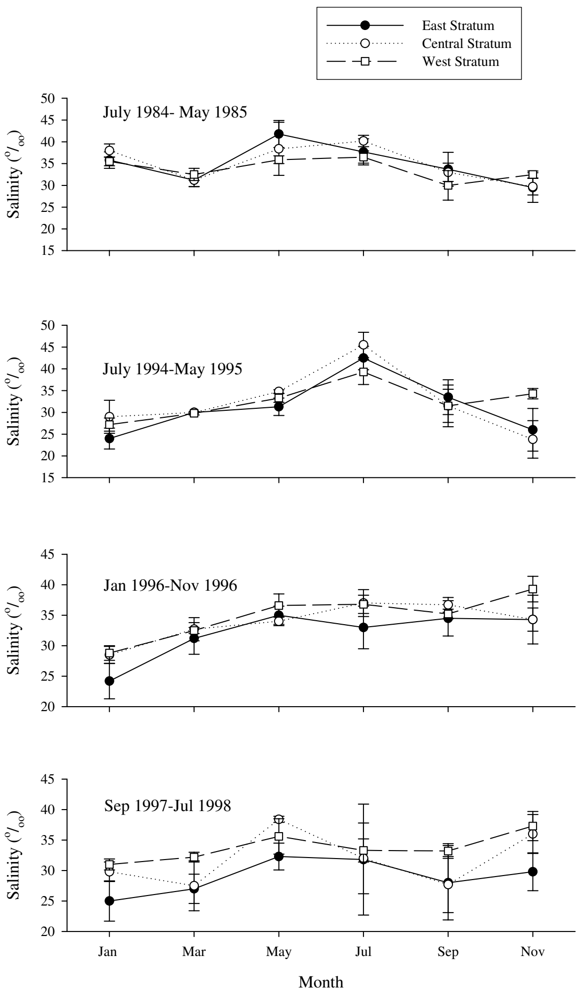


Figure 3.3

Mean monthly salinities by stratum and year. Error bars are one standard deviation from the mean. For location of strata see Fig. 2.1.

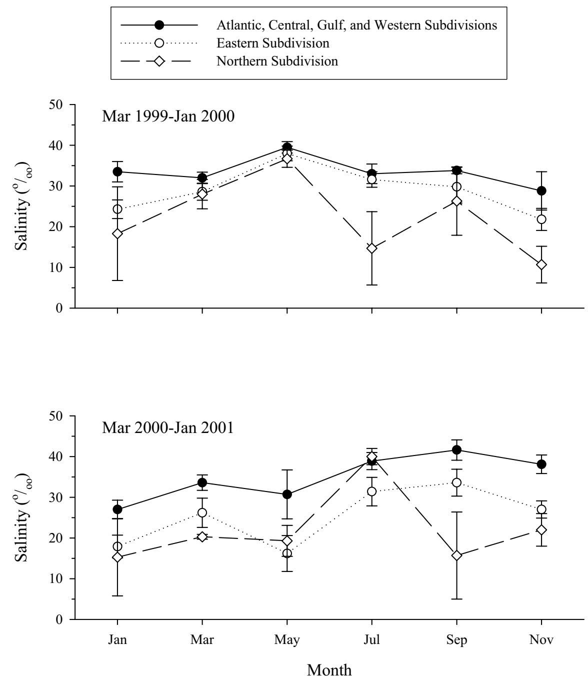


Figure 3.4

Mean monthly salinities by subdivision and year. Error bars are one standard deviation from the mean. For location of strata see Fig. 2.1. Subdivisions were pooled when there were no significant differences among them.

32.6, 30.9, 13.5, 13.3, 11.7, and 9.9 in the Gulf, Western, Central, Atlantic, Northern, and Eastern subdivisions, respectively.

***Halodule wrightii* (shoalgrass)** Shoalgrass, a member of the Caribbean flora, is dominant only in limited areas of Florida Bay where temperature and salinity extremes occur; i.e., where physical conditions rule out dense stands of turtle grass (Zieman et al., 1989; Hemminga and Duarte, 2000).

We observed that short-shoot densities of shoalgrass declined from a bay-wide average of 142 short-shoots m^{-2} in 1984–1985 to 1 short-shoot m^{-2} in 1996. Densities from 1997–1998 through 2001 were similar to 1984–1985 densities, but slightly lower (Figs. 3.5 and 3.9).

Bay-wide standing-crop biomass declined from 4.2 g m^{-2} in 1984–1985 to 0.7 g m^{-2} in 1996 (Figs. 3.6 and 3.10). Shoalgrass biomass was highest in the West stratum (3.8 g m^{-2}) and Western subdivision (7.3 g m^{-2}). Low biomass values were observed in the East stratum (0.04 g m^{-2}) and Atlantic and Eastern subdivision (0.04 g m^{-2}). Shoalgrass was relatively more abundant in the central part of the Bay in 2001, perhaps indicating a recovery of seagrasses in this area (Fig. 3.9) as shoalgrass is an early colonizer in disturbed areas (Zieman and Adams, 1982).

***Syringodium filiforme* (manatee grass)** Manatee grass, a member of the Caribbean flora, is locally dominant in areas where lower light energy occurs; i.e., where turtle grass is light limited. It would be expected to occur in deeper areas in Florida Bay (Zieman et al., 1989; Hemminga and Duarte, 2000).

We observed that short-shoot densities of manatee grass differed only spatially. This species had the most limited distribution of the seagrasses in Florida Bay (Figs. 3.11 and 3.12). Manatee grass was collected only in the West stratum, mainly in the Western and

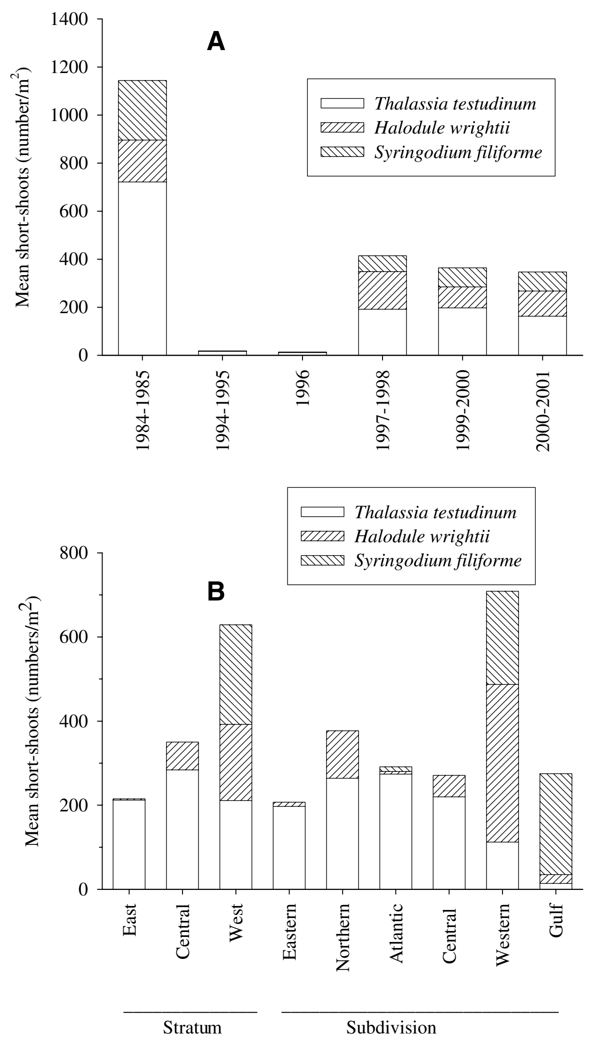


Figure 3.5

Mean number of seagrass short-shoots by (A) year and (B) stratum/subdivision. For location of strata and subdivisions see Fig. 2.1.

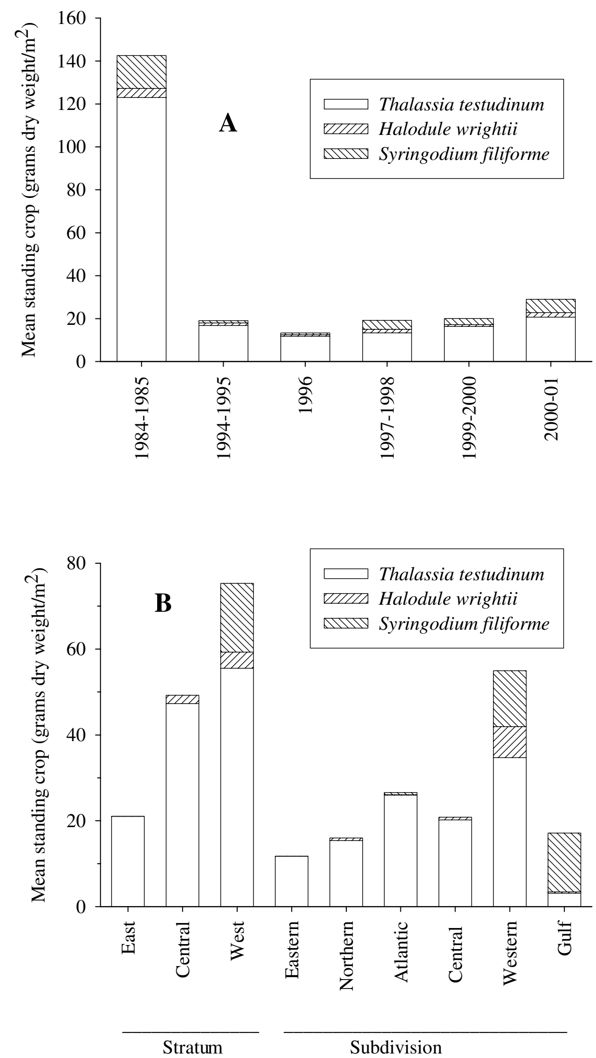


Figure 3.6

Mean above-ground standing crop of seagrasses by (A) year and (B) stratum/subdivision. For location of strata and subdivisions see Fig. 2.1.

Gulf subdivisions (Figs. 3.5 and 3.11). Although we found no significant differences in short-shoot densities among years, Thayer et al. (1999) and Hall et al. (1999) found significant declines of short-shoot densities following the seagrass die-off in Florida Bay. Our data for 1984–1985 versus 1994–1996 indicated a dramatic decline during the latter time period. Bay-wide densities of short-shoots declined from 248 m^{-2} to 1 m^{-2} (Fig. 3.5).

The pattern of standing crop biomass, including the decline noted by Hall et al. (1999) and Thayer et al. (1999), was similar to that observed for short-shoot densities, with highest standing crop values observed in western Florida Bay (Figs. 3.6 and 3.12).

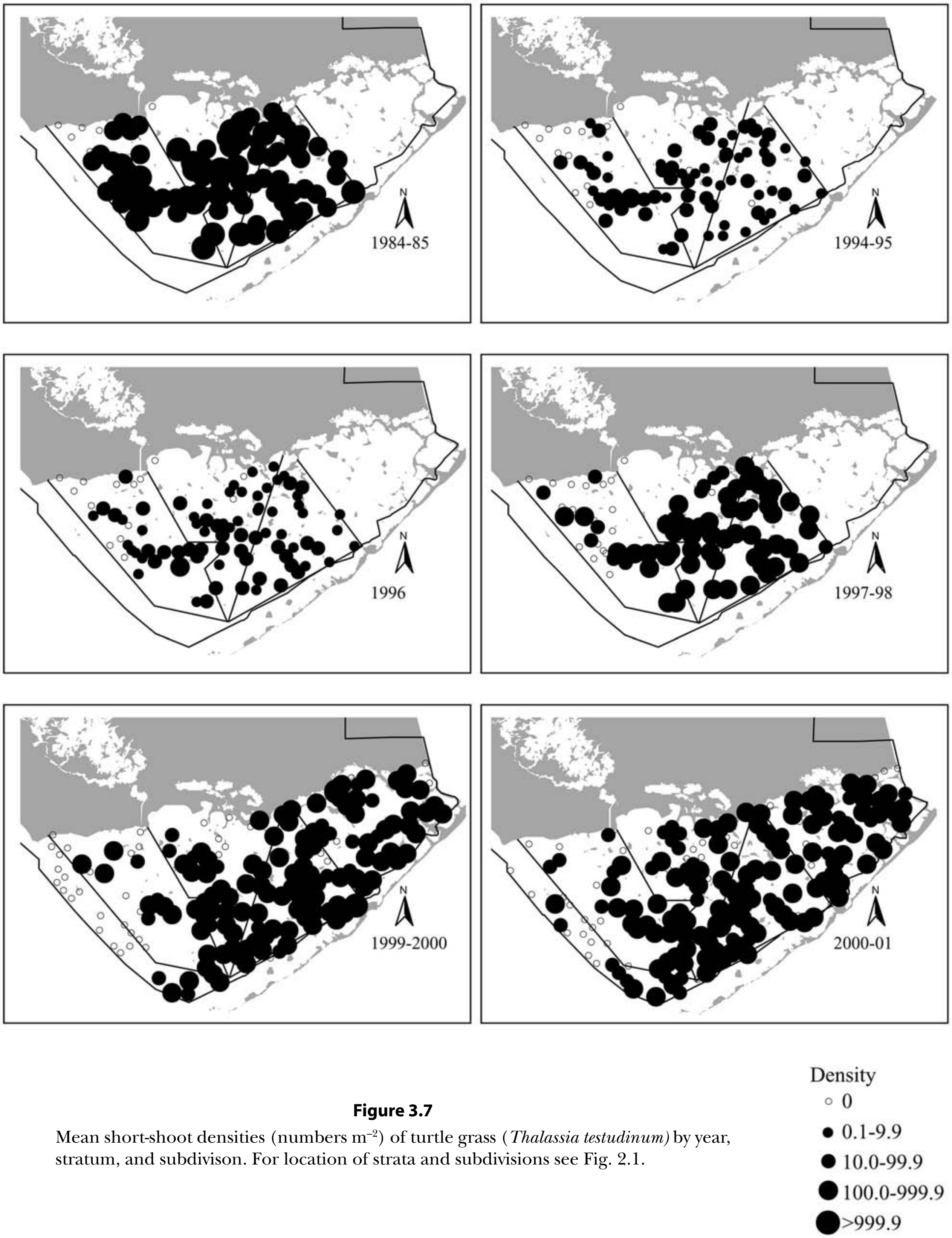


Figure 3.7

Mean short-shoot densities (numbers m^{-2}) of turtle grass (*Thalassia testudinum*) by year, stratum, and subdivison. For location of strata and subdivisions see Fig. 2.1.

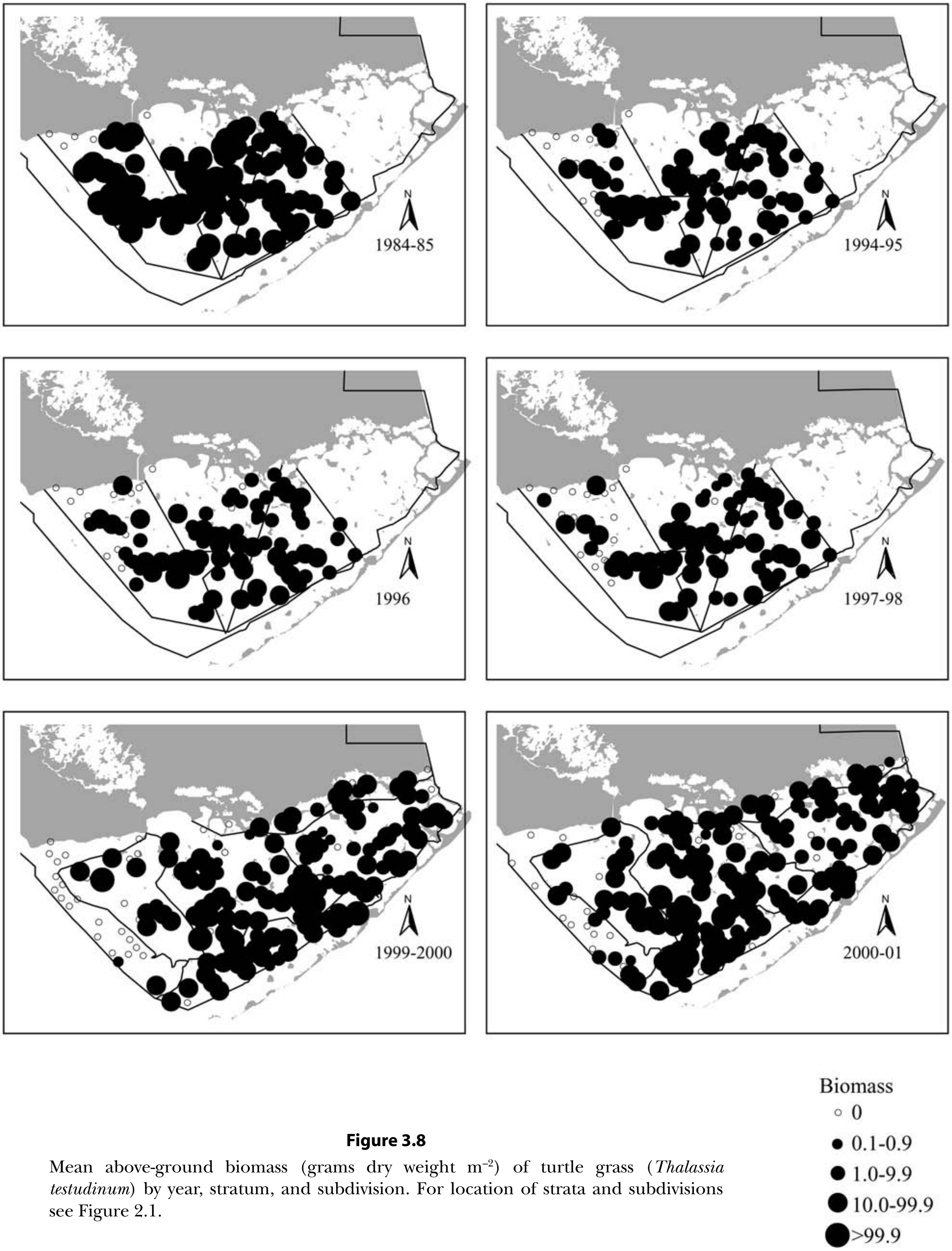
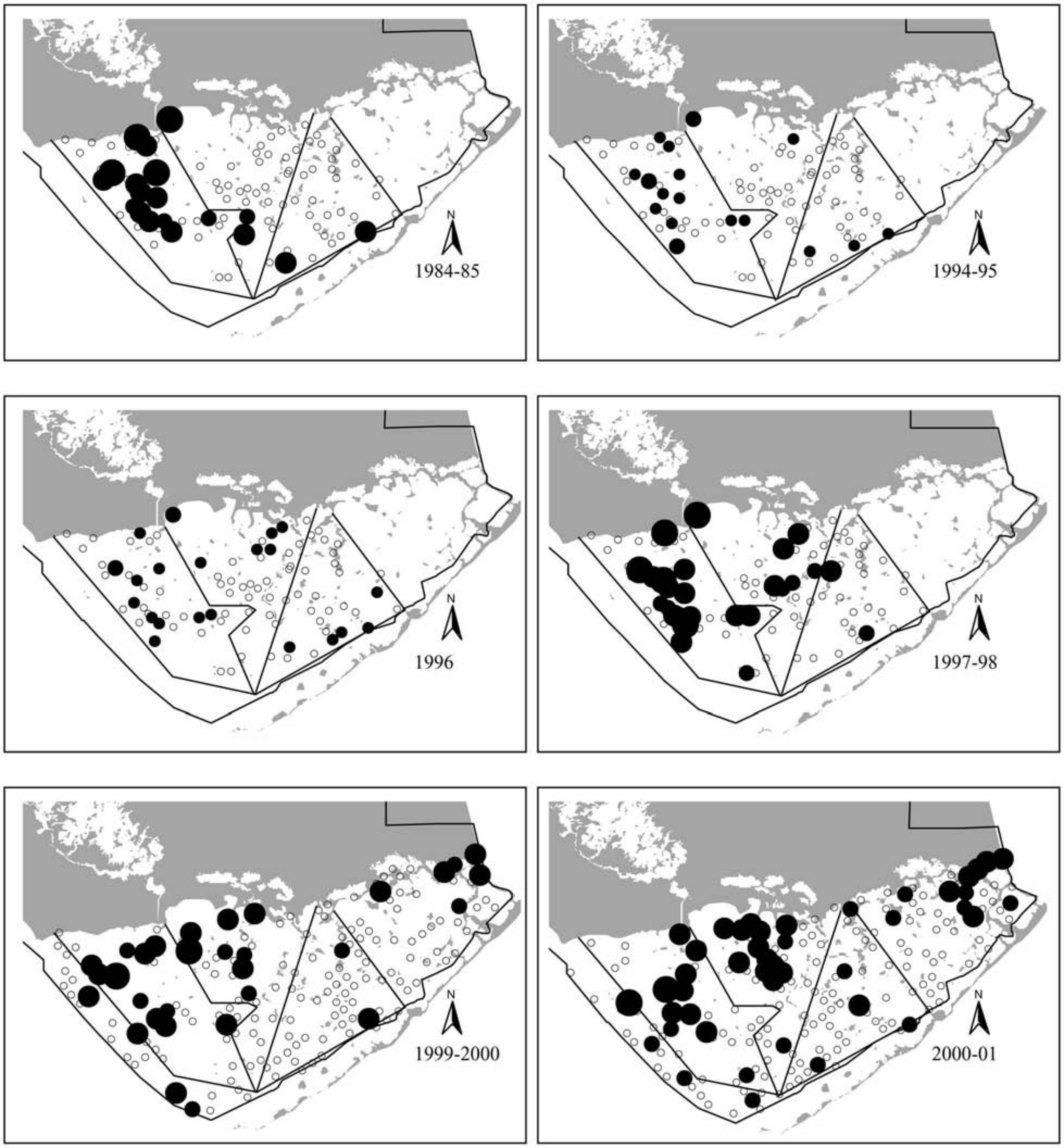


Figure 3.8

Mean above-ground biomass (grams dry weight m^{-2}) of turtle grass (*Thalassia testudinum*) by year, stratum, and subdivision. For location of strata and subdivisions see Figure 2.1.



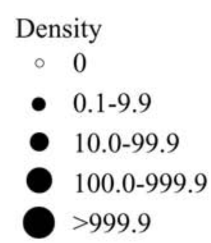


Figure 3.9

Mean short-shoot densities (numbers m^{-2}) of shoalgrass (*Halodule wrightii)* by year, stratum, and subdivision. For location of strata and subdivisions see Fig. 2.1.

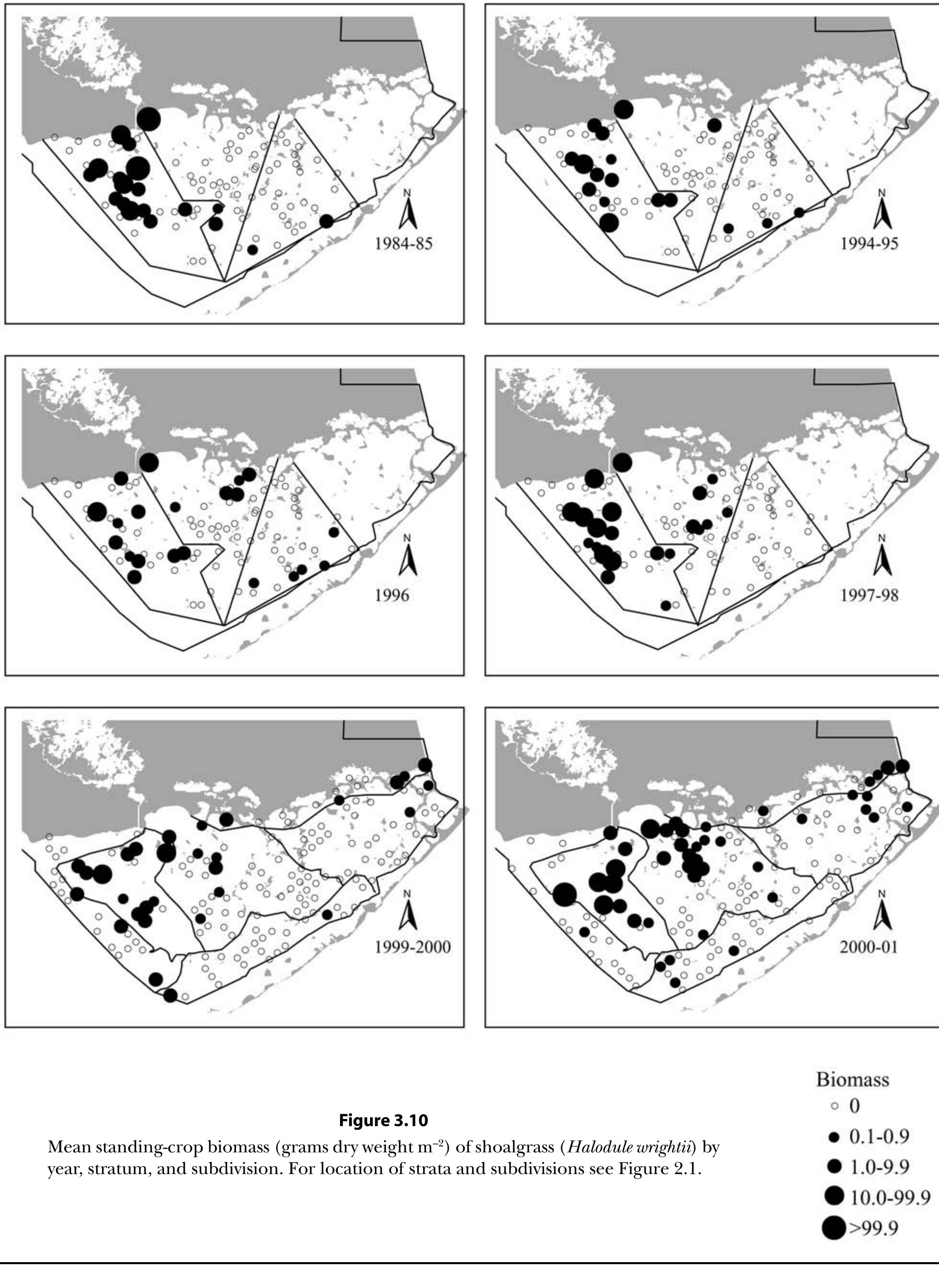


Figure 3.10

Mean standing-crop biomass (grams dry weight m^{-2}) of shoalgrass (*Halodule wrightii*) by year, stratum, and subdivision. For location of strata and subdivisions see Figure 2.1.

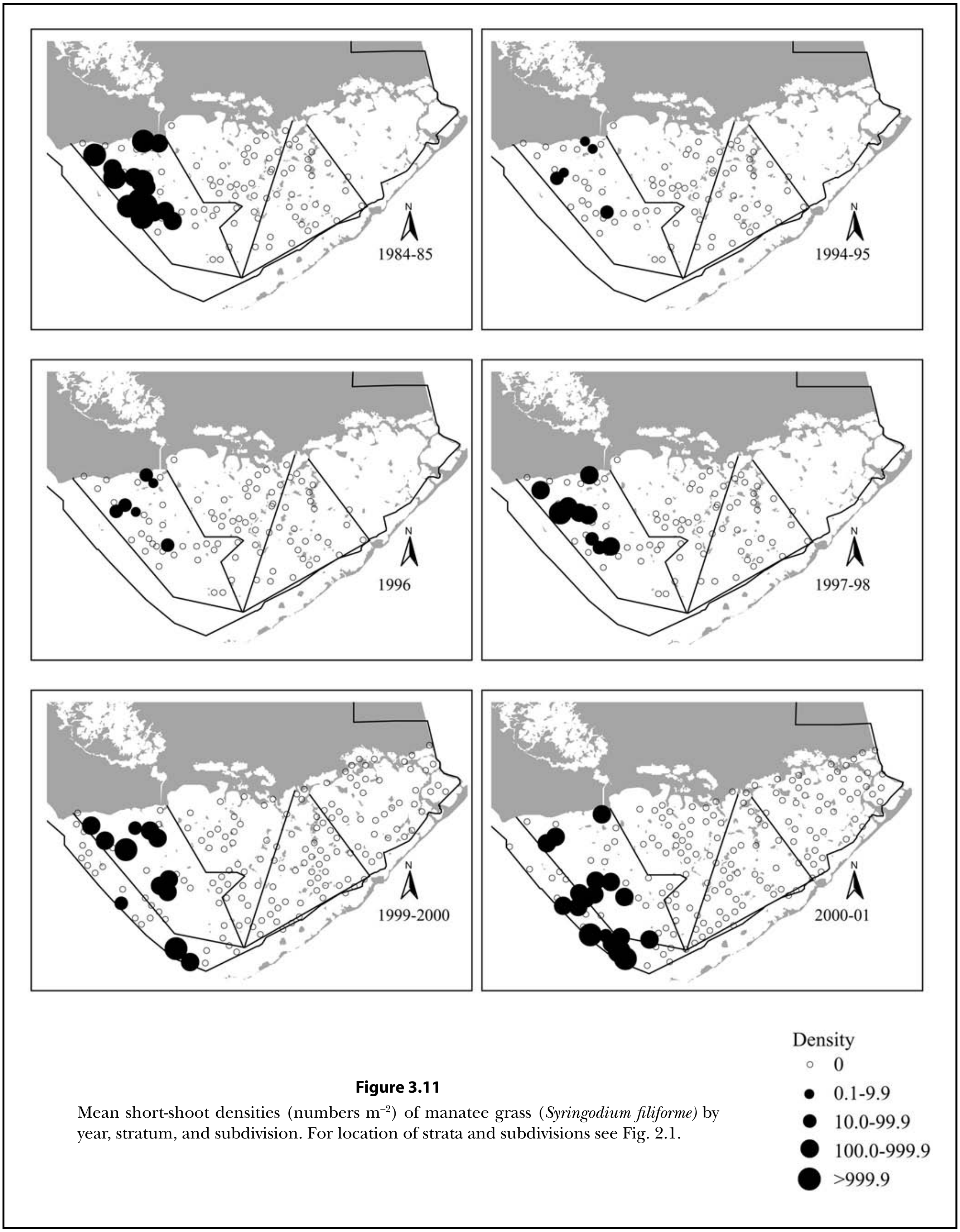


Figure 3.11

Mean short-shoot densities (numbers m^{-2}) of manatee grass (*Syringodium filiforme*) by year, stratum, and subdivision. For location of strata and subdivisions see Fig. 2.1.

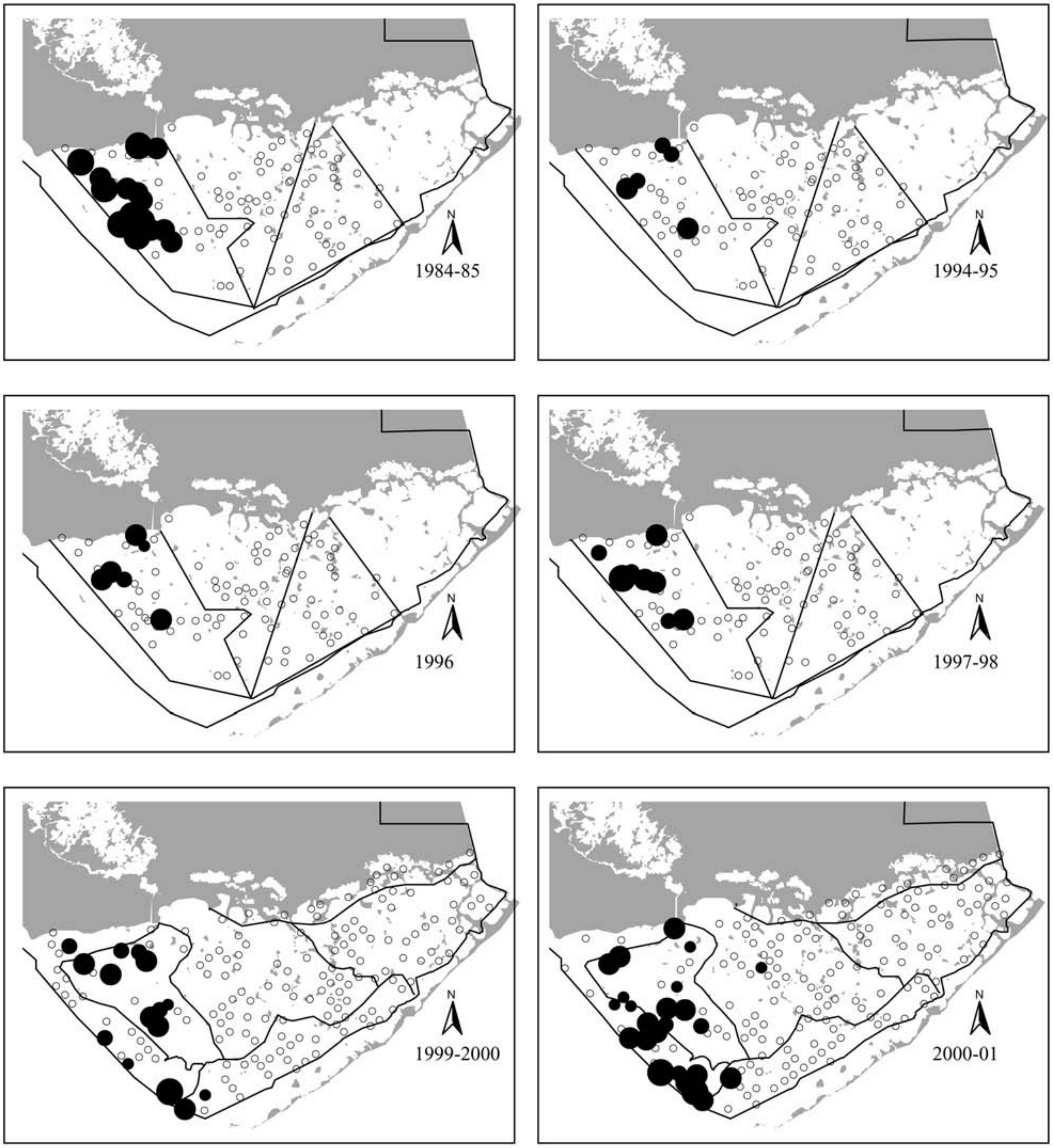


Figure 3.12

Mean above-ground biomass (grams dry weight m^{-2}) of manatee grass *(Syringodium filiforme*) by year, stratum, and subdivison. For location of strata and subdivisions see Figure 2.1.

Chapter 4. Family Clupeidae

Brevoortia smithi (yellowfin menhaden)

Total numbers collected and rank of yellowfin menhaden by sampling method. There were 14 species collected by surface trawl in each habitat.

Gear	Habitat	Year	Number	Rank
Surface trawl	Basins	1984–1985	37	13
Surface trawl	Channels	1984–1985	76	8

Life history An Atlantic population of yellowfin menhaden occurs from Cape Lookout, North Carolina to Jupiter Inlet, Florida. A Gulf of Mexico population occurs from Florida Bay to Louisiana (Dahlberg, 1970). Yellowfin menhaden spawn during winter in nearshore waters as early as November, but most commonly from February to March. Eggs, larvae, and juveniles are pelagic (Hettler, 1968; Dahlberg, 1970). Size of larvae at hatching is approximately 3.0 mm NL. Transformation to the juvenile stage begins at 14 mm SL and is complete between 20–23 mm SL (Houde and Swanson, 1975). Sexual maturity is attained at approximately 220 mm FL (Pattillo et al., 1997).

Diet Juveniles are filter-feeding planktivores that feed on phytoplankton, small zooplankton, and detritus (Dahlberg, 1970; Ahrenholz, 1991).

Abundance and distribution Yellowfin menhaden were commonly collected by surface trawl in Florida Bay, but were limited to the western portion (Fig. 4.1). These fish were most likely spawned in Gulf of Mexico waters during the winter. They were mainly collected in 1984–1985, with highest densities from channel collections (Fig. 4.2). Significant differences in densities were only observed between months. They were collected only in spring, mainly in March (Fig. 4.2). They were never collected by otter trawl.

Tabb et al. (1962) stated that this species was abundant in muddy shallow waters of Whitewater and Coot Bays (salinities ranged from 12–38 ppt), when Coot Bay was connected to Florida Bay by the Buttonwood Canal. However, Thayer et al. (1987a) collected few yellowfin menhaden in Coot and southern Whitewater Bays after the connection to Florida Bay was blocked.

Length-frequency distributions No data were available.

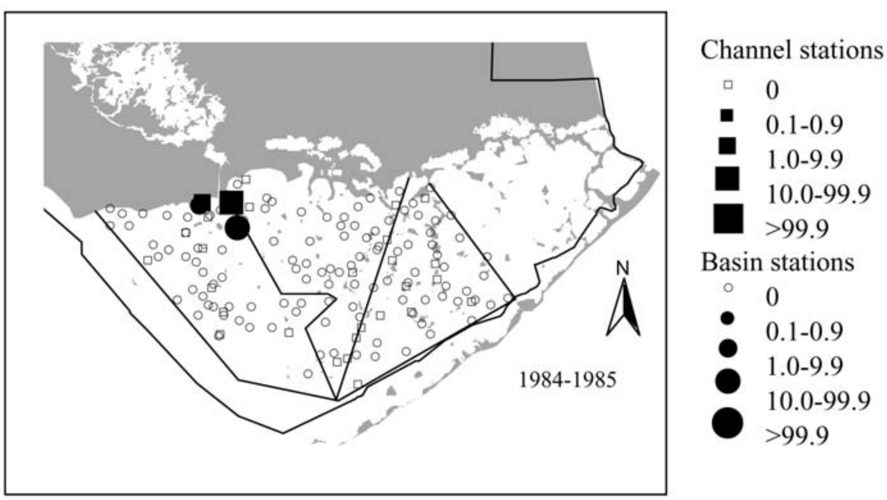


Figure 4.1

Mean densities (numbers 1000 m^{-2}) of yellowfin menhaden (*Brevoortia smithi)* collected by surface trawl in Florida Bay basins and channels during 1984–1985.Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

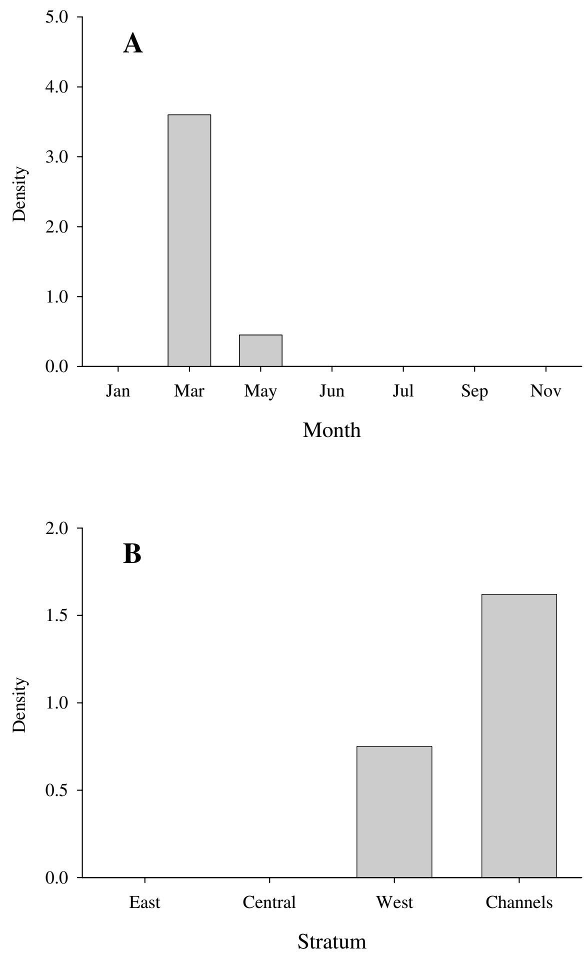


Figure 4.2

Mean densities (numbers 1000 m^{-2}) of yellowfin menhaden (*Brevoortia smithi*) collected by surface trawl in Florida Bay basins and channels during 1984–1985 by (A) month and (B) stratum. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

Harengula jaguana (scaled sardine)

Total numbers collected and rank of scaled sardine by sampling method. There were 39 species collected by otter trawl; 14 by surface trawl in each habitat.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	123	25
Surface trawl	Basins	1984–1985	27	14
Surface trawl	Channels	1984–1985	102	7

Life history Scaled sardine reside in warm temperate and tropical coastal waters from New Jersey to Florida, throughout the Gulf of Mexico, and along Caribbean coastal waters to southern Brazil, Bermuda, Bahamas, and West Indies (Whitehead, 1978). They are extremely rare north of Cape Hatteras, North Carolina and not commonly collected north of Cape Canaveral, Florida (Shaw and Drullinger, 1990). This species spawns in nearshore waters of the northern Gulf of Mexico during March–August (Houde and Fore, 1973), but mainly in June and July (Shaw and Drullinger, 1990). In Florida waters (Tampa Bay), spawning appears to occur year round (Pierce et al., 2001). Collins and Finucane (1984) mainly collected larvae in May and August in Gulf of Mexico coastal waters off southwest Everglades National Park. They did not collect larvae in November or in estuarine waters. Eggs, larvae, and juveniles are pelagic. Size of larvae at hatching is 2.4 mm NL. Transformation to the juvenile stage is completed at 22–24 mm SL (Houde et al., 1974). Sexual maturity, estimated from specimens collected mainly in Biscayne Bay, is attained at 75–85 mm SL (Martinez and Houde, 1975).

Diet Quantitative food studies of fishes from the Whitewater Bay system, adjacent to Florida Bay, indicated that scaled sardines between 64 and 96 mm SL fed mainly on amphipods and mysids (Odum and Heald, 1972). In another Florida study, juveniles between 21 and 25 mm SL fed mainly on veligers, followed by copepods and cypris larvae. Between 26 and 30 mm SL, crab megalops dominated the diet with a marked decrease in the occurrence of veligers and copepods (Carr and Adams, 1973).

Abundance and distribution Based on surface trawl data, there were no significant spatial or temporal differences in densities of scaled sardine, even though densities appeared to be higher in channels (Figs. 4.3 and 4.4). Scaled sardine, like yellowfin menhaden, appeared to be most abundant in channel habitats.

Based on otter trawl data, only significant interannual differences were observed. Highest densities occurred in 1994–1995, lowest in 1999–2001 (Figs. 4.5 and 4.6). The distribution of this species in Florida Bay suggests recruitment into the Bay from both the Atlantic and Gulf of Mexico (Fig. 4.3).

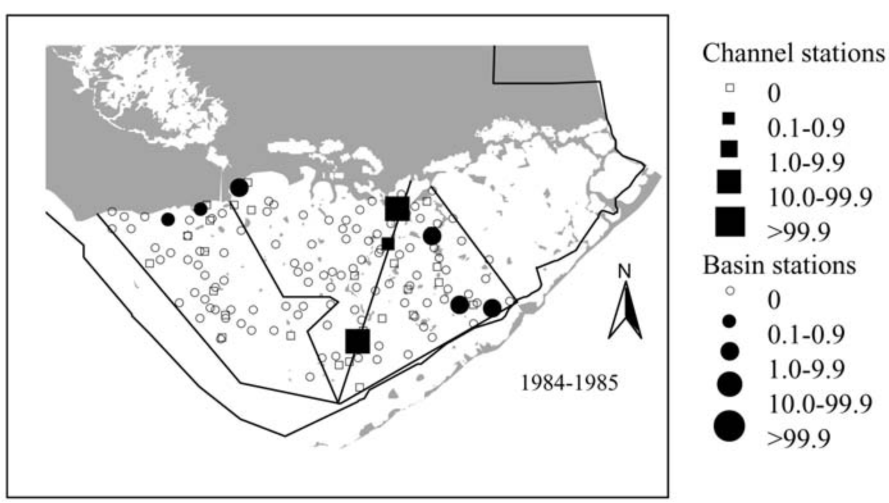


Figure 4.3

Mean densities (numbers 1000 m^{-2}) of scaled sardine (*Harengula jaguana*) collected by surface trawl in Florida Bay basins and channels during 1984–1985. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

Scaled sardine is one of the more abundant clupeids occurring in Florida Bay (FMRI[1,2,3,4]) and were extremely abundant during the summer and fall in Buttonwood Canal when it was connected to Florida Bay (Roessler, 1970). Other studies of juvenile fishes in Florida Bay have shown that scaled sardine abundances declined markedly between 1994–1995 and 1996–1997, and this species was consistently more abundant in August (FMRI[1,2,3,4]).

Length-frequency distributions There appeared to be constant recruitment into Florida Bay from late spring to late fall. One size class was dominant; it appeared to be comprised of recently transformed juveniles (20–29 mm SL) (Fig. 4.7). Sexually-mature scaled sardines (>75 mm) were rarely collected in Florida Bay. This species attains a maximum size of 180 mm TL (Robins and Ray, 1986), which is larger than the specimens we collected.

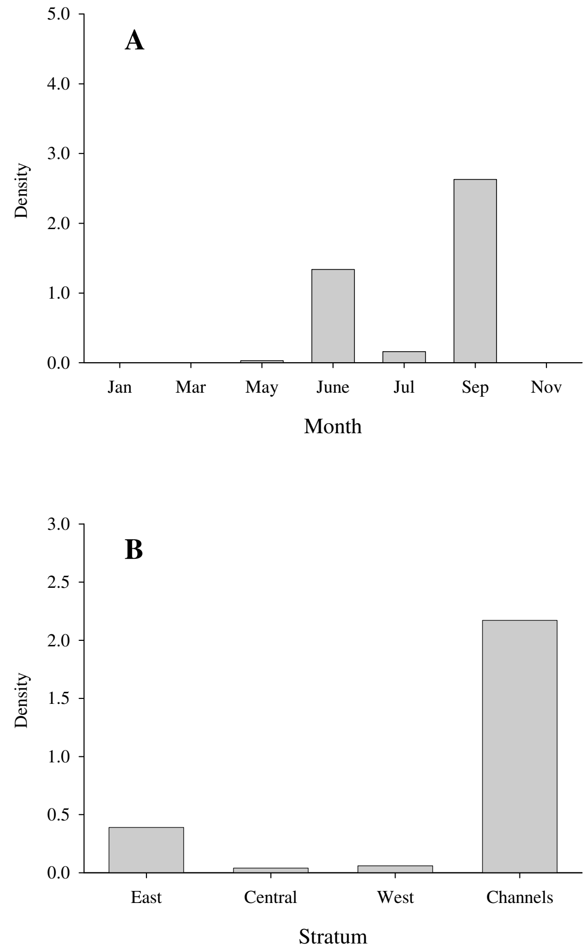


Figure 4.4

Mean densities (numbers 1000 m^{-2}) of scaled sardine (*Harengula jaguana*) collected by surface trawl in Florida Bay basins and channels during 1984–1985 by (A) month and (B) stratum. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

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[2] FMRI. 1996. Fisheries-independent monitoring program, 1995 annual data summary report. Florida Marine Research Institute, Florida Department of Environmental Protection, St. Petersburg, FL, 195 p.

[3] FMRI. 1997. Fisheries-independent monitoring program, 1996 annual data summary report. Florida Marine Research Institute, Florida Department of Environmental Protection, St. Petersburg, FL, 227 p.

[4] FMRI. 1998. Fisheries-independent monitoring program, 1997 annual data summary report. Florida Marine Research Institute, Florida Department of Environmental Protection, St. Petersburg, FL, 236 p.

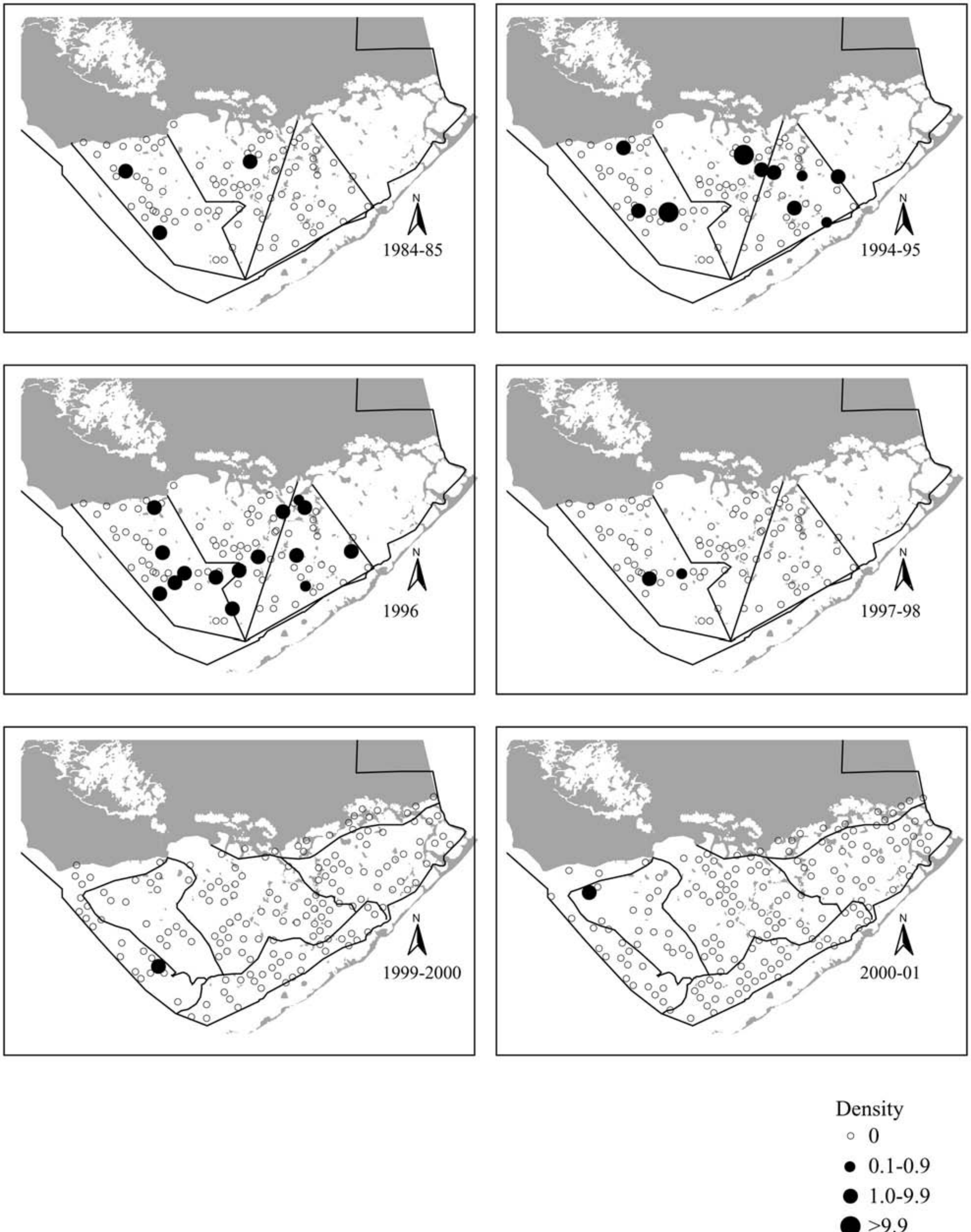


Figure 4.5

Mean densities (numbers 1000 m^{-2}) of scaled sardine (*Harengula jaguana*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

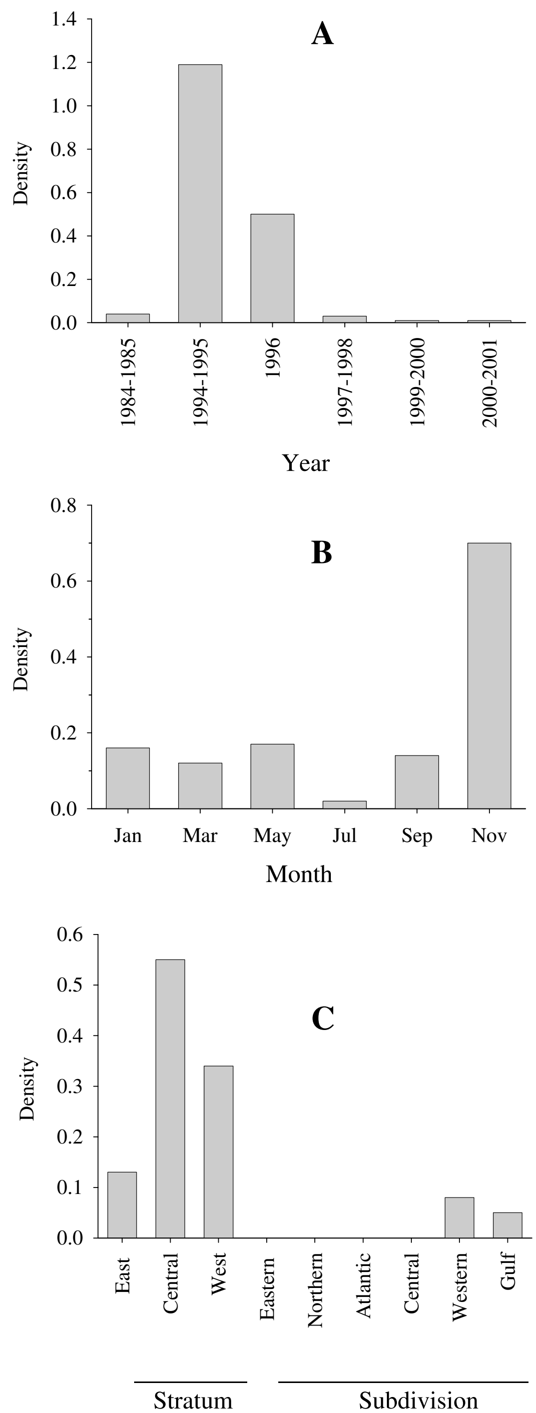


Figure 4.6

Mean densities (numbers 1000 m^{-2}) of scaled sardine (*Harengula jaguana)* from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

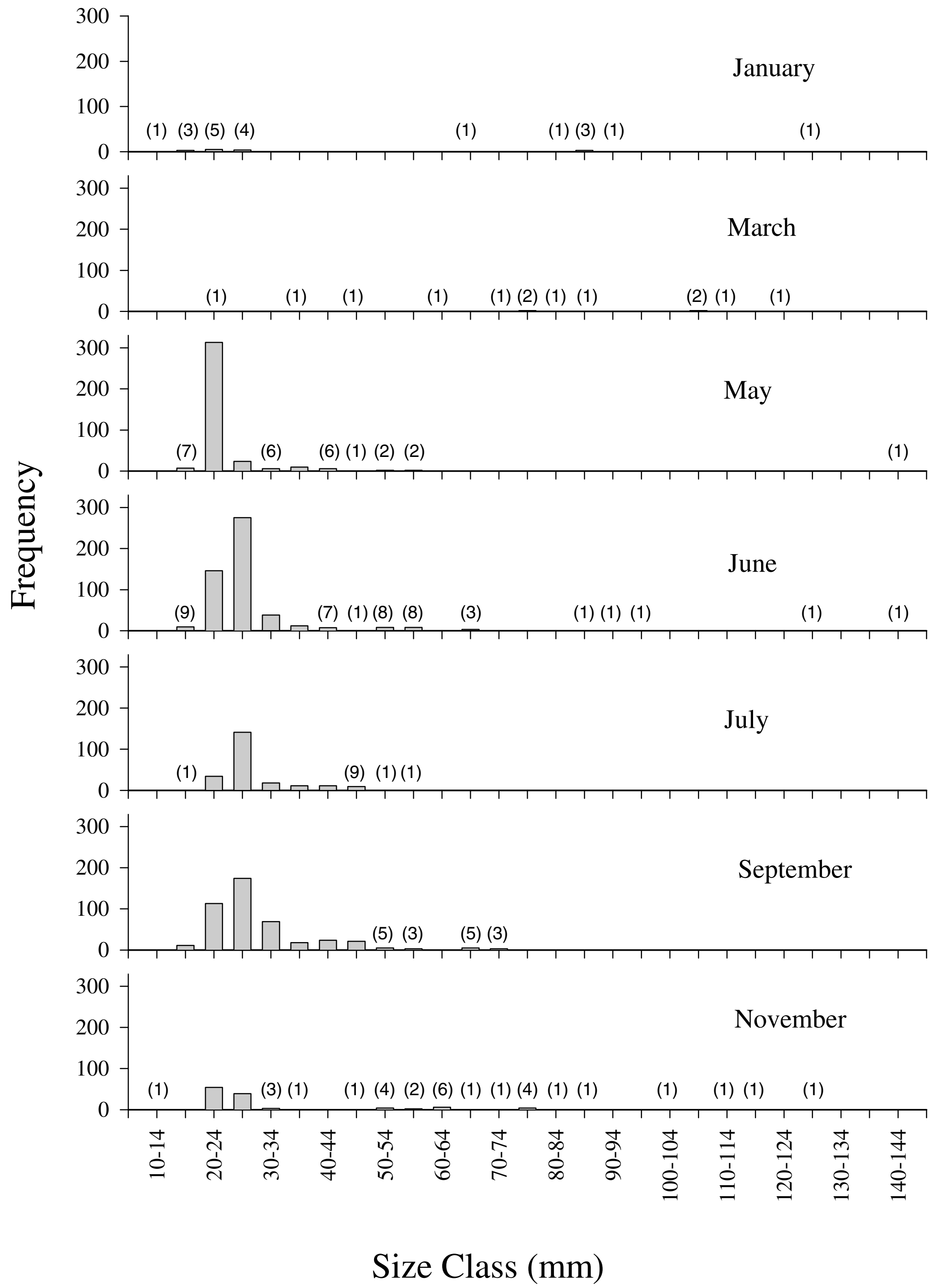


Figure 4.7

Monthly length-frequency distributions of scaled sardine (*Harengula jaguana*) from Florida Bay. Values are shown for numbers <10 for clarity.

Opisthonema oglinum (Atlantic thread herring)

Total numbers collected and rank of Atlantic thread herring by sampling method. There were 39 species collected by otter trawl; 14 by surface trawl in each habitat.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	57	37
Surface trawl	Basins	1984–1985	119	10
Surface trawl	Channels	1984–1985	8	13

Life history Atlantic thread herring occur in coastal waters from Cape Cod (although not common north of North Carolina) to Florida, and throughout the Gulf of Mexico to Brazil, West Indies, and Bermuda (Whitehead, 1978; Robins and Ray, 1986; Smith, 1994).

They spawn during May–June off North Carolina (Whitehead, 1978), and in the northern Gulf of Mexico their larvae are commonly collected in inner shelf waters during May–August (Shaw and Drullinger, 1990). Collins and Finucane (1984) mainly collected larvae in August in Gulf of Mexico coastal waters off southwest Everglades National Park. Larvae were also collected in November, February, and May. They were not collected by Collins and Finucane (1984) in estuarine waters. Eggs, larvae, and juveniles are pelagic. Size of larvae at hatching is 3.8–4.0 mm NL. Transformation to the juvenile stage occurs between 17–25 mm SL (Richards et al., 1974).

Diet Juvenile Atlantic thread herring, between 21 and 24 mm SL, feed mainly on veligers, followed by detritus and copepods (Carr and Adams, 1973). The portion of the diet consisting of veligers decreases during ontogeny with concurrent increases in copepods, mysids, and megalops for juveniles 36–40 mm SL. Detritus is a significant part of the juvenile diet.

Abundance and distribution Atlantic thread herring, sampled by surface trawl, were collected only in the West stratum and only in May (Figs. 4.8 and 4.9).

Based on otter trawl samples (Figs. 4.10 and 4.11), Atlantic thread herring were collected in highest densities in 1997–1998 and 2000–2001, and were absent in 1994–1995 and 1999–2000. From 1984 through 1996 highest densities were observed in the Central stratum, lowest in the West stratum. No significant differences in monthly densities were observed in the otter trawl collections in basins, even though September and November mean densities appeared to be higher than the other months. This species appeared to prefer basin habitats to channels, but compared to other pelagics (except clupeids), this species ranked relatively low in total numbers collected (see table above).

Other studies in Florida Bay report patterns of abundances similar to our observations for Atlantic thread

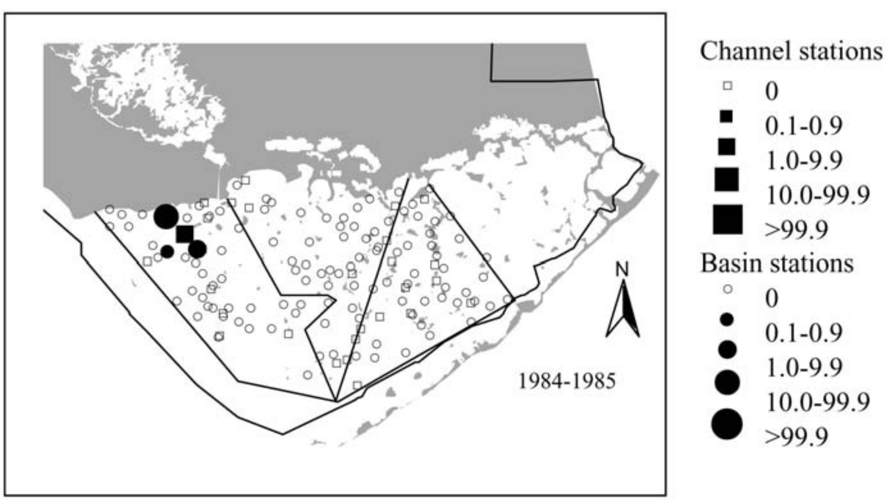


Figure 4.8

Mean densities (numbers 1000 m^{-2}) of Atlantic thread herring (*Opisthonema oglinum*) collected by surface trawl in Florida Bay basins and channels during 1984–1985. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

herring; i.e, abundances declined markedly between 1994–1995 and 1996–1997 (FMRI[1,2,3,4]). In those studies, Atlantic thread herring were most abundant in August (1994 and 1996), July (1995), and October (1997). Atlantic thread herring were collected in comparable numbers to scaled sardines, which is in concordance with other studies in Florida Bay (Sogard et al., 1989a; (FMRI[1,2,3,4]). Hence, they, along with scaled sardine, could be considered the two most abundant clupeids in Florida Bay. They are also one of the two most abundant clupeids in adjacent Biscayne Bay (Houde and Lovdal, 1984).

Length-frequency distributions Larvae or transforming juveniles recruited into Florida Bay throughout most of the year (Fig. 4.12). Smallest larvae and transforming juveniles (<25 mm SL) were collected by otter trawl in all months except January, March, and June. Length-frequency distributions in March indicate that recruitment into Florida Bay also occurred during winter. Few large juveniles were collected with the otter trawl. The largest Atlantic thread herring collected were ca. 155 mm SL, much smaller than the reported maximum length of 300 mm TL (Robins and Ray, 1986).

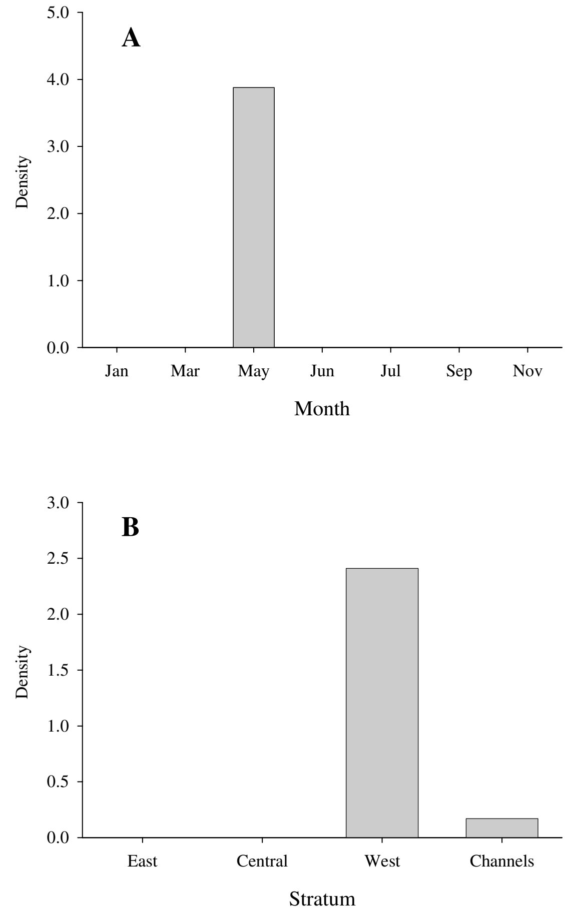


Figure 4.9

Mean densities (numbers 1000 m^{-2}) of Atlantic thread herring (*Opisthonema oglinum*) collected by surface trawl in Florida Bay basins and channels during 1984–1985 by (A) month and (B) stratum. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

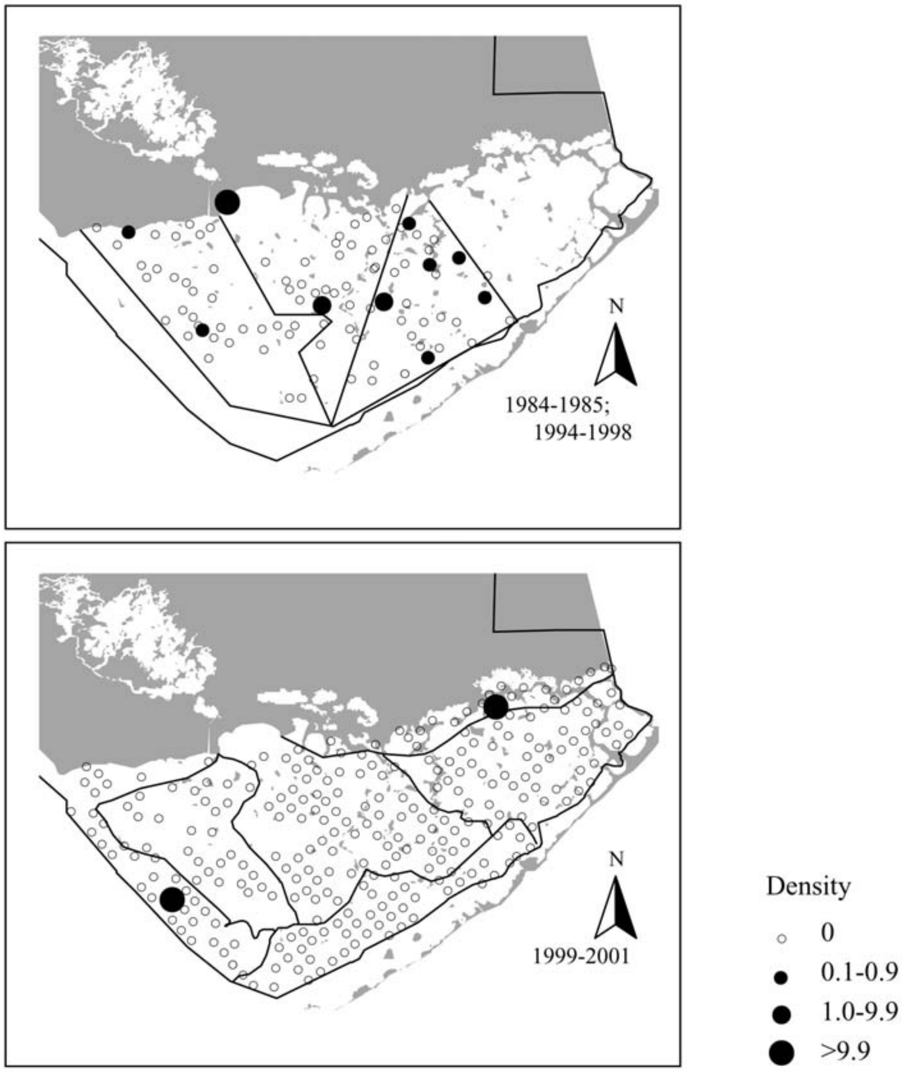


Figure 4.10

Mean densities (numbers 1000 m^{-2}) of Atlantic thread herring (*Opisthonema oglinum*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

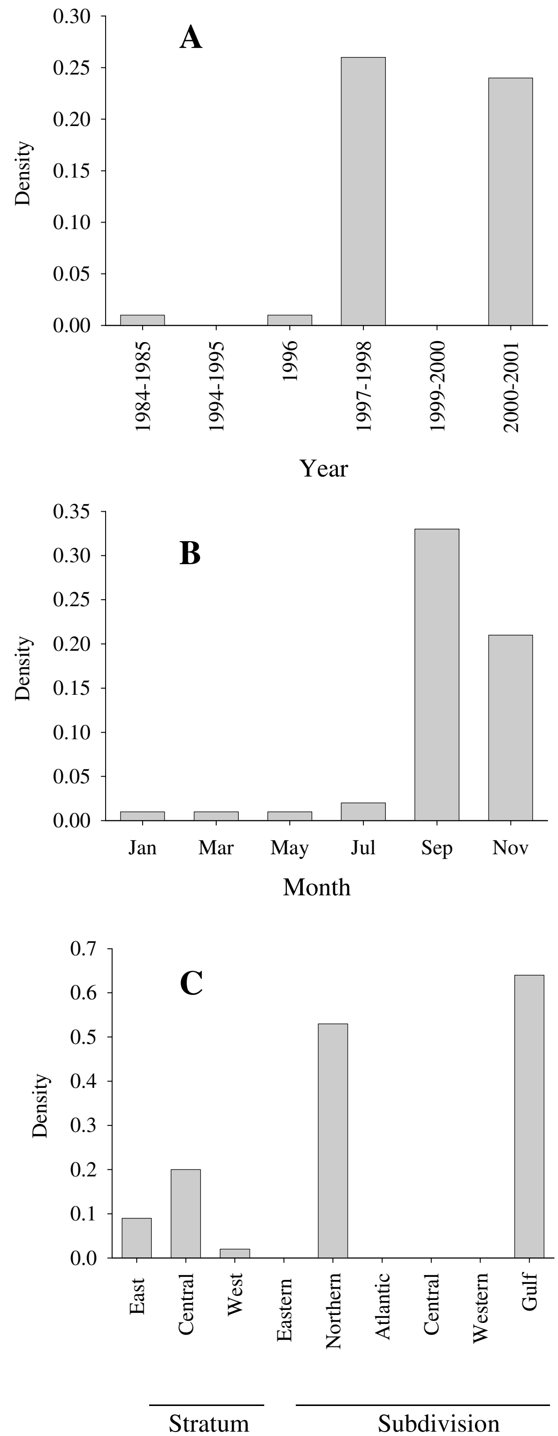


Figure 4.11

Mean densities (numbers 1000 m^{-2}) of Atlantic thread herring (*Opisthonema oglinum*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

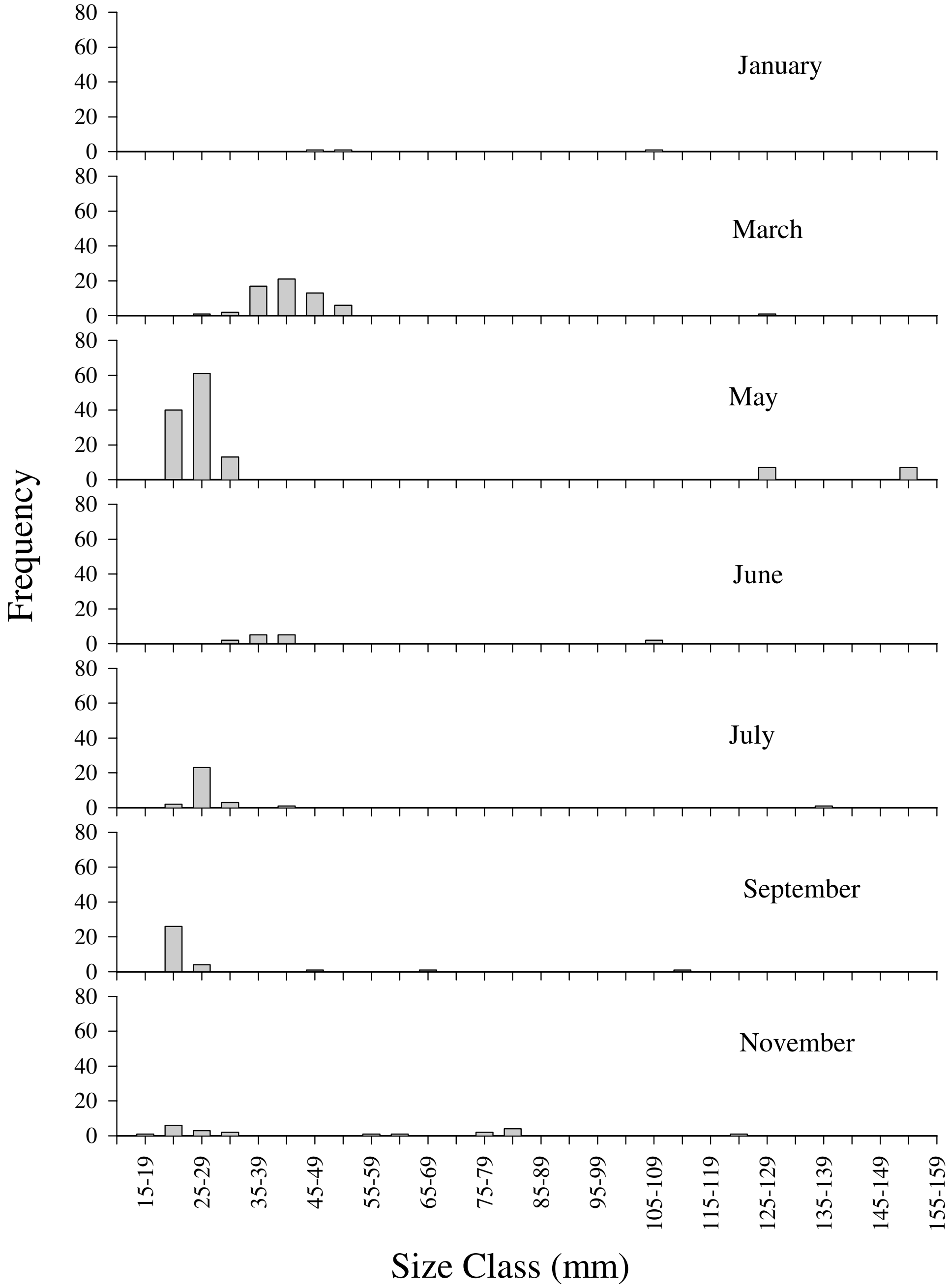


Figure 4.12

Monthly length-frequency distributions of Atlantic thread herring (*Opisthonema oglinum*) from Florida Bay.

Sardinella aurita (Spanish sardine)

Total numbers collected and rank of Spanish sardine by sampling method. There were 39 species collected by otter trawl; 14 by surface trawl in each habitat.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	84	30
Surface trawl	Basins	1984–1985	163	9
Surface trawl	Channels	1984–1985	1	14

Life history Spanish sardine occur in coastal waters from Cape Cod to Florida, throughout the Gulf of Mexico, and along the Caribbean coast to southern Brazil, Bermuda, Bahamas, and West Indies (Whitehead, 1978). In the eastern Gulf of Mexico Spanish sardines have a protracted spawning season with a peak during spring and summer. Along southwest Florida they spawn primarily in the fall and winter (Houde and Fore, 1973; Shaw and Drullinger, 1990). Size of larvae at hatching is approximately 2.5 mm NL. Transformation to the juvenile stage begins at 16 mm SL and is completed at 23 mm SL (Ditty et al., 1994). In western Florida waters, 50% of females mature at 147 mm FL (Shaw and Drullinger, 1990).

Diet Juvenile Spanish sardine feed on diatoms and small copepods (Wang and Qiu, 1986).

Abundance and distribution Spanish sardine were common in surface trawl collections (but only collected at three stations) and uncommon in otter trawl basin collections. Based on surface trawl data (Fig. 4.13), there were no significant spatial or temporal differences in densities; however, Spanish sardine were only collected in the Central and West strata (Fig. 4.14). This species, like the Atlantic thread herring, appeared to prefer basin habitats to channels.

In otter trawl collections in basins (Fig. 4.15), Spanish sardine were only collected during 1999–2000 and 2000–2001 (Fig. 4.16). There were no significant differences in densities among months, although we failed to collect any specimens during three (January, March, and July) of the six months sampled. Spatially, highest densities were observed in the Gulf subdivision, moderate in the Central and Eastern subdivisions, low in the Northern subdivision, and they were absent in the Atlantic or Western subdivisions (Fig. 4.16).

Other studies of juvenile fishes in Florida Bay and adjacent waters indicate that this species is rare in Florida Bay and was also rare in the Buttonwood Canal when it was connected to Florida Bay (Roessler, 1970; FMRI[1,2,3,4]).

Length-frequency distributions Based on limited length-frequency data, Spanish sardine recruited mainly to Florida Bay during spring (Fig. 4.17); however, some recruitment may occur throughout the year. In May specimens were mainly larvae and transforming juveniles (14–24 mm SL). In June juveniles were dominant. No sexually mature (ca. 145 mm SL) Spanish sardine were collected. The largest specimens collected by otter trawl were ca. 55 mm SL, much smaller than the reported maximum size of 250 mm TL (Robins and Ray, 1986).

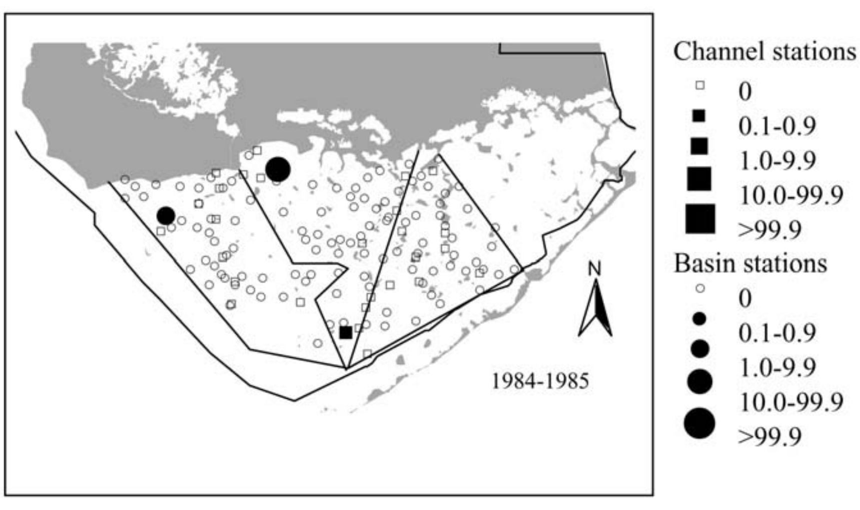


Figure 4.13

Mean densities (numbers 1000 m^{-2}) of Spanish sardine (*Sardinella aurita*) collected by surface trawl in Florida Bay basins and channels during 1984–1985. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

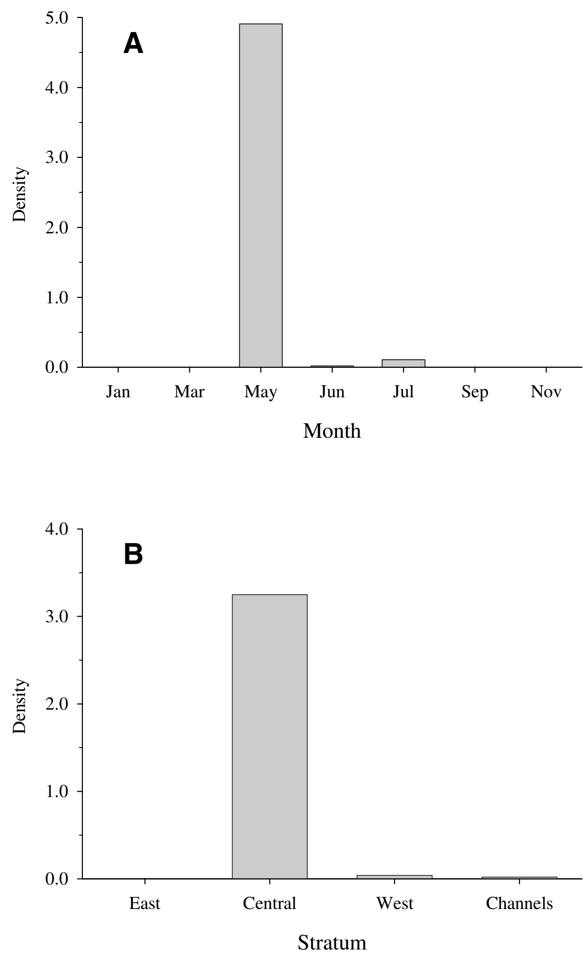


Figure 4.14

Mean densities (numbers 1000 m^{-2}) of Spanish sardine (*Sardinella aurita*) collected by surface trawl in Florida Bay basins and channels during 1984–1985 by (A) month and (B) stratum. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

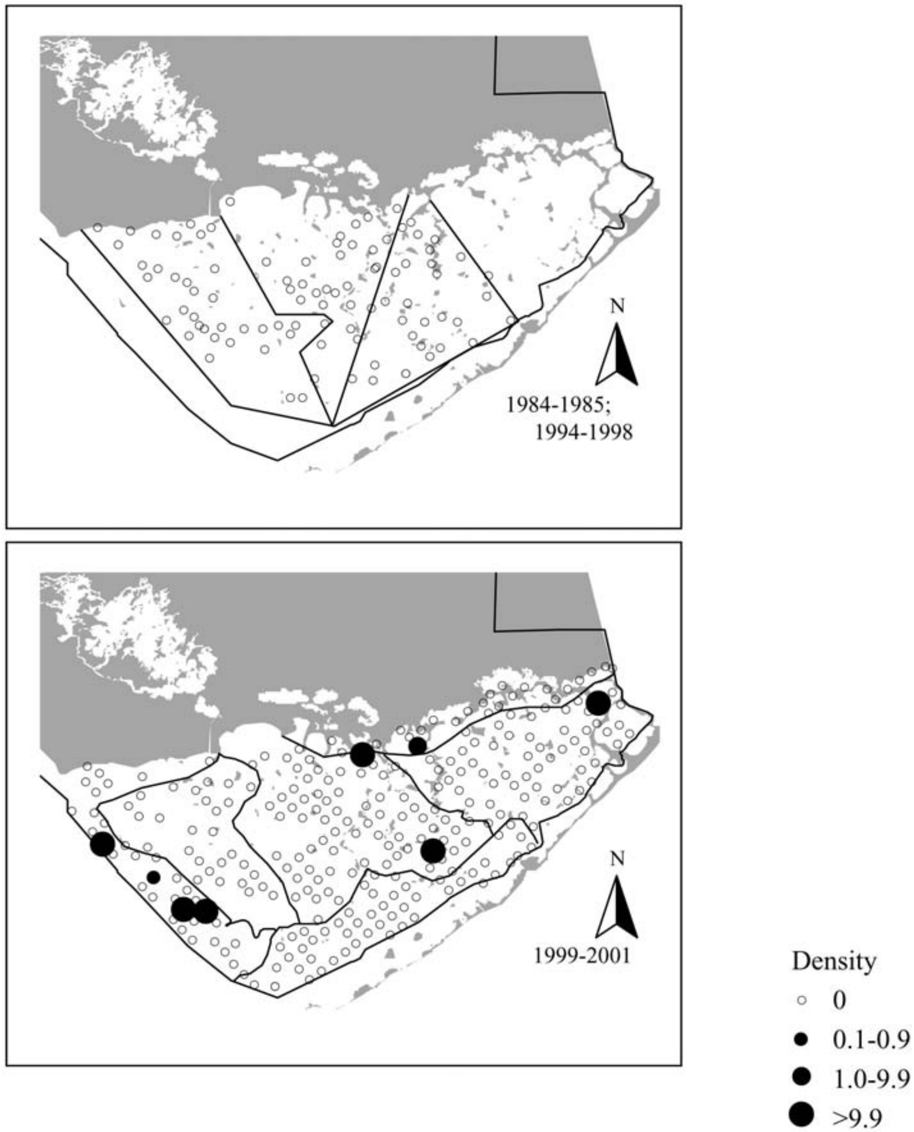


Figure 4.15

Mean densities (numbers 1000 m^{-2}) of Spanish sardine (*Sardinella aurita*) from bimonthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

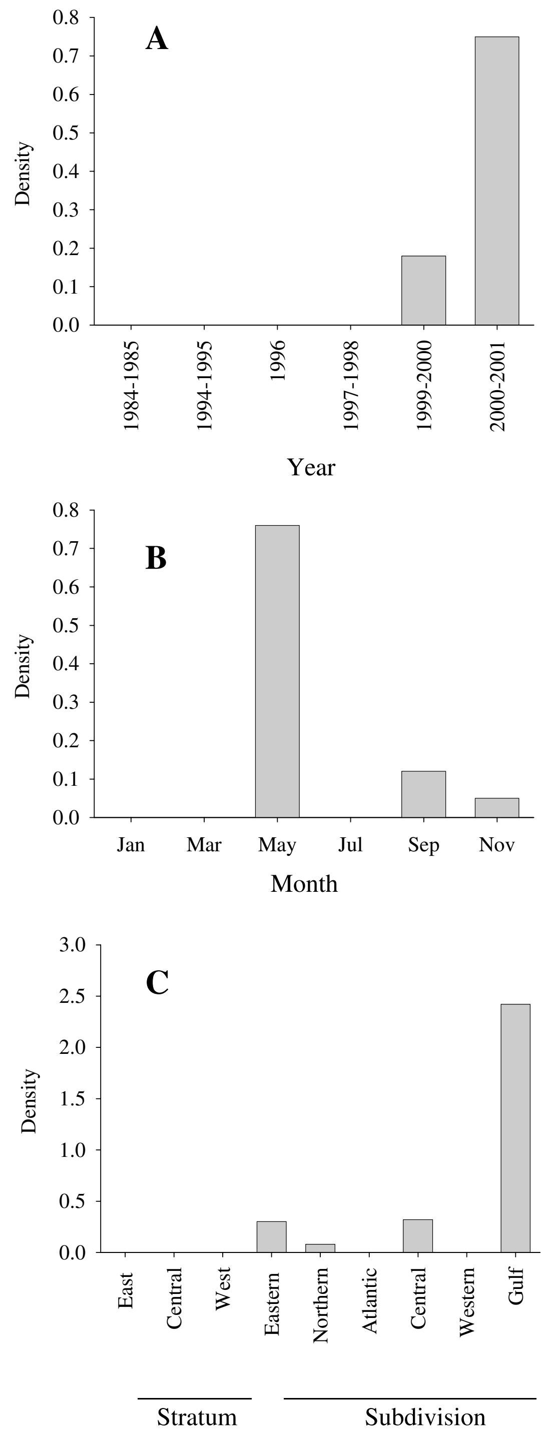


Figure 4.16

Mean densities (numbers 1000 m^{-2}) of Spanish sardine (*Sardinella aurita*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

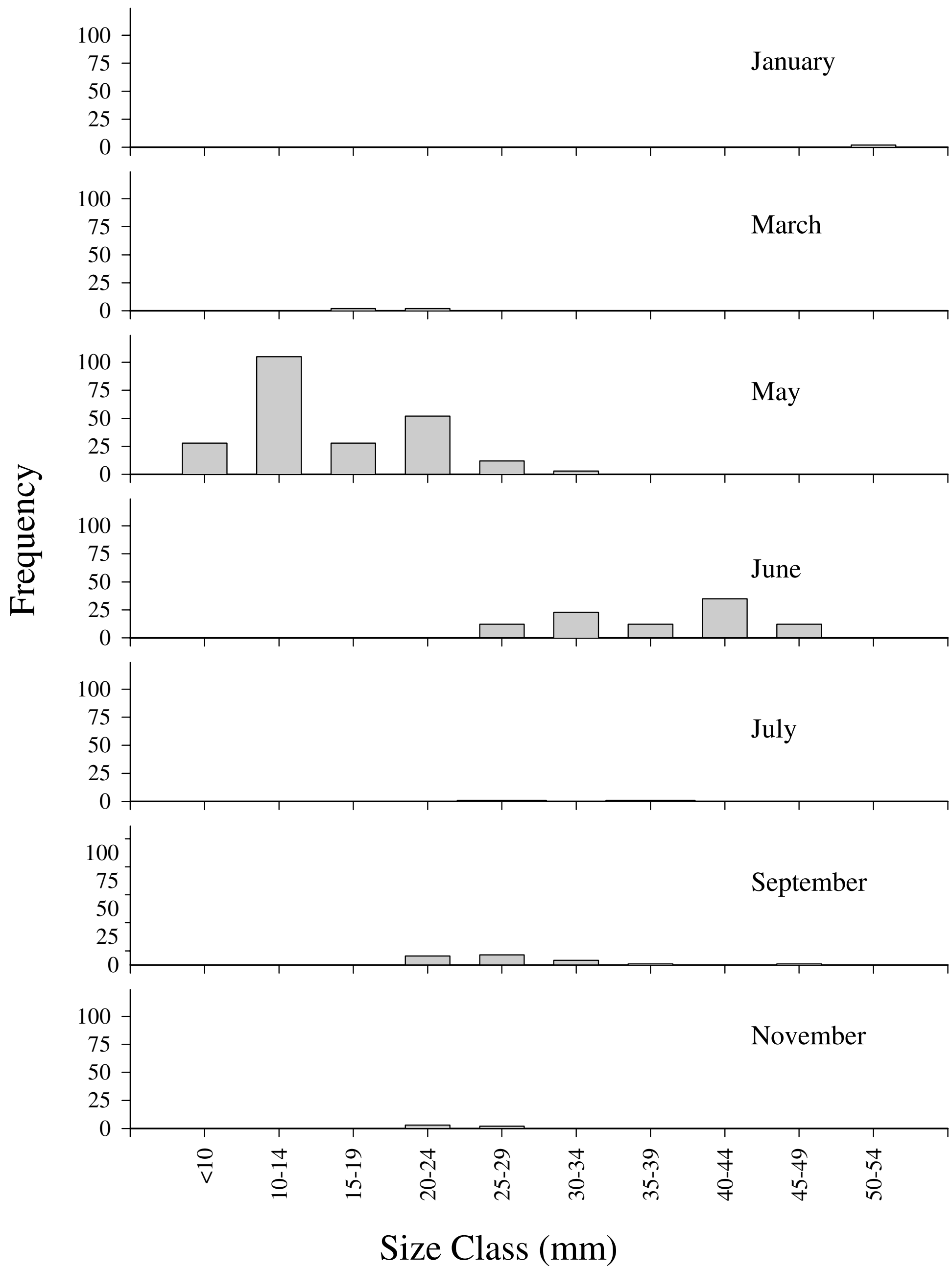


Figure 4.17

Monthly length-frequency distributions of Spanish sardine (*Sardinella aurita)* from Florida Bay.

Chapter 5. Family Engraulidae

Anchoa hepsetus (striped anchovy)

Total numbers collected and rank of striped anchovy by sampling method. There were 39 species collected by otter trawl; 14 by surface trawl in each habitat.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	81	31
Surface trawl	Basins	1984–1985	496	4
Surface trawl	Channels	1984–1985	29	11

Life history Striped anchovy inhabit shallow coastal waters from Nova Scotia to Florida, throughout the Gulf of Mexico, and along the Caribbean coast to Uruguay, the Bahamas, and the West Indies (Whitehead, 1978; Able and Fahay, 1998). Striped anchovy spawn in harbors, estuaries, sounds, and offshore waters (Whitehead, 1978). Spawning occurs from April–July in South Carolina waters (Whitehead, 1978); throughout the year, with peaks in April–June, off Campeche, Mexico (Valencia et al., 1998); and November through April in Biscayne Bay, Florida (Jones et al., 1978). Eggs, larvae, and juveniles are pelagic, and occupy the higher part of the water column relative to other zooplanktivorous fishes (Allen et al., 1995). Size at hatching is 3.6–4.0 mm TL; transformation to the juvenile stage occurs at approximately 30 mm SL (Jones et al., 1978). The minimal size at sexual maturity is 43 mm and 48 mm TL for males and females, respectively (Valencia et al., 1998).

Diet Juvenile striped anchovy (25–50 mm SL) feed mainly on veliger larvae (Carr and Adams, 1973). Copepods, mysids, zooea, and fish larvae are also consumed, but their contribution is small compared to veligers.

Abundance and distribution This species was commonly collected with a surface trawl, especially in basin habitats, but only in the northern Central and West strata, and only in May (Figs. 5.1 and 5.2). These spatial and temporal differences in densities were significant.

The striped anchovy was uncommon in otter trawl collections (Fig. 5.3), and its distribution and abundance were most likely underestimated as this species occurs mainly in surface waters (Allen et al., 1995). There were significant differences in otter trawl densities among strata and subdivisions, and year, but not among months (Fig. 5.4). Highest densities were observed in the West stratum, the lowest in the East stratum; and they were absent in the Central stratum. From 1999–2001 this species was only collected in the Gulf subdivision (Fig. 5.3).

Length-frequency distributions All life history stages of striped anchovy were collected in Florida Bay (Fig. 5.5). The smallest larvae were collected in May, but larvae and transforming juveniles(<30 mm SL) were collected in all months sampled. Sexually mature striped anchovy (30–35 mm SL) were also collected in all months.

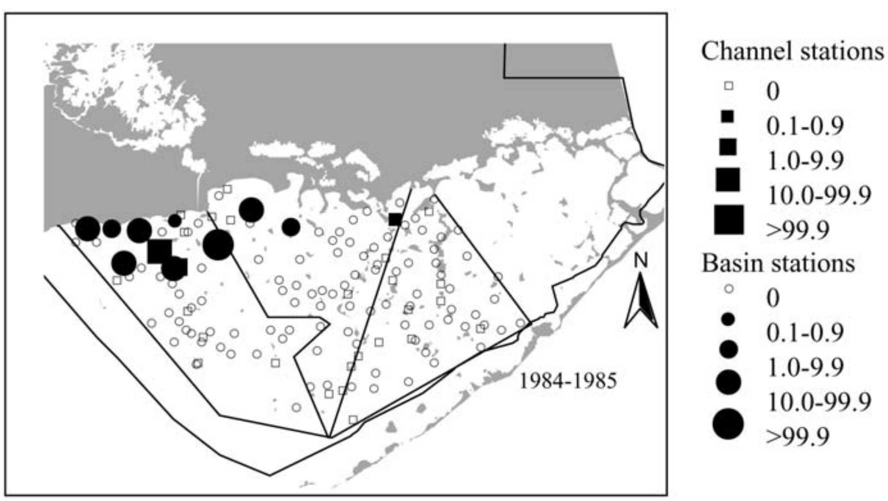


Figure 5.1

Mean densities (numbers 1000 m^{-2}) of striped anchovy (*Anchoa hepsetus*) collected by surface trawl in Florida Bay basins and channels during 1984–1985. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

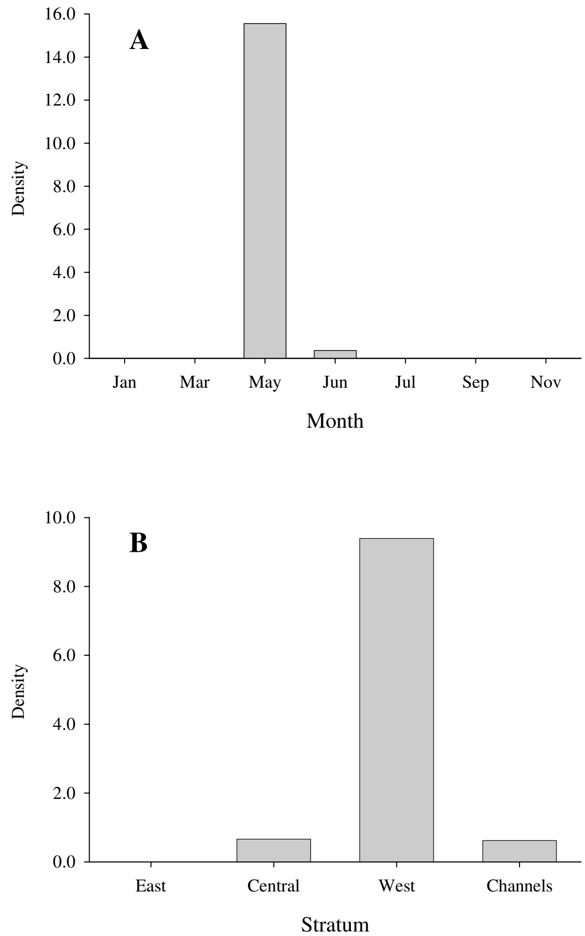


Figure 5.2

Mean densities (numbers 1000 m^{-2}) of striped anchovy (*Anchoa hepsetus*) collected by surface trawl in Florida Bay basins and channels during 1984–1985 by (A) month and (B) stratum. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

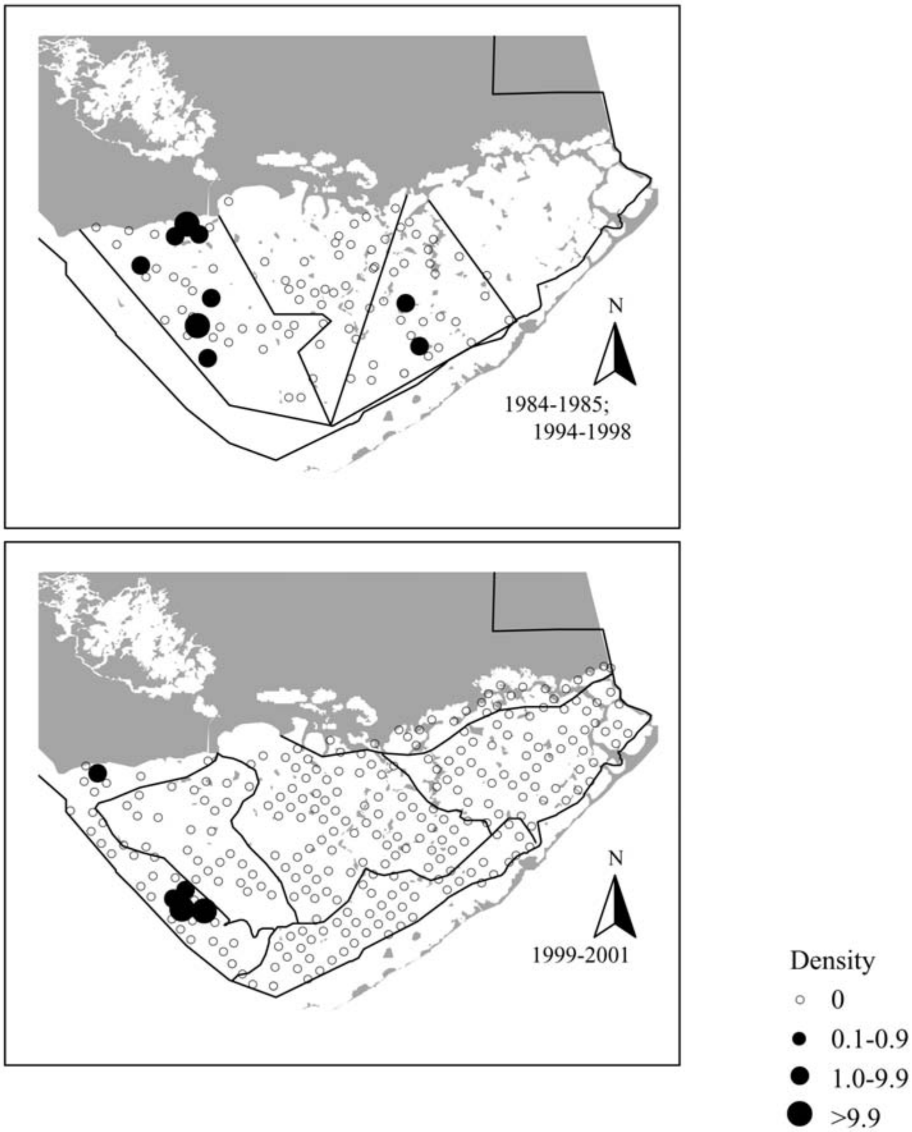


Figure 5.3

Mean densities (numbers 1000 m^{-2}) of striped anchovy (*Anchoa hepsetus*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

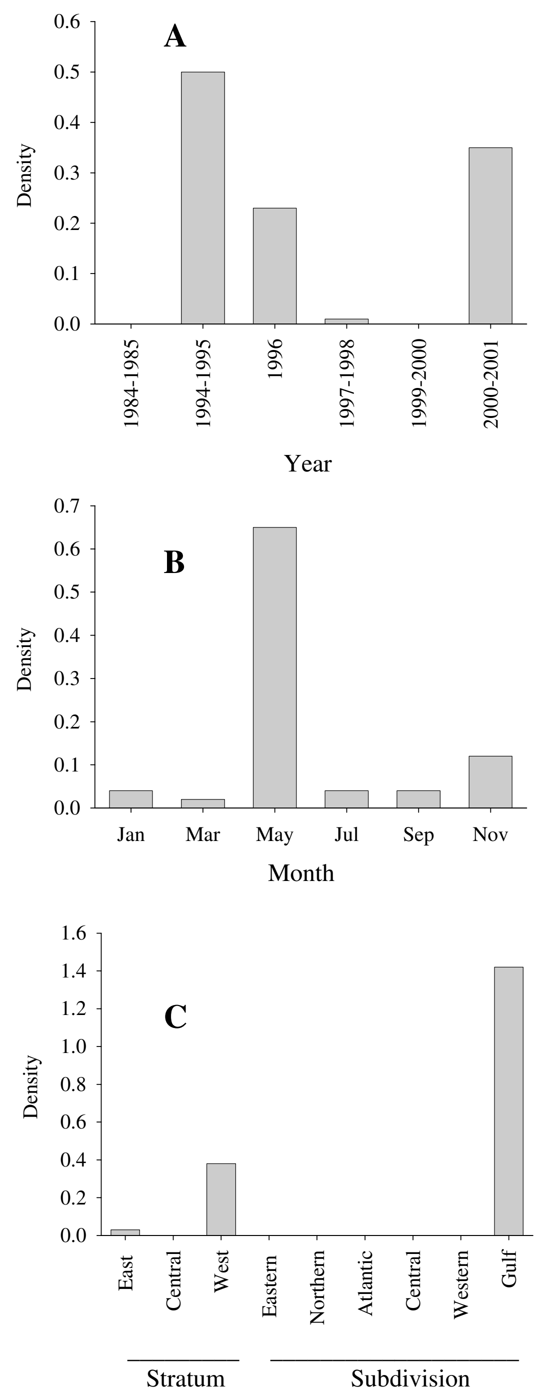


Figure 5.4

Mean densities (numbers 1000 m^{-2}) of striped anchovy (*Anchoa hepsetus*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

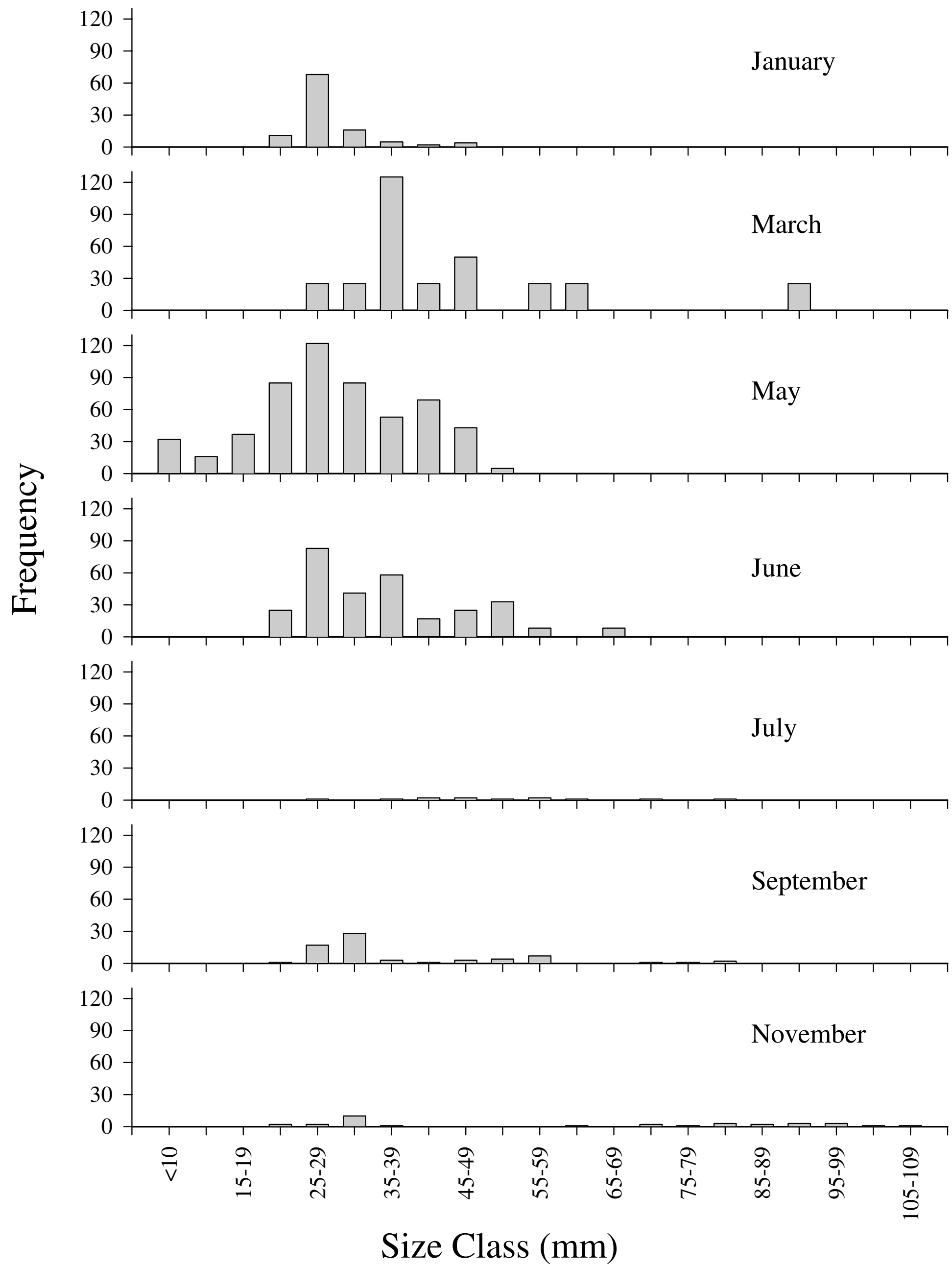


Figure 5.5

Monthly length-frequency distributions of striped anchovy (*Anchoa hepsetus*) from Florida Bay.

Anchoa mitchilli (bay anchovy)

Total numbers collected and rank of bay anchovy by sampling method. There were 39 species collected by otter trawl; 14 by surface trawl in each habitat.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	9284	3
Surface trawl	Basins	1984–1985	181	8
Surface trawl	Channels	1984–1985	409	3

Life history The bay anchovy ranges from the Gulf of Maine to Florida, throughout the Gulf of Mexico, and along the Caribbean coast to Belize. It is rare in the Yucatan, Gulf of Maine, and Florida Keys, and absent from the West Indies (Robins and Ray, 1986; Leak and Houde, 1987; Pattillo et al., 1997). This species most likely constitutes the greatest biomass of ichthyofauna in the southeast and U. S. Gulf of Mexico (Pattillo et al., 1997). In adjacent Biscayne Bay, bay anchovy eggs occurred throughout the year, but were most abundant in summer, and rare to absent during winter (Jones et al., 1978; Houde and Lovdal, 1984). Whereas, in Tampa Bay, Florida, spawning occurs when water temperatures reach 20°C and ceases by November (Pattillo et al., 1997). Eggs, larvae, and juveniles are pelagic, but bay anchovy dominate the lower portion of the water column relative to other zooplanktivorous fishes (Allen et al., 1995). Size at hatching is 1.8–2.7 mm TL; transformation to the juvenile stage begins at 16 mm SL and is complete by 22 mm SL. Males and females mature at lengths of approximately 40 mm SL (Zastrow et al., 1991).

Diet In the Whitewater Bay system, larval and juvenile bay anchovy <25 mm SL fed mainly on microzooplankton (copepods, copepodites, and naupli) by size-selective capture of individual organisms (Odum and Heald, 1972).

Abundance and distribution Bay anchovy were common in surface trawl collections, and densities differed among strata and months (Figs. 5.6 and 5.7). Highest densities were observed in May, the lowest in January and July. Densities were highest in the West stratum. Unlike the striped anchovy, they appeared to prefer channel habitats to basins.

Bay anchovy were abundant in otter trawl collections. Considerable interannual variability was observed in the abundance of bay anchovy (Figs. 5.8 and 5.9). Relatively low densities were observed in 1984–1985 and 2000–2001, and to a lesser degree in 1998. Relatively high densities were observed in 1994–1995 and 1996. Significant spatial and temporal differences in densities were observed (Fig. 5.9). Highest densities were observed in November and lowest in July. From 1984–1998, bay anchovy were collected at highest densities in the Central stratum with lower values in the East and West

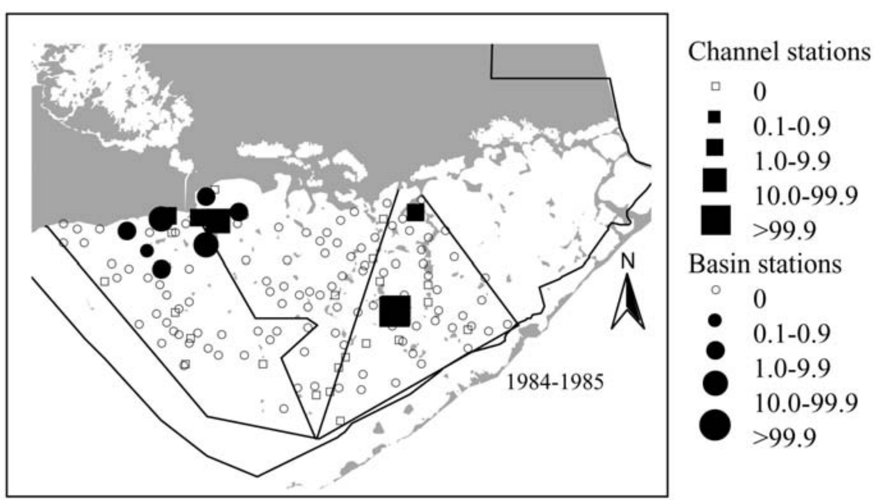


Figure 5.6

Mean densities (numbers 1000 m^{-2}) of bay anchovy (*Anchoa mitchilli*) collected by surface trawl in Florida Bay basins and channels during 1984–1985.Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

strata; from 1999–2001, highest densities occurred in the Northern, Central, and Gulf subdivisions. They were not collected in the Atlantic subdivision.

Because this species occurs in the lower water column (Allen et al., 1995), otter trawl densities probably are good estimators of its distribution and abundance. Highest values we observed followed seagrass die-off, persistent turbidity, and phytoplankton blooms (Fourqurean and Robblee, 1999), which might be due to their attraction to unvegetated bottoms and high turbidity (Pattillo et al., 1997).

Contrary to our findings, Sogard et al. (1987) reported significant differences in densities of bay anchovy among sites, with highest densities occurring at Eagle Key (Fig. 1.1).

Length-frequency distributions Based on length-frequency distributions, spawning occurred throughout the year in Florida Bay (Fig. 5.10). Otter trawl collections in Florida Bay were dominated by transforming juveniles (16–22 mm SL) and juveniles (22–40 mm SL). Growth of bay anchovy was difficult to discern from length-frequency distributions because of their protracted spawning period. In Biscayne Bay, bay anchovy (<14 mm SL) grow approximately 0.50 mm per day (Leak and Houde, 1987). Anchovies collected near Beaufort, North Carolina, grew exponentially (approximately 4% per day) during their first 49 days (Fives et al., 1986). Fish spawned in spring could grow to maturity and spawn during their first summer.

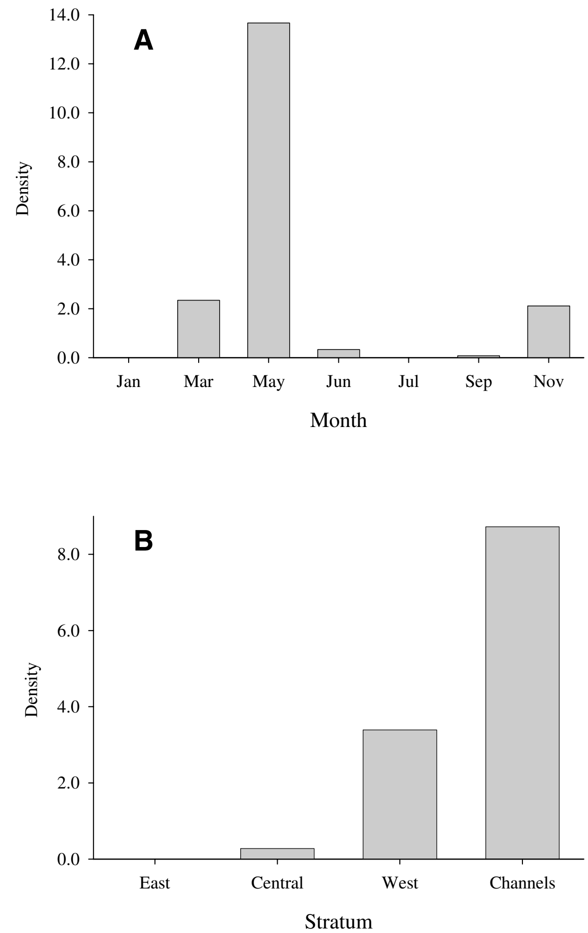


Figure 5.7

Mean densities (numbers 1000 m^{-2}) of bay anchovy (*Anchoa mitchilli*) collected by surface trawl in Florida Bay basins and channels during 1984–1985 by (A) month and (B) stratum. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

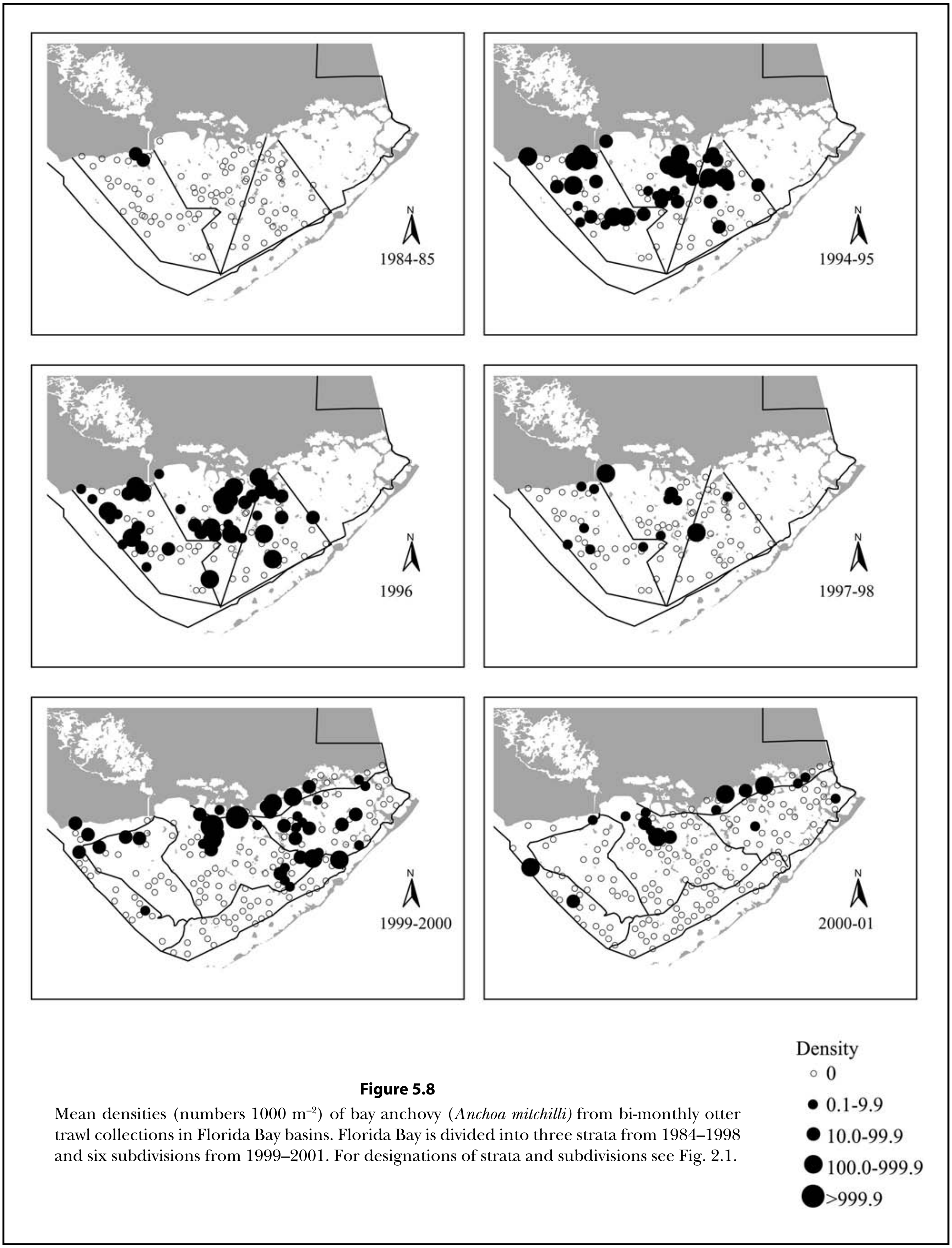


Figure 5.8

Mean densities (numbers 1000 m^{-2}) of bay anchovy (*Anchoa mitchilli)* from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

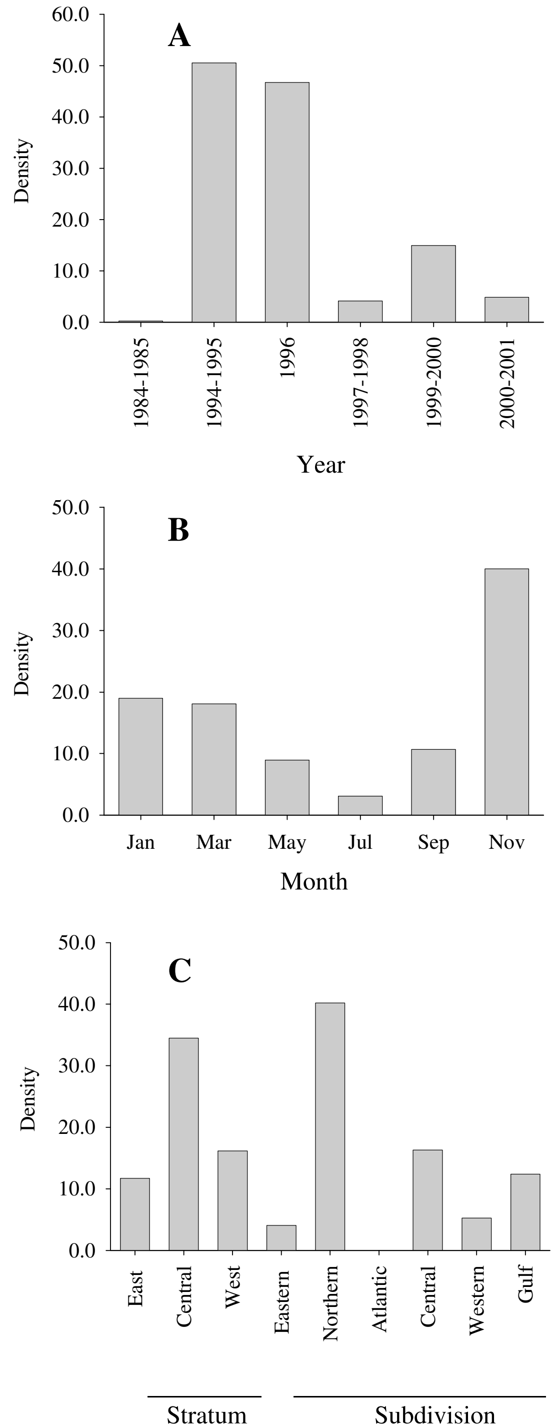


Figure 5.9

Mean densities (numbers 1000 m^{-2}) of bay anchovy (*Anchoa mitchilli*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

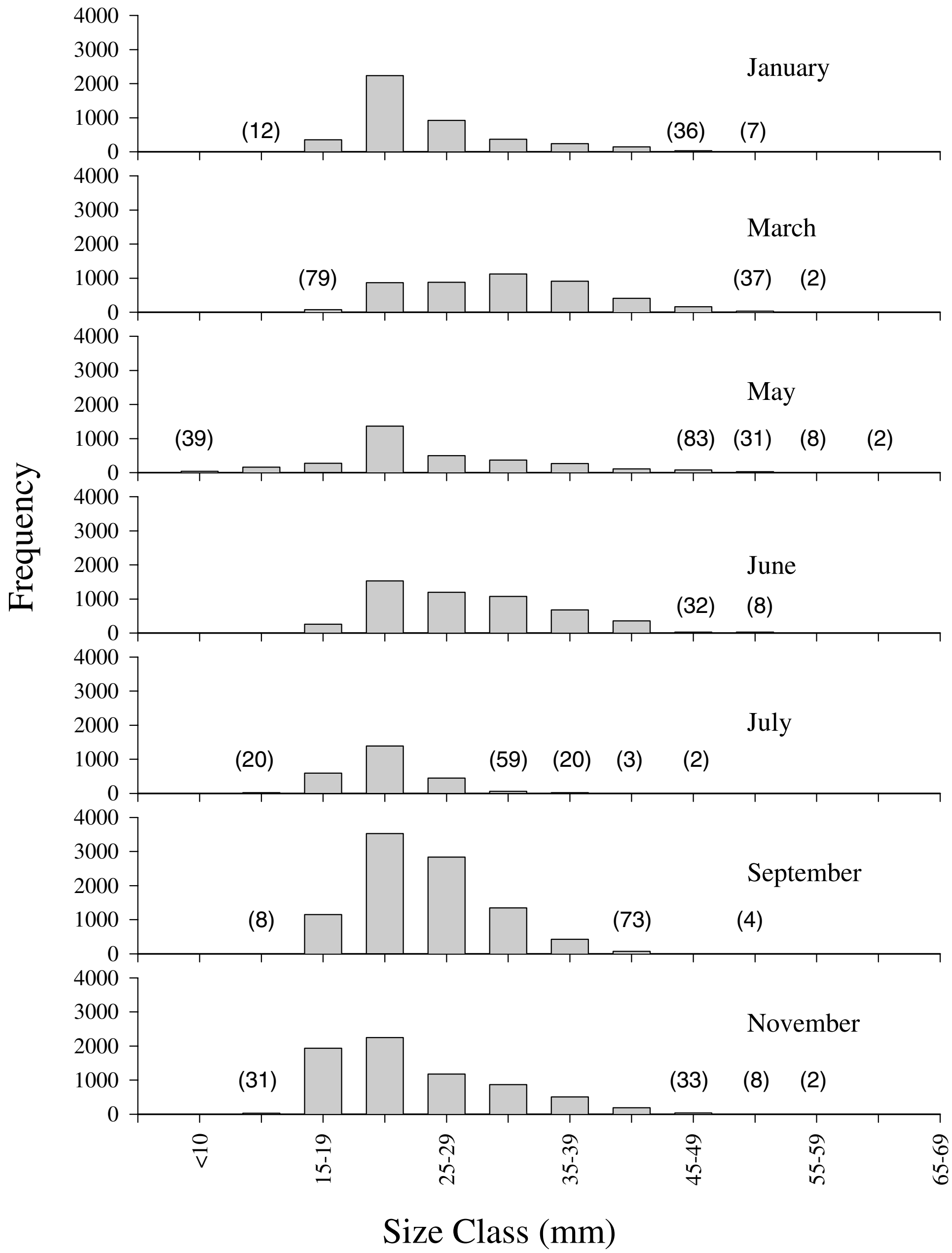


Figure 5.10

Monthly length-frequency distributions of bay anchovy (*Anchoa mitchilli*) from Florida Bay. Values are shown for numbers <100 for clarity.

Chapter 6. Family Ariidae

Arius felis (hardhead catfish)

Total number collected and rank of hardhead catfish by sampling method. There were 39 species collected.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	120	26

Life history The hardhead catfish ranges from Cape Cod, Massachusetts, to Florida and throughout the Gulf of Mexico to the Yucatan Peninsula, but is not common north of Virginia. It is generally found in turbid waters over muddy bottoms in brackish and marine environments, occasionally entering fresh water (Breder, 1948; Taylor and Menezes, 1978). It is a ubiquitous species in shallow brackish and marine waters of the northern Gulf of Mexico, and juveniles are absent from seagrass beds. In the Gulf of Mexico, breeding occurs from May to September in shallow waters of secondary and primary bays, and inlets (Pattillo et al., 1997). Eggs are brooded in the mouths of males. Size at hatching is 29–45 mm TL, and juveniles are released from the males at 31–62 mm TL (Pattillo et al., 1997).

Diet Juvenile hardhead catfish are nocturnal bottom feeders with copepods being the most important food source for juveniles <100 mm TL; for individuals >100 and <200 mm TL, benthic macro-invertebrates are important food sources (Darnell, 1958).

Abundance and distribution Hardhead catfish were common in otter trawl collections. Significant differences in hardhead catfish densities were observed spatially, and among years, but not months. Densities were highest in western Florida Bay (Figs. 6.1 and 6.2). They were absent in the Atlantic and Eastern subdivision and rarely collected in the East stratum and Central and Northern subdivisions. There was a decline in densities from 1984–1985, increases in 1996 and 1997–1998, then decreases to lowest densities in 1999–2000 and 2000–2001 (Fig. 6.2).

Our findings in western Florida are in concordance with those of Sogard et al. (1989a), while the decline in densities from 1984–1985 mirrored the die-off of seagrasses (Fourqurean and Robblee, 1999).

Length-frequency distributions Spawning occurred in summer and fall, based on the presence of specimens <50 mm (Fig. 6.3). Although spawning was contracted, we could not discern any patterns of growth by following modes, nor could we identify size classes. There was a wide range of lengths from July through January. This species attains a maximum length of 600 mm TL (Robins and Ray, 1986).

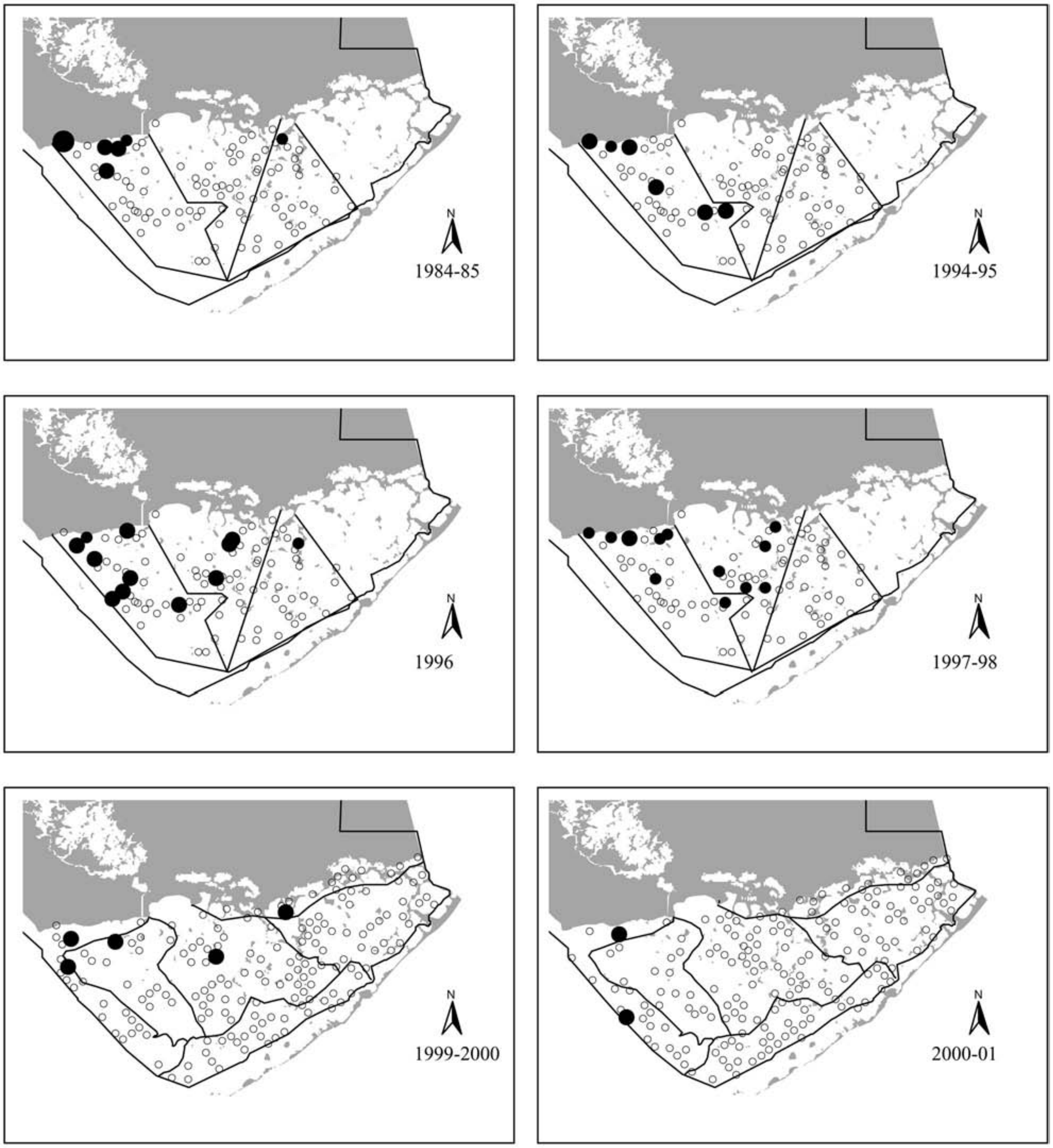


Figure 6.1

Mean densities (numbers 1000 m^{-2}) of hardhead catfish (*Arius felis*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

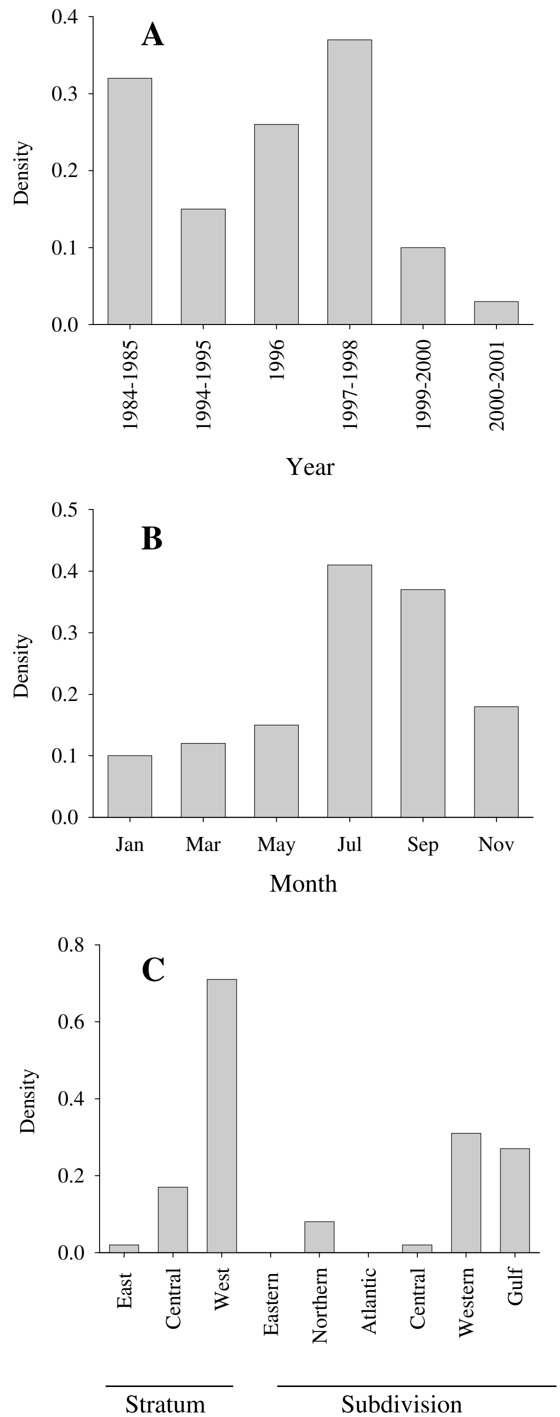


Figure 6.2

Mean densities (numbers 1000 m^{-2}) of hardhead catfish (*Arius felis*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

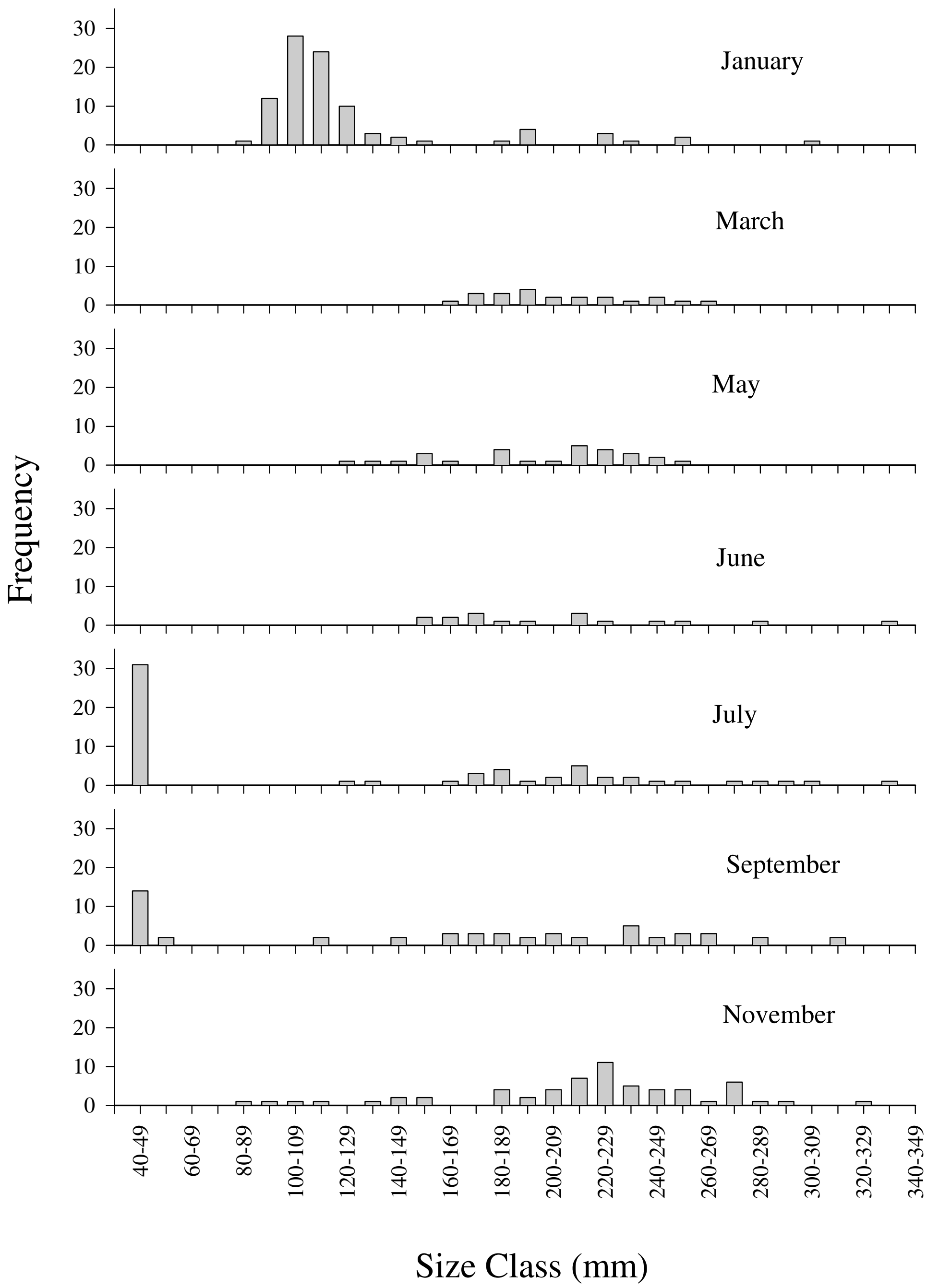


Figure 6.3

Monthly length-frequency distributions of hardhead catfish (*Arius felis*) from Florida Bay.

Chapter 7. Family Synodontidae

Synodus foetens (inshore lizardfish)

Total number collected and rank of inshore lizardfish by sampling method. There were 39 species collected.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	262	18

Life history Inshore lizardfish range from Massachusetts to Brazil including the northern Gulf of Mexico. It is rare north of South Carolina, and is not found north of Cape Hatteras during winter. It occurs most frequently on mud bottoms in shallow waters, but has been taken at depths of 200 m (Breder, 1948; Anderson et al., 1966; Robins and Ray, 1986; Able and Fahay, 1998). In New Jersey estuarine waters, inshore lizardfish are most abundant in macroalgae beds over sandy substrates, where they burrow into the substrate, but are also commonly collected over silty bottoms (Able and Fahay, 1998). Inshore lizardfish spawn in continental shelf waters throughout the year, possibly more intense in spring (Jones et al., 1978). Eggs, larvae, and prejuveniles are pelagic. Larvae hatch at approximately 2.5 mm NL, transformation to the prejuvenile stage occurs at approximately 16 mm TL, and transformation to the juvenile stage occurs at 30–44 mm TL. Juveniles begin to settle to the bottom at approximately 30–40 mm TL (Jones et al., 1978; Able and Fahay, 1998). Size at sexual maturity is not known.

Diet Juvenile inshore lizardfish (41–140 mm SL) feed almost exclusively on fish and apparently are extremely opportunistic (Carr and Adams, 1973). Anchovies and tidewater silversides are most frequently eaten, but gobies, killifishes, silver perch, pipefish, spotted seatrout, and puffers are also consumed.

Abundance and distribution Inshore lizardfish were common in otter trawl collections. There were no significant differences in densities of inshore lizardfish, between strata, but there were between subdivisions. They were more common in the Western, Central, and Atlantic subdivisions, and rarely collected in the Northern and Eastern subdivisions; the latter where salinities are relatively lower (Figs. 3.1, 7.1, and 7.2). Significant differences in densities between months and years were observed (Fig. 7.2). However, no distinct monthly patterns could be discerned. They were more abundant in the spring and late fall and least abundant in early fall. This species was more frequently encountered in 1997–1998 and 1999–2000; it was less frequently encountered in 1994–1995 (Fig. 7.1).

The abundance of inshore lizardfish was negatively correlated with its reported preferred food. This species was more frequently encountered when its preferred food source, bay anchovy (Carr and Adams, 1973), was rarely encountered and less frequently encountered when its food source was most abundant (Figs. 5.9 and 7.1).

Length-frequency distributions Inshore lizardfish recruit into Florida Bay throughout the year (Fig. 7.3). A wide size range of juvenile sizes was collected. This species attains a maximum length of 450 mm, but we rarely collected specimens > ca. 230 mm SL, which could be either due to gear avoidance or the species leaving Florida Bay at this size.

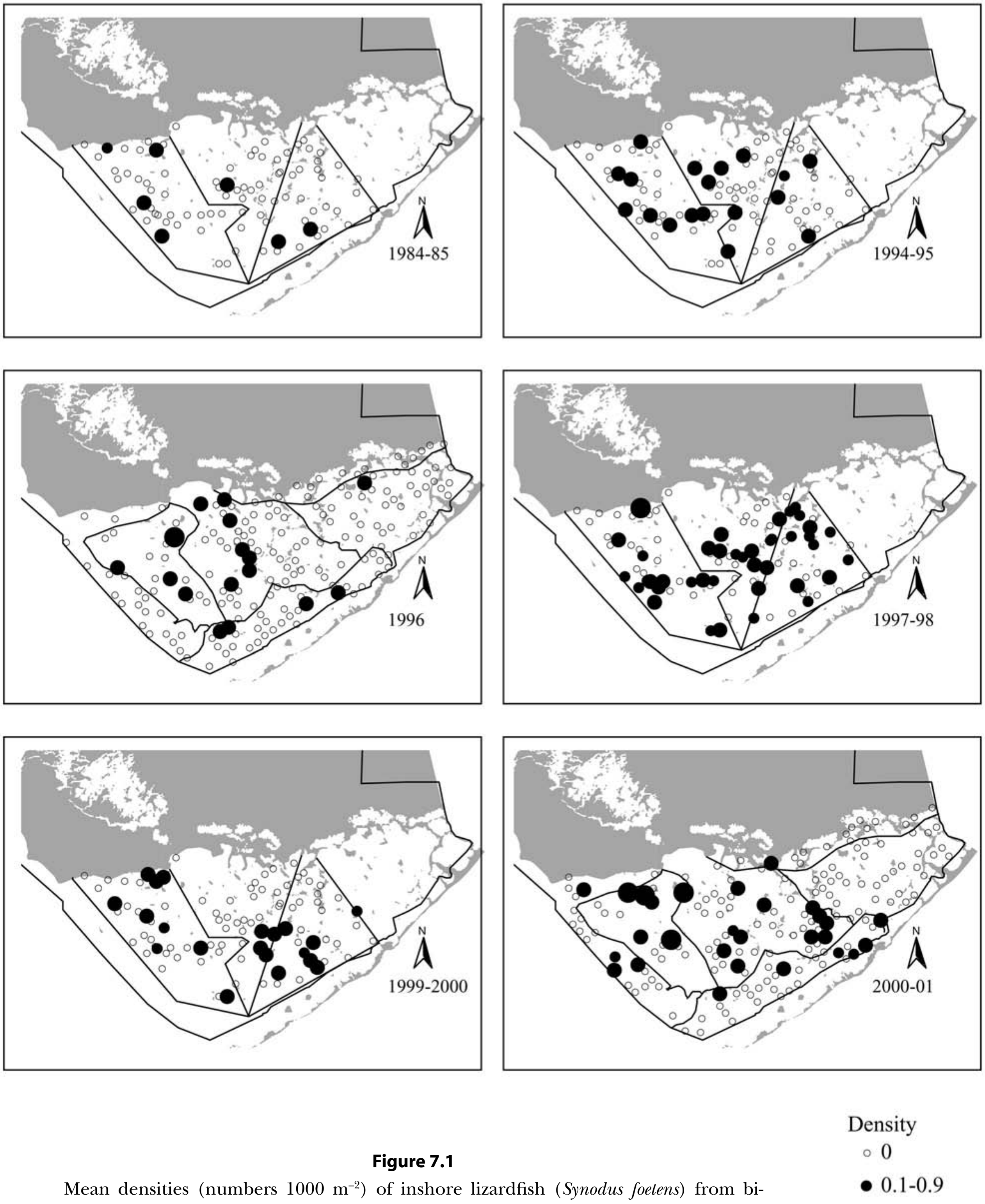


Figure 7.1

Mean densities (numbers 1000 m^{-2}) of inshore lizardfish (*Synodus foetens*) from bimonthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

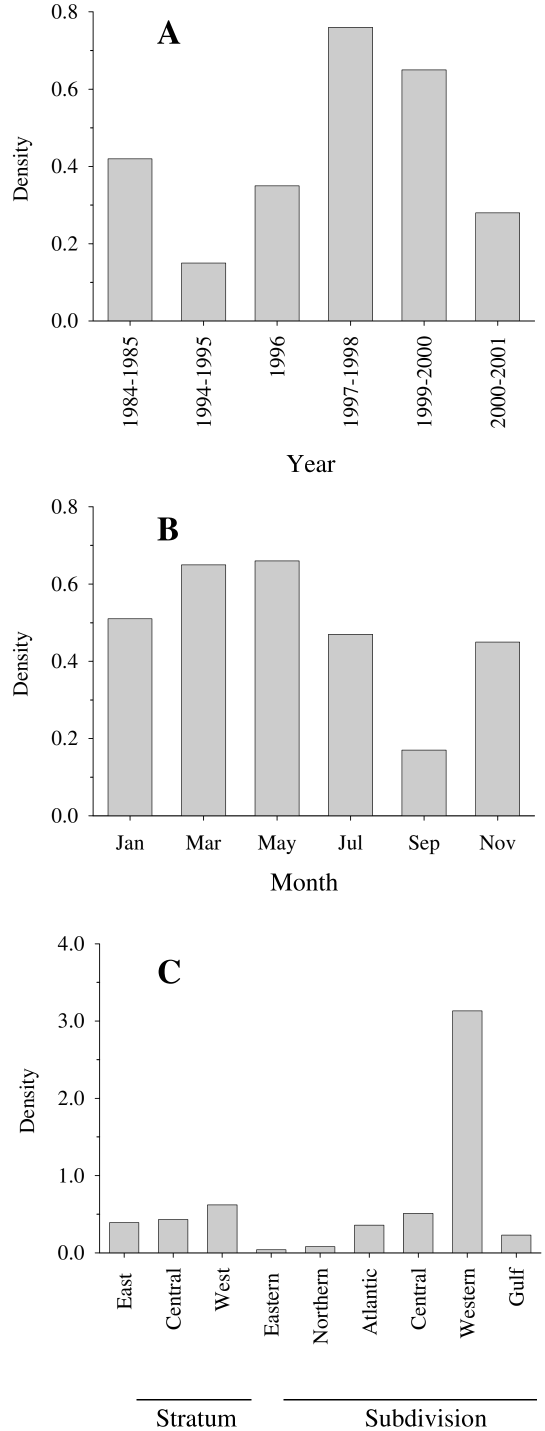


Figure 7.2

Mean densities (numbers 1000 m^{-2}) of inshore lizardfish (*Synodus foetens*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

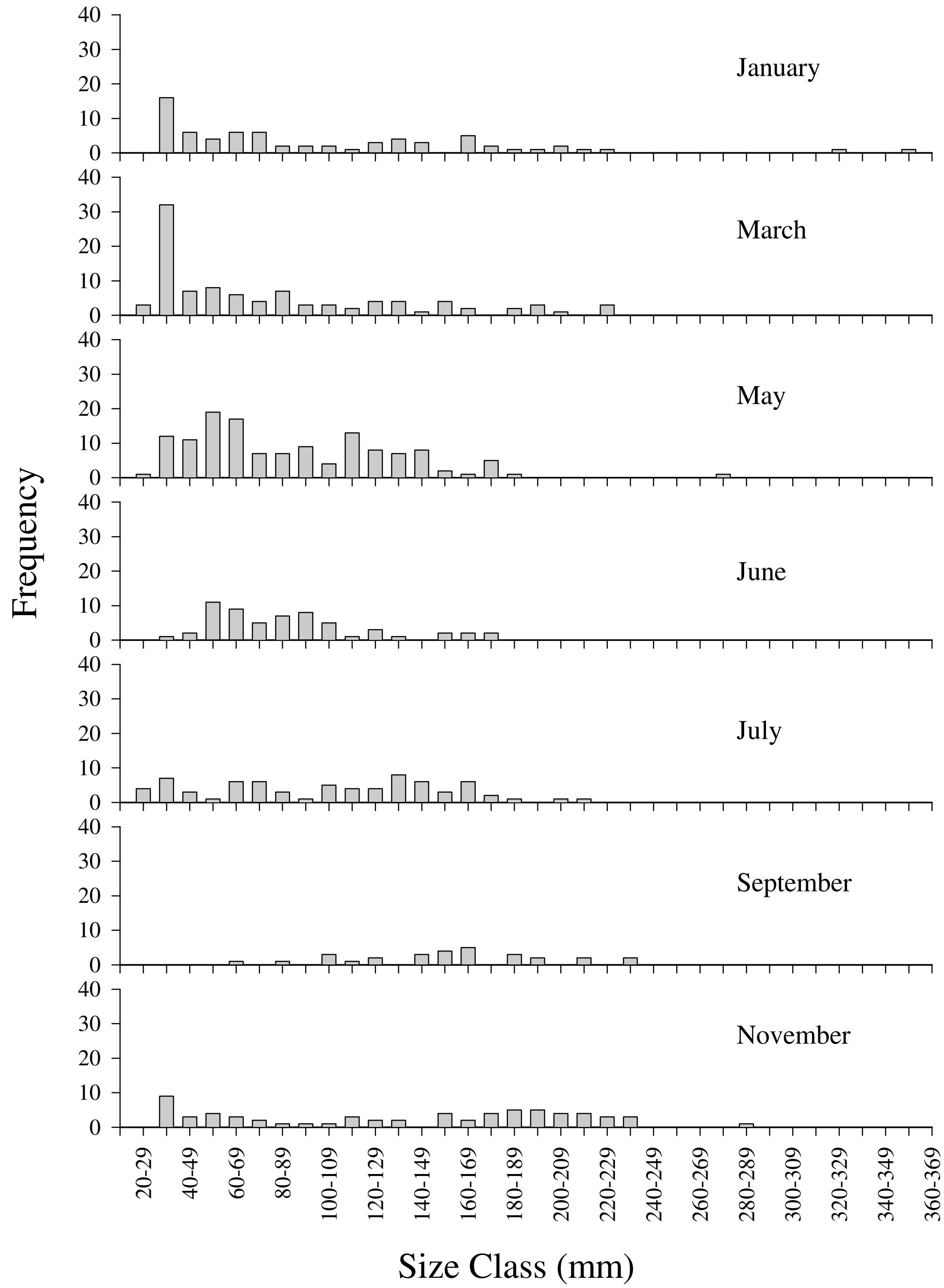


Figure 7.3

Monthly length-frequency distributions of inshore lizardfish (*Synodus foetens*) from Florida Bay.

Chapter 8. Family Batrachoididae

Opsanus beta (gulf toadfish)

Total number collected and rank of gulf toadfish by sampling method. There were 39 species collected.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	649	13

Life history Gulf toadfish range from Cape Canaveral, Florida, Little Bahama Bank, and throughout the Gulf of Mexico to Campeche (Robins and Ray, 1986). In general, it is common in seagrass beds and rocky cuts in estuaries, and in shallow coastal waters (Robins and Ray, 1986). Gulf toadfish spawn in western Florida from February to March at temperatures 15–22°C (Breder, 1941). Eggs are demersal and attached in empty shells and sponge cavities. Eggs are guarded by the male. Although little information is available for gulf toadfish, life histories are probably similar to its temperate congener, *O. tau* (oyster toadfish). Oyster toadfish have no definable larvae as the juvenile stage is attained at yolk absorption. Juveniles become free swimming at 16–18 mm TL. Gulf toadfish are sexually mature at approximately 95 mm SL and attain a length of approximately 65 mm SL after a year of growth (Breder, 1941).

Diet We are unaware of any information on diet.

Abundance and distribution Gulf toadfish were common in otter trawl collections in basins. There were significant differences in densities of gulf toadfish between strata and subdivisions (Figs. 8.1 and 8.2). Densities were highest in Central and West strata and Central and Western subdivisions. Considerable densities were also observed in the Eastern subdivision (northern and eastern stations). We observed significant intra-annual differences in densities of gulf toadfish (Fig. 8.2). Highest densities were observed in May and July, lowest in September and January.

Gulf toadfish appear to have an affinity for the seagrass *Thalassia testudinum,* which is more dense in western and central Florida Bay (Fig. 3.6). Sheridan et al. (1997) reported that highest densities of gulf toadfish in Florida Bay were consistently higher in *T. testudinum* grass beds than in either *Halodule wrightii* grass beds, macroalgae, or mud patches, while Serafy et al. (1997a) concludes that shallow *Thalassia* beds, where high nocturnal dissolved oxygen levels occur, might be important habitat features for this species. However, in a study in the Bay after the die-off of seagrasses in the late 1980s, declines in standing crops of seagrass were correlated with increases in the abundance of gulf toadfish (Matheson et al., 1999). Contrary to these latter findings, we observed significantly higher densities in 1984–1985 (pre-seagrass die-off) than 1994–1995 (post-seagrass die-off) in basin habitats.

Serafy et al. (1997a) observed seasonal differences in densities of gulf toadfish at some sites in adjacent Biscayne Bay. These differences were explained by spawning behavior; i.e., concentration of spawning adults in shallow *T. testudinum* habitat during winter. Based on their speculation, our lowest concentrations in January could be indicative of movement from deeper basins to shallow banks, the latter area not sampled by us. Our highest concentrations in May and July are more difficult to explain.

Length-frequency distributions The distribution of small juveniles indicated that spawning occurred throughout the year in Florida Bay (Fig. 8.3). This is contrary to the spawning season reported by Breder (1941) for western Florida (February–March). Juveniles ranged from 20 mm SL to 190 mm SL, which was considerably different than gulf toadfish in Biscayne Bay (28–268 mm TL) (Serafy et al., 1997a). This difference could be attributed to differences in gear and mesh size.

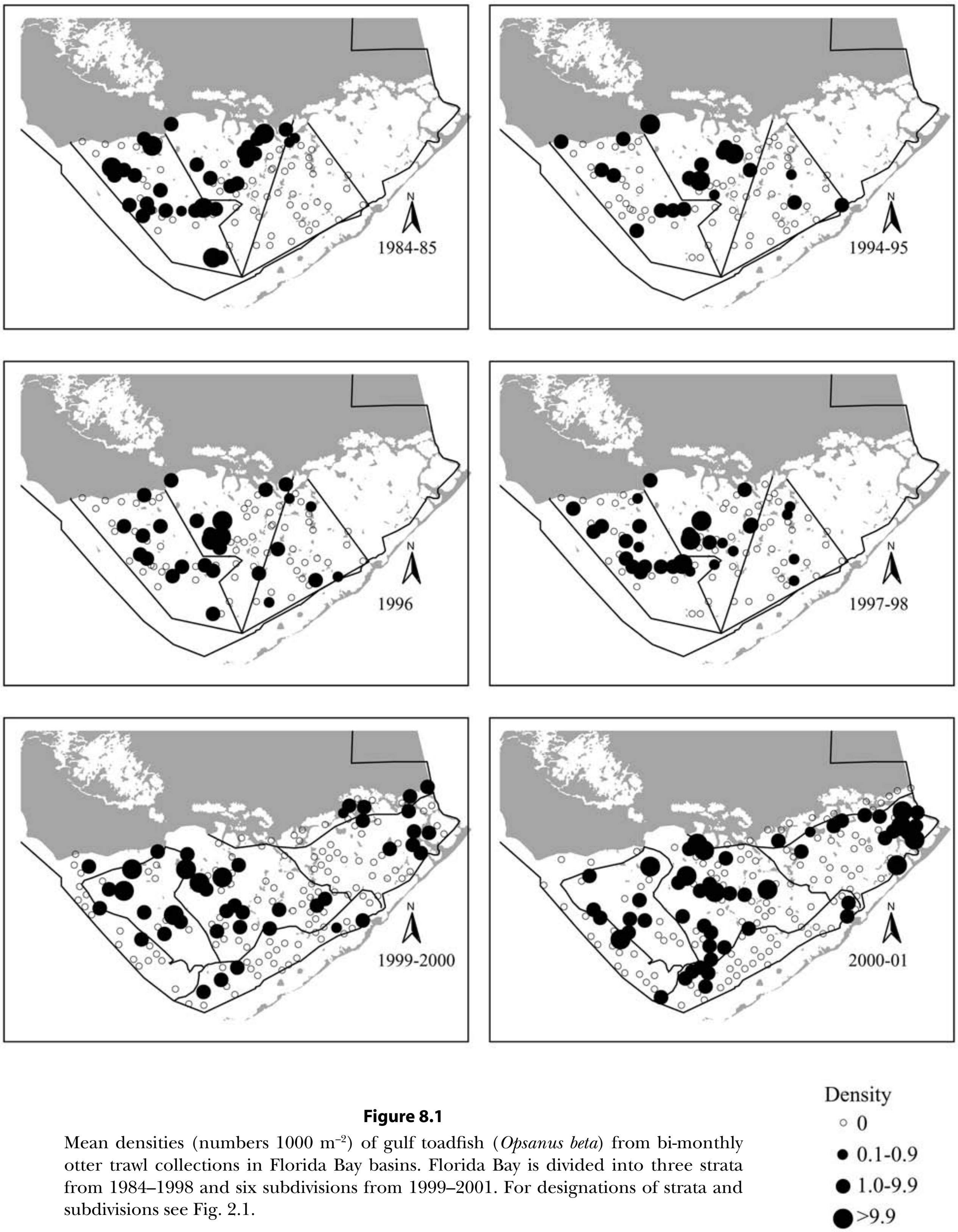


Figure 8.1

Mean densities (numbers 1000 m^{-2}) of gulf toadfish (*Opsanus beta*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

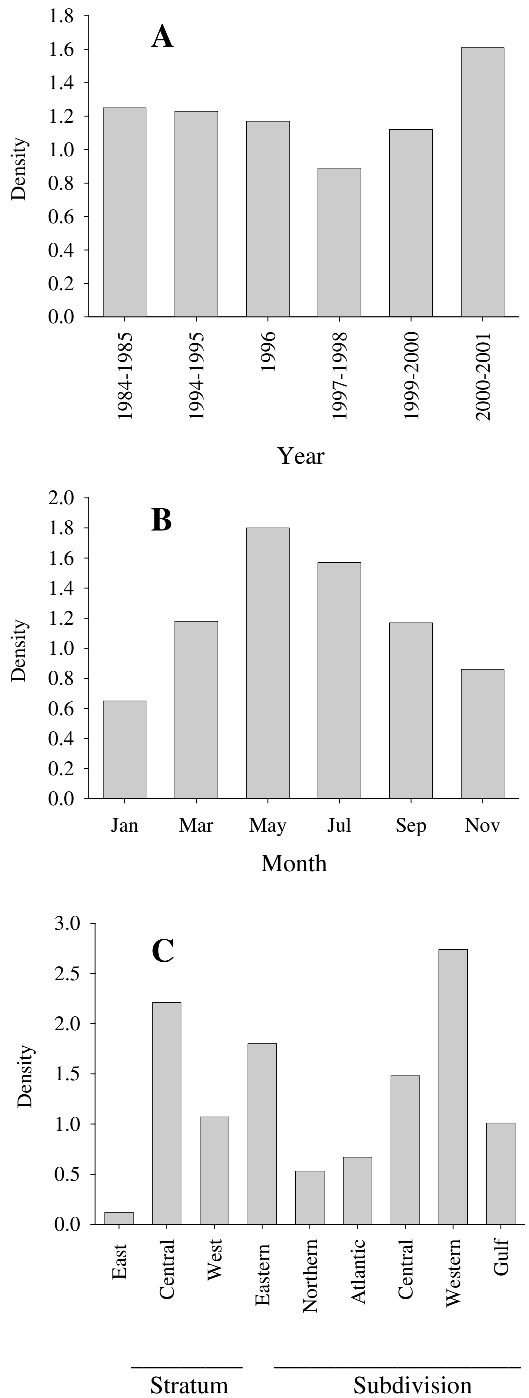


Figure 8.2

Mean densities (numbers 1000 m^{-2}) of gulf toadfish (*Opsanus beta*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

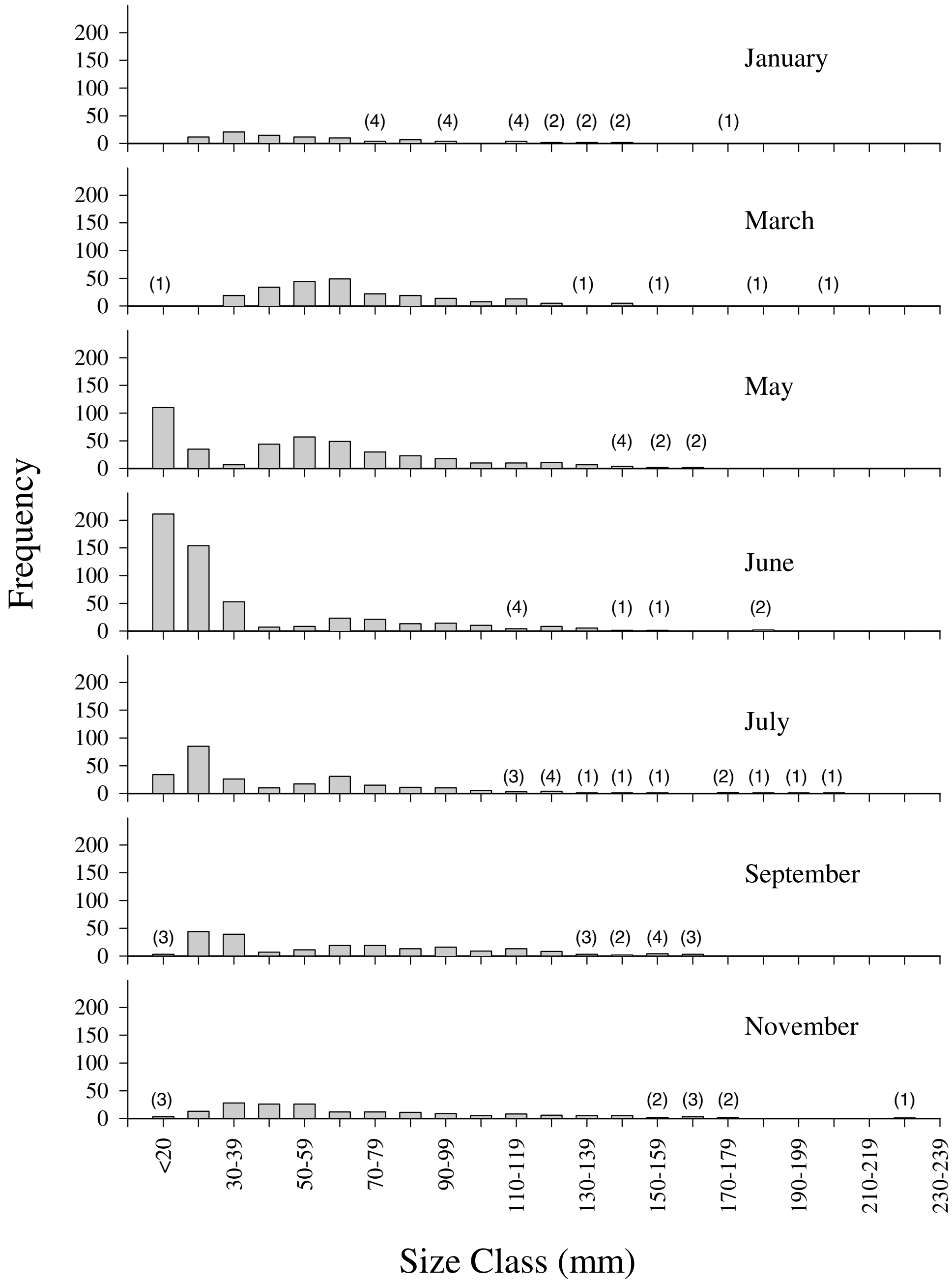


Figure 8.3

Monthly length-frequency distributions of gulf toadfish (*Opsanus beta*) from Florida Bay. Values are shown for numbers <5 for clarity.

Chapter 9. Family Hemiramphidae

Chriodorus atherinoides (hardhead halfbeak)

Total numbers collected and rank of hardhead halfbeak by sampling method. There were a total of 14 species collected by surface trawl in each habitat.

Gear	Habitat	Year	Number	Rank
Surface trawl	Basins	1984–1985	561	3
Surface trawl	Channels	1984–1985	150	5

Life history Hardhead halfbeaks range from the Bahamas, southeast Florida, and northern Gulf of Mexico to Cuba and Yucatan. They are a pelagic, schooling fish that inhabits bays and waterways and is typically associated with seagrass beds (Böhkle and Chaplin, 1968; Robins and Ray, 1986). Very little is known about life history characteristics of this species. Breder (1934) collected hardhead halfbeaks ranging 77–105 mm with ripening ovaries in January.

Diet Breder (1934) noted that this species feeds in the alga *Batophora*, which is populated by diatoms and other small organisms.

Abundance and distribution Hardhead halfbeaks were common in surface trawl collections in channels and basins in 1984–1985, and exhibited significant temporal and spatial differences. They were more abundant in the East and Central strata and in channels (Figs. 9.1 and 9.2). Hardhead halfbeak were most abundant in June and July, and less abundant from September through March (Fig. 9.2). Hardhead halfbeak are considered to be the numerically dominant species in eastern Florida Bay (Schmidt, 1979).

Length-frequency distributions We observed two size classes of hardhead halfbeaks in Florida Bay that could represent juveniles and adults (Fig. 9.3). Although there is limited data from September through March, this species could spawn in all seasons. Based on May and June length-frequency distributions, fish were estimated to grow approximately 80 mm SL per year.

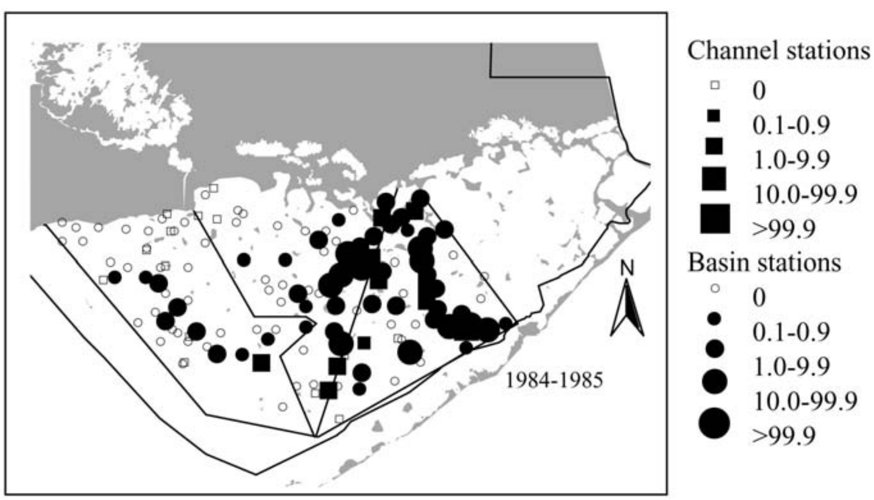


Figure 9.1

Mean densities (numbers 1000 m^{-2}) of hardhead halfbeak (*Chriodorus atherinoides*) collected by surface trawl in Florida Bay basins and channels during 1984–1985. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

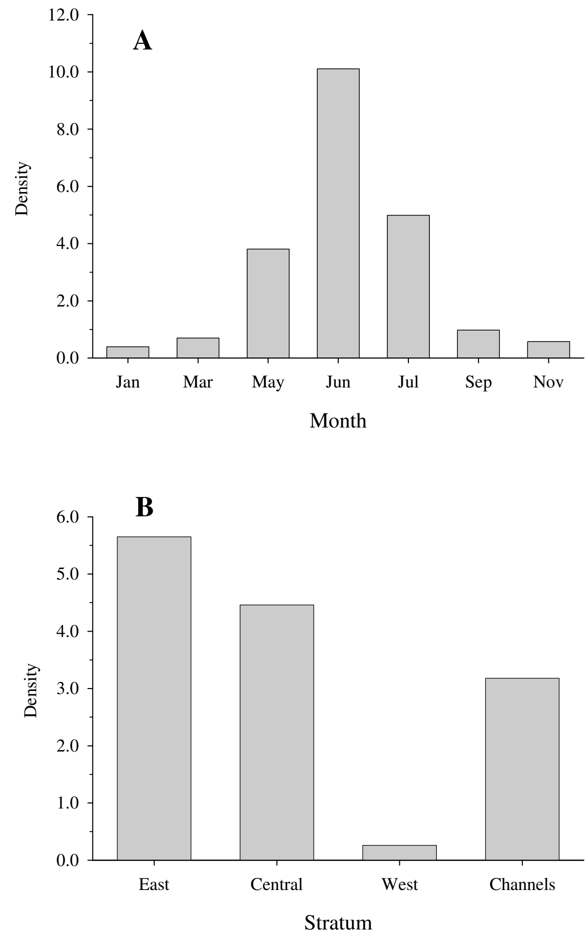


Figure 9.2

Mean densities (numbers 1000 m^{-2}) of hardhead halfbeak (*Chriodorus atherinoides*) collected by surface trawl in Florida Bay basins and channels during 1984–1985 by (A) month and (B) stratum. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

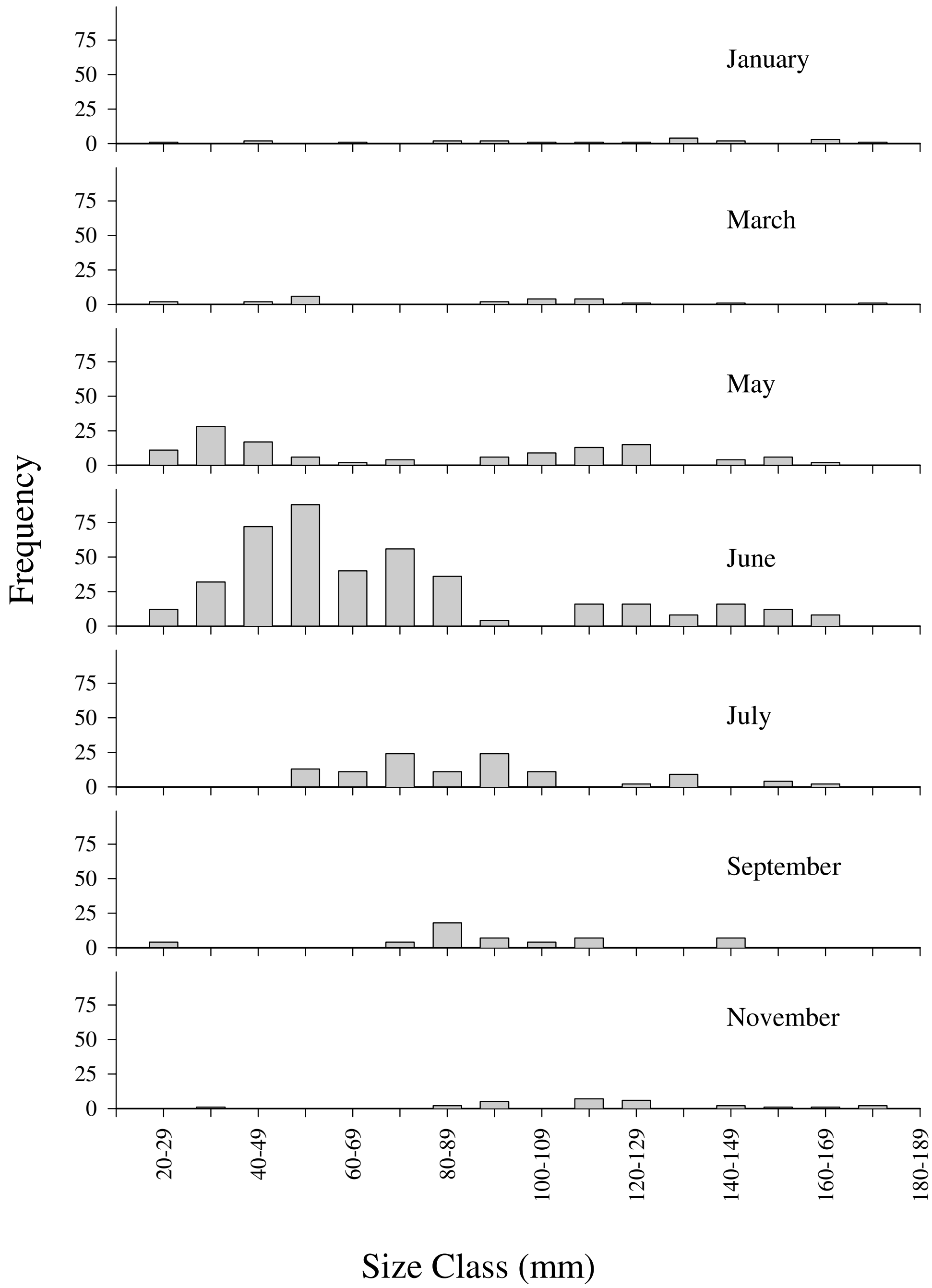


Figure 9.3

Monthly length-frequency distributions of hardhead halfbeak (*Chriodorus atherinoides*) from Florida Bay.

Hemiramphus brasiliensis (ballyhoo)

Total numbers collected and rank of ballyhoo by sampling method. There were a total of 14 species collected by surface trawl in each habitat.

Gear	Habitat	Year	Number	Rank
Surface trawl	Basins	1984–1985	62	12
Surface trawl	Channels	1984–1985	40	10

Life history The ballyhoo occurs on both sides of the Atlantic Ocean. In the western Atlantic it ranges from Woods Hole, Massachusetts to Rio de Janeiro, Brazil, and throughout the Gulf of Mexico, Caribbean Sea, and the Bahamas. It is a straggler north of Florida (Breder, 1948; Collette, 1978a; Hardy, 1978). They are inshore, pelagic fish occurring in large schools (Collette, 1978a) and are an important bait fishery in Florida Bay. Florida Bay has been identified as a spawning area for ballyhoo (McBride et al., 2003). Spawning occurs from March through August in Florida waters and in Florida Bay in association with mud banks and basins (Berkeley and Houde, 1978; McBride et al., 2003). Eggs are demersal and have long filaments attached to the chorion (Berkeley and Houde, 1978). Larvae are 5–7 mm SL at hatching and are well developed (Berkeley and Houde, 1978). The smallest juvenile that has been described was 35 mm (Hardy, 1978). Females attain sexual maturity in their first year (Berkeley and Houde, 1978). Ballyhoo attain a maximum size of 400 mm (Robins and Ray, 1986).

Diet Ballyhoo (<180 mm FL) consume mainly decapods and copepods, and with increasing growth there is a change in food habits toward increases in seagrasses (Berkeley and Houde, 1978).

Abundance and distribution Ballyhoo were commonly collected by surface trawl in basins and channels, and never collected by otter trawl. Densities were different between strata, but not months (Figs. 9.4 and 9.5). Based on data in 1984–1985, ballyhoo occurred in all strata, but were more abundant in the West stratum. This species is rarely collected on Florida Bay mud banks (Sogard et al., 1989a).

Length-frequency distributions Ballyhoo spawn in Florida Bay during late spring and early summer (Fig. 9.6). Because of limited data, we were unable to discern age or size classes, or estimate growth.

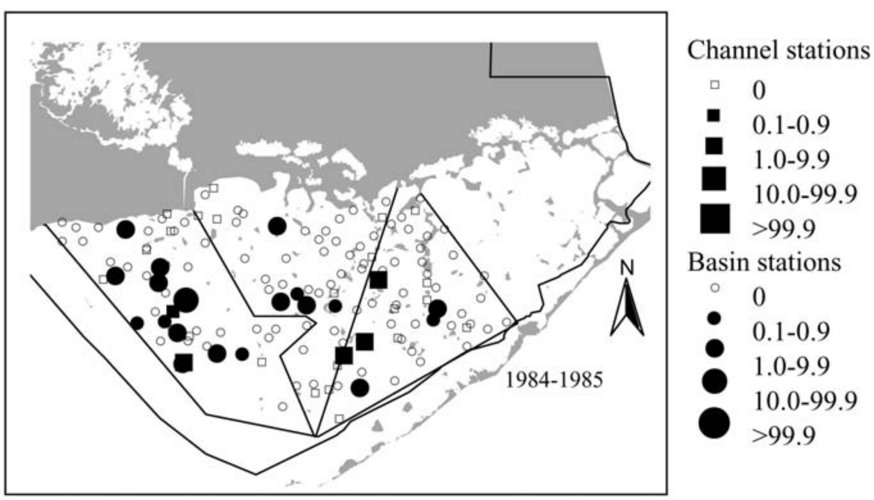


Figure 9.4

Mean densities (numbers 1000 m^{-2}) of ballyhoo (*Hemiramphus brasiliensis*) collected by surface trawl in Florida Bay basins and channels during 1984–1985. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

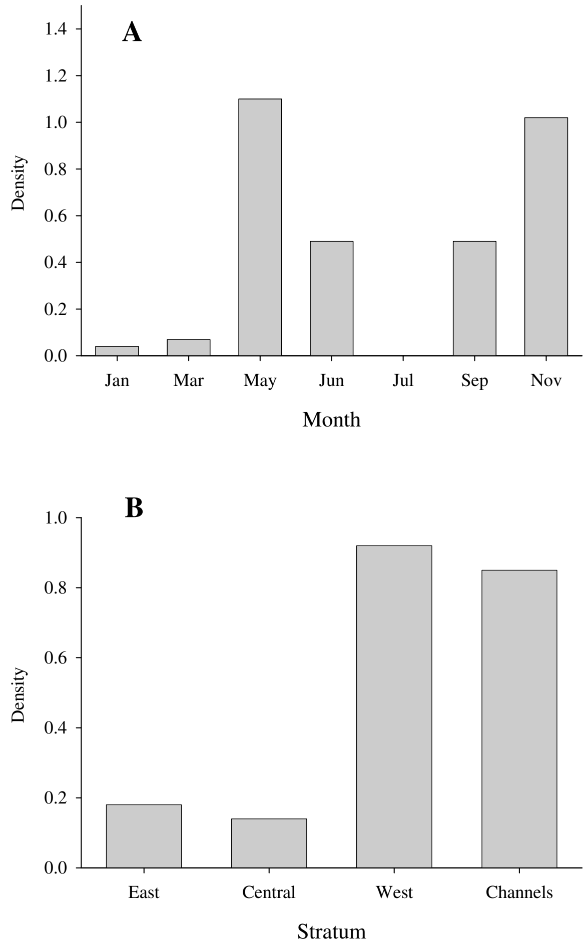


Figure 9.5

Mean densities (numbers 1000 m^{-2}) of ballyhoo (*Hemiramphus brasiliensis*) collected by surface trawl in Florida Bay basins and channels during 1984–1985 by (A) month and (B) stratum. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

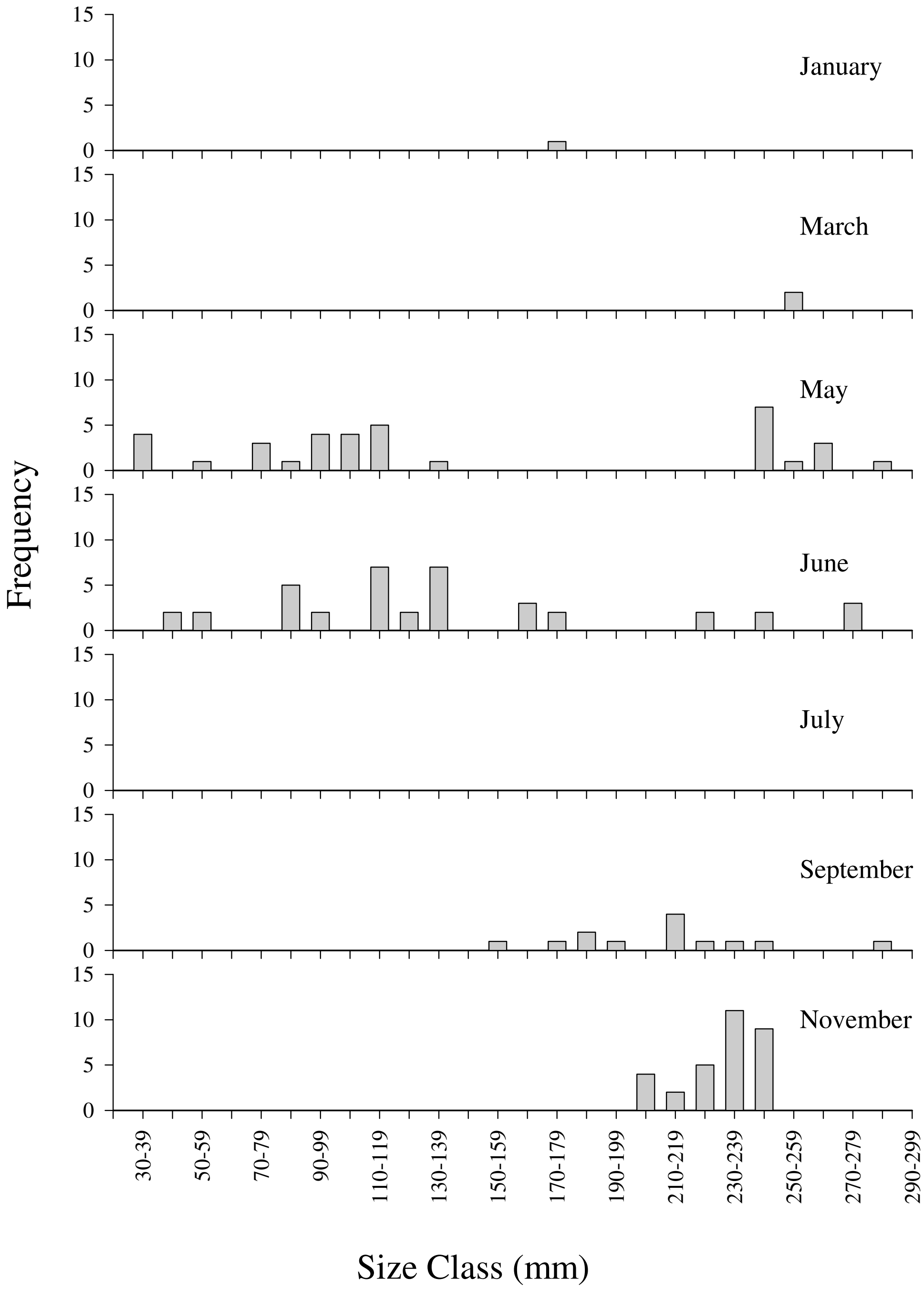


Figure 9.6

Monthly length-frequency distributions of ballyhoo (*Hemiramphus brasiliensis)* from Florida Bay.

Hyporhamphus unifasciatus (halfbeak)

Total numbers collected and rank of halfbeak by sampling method. There were a total of 39 species collected by otter trawl; 14 by surface trawl in each habitat.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	119	27
Surface trawl	Basins	1984–1985	1249	1
Surface trawl	Channels	1984–1985	276	4

Life history Halfbeak occur in Bermuda, peninsular Florida, the West Indies, and from Campeche Bay southward to Uruguay. It is a pelagic, inshore schooling species that frequently enters estuaries (Collette, 1978a). Little information on its life history is known. Hardy (1978) summarized life history information on the halfbeak, but because of taxonomic confusion between *H. meeki* and *H. unifasciatus* (Banford and Collette, 1993), Hardy's summary pertains mainly to *H. meeki*. Halfbeak spawn in March in the West Indies. Eggs have filaments attached to the chorion and have been found on *Thalassia* in shallow water in Puerto Rico. Size at sexual maturity (female) is approximately 150 mm (Hardy, 1978).

Diet We are unaware of any information on diet.

Abundance and distribution Halfbeak were abundant in surface trawl collections in 1984–1985 and common in otter trawl collections. It was the most abundant pelagic species collected by surface trawl in basins in 1984–1985. We observed significant differences in halfbeak densities between strata and months for the surface trawl data (Figs. 9.7 and 9.8). Highest densities were observed in the West stratum, lowest in the Central stratum. Temporally, we observed highest densities in September (Fig. 9.8).

Although we collected 119 halfbeak in otter trawl collections in basins (Fig. 9.9 and 9.10), they were mainly collected at one station in 1984–1985. There were no significant spatial or temporal differences, which is to be expected given the high number of zero catches.

Length-frequency distributions Spawning and/or recruitment occurred in spring and summer (Fig. 9.11). Sexually mature fish (approximately 150 mm SL) were present during all months. Multiple cohorts, and possibly two age groups, were present from at least May through November.

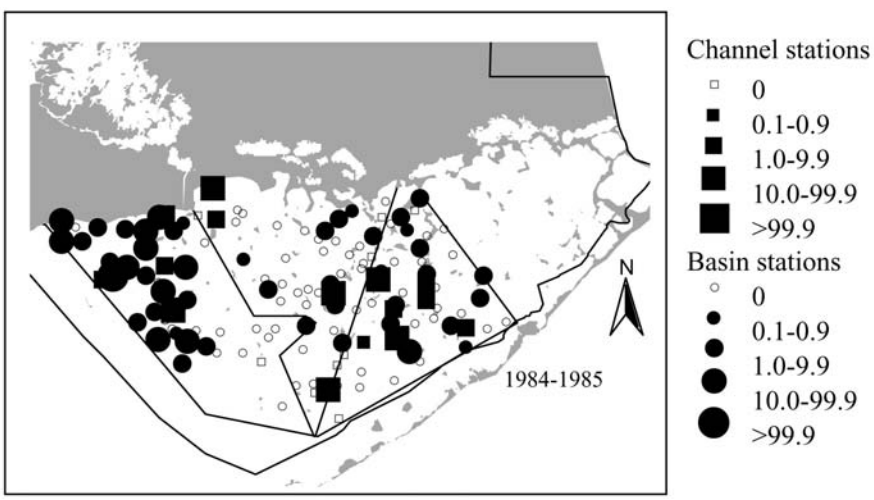


Figure 9.7

Mean densities (numbers 1000 m^{-2}) of halfbeak (*Hyporhamphus unifasciatus*) collected by surface trawl in Florida Bay basins and channels during 1984–1985. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

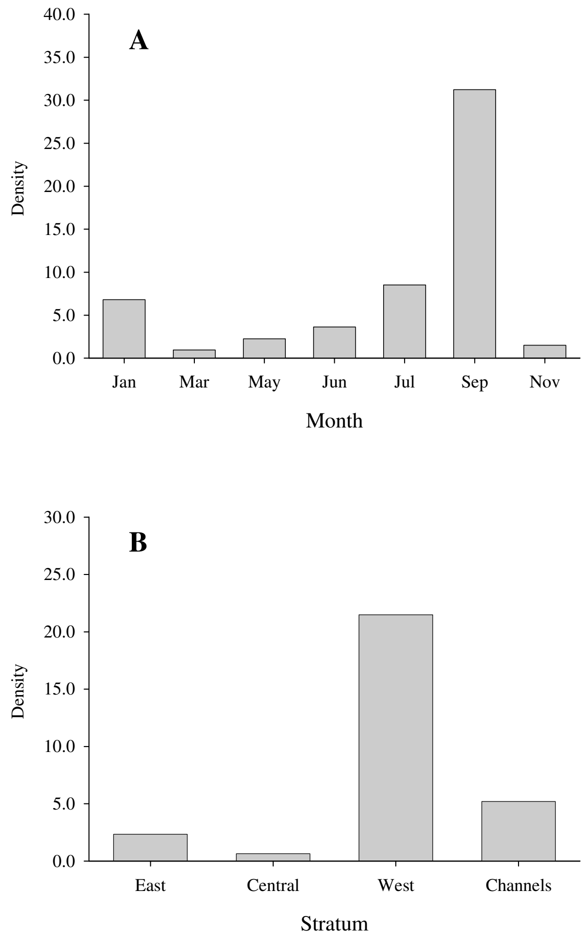


Figure 9.8

Mean densities (numbers 1000 m^{-2}) of halfbeak (*Hyporhamphus unifasciatus*) collected by surface trawl in Florida Bay basins and channels during 1984–1985 by (A) month and (B) stratum. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

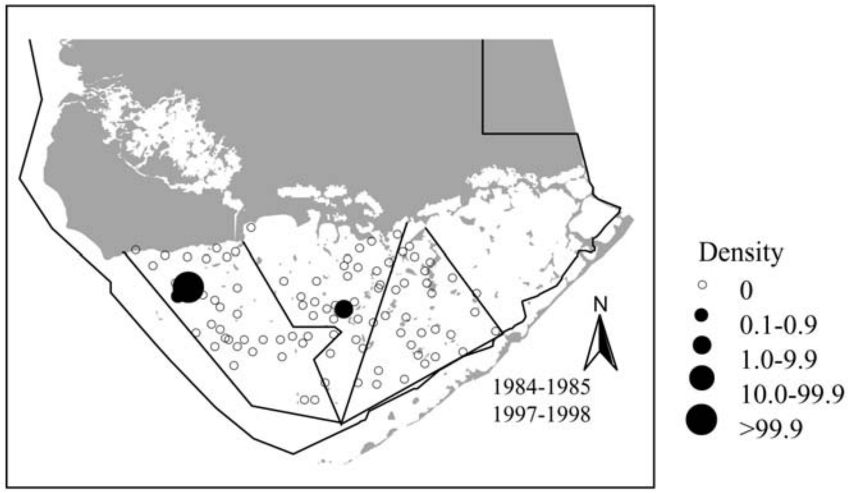


Figure 9.9

Mean densities (numbers 1000 m^{-2}) of halfbeak (*Hyporhamphus unifasciatus*) from bimonthly otter trawl collections in Florida Bay basins. Specimens were only collected in 1984–1985 and 1997–1998.Florida Bay is divided into three strata in 1984–1985. For designations of strata see Fig. 2.1.

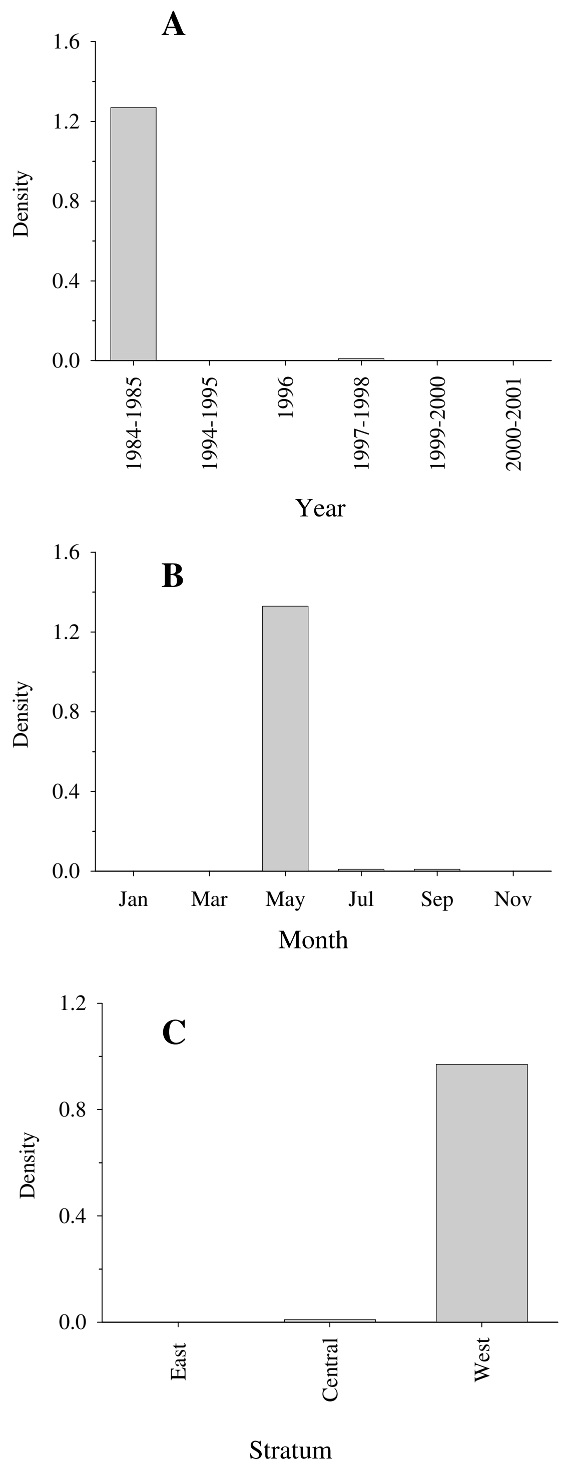


Figure 9.10

Mean densities (numbers 1000 m^{-2}) of halfbeak (*Hyporhamphus unifasciatus*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum. Specimens were only collected in 1984–1985. Florida Bay is divided into three strata in 1984–1985. For designations of strata see Fig. 2.1.

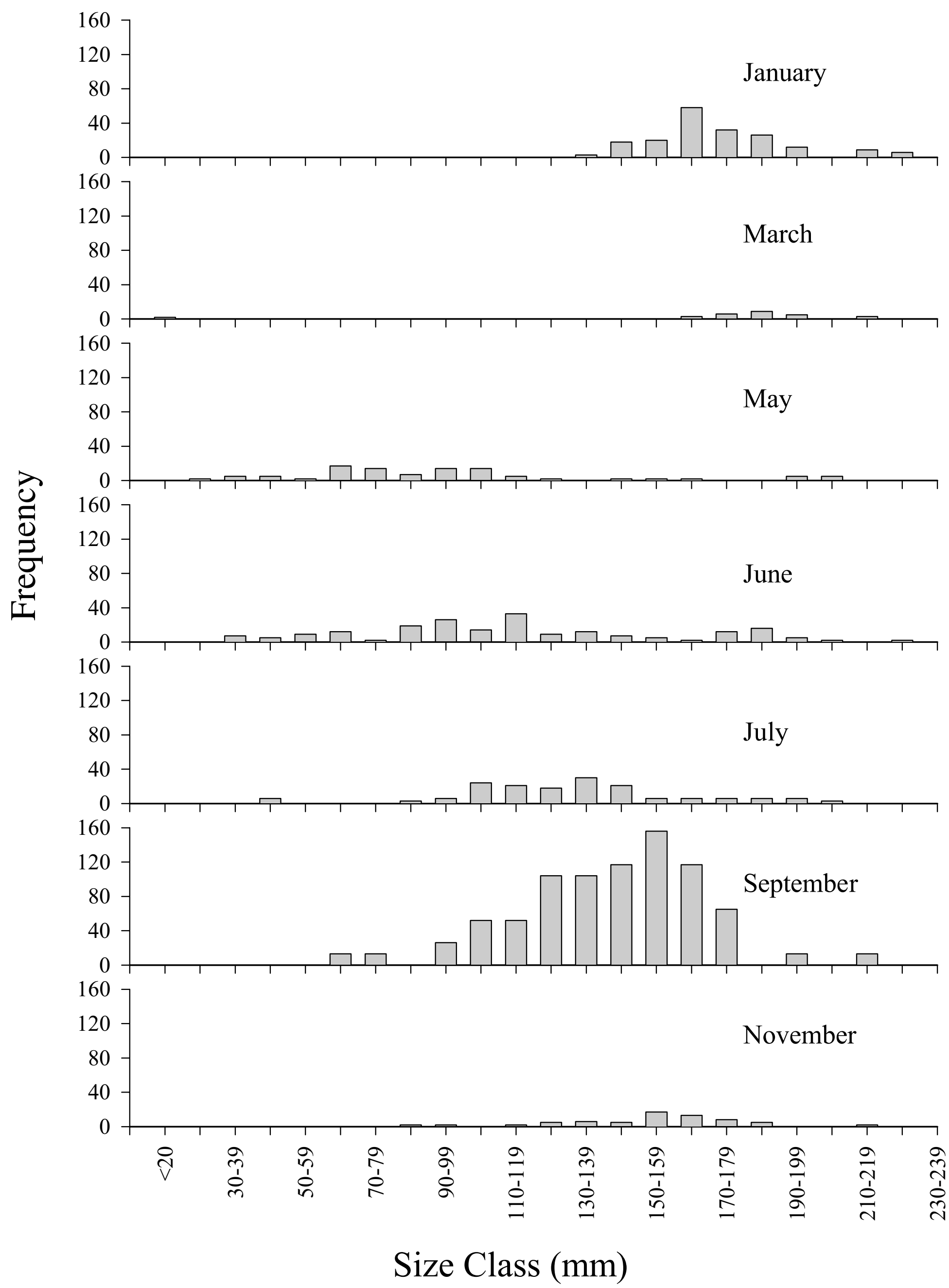


Figure 9.11

Monthly length-frequency distributions of halfbeak (*Hyporhamphus unifasciatus*) from Florida Bay.

Chapter 10. Family Belonidae

Strongylura notata (redfin needlefish)

Total numbers collected and rank of redfin needlefish by sampling method. There were a total of 39 species collected by otter trawl; 14 by surface trawl in each habitat.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	77	33
Surface trawl	Basins	1984–1985	595	2
Surface trawl	Channels	1984–1985	111	6

Life history Redfin needlefish range from Bermuda, Florida, Bahamas to the Lesser Antilles, and to Central America. Its preferred habitat is coastal waters, mainly bays and inlets (Robins and Ray, 1986). Very little information on the life history of this species is available. Redfin needlefish spawn in red mangrove (*Rhizophora mangel*) aerial root tangles. Eggs are assumed to be demersal and have external adhesive filaments attached to the chorion. Size at hatching is approximately 12 mm SL (Breder, 1959).

Diet Reid (1954) reported that individuals ranging from 75–125 mm contained various species of shrimp in their diets.

Abundance and distribution Redfin needlefish were commonly collected by surface trawl particularly in basins in 1984–1985. They were collected at many stations in all strata, but densities were significantly higher in the Central stratum (Figs. 10.1 and 10.2). The distribution of densities among months was clearly uni-modal with significantly highest densities occurring in July (Fig. 10.2), but they occurred at a greater percentage of stations in September and May (Fig. 10.1).

Redfin needlefish were uncommon in otter trawl collections (Fig.10.3). We observed significant differences in densities between strata, subdivisions, and months, but not years (Fig. 10.4). Contrary to the surface trawl data, densities were highest in the East stratum. High densities were observed in the Northern and Eastern subdivisions, and in July.

Sogard et al. (1989a) reported gillnet catches of redfin needlefish at three of their four sites in Florida Bay. They were Cowpen Keys, Buchanan Key, and Oyster Keys. Lower catch-per-unit-effort was observed at Eagle Key (Fig. 1.1).

Length-frequency distributions Recruitment of redfin needlefish was protracted, and spawning most likely occurs in all seasons, although minimally in winter (Fig. 10.5).

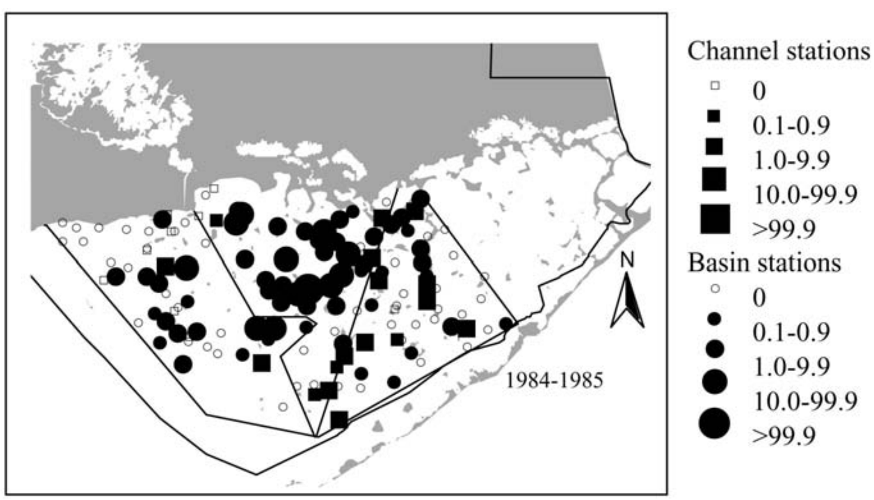


Figure 10.1

Mean densities (numbers 1000 m^{-2}) of redfin needlefish (*Strongylura notata)* collected by surface trawl in Florida Bay basins and channels during 1984–1985. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

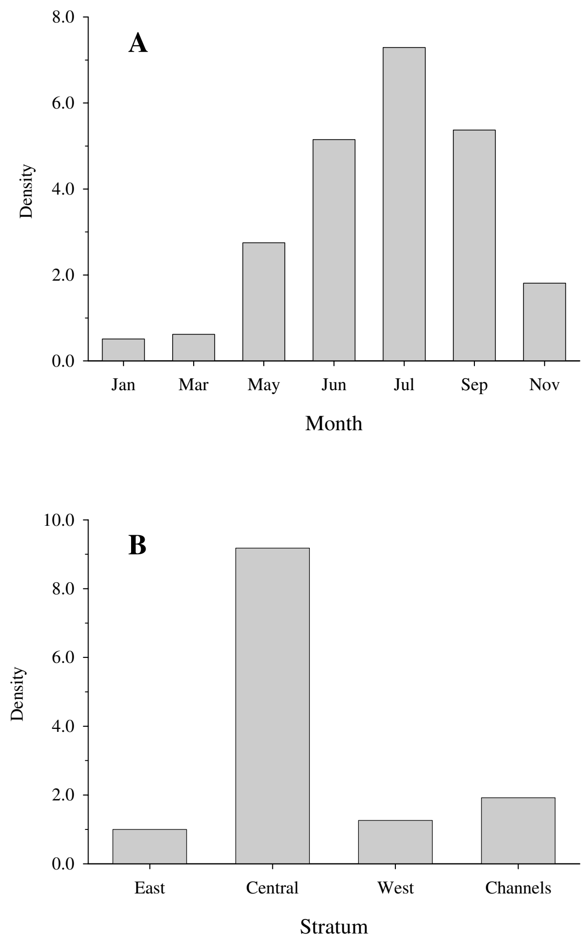


Figure 10.2

Mean densities (numbers 1000 m^{-2}) of redfin needlefish (*Strongylura notata*) collected by surface trawl in Florida Bay basins and channels during 1984–1985 by (A) month and (B) stratum. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

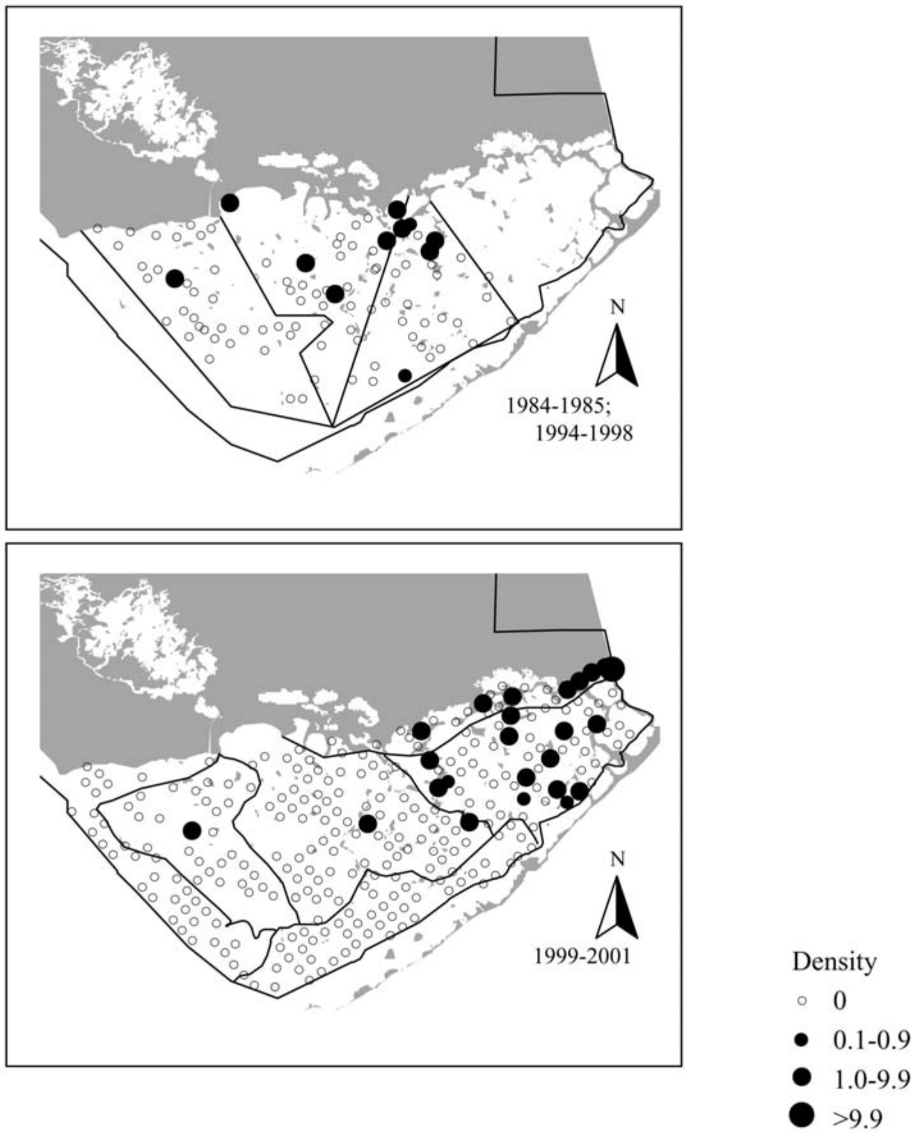


Figure 10.3

Mean densities (numbers 1000 m^{-2}) of redfin needlefish (*Strongylura notata*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

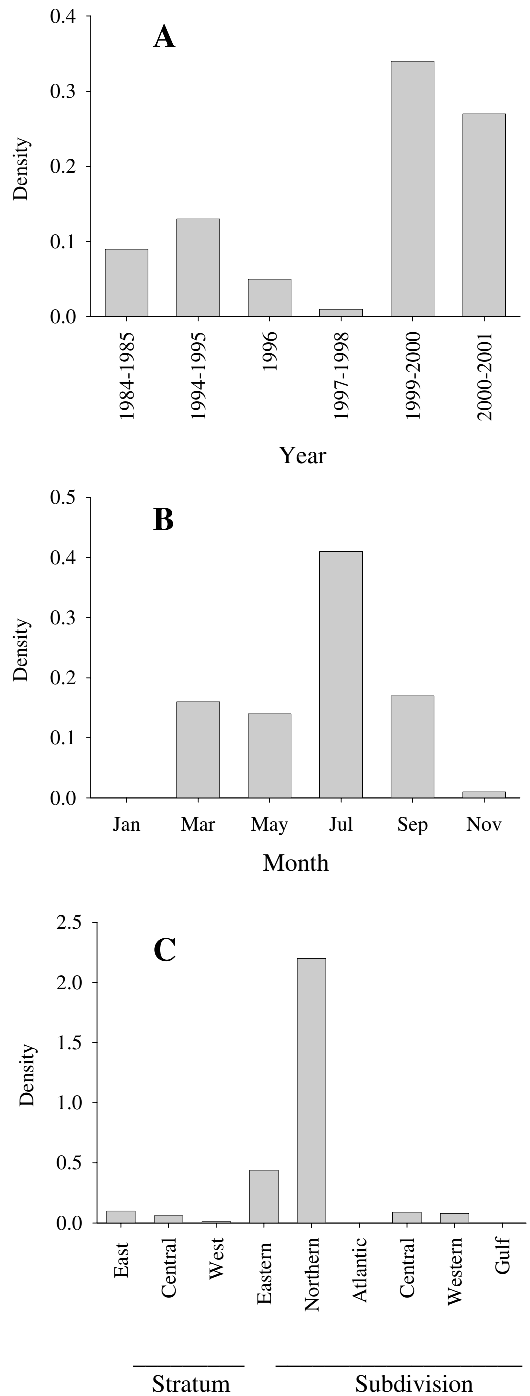


Figure 10.4

Mean densities (numbers 1000 m^{-2}) of redfin needlefish (*Strongylura notata)* from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

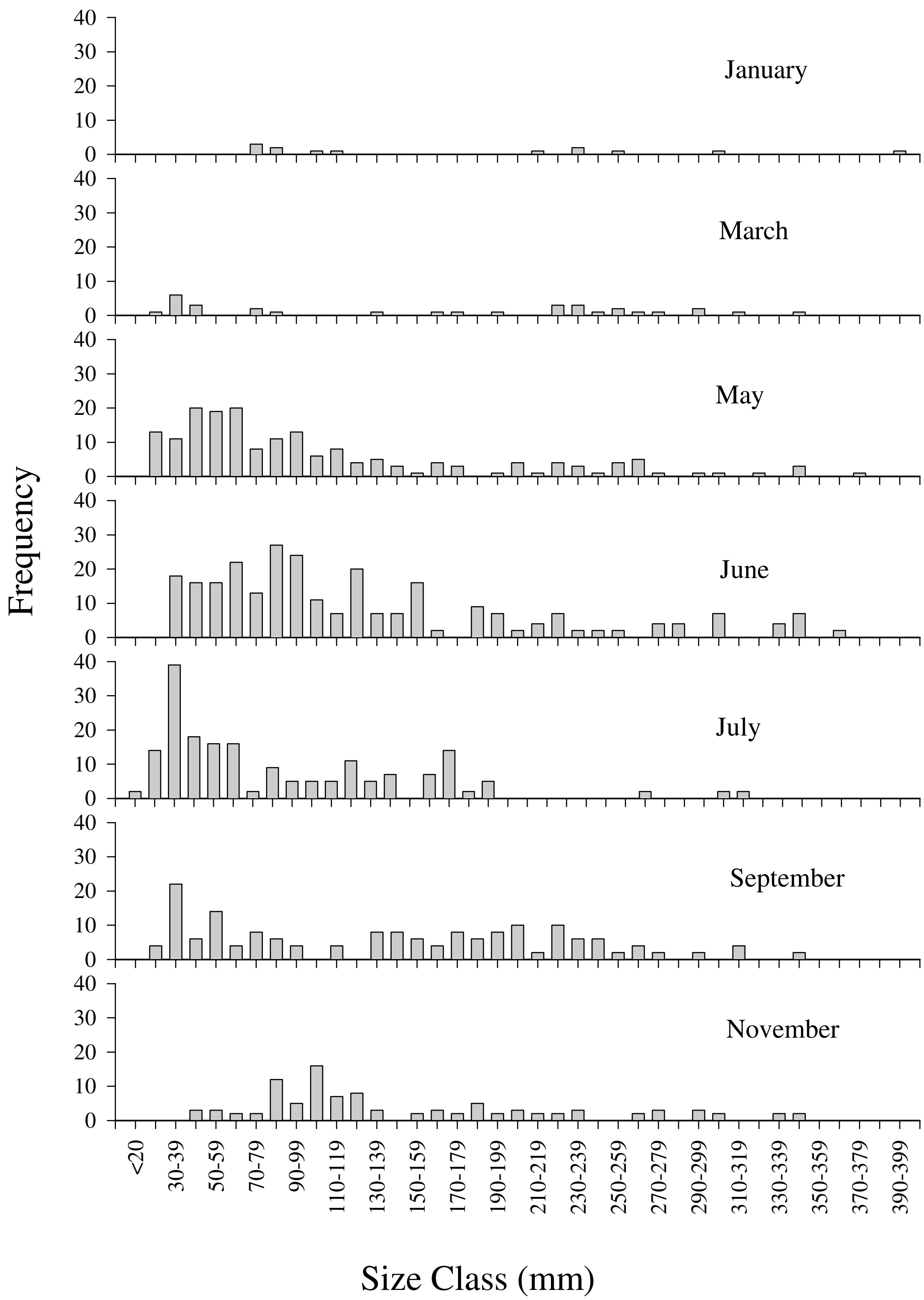


Figure 10.5

Monthly length-frequency distributions of redfin needlefish (*Strongylura notata*) from Florida Bay.

S. timucu (timucu)

Total numbers collected and rank of timucu by sampling method. There were a total of 14 species collected by surface trawl in each habitat.

Gear	Habitat	Year	Number	Rank
Surface trawl	Basins	1984–1985	112	11
Surface trawl	Channels	1984–1985	15	12

Life history Timucu range from Jupiter Inlet on the east coast of Florida to Pensacola on the west coast of Florida, the Bahamas, the Greater and Lesser Antilles, and from Yucatan, Mexico to Brazil (Collette, 1978b). It is an inshore species that frequents most of the same habitats as the redfin needlefish. Life history information on this species is lacking.

Diet Carr and Adams (1973) reported on the diets of Atlantic needlefish (*S. marina*) in a west coast Florida estuary, but were unaware at the time of their analysis that timucu was a valid species that occurred sympatrically with Atlantic needlefish in the eastern Gulf of Mexico. Hence, some of the smaller fish they analyzed could have been timucu. They observed a diet that progresses from small crustaceans to fish during ontogeny. Small juveniles (35–50 mm SL) fed on small crustaceans, especially amphipods, mysids, and very small shrimp. At approximately 50 mm SL and greater, they fed almost entirely on fish, especially anchovies and atherinids.

Abundance and distribution Timucu has a more restricted distribution in Florida Bay than its congener redfin needlefish (Figs. 10.1 and 10.6). Timucu, collected mainly by surface trawl in basins in 1984–1985, was rarely collected in the East and Central strata. High densities were collected in the West stratum (Figs. 10.6 and 10.7). Significant differences in densities occurred between months. Timucu were most abundant in March through May and, like their congener, least abundant in January (Fig. 10.7).

Based on the study of timucu occurrence on Florida Bay mud banks (Sogard et al., 1989a) and this study, the species occurs mainly in western Florida Bay.

Length-frequency distributions No measurements were taken in 1984–1985.

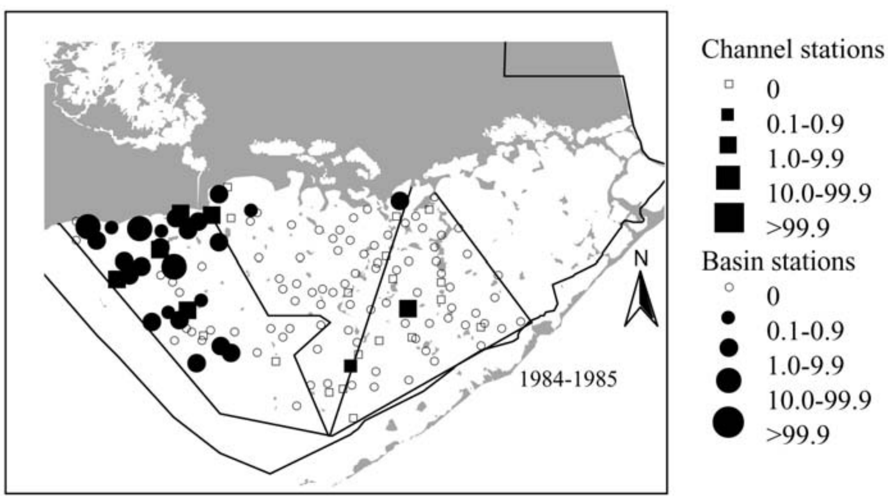


Figure 10.6

Mean densities (numbers 1000 m^{-2}) of timucu (*Strongylura timucu*) collected by surface trawl in Florida Bay basins and channels during 1984–1985. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

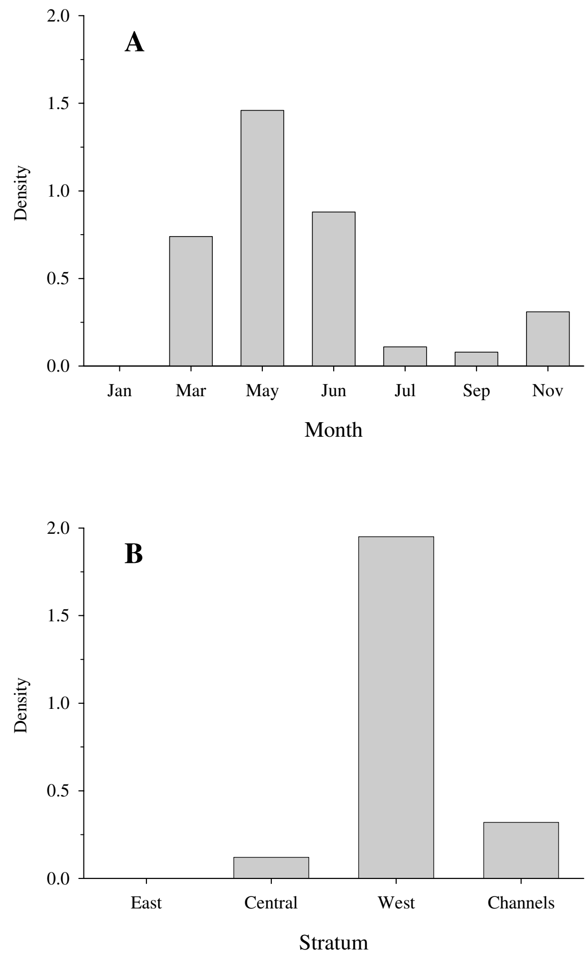


Figure 10.7

Mean densities (numbers 1000 m^{-2}) of timucu (*Strongylura timucu*) collected by surface trawl in Florida Bay basins and channels during 1984–1985 by (A) month and (B) stratum. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

Chapter 11. Families Fundulidae and Cyprinodontidae

Floridichthys carpio (goldspotted killifish)

Total numbers collected and rank of goldspotted killifish by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	1652	8

Life history The goldspotted killifish, a cyprinodont, ranges from southeastern Florida throughout the Gulf of Mexico. It is a small resident forage fish that occupies marine habitats (but enters brackish waters) on tidal flats and creeks (Robins and Ray, 1986). The ecological classification of this species is problematic (Matheson et al., 1999). It does not fit the definition of a benthic species, but it spends most of its time near the bottom. It is associated with seagrass beds, but is most abundant in sparse beds (Sogard et al., 1989a). On the other hand, Thayer et al. (1987b) found that in Florida Bay and adjacent estuarine waters this species prefers the mangrove root habitat rather than adjacent seagrass beds. Goldspotted killifish are annuals, with sexual maturity attained during the first year of life. They are benthic spawners; eggs are laid one at a time and are attached to the substrate. Multiple spawning occurs in this species (Nordlie, 2000).

Diet The diet of goldspotted killifish in northeastern Florida Bay has been related to habitat quality. Ley et al. (1994) observed a systematic variation of diet along an estuarine gradient. Goldspotted killifish ingested low quality food (algae) in areas where salinity was highly variable. In areas with less variability in salinity, high quality food (benthic invertebrates) was ingested. Ley et al. proposed that highly variable amounts of submerged aquatic vegetation in low quality food areas reduce abundances of benthic invertebrates.

Various studies report differences in diets of goldspotted killifish that can be explained by seasonal and ontogenetic differences. Motta et al. (1995) examined fish 46–87 mm SL from Tampa Bay, Florida, and found a diverse diet consisting of copepods, ostracods, eggs, gastropods, and amphipods. In the Whitewater Bay system, this species (14–59 mm SL) also consumed an extremely diverse group of organisms, with detritus and small amphipods being the dominant items (Odum and Heald, 1972).

Abundance and distribution Goldspotted killifish were abundant in otter trawl collections. They were collected in higher densities in the Central stratum and Northern subdivision, and were not collected in the Gulf subdivision (Figs. 11.1 and 11.2).

There was a decrease in abundance of this species following environmental changes in the late 1980s (Figs. 11.1 and 11.2). Mean annual densities declined considerably from 1984–1985 to 1996. They were not collected in the Central stratum in 1996. In 1997–1998 mean yearly densities were similar to those observed in 1994–1995 (Figs. 11.1 and 11.2). Highest mean annual densities were observed in 1999–2001, but this could be a result of an increase in sampling effort in the Eastern and Northern subdivisions.

Matheson et al. (1999) also observed a decrease in abundance of this species between the 1980s and 1990s on mud banks in Florida Bay. During the 1980s, Sogard et al. (1987) reported this species abundant at all their sampling sites on mud banks in Florida Bay. Similarly, Schmidt (1979) collected goldspotted killifish throughout Florida Bay, but it was most abundant in eastern Florida Bay. On the Atlantic Ocean side of the Florida Keys adjacent to Florida Bay, Springer and McErlean (1962) collected this species only in beds of *Halodule wrightii* in soft sediments. They suggested that goldspotted killifish burrow when seagrass is exposed.

Length-frequency distributions Goldspotted killifish spawned throughout the year in Florida Bay (Fig. 11.3). The largest specimens were collected in June and averaged 55–59 mm SL. In adjacent waters to Florida Bay on the Atlantic Ocean side, Springer and McErlean (1962) reported a maximum length of 49 mm SL, which is in concordance with our findings. They only collected juveniles (ca. 15 mm SL) of this species in June, July, and September, whereas we collected juveniles during all months in which we sampled (Fig. 11.3). The maximum reported size of this species is 65 mm TL (Robins and Ray, 1986).

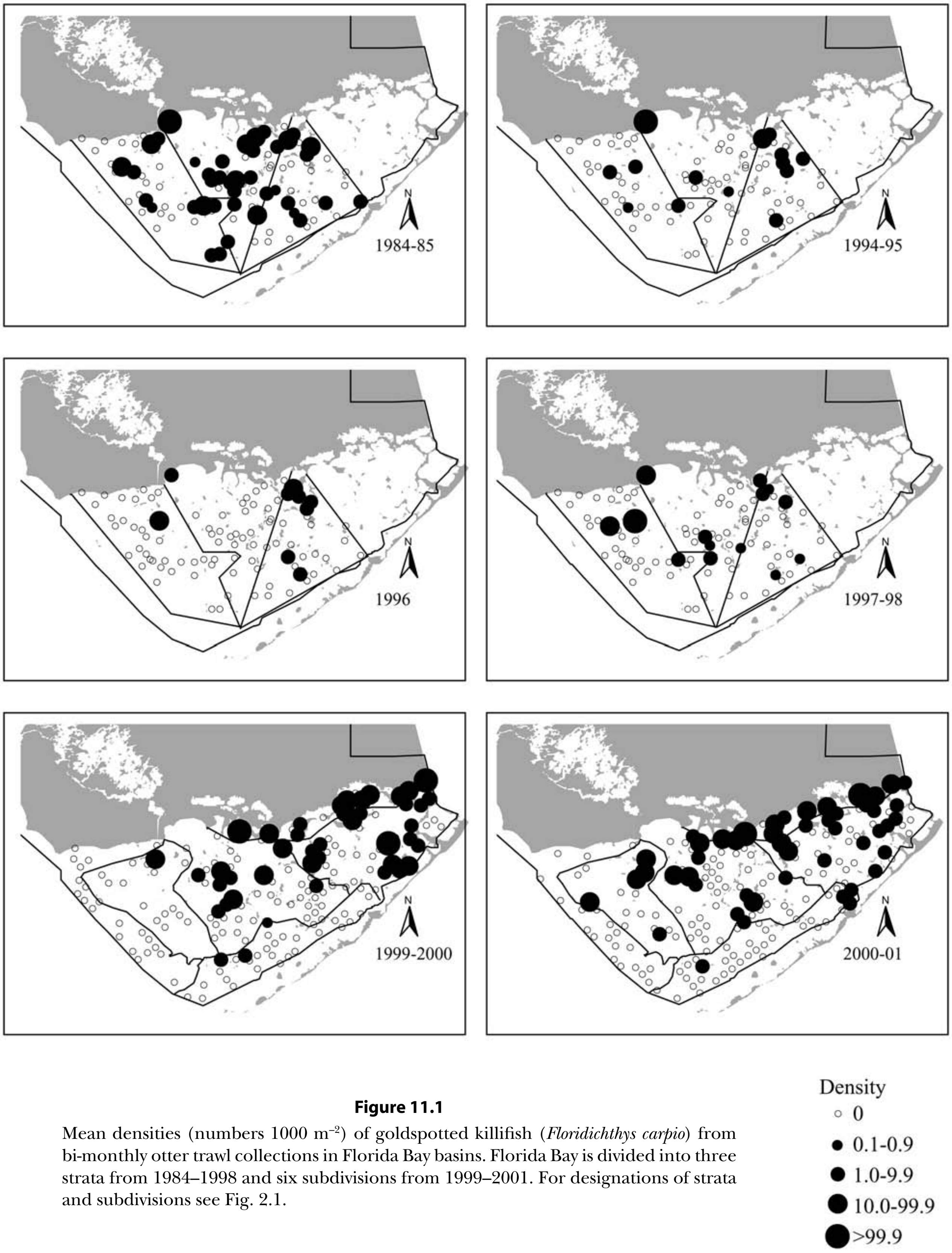


Figure 11.1

Mean densities (numbers 1000 m^{-2}) of goldspotted killifish (*Floridichthys carpio*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

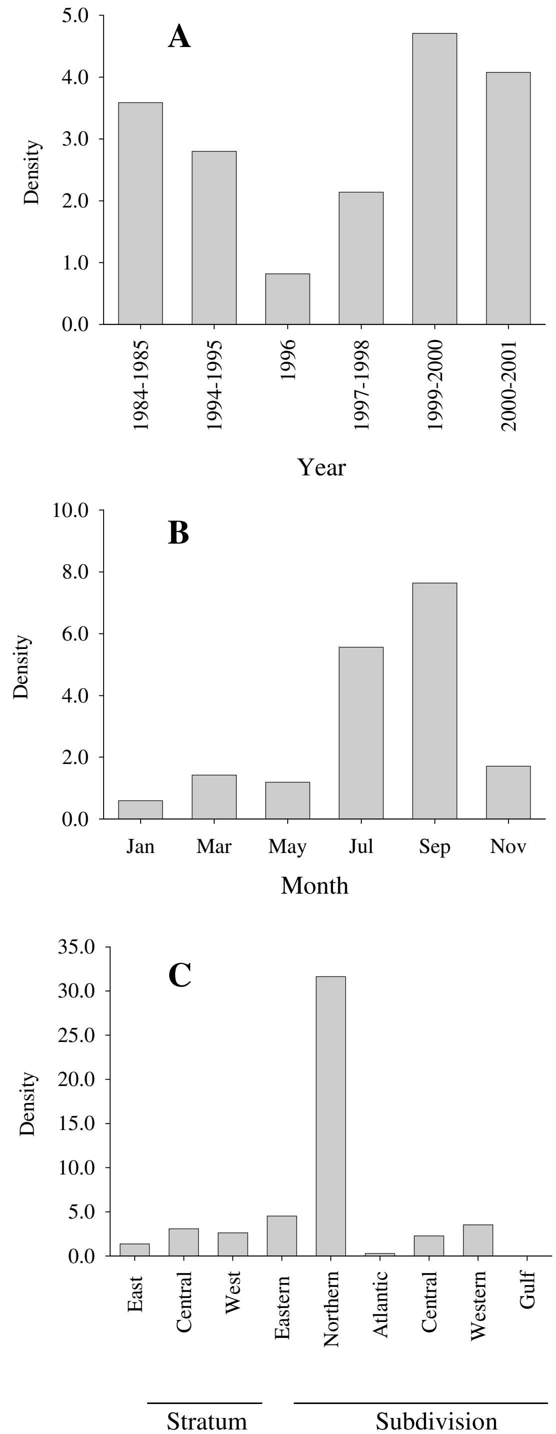


Figure 11.2

Mean densities (numbers 1000 m^{-2}) of goldspotted killifish (*Floridichthys carpio)* from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

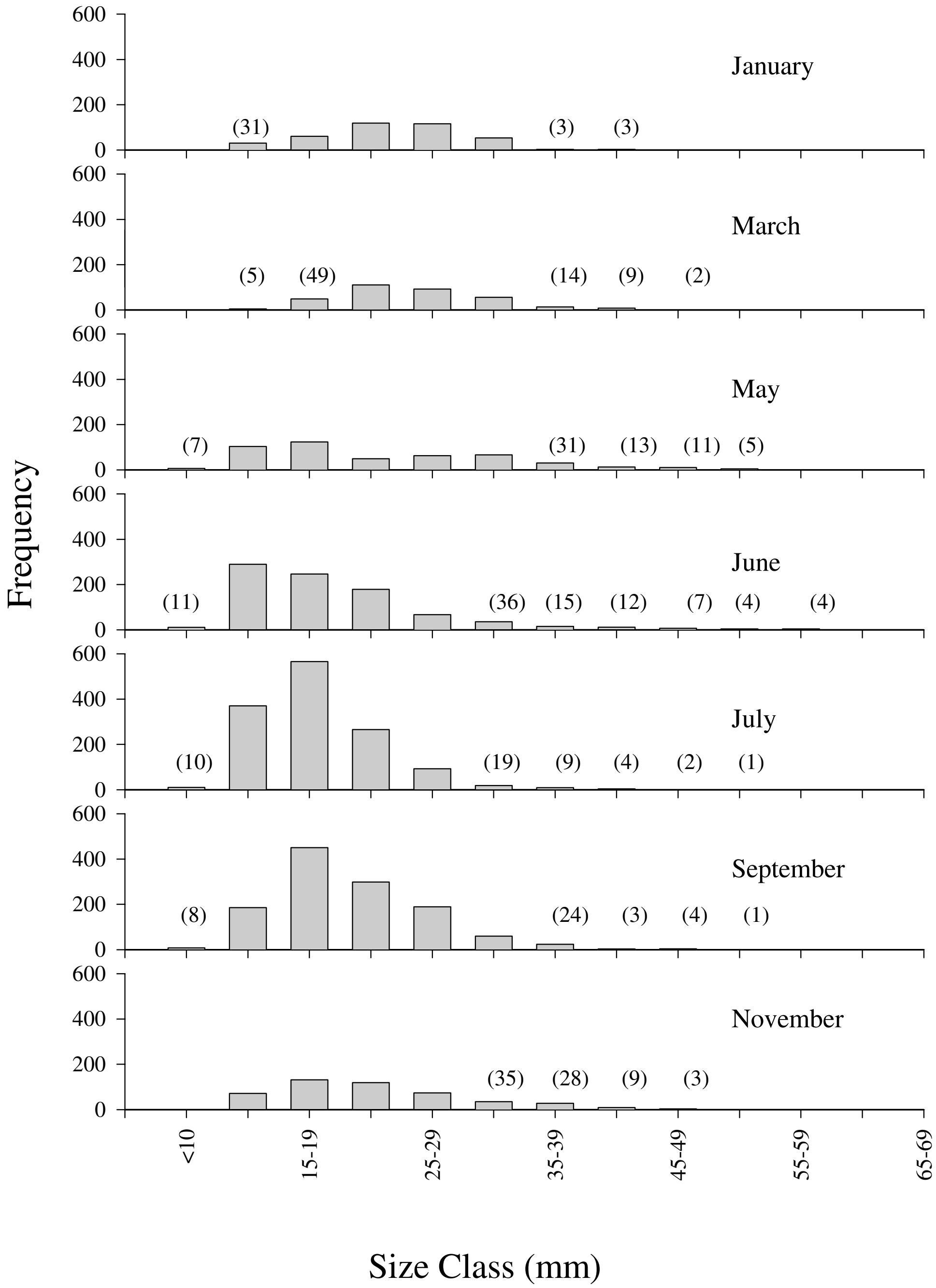


Figure 11.3

Monthly length-frequency distributions of goldspotted killifish (*Floridichthys carpio*) from Florida Bay. Values are shown for numbers <50 for clarity.

Lucania parva (rainwater killifish)

Abundance (numbers) and rank of rainwater killifish by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	11,132	2

Life history The rainwater killifish, a fundulid, occurs from Massachusetts and the northern Gulf of Mexico to the Florida Keys and northeast Mexico (Robins and Ray, 1986). It is a euryhaline species that is associated with submerged aquatic vegetation (Jordan, 2002).

Rainwater killifish hatch at 4.0 to 5.5 mm TL and reach a maximum size at 43 mm TL (Able and Fahay, 1998). The smallest juvenile described is 20 mm (Hardy, 1978). This species is sexually mature at approximately 23 mm SL and at ages of less than 2 months (Matheson et al., 1999).

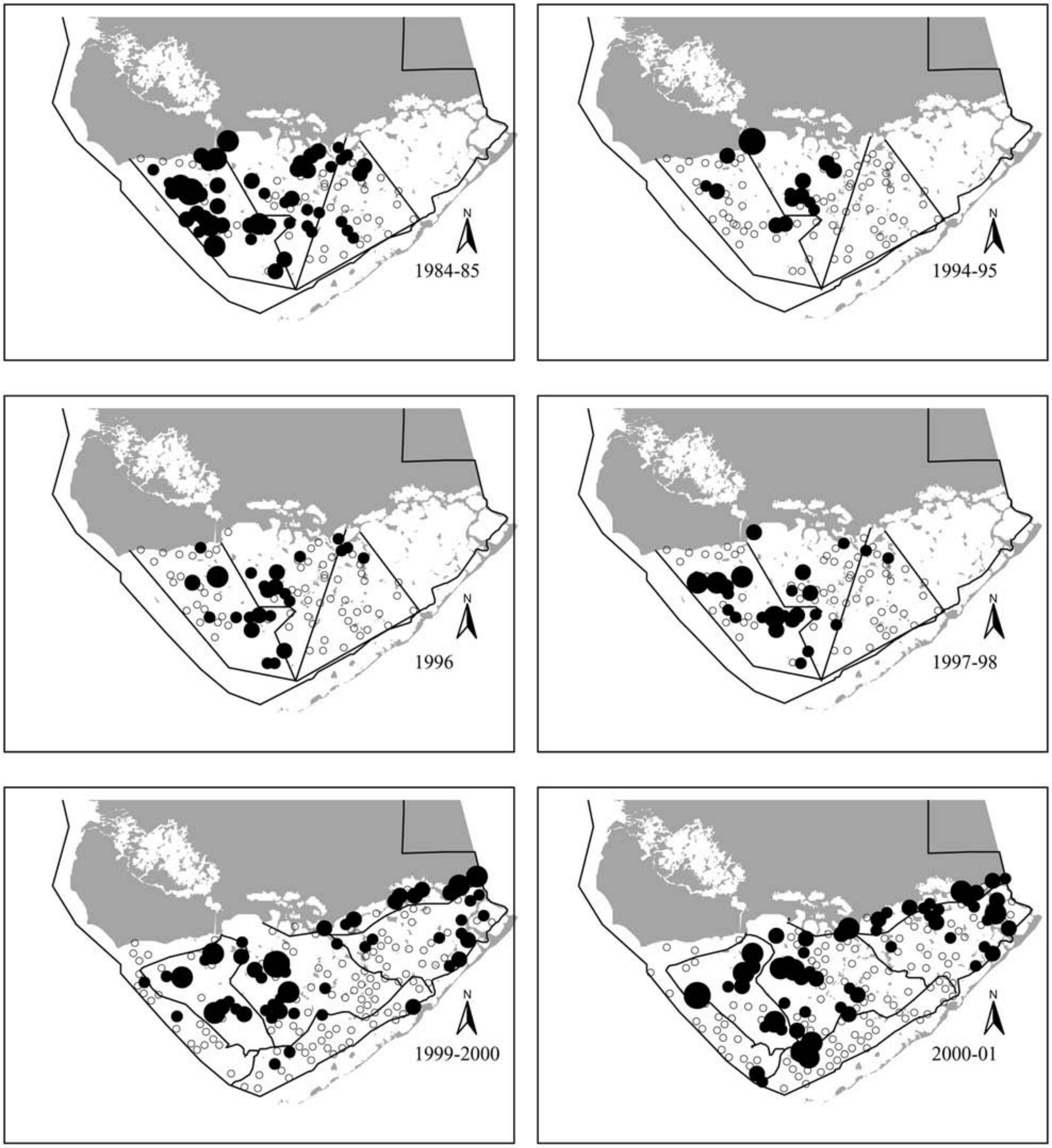
Diet In the Whitewater Bay system adjacent to Florida Bay, fish less than 20 mm SL feed exclusively on planktonic copepods, whereas the diet of fish 21 to 37 mm SL from the same area was more diverse. These larger fish have a diverse diet, and mainly consume amphipods and mysids (Odum and Heald, 1972).

Abundance and distribution Rainwater killifish were very abundant in otter trawl collections (Fig. 11.4). There were significant differences in densities among years, months, strata, and subdivisions. Mean annual densities followed a pattern similar to goldspotted killifish (Figs. 11.2 and 11.5). There was a decline from 1984–1985 to 1996, following the seagrass die-off and accompanying environmental changes. Densities increased from 1997 to 2000–2002, when densities mirrored those of 1984–1985. Rainwater killifish were collected at highest mean monthly densities during the middle of the wet season; i.e., September (Fig. 11.5).

Spatially, rainwater killifish were collected at highest densities in the West strata and Western subdivision, but occurred at more stations in the Northern subdivision (Figs. 11.4 and 11.5). They were relatively rare in the Gulf subdivision and absent in 1984–1985 in the East stratum.

Over mud banks of Florida Bay, this species was abundant at Cowpen Keys (Fig. 1.1) (Sogard et al., 1987) located in our Atlantic subdivision where we observed only moderate densities (Figs. 11.4 and 11.5). Schmidt (1979) found this species to be most abundant in eastern Florida Bay.

Length-frequency distributions Based on the presence of small larvae, spawning occurred throughout the year (Fig. 11.6). Because of multiple cohorts, a progression of size classes could not be used to estimate growth. Able and Fahay (1998) estimated summer growth to be 0.3 mm per day in the Middle Atlantic Bight, with little growth during winter. Length at the end of the first year is 30 to 40 mm TL (ca. 20–29 mm SL, based on measurements of Able and Fahay's rainwater killifish illustration). The reported maximum size of fish in Middle Atlantic Bight (43 mm TL; ca. 33 mm SL) is similar to the maximum size we observed.



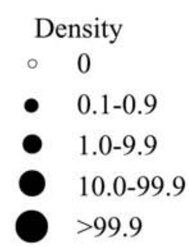


Figure 11.4

Mean densities (numbers 1000 m^{-2}) of rainwater killifish (*Lucania parva*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

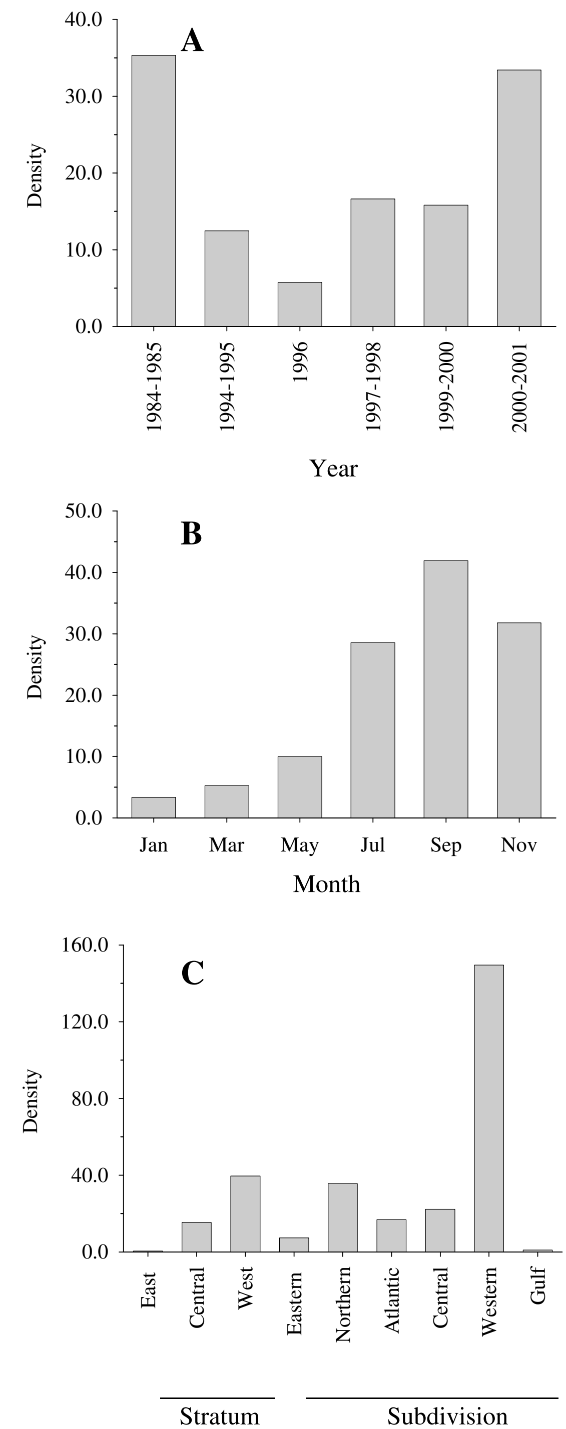


Figure 11.5

Mean densities (numbers 1000 m^{-2}) of rainwater killifish (*Lucania parva*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

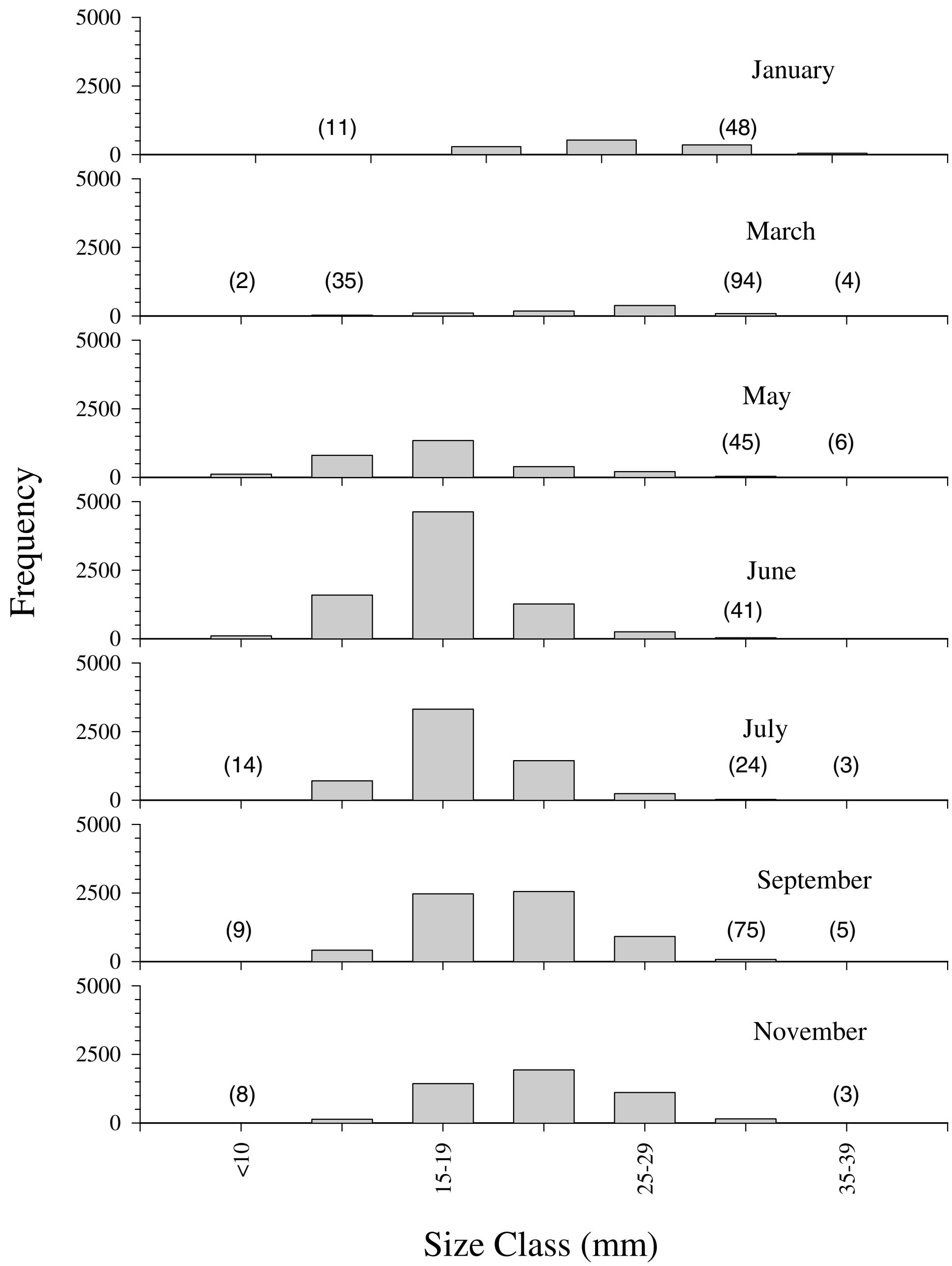


Figure 11.6

Monthly length-frequency distributions of rainwater killifish (*Lucania parva*) from Florida Bay. Values are shown for numbers <100 for clarity.

Chapter 12. Families Atherinidae and Atherinopsidae

Atherinomorus stipes (hardhead silverside)

Total numbers collected and rank of hardhead silversides by sampling method. There were a total of 14 species collected by surface trawl in each habitat.

Gear	Habitat	Year	Number	Rank
Surface trawl	Basins	1984–1985	457	5
Surface trawl	Channels	1984–1985	475	2

Life history The hardhead silverside, an atherinid and a coastal pelagic species, ranges from south Florida, the Bahamas, and the Yucatan to Brazil (Robins and Ray, 1986). Despite its abundance within its range, very little life history information is available. It spawns during June in south Florida. Like other atherinids, the eggs probably have filaments attached that entangle on submerged aquatic vegetation or other objects (Breder and Rosen, 1966).

Diet Hardhead silversides are zooplanktivores that primarily feed on shrimp larvae and copepods (Randall, 1967).

Abundance and distribution Hardhead silversides were commonly collected with a surface trawl in basins and channels in 1984–1985. They exhibited higher densities in the Central stratum and least in the East stratum (Figs.12.1 and 12.2). There were no significant differences in densities among months.

This species is strongly associated with mangrove prop root habitats in Whitewater Bay, Coot Bay, and Florida Bay (Thayer et al., 1987b), and mesohaline waters in northern Florida Bay and adjacent estuarine waters (Powell et al., 2002).

Length-frequency distributions Small individuals (15–19 mm SL), indicative of recent spawning, were collected in all seasons, but were absent in January, March, and July (Fig. 12.3). However, the occurrence of fish 20–24 mm SL indicated spawning occurred throughout most of the year. Hardhead silversides attain a maximum length of approximately 125 mm SL (Breder, 1948), a size much larger than we collected. This species could leave basin and channel habitats and recruit into other habitats not sampled by us at approximately 60–64 mm SL.

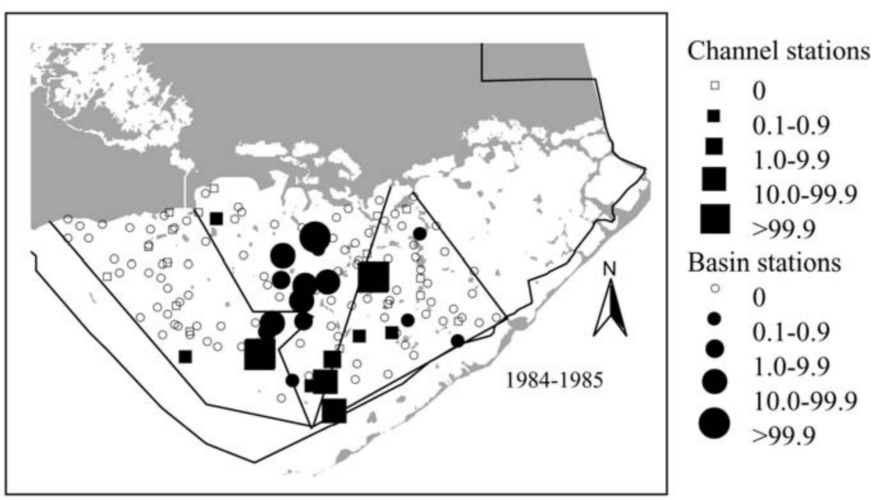


Figure 12.1

Mean densities (numbers 1000 m^{-2}) of hardhead silversides (*Atherinomorus stipes*) collected by surface trawl in Florida Bay basins and channels during 1984–1985. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

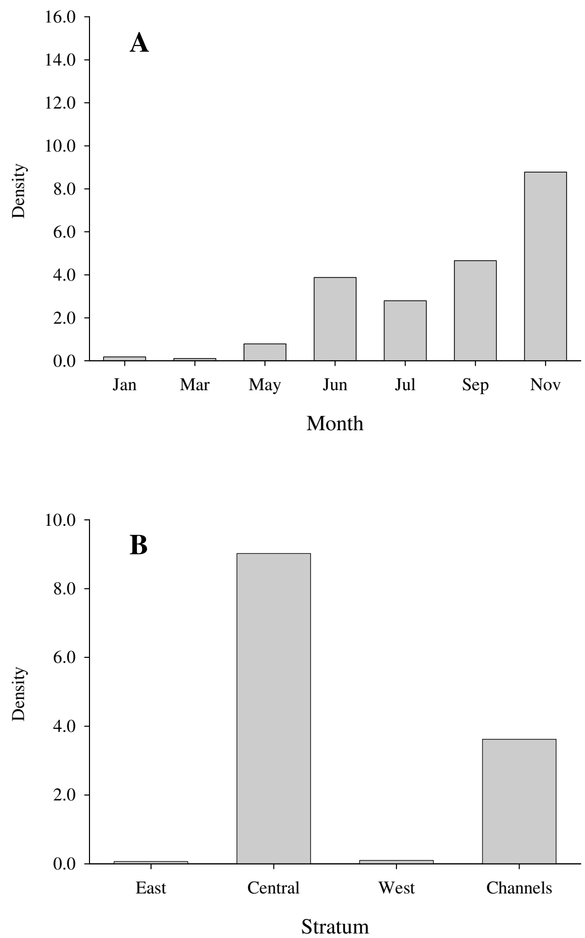


Figure 12.2

Mean densities (numbers 1000 m^{-2}) of hardhead silversides (*Atherinomorus stipes*) collected by surface trawl in Florida Bay basins and channels during 1984–1985 by (A) month and (B) stratum. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

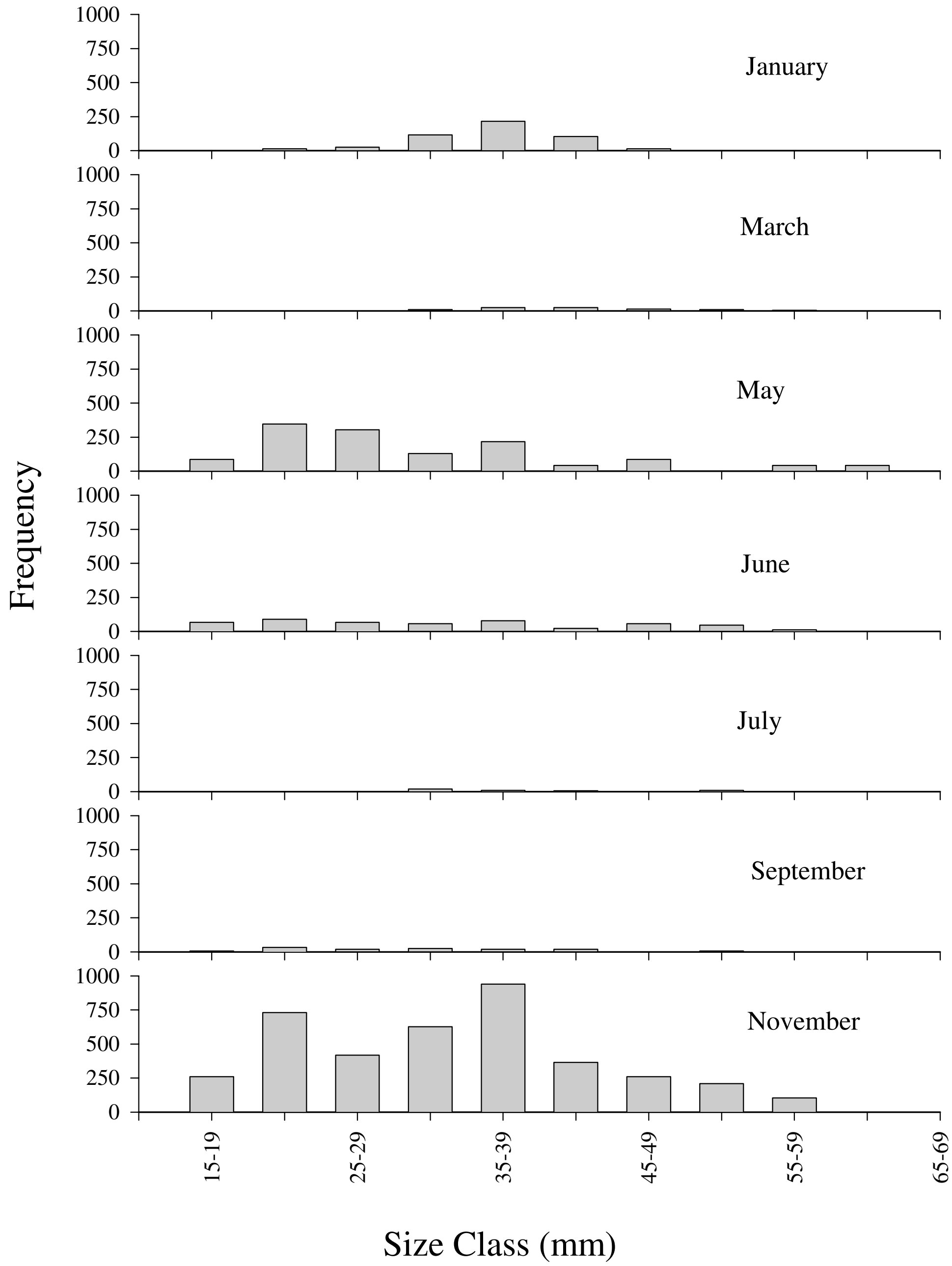


Figure 12.3

Monthly length-frequency distributions of hardhead silversides (*Atherinomorus stipes*) from Florida Bay.

Hypoatherina harringtonensis (reef silverside)

Total numbers collected and rank of reef silverside by sampling method. There were a total of 14 species collected by surface trawl in each habitat.

Gear	Habitat	Year	Number	Rank
Surface trawl	Basins	1984–1985	366	7
Surface trawl	Channels	1984–1985	844	1

Life history The reef silverside, an atherinid and a coastal and offshore pelagic zooplanktivore, ranges from Bermuda, south Florida, the Bahamas, and the Yucatan to northern South America (Robins and Ray, 1986). Very little life history information is available for this species. Like other atherinids, the eggs probably have filaments attached that entangle on submerged aquatic vegetation or other objects (Breder and Rosen, 1966).

Diet Reef silverside feeds predominantly on copepods (Randall, 1967).

Abundance and distribution Reef silverside were abundant in surface trawl collections from basins and channels. They were collected in significantly higher densities in the East stratum and lower densities in the West stratum. They were primarily collected at channel stations (Figs. 12.4 and 12.5). The distribution of this species was dissimilar to the hardhead silverside (Figs. 12.1 and 12.2), but like the hardhead silversides, it was abundant in surface trawl collections in channels.

This species was rarely collected in the mangrove prop habitat in Coot Bay, Whitewater Bay, and Florida Bay (Thayer et al., 1987b), and was not collected in northern Florida Bay and adjacent estuarine waters (Powell et al., 2002).

Length-frequency distributions Small reef silversides (10–14 mm SL), indicative of recent spawning, were collected in May, and spawning probably occurred in August based on the presence of 15–19 mm SL fish in September (Fig. 12.6). Growth could not be estimated and size classes were difficult to discern, although there appeared to be multiple size classes in May, June, and September. Based on the maximum reported size of approximately 75 mm SL (Breder, 1948) larvae, juveniles and adults were probably collected.

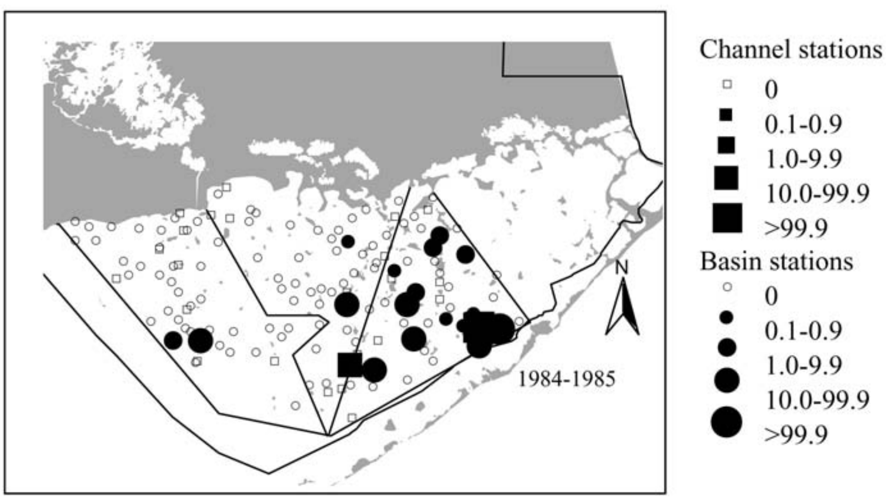


Figure 12.4

Mean densities (numbers 1000 m^{-2}) of reef silversides (*Hypoatherina harringtonensis*) collected by surface trawl in Florida Bay basins and channels during 1984–1985. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

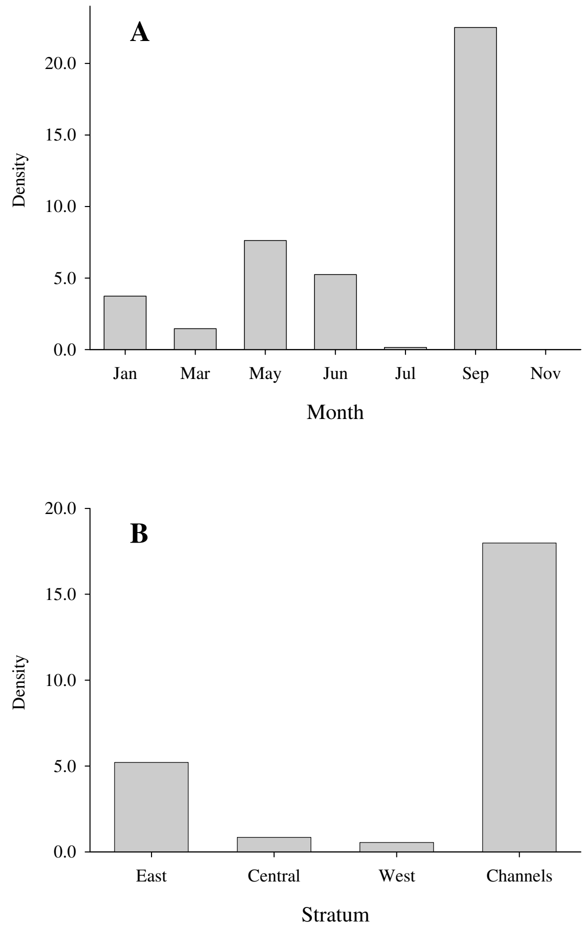


Figure 12.5

Mean densities (numbers 1000 m^{-2}) of reef silversides (*Hypoatherina harringtonensis*) collected by surface trawl in Florida Bay basins and channels during 1984–1985 by (A) month and (B) stratum. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

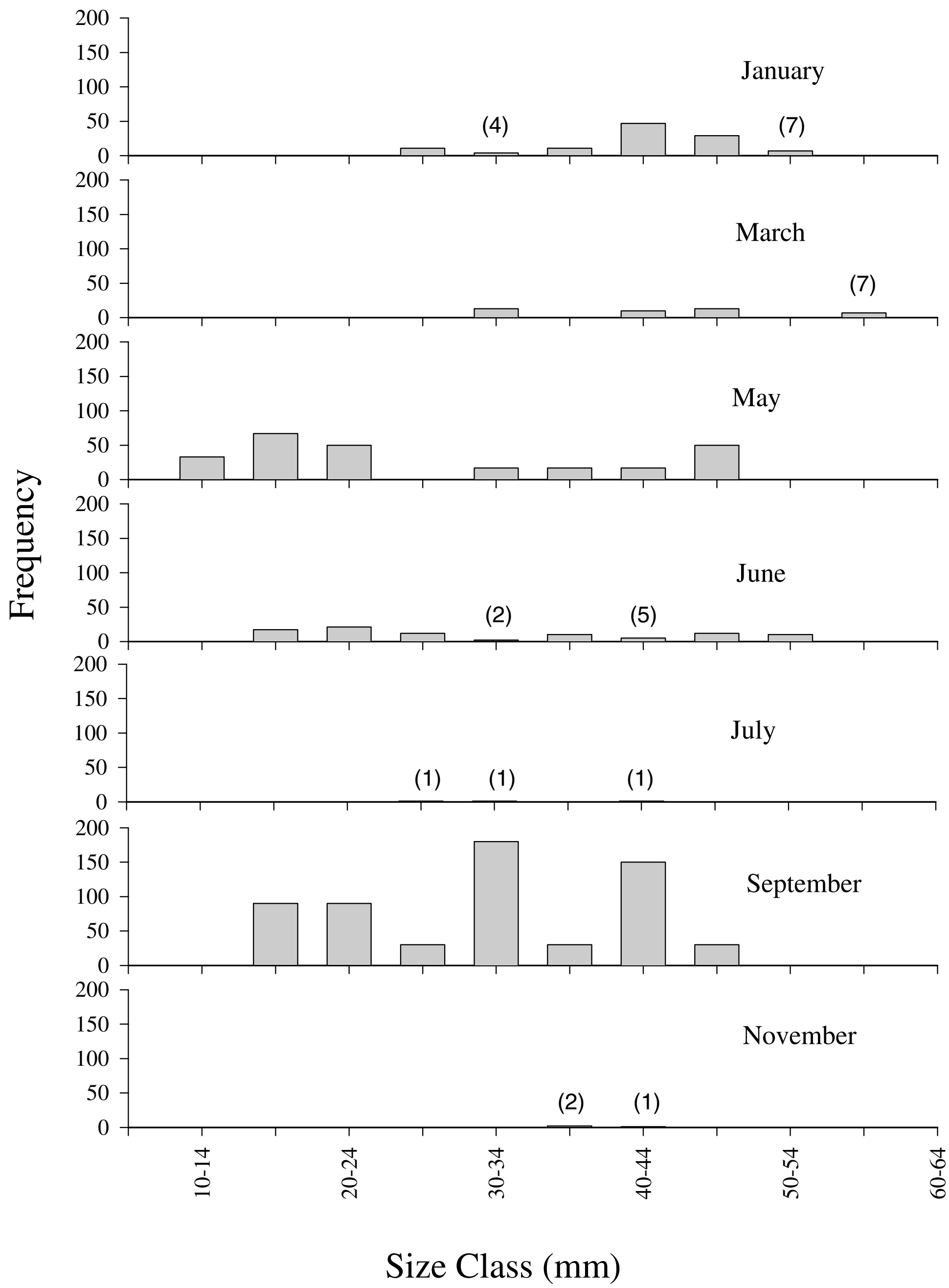


Figure 12.6

Monthly length-frequency distributions of reef silversides (*Hypoatherina harringtonensis*) from Florida Bay. Values are shown for numbers <10 for clarity.

Membras martinica (rough silverside)

Total numbers collected and rank of rough silverside by sampling method. There were a total of 14 species collected by surface trawl in each habitat.

Gear	Habitat	Year	Number	Rank
Surface trawl	Basins	1984–1985	408	6
Surface trawl	Channels	1984–1985	63	9

Life history The rough silverside, an atherinopsid and a pelagic zooplanktivore, ranges from New York to Florida and the northern Gulf of Mexico and northern Mexico. It is most abundant in the southern part of its range (Robins and Ray, 1986). This species inhabits shallow seagrass flats and is usually found along exposed shorelines and beaches over firm substrate (Murdy et al., 1997). In Chesapeake Bay, spawning is protracted and occurs from May to early August. Sexual maturity is attained at approximately 50 mm TL. Eggs have filaments that attach to vegetation on sand flats. The juvenile stage is attained at approximately 15 mm SL (Kuntz, 1916; Martin and Drewry, 1978; Murdy et al., 1997).

Diet This species feeds on copepods and other planktonic crustaceans (Murdy et al., 1997).

Abundance and distribution Rough silversides were commonly collected by surface trawl in basins and channels in 1984–1985. Although densities appeared greater in the West strata and in June, there were no significant differences in densities among strata and months (Figs. 12.7 and 12.8), although they were collected at a greater percentage of sites in the East stratum. This species appeared to slightly prefer basin habitats to channels.

In Whitewater Bay, Coot Bay, and Florida Bay, this species is strongly associated with red mangrove prop roots, but absent in adjacent seagrass beds (Thayer et al., 1987b). It has not been collected in northern Florida Bay and adjacent waters (Powell et al., 2002).

Length-frequency distributions Based on the presence of small rough silverside (15–24 mm SL), spawning occurred at least from April through August (Fig. 12.9). Juveniles dominated collections in May and September, while adults were more common in June. In Gulf of Mexico waters, juvenile rough silversides grew 9 mm per month (Martin and Drewry, 1978).

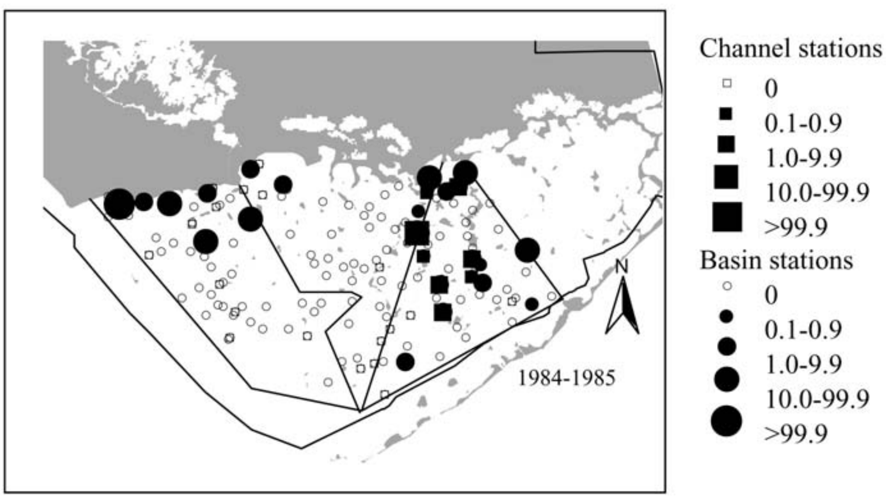


Figure 12.7

Mean densities (numbers 1000 m^{-2}) of rough silversides (*Membras martinica*) collected by surface trawl in Florida Bay basins and channels during 1984–1985. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

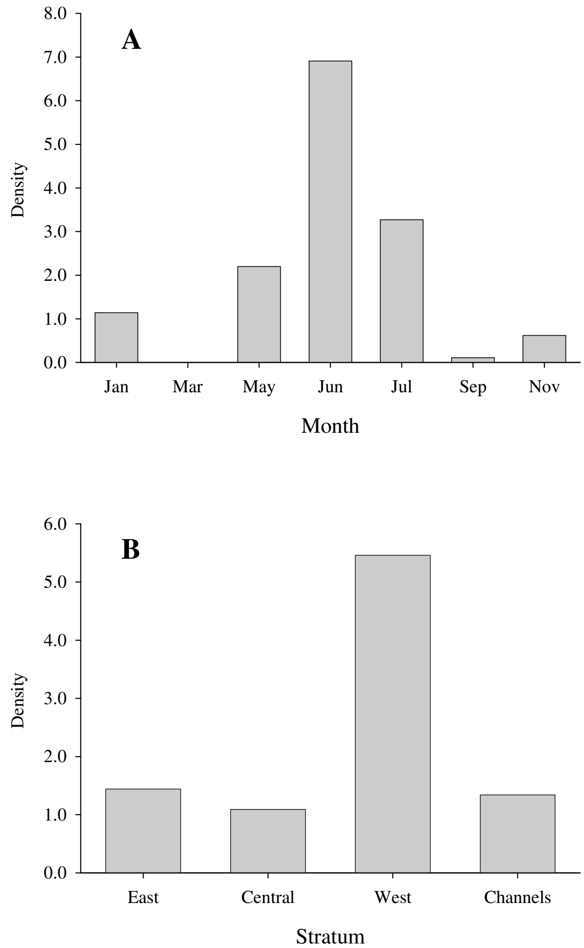


Figure 12.8

Mean densities (numbers 1000 m^{-2}) of rough silversides (*Membras martinica*) collected by surface trawl in Florida Bay basins and channels during 1984–1985 by (A) month and (B) stratum. Florida Bay basins are divided into three strata. For designations of strata see Fig. 2.1.

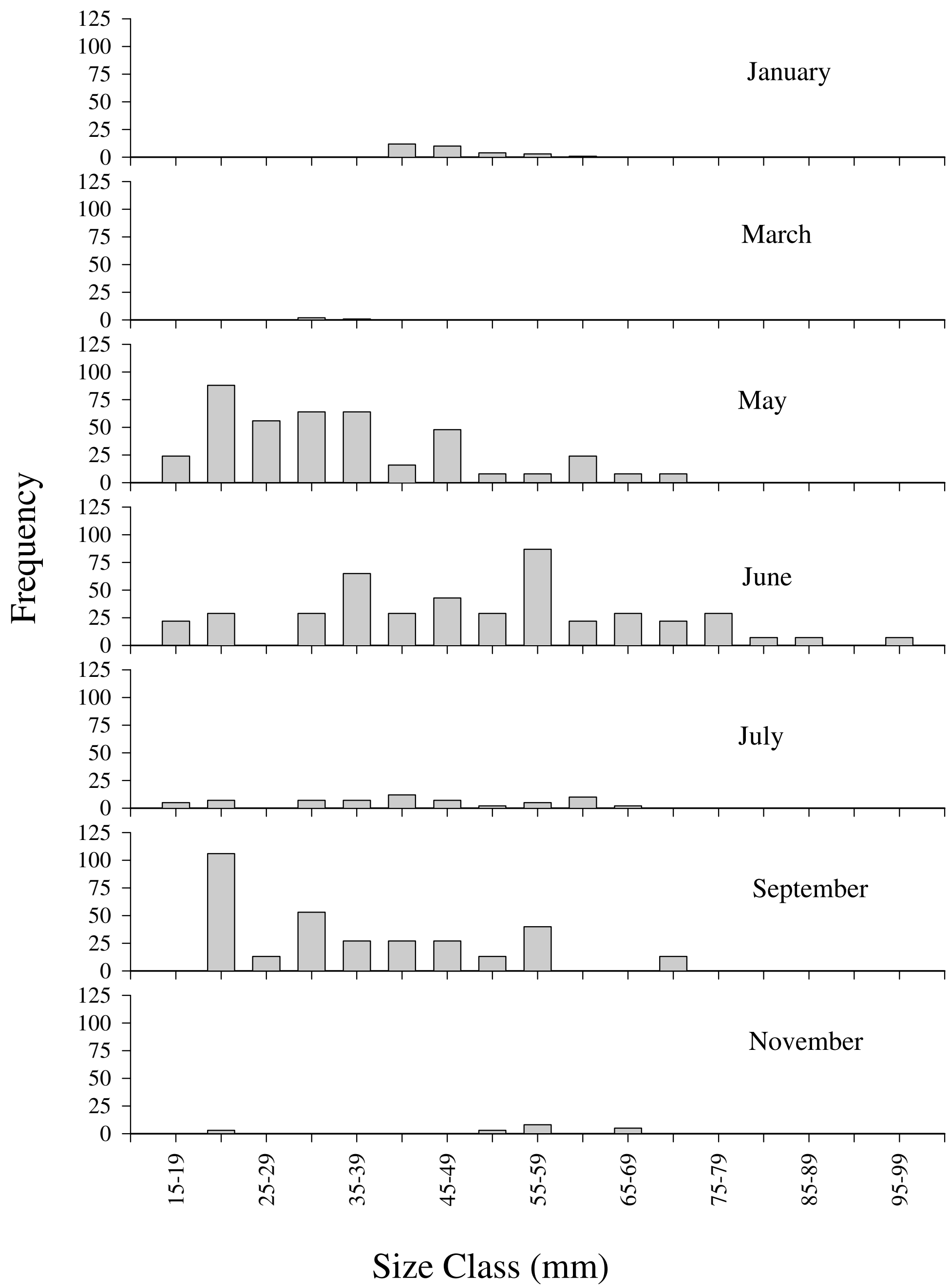


Figure 12.9

Monthly length-frequency distributions of rough silversides (*Membras martinica)* from Florida Bay.

Chapter 13. Family Syngnathidae

Anarchopterus criniger (fringed pipefish)

Total numbers collected and rank of fringed pipefish by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	459	15

Life history Fringed pipefish range from North Carolina, the Bahamas, and northern Gulf of Mexico to Brazil (Robins and Ray, 1986). Like all syngnathids, females deposit eggs in the marsupium (brood pouch) of the male where eggs are then incubated. Young exit through a lengthwise seam in the marsupium (Robins and Ray, 1986; Murdy et al., 1997). In Cedar Key, Florida, Reid (1954) observed breeding males in May, August, and September.

The fringed pipefish is listed as vulnerable under the Distinct Population Segments concept defined as "populations that are markedly separated from other populations of the same taxon as a consequence of physical, ecological, or behavioral factors to which it belongs" (Musick et al., 2000). The risk factors are: it is rare, but locally common in Florida Bay grassbeds, which have undergone seagrass losses (Schmidt, 1979; Fourqurean and Robblee, 1999).

Diet The diet of fringed pipefish consists of copepods and other microcrustaceans (Reid, 1954), which are sucked into an elongated tube-like snout with a small trap door at the tip, which works like a "slurp gun" (Robins and Ray, 1986).

Abundance and distribution Fringed pipefish were common in otter trawl collections in basins. There were no significant differences in densities of fringed pipefish between strata, but there were differences between subdivisions. This species occurred at greatest densities in the Western subdivision; at moderate densities in the Eastern, Atlantic, and Central subdivisions; and at least densities in the Northern and Gulf subdivisions (Figs. 13.1 and 13.2). Among areas, it occurred at a greater frequency of stations in the Western and Eastern subdivisions. Temporally, there were significant inter-annual differences in densities. This species was least common in 1984–1985 prior to the seagrass die-off in western Florida Bay (where this species was most abundant in this study), and more common after the die-off of seagrasses in 1994–1995 (Figs. 13.1 and 13.2). Highest densities occurred in 1999–2000 and 2000–2001. These most recent high densities could be related to an increase in spatial sampling (Fig. 13.1). On Florida Bay mud banks, this species was most common at Buchanan Keys (Fig. 1.1) (Sogard et al., 1987).

Length-frequency distributions Based on length-frequency distributions, spawning was protracted in Florida Bay and occurred throughout all seasons (Fig. 13.3). Because of multiple cohorts, growth of fringed pipefish could not be estimated by following progressive size classes. Smallest pipefish (<20 mm SL) were collected in two of seven months that we sampled. The largest adults were 90–99 mm SL.

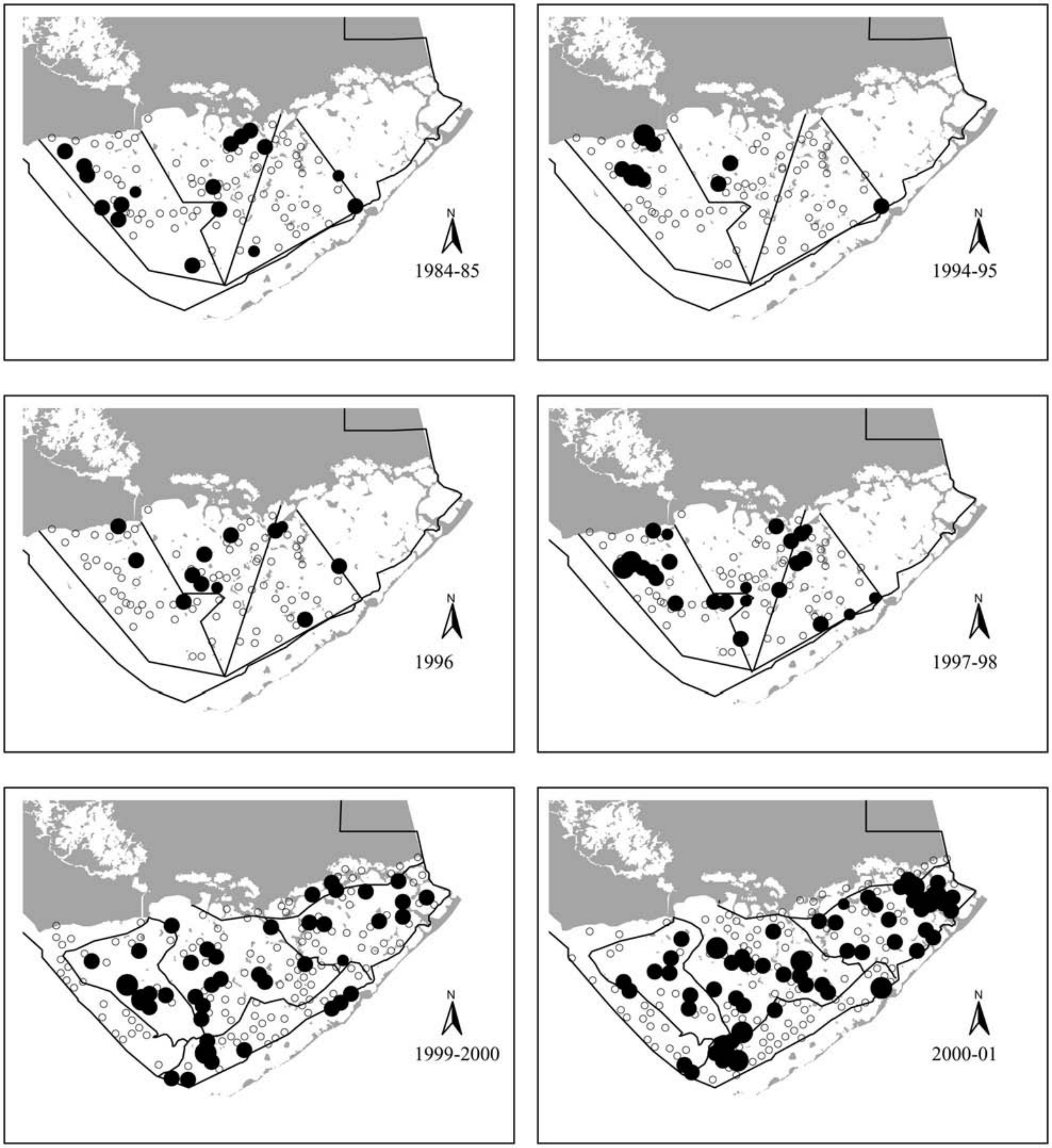


Figure 13.1

Mean densities (numbers 1000 m^{-2}) of fringed pipefish (*Anarchopterus criniger*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

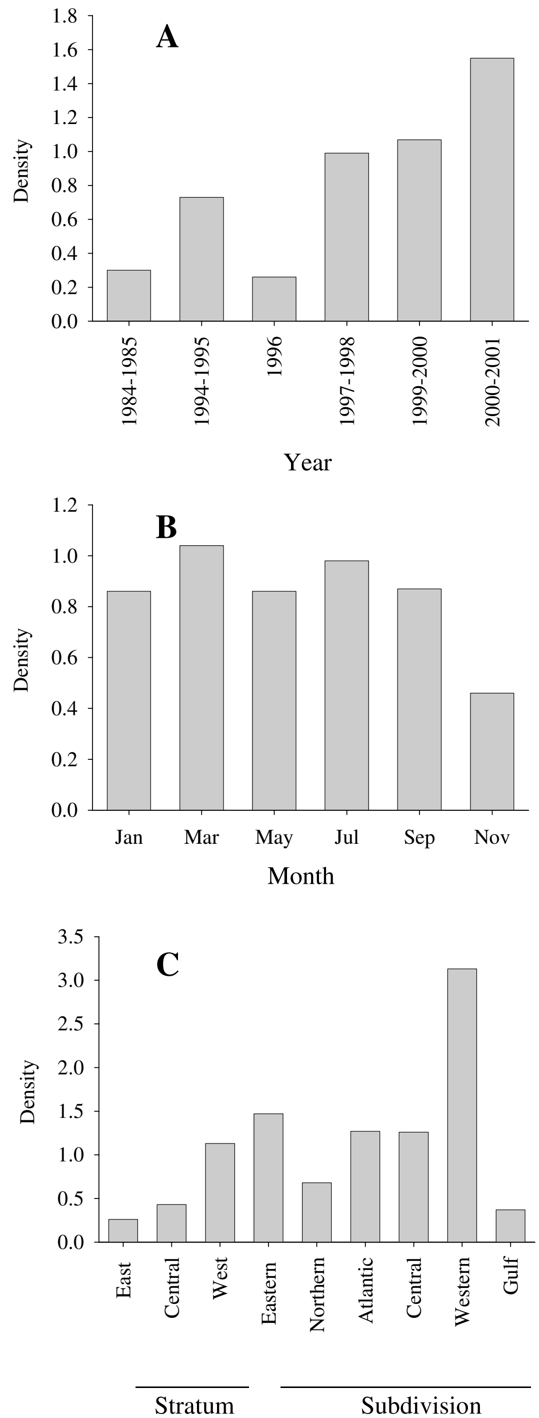


Figure 13.2

Mean densities (numbers 1000 m^{-2}) of fringed pipefish (*Anarchopterus criniger)* from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

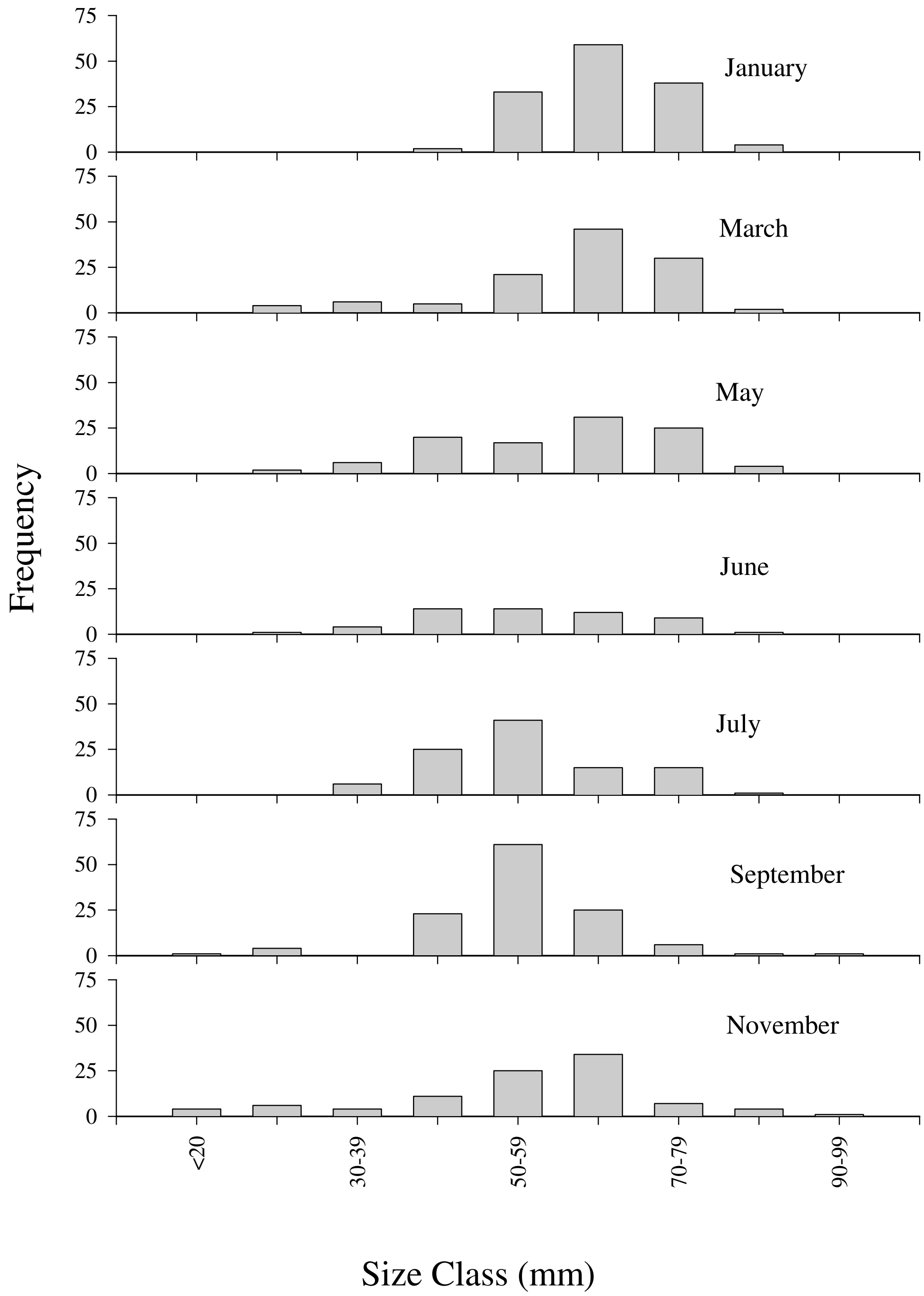


Figure 13.3
Monthly length-frequency distributions of fringed pipefish (*Anarchopterus criniger*) from Florida Bay.

Syngnathus floridae (dusky pipefish)

Total numbers collected and rank of dusky pipefish by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	1683	6

Life history Dusky pipefish range from Chesapeake Bay, Bermuda, Bahamas, and northern Gulf of Mexico to Panama. They are common in seagrass beds (Robins and Ray, 1986). A description of their reproductive habits is given above for the fringed pipefish. Minimum size at sexual maturity for males is 116 mm SL; females, 137 mm SL (Reid, 1954). Spawning occurs throughout the year in Cedar Key, Florida, but spawning is minimal from November through January (Reid, 1954).

Diet The diet of the dusky pipefish consists mainly of very small crustaceans (Murdy et al., 1997). Near Cedar Key, Florida, Reid (1954) reported copepods as a dominant food item, followed by amphipods and small shrimp. A description of their feeding behavior is given above for the fringed pipefish.

Abundance and distribution Dusky pipefish were abundant in otter trawl collections in basins. Temporally, there were significant differences in densities for dusky pipefish between years, but not months (Figs. 13.4 and 13.5). In concordance with the seagrass die-off, there was a decrease in mean densities from 1984–1985 to 1996, then a progressive increase until 2000–2001 when mean densities were at their maximum. They were, however, collected at a greater frequency of sites in 1984–1985 (Fig. 13.4). Spatially, there were significant differences in mean densities between strata and subdivision. Relatively high densities were collected in the West stratum compared to the East and Central strata (Figs. 13.4 and 13.5). Relatively high densities were observed in the Western subdivision providing further evidence that this species is associated with lush seagrass beds (Thayer and Chester, 1989). This species, along with the gulf pipefish, are the two most abundant pipefishes in Florida Bay (this study; Schmidt, 1979; FMRI[1,2,3,4]).

Length-frequency distributions Based on length-frequency distributions, spawning occurred throughout the year in Florida Bay (Fig. 13.6). Two size classes could be identified from November length-frequency distributions, with modes at 90–99 and 180–189 mm SL that could represent juveniles and adults.

Figure 13.4

Mean densities (numbers 1000 m^{-2}) of dusky pipefish (*Syngnathus floridae)* from bimonthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

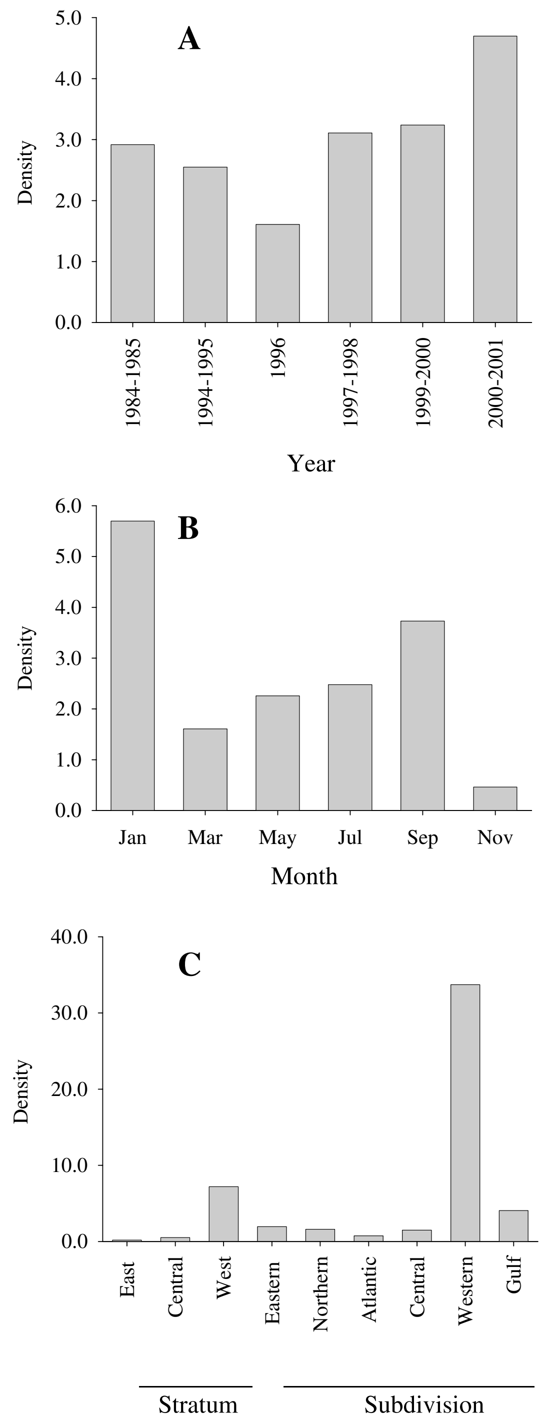


Figure 13.5

Mean densities (numbers 1000 m^{-2}) of dusky pipefish (*Syngnathus floridae*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

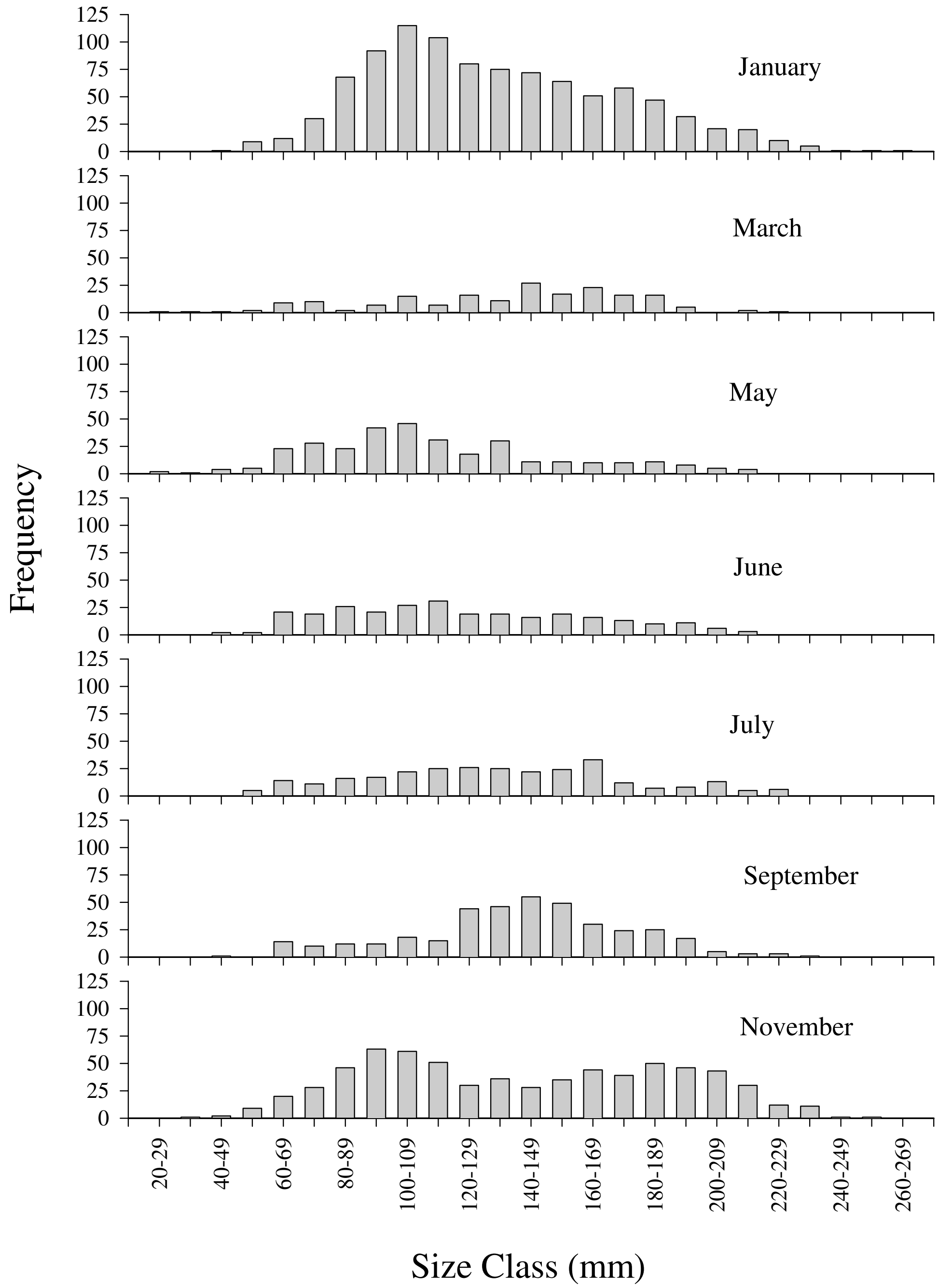


Figure 13.6

Monthly length-frequency distributions of dusky pipefish (*Syngnathus floridae*) from Florida Bay.

S. scovelli (gulf pipefish)

Total numbers collected and rank of gulf pipefish by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	2426	6

Life history Gulf pipefish range from northern Georgia and the northern Gulf of Mexico to northern South America (Targett, 1984; Robins and Ray, 1986). A description of their reproductive habits is given above for the fringed pipefish. Spawning occurs throughout the year in waters near Cedar Key, Florida (Reid, 1954). Males attain sexual maturity at 85 mm SL, females at 99 mm SL. Young leave the brood pouch at 15 mm SL (Reid, 1954).

Diet Copepods are the dominant item in the diet of gulf pipefish in waters near Cedar Key, Florida. Amphipods and small shrimp are also eaten, and occasionally gastropods (Reid, 1984). In Tampa Bay, Florida, this species feeds mainly on cypris larvae and amphipods, a diet that overlaps with the zooplanktivore, the scaled sardine, *Harengula jaguana* (Motta et al., 1995). A description of their feeding behavior is given above for the fringed pipefish.

Abundance and distribution Gulf pipefish were abundant in otter trawl collections. There were significant temporal and spatial differences in gulf pipefish densities. Densities were relatively low from 1984–1985 through 1996 and relatively high from 1997–1998 through 2000–2001 (Figs. 13.7 and 13.8), and thus were not necessarily correlated with seagrass die-off, which occurred in the late 1980s. Monthly densities were highest in July and September, and relatively low but approximately equal in density from November through May (Figs. 13.7 and 13.8). Spatially, from 1984–1985 through 1998, densities were highest in the West stratum and lowest in the East stratum (Fig. 13.8). From 1999–2000 through 2000–2001, densities were highest in the Western and Northern subdivisions and relatively low in the Atlantic, Gulf, and Eastern subdivisions. Gulf pipefish occurred at a greater percentage of stations in the Northern subdivision, least in the Gulf subdivision. This species, along with the dusky pipefish, are the two most abundant pipefishes in Florida Bay (this study; Schmidt, 1979; FMRI[1,2,3,4]).

Length-frequency distributions Length-frequency distributions were unimodal and similar (Fig. 13.9), suggesting that spawning occurred throughout the year. Both juvenile and adult gulf pipefish were collected.

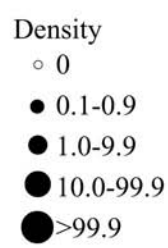


Figure 13.7

Mean densities (numbers 1000 m^{-2}) of gulf pipefish (*Syngnathus scovelli*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

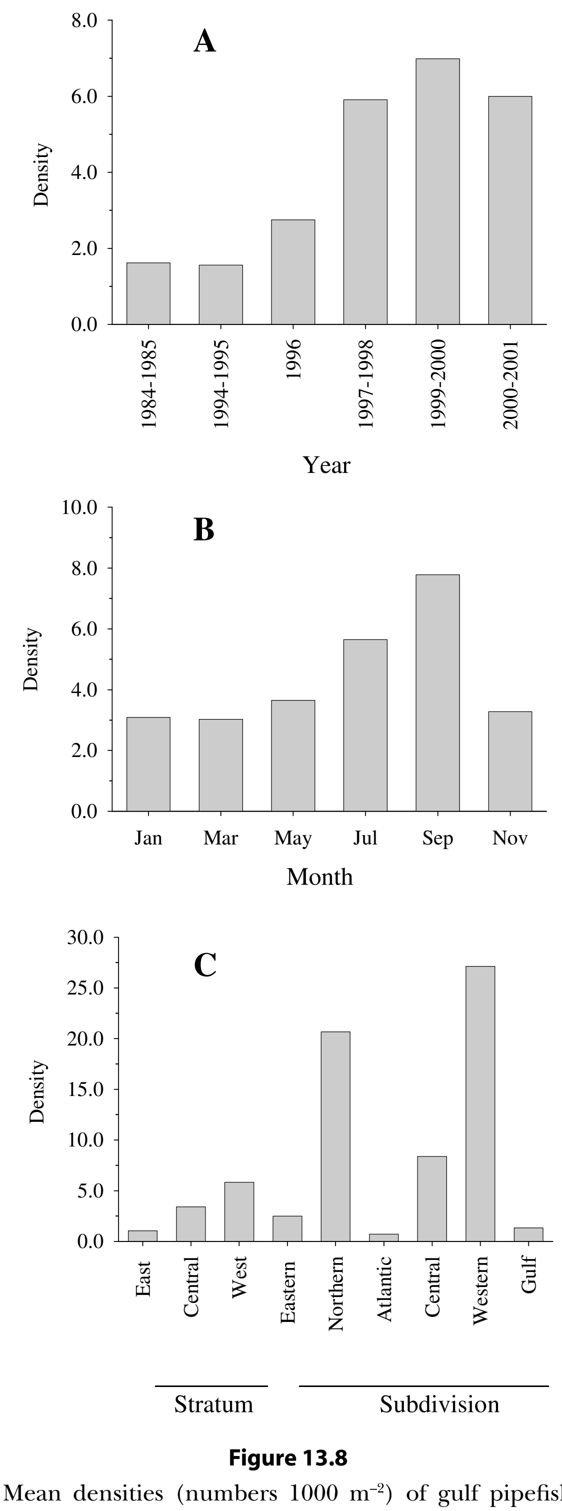


Figure 13.8

Mean densities (numbers 1000 m^{-2}) of gulf pipefish (*Syngnathus scovelli*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

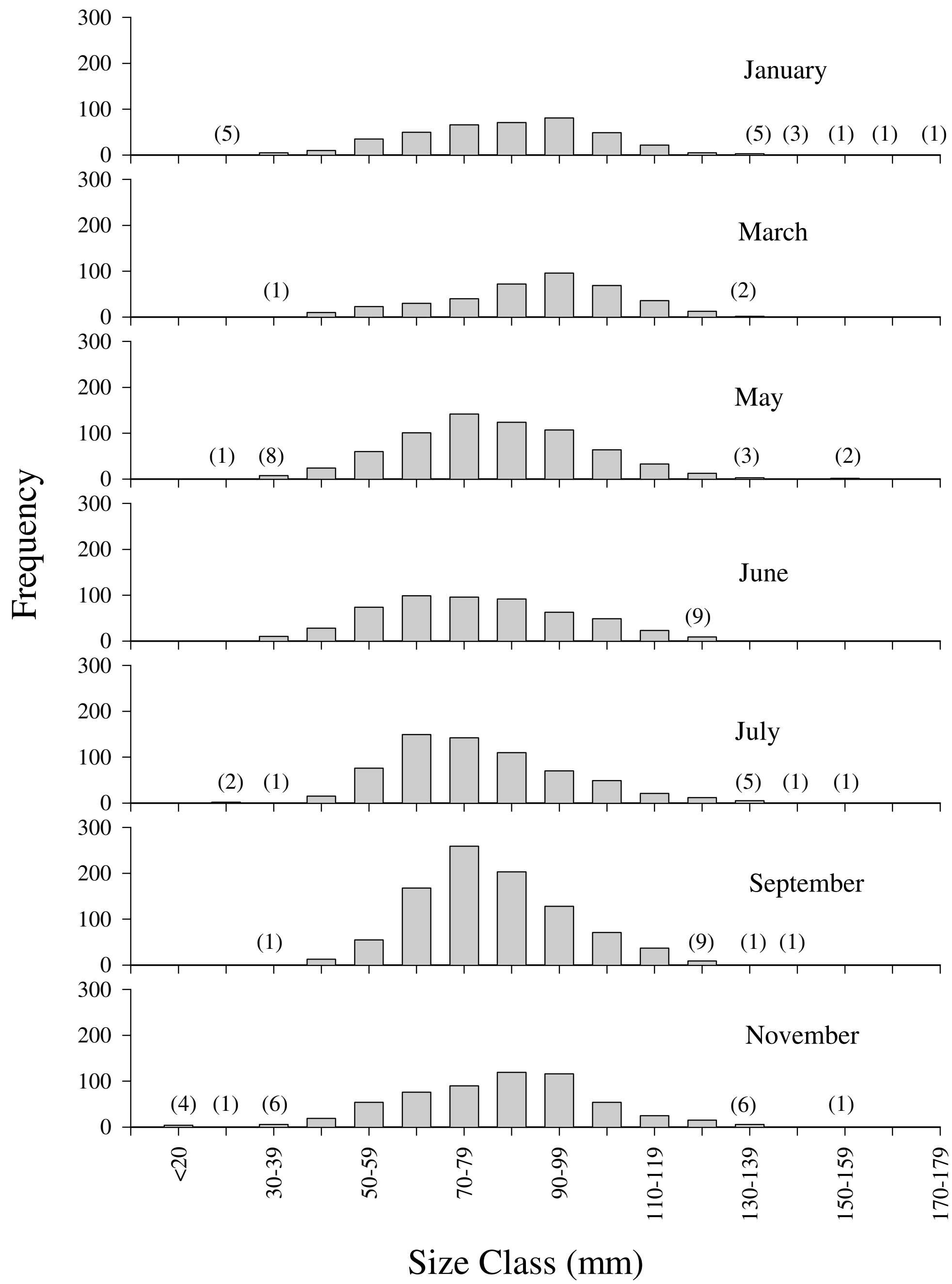


Figure 13.9

Monthly length-frequency distributions of gulf pipefish (*Syngnathus scovelli*) from Florida Bay. Values are shown for numbers <10 for clarity.

Hippocampus erectus (lined seahorse)

Total numbers collected and rank of lined seahorse by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	78	32

Life history Lined seahorse range from Nova Scotia to Uruguay or Argentina, northern Gulf of Mexico, Bermuda, and the Caribbean Sea. They are rare north of Cape Cod, Massachusetts (Breder, 1948; Robins and Ray, 1986; Murdy et al., 1997). A description of their reproductive habits is given above for the fringed pipefish. The size of expulsion from the male brood pouch is approximately 7 mm TL (Breder, 1948). Lined seahorses are monogamous. Males mature at 80 mm TL, females at 60 mm TL (Teixeira and Musick, 2001). This species has been presumed to spawn throughout the year in Florida waters, although males with distended brood pouches were only collected in December (Reid, 1954).

Diet Lined seahorse are voracious ambush predators and feed mainly on amphipods (Murdy et al., 1997; Teixeira and Musick, 2001). Shrimp and microcrustaceans also occur in their diets (Reid, 1954). A description of their feeding behavior is given above for the fringed pipefish.

Abundance and distribution The lined seahorse was uncommon in otter trawl collections in Florida Bay basins (Figs. 13.10 and 13.11). Although densities appeared low in 1996, there were no significant differences in densities among years, but differences were observed among months (Fig. 13.11). This species was most abundant in July. Spatially, differences in densities were observed among both strata and subdivisions (Figs. 13.10 and 13.11). This species is relatively more common in western Florida Bay, but rarely collected in the Gulf subdivision, and never collected in the Northern subdivision.

The high observed densities in July coincide with the first part of the wet season, when low water levels, high temperatures, and increasing salinities have been observed (Sogard et al., 1987). Lined seahorses do not appear to utilize mud banks in Florida Bay (Sogard et al., 1987).

Length-frequency distributions Based on our length-frequency distributions, small fish in March were probably spawned in winter (Fig. 13.12). In addition, there is evidence for spawning in May and September, but based on a limited number of specimens we were unable to demonstrate that spawning occurs throughout the year. No discrete modal groups were observed, which is probably a result of small sample size. Juveniles recently released (approximately 7 mm TL) from the male brood patch and small juveniles were not encountered (≤20–24 mm TL). Recently released lined seahorses were probably extruded through the net, but we are puzzled by the lack of specimens between 20–29 mm TL. A wide range of sizes was collected in most months (Fig. 13.12).

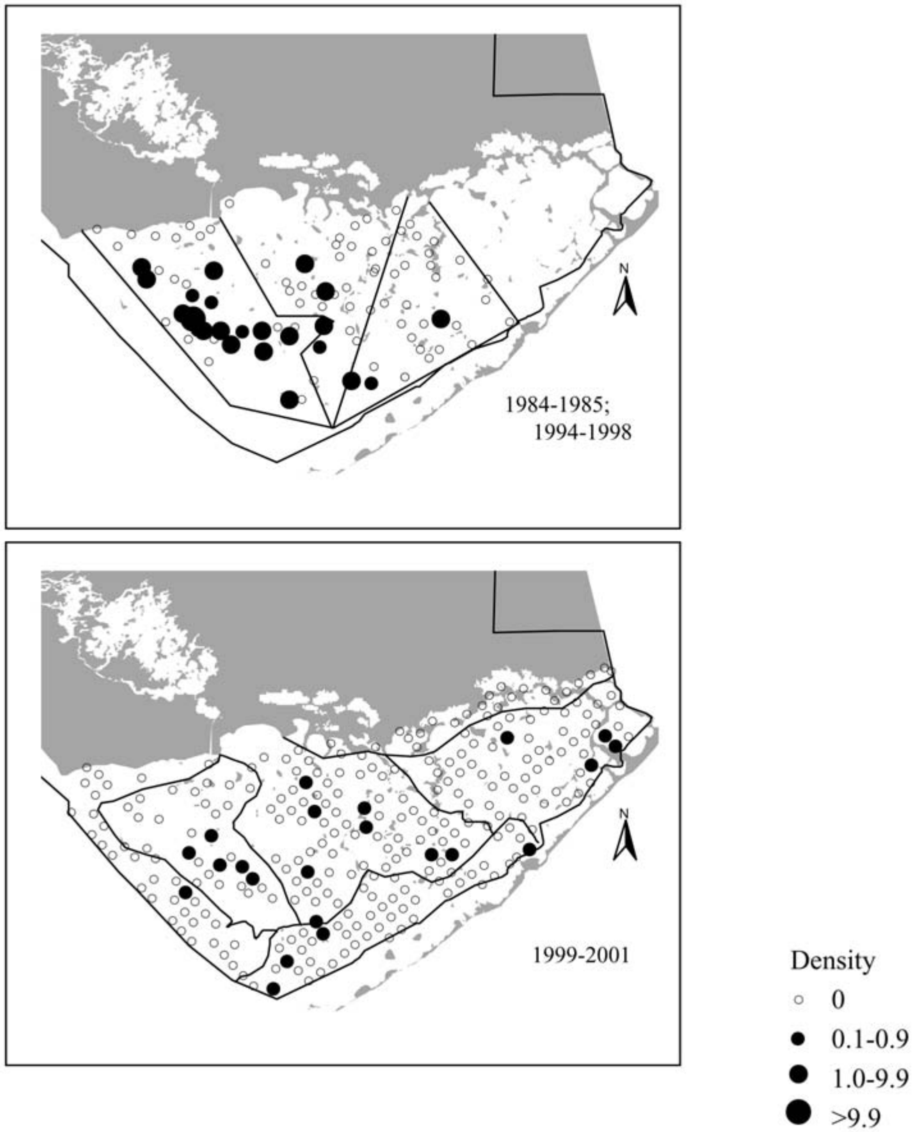


Figure 13.10

Mean densities (numbers 1000 m^{-2}) of lined seahorse (*Hippocampus erectus*) from bimonthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

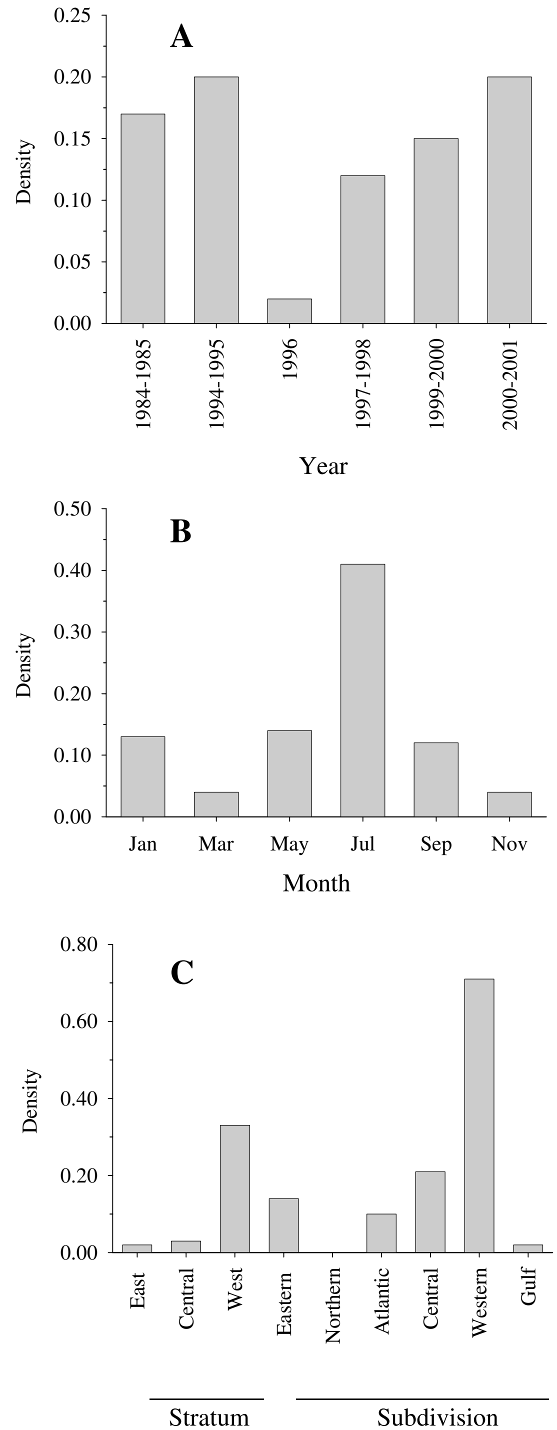


Figure 13.11

Mean densities (numbers 1000 m^{-2}) of lined seahorse (*Hippocampus erectus*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

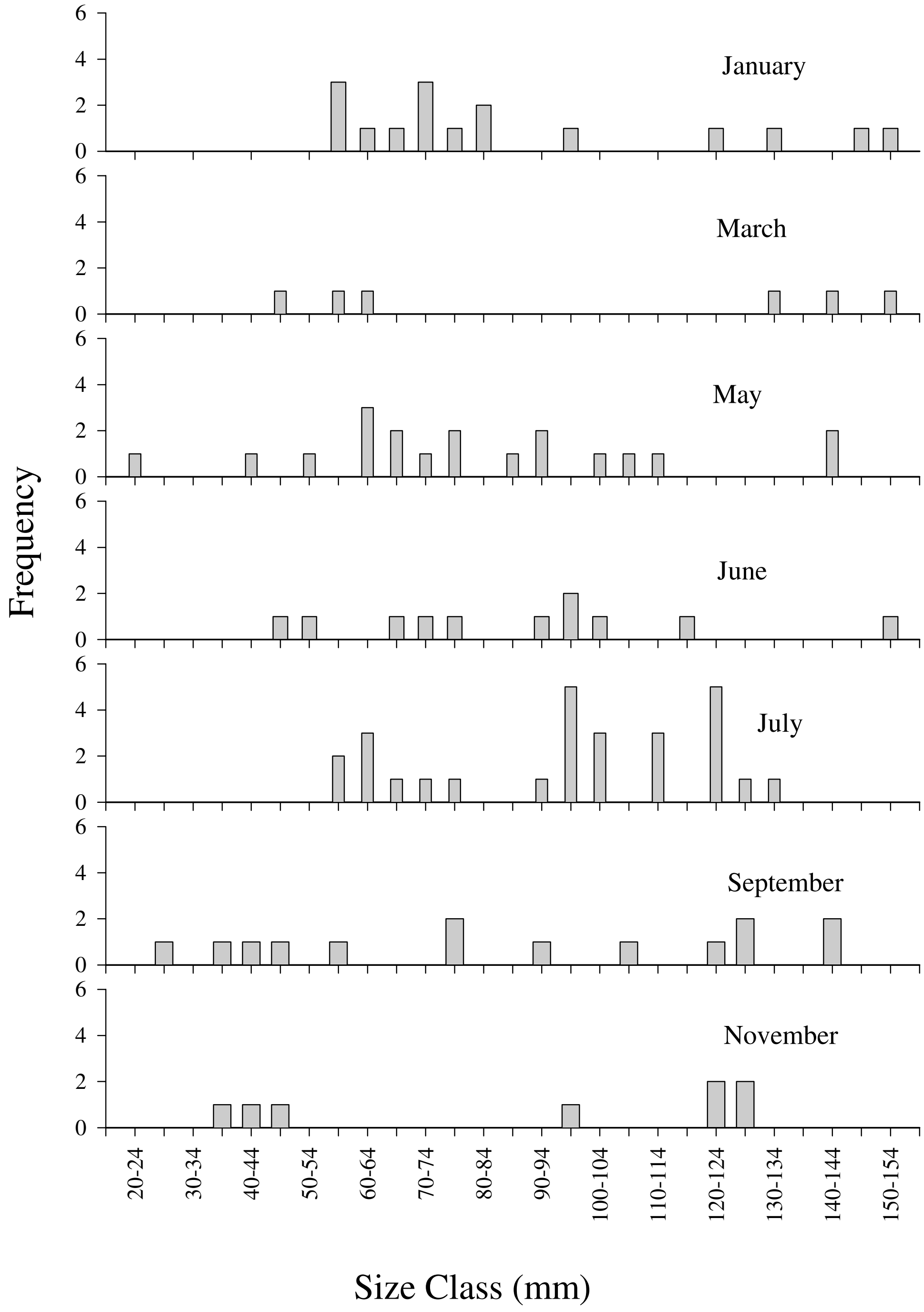


Figure 13.12

Monthly length-frequency distributions of lined seahorse (*Hippocampus erectus)* from Florida Bay.

H. zosterae (dwarf seahorse)

Total numbers collected and rank of dwarf seahorse by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	1529	9

Life history In Florida, dwarf seahorses range from Biscayne Bay to Pensacola, and also occur in the Bahamas and Cuba (Böhlke and Chaplin, 1968) and in the entire Gulf of Mexico (Robins and Ray, 1986). At Cedar Key, Florida, breeding begins in early or mid-February and terminates by late October or early November. The breeding season has been correlated with day length. Males mature at approximately 25 mm at an age of approximately three months. A description of their reproductive habits is given above for the fringed pipefish. Recently released young expelled from the male brood pouch average 7–9 mm. At least three broods are produced per year (Strawn, 1958).

The dwarf pipefish is listed as vulnerable under the Distinct Population Segments concept defined as "populations that are markedly separated from other populations of the same taxon as a consequence of physical, ecological, or behavioral factors to which it belongs" (Musick et al., 2000).

Diet We are unaware of any information on the diet of this species.

Abundance and distribution The dwarf seahorse was abundant in otter trawl collections in basins in Florida Bay. Spatially, there were significant differences in densities among strata and subdivision (Figs. 13.13 and 13.14). This species was collected at highest densities in the West stratum, but occurred at more sites in the Central stratum. Relatively higher densities occurred in the Western subdivision, while relatively low densities were observed in the Atlantic, Gulf, and Northern subdivisions. Temporally, there were significant differences among months and years (Figs. 13.13 and 13.14). We believe these yearly differences are related to the change in the sampling design that occurred in 1999. Densities were very similar from 1984 through 1998 when strata were employed and very similar from 1999 through 2001 when subdivisions were employed. Dwarf seahorse were collected at highest densities in July and September, which coincides with the wet season.

Similar to our findings, dwarf seahorse have been collected at highest densities over Florida Bay mud banks in western Florida Bay (Oyster Key), and lowest at Cowpen Keys, located in our Atlantic subdivision (Fig. 1.1; Sogard et al., 1987). Dwarf pipefish have a greater affinity for seagrass than mangrove habitats (Thayer et al., 1987b) and appear to have a preference for the seagrasses *Thalassia testudinum* and *Halodule wrightii* over algae and mud substrate (Sheridan et al., 1997).

Length-frequency distributions Dwarf seahorse length-frequency distribution patterns were similar to that observed for gulf pipefish (Figs. 13.9 and 13.15), and much smaller fish were collected compared to the lined seahorse (Fig. 13.12). Length-frequency distributions were uni-modal. Monthly modes were approximately similar, suggesting that spawning occurred throughout the year. Growth could not be confirmed from distributions, but in the laboratory fish grew from 8 mm to 18 mm in 17 days (Strawn, 1958).

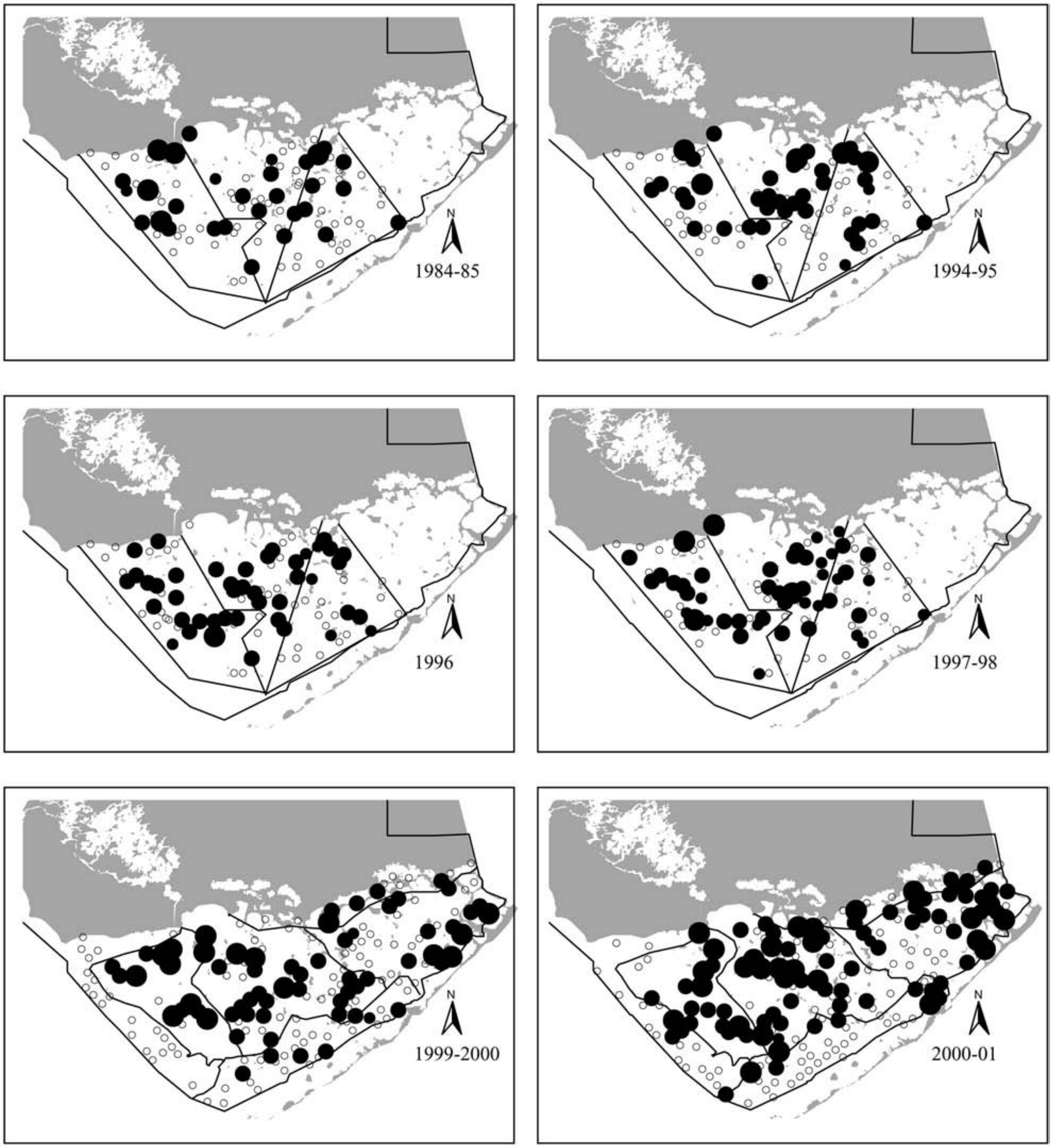


Figure 13.13

Mean densities (numbers 1000 m^{-2}) of dwarf seahorse (*Hippocampus zosterae*) from bimonthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

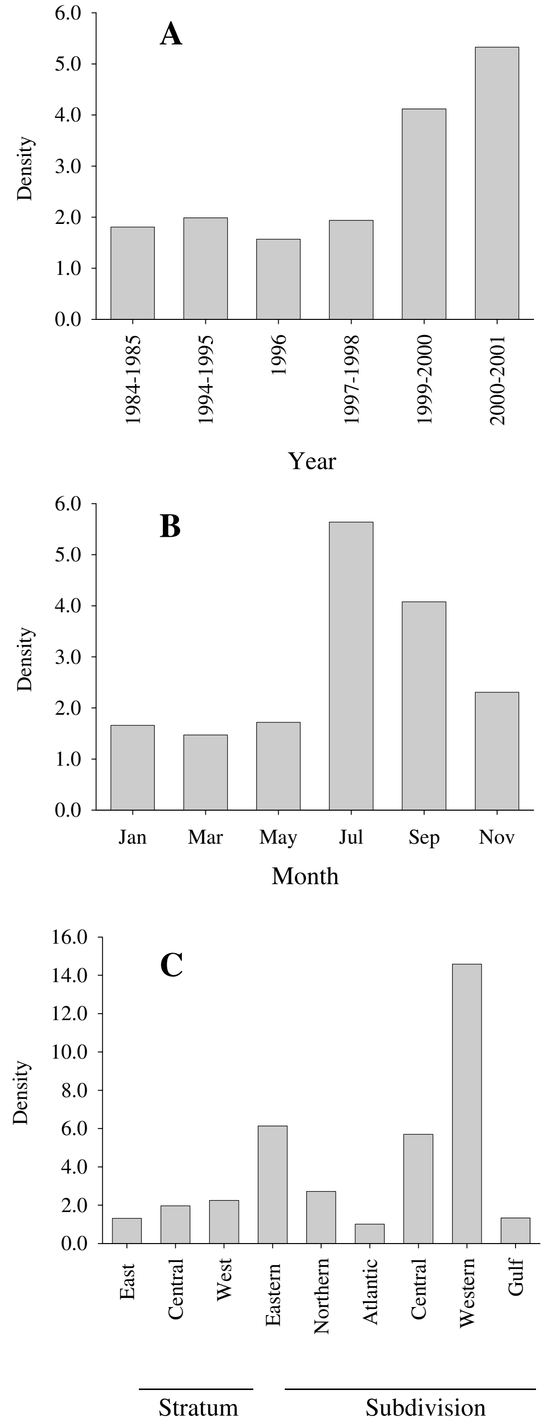


Figure 13.14

Mean densities (numbers 1000 m^{-2}) of dwarf seahorse (*Hippocampus zosterae*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

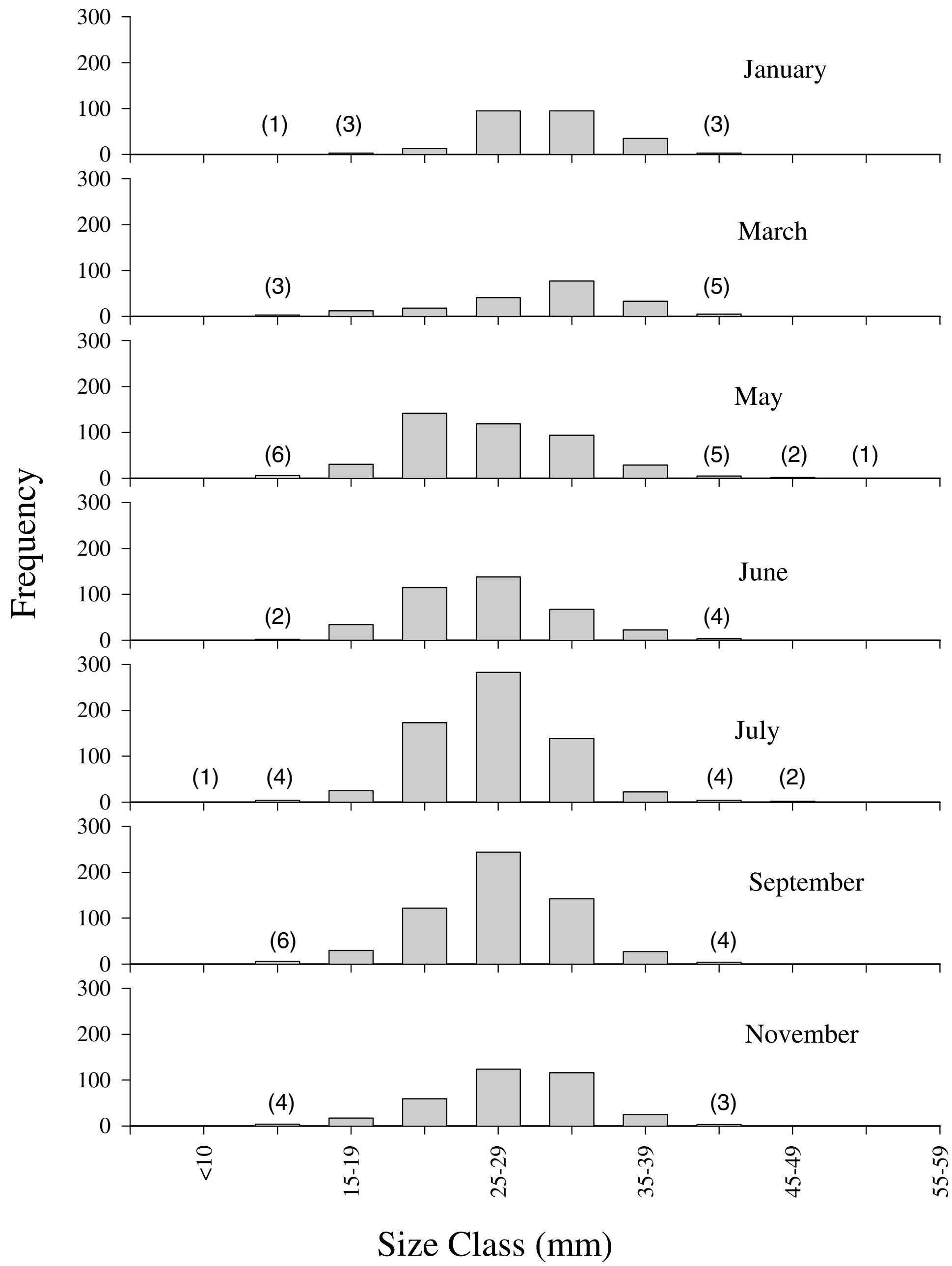


Figure 13.15

Monthly length-frequency distributions of dwarf seahorse (*Hippocampus zosterae)* from Florida Bay. Values are shown for numbers <10 for clarity.

Chapter 14. Family Lutjanidae

Lutjanus griseus (gray snapper)

Total numbers collected and rank of gray snapper by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	132	24

Life history The gray snapper, a shallow-water tropical species, ranges in the western Atlantic from Florida to Brazil including the Gulf of Mexico, Bermuda, the Bahamas, and West Indies. Juveniles occur as far north as Massachusetts. Transforming juveniles are commonly collected in North Carolina inlets, but the fate of these juveniles is unknown (Vergara, 1978a; Burton, 2001; Tzeng et al., 2003). Gray snapper spawn mainly from June through September in waters adjacent to Florida Bay with peaks in June and July (Starck and Schroeder, 1970; Rutherford et al., 1983, 1989). However, in other southwestern Florida waters they mainly spawn in winter and summer (Allman and Grimes, 2002). Males mature at approximately 185 mm SL, females at 200 mm SL (Starck and Schroeder, 1970). Eggs and larvae are pelagic (Thresher, 1991). Recently hatched larvae are approximately 2.5 mm NL and settlement occurs at 10–15 mm SL (Richards et al., 1994; Tseng et al., 2003), although Lindeman (1997) reported larger sizes (15–19 mm SL) at settlement. The average duration of the pre-settlement stage is 25–27-d (Allman and Grimes, 2002; Tzeng et al., 2003) and 33-d (Lindeman, 1997).

Diet Gray snapper from Florida Bay, <250 mm SL, fed almost entirely on crustaceans and fishes (Hettler, 1989). Copepods, amphipods, and mysids were important dietary items for fish <50 mm SL. Penaeid shrimp, the overall dominant prey item, and caridean shrimp increased in frequency of occurrence with increasing fish size. The fish component was dominated by rainwater killifish.

Abundance and distribution Gray snapper were common in otter trawl collections in basins. There were no significant differences in densities of gray snapper among years, but there were among months (Figs. 14.1 and 14.2). Highest densities were observed in spring and fall (Fig. 14.2); however in March gray snapper were collected at fewer stations. Spatially, there were differences in densities among strata and subdivisions. Gray snapper were collected at highest densities in western Florida Bay and the Atlantic subdivision (Figs. 14.1 and 14.2), suggesting they recruit into Florida Bay from the Florida Keys side as well as from the southwest Florida shelf.

Habitat for juvenile gray snapper is stage specific. Studies in Biscayne Bay (Lindeman et al., 1998) and the Florida Keys (Starck and Schroeder, 1970) indicate recently settled fish prefer seagrass beds, while older juveniles (approximately 90 mm SL and greater) utilize seagrass beds, mangrove prop and drop roots, and edges of channels. Fish >200 mm SL move offshore to reefs and wrecks. In the Atlantic subdivision, Chester and Thayer (1990) suggested that gray snapper recruit mainly to channels where seagrass communities are more diverse and luxuriant than those at adjacent basins of the Atlantic subdivision. Older juveniles apparently prefer mangrove habitats to adjacent seagrass sites in Florida Bay and adjacent waters (Thayer et al., 1987b), and in a Caribbean study, juvenile gray snapper (>50 mm TL) also preferred mangrove habitats over seagrass beds (Cocheret de la Morinière et al., 2002).

Length-frequency distributions We collected juvenile gray snapper throughout the year, but the smallest fish were collected in fall and winter (Fig. 14.3). Starck and Schroeder (1970) reported that 10–20 mm SL fish are abundant in July and August in the Florida Keys and suggested that spawning peaks in June and July. We collected that size class in September and November, but many of the smallest individuals probably escaped through our gear. This suggested a somewhat later spawning date for gray snapper that recruit into Florida Bay.

Based on an age and growth study of adult gray snapper from south Florida (Burton, 2001), our collections consisted mainly of young-of-year, yearlings, and two-year olds. The yearlings and two-year olds were most apparent in June and July, while young-of-year and yearlings were most apparent in September and November (Fig. 14.3). Juvenile gray snapper (32–110 mm SL) have been reported to grow between 0.60 and 1.02 mm d^{-1} (Allman and Grimes, 2002).

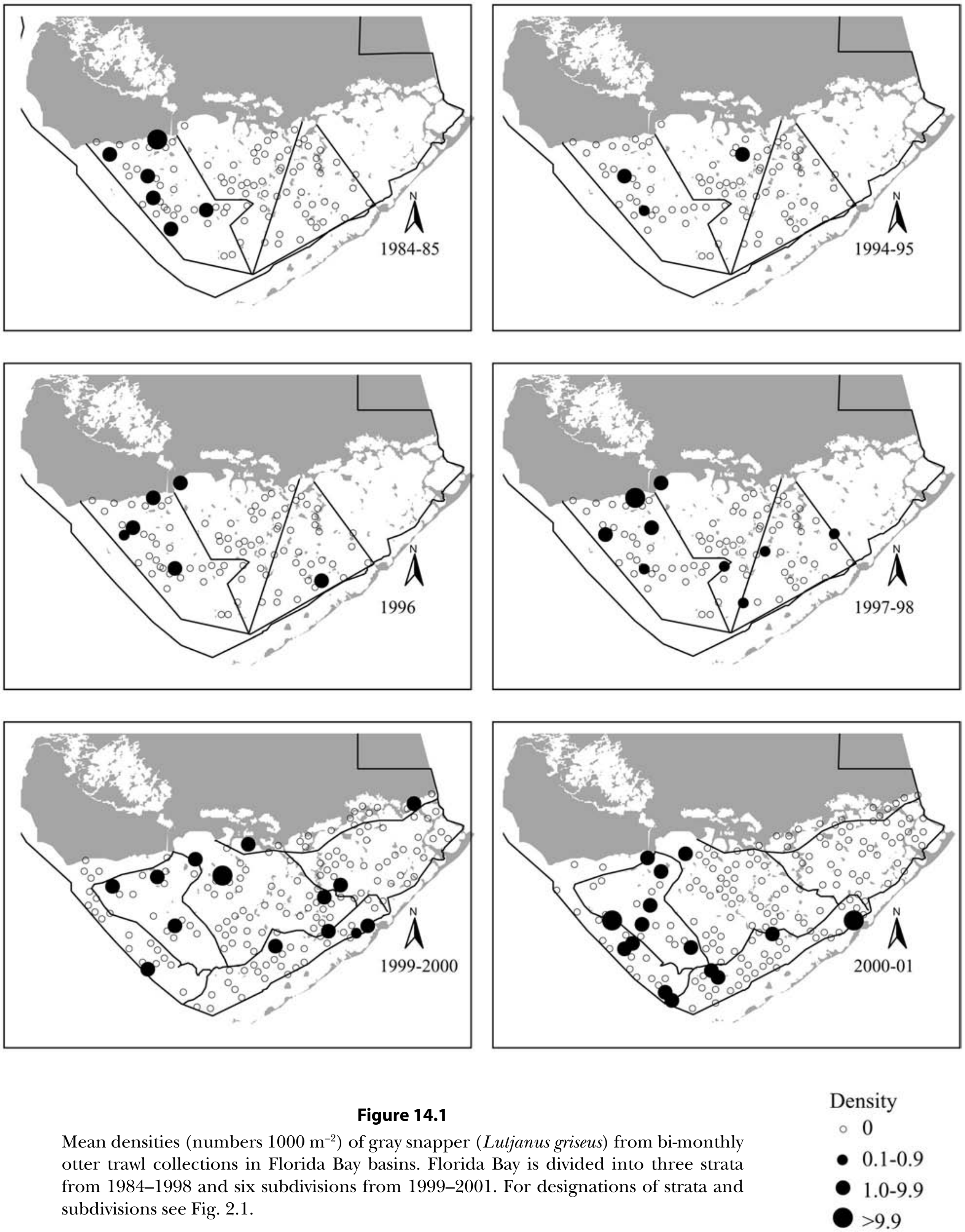


Figure 14.1

Mean densities (numbers 1000 m^{-2}) of gray snapper (*Lutjanus griseus*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

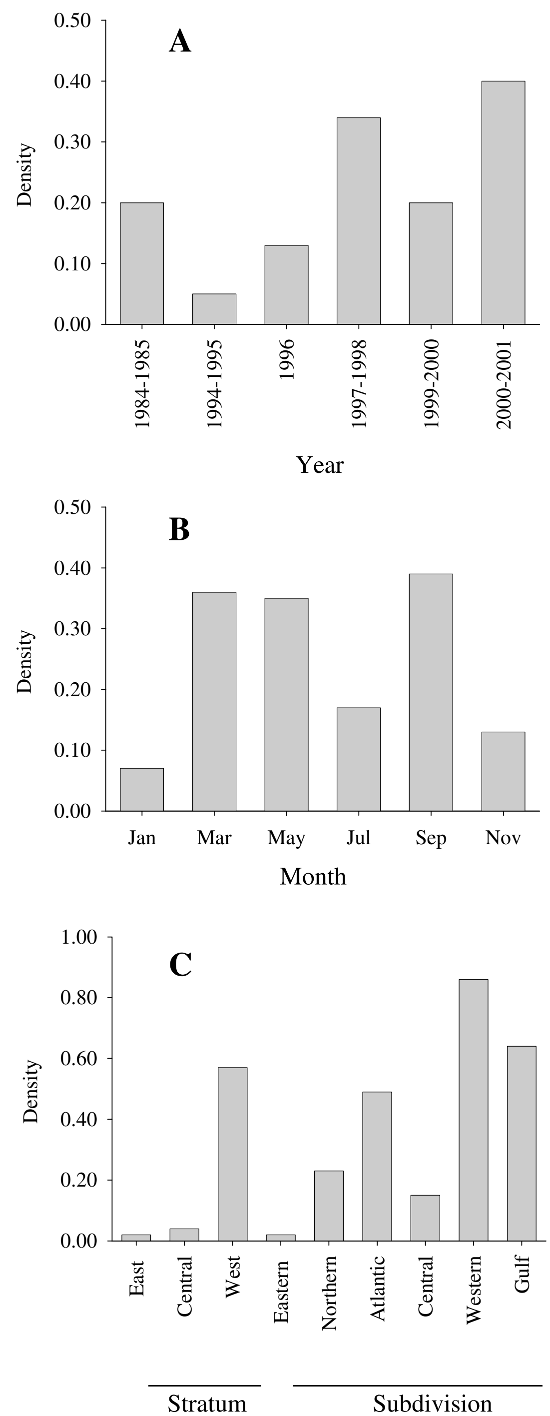


Figure 14.2

Mean densities (numbers 1000 m^{-2}) of gray snapper (*Lutjanus griseus*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

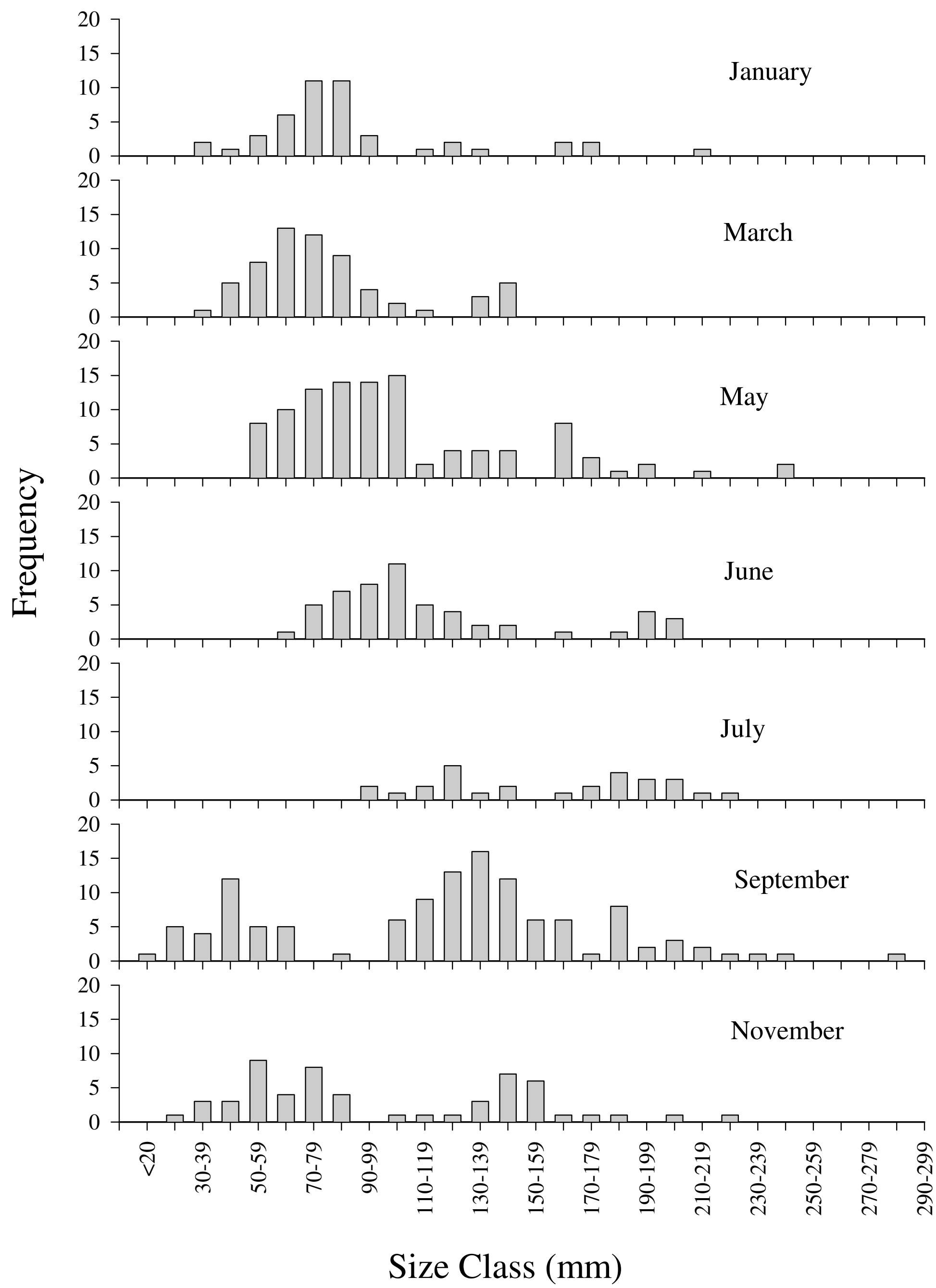


Figure 14.3

Monthly length-frequency distributions of gray snapper (*Lutjanus griseus*) from Florida Bay.

L. synagris (lane snapper)

Total numbers collected and rank of lane snapper by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	630	13

Life history Lane snapper range from North Carolina around the Florida peninsula, throughout the Gulf of Mexico, southward to southeastern Brazil, the Bahamas, Bermuda, and the West Indies. Adults are most common around the Antilles, on the Campeche Bank, off Panama, and the northern coast of South America (Vergara, 1978a). Lane snapper have a protracted spawning period. Off east Florida, lane snapper spawn from April to July (Herrema et al., 1985), and off Key West, Florida from June to September with peaks in July and August (Domeier et al., 1996). The minimum size at sexual maturity of fish from Key West is 182 mm SL and 198 mm SL for males and females, respectively (Domeier et al., 1996). Eggs and larvae are pelagic (Thresher, 1991). Recently-hatched larvae are approximately 2.4 mm NL and settlement occurs at 10–15 mm SL (Richards et al., 1994; Lindeman, 1997).

Diet Juvenile lane snapper in the northern Gulf of Mexico mainly feed, in descending order, on the shrimp, *Latreutes parvlus*, and fish (Franks and VanderKooy, 2000).

Abundance and distribution Lane snapper were common in otter trawl collections in basins and are the most abundant snapper in the Bay. Temporally, there were significant differences in lane snapper among years and months. Relatively high densities were collected in 1999–2000 and in fall and winter (Figs. 14.4 and 14.5). Low densities were observed in 1996 and in July. Spatially, there were significant differences in densities among strata and subdivisions. This species is most abundant in western Florida Bay. It was not collected in the Northern subdivision, and its presence in the Atlantic subdivision suggests, like gray snapper, it recruits into Florida Bay from the Florida Keys as well as from the southwest Florida shelf (Figs. 14.4 and 14.5).

Like gray snapper, habitat for lane snapper is stage specific. Early juveniles prefer mangrove prop root canopies, but recently settled snapper are rare there (Lindeman et al., 1998). On the other hand, in Florida Bay and adjacent waters, unlike gray snapper, lane snapper do not use mangrove prop root habitats, but prefer adjacent seagrass beds (Thayer et al., 1987b).

Length-frequency distributions Based on length-frequency distributions, lane snapper appeared to recruit into Florida Bay in summer, fall, and possibly winter (Fig. 14.6). Snapper <30 mm SL collected in July, September, and November indicated summer and fall recruitment. The presence of small juveniles in January and March indicated winter spawning.

Unpublished data[5] on juvenile lane snapper (approximately 25–125 mm SL) collected in Florida Bay indicated that growth rates ranged from 0.6 mm day^{-1} to 0.7 mm day^{-1}. Back-calculated lengths of lane snapper from east Florida waters at age-1 and age-2 were 135 mm TL and 196 mm TL, respectively (Manooch and Mason, 1984). Based on our length-frequency distributions, we collected mainly young-of-the year (Fig. 14.6). This species appears to leave the Bay at a much smaller size than the gray snapper (Fig. 14.3).

5 Settle, L. Unpublished data (March 2003). NOAA, Center for Coastal Fisheries and Habitat Research, 101 Pivers Island Road, Beaufort, NC 28516.

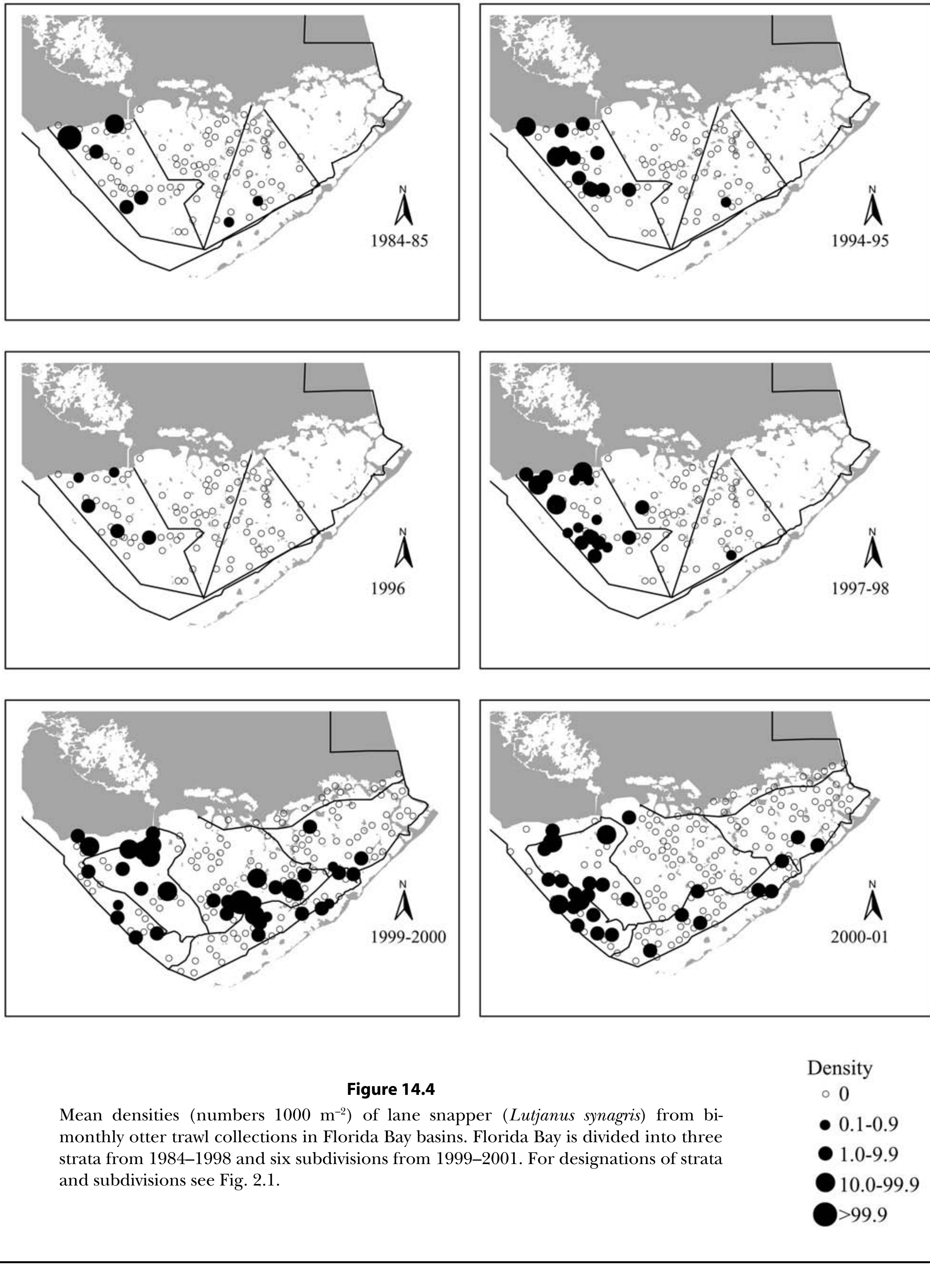


Figure 14.4

Mean densities (numbers 1000 m^{-2}) of lane snapper (*Lutjanus synagris*) from bimonthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

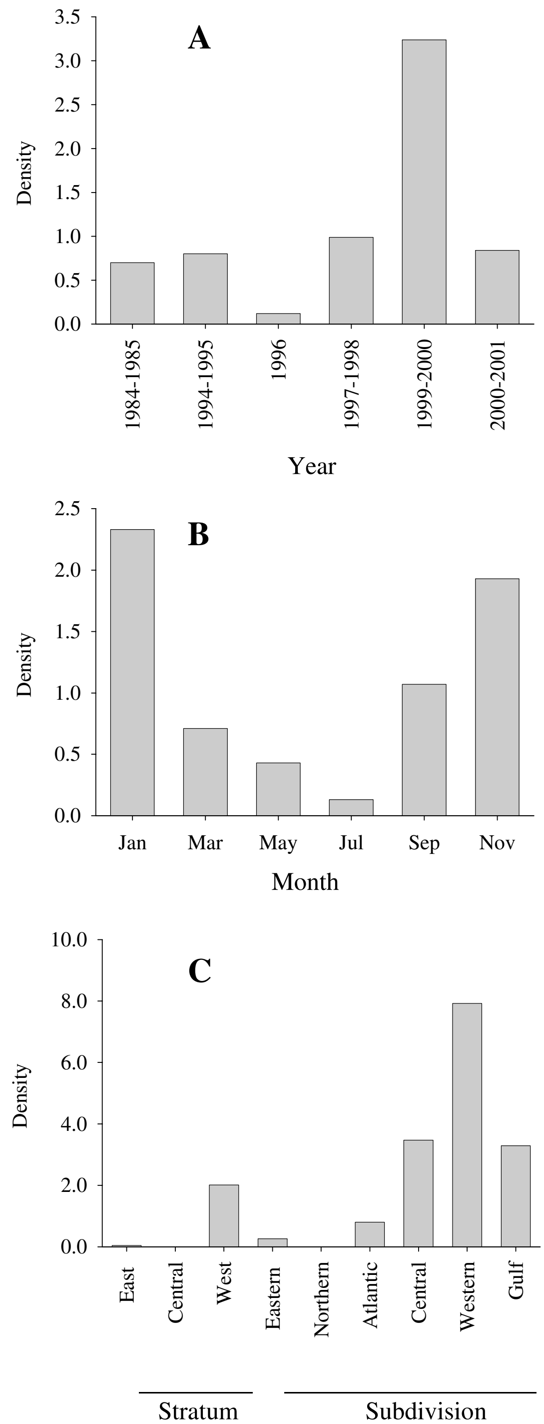


Figure 14.5

Mean densities (numbers 1000 m^{-2}) of lane snapper (*Lutjanus synagris*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

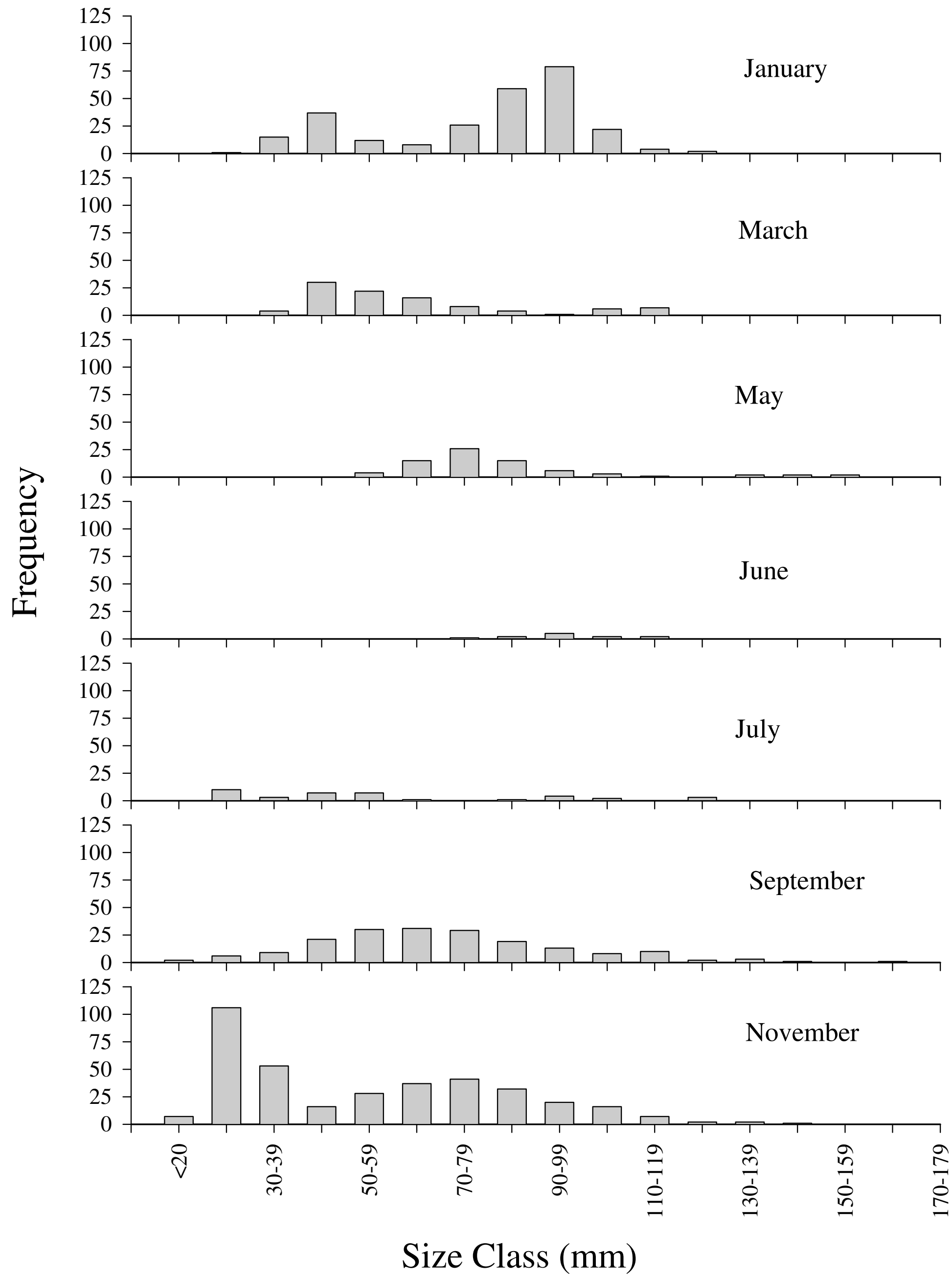


Figure 14.6

Monthly length-frequency distributions of lane snapper (*Lutjanus synagris*) from Florida Bay.

Chapter 15. Family Gerreidae

Note: We identified two species of *Eucinostomus*: *E. argenteus* and *E. gula*. The majority of *E. argenteus* were most likely *E. harengulus*. Because of this conflict we did not include these taxa. In addition, because of the morphological similarities between young (Matheson and Gilmore, 1995), we only felt confident in identifying *E. gula* that were ≥30 mm SL.

Eucinostomus gula (silver jenny)

Total numbers collected and rank of silver jenny by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	13,347	1

Life history Silver jenny range from Massachusetts to Argentina, including the northern Gulf of Mexico, Bahamas, and Bermuda, but occur only as stragglers north of Beaufort, North Carolina (Böhkle and Chaplin, 1968; Johnson, 1978; Robins and Ray, 1986). There is very little information on the reproductive habits of this species. Silver jenny have been reported to spawn offshore during late winter and spring. Larvae have been collected in Texas during June–October but we question if this data include more than one species of *Eucinostomus* (Johnson, 1978). In the Whitewater Bay–Shark River estuary, Schmidt (1989) observed maturing female and male specimens as small as 60 and 73 mm SL.

Diet Juveniles from northwest Florida waters show a clear transition from a zooplanktivore (11–15 mm SL) feeding exclusively on copepods, to a benthic carnivore (40–60 mm SL) feeding almost exclusively on polychaetes (Carr and Adams, 1973). In the Whitewater Bay system (North River), Odum and Heald (1972) reported that harpacticoid copepods were also an important food item, but polychaetes were insignificant in the diets of silver jenny and appeared to be replaced by amphipods. This suggested that polychaetes are rare in the sediments of this habitat. On the other hand, in the Whitewater Bay–Shark River estuary in close proximity to Odum and Heald's site, Schmidt (1989) found nereid polychaetes to be the most important food item consumed by silver jenny, followed by crustaceans (isopods, amphipods, and tanaids). In southeast Florida waters, Brook (1977) also found that the incidence of copepods decreased with increasing fish size. Brook concluded that since the copepods were almost exclusively harpacticoid, silver jenny feed among grass blades and on the bottom.

Abundance and distribution Silver jenny were the most abundant species collected by otter trawl in basins (Figs. 15.1 and 15.2). Differences in mean densities were observed among years and months. This species was most abundant in 1984–1985, with lowest values observed in 1994–1995, following the die-off of seagrasses (Figs. 15.1 and 15.2). From 1994 to 2000, there was a progressive increase in mean densities with a slight decrease in 2000–2001. Seasonally, highest densities were observed during the wet season months (Fig. 15.2).

Silver jenny could be considered a ubiquitous species in Florida Bay, although they were collected at highest mean densities in the West stratum and Western subdivision (Figs. 15.1 and 15.2), where standing crop of seagrasses and species diversity is highest (Zieman and Fourqurean, 1985; Thayer and Chester, 1989). In the Indian River Lagoon, Florida, silver jenny were commonly collected in open waters, often near seagrass beds (Matheson and Gilmore, 1995). They also have an affinity for mangrove prop root habitat (Thayer et al., 1987b).

Length-frequency distributions Silver jenny recruited into Florida Bay throughout the year (Fig. 15.3). Peak recruitment occurred in fall, but could have also occurred in August, a month when we did not sample. The range of sizes was truncated in June then increased to a maximum in January (Fig. 15.3). This could indicate a movement of larger fish out of the Bay after January until June; from July through January some larger fish remain in the Bay.

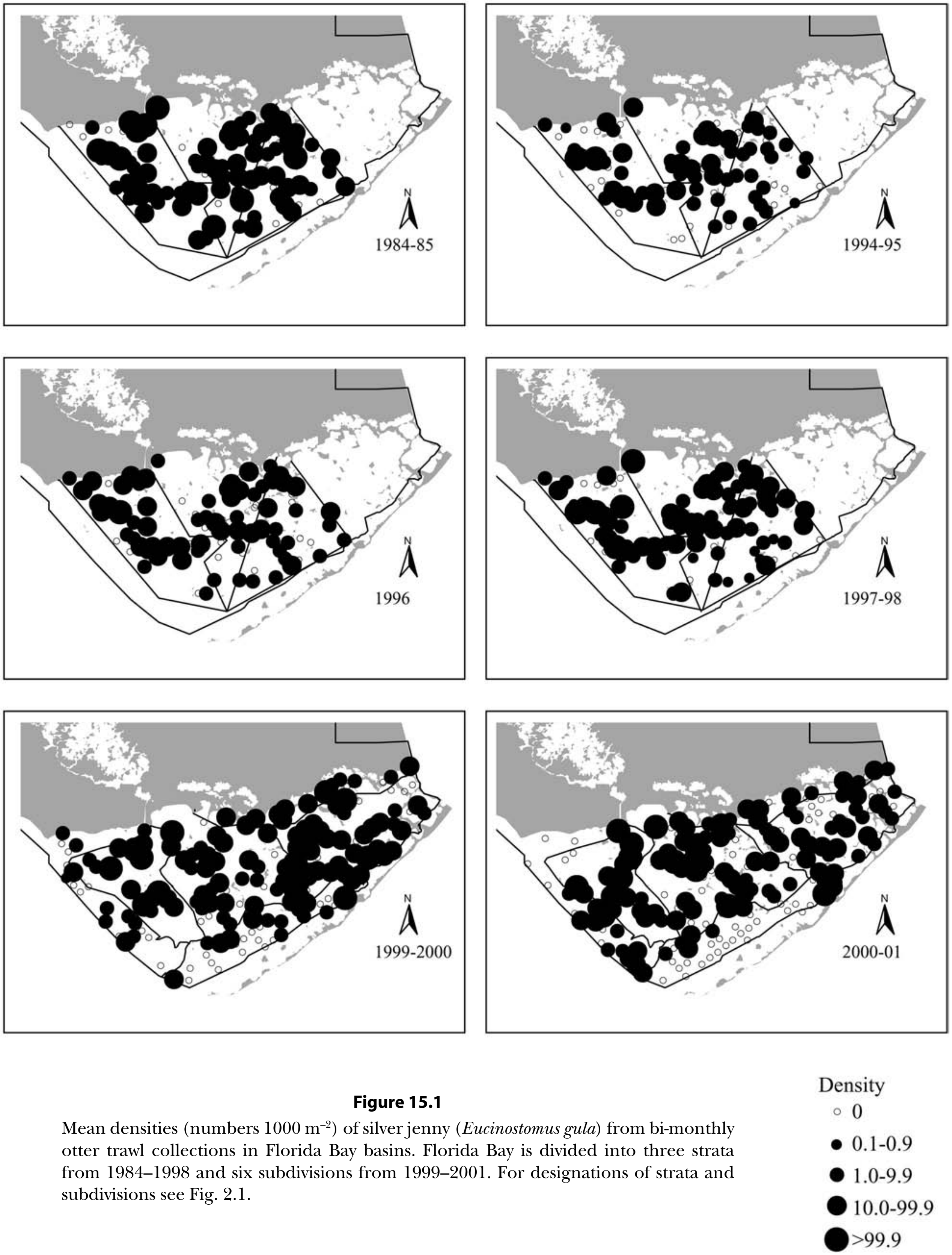


Figure 15.1

Mean densities (numbers 1000 m^{-2}) of silver jenny (*Eucinostomus gula*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

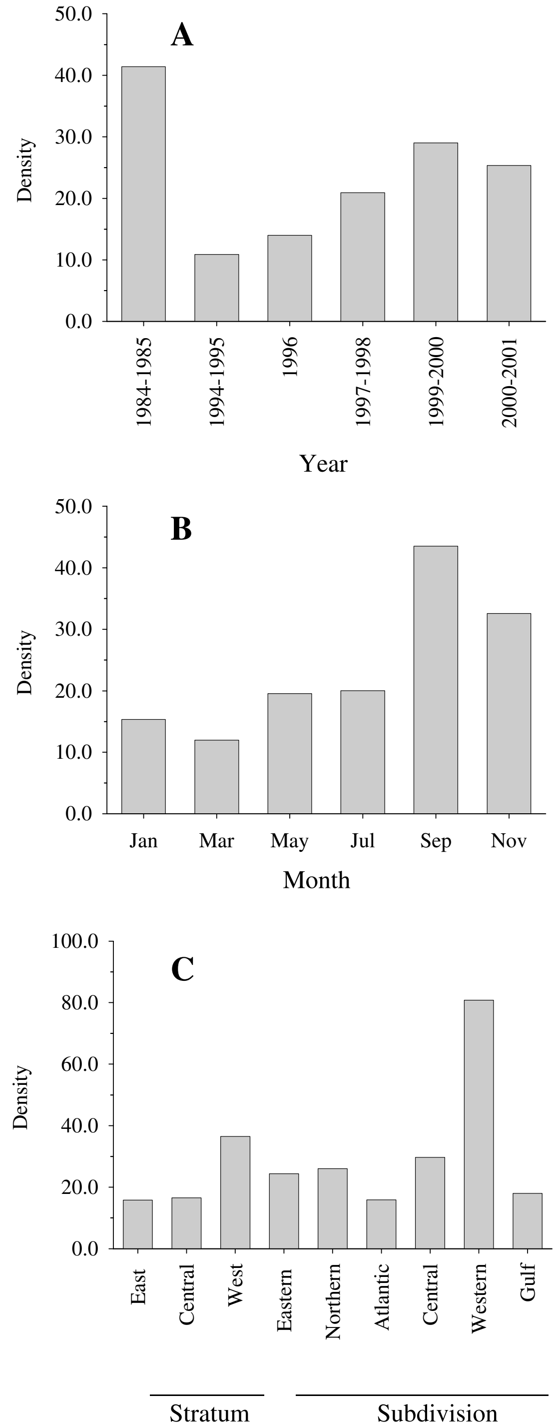


Figure 15.2

Mean densities (numbers 1000 m^{-2}) of silver jenny (*Eucinostomus gula*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

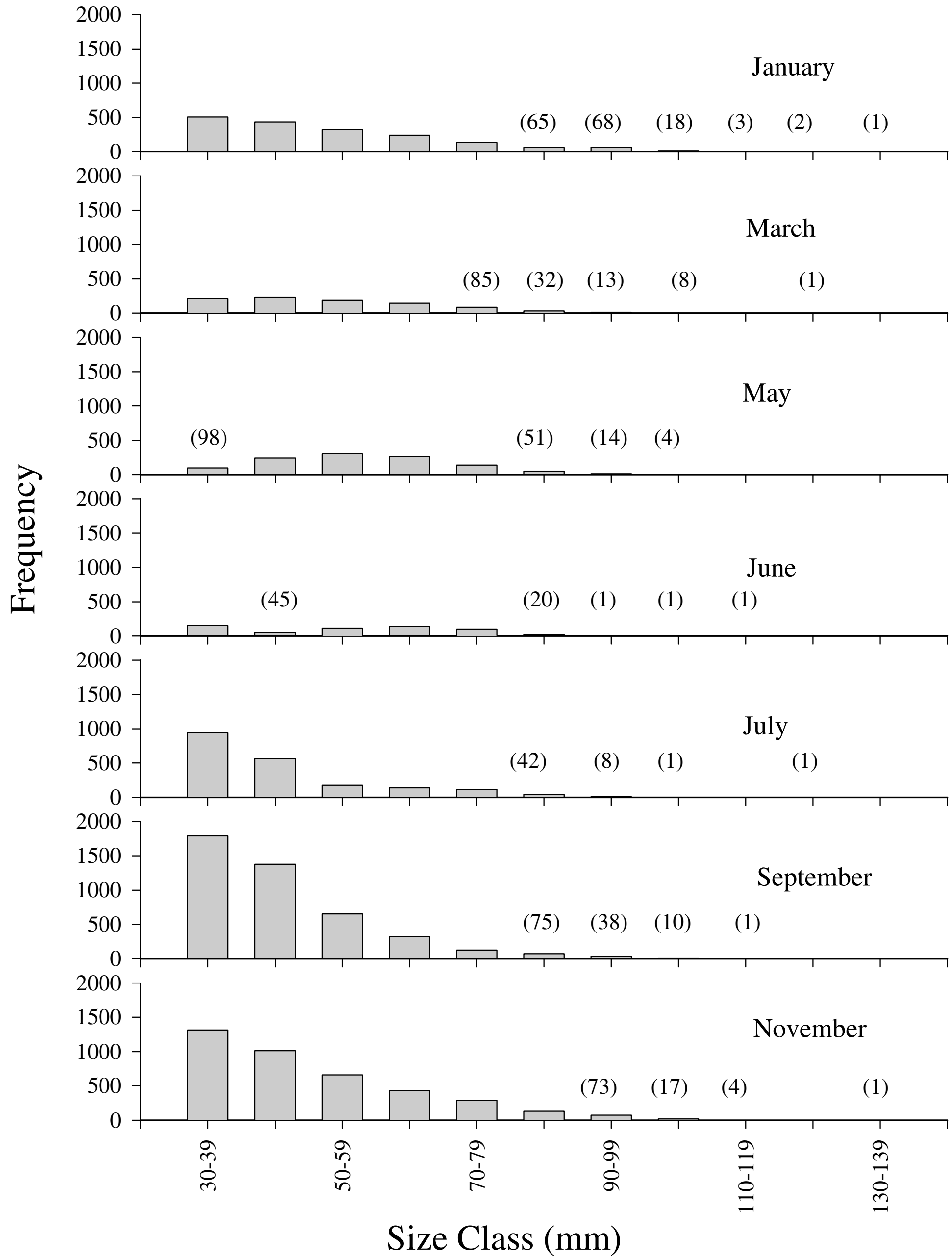


Figure 15.3

Monthly length-frequency distributions of silver jenny (*Eucinostomus gula*) from Florida Bay. Values are shown for numbers <100 for clarity.

Chapter 16. Family Haemulidae

Haemulon plumieri (white grunt)

Total numbers collected and rank of white grunt by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	1606	8

Life history White grunt range from the Cape Hatteras, North Carolina, to southern Florida, the Bahamas, and Bermuda throughout the West Indies and Caribbean Sea, to Brazil (Breder, 1948; Courtenay and Sahlman, 1978). They spawn year round in the Caribbean, with peaks in March or April and minimal spawning in June–July (Munro et al., 1973; Gaut and Munro, 1983). Off east Florida, white grunt spawn in May–June (Herrema et al., 1985). Eggs and larvae are pelagic. White grunt are 2.7 mm NL at hatching. The flexion stage begins at 6.0 mm NL, postflexion at 7.0 mm SL (Saksena and Richards, 1975). Based on general data on western Atlantic haemulids, white grunt settle out of the plankton at approximately 6 mm SL (Lindeman et al., 1998). There are at least two demersal life stage terminologies described for white grunt. Helfman et al. (1982) depicts fish 8–12 mm SL as small juveniles, 12–24 mm SL as medium juveniles, 24–32 mm SL as transitional juveniles, and 32–96 as large juveniles. Appeldoorn et al. (1997) depicts fish 9–37 mm SL as stage 0 juveniles, 37–65 mm SL as stage 1 juveniles, 65–120 mm SL as stage 2 juveniles, and 120–155 as subadults.

Diet Carr and Adams (1973) reported on the diets of juveniles between 21 and 40 mm SL. The smallest juveniles (21–25 mm SL) feed mainly on copepods. Juveniles between 26–35 mm SL feed mainly on copepods, but mysids and postlarval shrimp are also consumed. Mysids and postlarval shrimp are the dominant item (60% of stomach contents) of the larger juveniles (36–40 mm SL), but copepods are also consumed. The presence of sand grains in the diet of all the size ranges indicates that juveniles feed on or near the bottom.

Abundance and distribution White grunt were abundant in otter trawl collections in basins (Figs. 16.1 and 16.2) and were the most abundant *Haemulon* spp. collected. There were no significant differences in densities among months or years. There were significant differences in densities among strata and subdivisions. White grunt were most abundant in western Florida Bay, and absent in the north-central and eastern areas of the Bay. Based on the distribution of juveniles, it appeared that white grunt recruit into Florida Bay mainly from Gulf of Mexico waters, however some recruitment appeared to occur from the Atlantic (Fig. 16.1).

White grunt were the most common grunt collected in grassy shore habitat in the Atlantic side of the Florida Keys adjacent to Florida Bay (Springer and McErlean, 1962). In Biscayne Bay, Florida, recently settled white grunt utilize a variety of habitats including attached seagrasses and macroalgae, detached macroalgae, invertebrate assemblages (mixture of gorgonians, sponges, and corals), and sedimentary habitats. Juveniles 15–50 mm SL use habitats similar to recently settled fish, but also use exposed hard bottom and red mangrove prop roots. Juveniles >50 mm SL use red mangrove prop root habitats and invertebrate assemblages and are absent from attached seagrass beds or macroalgae (Lindeman, 1997). To the contrary, white grunt were not collected in mangrove prop roots in Florida Bay (Thayer et al., 1987b).

Length-frequency distributions Following Appeldoorn et al. (1997), our collections mainly were comprised of stage 0, stage 1, and stage 2 juveniles. Subadults and adults were rarely collected (Fig. 16.3). Recruitment of white grunt into Florida Bay occurred throughout the sampling period, indicating that spawning in adjacent coastal waters occurred throughout the year. Lindeman (1997) reported that juvenile white grunt (17–38 mm SL) grow 0.38 mm day^{-1}.

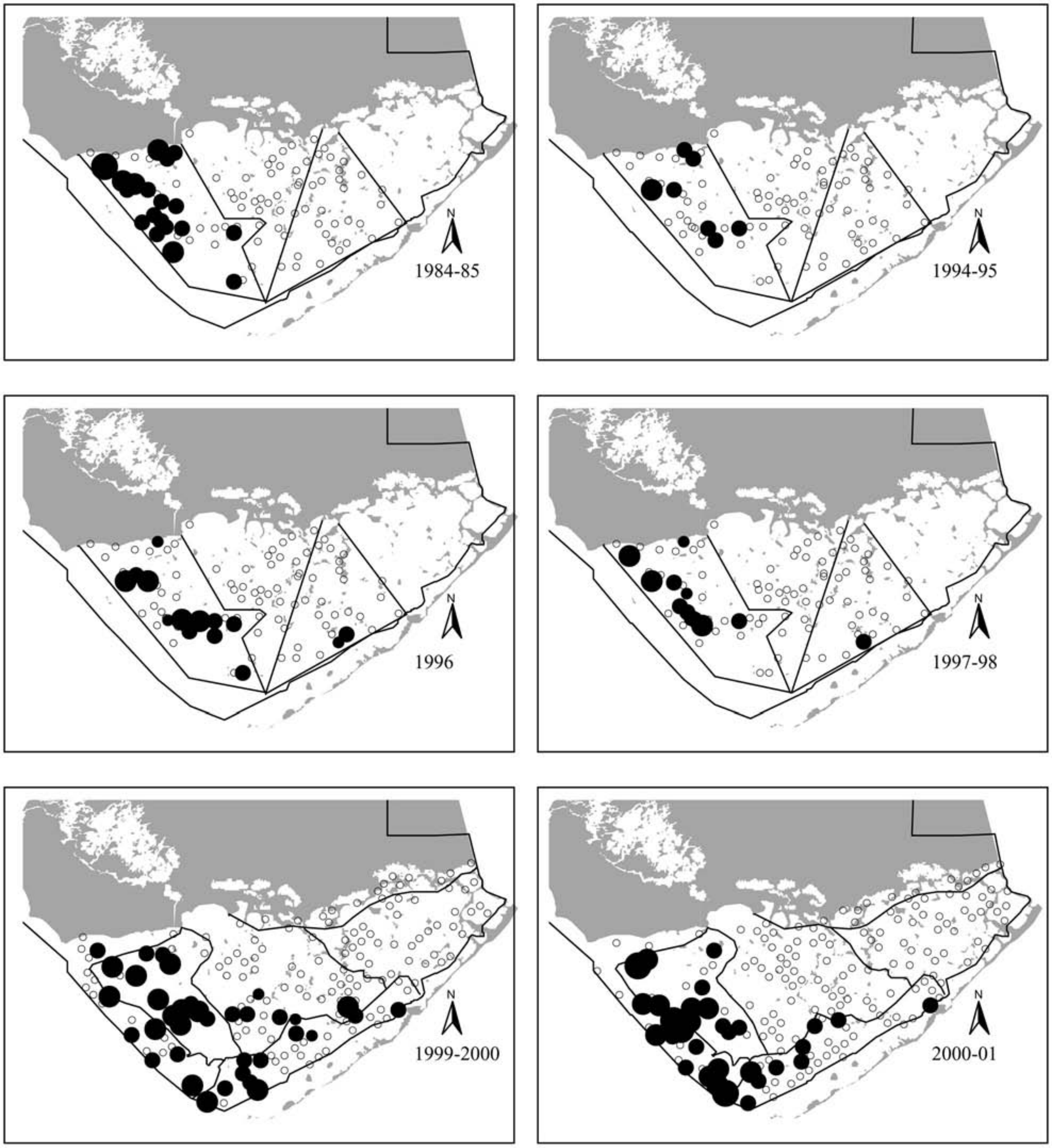


Figure 16.1

Mean densities (numbers 1000 m^{-2}) of white grunt (*Haemulon plumieri*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

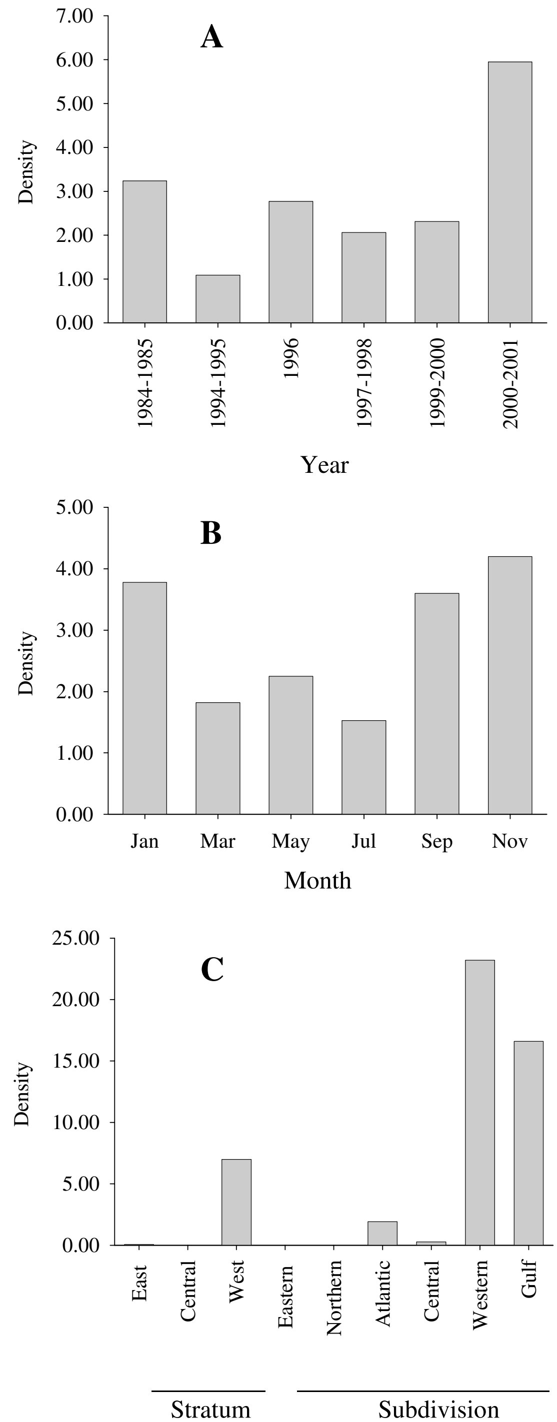


Figure 16.2

Mean densities (numbers 1000 m^{-2}) of white grunt (*Haemulon plumieri*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

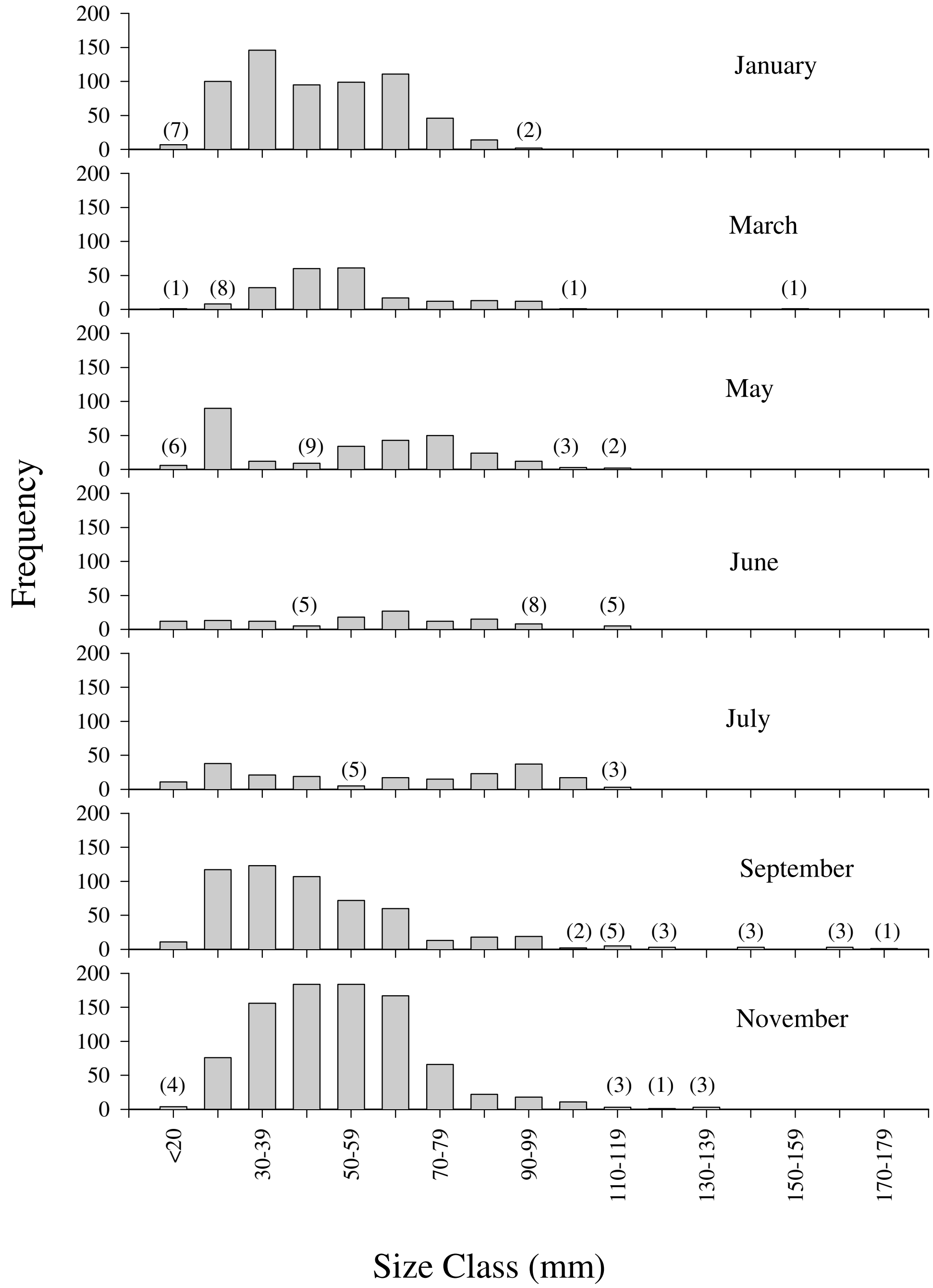


Figure 16.3

Monthly length-frequency distributions of white grunt (*Haemulon plumieri*) from Florida Bay. Values are shown for numbers <10 for clarity.

H. sciurus (bluestriped grunt)

Total numbers collected and rank of bluestriped grunt by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	69	35

Life history Bluestriped grunt range from south Florida, the Bahamas, the West Indies, Bermuda, lower Gulf of Mexico, and the Caribbean Sea south to Brazil (Courtenay and Sahlman, 1978). In the Caribbean, they spawn mainly from November through April with a maximum in January–February. Spawning is minimal from May through October. Females mature at approximately 220 mm FL (Gaut and Munro, 1983). The eggs and larvae of bluestriped grunt are pelagic (Thresher, 1991). Based on general data on western Atlantic haemulids, the postflexion stage occurs from ca. 6–10 mm SL, transforming juvenile stage ca. 10–15 mm SL, early juvenile stage ca. 15–20 mm SL to ca. 50 mm SL, and late juvenile stage from ca. 50 mm SL to 110–170 mm SL (Lindeman, 1997).

Diet The diet of bluestriped grunt most likely follows that of other grunt species as described by Lindeman (1997). Newly settled fish (ca. 7–20 mm SL) are diurnal plankton feeders; early juveniles (ca. 20–50 mm SL) feed on both plankton and benthic invertebrates and might be nocturnal feeders. Juveniles (ca. 50–100 mm SL) are nocturnal benthic macro-invertebrate feeders.

Abundance and distribution The bluestriped grunt was uncommon in otter trawl collections in basins. Significant differences in densities were observed among years, but not months. Highest densities occurred, in descending order, in 1999–2000, 1984–1985, and 1997–1998 (Figs. 16.4 and 16.5). They occurred at a greater percentage of stations in 1997–1998. We observed no significant differences in densities among strata. There were, however, differences in densities among subdivisions. Highest densities occurred in the Atlantic, Gulf, and Western subdivisions, suggesting that recruitment into Florida Bay occurred from both the Atlantic and Gulf of Mexico (Figs. 16.4 and 16.5).

In Biscayne Bay, newly settled early juveniles and juveniles were observed in habitats similar to white grunt (see above). In the Caribbean and Belize, bluestriped grunt juveniles prefer mangroves (Sedberry and Carter, 1993; Cocheret de la Morinière, 2002) or seagrass beds (Nagelkerken et al., 2000). In Belize, bluestriped grunt appear to increase in abundance in mangrove creeks during January–June and decrease during July–December. Among mangrove, seagrass, and reef sites in the Caribbean, the mean size of individuals differs among habitats. Smallest average size fish were found in seagrass habitat, largest on reefs. Given the choice, bluestriped grunt prefer mangroves during the day as resting sites and seagrasses at night where they forage (Cocheret de la Morinière, 2002). They are common in grassy shore habitat in the Atlantic side of the Florida Keys adjacent to Florida Bay (Springer and McErlean, 1962).

Length-frequency distributions Based on Lindeman's (1997) stage terminology (see above), all juvenile stages were present, but adults and sexually mature females (ca. 220 mm FL) were absent or rare (Fig.16.6). Recruitment into Florida Bay occurred throughout the year, indicating either that spawning occurred locally throughout the year or bluestriped grunt cohorts were from various sources with different spawning times. Sedberry and Carter (1993) observed that the maximum mean size of juvenile fish from Belize occurred in September and that length-frequency distributions were bimodal with a strong mode of smaller fish during winter and early spring. Because of constant recruitment, our modes were weak (Fig. 16.6).

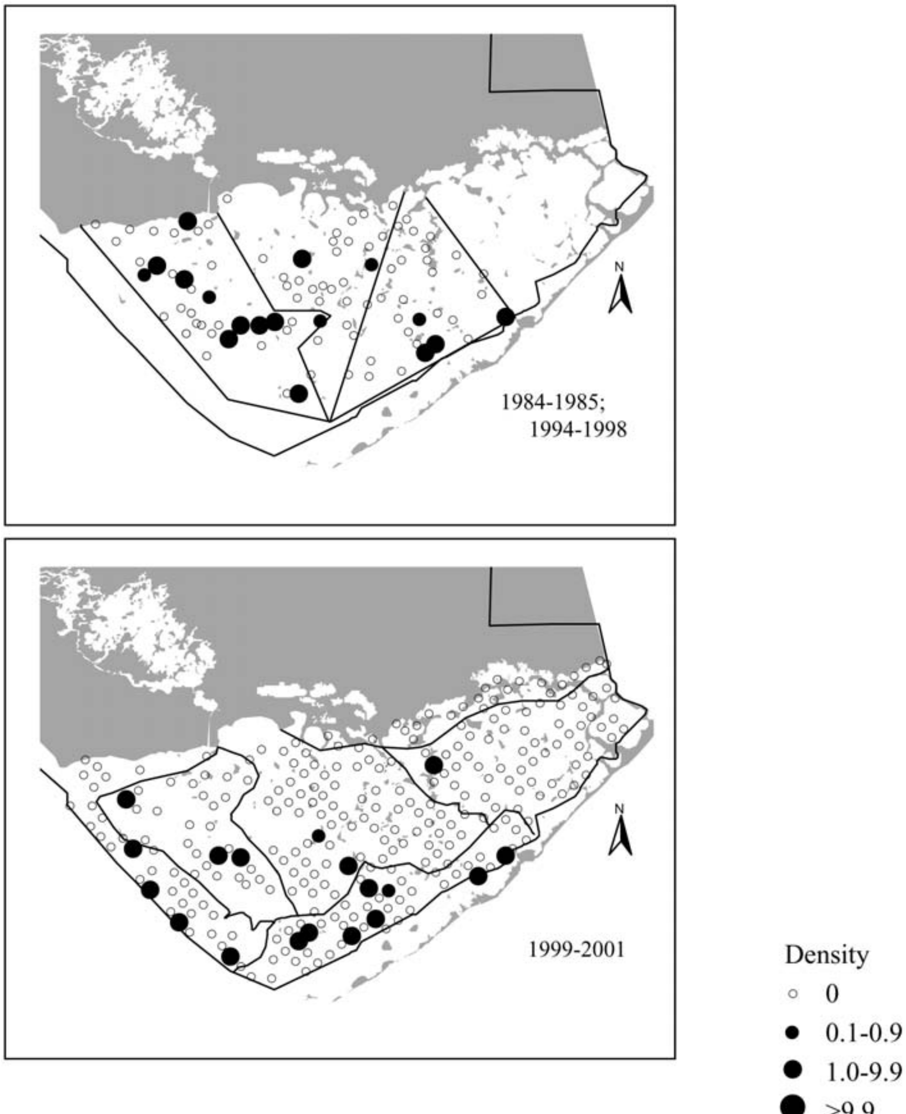


Figure 16.4

Mean densities (numbers 1000 m^{-2}) of bluestriped grunt (*Haemulon sciurus*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

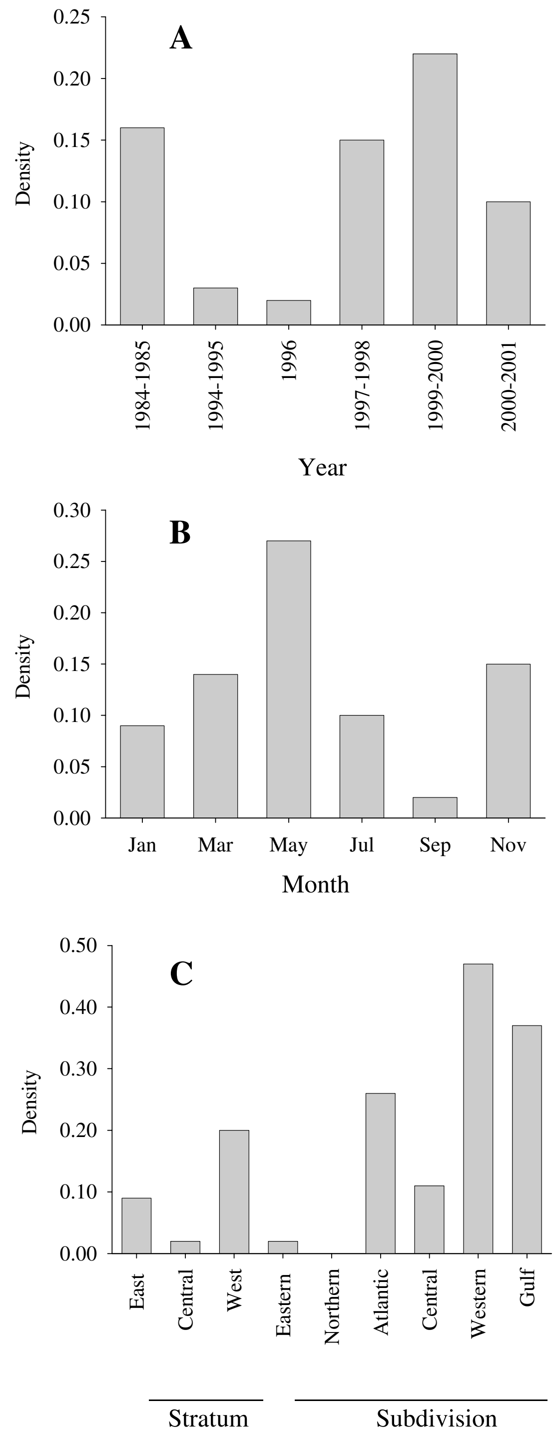


Figure 16.5

Mean densities (numbers 1000 m^{-2}) of bluestriped grunt (*Haemulon sciurus*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

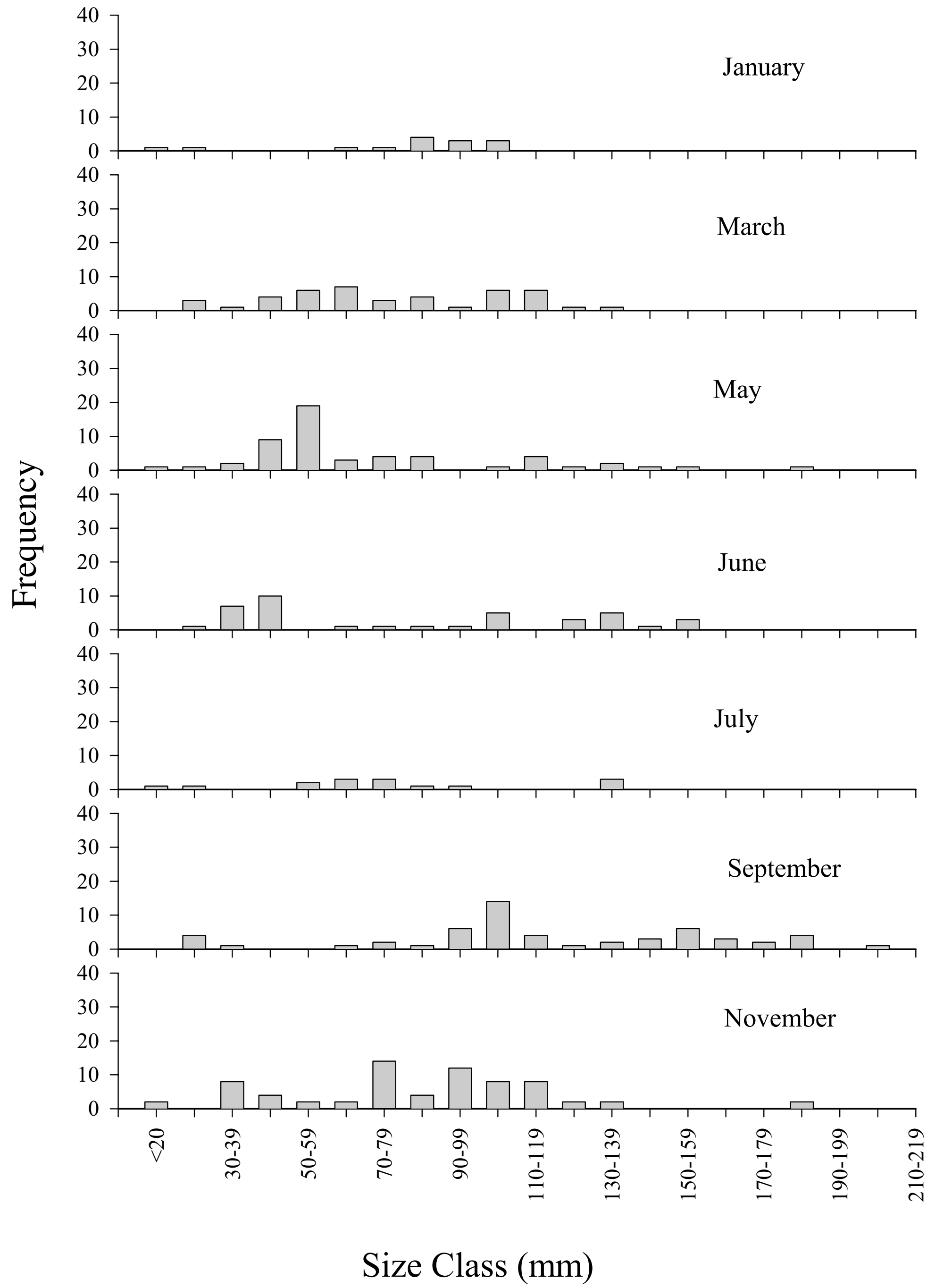


Figure 16.6

Monthly length-frequency distributions of bluestriped grunt (*Haemulon sciurus*) from Florida Bay.

Orthopristis chrysoptera (pigfish)

Total numbers collected and rank of pigfish by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	1246	11

Life history Pigfish range along the Atlantic coast from New Jersey (uncommon north of Virginia) to the tip of Florida, throughout the Gulf of Mexico to Yucatan, and in Bermuda. Adults inhabit coastal waters and occur over mud and sand substrates (Courtenay and Sahlman, 1978; Johnson, 1978). In Florida waters, pigfish spawn during spring, but studies in the Gulf of Mexico report spawning in late winter (Sutter and McIlwain, 1987). Pigfish eggs are pelagic, and larvae are approximately 1.4 mm NL at hatching. The juvenile stage is attained at 20 mm SL and sexual maturity is usually attained at 200–215 mm TL. Pigfish reach a maximum length of 460 mm SL (Hildebrand and Cable, 1930; Johnson, 1978; Sutter and McIlwain, 1987).

Diet Carr and Adams (1973) examined the diets of pigfish between 16 and 80 mm SL that were collected near Crystal River, Florida. They found that juvenile pigfish pass through two distinct feeding stages with a gradual transition from planktivory to carnivory. Juveniles 16–30 mm SL are planktivorous, mainly feeding on copepods, mysids, and postlarval shrimp. The smallest fish (16–20 mm SL) feed mainly on copepods and with subsequent growth, mysids and shrimp dominated their diet. At approximately 26 mm SL, polychaetes appear in their diets. Transition is complete at 41–45 mm SL, at which time pigfish mainly consume polychaetes, mysids, and small quantities of amphipods. With increasing size, polychaetes decline in importance and caridean and penaeid shrimp became dominant food items.

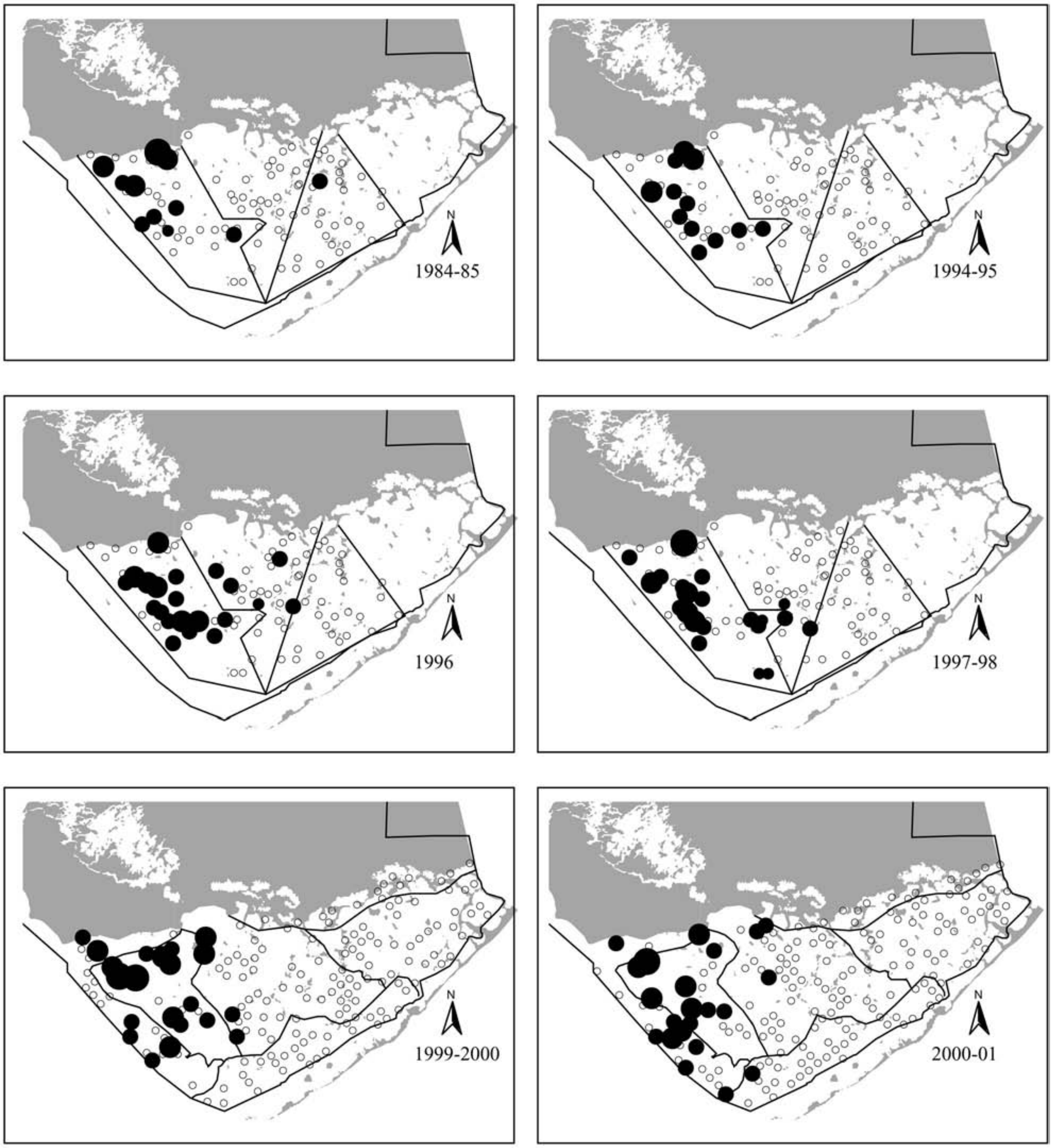
In the Whitewater Bay–Shark River estuary, pigfish (20–39 mm and 40–89 mm SL) consume crustaceans (mainly gammaridean amphipods and isopods) more frequently than polychaetes and mollusks. However, larger fish feed on a greater proportion of polychaetes and mollusks (Schmidt, 1993). In the northern Gulf of Mexico, Howe (2001) noted two distinct size-specific diets. Small pigfish (108–150 mm SL) mainly consume, in descending order, polychaetes, penaeid shrimp, and sea anemones; while larger fish (151–198 mm SL) mainly consume, in descending order, penaeid shrimp, polychaetes, and fishes.

Abundance and distribution Pigfish were abundant in otter trawl collections in basins, and were the most abundant grunt collected in Florida Bay. Significant differences in densities were observed among months and years, although differences among years could be biased by the increase in spatial sampling in the Northern and Eastern subdivisions during 1999–2001 (Fig. 16.7). Monthly, highest densities occurred in spring, lowest in summer and fall (Fig. 16.8). There were significant differences in densities of pigfish among strata and subdivisions. This species mainly occurs in western Florida Bay (Figs. 16.7 and 16.8).

At Cedar Key, Florida, pigfish apparently occupy different habitats seasonally (Reid, 1954). Reid collected the majority of pigfish from May through November. During spring and early summer, juveniles occupy shallow flats with considerable seagrass, and as summer and early fall progress, juveniles (75–115 mm SL) are mainly in channels and deep flats with little vegetation. Unlike our findings, Tabb and Manning (1961) collected juveniles from July through October in western Florida Bay.

Apparently, pigfish spawn in Gulf of Mexico waters and recruit into the Bay from the Gulf. Pigfish do not appear to utilize mangrove prop root habitats in Florida Bay and adjacent waters (Thayer et al., 1987b), and have not been collected in a grassy shore habitat in the Atlantic side of the Florida Keys (Springer and McErlean, 1962), further indicating this species recruits into the Bay from the Gulf of Mexico.

Length-frequency distributions Pigfish recruited into Florida Bay at a size <25 mm SL during winter and early spring (Fig. 16.9). It appeared that two age classes (young-of-the-year and yearlings) were collected at least from January through July. Sexually mature fish (>200 mm SL) were rarely encountered. Near the end of the growing season (November) young-of the-year fish ranged from 70 to 190 mm SL with a slight mode at 120–129 mm SL.



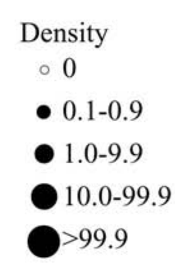


Figure 16.7

Mean densities (numbers 1000 m^{-2}) of pigfish (*Orthopristis chrysoptera*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

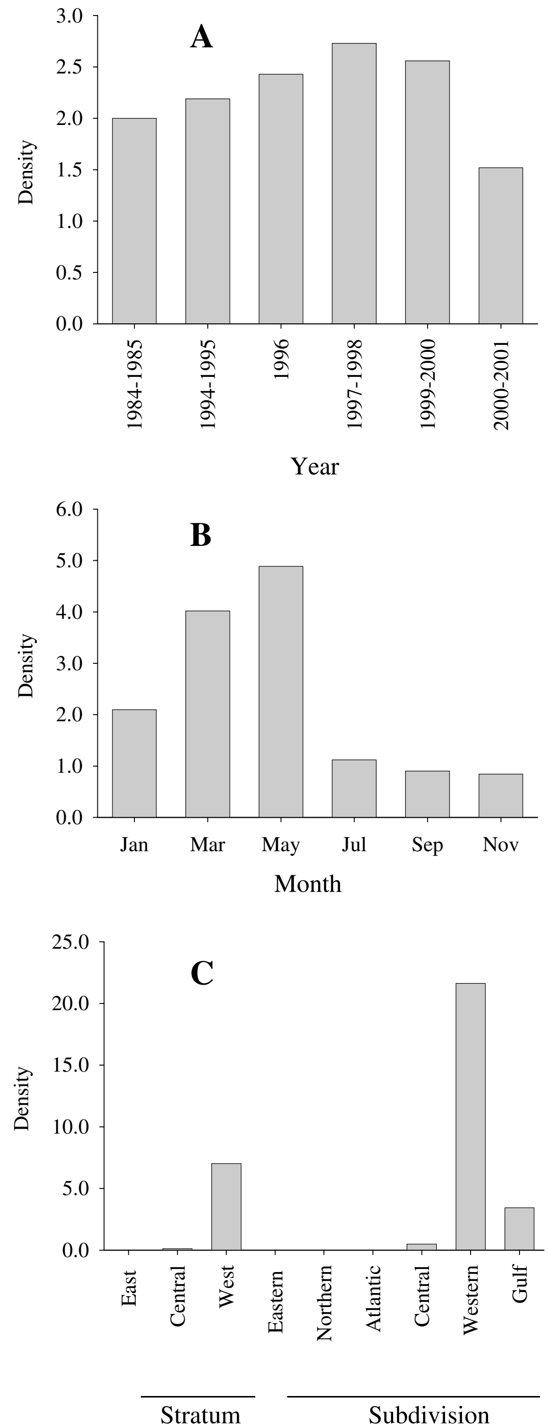


Figure 16.8

Mean densities (numbers 1000 m^{-2}) of pigfish (*Orthopristis chrysoptera*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

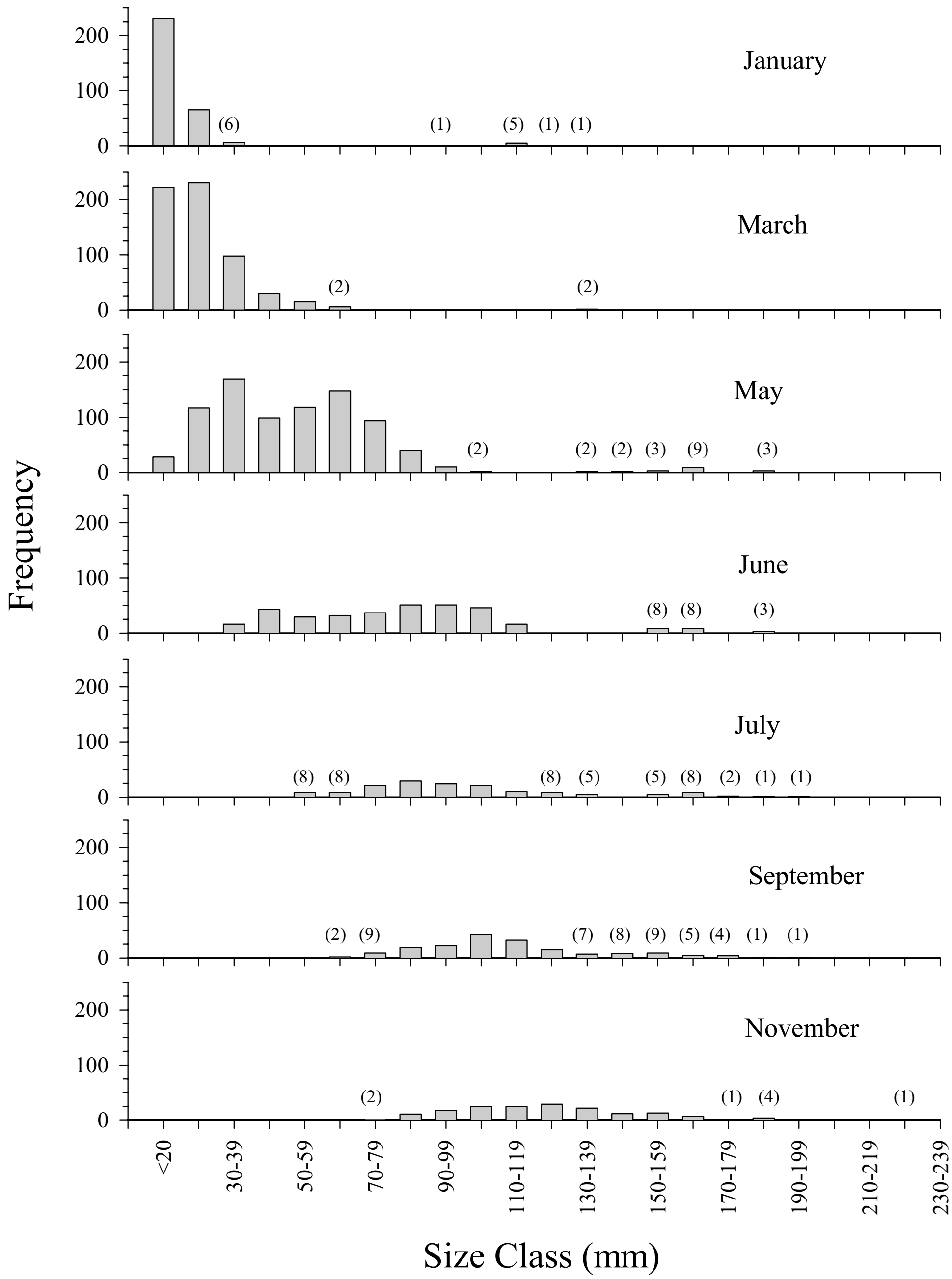


Figure 16.9

Monthly length-frequency distributions of pigfish (*Orthopristis chrysoptera*) from Florida Bay.

Chapter 17. Family Sparidae

Archosargus probatocephalus (sheepshead)

Total numbers collected and rank of sheepshead by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	89	28

Life history Sheepshead range from Nova Scotia to Florida, throughout the Gulf of Mexico and Caribbean Sea, to Brazil. They are absent from the West Indies and Bermuda. Late larvae and juveniles (ca. <50 mm) inhabit seagrass beds; larger juveniles and adults are associated with rocks, pilings, wrecks, and bulkheads (Johnson, 1978; Randall and Vergara, 1978; Robins and Ray, 1986; Able and Fahay, 1998). Spawning occurs offshore during February through April in Louisiana and east Florida (Johnson, 1978; Render and Wilson, 1992). Sexual maturity is first attained at age-2 for both sexes (ca. 300 mm FL). Eggs are pelagic and sheepshead are 1.6–1.7 mm NL at hatching. Settlement occurs at ca. 8 mm SL and the mean size attained in the juvenile period is 19 mm SL (Parsons and Peters, 1989; Beckman et al., 1991; Render and Wilson, 1992; Tucker and Alshuth, 1997).

Diet Sheepshead undergo ontogenetic shifts in diet from a juvenile diet composed of soft-bodied forms (e.g., copepods, amphipods, and mysids) that are associated with seagrasses to a diet composed of hard prey items (e.g., crabs, barnacles, oysters, and clams). Their consumption of hard prey items is linked to the development (>60 mm SL) of an apparatus termed oral jaw crushers. At approximately 60 mm SL, sheepshead leave grassbeds and occupy adult habitats (described above) when barnacles become an important dietary item. Ontogenetic shifts in their diet are exemplified by their consumption of crabs. At 30–90 mm SL, sheepshead consume crab zoea; at 91–180 mm SL, small stone crabs; and at >80 mm SL, large stone crabs. Similarly, smaller fish consume small, soft-shelled bivalves, while more robust bivalves increasingly are consumed during ontogeny (Johnson, 1978; Hernandez and Motta, 1997).

In the Whitewater Bay system (North River), Odum and Heald (1972) observed that newly recruited sheepshead feed in seagrass beds, first restricted to copepods then to amphipods, chironomods, and mysids. At approximately 35–40 mm SL they move into the hard substrate of the North River and move upstream where their diet consists of encrusting forms.

Abundance and distribution Sheepshead were uncommon in otter trawl collections in basins, indicating that Florida Bay is not an important nursery area for this species. Significant differences in densities were observed among years, but not months. Highest densities were observed in 1996, and they were absent from collections in three annual periods (Figs. 17.1 and 17.2). Sheepshead were mainly collected in western Florida Bay, indicating that recruitment was from the Gulf of Mexico.

Sheepshead have not been collected in grassy shore habitat in the Atlantic side of the Florida Keys adjacent to Florida Bay (Springer and McErlean, 1962), further indicating this species recruits into the Bay from the Gulf of Mexico. In Tampa Bay, sheepshead are mainly associated with the macroalgae, *Diplanthera*. They move off the grass beds in August (mean size = 41 mm SL) and enter the adult habitat (Springer and Woodburn, 1960).

In the Whitewater Bay system (North River), Odum and Heald (1972) found sheepshead to be the second most abundant gamefish species. They spend their first months in Whitewater Bay seagrass beds. At about 35–40 mm SL they begin to move into the mouth of the North River. The influx of these small fish begins at the mouth of the river in June and lasts until late fall. Movement from the Bay to the river system appears to be related to diet (see above).

Length-frequency distributions Sheepshead recruit into Florida Bay in spring and early summer (Fig. 17.3). Based on modes of young-of-the-year from March to November, fish grew 40 mm in SL in six months, a relatively slow rate of growth. Annuli form on sheepshead sagittae during April–May (Beckman et al., 1991), and based on that study, we ascribed a mode observed of 70–79 mm SL in March as one growth year. Johnson (1978) summarized growth rates of sheepshead from Beaufort, North Carolina, and Tampa Bay, Florida, and also concluded that this species is slow growing. Sheepshead from Tampa Bay, which averaged 21 mm SL in June, 29 mm SL in July, and 42 mm SL in August (Springer and Woodburn, 1960), were slightly smaller than our specimens (Fig. 17.3). The progressive decline in our modal frequencies from May (mode = 20–29 mm SL) to November (mode = 60–69 mm SL) could indicate a movement of juveniles into their adult habitat as reported by Springer and Woodburn (1960) in Tampa Bay (see above), although this is confounded by natural mortality.

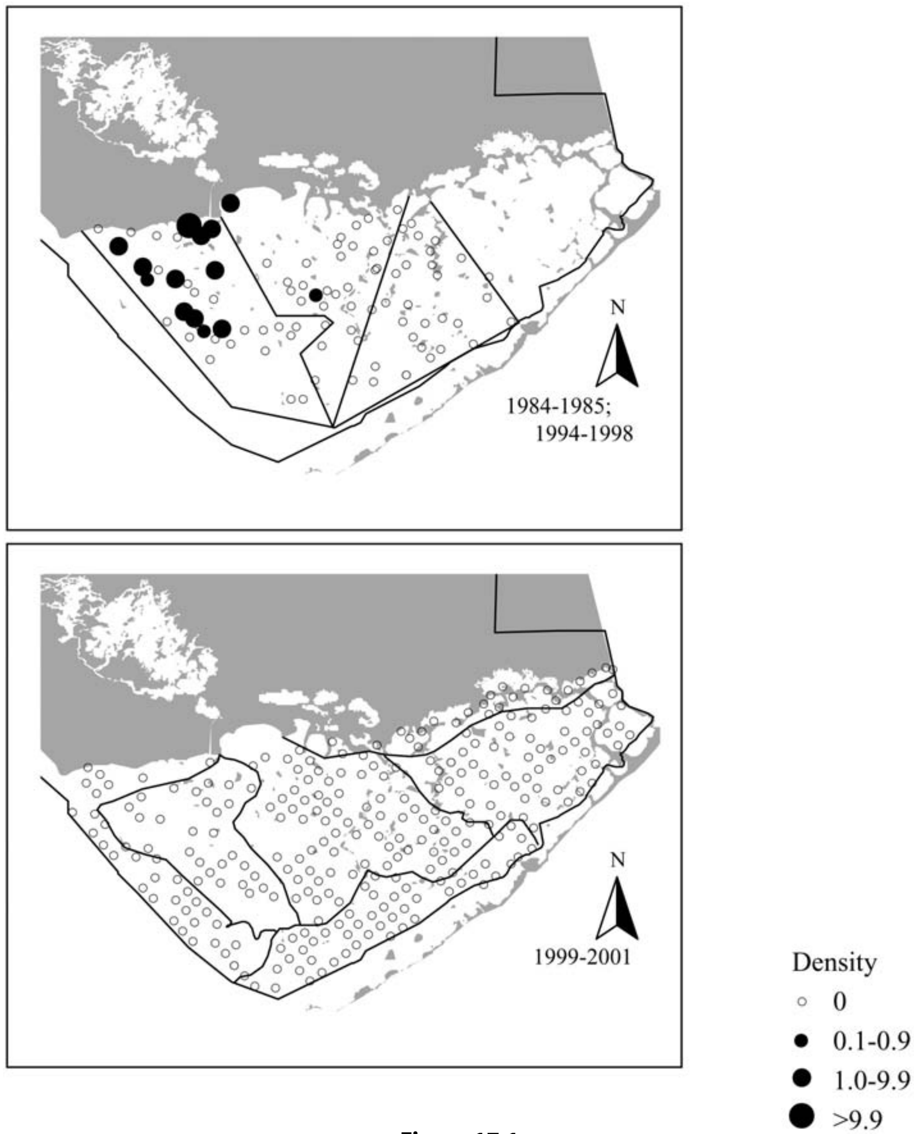


Figure 17.1

Mean densities (numbers 1000 m^{-2}) of sheepshead (*Archosargus probatocephalus*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

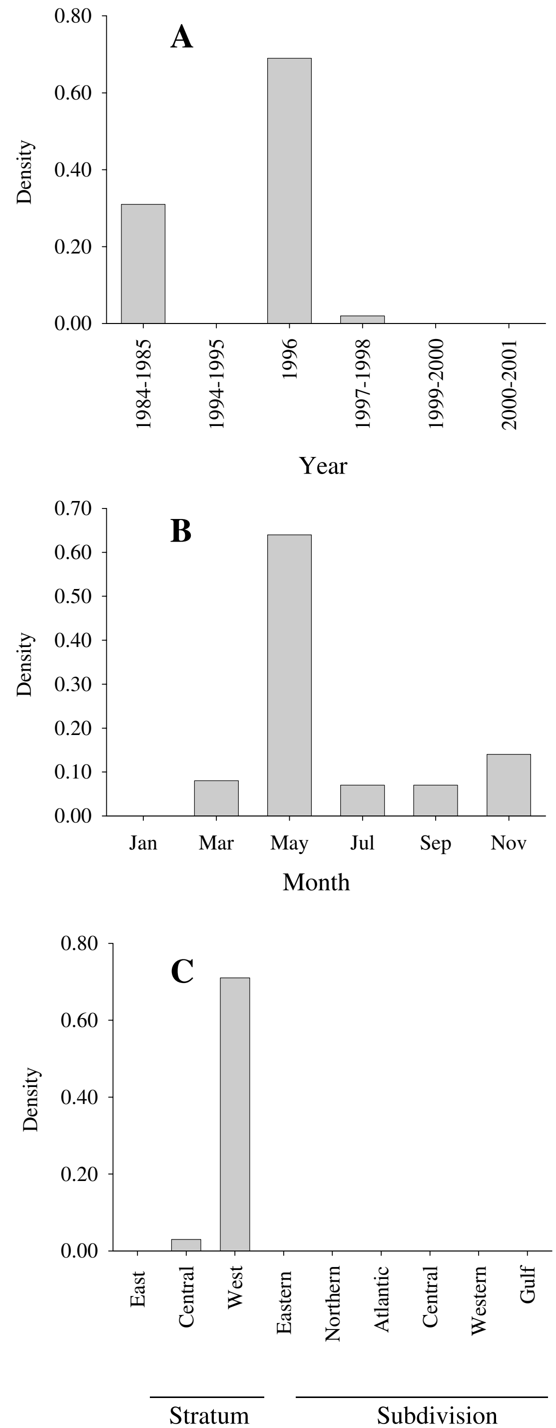


Figure 17.2

Mean densities (numbers 1000 m^{-2}) of sheepshead (*Archosargus probatocephalus)* from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

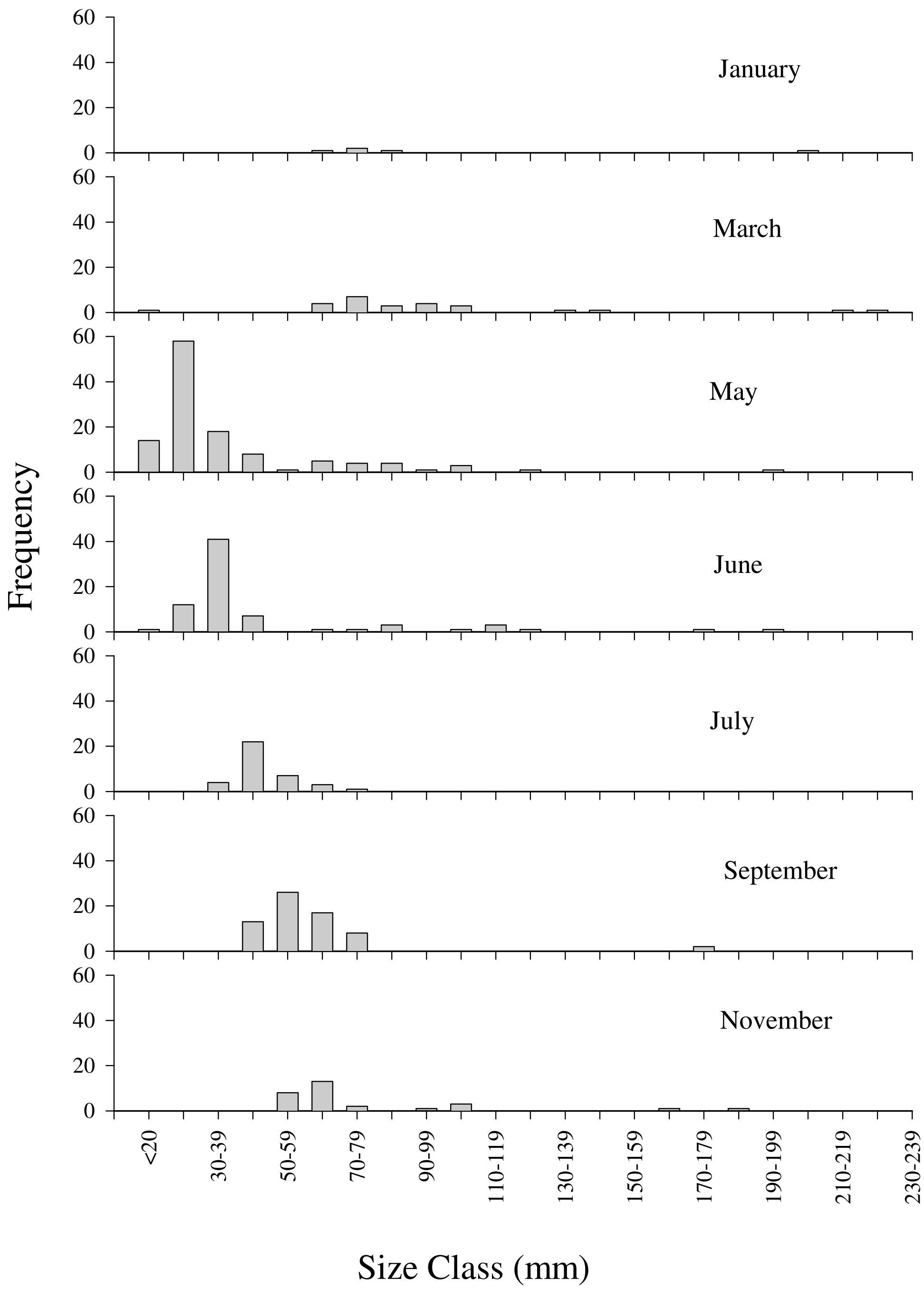


Figure 17.3

Monthly length-frequency distributions of sheepshead (*Archosargus probatocephalus)* from Florida Bay.

Calamus arctifrons (grass porgy)

Total numbers collected and rank of grass porgy by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	71	34

Life history Grass porgy range primarily along the west coast of Florida in shallow water, but occasionally stray to Louisiana and Texas. The adults prefer shallow seagrass beds and other vegetated bottoms, and are also found over hard bottoms. Grass porgy are most likely hermaphroditic. Spawning apparently occurs in offshore waters during winter and spring (Darcy, 1986). Based on the presence of small fish collected at Cedar Key, Florida, Reid (1954) suggested that spawning occurs during early spring. Size and age at maturity are unknown. They attain a maximum length of 220 mm (type of measurement unspecified) (Darcy, 1986).

Diet Grass porgy ranging from 19 to 140 mm SL were found to mainly feed on crustaceans (copepods, amphipods, mysids, and shrimps), occasionally on pelycepod and gastropod mollusks, and rarely on polychaetes (Reid, 1954).

Abundance and distribution Grass porgy were uncommon in otter trawl collections in basins (Figs. 17.4 and 17.5), indicating that Florida Bay is a marginal nursery area for this species. We observed significant differences in densities among years, but not months. Densities were highest in 2001 and lowest in 1994–1995 (Figs. 17.4 and 17.5) following the die-off of seagrass. However, grass porgy were collected at a greater percentage of stations in 1997–1998 and 1984–1985 (Fig. 17.4). Grass porgy mainly occurred in western Florida Bay, although few fish were collected in the Atlantic subdivision, indicating that recruitment into Florida Bay is mainly from the Gulf of Mexico, although recruitment through the Florida Keys is possible (Figs. 17.4 and 17.5).

Grass porgy are restricted to shallow water, probably because of their affinity for benthic vegetation (Darcy, 1986), but they have not been collected on mud banks in Florida Bay (Sogard et al., 1987, 1989a; Sheridan et al., 1997; Matheson et al., 1999). They apparently do not use mangrove prop root habitats (Thayer et al., 1987b). They were rarely collected in grassy shore habitat in the Atlantic side of the Florida Keys adjacent to Florida Bay (Springer and McErlean, 1962), which could be related to minimal recruitment to the Bay from the Keys. Although uncommon in Florida Bay, this species has been reported to be abundant on the west Florida shelf with highest abundances recorded in shallow (9–18 m) water associated with hard bottom (Darcy, 1986). The lack of hard bottom habitat in western Florida Bay could limit their use of Florida Bay.

In western Florida Bay, Tabb and Manning (1961) reported that grass porgy were abundant during 1957–1959, but in future years they were uncommon. They attributed their decline to an increase in turbid waters from Joe Kemp Key to East Cape Sable. If they are sensitive to turbid waters, this could be a potential indicator species for Florida Bay water quality. Their sensitivity to turbid waters could possibly be a factor that explains their absence from turbid northwestern Gulf of Mexico waters (Darcy, 1986).

Length-frequency distributions Based on the collection of small fish, recruitment into Florida Bay occurred from February through May (Fig. 17.6). The growth rate of grass porgy is unknown (Darcy, 1986) and, based on limited data, we estimated grass porgy to attain a modal length of 90–99 mm SL in March after a year of growth (Fig. 17.6). Based on July through November modes, grass porgy grew approximately 0.3 mm SL day^{-1} (10 mm SL per month), which would relate to 120 mm SL at age-1.

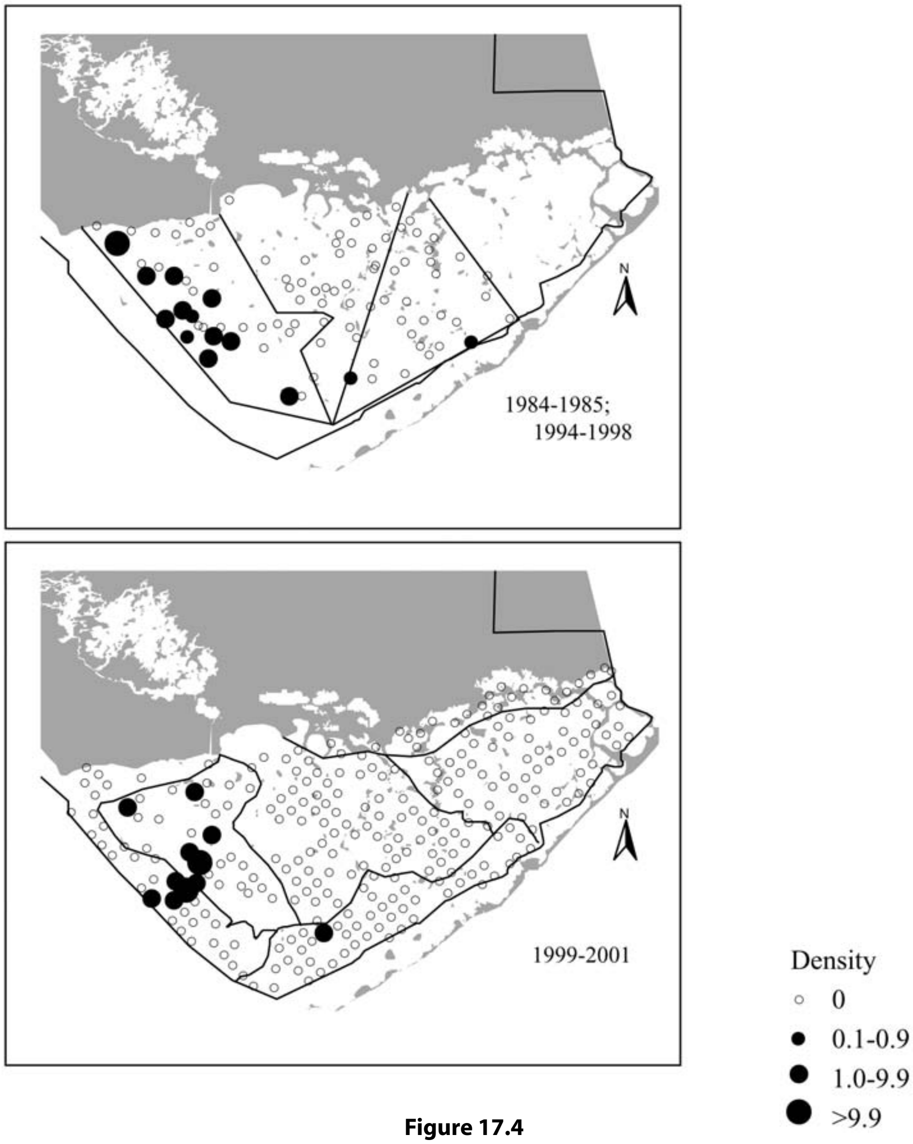


Figure 17.4

Mean densities (numbers 1000 m^{-2}) of grass porgy (*Calamus arctifrons*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

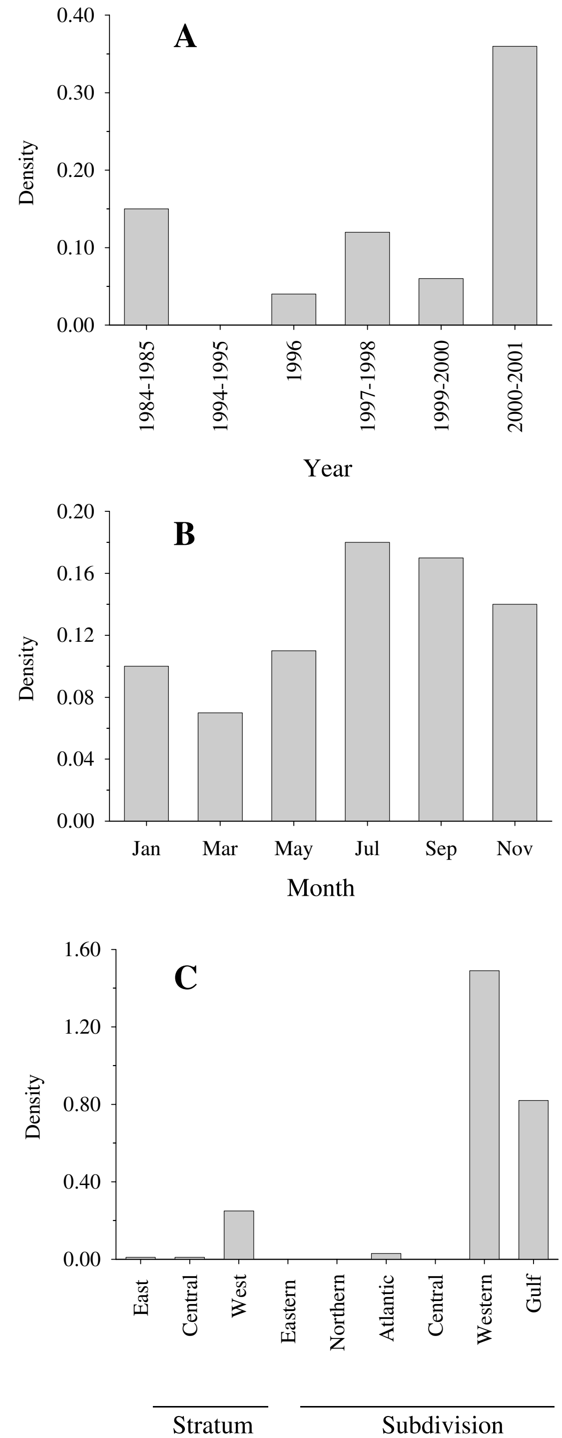


Figure 17.5

Mean densities (numbers 1000 m^{-2}) of grass porgy (*Calamus arctifrons*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

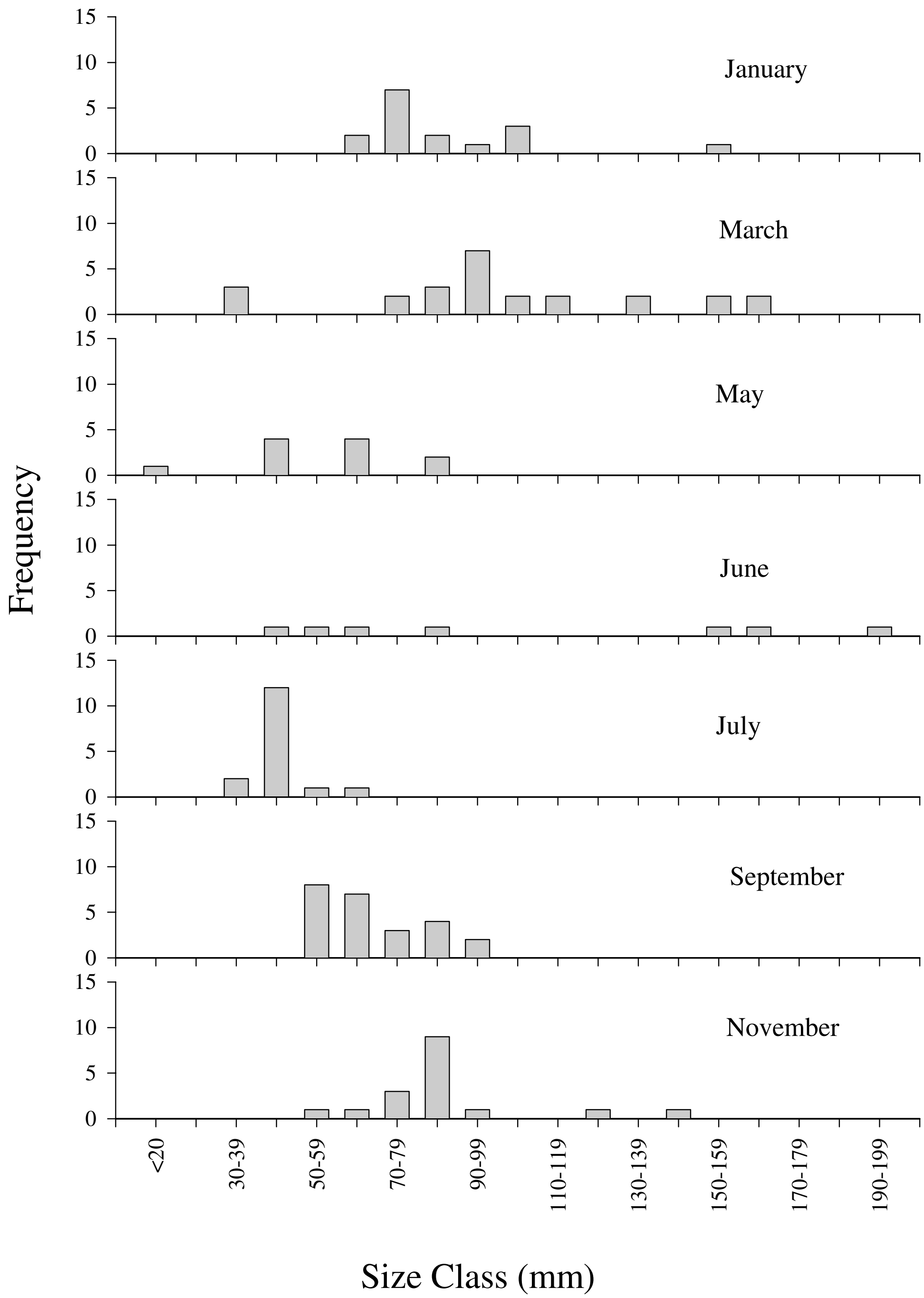


Figure 17.6
Monthly length-frequency distributions of grass porgy (*Calamus arctifrons*) from Florida Bay.

Lagodon rhomboides (pinfish)

Total numbers collected and rank of pinfish by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	7626	4

Life history Pinfish range from Cape Cod southward along the Atlantic coast to Florida, around the tip of Florida, throughout the Gulf of Mexico to Yucatan, Mexico, along northern Cuba, and Bermuda. It is not abundant north of Delaware (Breder, 1948; Caldwell, 1957; Randall and Vergara, 1978). Caldwell (1957) noted that " … pinfish is amazingly ubiquitous in its ecological distribution. It is found associated with wide ranges of temperature, salinity, depth, bottom type, current, and other ecological conditions, and this tolerance of the species to wide ranges of physical factors permits it to exist in many types of habitats." Pinfish spawn in offshore waters, and numerous studies in the Gulf of Mexico (summarized by Darcy, 1985) suggest that spawning occurs during fall, winter, and spring. Collins and Finucane (1984) conducted an ichthyoplankton survey of inshore Gulf of Mexico waters (≥10 m water depth) adjacent to the Florida Everglades and did not collect any pinfish larvae. However, Houde et al.[7] sampled offshore of Collins and Finucane (1984) and collected pinfish larvae, mainly, during winter. A great percentage (>60%) of larvae were taken in waters <30 m, but larvae were also collected in waters of 7–64 m depths. Pinfish eggs are pelagic, larvae hatch at 2.3 mm TL (Darcy, 1985), and the juvenile stage is attained at 13 mm SL (Zieske, 1989). Ingress into estuaries occurs at 10–20 mm SL (Tabb and Manning, 1961; Darcy, 1985). Females mature at approximately 80–100 mm SL (Hansen, 1970; Schmidt, 1993).

Diet Pinfish are visual feeders and generally are planktivores as small juveniles, then shift to larger benthic organisms and algae during ontogeny (Darcy, 1985). Differences in seagrass composition appear to influence the diet of pinfish (Carr and Adams, 1973; Stoner, 1980). Carr and Adams (1973) study site was dominated by *Ruppia maritima* and *Halodule wrightii*; whereas, Stoner's sites were dominated by *Thalassia testudinum*. In Florida Bay the distribution of pinfish (Fig. 17.7) mainly coincides with *T. testudinum* (Thayer and Chester, 1989); hence, we expect the diet of pinfish in Florida Bay to generally resemble the diet of pinfish from Apalachee Bay. Where *H. wrightii* dominates (e.g., western and northeastern Florida Bay, Figs. 3.6 and 3.7), the diet might resemble that of pinfish from Crystal River.

Abundance and distribution Pinfish were abundant in otter trawl collections in basins (Figs. 17.7 and 17.8) indicating that Florida Bay is a nursery area for this forage species. We observed significant differences in densities among years, but not months, even though densities in May appeared to be relatively high. Densities were relatively low following the die-off of seagrass (1994–1996), highest in 1997–1998, but then depressed in 1999–2000 (Figs. 17.7 and 17.8). Seagrass die-off could have influenced the density of pinfish, but this species spawns in offshore waters where biological and physical conditions could confound our understanding of the effect of seagrass die-off on pinfish populations.

At Cedar Key, Florida, pinfish occurred throughout the year, but numbers diminish during winter (Reid, 1954). In western Florida Bay, pinfish have been reported to occur in shallow water during warmer months and move to deeper waters during winter (Tabb and Manning, 1961). In west coast Florida waters, Nelson (1998) mainly collected young-of-the-year pinfish in water depths <3.5 m, and concluded their distribution is depth limited due to their dependence on seagrass for cover and food. This species, which is considered to be ubiquitous and tolerant of a wide range of physical and biological conditions (Caldwell, 1957), was rarely collected in the Eastern subdivision and absent from the Northern subdivision. Recruitment constraints could limit their distribution in these areas.

Length-frequency distributions Based on the appearance of fish <20 mm SL, pinfish recruited into Florida Bay during winter and spring (Fig. 17.9). Our length-frequency patterns resemble that for Cedar Key, Florida (Reid, 1954), in that collections are dominated by young-of-the-year fish. However, in November, the mode for young-of-the-year pinfish in Florida Bay is 80–99 mm SL; in Cedar Key the mode is at 60–70 mm SL, suggesting faster growth of Florida Bay fish. Nelson (1998) calculated monthly instantaneous growth rates (Ricker, 1975) for pinfish from April through July for three west coast Florida Bays. The average monthly instantaneous growth rate was 0.18 (20% monthly increase in body length), which Nelson (1998) considered to be fast growth. We calculated instantaneous growth rates from modal lengths from March through November (Fig. 17.9) and observed a similar rate (0.17), suggesting that environmental (e.g., temperature, salinity) and biological (e.g., prey abundance and quality) conditions in these Florida waters are suitable for pinfish habitat.

[7] Houde, E. D, J. C. Leak, C. E. Dowd, S. A. Berkeley, and W. J. Richards. 1979. Ichthyoplankton abundance and diversity in the eastern Gulf of Mexico. Report to the Bureau of Land Management under contract no. AA550-CT7-28, June 1979, 546 p.

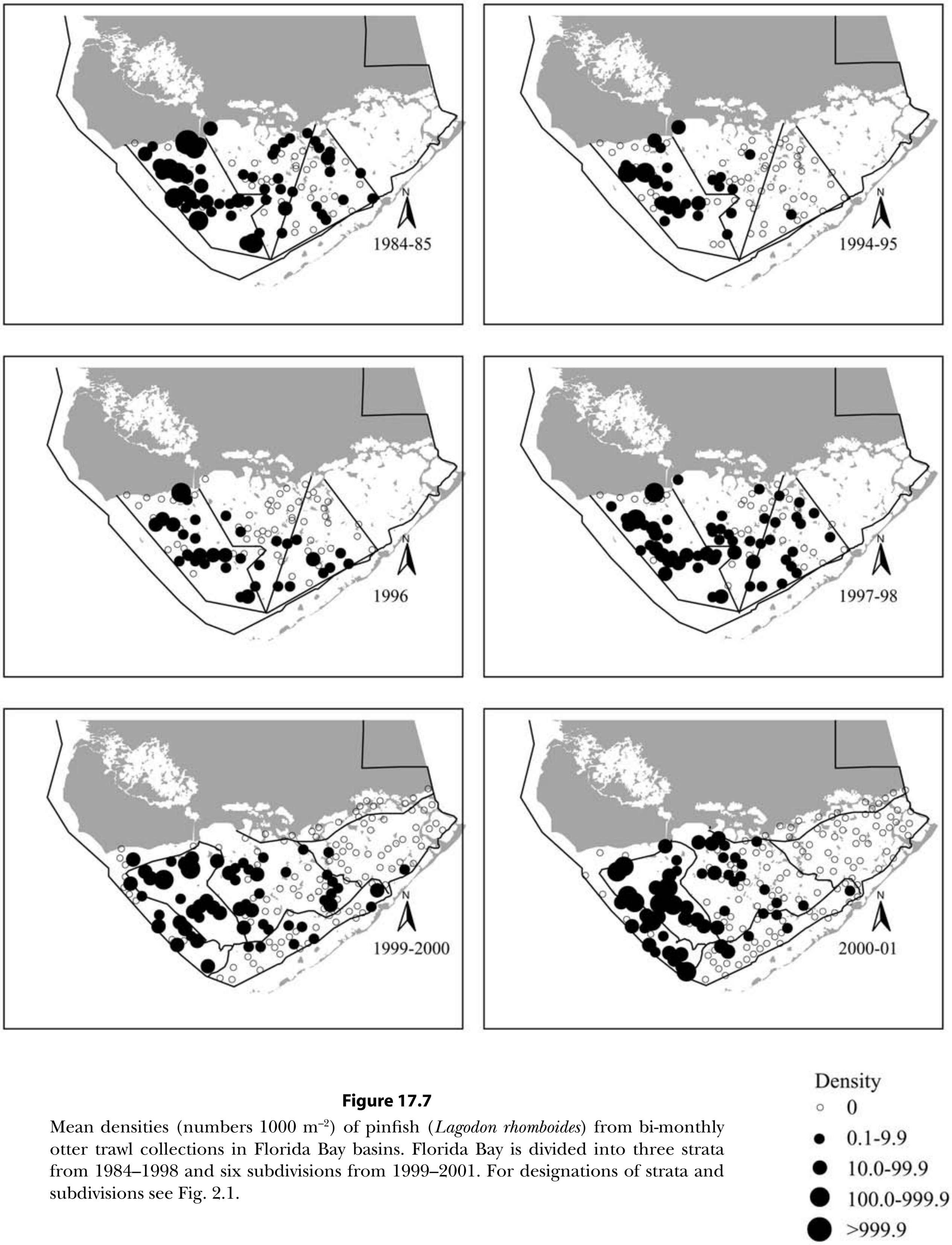


Figure 17.7

Mean densities (numbers 1000 m^{-2}) of pinfish (*Lagodon rhomboides*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

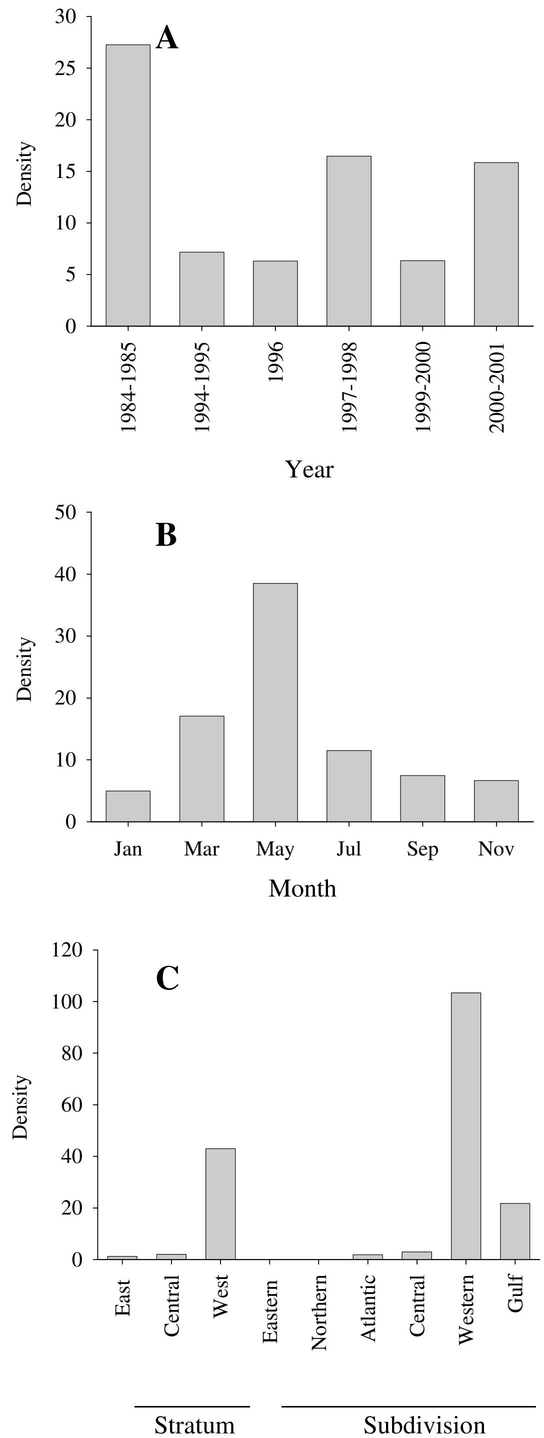


Figure 17.8

Mean densities (numbers 1000 m^{-2}) of pinfish (*Lagodon rhomboides*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

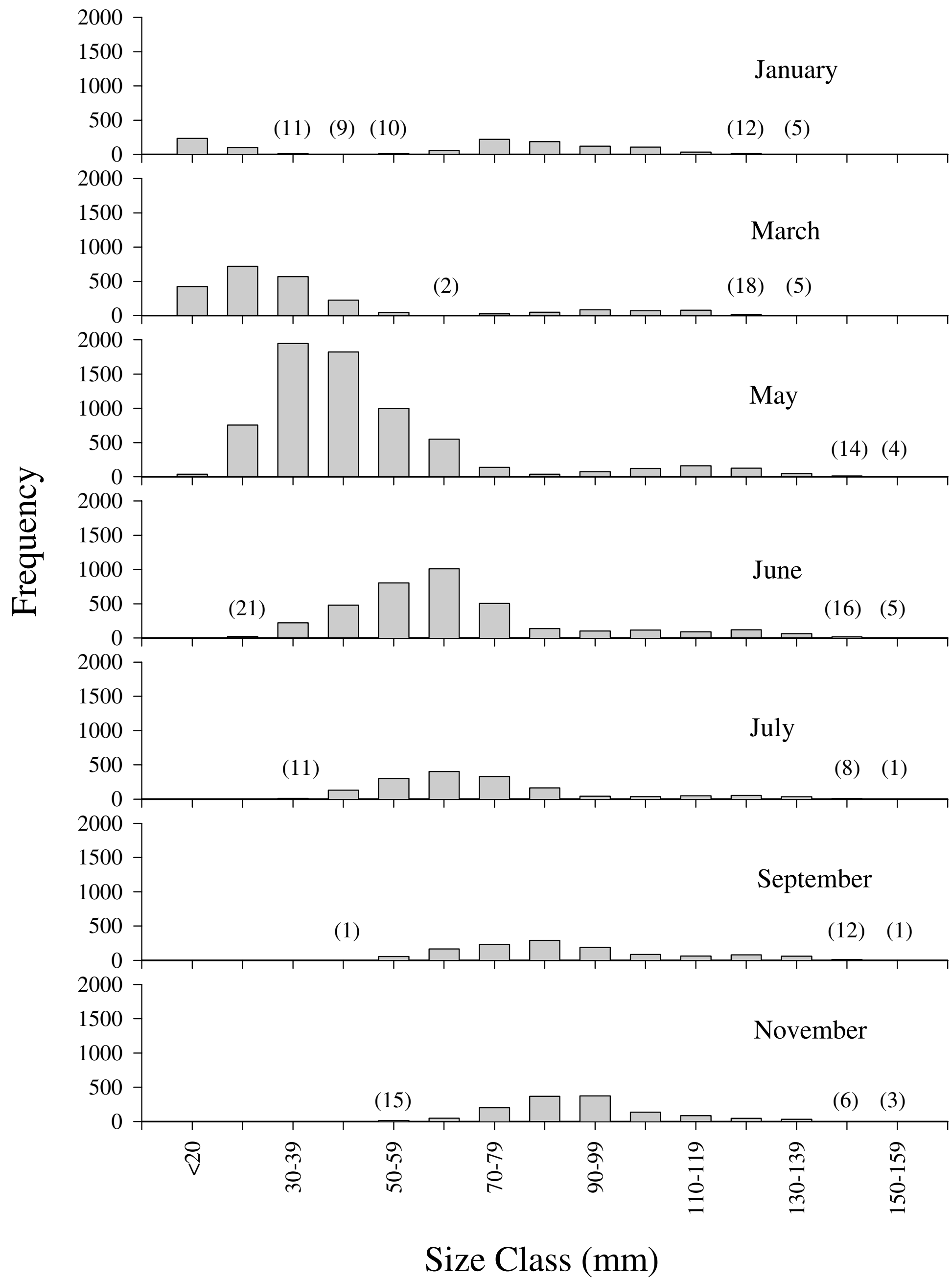


Figure 17.9

Monthly length-frequency distributions of pinfish (*Lagodon rhomboides*) from Florida Bay. Values are shown for numbers <25 for clarity.

Chapter 18. Family Sciaenidae

Bairdiella chrysoura (silver perch)

Total numbers collected and rank of silver perch by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	1296	10

Life history Silver perch range along the Atlantic coast from Connecticut to Florida, around the tip of Florida, and throughout the Gulf of Mexico to Rio Grande (Chao, 1978). In the northern part of their range they appear in bays only in summer (Breder, 1948). Larvae have been collected in all months sampled (February, May, August, and September) in Gulf of Mexico coastal and estuarine waters adjacent to Everglades National Park (Collins and Finucane, 1984). Running ripe male and female fish have been observed in Conchie Channel in northwest Florida Bay (Tabb and Manning, 1961), but larvae have not been collected in the Bay (Powell, 2002). Eggs are pelagic and hatching occurs at 1.5–1.8 mm NL. Transformation to the juvenile stage occurs at 10–12 mm SL (Ditty and Shaw, 1994).

Diet Carr and Adams (1973) reported on the diets of juvenile silver perch (96–160 mm SL) collected in northwestern Florida. Smallest juveniles (6–15 mm SL) consume copepods exclusively. For fish 16–40 mm SL, consumption of copepods decreases and mysids and very small shrimp increases. For fish greater than 40 mm SL, small caridean shrimp dominates the diet and small fish, amphipods, and polychaetes are occasionally significant dietary items in larger fishes. In the Whitewater Bay–Shark River estuary, small silver perch (≤50 mm SL) consume mainly crustaceans (in descending order, isopods, amphipods, and non-penaeid shrimp). Intermediate size fish (51–92 mm SL) consume mainly non-penaeid shrimp. Largest silver perch (≥93 mm SL) have a diverse diet that is dominated by crustaceans (in descending order, non-penaeid shrimp, penaeids, amphipods, and isopods) (Schmidt, 1993).

Abundance and distribution Silver perch were abundant in otter trawl collections in basins (Figs. 18.1 and 18.2), indicating that Florida Bay basins are a valuable nursery area for this species. We observed significant differences in mean densities among years, but not months. This species was most abundant in 1996 following a decline in densities from the previous year. Silver perch were distributed mainly in western and north-central Florida Bay. In the Western subdivision, silver perch were most abundant and occurred at a majority of stations (Figs. 18.1 and 18.2).

This species is uncommon in adjacent Biscayne Bay, which is influenced by Straits of Florida waters (Serafy et al., 1997b), and does not appear to inhabit mangrove prop root habitats in Florida Bay and adjacent waters (Thayer et al., 1987b). It is common on western Florida Bay mud banks where it is nocturnally active (Sogard et al., 1989a; 1989b).

Length-frequency distributions Silver perch recruited in Florida Bay throughout the year (Fig. 18.3), indicating protracted spawning. Recruitment appeared to be most intense in April (based on the May distribution), May, and June; hence, recruits during these three months supplied the greatest proportion to the age-0 age class. Based on modes from June through November, silver perch grew approximately 16 mm SL per month. Based on the slight mode in March, fish attain an average length of 110–119 mm SL after one year's growth. Silver perch from Florida Bay are apparently slower growing than fish from temperate estuaries. Fish from Delaware Bay grew 34 mm per month from June through September and attained a size of 130 mm at age-1 (Johnson, 1978).

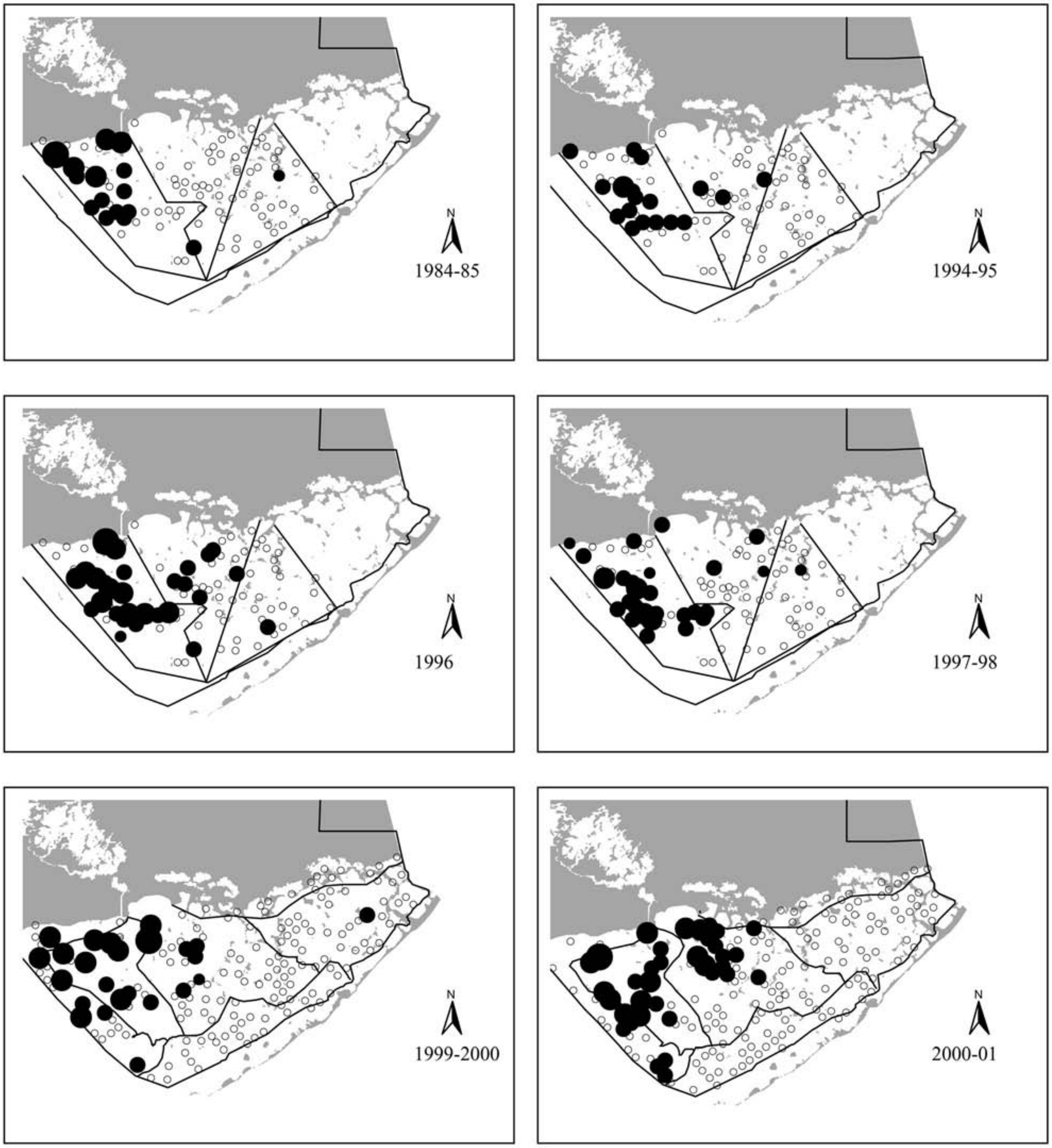


Figure 18.1

Mean densities (numbers 1000 m^{-2}) of silver perch (*Bairdiella chrysoura*) from bimonthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

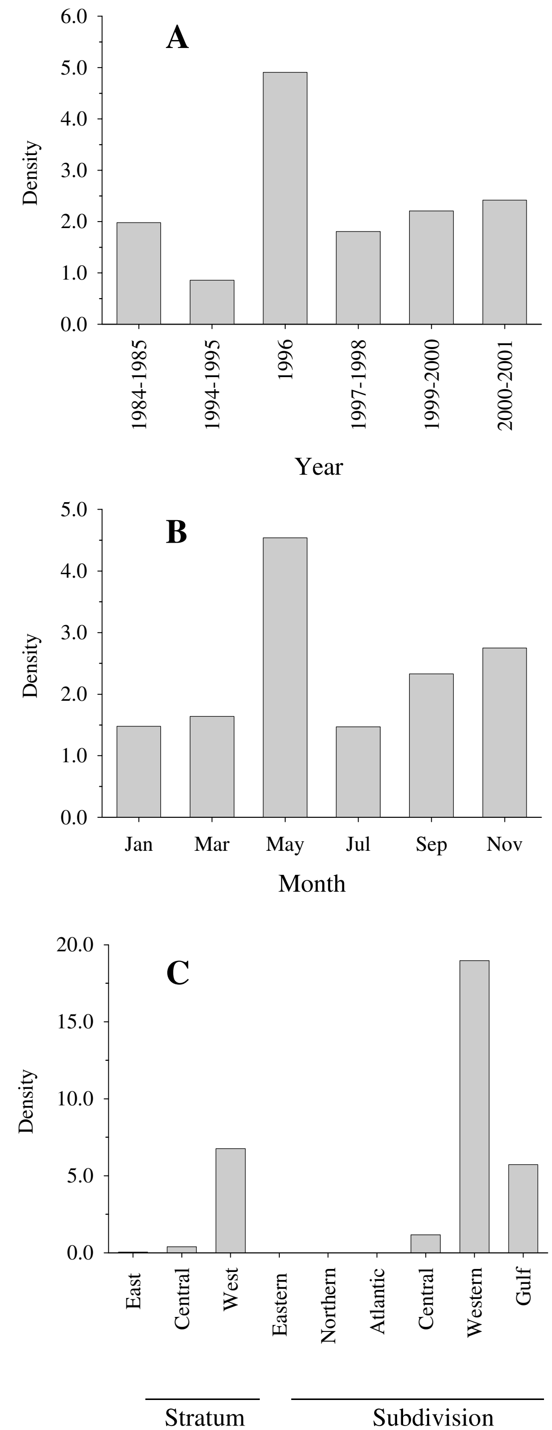


Figure 18.2

Mean densities (numbers 1000 m^{-2}) of silver perch (*Bairdiella chrysoura*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

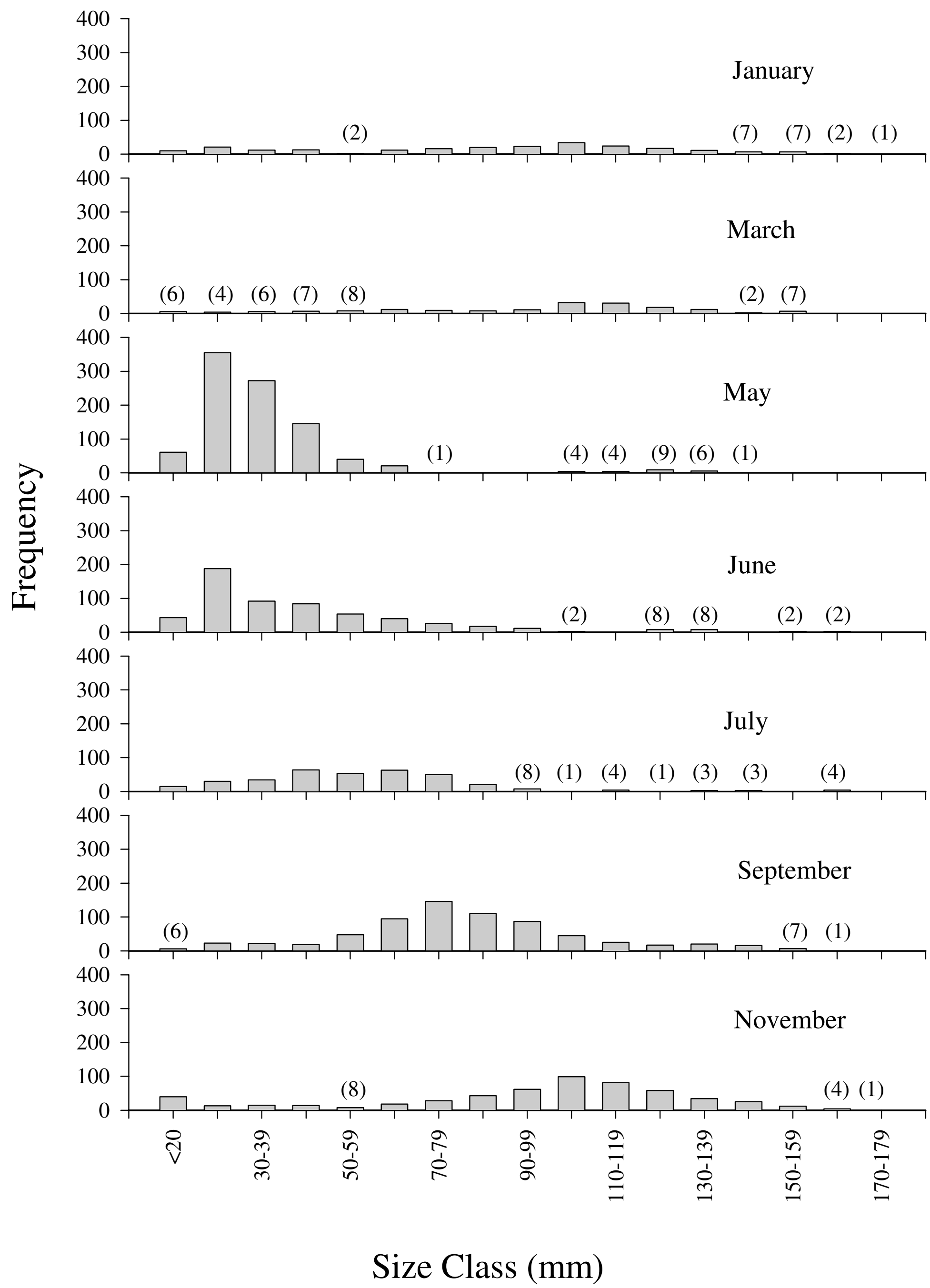


Figure 18.3

Monthly length-frequency distributions of silver perch (*Bairdiella chrysoura*) from Florida Bay. Values are shown for numbers <10 for clarity.

Cynoscion nebulosus (spotted seatrout)

Total numbers collected and rank of spotted seatrout by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	215	19

Life history Spotted seatrout range from New York to the tip of Florida and throughout the Gulf of Mexico to Laguna Madre, Mexico. They are uncommon north of Delaware. They are generally found in estuaries and shallow coastal waters over sand bottoms and in seagrass beds. They spend their entire life history in Florida Bay (Breder, 1948; Chao, 1978; Rutherford et al., 1989). They have a protracted spawning season, are multiple spawners, and reach sexual maturity at an early age (Brown-Peterson and Warren, 2001). Hatchdate distributions calculated for spotted seatrout in Florida Bay (Powell et al., 2004), along with early stage larval collections (Powell, 2003), indicate spotted seatrout spawn between March and October with the majority of spawning occurring between 27° and 35°C , with very little spawning between 20° and 26°C. However, Stewart (1961) observed that spotted seatrout in Florida Bay spawn throughout the year with peaks in spring and fall. Another larval fish study in Florida Bay indicated that some spawning occurs as early as February and continues into December (Rutherford et al., 1989).

Peak spawning activity of spotted seatrout is highly variable (McMichael and Peters, 1989; Brown-Peterson and Warren, 2001). Spawning peaks, based on larval collections in Florida Bay, occur in June, August, and September (Powell, 2003), and early May, late June, and late August/early September, based on 1995 hatchdate distributions (Powell et al., 2004). McMichael and Peters (1989) observed two spawning peaks – spring and summer in Florida waters. Tucker and Faulkner (1987) observed that older fish participate in two peak spawning periods, and a portion of the larger spring-spawned fish (age-1+) enter the spawning population for their first time during their second summer, augmenting the summer spawn.

Eggs of spotted seatrout are pelagic and larvae hatch at 1.3–1.6 mm NL. Settlement occurs between 4–8 mm SL and transformation to the juvenile stage occurs at 10–12 m SL (Ditty and Shaw, 1994; Rooker et al., 1998).

Diet Hettler (1989) reported on the food habits of juvenile spotted seatrout from Florida Bay, mainly from seagrass beds. Smallest juveniles (<30 mm SL) collected in seagrass beds feed mainly on amphipods (*Gammarus* spp.), mysids, and carideans (*Periclimenes* sp. and *Tozeuma carolinensis*). Pink shrimp (*Farfantepenaeus duorarum*) dominate the diet of fish >30 mm SL. At 50 mm SL there is an increase of fish in the diet, mainly the rainwater killifish (*Lucania parva*). Hettler (1989) also observed seasonal shifts in diet that might coincide with the abundance of prey, particularly the seasonal abundance of pink shrimp.

Abundance and distribution Spotted seatrout were common in otter trawl basin collections (Figs. 18.4 and 18.5). Significant differences in mean densities was not observed among years or months, although spotted seatrout were collected at a greater percentage of stations in 1996. There were significant differences among strata and subdivisions. Spotted seatrout were most common in western Florida Bay, but there is an indication that their distribution has extended into the northern central portion of the Bay where hyperhaline conditions can occur.

Thayer et al. (1999), in a comparison between pre- and post-seagrass die-off (1984–1995 vs. 1994–1996), also observed the extension of spotted seatrout into the north central Bay in their 1994–1996 sampling. This extension could be explained by the absence of hyperhaline conditions during this period (Boyer et al., 1999).

Somewhat different than our results, staff at the Florida Marine Research Institute (FMRI), sampling fixed stations with trawls and seines in Florida Bay, collected a considerable number of spotted sea trout in 1994 (n = 317) and 1995 (n = 598) relative to 1996 (n = 130) and 1997 (n = 128). The majority of their fish were also collected in western and north-central Florida Bay (FMRI[1,2,3,4]).

Length-frequency distributions Length-frequency distributions for spotted seatrout were similar from May through November, which is indicative of their protracted spawning habit (Fig. 18.6). Juveniles were fully recruited to our gear at 20–29 mm SL, which equates to 35–50 days old. Growth of larvae and juveniles (<80 mm SL) is best described by the equation $\log_e$ SL = –1.31 + 1.2162 ($\log_e$ age), and for juveniles (12–80 mm SL) by the equation SL = –7.50 + 0.8417 (age). Hence juveniles 12–80 mm SL grow 0.8 mm in SL day^{-1} (Powell et al., 2004).

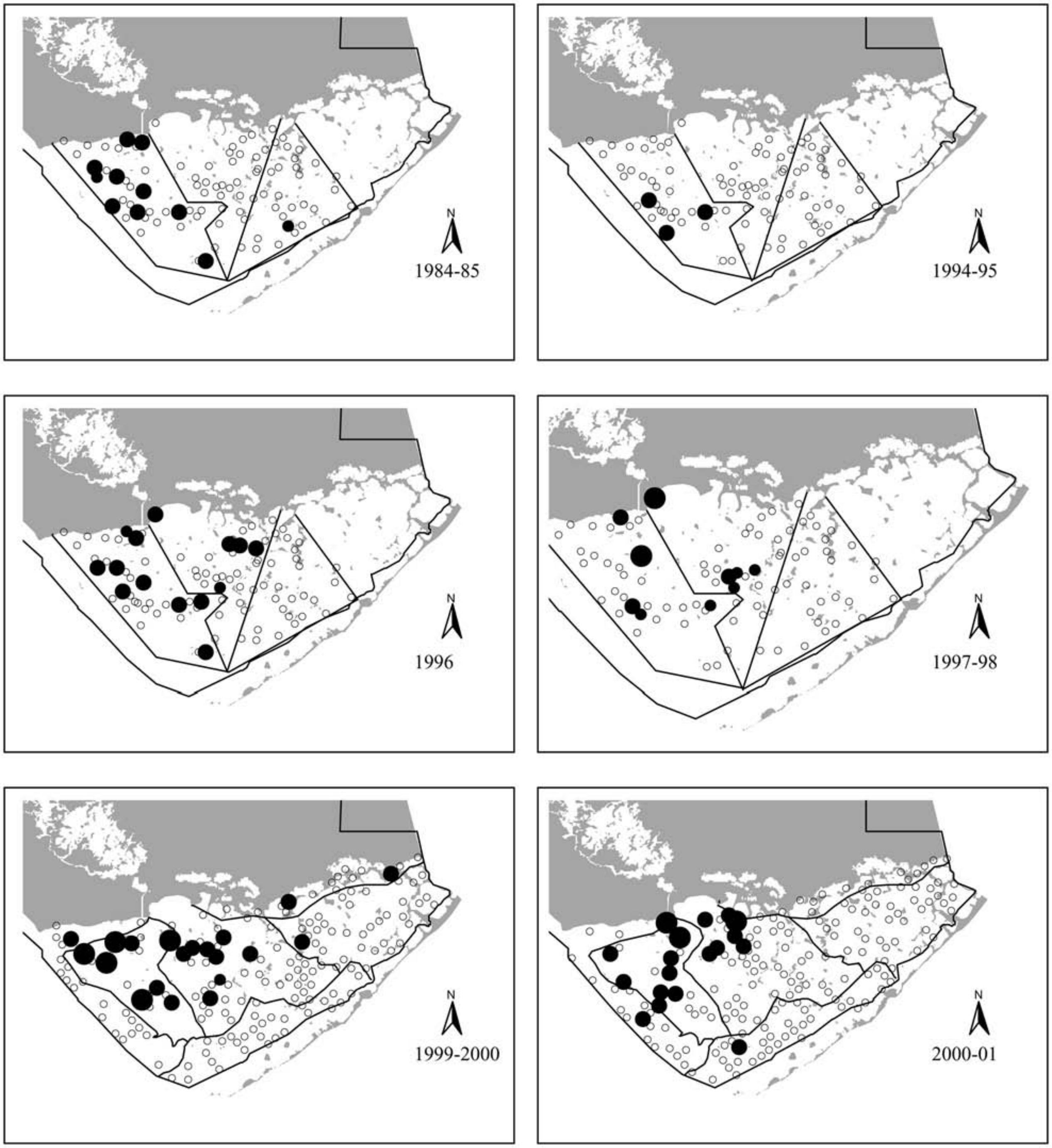


Figure 18.4

Mean densities (numbers 1000 m^{-2}) of spotted seatrout (*Cynoscion nebulosus*) from bimonthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

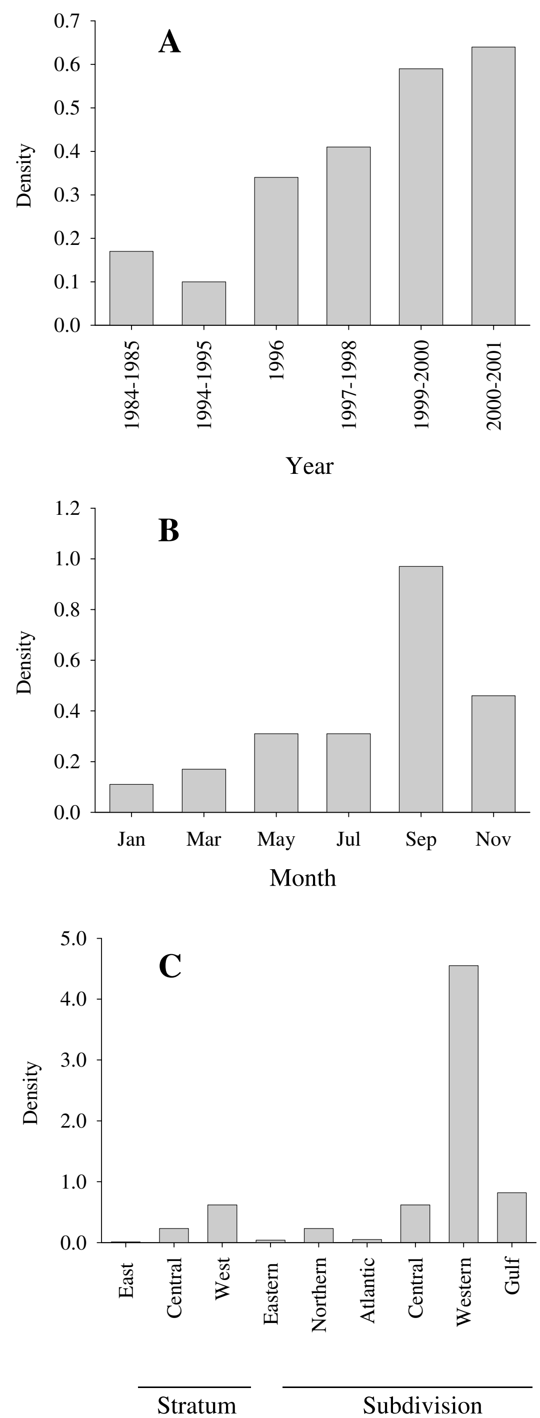


Figure 18.5

Mean densities (numbers 1000 m^{-2}) of spotted seatrout (*Cynoscion nebulosus*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

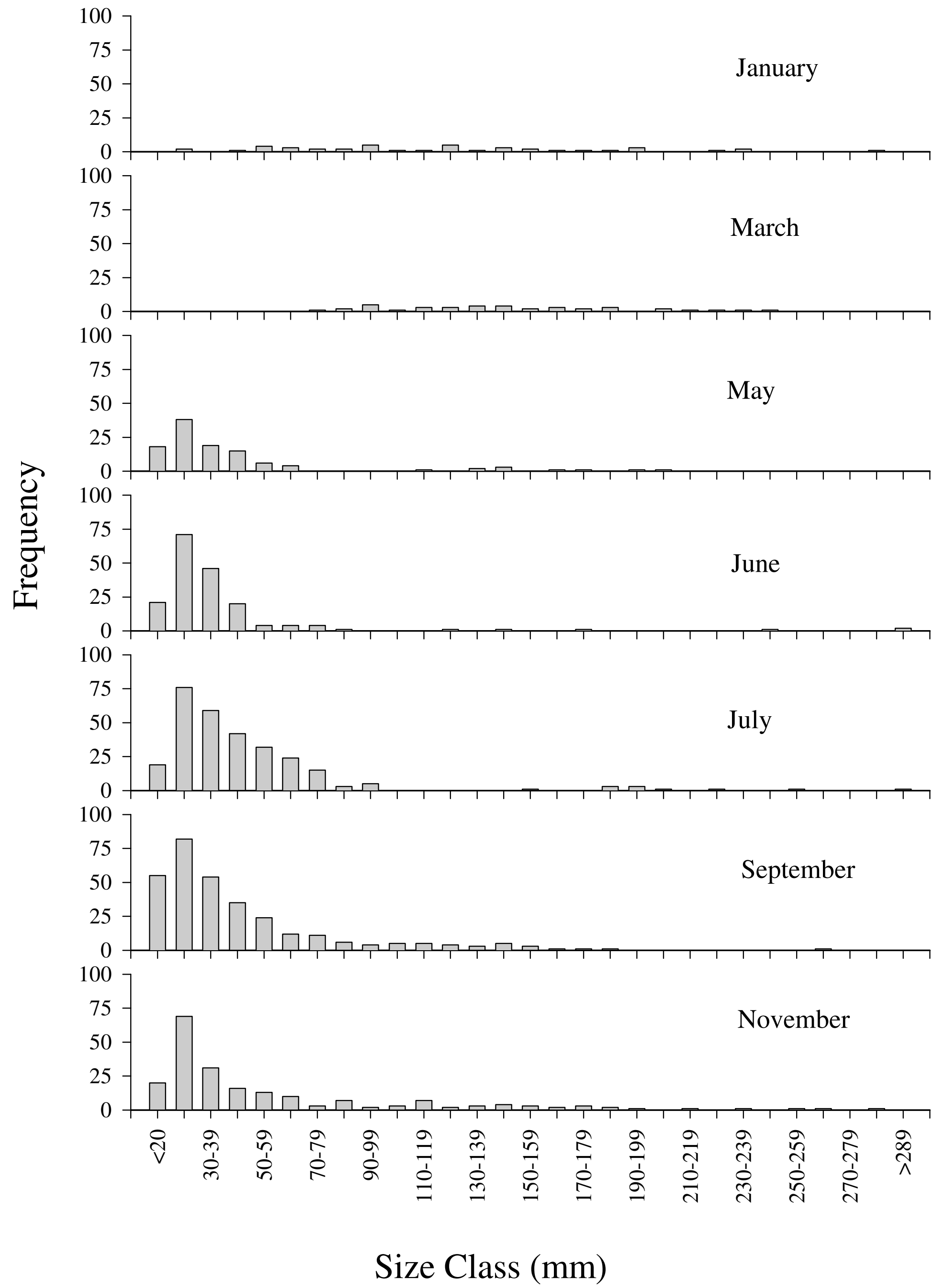


Figure 18.6

Monthly length-frequency distributions of spotted seatrout (*Cynoscion nebulosus*) from Florida Bay.

Chapter 19. Family Sphyraenidae

Sphyraena barracuda (great barracuda)

Total numbers collected and rank of great barracuda by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	88	29

Life history Great barracuda range along the Atlantic coast from Massachusetts to Brazil, throughout the Gulf of Mexico and Caribbean Sea, West Indies, Bahamas, and Bermuda. It is a straggler north of South Carolina. Small individuals inhabit shallow waters, often forming schools, while adults are solitary and inhabit reefs (Breder, 1948; Vergara, 1978b). Great barracuda have been reported to spawn in the Miami, Florida, area from April through October (DeSylva, 1963). Based on hatchdate distributions from juveniles collected in Florida Bay, spawning occurs throughout the year with peaks in summer, but 90% of the spawning is complete by October. Spawning also occurs throughout the lunar year with peaks during the full and new months (Settle et al.[8]). Some males mature at 423 mm SL, with most mature at 460 mm SL (age-2). Females first mature at 533 mm SL (age-3), but most do not mature until 606 mm SL (age-4) (DeSylva, 1963). Eggs are pelagic, size at hatching is unknown, and transformation to the juvenile stage occurs at approximately 12 mm SL (Ditty et al., 1999).

Diet Great barracuda are piscivorus. The diets of juveniles (64–322 mm SL) from Florida Bay mainly consisted of two cyprinodontids – goldspotted killifish *(Floridicthys carpio)* and rainwater killifish (*Lucania parva)* (Schmidt, 1989). These two species are prevalent in seagrass habitat, which was where the great barracuda were collected. The diet of fish from mangrove prop root habitats might differ from those occupying seagrass habitats.

Fishes also dominated the diets of young (<276 mm SL) great barracuda collected in other Florida waters (off Miami), although the diet differed from fish from Florida Bay, with the majority of fishes being small pelagic schooling fishes, especially atherinids and clupeiforms. Young great barracuda collected from the Bahamas also show a preference for fish. Fish smaller than approximately 70 mm SL feed mainly on gobiids; whereas fish >70 mm SL feed mainly on pelagic schooling fishes. This could indicate a transition between habitats and/or prey availability. Smaller fish tend to inhabit detritus-rich shallow water where gobiids, cyprinodontids, and small gerreids are abundant. Older great barracuda inhabit deeper water where pelagic prey species (mainly belonids, carangids, mugilids, clupeiforms, and scombrids) are more common (DeSylva, 1963).

Abundance and distribution Great barracuda were uncommon in otter trawl collections in basins (Figs. 19.1 and 19.2). Spatially, there were no significant differences in densities. Temporally, there were no significant differences in mean densities among years, but there were among months. Densities increased steadily from March through November.

Our estimates of densities in basins probably underestimated the abundance of this species in Florida Bay because juveniles are highly associated with mangrove prop root habitat (Thayer et al., 1987b; Ley and McIvor, 2002). We believe that the low densities of fishes we observed in March and May can be attributed to recruitment and gear avoidance. Great barracuda recruit into Florida Bay at approximately 23–26 mm SL or age 30-d (Settle et al.[8]). As peak spawning occurs during summer, recruitment should begin to increase in July and, with the build-up of cohorts, reach maximum in fall. However, as the fish grow they avoid the gear, hence densities of juveniles would appear to decline during winter and spring. In addition, larger fish move into deeper waters and eventually move out of Florida Bay and on to reefs.

Length-frequency distributions Great barracuda recruited into Florida Bay throughout the year (Fig. 19.3) and were first collected by our gear at approximately 23–26 mm SL (30-d). Growth after ingress averages 2 mm in SL d^{-1} for the first 60-d of residency in Florida Bay, then declines; fish 90-d post-ingress average 185 mm SL, 120-d post-ingress average 210 mm SL (Settle et al.[8]). We observed two patterns of length-frequency distributions. From September through March a wider size range of fishes were collected that might be related to the availability of larger prey.

[8] Settle, L. R., M. D. Greene, E. H. Laban, and M. Lacroix. Unpublished manuscript. Growth, condition, survival and spawning-date distribution of juvenile great barracuda, *Sphryaena barracuda* (Walbaum, 1792) in Florida Bay. NOAA, Center for Coastal Fisheries and Habitat Research, 101 Pivers Island Road, Beaufort, NC 28516.

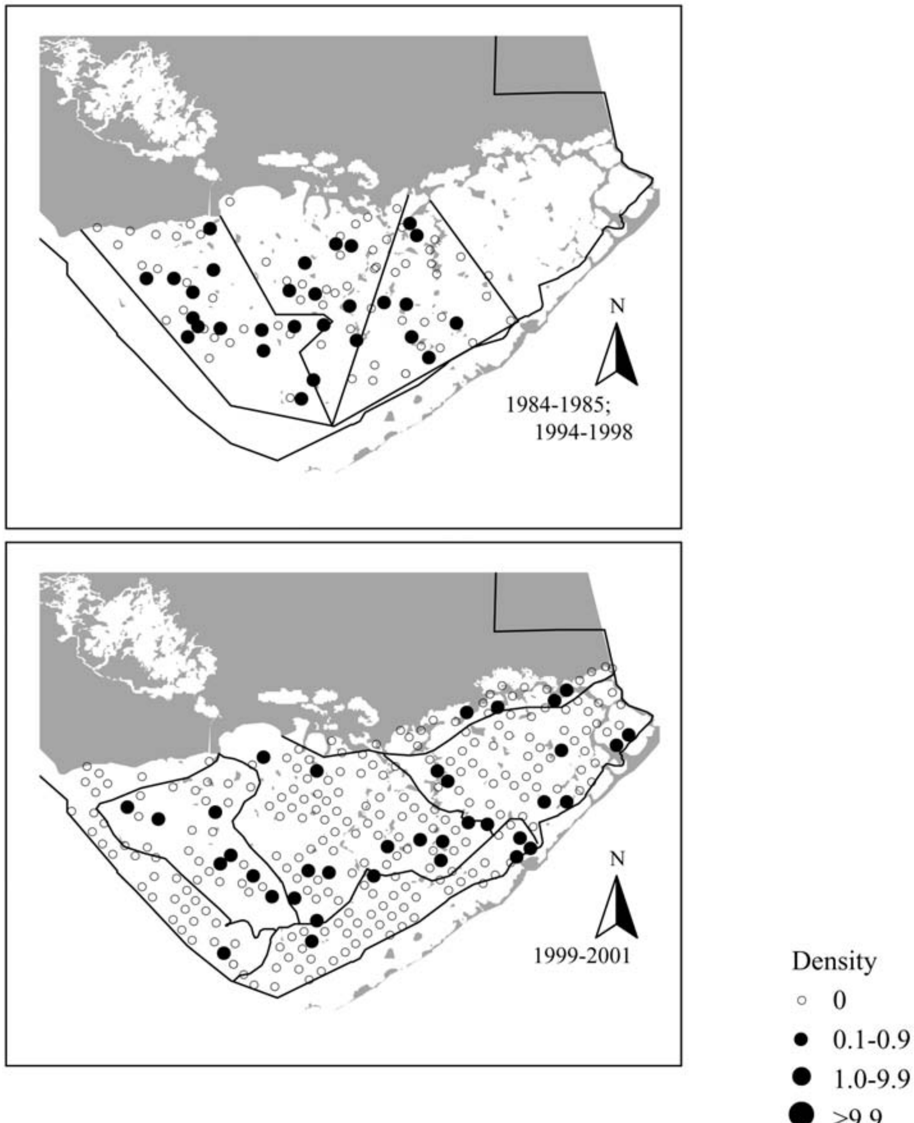


Figure 19.1

Mean densities (numbers 1000 m^{-2}) of great barracuda (*Sphyraena barracuda*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

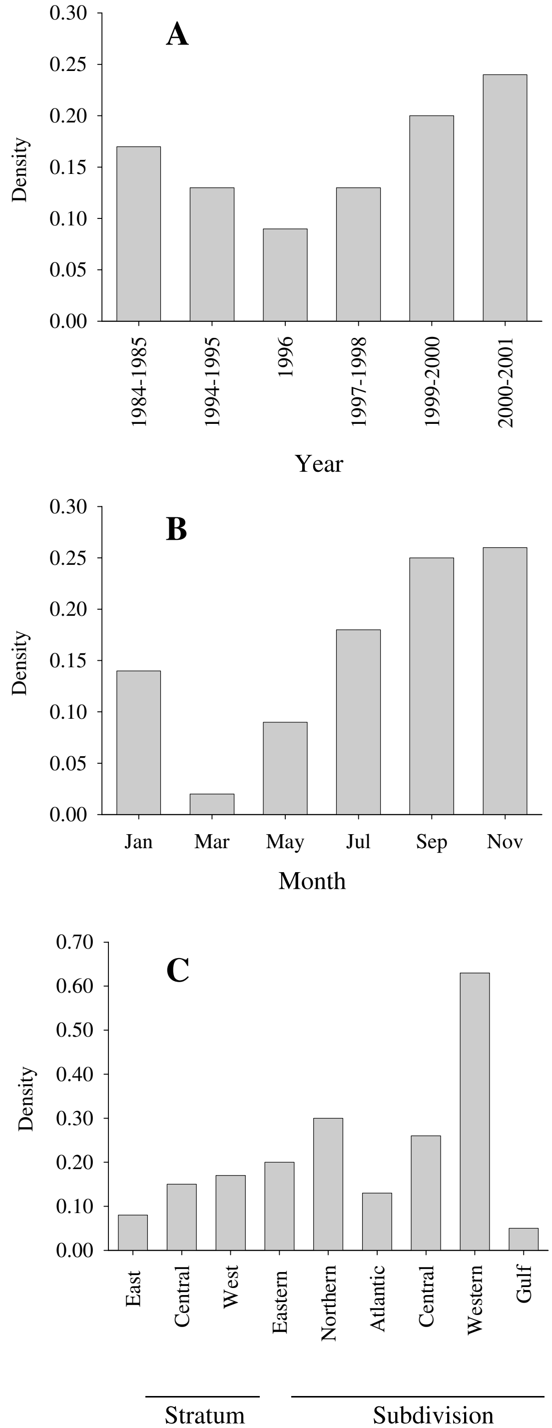


Figure 19.2

Mean densities (numbers 1000 m^{-2}) of great barracuda (*Sphyraena barracuda*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

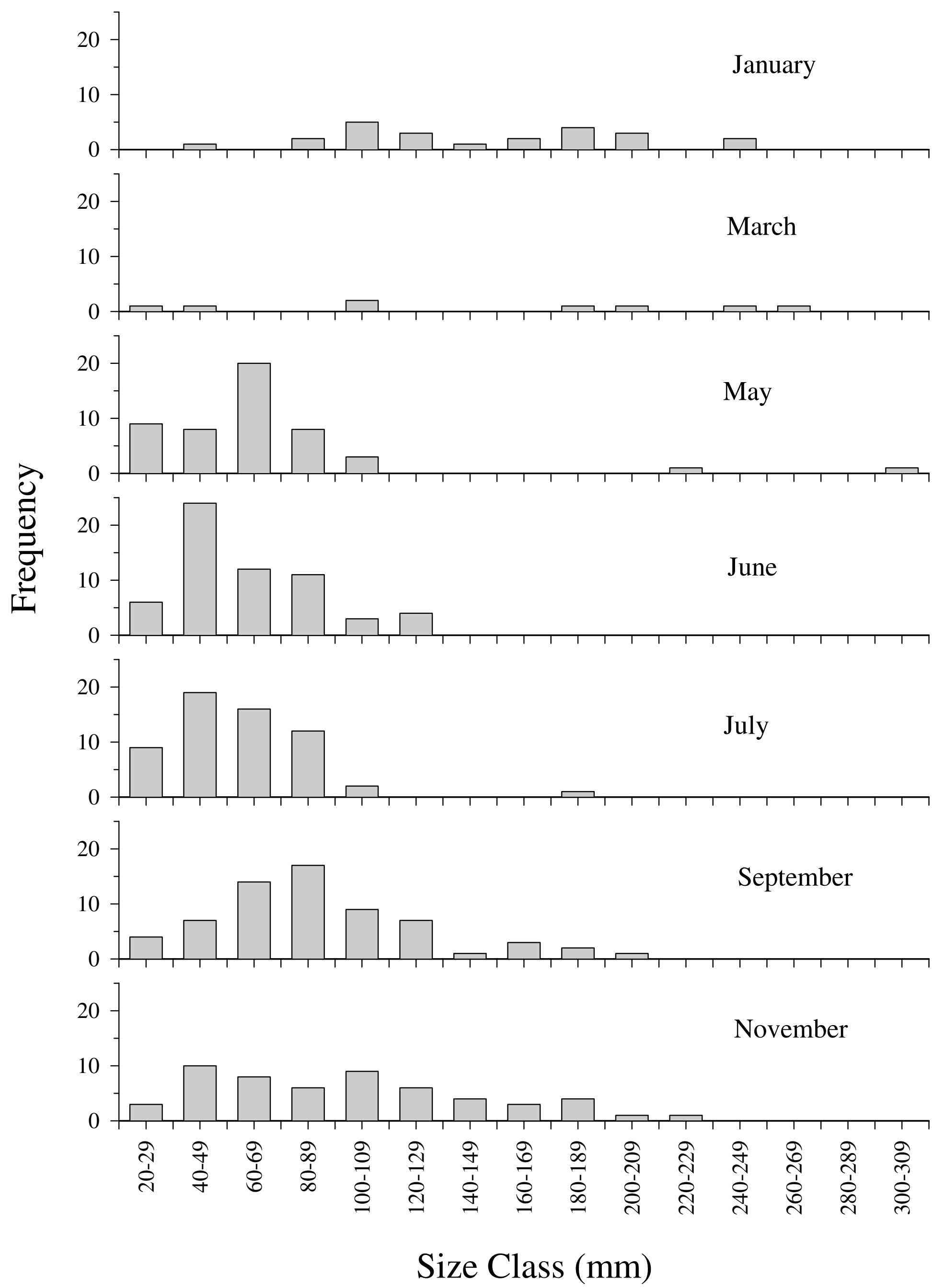


Figure 19.3

Monthly length-frequency distributions of great barracuda (*Sphyraena barracuda*) from Florida Bay.

Chapter 20. Family Scaridae

Nicholsina usta (emerald parrotfish)

Total numbers collected and rank of emerald parrotfish by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	55	39

Life history Emerald parrotfish range along the Atlantic from New Jersey to Brazil, Caribbean Sea, and in the West Indies only from Cuba and Hispaniola. It is probably uncommon north of South Carolina. The preferred habitat appears to be turtle grass beds (Breder, 1948; Randall, 1978). The eggs of other scarid species that have been studied are pelagic (Thresher, 1991).

Diet Based on the preferred habitat (*Thalassia testudinum* beds), dentition, and pharyngeal bone morphology, emerald parrotfish most probably feed on plant material. Unlike most other scarid species, that have fused teeth that form beak-like dental plates that allow them to graze on algae from corals; emerald parrotfish front teeth are fused basally, but the tips are separate and pointed (Randall, 1983). Their dentition, along with their pharyngeal bone morphology (pharyngeal mill), appears to be adapted to consume seagrasses.

Abundance and distribution Emerald parrotfish were uncommon in otter trawl collections in basins (Figs. 20.1 and 20.2) and were ranked lowest. Significant differences in mean densities were observed among years but not months. This species was collected in highest densities in recent collections, and despite being uncommon, it was collected in every bi-monthly sampling period (Figs. 20.1 and 20.2). Spatially, differences among stratum and subdivision were observed. Emerald parrotfish were collected almost entirely in western Florida Bay.

Tabb and Manning (1961) reported that this species was moderately common in western Florida Bay in clear waters of *Thalassia* flats. It was rarely collected in grassy shore habitat on the Atlantic side of the Florida Keys adjacent to Florida Bay (Springer and McErlean, 1962). This species has not been collected from Florida Bay mud banks (Sogard et al., 1987; 1989a).

Length-frequency distributions We were unable to discern any patterns in recruitment or growth of emerald parrotfish from length-frequency distributions (Fig. 20.3). A relatively wide range of sizes was encountered during most months. Emerald parrotfish, which attain a maximum length of 300 mm (Robins and Ray, 1986), appeared to leave Florida Bay basins at >200 mm SL and move to deeper water.

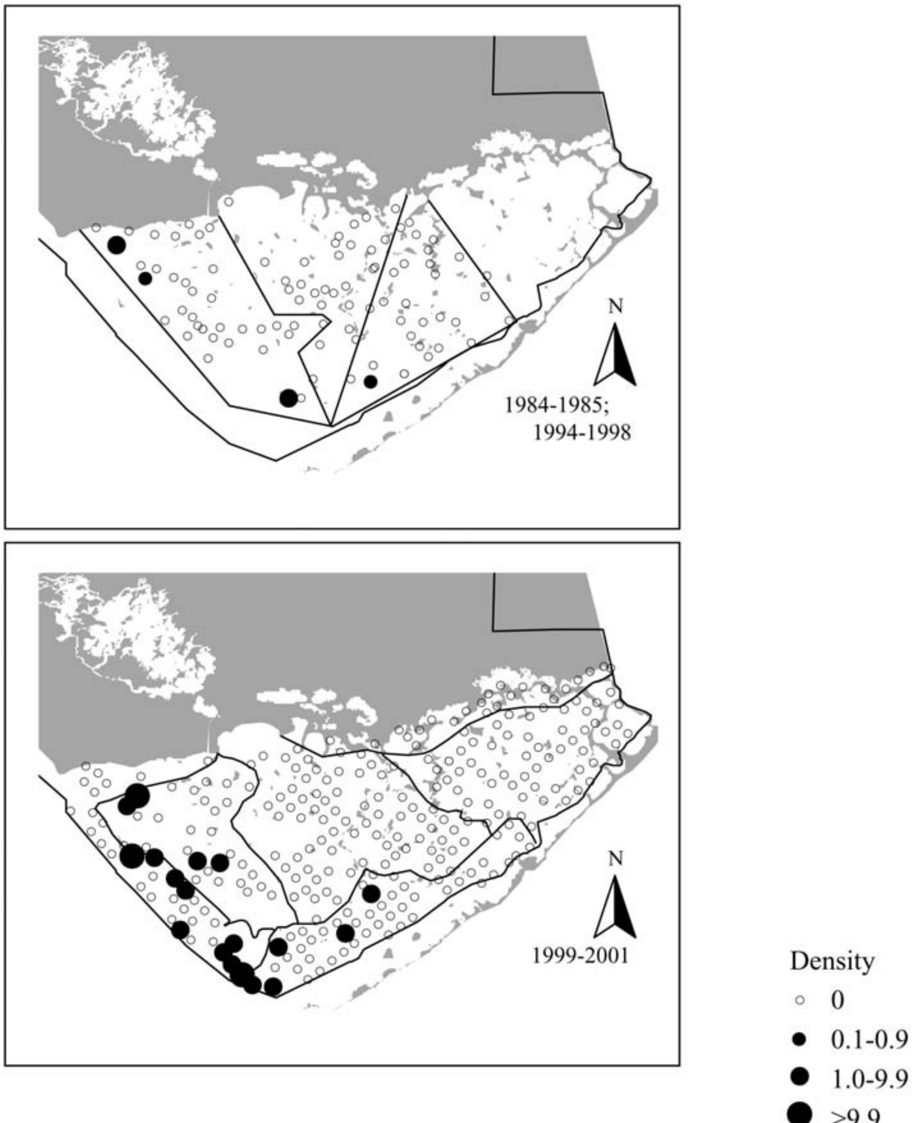


Figure 20.1

Mean densities (numbers 1000 m^{-2}) of emerald parrotfish (*Nicholsina usta*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

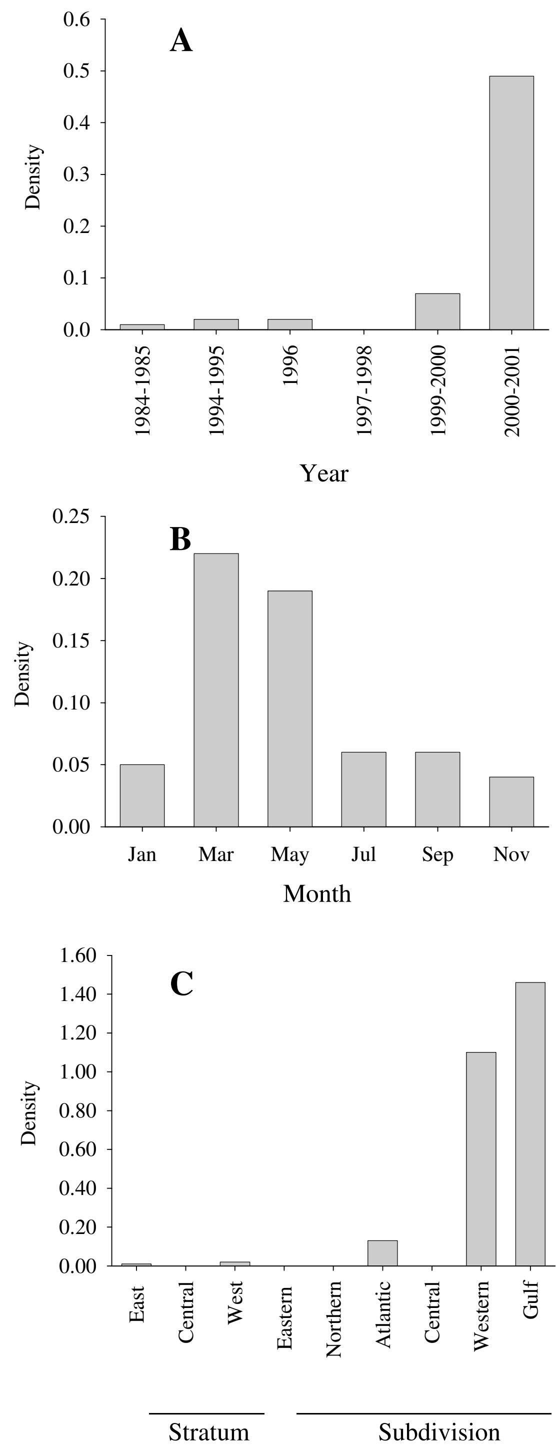


Figure 20.2

Mean densities (numbers 1000 m^{-2}) of emerald parrotfish (*Nicholsina usta*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

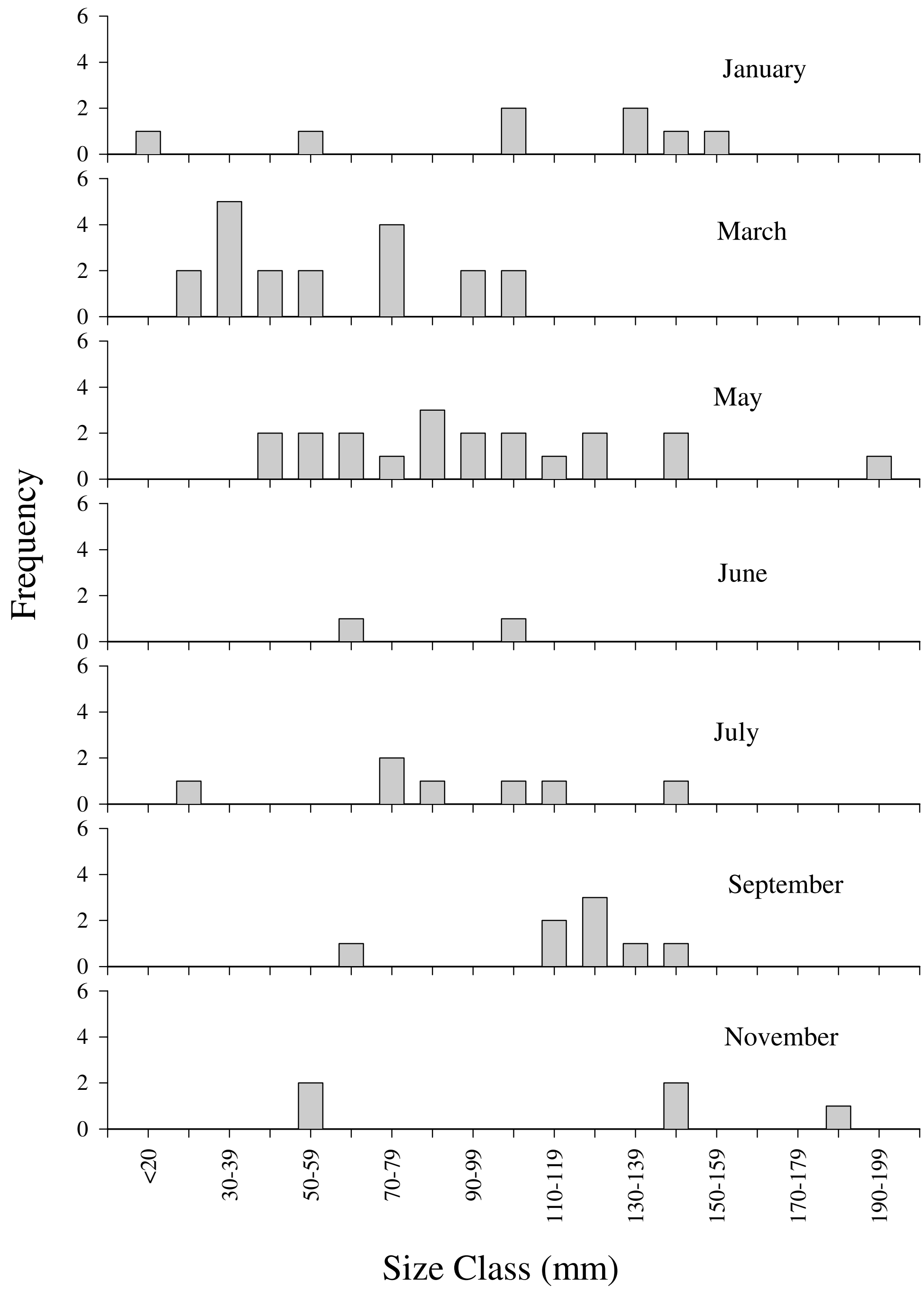


Figure 20.3

Monthly length-frequency distributions of emerald parrotfish (*Nicholsina usta*) from Florida Bay.

Chapter 21. Family Callionymidae

Diplogrammus pauciradiatus (spotted dragonet)

Total numbers collected and rank of spotted dragonet by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	66	36

Life history Spotted dragonet range from North Carolina to Columbia and Bermuda. They inhabit seagrass beds in sub-tropical waters and the continental shelf (18–55 m) in temperate waters. Spawning occurs throughout the year in tropical waters and from spring through fall in temperate and sub-tropical waters (Powell and Greene, 2000). Based on larval collections, peak spawning in adjacent Biscayne Bay occurs in spring (Houde and Lovdal, 1984), whereas in Florida Bay peak spawning occurs from May through July and September (Powell, 2002). Males first mature at 12–15 mm SL, females at 11–12 mm SL. Eggs and larvae are pelagic. Spotted dragonet hatch at <1.2 mm NL and size at settlement is approximately 8 mm SL (Davis, 1966; Powell and Greene, 2000). This species, which is a resident species in Florida Bay, lives for only one year (Sogard, 1984).

Diet Spotted dragonet in adjacent Biscayne Bay fed mainly on meiofauna. Harpacticoid copepods were the most important food item throughout ontogeny, followed by smaller amounts of ostracods, mites, nematodes, gastropods, and amphipods. They have small mouths and highly protrusible jaws that allow them to select small individual prey (Sogard, 1984).

Abundance and distribution Spotted dragonet were uncommon in otter trawl collections in basins (Figs. 21.1 and 21.2). Temporally, there were only significant differences in mean densities among months. They were collected in greatest densities during summer and to a lesser degree in winter (Fig. 21.2). Spatially, there were differences among strata and subdivisions. Juveniles and adults of this species mainly were collected in the central and eastern section of Florida Bay (Figs. 21.1 and 21.2), mirroring the distribution of their larvae (Powell et al., 1989; Powell, 2002).

The temporal differences we observed among months could be linked to differential spawning activity. Significant differences in larval densities among months and peak spawning periods have been observed (Powell, 2002). Hence, high densities of spotted dragonet during certain periods could be a result of differential spawning activity.

On Florida Bay mud banks, this species was almost exclusively collected at Buchanan Keys (Fig. 1.1), a site with no freshwater input, minor salinity changes, and dense stands of *Thalassia testudinum* and green algae (Sogard et al., 1987). Although spotted dragonet were uncommon in our otter trawl collections, their larvae are a dominant component of the ichthyoplankton in Biscayne Bay and Florida Bay (Houde and Lovdal, 1984; Powell et al., 1989; Powell, 2002).

Length-frequency distributions Our collections were mainly comprised of adults (approximately >15 mm SL), though juveniles were most likely extruded through our gear (Fig. 21.3). Fish >40–44 mm SL were rarely collected, which suggested that it attains a length of 40–44 mm SL after one year of growth and dies shortly thereafter. We observed modes at 20–24 mm SL in four of seven months that probably have little biological meaning, but represent the size that spotted dragonet are fully recruited to the gear (Fig. 21.3).

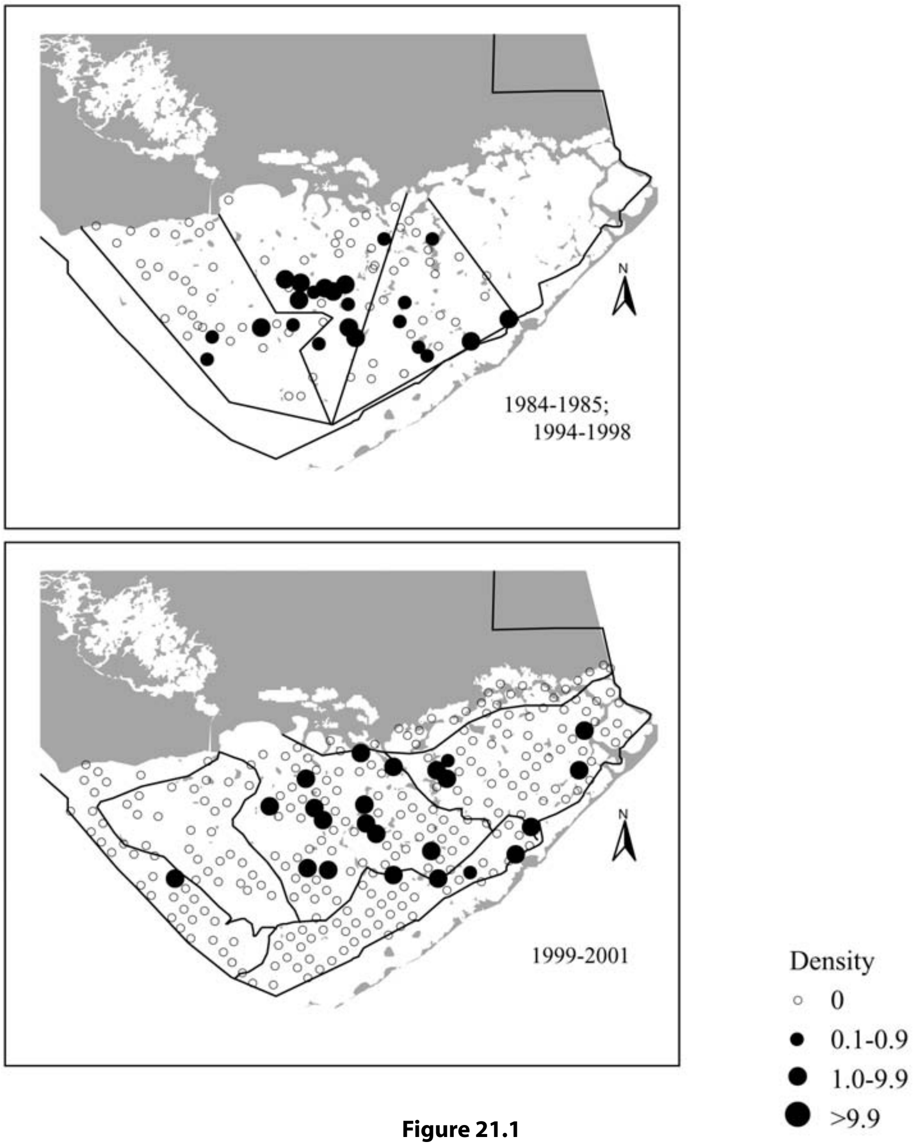


Figure 21.1

Mean densities (numbers 1000 m^{-2}) of spotted dragonet (*Diplogrammus pauciradiatus*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984-1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

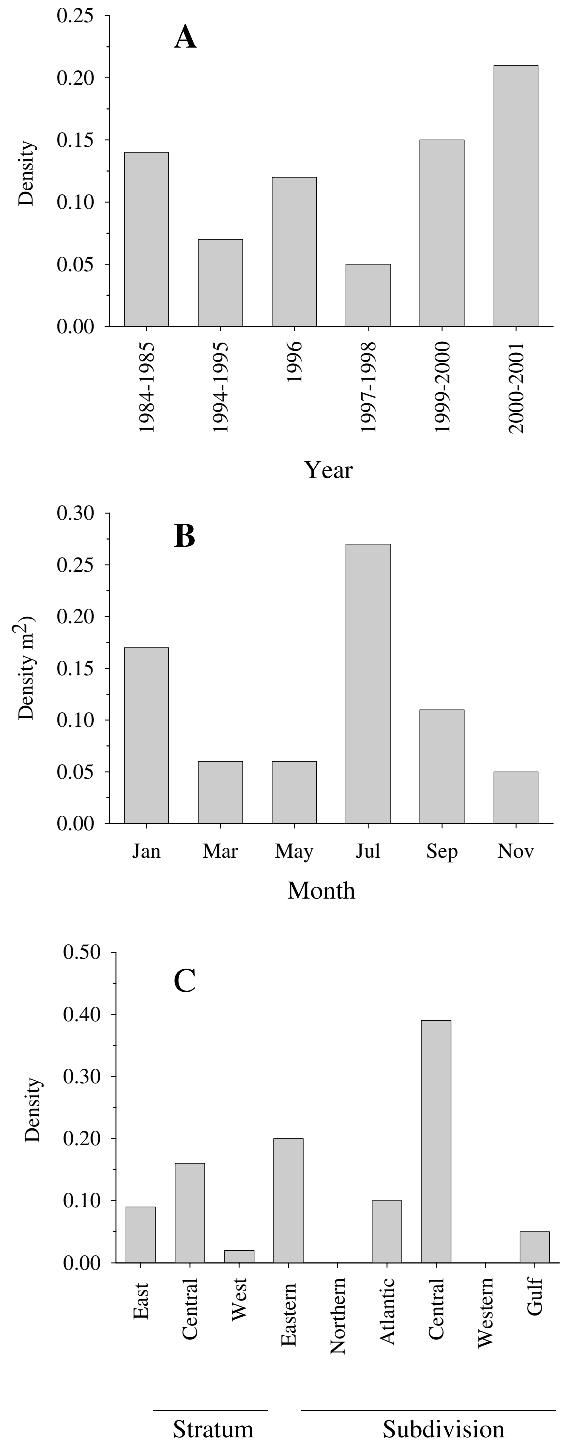


Figure 21.2

Mean densities (numbers 1000 m^{-2}) of spotted dragonet (*Diplogrammus pauciradiatus*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

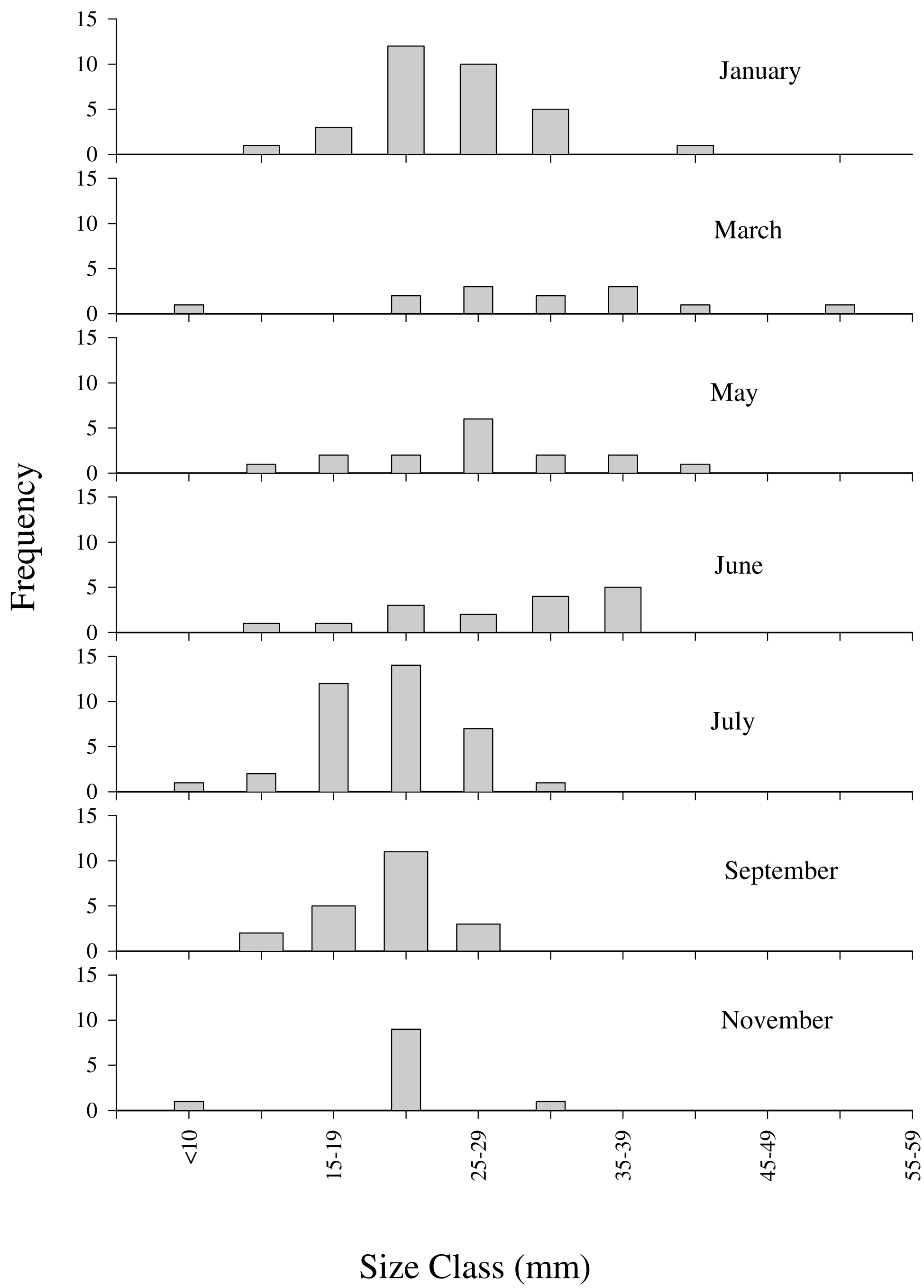


Figure 21.3

Monthly length-frequency distributions of spotted dragonet (*Diplogrammus pauciradiatus*) from Florida Bay.

Chapter 22. Family Gobiidae

Gobiosoma robustum (code goby)

Total numbers collected and rank of code goby by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	313	16

Life history Code goby range from northeast Florida to the Florida Keys and throughout the Gulf of Mexico. They are generally found in seagrass beds and algae mats in shallow protected fully saline waters (Robins and Ray, 1986). Code gobies spawn throughout the year in Gulf of Mexico waters. Eggs are demersal and attach by adhesive threads to shells or sponges, and larvae are pelagic. The juvenile stage is reached at 6–8 mm SL and males attain sexual maturity at 16 mm SL, females at 16–22 mm SL (Breder, 1942; Pattillo et al., 1997).

Diet Seasonal variation was observed in the diets of fish 11–20 mm SL from Texas waters that were linked to prey availability (Huh and Kitting, 1985). During spring and fall, amphipods and polychaetes were dominant diet items, whereas during winter copepods were heavily preyed on. Fish >20 mm SL had a consistent diet throughout the year regardless of prey availability. Amphipods were the dominant prey for this size group (Huh and Kitting, 1985). In the Whitewater Bay system (North River), Odum and Heald (1972) found little seasonal changes in the diets of fish 15–35 mm SL. Fish consumed mainly amphipods with smaller quantities of chironomid larvae, mysids, and cladocerans. Smaller fish (7–15 mm SL) fed on harpacticoid copepods, juvenile mysids, cumaceans, and many pennate diatoms.

Abundance and distribution Code goby were common in otter trawl collections in basins (Figs. 22.1 and 22.2). There were no significant differences in mean densities among months or years, but there were differences in mean densities among strata and subdivisions. This species was most abundant in central and western Florida Bay (Figs. 22.1 and 22.2).

Sogard et al. (1987) collected the greatest number of the code goby over a mudbank near Buchanan Keys (Fig. 1.1), located in our Atlantic subdivision where we encountered the lowest densities. Their mudbank station was characterized by lush *T. testudinum* stands and high coverage of green algae, which suggested that in areas where overall seagrass densities are relatively low, the code goby will exploit locally lush seagrass stands (Schofield, 2003). This species also has an affinity for mangrove prop root habitat (Thayer et al., 1987b). Code goby have been observed to occur at low densities when prey densities are low (Huh and Kitting, 1985).

Length-frequency distributions Length-frequency distributions were uni-modal and monthly distributions were quite similar, which suggested that recruitment occurred throughout the year (Fig. 22.3). Both juveniles (approximately <20 mm SL) and adults were collected, but we did not collect large adults that attain a size of 75 mm TL (Robins and Ray, 1986).

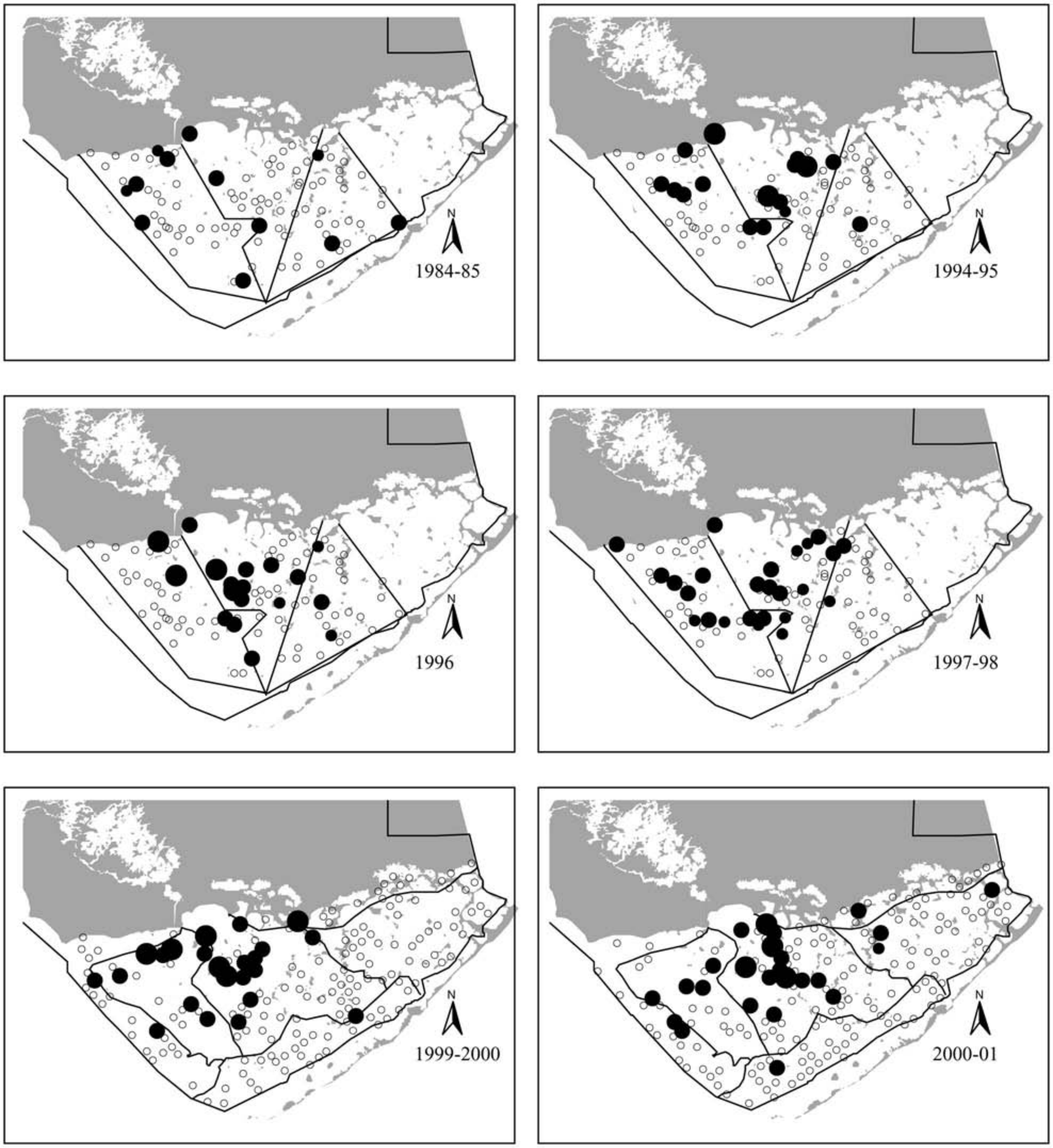


Figure 22.1

Mean densities (numbers 1000 m^{-2}) of code goby (*Gobiosoma robustum*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

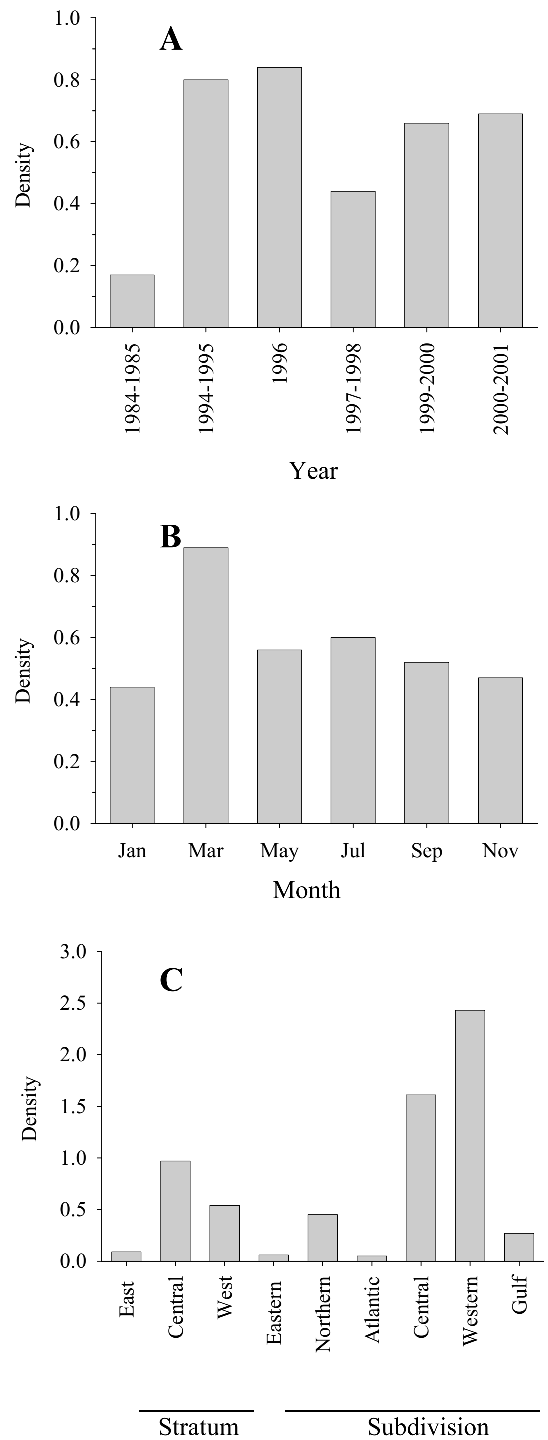


Figure 22.2

Mean densities (numbers 1000 m^{-2}) of code goby (*Gobiosoma robustum*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

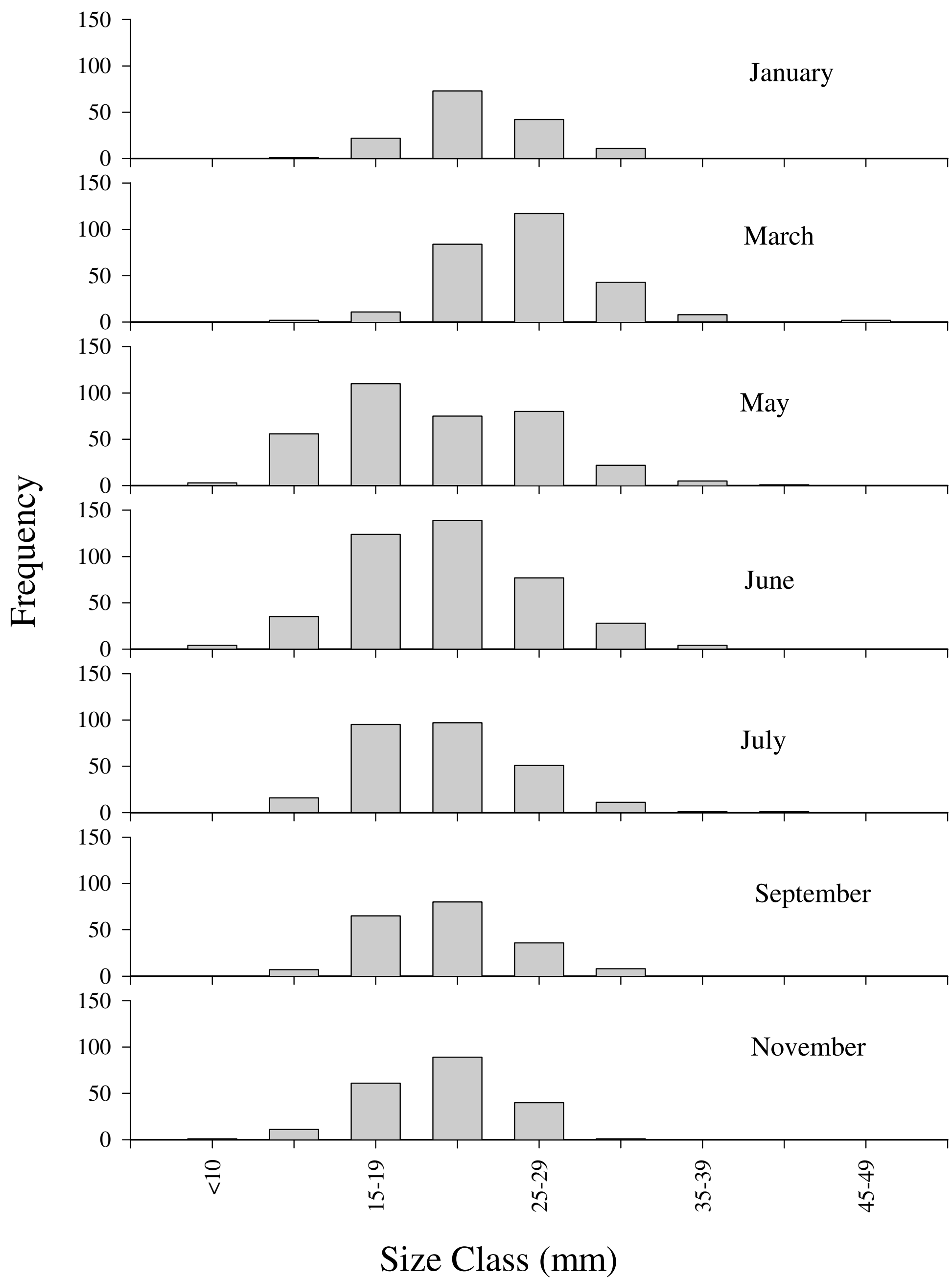


Figure 22.3

Monthly length-frequency distributions of code goby (*Gobiosoma robustum*) from Florida Bay.

Microgobius gulosus (clown goby)

Total numbers collected and rank of clown goby by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	307	17

Life history The clown goby ranges along the Atlantic coast from Maryland to south Florida, around the tip of Florida, and throughout the northern Gulf of Mexico to Texas, where it occurs in muddy waters in variable salinities (Robins and Ray, 1986). In estuaries near Cape Canaveral, spawning, based on gonosomatic indices, was reported to begin in mid-spring, decline and remain low through fall and winter, then increase in intensity in late winter (Provancha and Hall, 1991). Both Reid (1954) and Kilby (1955) reported year round spawning in northwestern Florida estuarine waters. Eggs are demersal (Thresher, 1991) and larvae are pelagic. Females appear to mature at 35 mm TL (Provancha and Hall, 1991).

Diet Clown goby are opportunistic feeders. In eastern Florida estuaries, clown goby diets vary by location. Between two sites the diet is dominated either by crustaceans (tanaids, amphipods, decapods, and cumaceans) or annelids (Provancha and Hall, 1991). Reid (1954) examined clown goby diet (15–57 mm SL) from Cedar Key, Florida, and found they mainly consume copepods, mysids, and amphipods. In the Whitewater Bay system (North River), Odum and Heald (1972) reported that the diet of the clown goby is similar to that of the code goby. They consume mainly amphipods followed by hapacticoid copepods, chironomid larvae, and cumaceans; cladocerans, algal strands, plant detritus, and mysids make up a smaller percentage. Clown gobies (11–40 mm SL) from Crystal River, Florida, are considered to be omnivores, but all size classes consume a considerable amount of detritus. Fish in the size range of 11–25 mm SL consume mainly detritus and copepods; those 26–40 mm SL shift to a diet of primarily detritus, amphipods, and polychaetes. Sand is present in the stomachs of all size classes, indicating juveniles of this species feed directly on the bottom (Carr and Adams, 1973).

Abundance and distribution Clown goby were common in otter trawl collections (Figs. 22.4 and 22.5). Temporally, there were significant differences in mean densities among years; this was most probably influenced by change in sampling design, since prior to 1999 sampling rarely occurred in north-central and northeastern Florida Bay (Fig. 22.4). Significant differences among months were also observed. Highest densities were observed in July (Fig. 22.5), which could be influenced by recruitment patterns (Fig. 22.6). Spatially, there were significant differences in mean densities. This species was markedly more abundant in north-central and northeastern Florida Bay (Figs. 22.4 and 22.5).

Provancha and Hall (1991) also observed variation in clown goby mean monthly densities and suggested that differences in densities could also be influenced by recruitment patterns. However, their observations of clown goby abundance patterns at Cape Canaveral, Florida, differed from what we observed in Florida Bay.

Our results are in concordance with those of Sogard et al. (1987) who found highest densities of this species on mud banks in sparsely vegetated northeastern Florida Bay. Both the code goby (see above) and the clown goby are ecologically similar (Schofield, 2003); however, their relative densities are dissimilar in the Bay. Their distributions overlap somewhat, but the code goby is most prevalent in western and central Florida Bay where seagrass densities are relatively lush, while the clown goby inhabits sparsely vegetated sites. Clown goby prefers muddy sediments and quiet waters where it burrows in the bottom (Birdsong, 1981). When paired with the code goby in laboratory experiments, the clown goby is pushed out of a structured habitat that is the preferred habitat of the code goby (Schofield, 2003). Based on these results, Schofield (2003) concluded that when these species occur sympatrically, competition appears to modify their habitat selection.

Length-frequency distributions The majority of clown goby were young-of-the-year (30–34 mm SL) based on estimates by Provancha and Hall (1991; 35–40 mm TL at end of first year), but few were ripe adults (>35 mm TL; ca. 30 mm SL) (Fig. 22.6). Spawning appeared to occur throughout the year.

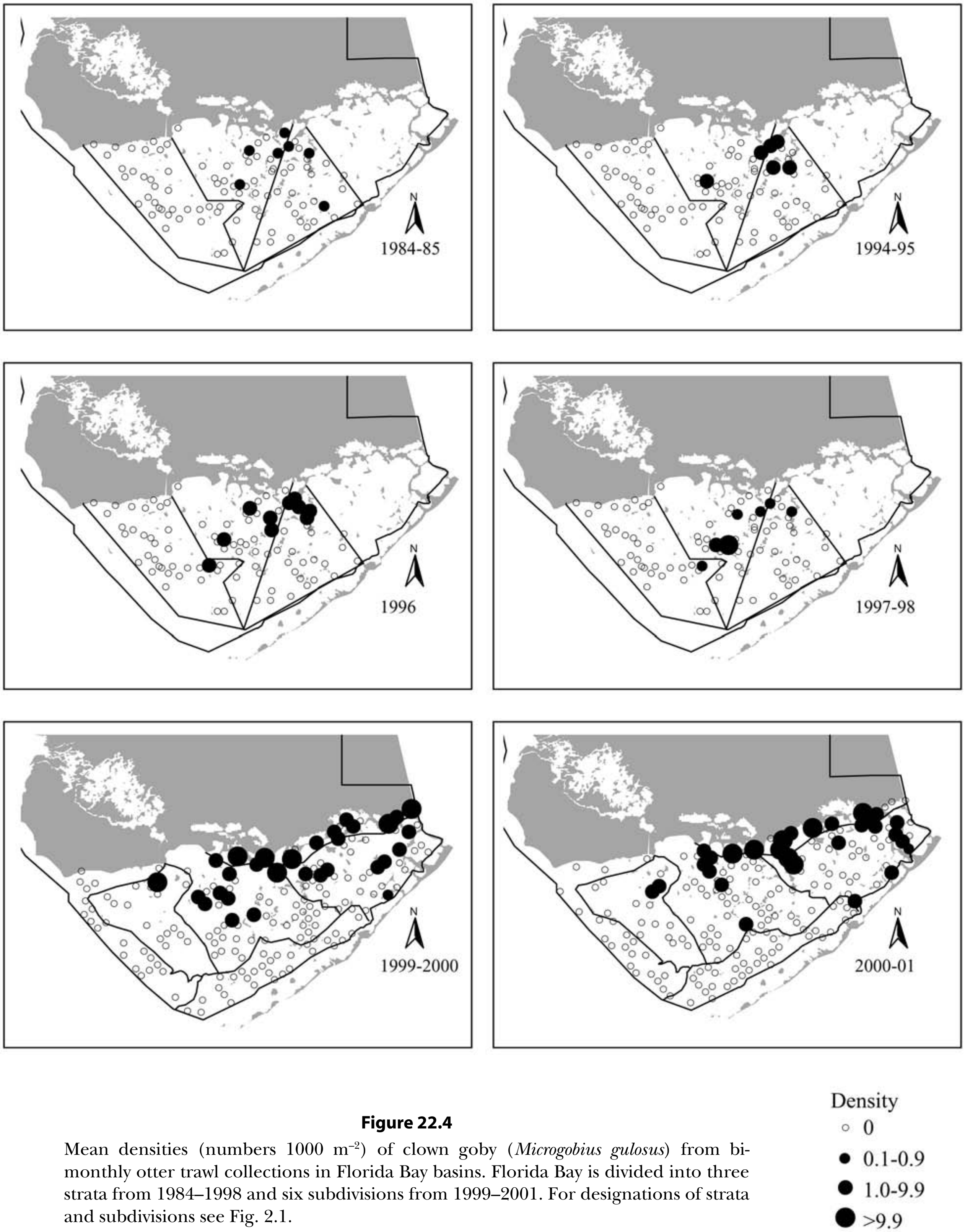


Figure 22.4

Mean densities (numbers 1000 m^{-2}) of clown goby (*Microgobius gulosus*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

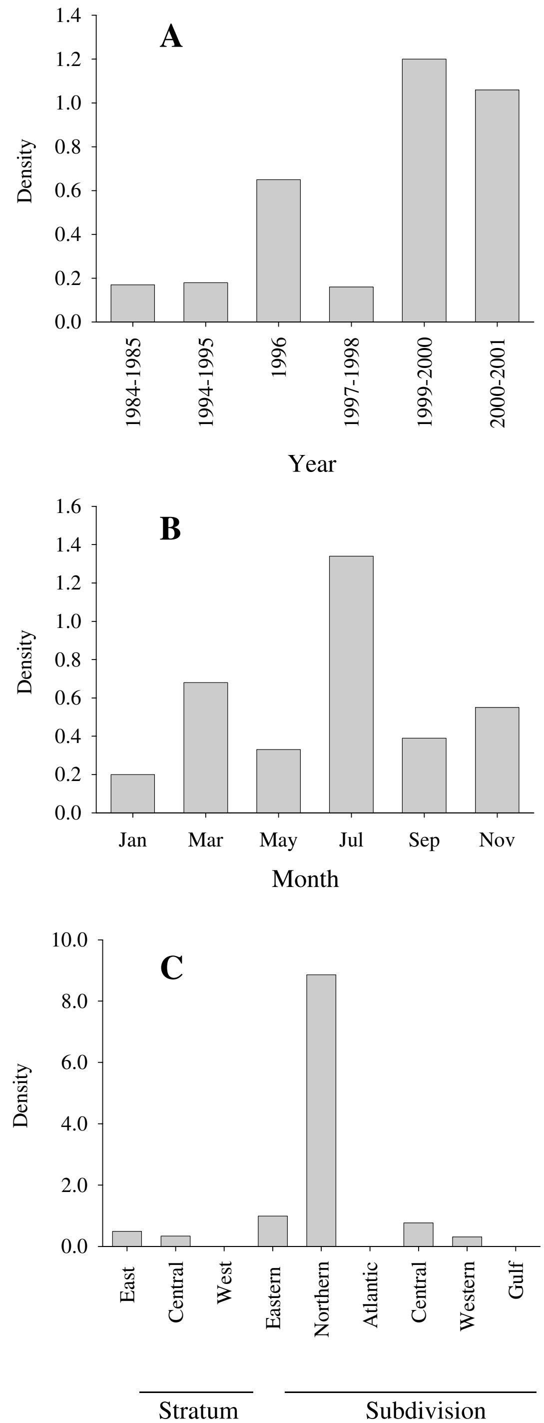


Figure 22.5

Mean densities (numbers 1000 m^{-2}) of clown goby (*Microgobius gulosus*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

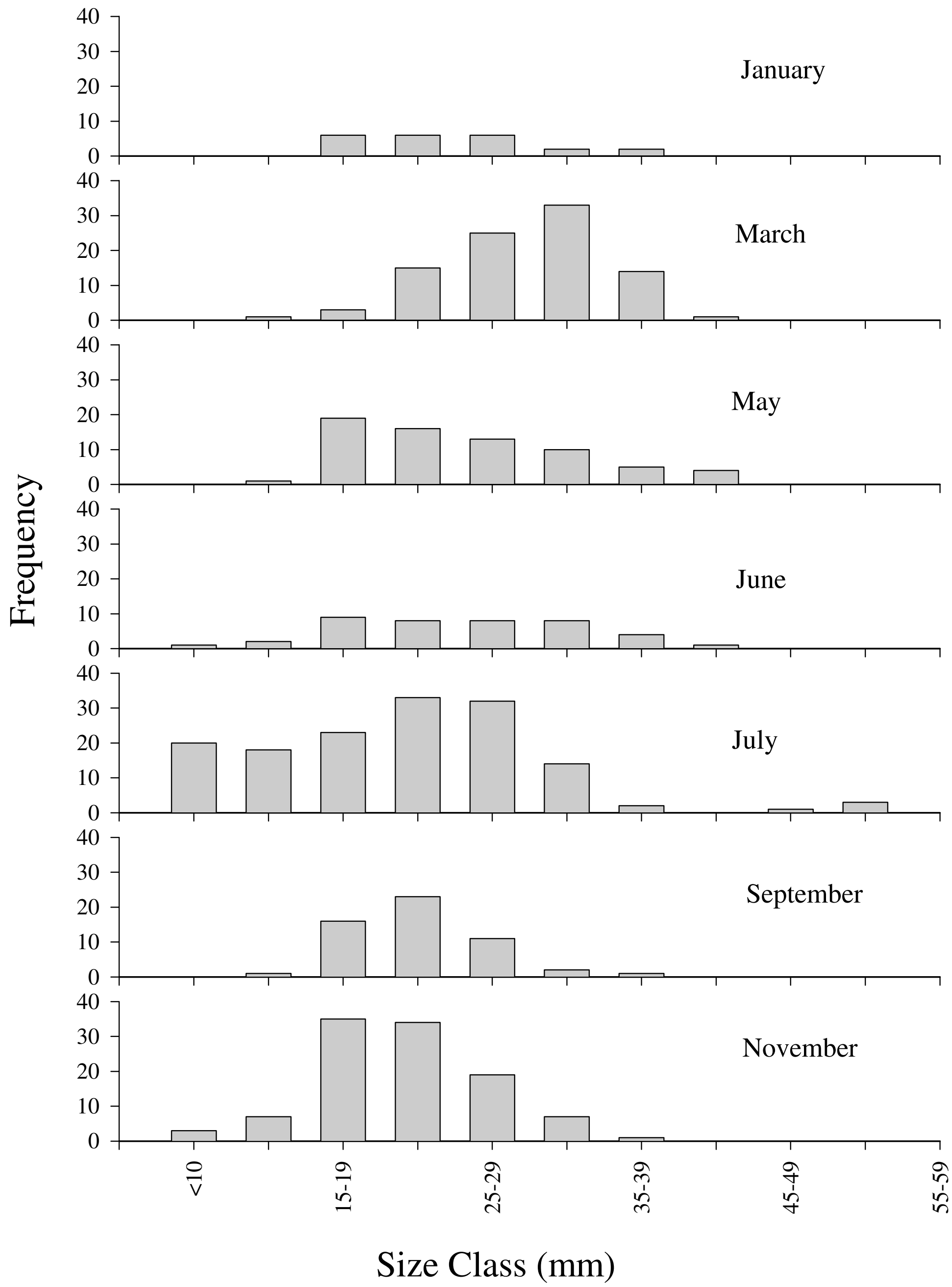


Figure 22.6

Monthly length-frequency distributions of clown goby (*Microgobius gulosus*) from Florida Bay.

Microgobius microlepis (banner goby)

Total numbers collected and rank of banner goby by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	156	22

Life history Banner goby range from south Florida to Yucatan and Belize, and inhabit shallow water muddy bottom where they burrow, at least in the mating season (Longley and Hildebrand, 1940; Robins and Ray, 1986). Spawning in the Dry Tortugas and Florida Keys occurs throughout summer and might occur in burrows, but no eggs have been found in the burrows examined (Longley and Hildebrand, 1940; Birdsong, 1981). Eggs are demersal (Thresher, 1991) and larvae are pelagic.

Diet Based on the examination of a few specimens, this species feeds on copepods and ostracods (Longley and Hildebrand, 1940).

Abundance and distribution Banner goby were common in otter trawl collections in basins (Figs. 22.7 and 22.8). Mean densities differed among years, but not months. Significant differences among years could partially be explained by increased sampling in eastern Florida Bay, although densities in 2000–2001 were comparable to those of 1996 when sampling was not as extensive in eastern Florida Bay (Figs. 22.7 and 22.8). There were significant differences in densities among strata and subdivisions. Banner goby were most abundant in the Eastern subdivision, where seagrass short-shoot densities are low and sediments shallow (Thayer and Chester, 1989).

This species was not collected in northeastern Florida Bay where fluctuations in freshwater inflow cause wide fluctuations in salinity (Schmidt, 1979), and rarely in western Florida Bay (excluding the Gulf subdivision) where lush seagrass beds occur (Thayer and Chester, 1989). Banner goby have not been collected on mud banks in Florida Bay (Sogard et al., 1987; Sheridan et al., 1997). This species was not collected in a grassy shore habitat on the Atlantic side of the Florida Keys adjacent to Florida Bay (Springer and McErlean, 1962) or in early studies in northwestern Florida Bay (Tabb and Manning, 1961). In the Florida Keys, abundances of banner gobies vary considerably among years in any given locality (Birdsong, 1981).

Length-frequency distributions Banner goby have a protracted spawning period based on length-frequency distributions, but spawning might be discontinuous throughout the year (Fig. 22.9). The absence of small fish (<15 mm SL) in March and June suggested that spawning was minimal or did not occur during certain months. However, the absence and relatively small numbers of fish <15 mm SL could mean that this size class was not vulnerable to our gear. Without growth data it would be difficult to link monthly cohorts with the size class distributions to determine the months when fish <15 mm SL were spawned.

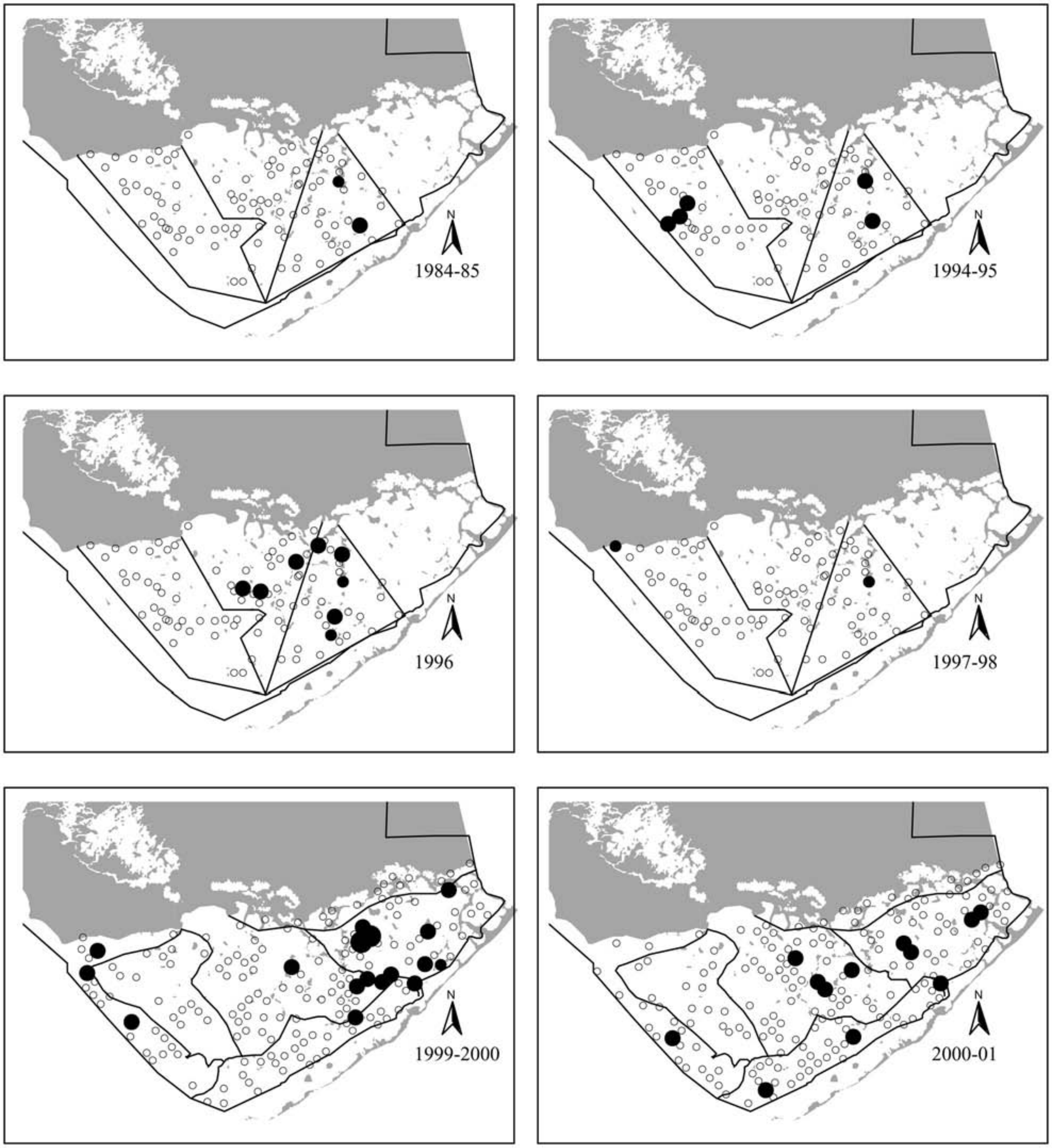


Figure 22.7

Mean densities (numbers 1000 m^{-2}) of banner goby (*Microgobius microlepis)* from bimonthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

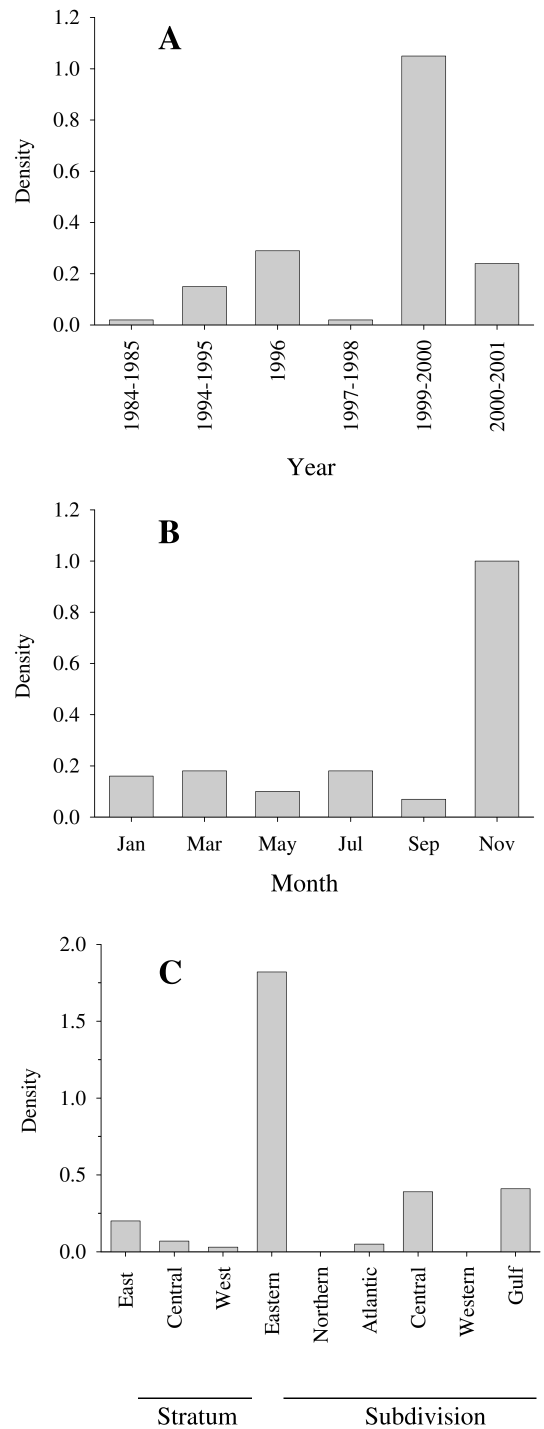


Figure 22.8

Mean densities (numbers 1000 m^{-2}) of banner goby (*Microgobius microlepis)* from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

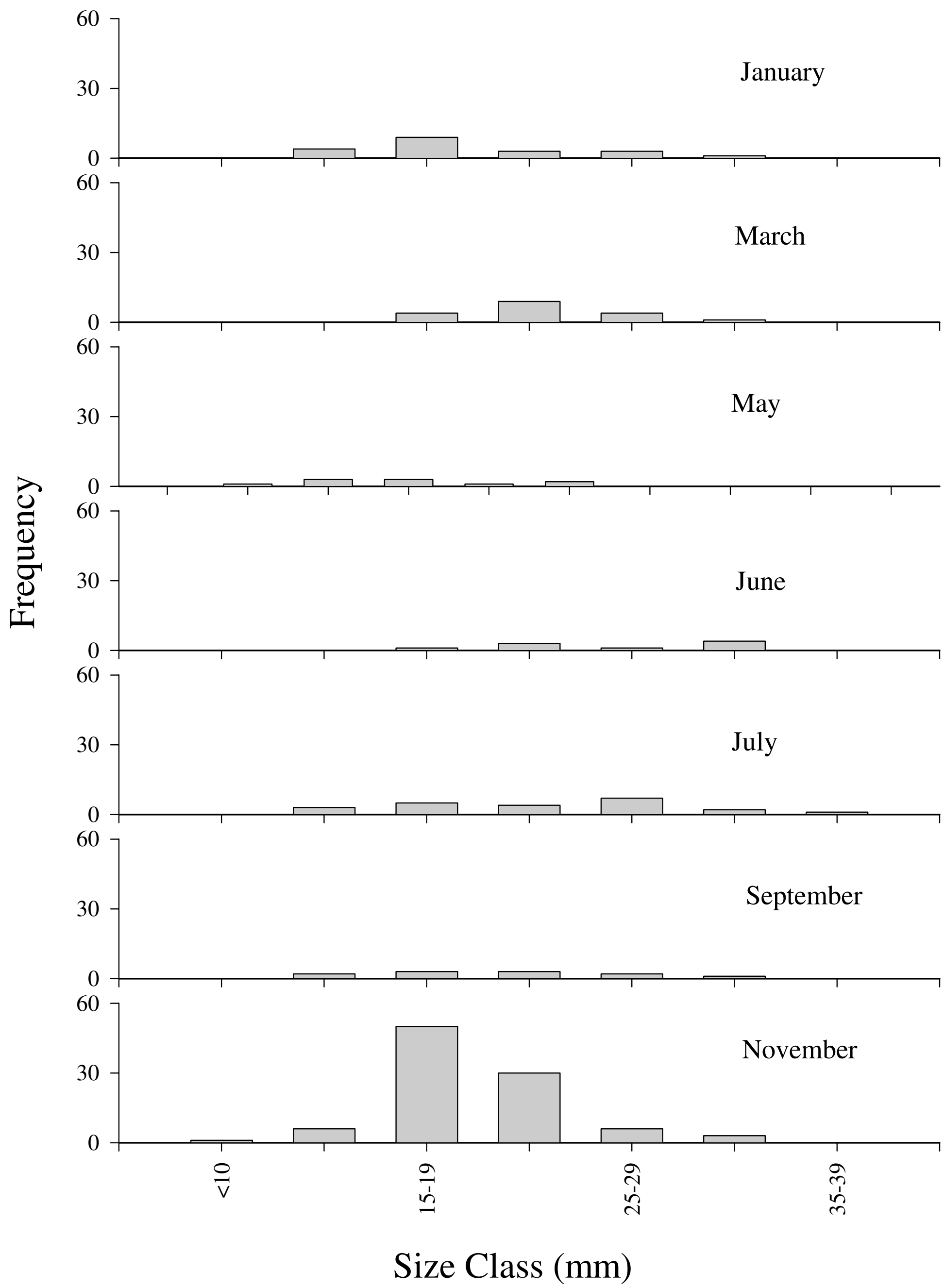


Figure 22.9

Monthly length-frequency distributions of banner goby (*Microgobius microlepis)* from Florida Bay.

Chapter 23. Family Monacanthidae

Monacanthus ciliatus (fringed filefish)

Abundance (numbers) and rank of fringed filefish by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	627	14

Life history Fringed filefish range along the Atlantic coast from Newfoundland to Argentina and throughout the Gulf of Mexico, Caribbean, Bahamas, and Bermuda. They occur in shallow water to 50 m over sandy and rocky bottoms, but mostly in seagrass beds (Tyler, 1978a). Based on the rarity of larvae of this family, fringed filefish probably spawn outside of Florida Bay (Powell et al., 1989; Powell, 2002). The eggs are demersal and termed "balistid type" in that eggs are tended for a short period of time, if at all, before they hatch rapidly into yolk-sac larvae, similar to larvae hatched from pelagic eggs. The larvae from "balistid type" eggs generally remain in the plankton longer than demersal spawners, which implies extensive dispersal (Thresher, 1991).

Diet Young fish (39–55 mm SL) feed primarily on copepods and mollusks, but amphipods and ostracods are also consumed (Reid, 1954).

Abundance and distribution Fringed filefish were common in otter trawl collections in basins (Figs. 23.1 and 23.2). Densities did not differ significantly among months or years, but differed among strata and subdivisions. Although our monthly densities were marginally non-significant ($P = 0.07$), we observed highest densities in September, lowest in March. There were significant differences in densities among strata and subdivisions. Fringed filefish is most abundant in western Florida Bay, which could be attributed to lush seagrass beds (Thayer and Chester, 1989) and more intense recruitment from Gulf of Mexico waters (Figs. 23.1 and 23.2).

Other studies in Florida Bay indicate that this species is common in summer, fall, and early winter, uncommon to rare from January through April, and generally absent in May (Schmidt, 1979; FMRI[1,2,3,4]). In grassy shore habitats on the Atlantic side of the Florida Keys adjacent to Florida Bay, Springer and McErlean (1962) found this species to be more abundant from October through December and rare to absent from January through August. From the years 1994 through 1997, Florida Marine Institute staff reported a steady decline in abundance (FMRI[1,2,3,4]). similar to what we observed (Fig. 23.2).

Tabb and Manning (1961) found the fringed filefish to be the most common filefish in western Florida Bay in higher salinity waters and associated with *Thalassia testudinum*. There appears to be only minor recruitment from the Florida Keys, although this species is common in grassy shore habitats on the Atlantic side of the Florida Keys adjacent to Florida Bay (Springer and McErlean, 1962).

Length-frequency distributions Based on specimens <20 mm SL, fringed filefish appeared to recruit during most months (Fig. 23.3). Fringed filefish reach a length of 200 mm TL (Robins and Ray, 1986) but our collections are comprised of much smaller fish. Although we are unaware of the size at sexual maturity of this species, Clark (1950) identified adult males at 58 mm SL and females at 43 mm SL. The majority of our fish could be juveniles and young adults, as could those collected by Springer and McErlean (1962) in grassy shore habitats on the Atlantic side of the Florida Keys adjacent to Florida Bay. Speculatively, Florida Bay provides nursery habitat for fringed filefish as well as do grassy shore habitats of the Florida Keys.

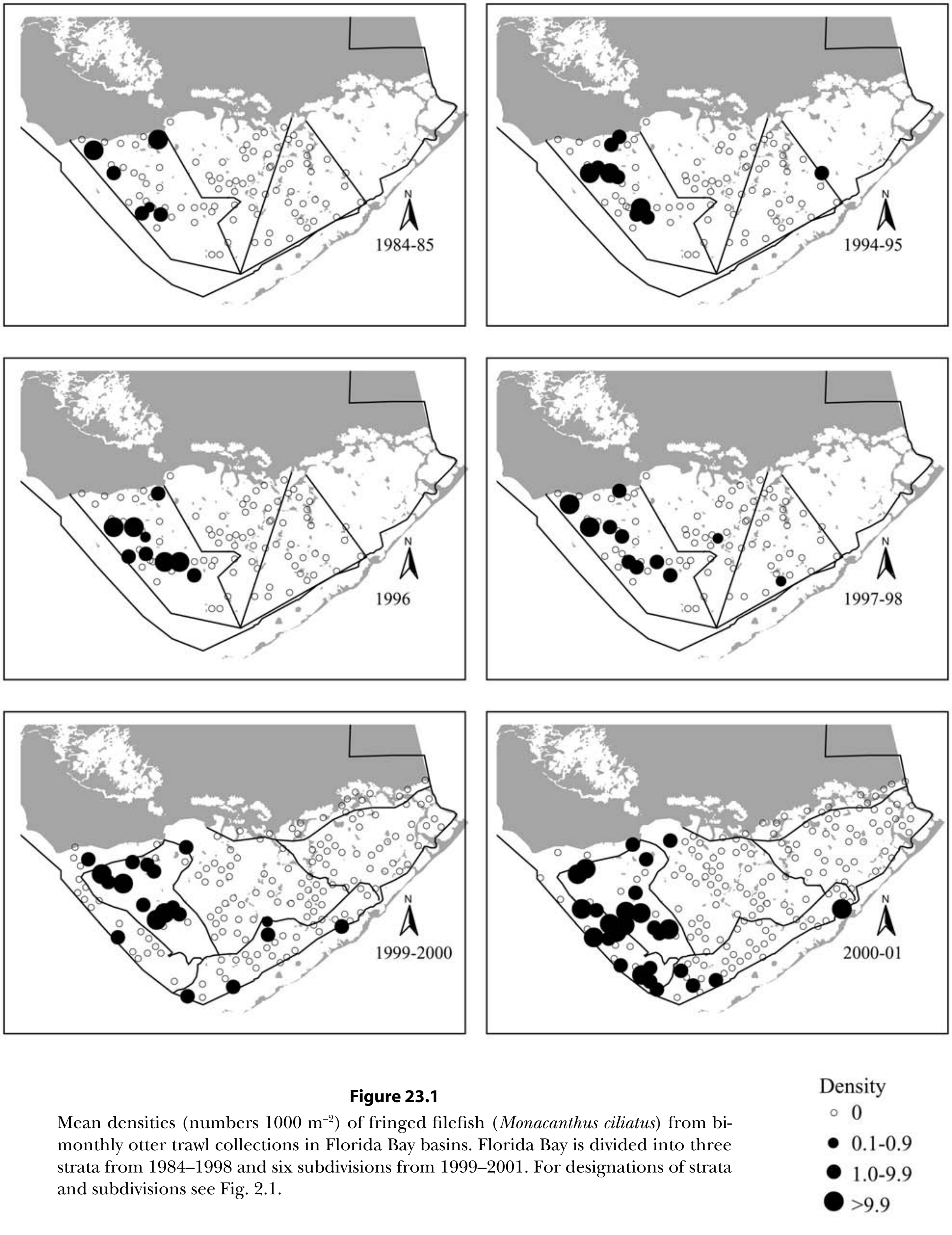


Figure 23.1

Mean densities (numbers 1000 m^{-2}) of fringed filefish (*Monacanthus ciliatus*) from bimonthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

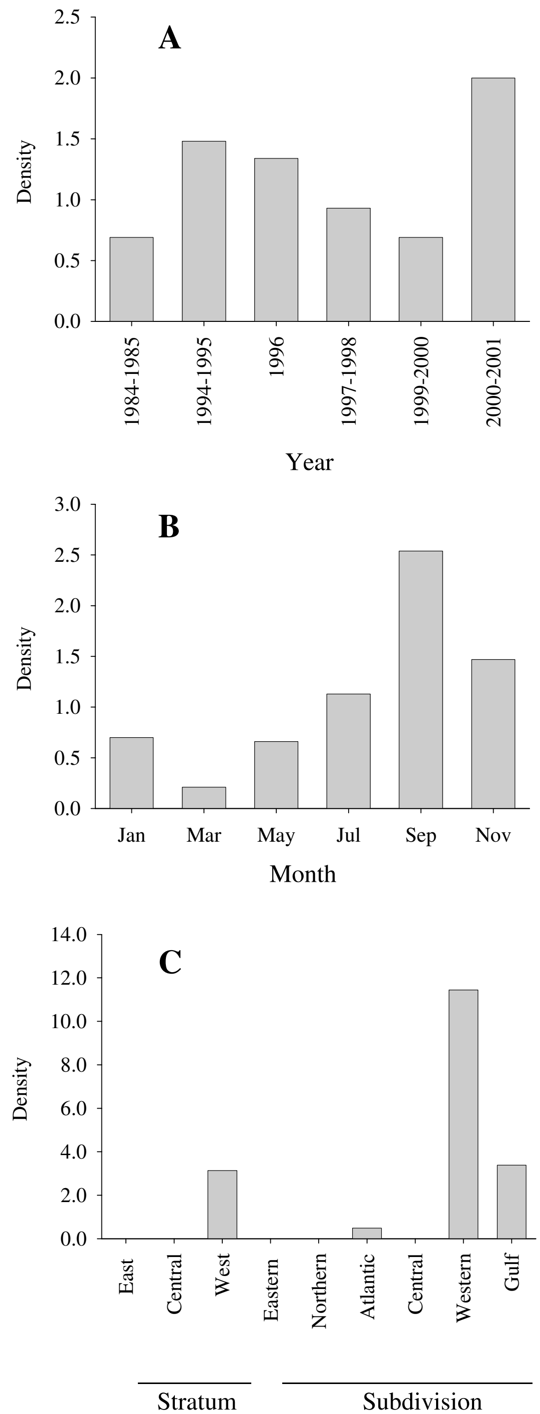


Figure 23.2

Mean densities (numbers 1000 m^{-2}) of fringed filefish (*Monacanthus ciliatus*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

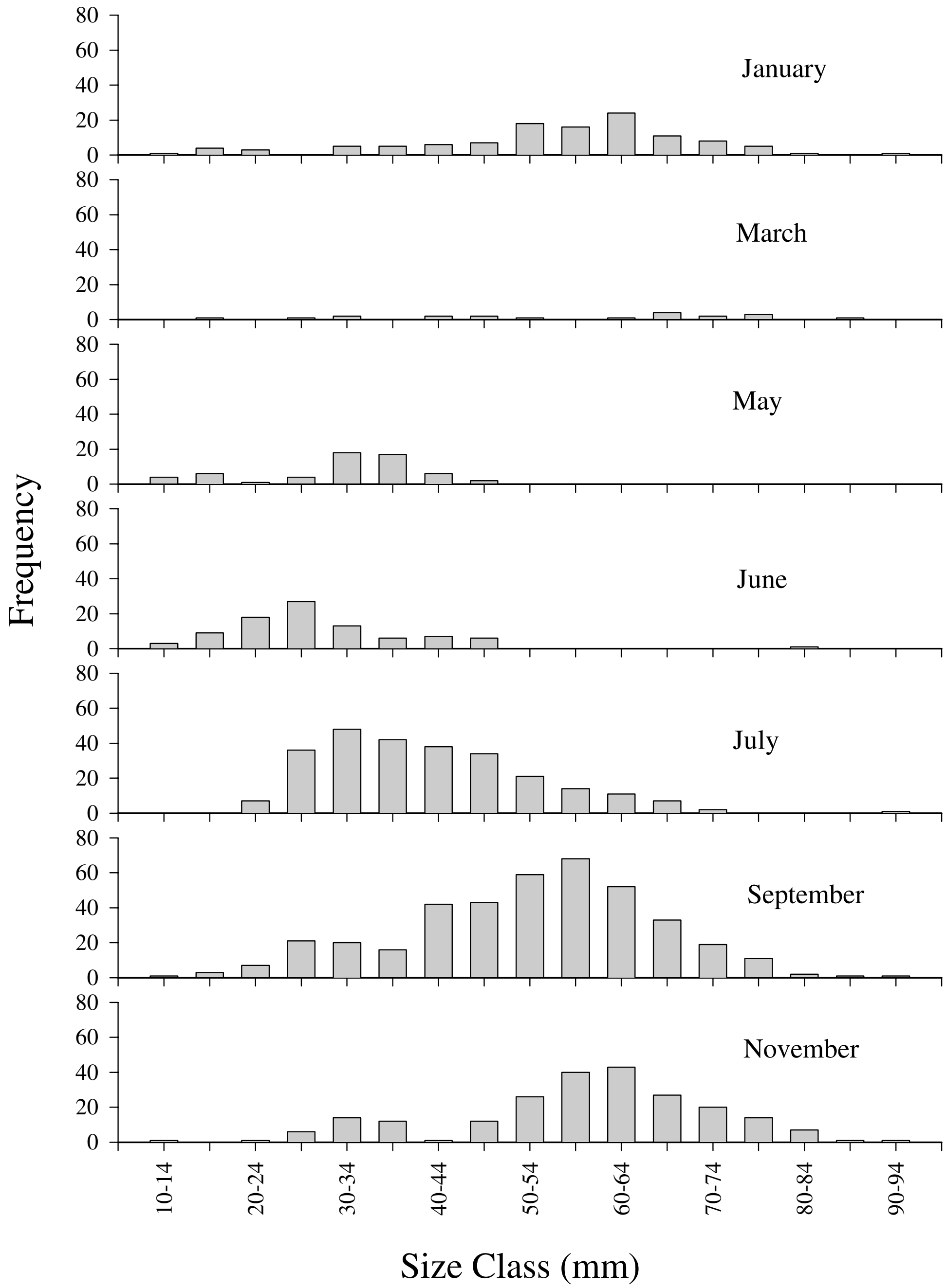


Figure 23.3

Monthly length-frequency distributions of fringed filefish (*Monacanthus ciliatus*) from Florida Bay.

M. hispidus (planehead filefish)

Abundance (numbers) and rank of planehead filefish by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	179	21

Life history Planehead filefish range from Nova Scotia to Brazil, northern Gulf of Mexico, and Bermuda. They are absent in the Bahamas (Robins and Ray, 1986). Spawning is prolonged and most likely occurs throughout the year south of Cape Hatteras (Fahay, 1983). Based on the rarity of larvae of this family, planehead filefish probably spawn outside of Florida Bay (Powell et al., 1989; Powell, 2002); however, Matheson et al. (1999) list this as a resident species in Florida Bay. Pelagic eggs have been reported (Martin and Drewry, 1978), but are most likely the "balistid type" in that eggs are demersal and are tended for a short period of time, if at all, before they hatch rapidly into yolk-sac larvae, similar to larvae hatched from pelagic eggs. The larvae from "balistid type" eggs generally remain in the plankton longer than demersal spawners, which implies extensive dispersal (Thresher, 1991). Young planehead filefish larvae occur near the bottom, while the juvenile stage is associated with sargassum weed. The transition from larvae to juveniles occurs at approximately 8 mm SL (Fahay, 1983; Rogers et al., 2001). Females at 81 mm SL have been observed with large eggs, maturing males exhibited secondary sexual characters at 104 mm SL (Berry and Vogele, 1961).

Diet Planehead filefish, 15–82 mm SL, collected at Cedar Key, Florida, had a diet similar to the fringed filefish (see above). They consumed mainly amphipods, with fewer amounts of pelecypod mollusks and polychaetes (Reid, 1954).

Abundance and distribution Planehead filefish were common in otter trawl collections in basins, but less abundant than its congener, the fringed filefish (Figs. 23.1, 23.2, 23.4, and 23.5). Densities differed significantly among years, but not months, although monthly differences were marginally non-significant ($P = 0.09$). Planehead filefish were considerably more abundant in recent years, and more abundant in January (Fig. 23.5). Densities differed among strata and subdivisions. Like the fringed filefish, the planehead filefish was most abundant in western Florida Bay, which could be attributed to lush seagrass beds (Thayer and Chester, 1989) and more intense recruitment from Gulf of Mexico waters (Figs. 23.1 and 23.2).

This species might also recruit into the Atlantic subdivision from the Florida Keys, as it is abundant in grassy shore habitats on the Atlantic side of the Florida Keys adjacent to Florida Bay; but as in Florida Bay, not as abundant as the fringed filefish (Springer and McErlean, 1962).

Seasonally, Springer and McErlean (1962) observed the opposite. They collected relatively few fish in January compared to November, February, and March, and Schmidt (1979) found them to be most abundant in Florida Bay in summer and least in fall.

Length-frequency distributions Planehead filefish recruited into Florida Bay throughout the year (Fig.23.6). Their length-frequency pattern differs from the fringed filefish (Fig. 23.3) in that smaller planehead filefish were more dominant. A relatively narrow range of sizes was observed in January and July, while a wider range was observed in fall collections that could be related to the intensity of recruitment (Fig. 23.6). Rogers et al (2001) reported that maximum growth of juveniles approximately 8–30 mm SL was 0.8 mm day^{-1}. Based on modal sizes (Fig. 23.6) during the period July (30–34 mm SL), September (40–44 mm SL), and November (55–59 mm SL), juveniles grew approximately 0.2 mm SL day^{-1}.

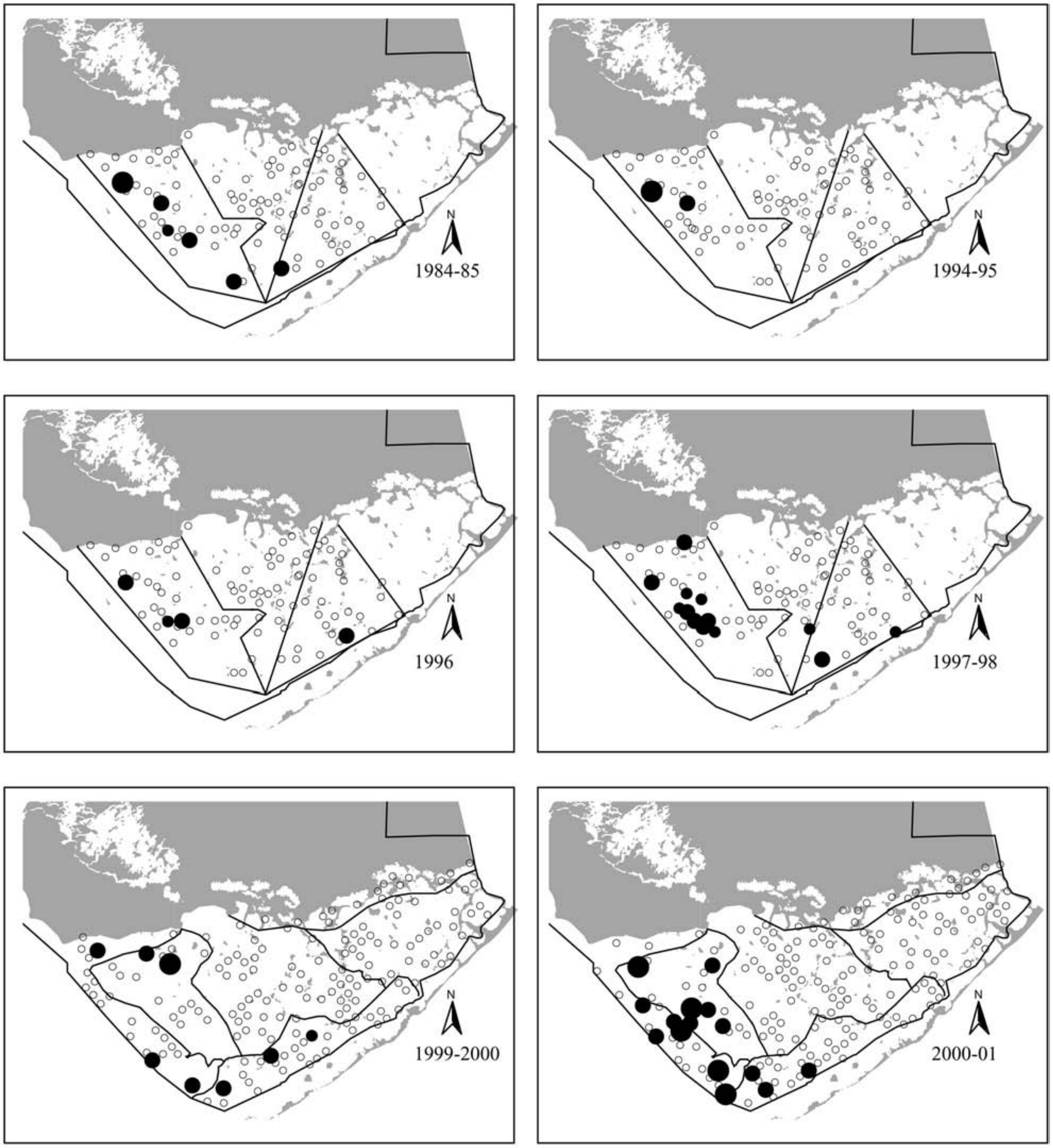


Figure 23.4

Mean densities (numbers 1000 m^{-2}) of planehead filefish (*Monacanthus hispidus*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

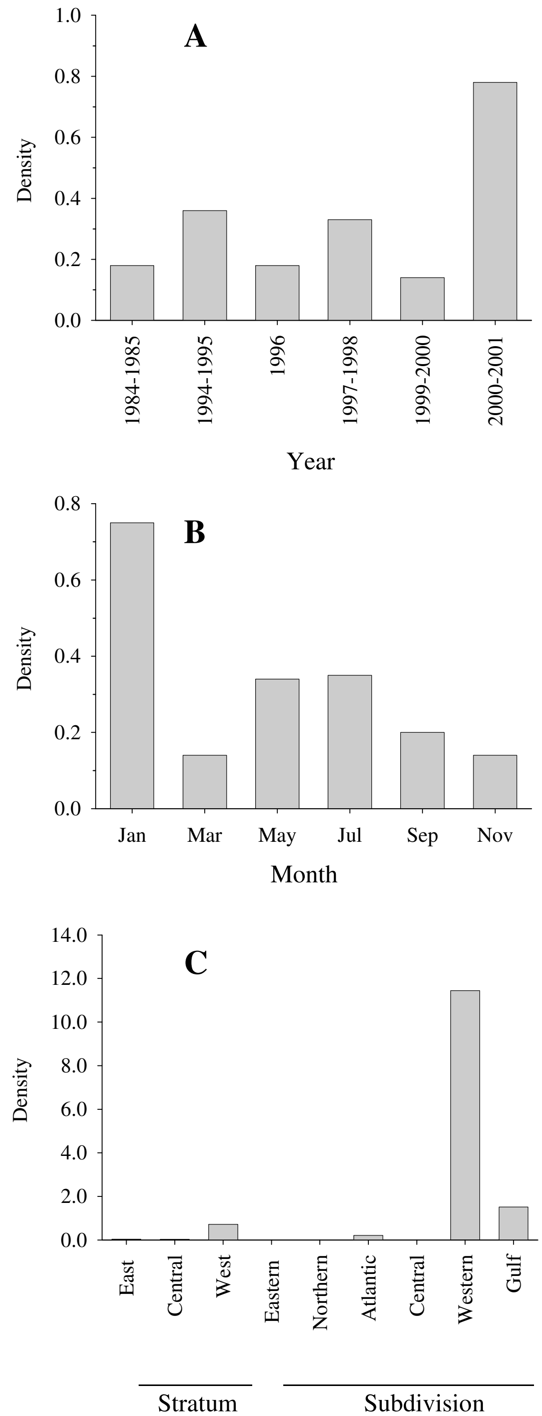


Figure 23.5

Mean densities (numbers 1000 m^{-2}) of planehead filefish (*Monacanthus hispidus*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

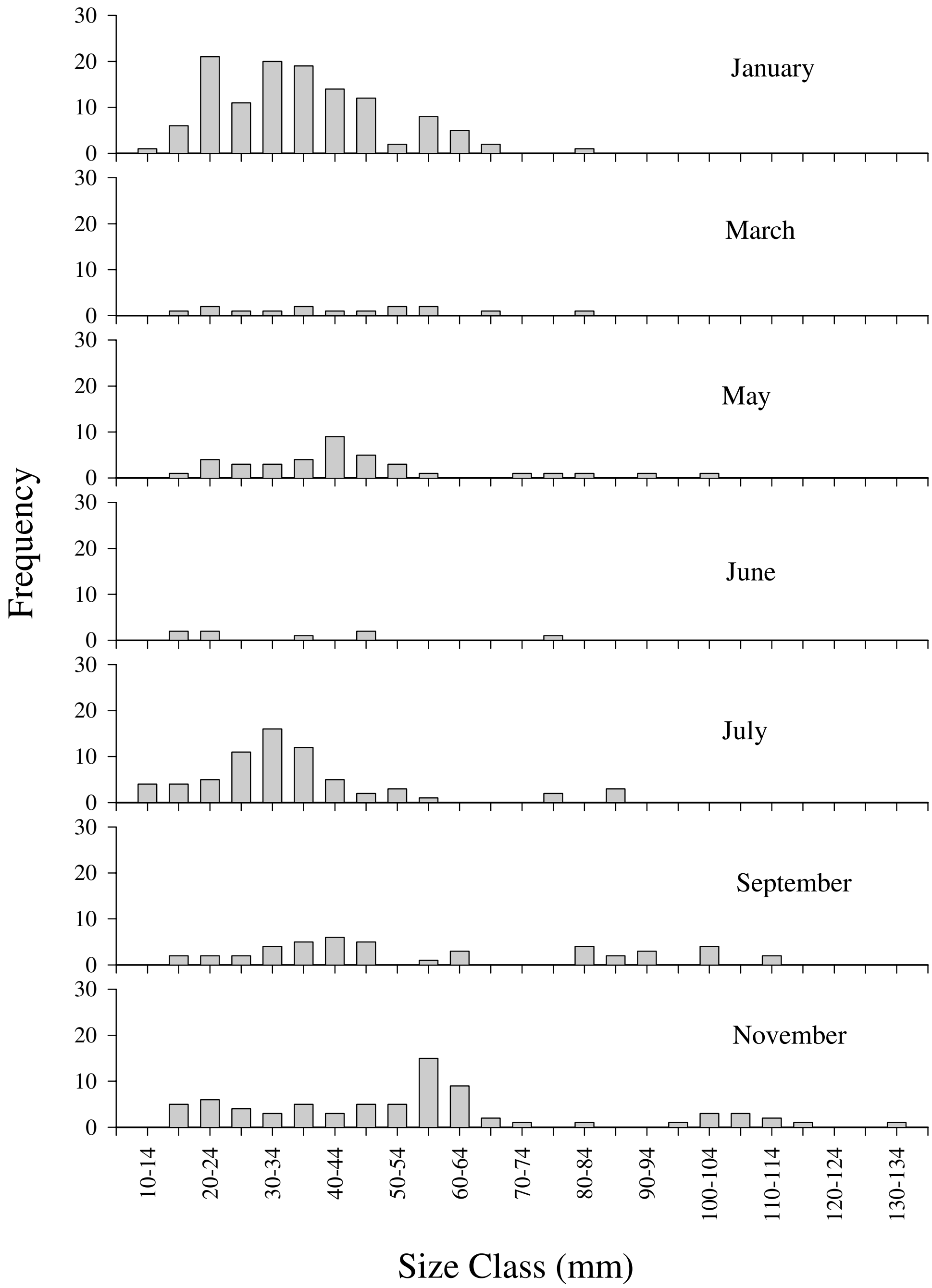


Figure 23.6

Monthly length-frequency distributions of planehead filefish (*Monacanthus hispidus*) from Florida Bay.

Chapter 24. Family Ostraciidae

Lactophrys quadricornis (scrawled cowfish)

Abundance (numbers) and rank of scrawled cowfish by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	145	23

Life history Scrawled cowfish range from Massachusetts to Brazil, Bermuda, Gulf of Mexico, and the Caribbean, and generally inhabit seagrass beds. It is a straggler north of the Carolinas (Breder, 1948; Tyler, 1978b). In the Caribbean, scrawled cowfish spawn throughout the year with maximum spawning occurring in May or earlier (Munro et al., 1973). Spawning occurs in bays, nearshore, and offshore (Martin and Drewry, 1978). Eggs have been collected in adjacent Biscayne Bay (Palko and Richards, 1969), but based on ichthyoplankton surveys there is no solid evidence that this species spawns in Florida Bay (Powell et al., 1989; Powell, 2002). Larval scrawled cowfish have been collected in Gulf of Mexico inshore waters off southwestern Florida, but not in estuarine waters (Collins and Finucane, 1984). Eggs and larvae are pelagic. Larvae hatch at 6 mm NL, but shrink during the preflexion stage to at least 2.5 mm NL (Palko and Richards, 1969; Aboussouan and Leis, 1984). The juvenile stage is attained at 10 mm TL, and size at sexual maturity is unknown (Martin and Drewry, 1978).

Diet Reid (1954) reported scrawled cowfish (13–65 mm SL) consume undetermined vegetation, algae, and pelecypods. This species (size unknown) also feeds on tunicates, gorgonians, sponges, and slow-moving crustaceans (Tyler, 1978b).

Abundance and distribution Scrawled cowfish were common in otter trawl collections in basins (Figs. 24.1 and 24.2). Temporally, there were significant differences in mean densities among years, but not months. There was a decline from 1984–1985 to 1994–1995, the latter date following the die-off of seagrasses and increased turbidity. Densities increased from 1994–1995 through 2000–2001 (Fig. 24.2). Spatially, significant differences in scrawled cowfish densities were observed among strata and subdivisions. This species was most abundant in western Florida Bay (Figs. 24.1 and 24.2), where seagrass standing crop and diversity is greatest (Thayer and Chester, 1989). Moderate densities were observed in waters adjacent to the Keys (Atlantic subdivision) suggesting maximum recruitment from Gulf of Mexico waters and moderate recruitment from the Straits of Florida.

Scrawled cowfish are common in western Florida Bay *Thalassia* beds, prefer clear water and moderately high salinities (Springer and Woodburn, 1960; Tabb and Manning, 1961), and could be a good indicator of seagrass health and water quality. We did not observe any differences in densities among months. However, other workers in Florida Bay reported that it was most abundant in winter when western Florida Bay water tends to be less turbid (Tabb and Manning, 1961), or most abundant in summer and fall (Schmidt, 1979).

Although we observed moderate densities in waters adjacent to the Keys, and suggested moderate recruitment from this area, this species was found to be uncommon in the Atlantic Ocean side of the Florida Keys adjacent to Florida Bay (Springer and McErlean, 1962). This species was rarely collected on Florida Bay mud banks (Sogard et al., 1987; 1989a), and absent in mangroves (Thayer et al., 1987b).

Length-frequency distributions Recruitment into Florida Bay by scrawled cowfish is protracted, although it appeared that recruitment did not occur in late spring and early summer (Fig. 24.3). Based on length-frequency distributions, spawning of scrawled cowfish recruiting into Florida Bay appeared to be more protracted than in Tampa Bay where this species has been reported to spawn from June–September (Springer and Woodburn, 1960). We collected a wide range of sizes that were similar to those reported from Tampa Bay (Springer and Woodburn, 1960), but differed from that reported in western Florida Bay by Tabb and Manning (1961). The latter investigators did not collect any scrawled cowfish >120 mm SL, suggesting to them that only young cowfish utilize Florida Bay and spawning does not occur in western Florida Bay.

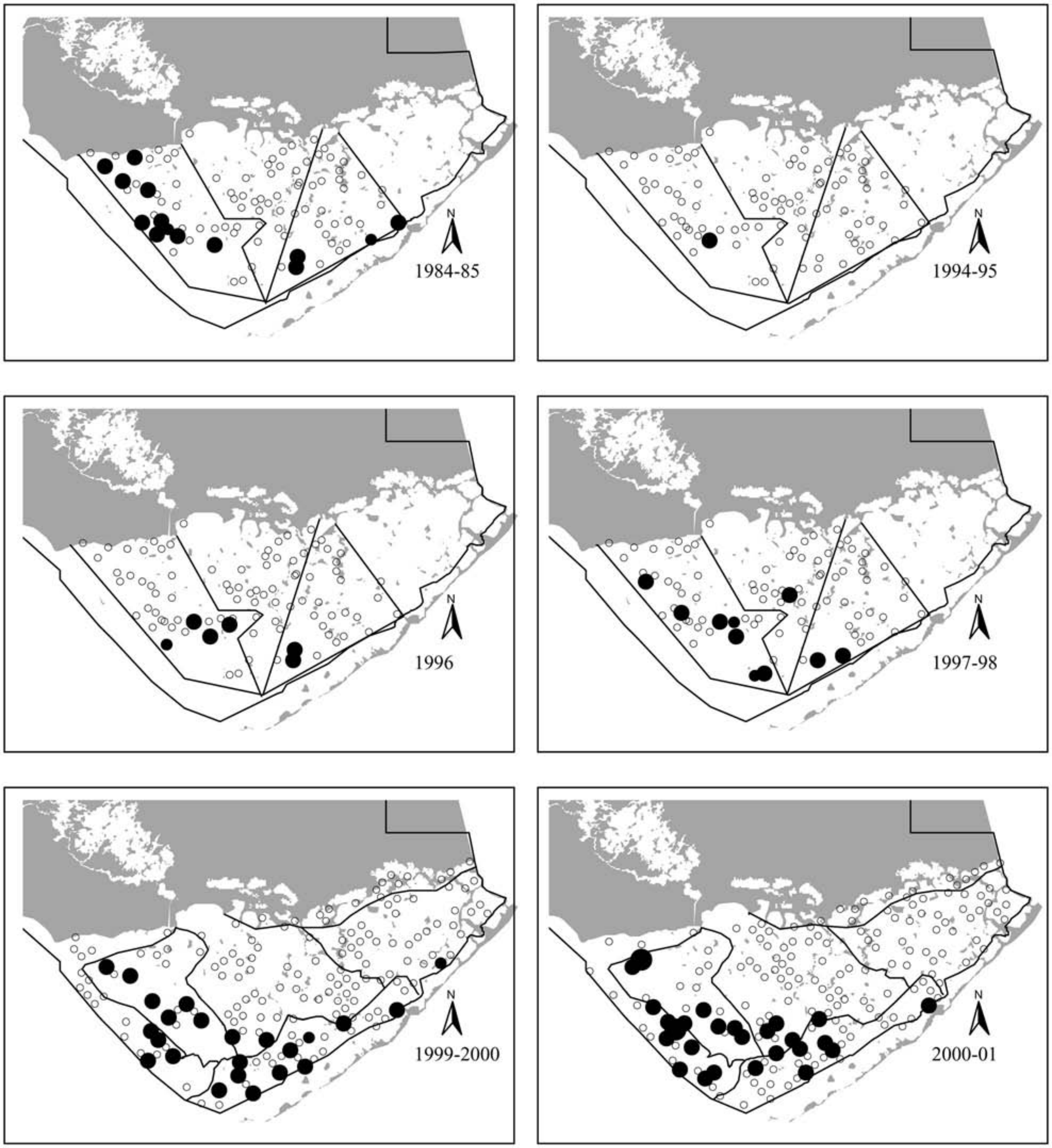


Figure 24.1

Mean densities (numbers 1000 m^{-2}) of scrawled cowfish (*Lachtophrys quadricornis*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

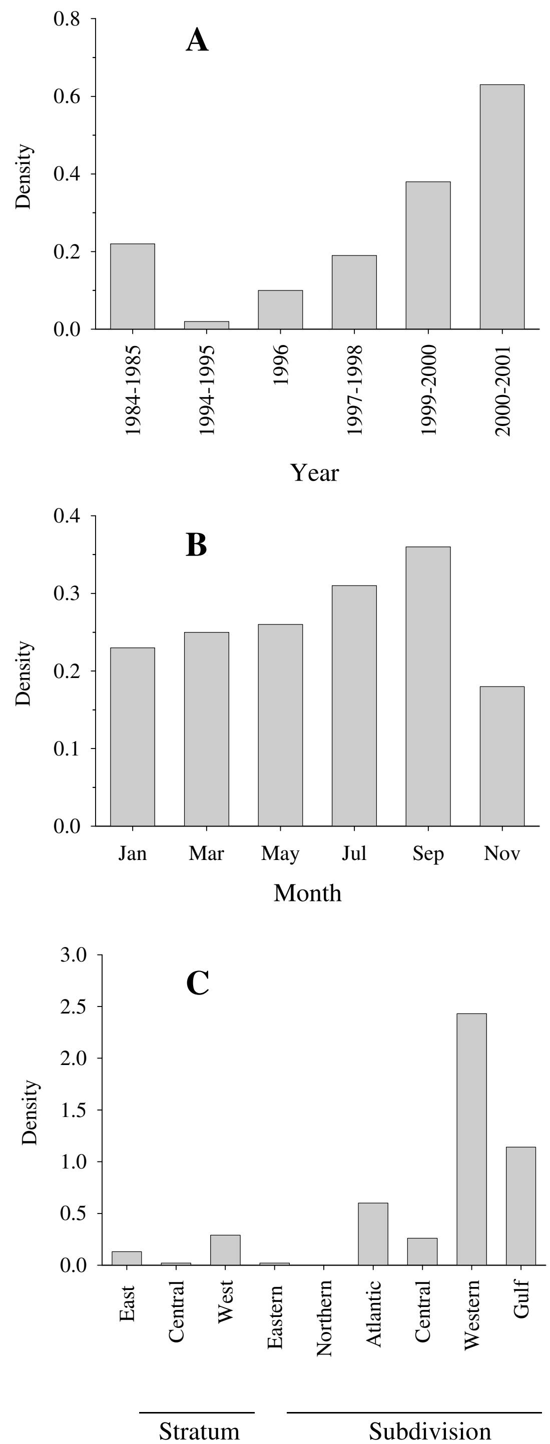


Figure 24.2

Mean densities (numbers 1000 m^{-2}) of scrawled cowfish (*Lachtophrys quadricornis*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

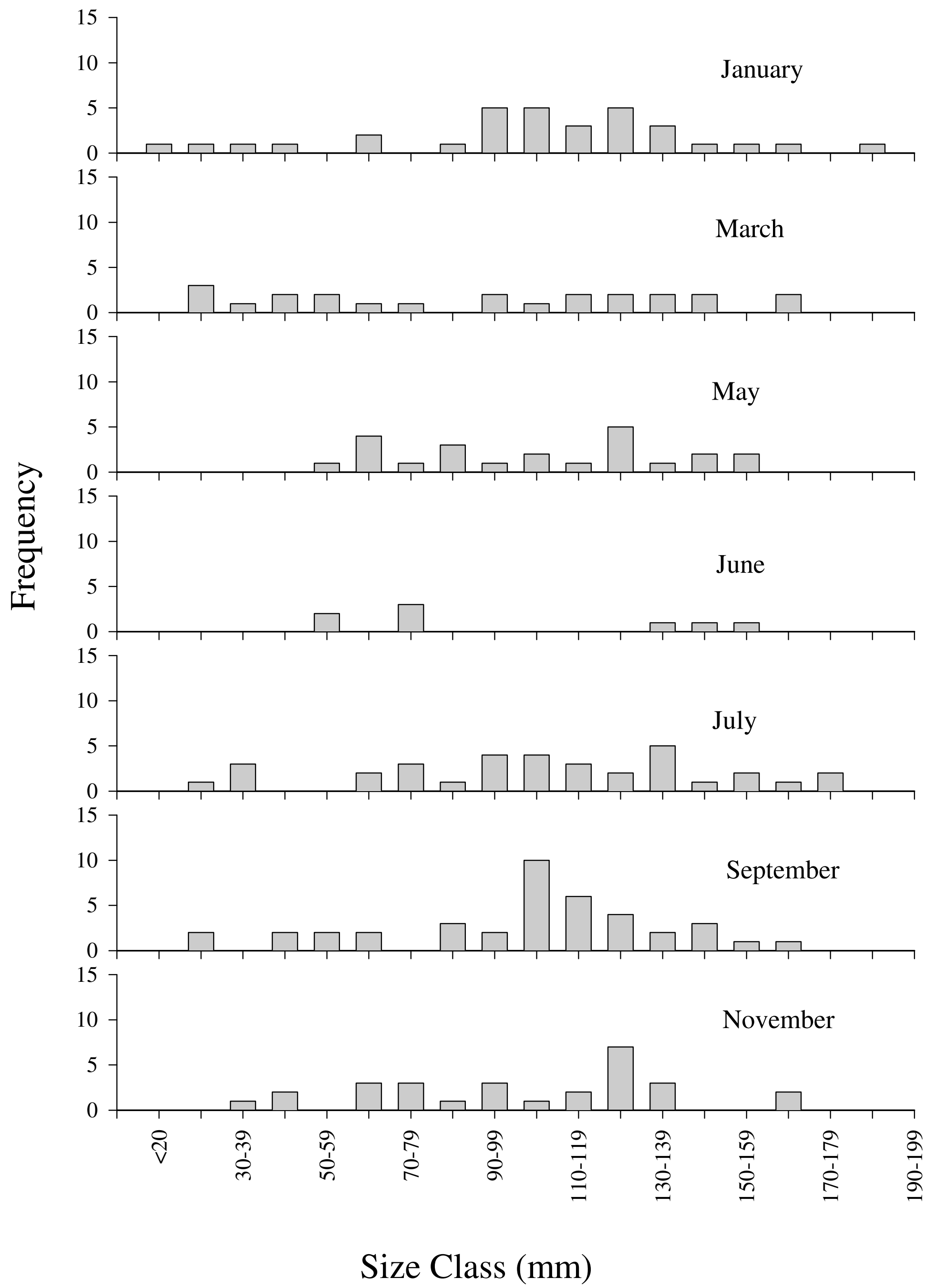


Figure 24.3

Monthly length-frequency distributions of scrawled cowfish (*Lachtophrys quadricornis*) from Florida Bay.

Chapter 25. Family Tetraodontidae

Sphoeroides nephelus (southern puffer)

Abundance (numbers) and rank of southern puffer by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	55	39

Life history Southern puffer range along the Atlantic coast from northeast Florida to southern Florida, throughout the Caribbean to Martinique, the Bahamas, in the eastern Gulf of Mexico from the tip of Florida to western Florida, and in the Yucatan. It is rare along the Central American coast and is a straggler on the Atlantic coast to North Carolina (Shipp, 1974). At Cedar Key, Florida, Reid (1954) collected ripe males in October (189 mm SL) and March (155 mm SL). Young (approximately 15 mm SL) were collected in June and October, which led Reid to believe that spawning occurs in spring and summer. Eggs are "balistid type" in that they are demersal and are tended for a short period of time, if at all, before they hatch rapidly into yolk-sac larvae, similar to larvae hatched from pelagic eggs (Thresher, 1991). Larvae are pelagic (Leis, 1984).

Diet Small southern puffer (6–25 mm SL) are detritivores and feed directly on the bottom (Carr and Adams, 1973). Reid (1954) reported that diets of southern puffer (no sizes given) from Cedar Key, Florida, consists of crabs and mollusks.

Abundance and distribution Southern puffer were common in otter trawl collections in basins (Figs. 25.1 and 25.2). Temporally, mean densities differed significantly among years and months. There was a marked decline in densities between 1984–1985 and 1994–1995, following the die-off of seagrass. From 1996 to 2001, densities were similar, but not as high as 1984–1985. Southern puffer appeared to be most abundant from January through March, which might be related to recruitment into the Bay (Fig. 25.2). Spatially, mean densities differed significantly among strata and subdivision. Highest densities occurred in western Florida Bay. Southern puffer appeared to have an unusual distribution in that they were also abundant in northeastern Florida Bay (Figs. 25.1 and 25.2). However, densities of fish in the northeast were biased by one collection where relatively high densities were observed (Fig. 25.1).

In western Florida Bay, Tabb and Manning (1961) observed that larger southern puffer moved offshore, whereas young (20–30 mm SL) were common in tidal channels. Also in Florida Bay, Schmidt (1979) collected greater numbers in winter and spring and lesser in summer and fall, which is similar to our findings. This species was rarely collected on Florida Bay mud banks (Sogard et al., 1987; 1989a) and was absent in mangrove prop root habitats in the Bay (Thayer et al., 1987b). Southern puffer was uncommon in a grassy shore habitat on the Atlantic side of the Florida Keys adjacent to Florida Bay (Springer and McErlean, 1962).

Length-frequency distributions Small southern puffer occurred throughout the year, indicating protracted recruitment into the Bay (Fig. 25.3). Smaller fish, most likely juveniles, dominated collections. In concordance with Tabb and Manning (1961; see above) and based on January frequencies, larger fish appeared to leave the Bay during early winter.

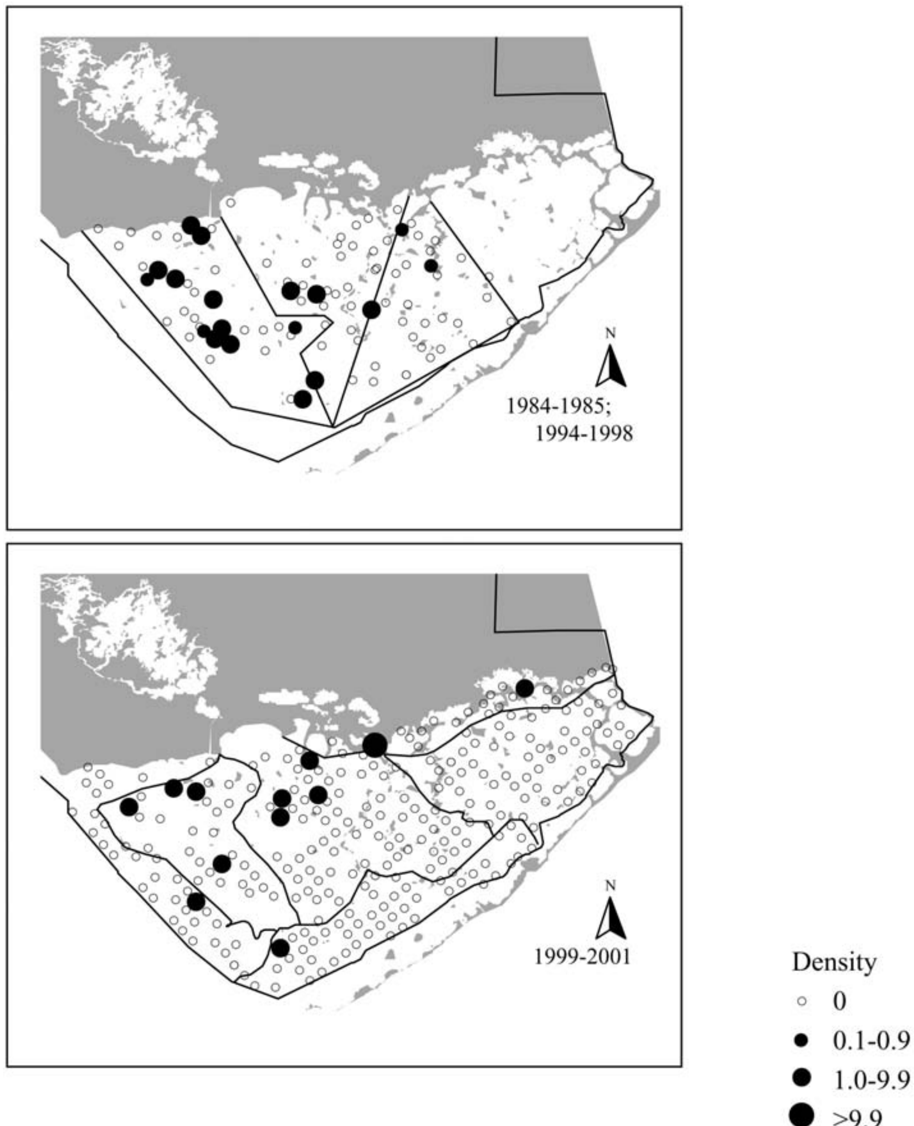


Figure 25.1

Mean densities (numbers 1000 m^{-2}) of southern puffer (*Sphoeroides nephalus*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

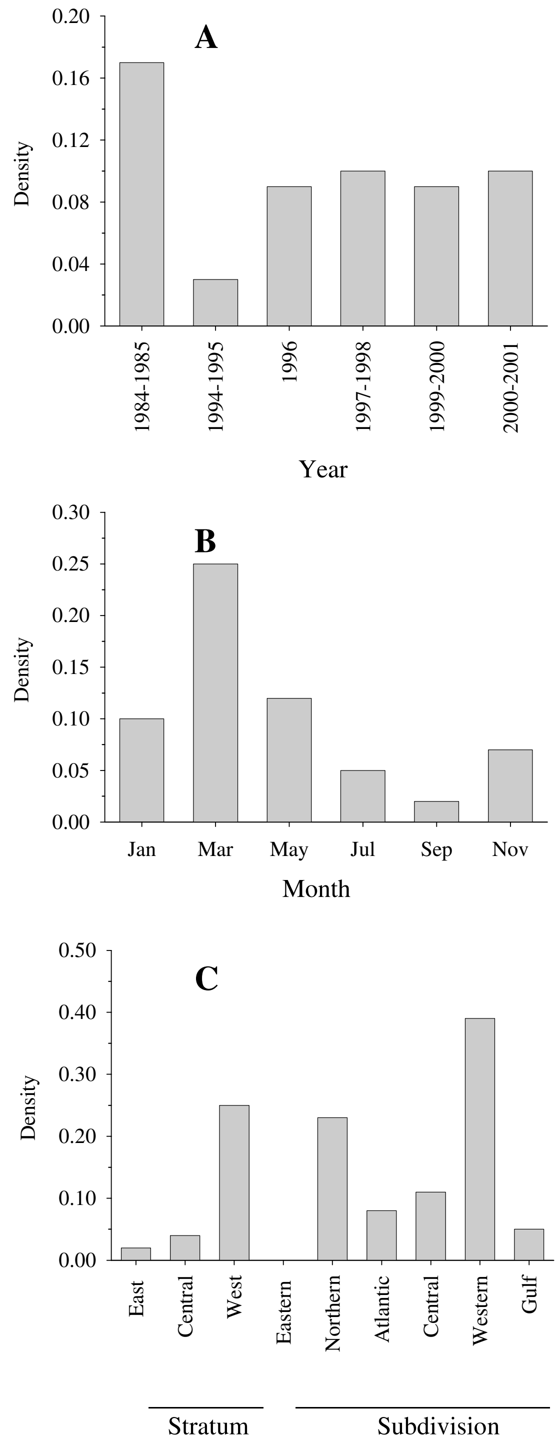


Figure 25.2

Mean densities (numbers 1000 m^{-2}) of southern puffer (*Sphoeroides nephalus*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

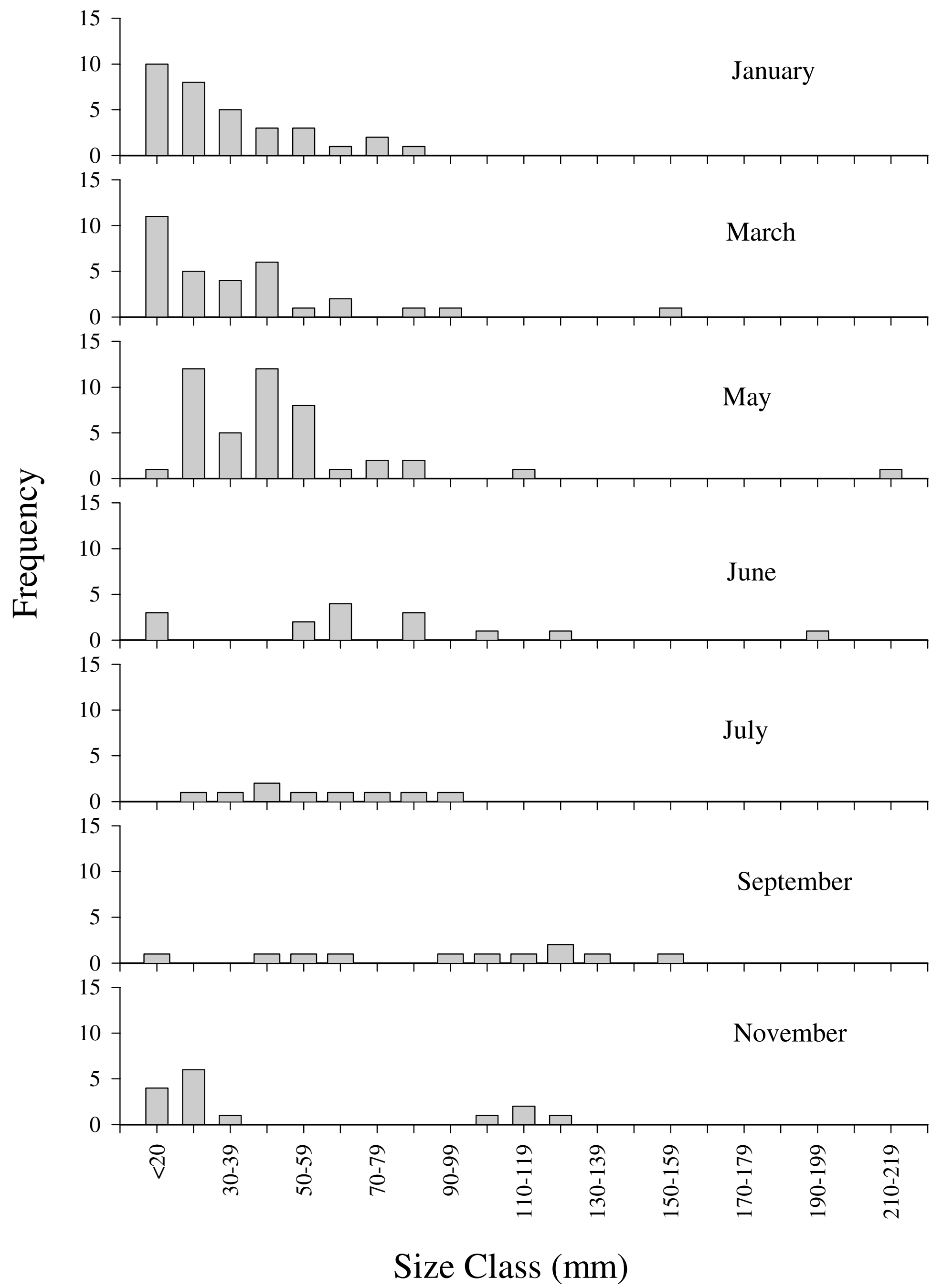


Figure 25.3

Monthly length-frequency distributions of southern puffer (*Sphoeroides nephalus*) from Florida Bay.

Chapter 26. Family Diodontidae

Chilomycterus schoepfi **(striped burrfish)**

Abundance (numbers) and rank of striped burrfish by sampling method. There were a total of 39 species collected by otter trawl.

Gear	Habitat	Year	Number	Rank
Otter trawl	Basins	1984–2001	185	20

Life history Striped burrfish range along the Atlantic coast from North Carolina (straying to Maine and Nova Scotia) to Brazil, the Bahamas (rare), and northern Gulf of Mexico, where it is common. It is absent from most of the West Indies. It is very common in seagrass beds (Robins and Ray, 1986). There is little information available on the reproductive habits of striped burrfish. Spawning might take place in spring in Gulf of Mexico waters off west Florida (Reid, 1954; Springer and Woodburn, 1960). Eggs and larvae are pelagic (Leis, 1984; Thresher, 1991).

Diet The diet of fish 126–215 mm SL from Tampa Bay, Florida, consisted of large gastropods, bivalves, and barnacles that are crushed by bony jaw plates (Bigelow and Schroeder, 1953; Motta et al., 1995).

Abundance and distribution Striped burrfish were common in otter trawl collections in basins (Figs. 26.1 and 26.2). Temporally, there were no significant differences in mean densities among years or months, although there was a steady increase in densities from 1984–1985 to 2000–2001 (Fig. 26.2). Spatially, we observed significant differences in mean densities among strata and subdivisions. This species is most abundant in western Florida Bay and least abundant in eastern Florida Bay (Figs. 26.1 and 26.2).

In Cedar Key, Florida, Reid (1954) collected this species mainly from May through November. In Tampa Bay, Florida, Springer and Woodburn (1960) collected this species mainly in the fall and less frequently during winter. Tabb and Manning (1961) also found the striped burrfish to be abundant in western Florida Bay in seagrass beds and shallow clear water. This species was rarely collected in a grassy shore habitat on the Atlantic Ocean side of the Florida Keys adjacent to Florida Bay (Springer and McErlean, 1962), absent from the mangrove prop root habitat (Thayer et al., 1987b), and rare on Florida Bay mud banks (Sogard et al., 1987; 1989a).

Length-frequency distributions Striped burrfish appeared to recruit into Florida Bay throughout the entire year (Fig. 26.3), suggesting that this species spawns throughout the year. Based on distributions in May and June, spawning appeared to be more intense in spring, which is in concordance with findings of Springer and Woodburn (1960) in Tampa Bay, Florida.

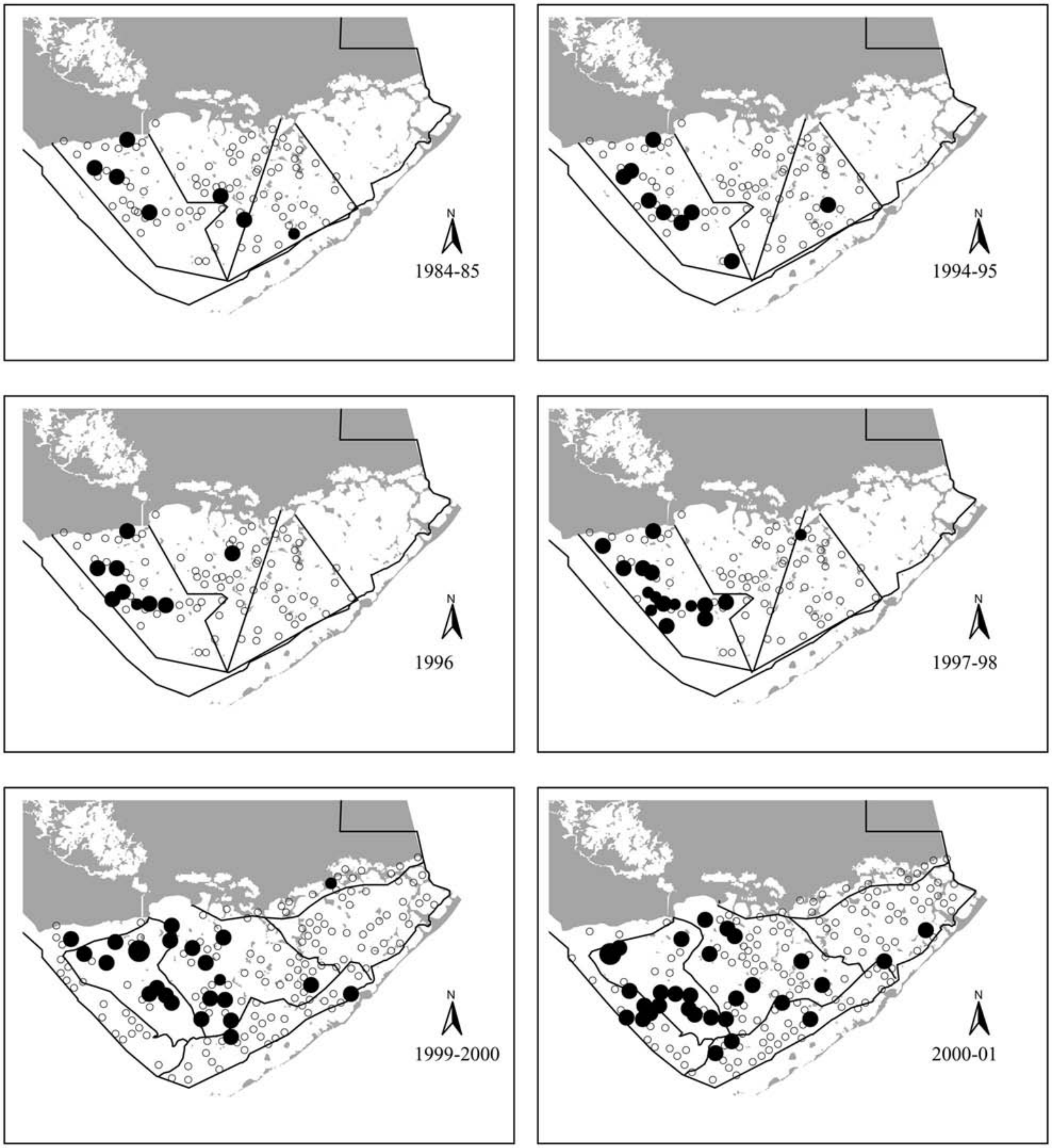
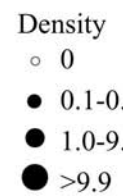


Figure 26.1

Mean densities (numbers 1000 m^{-2}) of striped burrfish (*Chilomycterus shoepfi*) from bi-monthly otter trawl collections in Florida Bay basins. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.



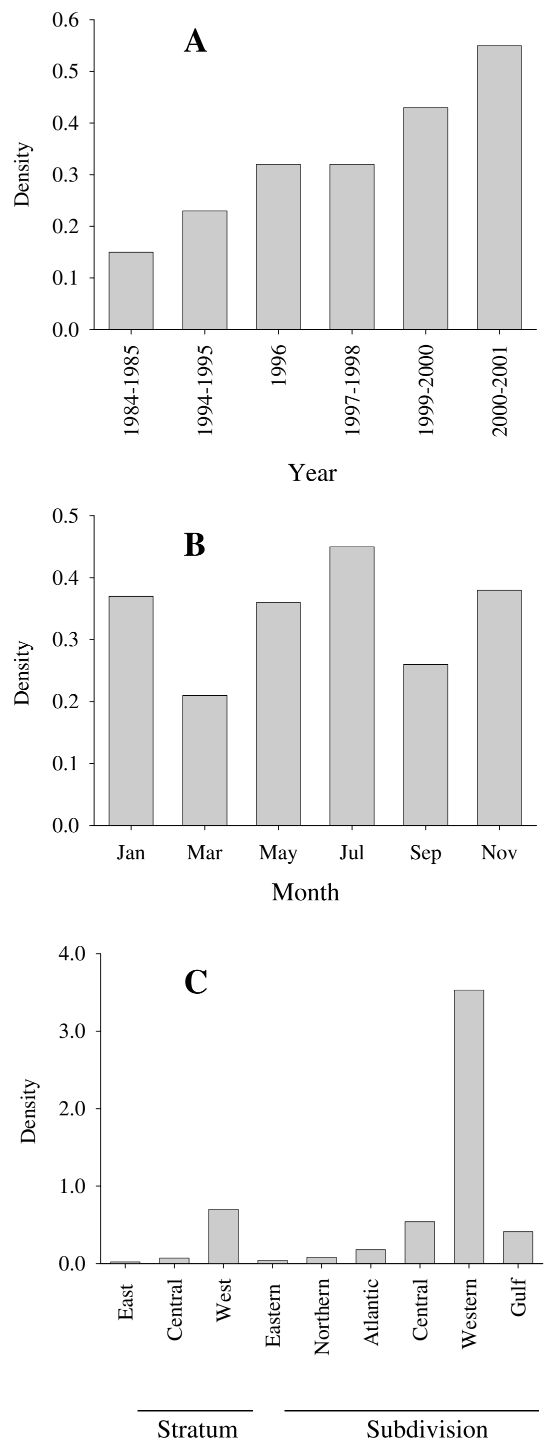


Figure 26.2

Mean densities (numbers 1000 m^{-2}) of striped burrfish (*Chilomycterus shoepfi*) from bi-monthly otter trawl collections in Florida Bay basins by (A) year, (B) month, and (C) stratum/subdivision. Florida Bay is divided into three strata from 1984–1998 and six subdivisions from 1999–2001. For designations of strata and subdivisions see Fig. 2.1.

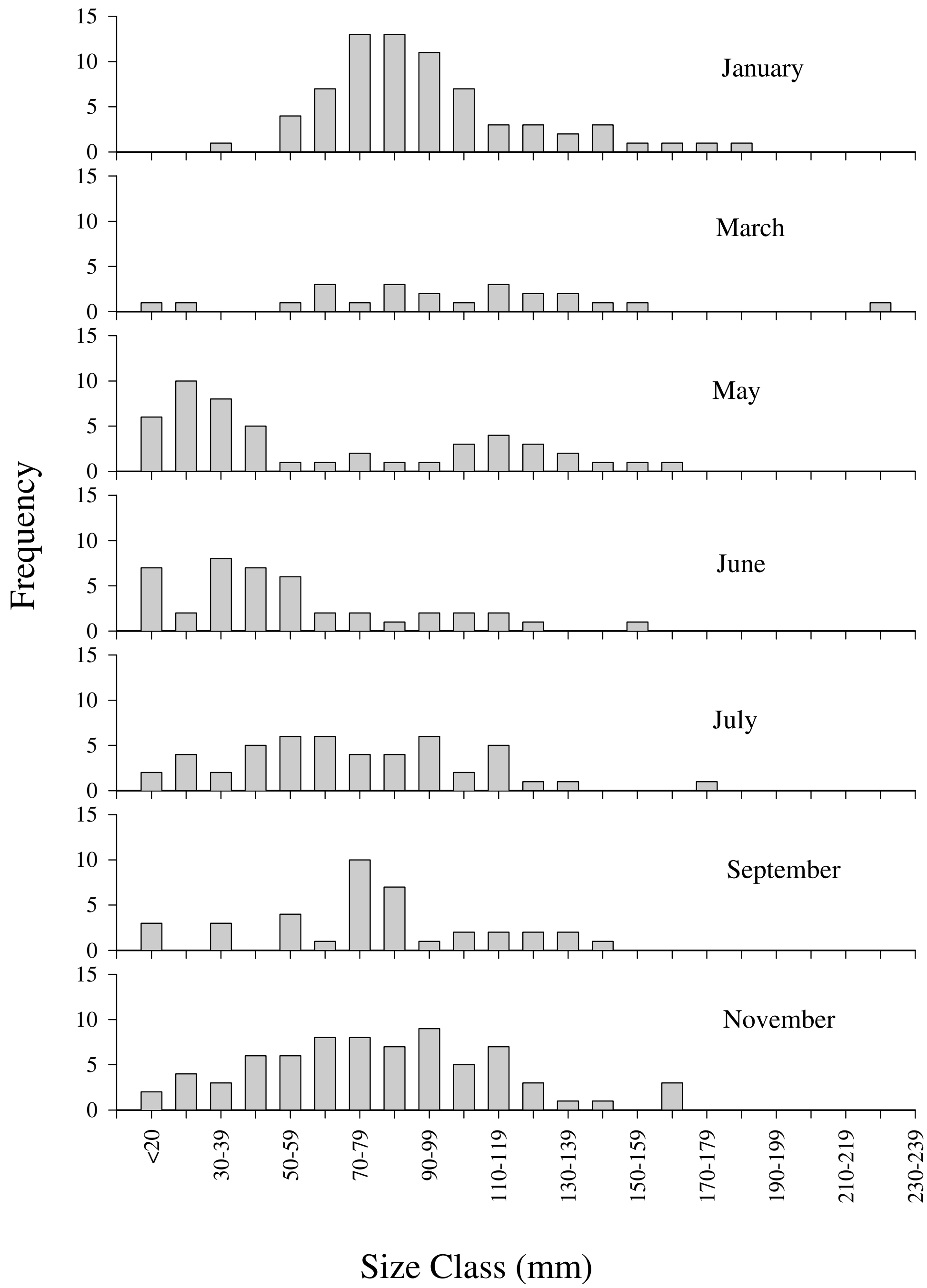


Figure 26.3

Monthly length-frequency distributions of striped burrfish (*Chilomycterus shoepfi*) from Florida Bay.

Chapter 27. Overview and future research needs

Overview

We have presented broad patterns in the abundance, distribution, and recruitment of 46 juvenile and small resident fish species from Florida Bay, along with brief information on life histories and diets. Approximately 56% of the fish species had tropical affinities (Antillean fauna), whereas 76% had warm temperate affinities (Gulf of Mexico and Carolinean fauna) (Table 2). Twenty-four percent were solely tropical, whereas 43% were solely warm temperate. Tabb and Roessler (1989), in a review of juvenile fish studies in Florida Bay and adjacent waters, concluded that the fish fauna in north-central to northwestern Florida Bay, as compared to Alligator Reef (adjacent to Florida Bay in the Straits of Florida), was more warm temperate than tropical. Holmquist et al. (1989a, 1989b) also noted that the crustacean fauna on Florida Bay mud banks appeared to be more temperate than tropical.

There were approximately equal numbers of resident and transient fish species collected in Florida Bay (Table 2). The pelagic species fell into two discrete resident and transient fish groups. Pelagic transient fishes included all the clupeid species. Pelagic resident fishes included the engraulids (all species), exocoetids and belonids, and the atherinids (all species). Demersal/benthic species represented a diverse group of families, equally divided among resident and transient species. The majority of the seagrass canopy dwellers were transient species and included some of the most abundant fishes (e.g., silver jenny, silver perch, and pinfish) and juveniles of an important recreational and commercial species (gray snapper). Although only four families of resident canopy dwellers were collected in Florida Bay (fundulids, cyprinodonts, syngnathids, and sciaenids), many of the species collected were abundant (cyprinodont: goldspotted killifish; syngnathids: dwarf seahorse, dusky pipefish, gulf pipefish), or very abundant (fundulid: rainwater killifish). The only sciaenid resident canopy-dweller collected was the spotted seatrout, an important recreational species.

The majority of species collected in basins by otter trawl exhibited significant spatial differences in densities (n = 46 species tested) both spatially (79%) and yearly (62%), but not monthly (46%). There were no discrete patterns that could explain the differences, but differences could pose questions for future research. Of those species that exhibited differences in densities among years (n = 25), 72% were resident fishes and 67% were transient. This provides little insight into factors influencing abundance. For example, dramatic unequal differences among years between resident and transient species could provide insight into whether factors inside or outside Florida Bay influenced abundances. There were also similar proportions of seagrass canopy dwellers (68%; n = 22 species), benthics (60%; n = 10 species), and pelagics (57%; n = 7 species from otter trawl collections in basins) that exhibited significant differences in densities among years. The canopy dwellers included almost all of the most abundant fishes (>1000); i.e, the transients – silver perch, silver jenny, white grunt, pinfish, and pigfish; the residents – goldspotted killifish, dwarf seahorse, rainwater killifish, dusky pipefish, and gulf pipefish; and one pelagic – bay anchovy. Following the seagrass die-off in the late 1980s, lowest densities of seagrass canopy dwellers were observed in 1994–1995 (gulf pipefish, silver jenny, white grunt, and silver perch) and in 1996 (goldspotted killifish, rainwater killifish, dusky pipefish, and pinfish) that could be attributed to seagrass die-off. We attributed the dramatic increase in bay anchovy following seagrass die-off to increases in algae blooms and turbidity. In general, we observed relatively high densities of the abundant transients during the last sampling period (2000–2001) with the exception of pigfish when lowest densities for this species were observed. The majority of the most abundant species (listed above) occurred at greatest densities in the Western subdivision. The exceptions were bay anchovy, which was most abundant in the Central and Northern subdivisions, and gulf pipefish, which was equally abundant in the Western and Northern subdivisions.

The richness of fauna in western Florida Bay has been well documented. Thayer and Chester (1989) concluded that richer and diverse fish communities are found in western Florida Bay where sediments are more organic and seagrass populations are more diverse. They attributed the low densities of fishes in the central part of the Bay to restricted circulation. Holmquist et al. (1989a; 1989b) also suggested that the mud bank network impedes circulation that acts as a barrier to recruitment of Gulf of Mexico and Atlantic crustaceans to the inner Bay. Tabb and Roessler (1989) believed that hypersalinity, which occurs predominantly in the central part of the Bay (Orlando et al., 1997), is a severe constraint on Florida Bay fish abundance and occurrence. In summary, frequently considered hypotheses for the distributional limits of species include physiological constraints, recruitment, competition, and predation, which might not be mutually exclusive (Quinn and Dunham, 1983). Very few studies conducted in Florida Bay have tested those hypotheses.

Notably absent from our study were the recreationally important tarpon (*Megalops atlanticus*), snook (*Centropo-*

mis undecimalis), and red drum (*Sciaenops ocellatus*). Despite their importance to the sport fishery in Florida Bay, the Bay is not a nursery area for these species. We are unaware of juvenile snook being collected in Florida Bay or adjacent waters (e.g., Whitewater Bay–Shark River estuary) in numbers that indicate nursery habitat. We believe that snook enter Florida Bay and adjacent waters as sub-adults from areas north of Florida Bay. Juveniles have been collected in east-central Florida (Gilmore et al., 1983), Tampa Bay and the Naples area (McMichael et al., 1989; Peters et al., 1998), and the Ten Thousand Islands (Carter et al., 1973).

Tarpon juveniles have been reported from shallow waters of the Whitewater-Coot Bay system (Tabb and Manning, 1961). They have been reported to inhabit salt marsh and mangrove ponds, tidal creeks, rivers, ditches, beaches, and mosquito-control impoundments where these habitats are shallow with no submerged vegetation and are lined by reeds or mangroves (Zale and Merrifield, 1989). This species was not collected during an extensive sampling program in quiet backwaters of Florida Bay and adjacent mesohaline waters (Powell et al., 2002).

Red drum is one of the most popular species sought by anglers in Florida Bay, but juveniles are rarely encountered. An extensive sampling program in northern Florida Bay and adjacent waters with characteristics of other areas where red drum occur (quiet backwaters, with oligohaline and mesohaline salinities) were unsuccessful in collecting any red drum juveniles (Powell et al., 2002). Oligohaline and meohaline waters in the Whitewater Bay–Shark River estuary might be a nursery area for this species (Odum and Heald, 1972).

Future research needs

We recommend the following research needs that should compliment and supplement this study:

1. Using this study's database from 1994, a multivariate analysis should be conducted to supplement the multivariate analysis performed with 1984–1985 data (Thayer and Chester, 1989) to evaluate fish-habitat associations among years.
2. There is very little life history information (especially process-oriented) on juvenile and small resident fishes in Florida Bay, particularly for the abundant forage fishes (e.g., silver jenny, *Eucinostomus gula*; silver perch, *Bairdiella chrysoura*; rainwater killifish, *Lucania parva*). Yet these species are undoubtedly ecologically important and the resident species, in particular, could be good indicators of water or habitat quality.
3. The low densities of fishes in the interior of the Bay might be a function of limited recruitment resulting from the lack of circulation in the Bay. Research should be directed that addresses the low densities of fauna in the interior of the Bay, taking into account not only recruitment, but also physiological constraints, competition, and predation.
4. Fruitful research could be conducted by using techniques such as otolith microchemistry to determine the source of snook, tarpon, and red drum that inhabit Florida Bay as adults. Adult populations could be enhanced by determining spawning and nursery areas and preserving these areas.

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Appendix A. Abundance of fishes by salinity regime

Appendix Table A

Densities (numbers 1000 m^{-2}) of juvenile and small resident fishes reported herein by salinity regime. There were 83 collections in hyperhaline, 698 in euhaline, 357 in polyhaline, and 30 in mesohaline waters. Densities are derived from all collections from 1984-2001.

Family	Species	Hyperhaline (≥40 ppt)	Euhaline (30-39 ppt)	Polyhaline (19-29 ppt)	Mesohaline (5-18 ppt)
Clupeidae	*Brevoortia smithi*	0	0.22	<0.01	0
	Harengula jaguana	0.07	0.22	2.38	0
	Opisthonema oglinum	0.28	0.11	0.23	1.66
	Sardinella aurita	0	0.5	0.05	1.62
Engraulidae	*Anchoa hepsetus*	0	0.33	0.41	0
	A. mitchilli	8.07	15.89	62.97	19.59
Ariidae	*Arius felis*	0.21	0.23	0.48	0.22
Synodontidae	*Synodus foetens*	0.47	0.59	0.27	0.05
Batrachoididae	*Opsanus beta*	2.46	1.68	1.44	1.67
Hemiramphidae	*Chriodorus atherinoides*	0.02	0.04	0.05	0.11
	Hemirhamphus brasiliensis	0	0.04	0	0
	Hyporhamphus unifasciatus	0	0.25	0	0
Belonidae	*Strongylura notata*	0.18	0.19	0.13	0.91
	S. timucu	0.04	0.21	0	0
Cyprinodontidae	*Floridichthys carpio*	4.74	4.36	4.88	10.13
Fundulidae	*Lucania parva*	44.86	37.85	15.31	22.57
Atherinidae	*Atherinomorus stipes*	0	1.03	0.47	0
	Hypoatherina harringtonensis	0	<0.01	0.02	0
Atherinopsidae	*Membras martinica*	0	<0.01	0	0
Syngnathidae	*Anarchopterus criniger*	0.38	1.03	0.99	2.12
	Syngnathus floridae	4.11	3.72	3.59	1.39
	S. scovelli	6.84	5.68	4.47	10.34
	Hippocampus erectus	0.15	0.15	0.12	0
	H. zosterae	0.15	3.44	0.12	0
Lutjanidae	*Lutjanus griseus*	0.7	0.55	0.26	0.14
	Lutjanus synagris	0.15	1.85	0.68	0.25
Gerreidae	*Eucinostomus gula*	37.43	29.02	20.91	13.17
Haemulidae	*Haemulon plumieri*	1.86	4.8	2.65	0
	H. sciurus	0.28	0.3	0.31	0
	Orthopristis chrysoptera	1.52	2.94	1.95	0
Sparidae	*Archosargus probatocephalus*	0.02	0.24	0	0
	Calamus arctifrons	0.06	0.21	0.06	0
	Lagodon rhomboides	12.9	22.74	5.47	0
Sciaenidae	*Bairdiella chrysoura*	2.79	3.61	1.6	0
	Cynoscion nebulosus	1.18	0.61	0.28	0.12
Sphyraenidae	*Sphyraena barracuda*	0.26	0.06	0.18	0.16
Scaridae	*Nicholsina usta*	0.18	0.19	0.04	0
Callionymidae	*Diplogrammus pauciradiatus*	0.16	0.2	0.16	0.17
Gobiidae	*Gobiosoma robustum*	0.56	0.94	0.82	0.24
	Microgobius gulosus	0.69	0.61	0.73	5.2
	M. microlepis	0.26	0.1	0.62	0.07
Monacanthidae	*Monacanthus ciliatus*	0.91	1.9	0.6	0
	M. hispidus	0.32	0.37	0.26	0
Ostraciidae	*Lactophrys quadricornis*	0.24	0.4	0.13	0
Tetraodontidae	*Sphoeroides nephalus*	0.1	0.16	0.06	0
Diodontidae	*Chilomycterus shoepfi*	0.52	0.48	0.33	0

Appendix B. Uncommon species—number and area collected

Appendix Table B

The total number of fishes and area collected of uncommon (<50 and ≥10) species in basins by otter trawl. Simple check mark (✓) indicates occurrence; bold (✔) relatively more abundant (arbitrarily assigned). Florida Bay was stratified into strata from 1984-1998, and subdivision from 1999-2001. For location of strata and subdivisions see Fig. 2.1.

			Strata[1]			Subdivision[2]					
Family	Species	Number	E	C	W	E	N	A	C	W	G
Ariidae	*Bagre marinus*	20		✓	✔						✔
Bythitidae	*Gunterichthys longipenis*	13	✓		✓		✔			✓	
Poeciliidae	*Poecilia latipinna*	32		✔							
Syngnathidae	*Syngnathus louisianae*	47	✓	✓	✓	✓	✓	✓	✓	✔	✓
Triglidae	*Prionotus scitulus*	11	✓	✓	✓				✔	✔	✔
Serranidae	*Diplectrum formosum*	11	✓					✔	✓	✔	
	Hypoplectrus unicolor	23			✓					✔	✔
Lutjanidae	*Ocyurus chrysurus*	10	✓					✓	✓		✔
Haemulidae	*Haemulon aurolineatum*	34					✔	✓			
	Haemulon parra	20	✓	✓	✔		✓				
Sparidae	*Archosargus rhomboidalis*	22			✓					✓	✔
Sciaenidae	*Bairdiella batabana*	19			✓					✔	✔
Ephippidae	*Chaetodipterus faber*	42	✓	✓	✓				✔		✔
Labridae	*Lachnolaimus maximus*	12			✓			✓		✓	✔
Scaridae	*Sparisoma rubripinne*	11			✔					✔	
Labrisomidae	*Paraclinus fasciatus*	40	✓		✓	✓	✓	✔	✔	✓	✓
	P. marmoratus	42	✓		✓	✓		✓	✓	✓	✔
Blennidae	*Chamodes saburrae*	24	✓	✓	✓	✓			✓	✔	
	Hypsoblennius ionthas	10				✓		✓	✔	✔	✔
Paralichthyidae	*Paralichthys albigutta*	10	✓		✓			✓	✓	✔	✓
Achiridae	*Achirus lineatus*	33	✓	✓	✓		✓		✔	✔	✓
Cynoglossidae	*Symphurus plagiusa*	24	✓	✓	✓			✓	✓		✔
Ostraciidae	*Lactophrys trigonis*	12	✓		✓			✓	✓	✔	
Tetraodontidae	*Sphoeroides spengleri*	16	✓	✓	✓		✔	✓		✓	

[1] E = East; C = Central; W = West
[2] E = Eastern; N = Northern; A = Atlantic; C = Central; W = Western; G = Gulf

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