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Summary of Ichthyoplankton Research by the NOAA Beaufort Laboratory in Florida Bay, Everglades National Park, Florida, USA

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Abstract. This paper summarizes two cooperative research studies between the Plankton Sorting and Identification Center (PSIC) and the Beaufort Laboratory in Florida Bay. Florida Bay is a shallow lagoon located for the most part in Everglades National Park, Florida, USA. The bay is compartmentalized into partially submerged carbonate mud banks, basins, and numerous mangrove islands. During the last two decades, significant changes have occurred in the bay with respect to ichthyofauna composition, seagrass abundance, salinity regimes, algal blooms, and water clarity. Ten larval collecting trips were made between March 1984 and September 1985. Twenty stations were sampled in Florida Bay and adjacent waters with a 61 cm bongo sampler fitted with 333 μm mesh nets. Only 11 stations occurred in Florida Bay and were located primarily along the Florida Keys and western Florida Bay. Four recreational important species were targeted – spotted seatrout (*Cynoscion nebulosus*, Family Sciaenidae), gray snapper (*Lutjanus griseus*, Family Lutjanidae), red drum (*Sciaenops ocellatus*, Family Sciaenidae), and snook (*Centropomus undecimalis*, Family Centropomidae). Spotted seatrout was the only target species whose larvae were commonly collected. We collected one red drum larvae, no snook larvae, and 15 potential gray snappers, but because of taxonomic problems, we could not identify the larval snappers to species. Spotted seatrout spend their entire life in Florida Bay and spawn mainly in the western Florida Bay. Based on larval collections, which were comprised mainly of preflexion stage larvae, spawning is minimal in late fall and the winter months, peaks during mid-to-late spring and continues during the summer at moderate levels, then declines in winter. One of the most striking patterns observed was the dominance and ubiquitous distribution of gobiid larvae. They ranked first in abundance at 13-, 16-, and 18- out of 20 stations in 1984-1985 during spring, summer and fall, respectively. They were dominant in diverse habitats. In 1994-1995 we conducted a comparative study (1984-1985 vs. 1994-1995) to examine changes in ichthyoplankton composition that might have occurred in response to environmental changes in the bay between 1984-1985 and 1994-1995. We sampled ichthyoplankton using the same techniques at six of the same stations visited in 1984-1985. We used the non-parametric Kruskal-Wallis test to compare densities between the two sampling periods. Zooplanktivorous engraulids made up a larger part of the ichthyoplankton in 1994-95, and their densities are underestimated as numerous unidentified clupeiforms were most likely engraulids. The most notable change in engraulid densities was observed in western Florida Bay where seagrass die-off was most pronounced. Dramatic changes in densities of juvenile engraulids, mainly bay anchovy (*Anchoa*

mitchelli), between 1984-85 and 1994-95 in Florida Bay occurred in concordance with the larval occurrences (Thayer *et al.* 1999). Relative to the other commonly collected taxa, there were no significant differences in densities between the two time periods for larval gobiids, callionymids or clinids.

Keywords: Florida Bay ichthyoplankton; changes in ichthyoplankton composition

INTRODUCTION

Florida Bay is a shallow lagoon located for the most part in Everglades National Park, Florida, USA. The bay is bordered on the north by the Florida mainland, south and east by the Florida Keys and Atlantic Ocean and west by the Gulf of Mexico (Figure 1). The bay is compartmentalized into partially submerged carbonate mud banks, basins, and numerous mangrove islands. The banks and islands impede water flow within the bay. An excellent account of the recent ecological history of Florida Bay is given by Fourqurean and Robblee (1999).

Prior to Center for Coastal Fisheries and Habitat Research (CCFHR) efforts (Powell *et al.* 1989), published ichthyoplankton studies from waters in and adjacent to Florida Bay were limited. Houde and Chitty (1976) and Collins and Finucane (1984) conducted ichthyoplankton surveys in coastal waters in the eastern Gulf of Mexico, but few stations were in Florida Bay and adjacent waters. From 1982 to 1984, Everglades National park personnel examined the distribution, habitat, and relative abundance of two important gamefish – spotted seatrout (*Cynoscion nebulosus*, Family Sciaenidae) and gray snapper (*Lutjanus griseus*, Family Lutjanidae). Their study was published concurrently with the first Florida Bay ichthyoplankton study by the CCFHR (Powell *et al.* 1989; Rutherford *et al.* 1989).

During the last two decades, significant changes have occurred in Florida Bay with respect to ichthyofauna composition, seagrass abundance, salinity regimes, algal blooms, and water clarity (Fourqurean and Robblee 1999). Now, plans have been developed and are being initiated that will significantly increase the freshwater flow into the Everglades National Park. The purpose of this paper is to summarize our ichthyoplankton data (collected over a 16 year period) so that it can be used to evaluate the effect of this change in freshwater flow with respect to ichthyoplankton distribution in the bay. Cooperation between the Plankton Sorting and Identification Center (PSIC) and the Beaufort Laboratory has resulted in numerous contributions. One of those contributions has been enhancing our understanding of the ichthyoplankton composition of Florida Bay and adjacent waters. The purpose of this paper is to summarize those cooperative contributions.

ICHTHYOPLANKTON RESEARCH RESULTS AND DISCUSSION

1984-1985 Study

Ten larval fish collecting trips were made between March 1984 and September 1985. Twenty stations were sampled in Florida Bay and adjacent waters with a 61 cm bongo sampler fitted

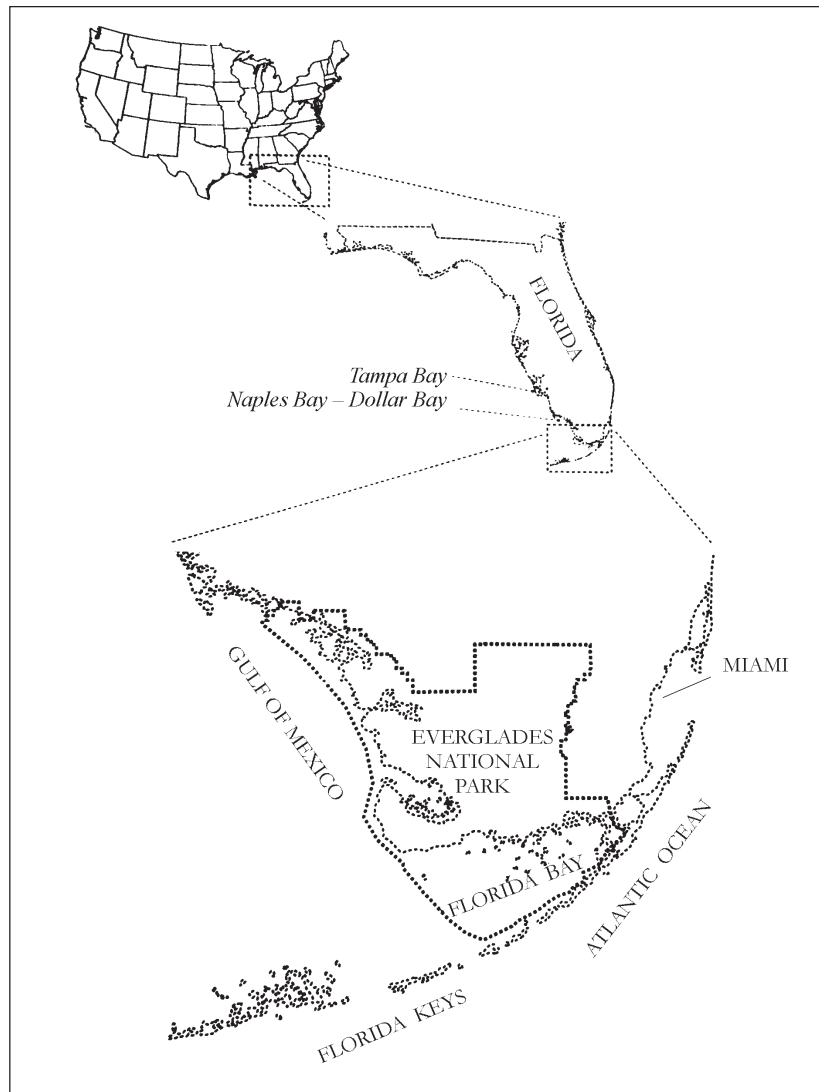


Fig. 1. Map showing the relation of Florida Bay to Florida and the United States

with 333 μm mesh nets (Figure 2). Only 11 stations occurred in Florida Bay and were located primarily along the Florida Keys and western Florida Bay. Four recreational important species were targeted – spotted seatrout, gray snapper, red drum (*Sciaenops ocellatus*, Family Sciaenidae), and snook (*Centropomus undecimalis*, Family Centropomidae). A detailed description of the methods, and results and discussion are given in Powell *et al.* (1989).

Spotted seatrout was the only target species whose larvae were commonly collected. We collected one red drum larvae, no snook larvae, and 15 potential gray snappers, but because of taxonomic problems, we could not identify the larval snappers to species. Based on conclusions reached by Powell *et al.* (1989) and a more recent study (Peters *et al.* 1998) snook do not use Florida Bay as a nursery area, but rather recruit into the bay as sub-adults. Investigators

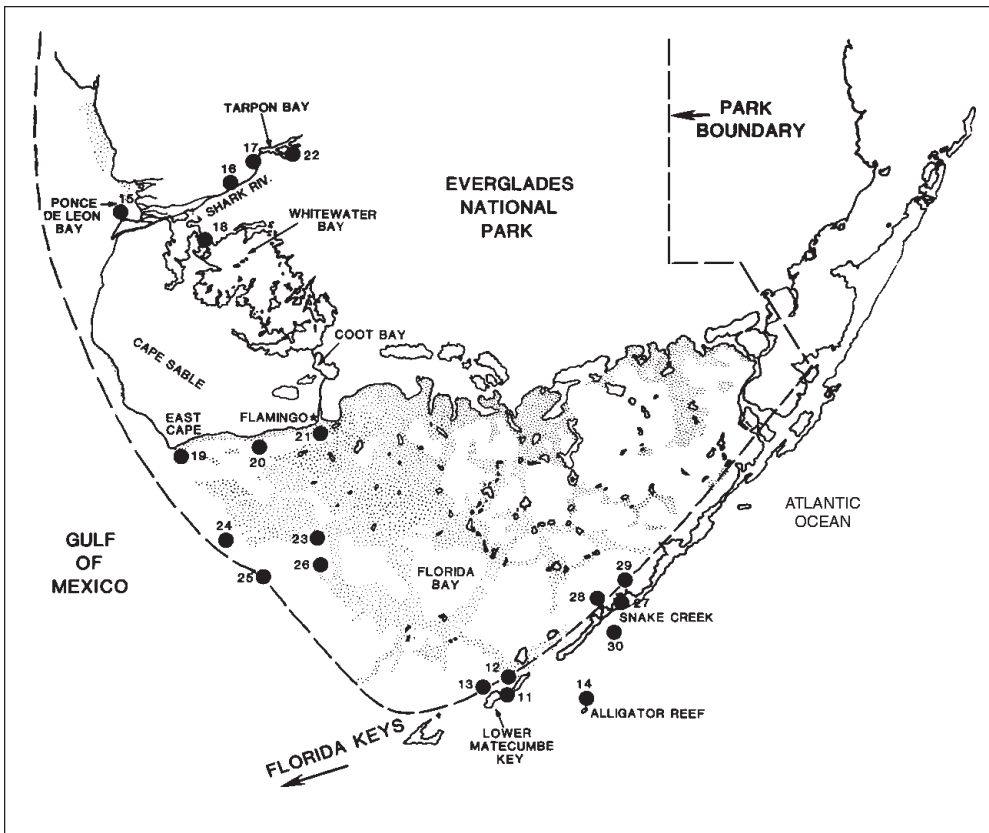


Fig. 2. Location of ichthyoplankton sampling stations for the 1984-85 study (from Powell *et al.* 1989)

who have extensively sampled juvenile fishes in Florida Bay (Thayer *et al.* 1987; Thayer and Chester 1989; Colvocoresses, unpubl. data* failed to collect any juvenile snook (or red drum). Important nursery areas for snook appear to be Tampa and Naples Bays (Figure 1) (Peters *et al.* 1998). Red drum, which do not appear to use Florida Bay as a nursery area, spawn in coastal Gulf of Mexico waters and, speculatively, use the rivers and bays in the western portion of Everglades National Park north of Florida Bay as nursery areas (Jannke 1971; Collins and Finucane 1984; Wilbur 1997). Our collections of early snapper larvae were taken only outside Florida Bay at Alligator Reef (Figure 2). The presence of snapper postflexion larvae and early juveniles at near-inlet stations (stations 12 and 13, Figure 2) suggests that snappers spawn outside Florida Bay and enter the bay as advanced larvae or early juveniles (Powell *et al.* 1989; Rutherford *et al.* 1989).

Spotted seatrout spend their entire life in Florida Bay. Based on larval collections, which were comprised mainly of preflexion stage larvae, spawning is minimal in late fall and the winter months, peaks during mid-to-late spring and continues during the summer at moderate

*Colvocoresses, James. unpublished data. Department of Environmental Protection, Florida Marine Research Institute, South Florida Regional Laboratory, 2796 Overseas Highway, Suite 119, Marathon, Florida 33050.

levels, then declines in winter (Jannke 1971; Powell *et al.* 1989). Based on the occurrence of preflexion larvae, spawning and the early life history of spotted seatrout occur mainly in north-western Florida Bay and adjacent estuarine waters, but spawning has also been reported in northeastern Florida Bay (Rutherford *et al.* 1989), an area we have not sampled. To determine specific spawning sites, we used the occurrence of preflexion larvae to indicate recent spawning (Figure 3). In estuarine waters adjacent to Florida Bay, spawning occurred at Cormorant Pass (station 18), and Ponce de Leon Bay (station 15). Spawning did not appear to occur in the upper Shark River (stations 16 and 17) nor Tarpon Bay (station 22). Within the bay, spawning occurred in all the areas trout larvae were collected (i.e., western Florida Bay) (Powell *et al.* 1989).

One of the most striking patterns observed was the dominance and ubiquitous distribution of gobiid larvae. They ranked first in abundance at 13-, 16-, and 18- out of 20 stations in 1984-1985 during spring, summer and fall, respectively. They are dominant in diverse habi-

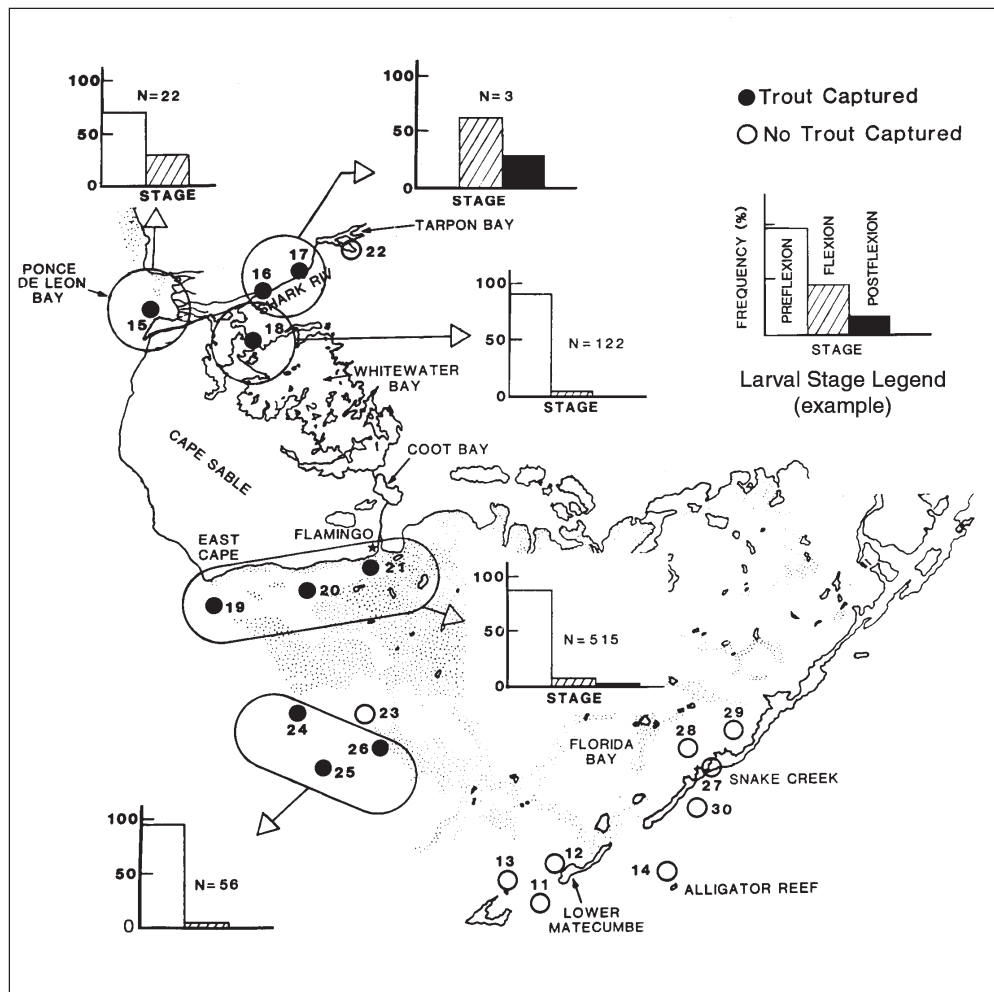


Fig. 3. Frequency distribution of larval spotted seatrout developmental stages (from Powell *et al.* 1989)

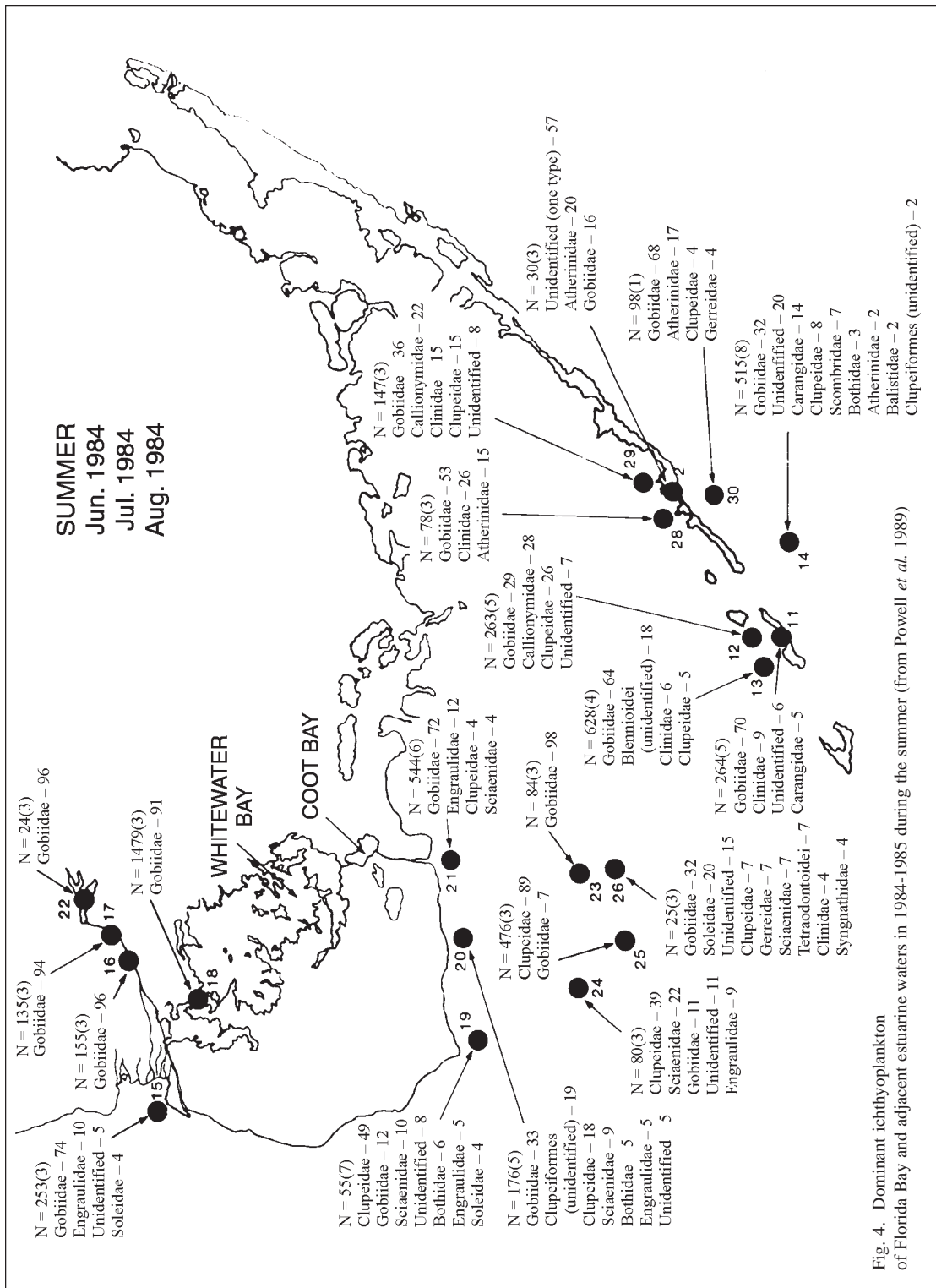


Fig. 4. Dominant ichthyoplankton of Florida Bay and adjacent estuarine waters in 1984-1985 during the summer (from Powell *et al.* 1989)

tats. For example, in 1984-1985 during the summer they ranked first in abundance at low-salinity stations at Shark River (stations 16, 17 and 22), at numerous northwestern bay stations (stations 20, 21, 23 and 26), at most stations in the bay adjacent to the Florida Keys (stations 11-13, 28, 29) at Alligator Reef (station 14) and Whale Harbor Channel (station 30) (Figures 2 and 4).

Decadal Comparison Study (1984-85 vs. 1994-95)

Beginning in 1987, an unprecedented die-off of the seagrass *Thalassia testudinum* (turtlegrass) occurred in western Florida Bay (Fourqurean and Robblee 1999). Accompanying this die-off was an increase in turbidity and algal blooms, both of which decreased the penetration of light in the water column. By 1991, concern for the health of Florida Bay was widespread among the public, scientists, commercial fishermen, and management agencies. Our ichthyoplankton and juvenile fish surveys in the 1980's (Powell *et al.* 1989; Thayer *et al.* 1987; Thayer and Chester 1989, 1990) provided an opportunity to initiate a comparative study of ichthyoplankton (and juvenile fishes) relative to the environmental changes that occurred over the decade. Details of this study are given in Thayer *et al.* (1999).

We sampled ichthyoplankton using the same techniques at six of the same stations visited in 1984-85 (Figure 5). We used the non-parametric Kruskal-Wallis test to compare densities

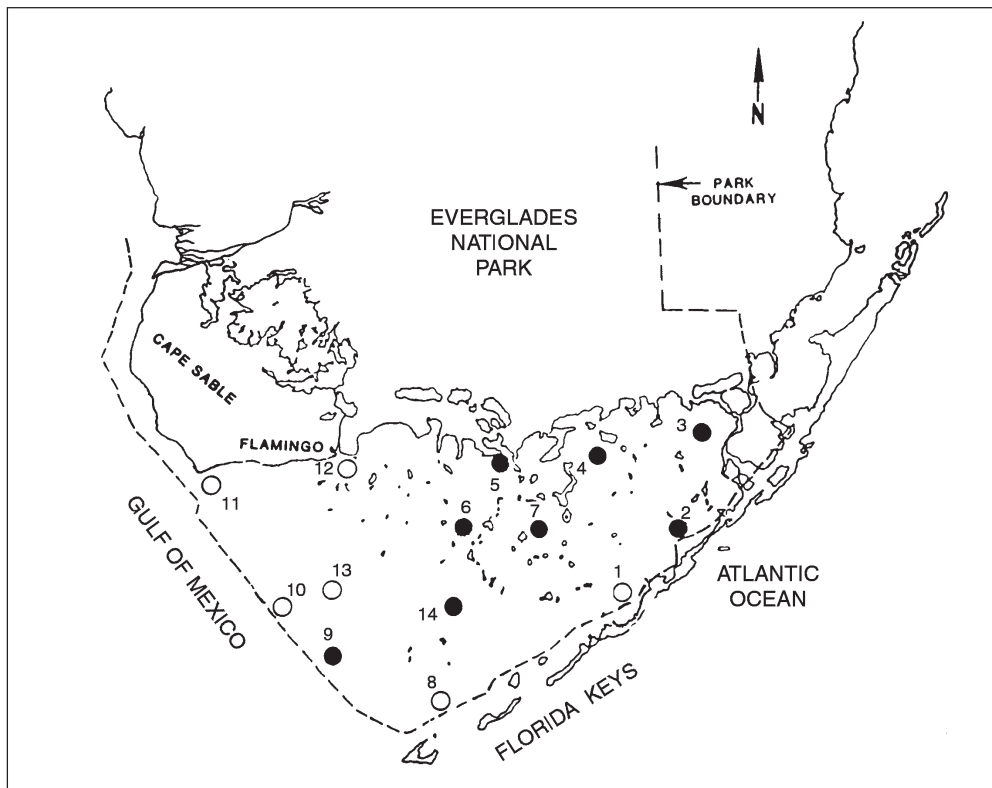


Fig. 5. Location of ichthyoplankton stations sampled in 1994-96. Data from stations 1,8,10,11,12,13 (open circles) were used in the decadal comparison study (1984-85 vs. 1994-95) (from Thayer *et al.* 1999)

Table 1. Comparison of the composition of ichthyoplankton in Florida Bay between 1984-1985 and 1994-1995. Ichthyoplankton was collected at the same stations during the same months for each time period (Thayer *et al.* 1999)

1984-1985		1994-1995	
Taxa	Percent	Taxa	Percent
Gobiidae	41.2	Gobiidae	37.1
Clupeidae	28.6	Clupeiformes ¹	27.1
Callionymidae	11.1	Clupeidae	11.3
Clinidae	6.0	Engraulidae	9.0
Engraulidae	4.4	Callionymidae	5.3
Sciaenidae	2.4	Sciaenidae	3.7
Atherinidae	1.2	Clinidae	3.1
Blenniidae	1.0	Soleidae	1.5
Syngnathidae	0.7	Syngnathidae	0.4
Tetraodontoidei	0.6	Tetraodontoidei	0.3
Paralichthyidae	0.6	Atherinidae	0.3
Soleidae	0.5	Blenniidae	0.3
Exocoetidae	0.5	Carangidae	0.2
Gerreidae	0.4	Monacanthidae	0.1
Gobioidae	0.2	Exocoetidae	0.1
Carangidae	0.2	Gobioidei	0.1
Monacanthidae	0.1	Cynoglossidae	<0.1
Belonidae	0.1		
Gobiesocidae	0.1		
Cynoglossidae	0.1		
Batrachoididae	<0.1		
Mugillidae	<0.1		

¹ Unidentified: either Clupeidae and/or Engraulidae.

between the two sampling periods. In 1996, we targeted spotted seatrout and only sampled at those stations where larval spotted seatrout had been collected previously (stations 10-13). We included data from these stations to examine variability between adjacent years relative to variability over a 10 year period. For a detailed account of methods used in the comparative study, refer to Thayer *et al.* (1999).

The order Clupeiformes (Clupeidae and Engraulidae) was a dominant group in both sampling periods (Table 1, Figure 6). However, engraulids made up a larger part of the ichthyoplankton in 1994-95, and their densities are underestimated as numerous unidentified clupeiforms were most likely engraulids. The most notable change in engraulid densities was observed in western Florida Bay (station 13, Figure 2). Here, this taxon was collected throughout most of the year in 1994-95, but never collected at station 13 in 1984-85. Dramatic changes in densities of juvenile engraulids, mainly bay anchovy (*Anchoa mitchelli*), between 1984-85 and 1994-95 in Florida Bay occurred in concordance with the larval occurrences (Thayer *et al.* 1999). Along with increasing densities of zooplanktivorous juvenile bay anchovy, there were increases in juvenile atherinids and clupeids, two other zooplanktivores, and a decrease in seagrass canopy dwelling species. Decreases in seagrass densities along with increased phytoplankton blooms could have contributed to the increase in planktivorous fishes.

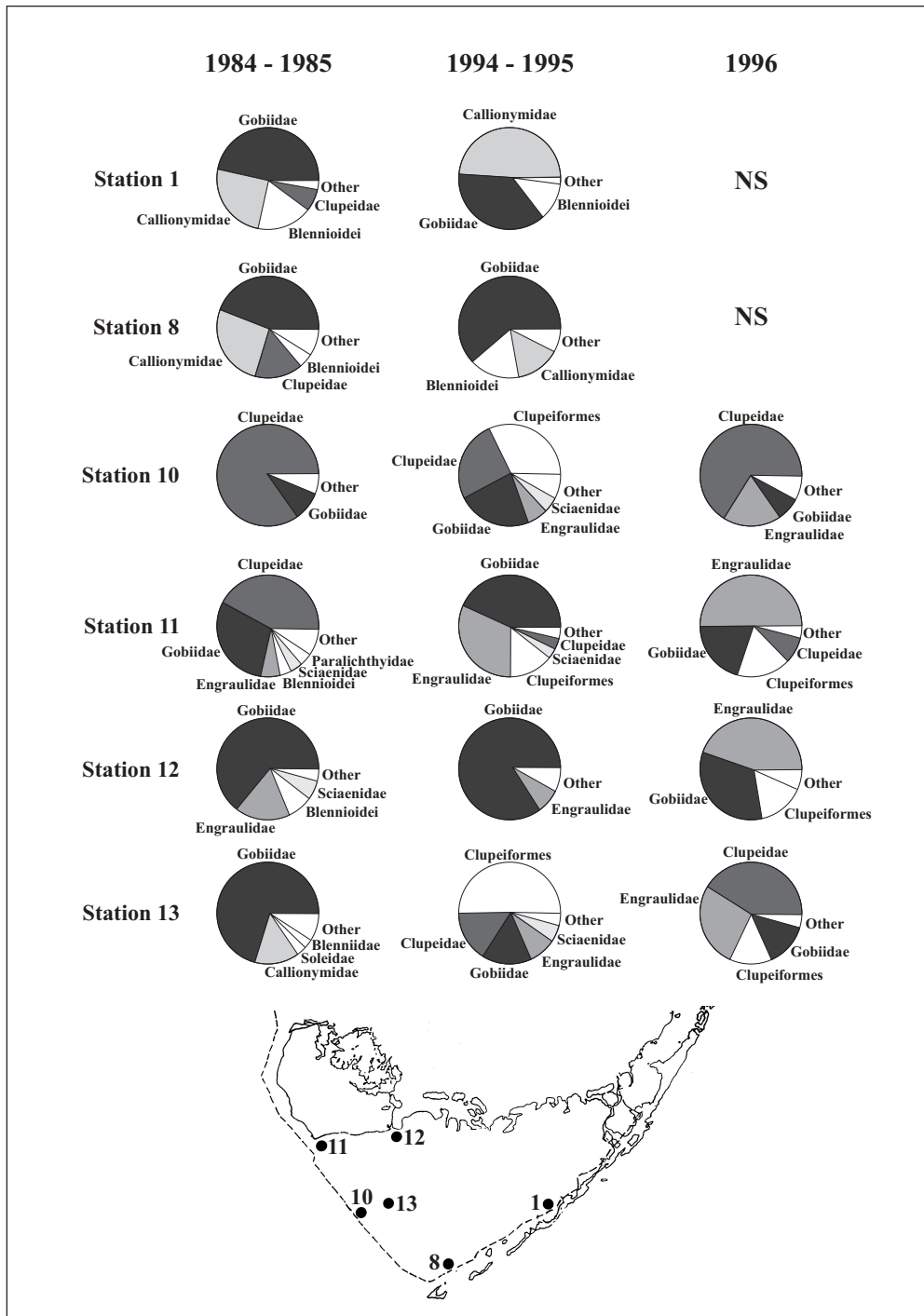


Fig. 6. Comparisons between 1984-85, 1994-95 and 1996 collections of the most abundant ichthyoplankton (>90% of the total) in Florida Bay. NS indicates samples were not taken (modified from Thayer *et al.* 1999)

The family Gobiidae, a demersal taxa, was a dominant component of the ichthyoplankton at all stations during both sampling periods (Table 1, Figure 6). There were no significant differences in goby densities between the two periods at any station. Total densities (number 100 m⁻³) summed over all stations and months for 1984-85 and 1994-95 were 3012 and 2771 larvae, respectively.

The family Callionymidae, represented by one demersal species (*Diplogrammus pauciradiatus*, spotted dragonet) in Florida Bay, was the third most abundant taxon collected during both time periods (Table 1, Figure 6). There were no significant differences in densities between the two time periods. The spotted dragonet has a relatively restricted distribution in Florida Bay, with most collected along the Florida Keys in areas where there is exchange with Atlantic Ocean waters (stations 1 and 8). The distribution of the demersal family Clinidae, which was a dominant component of the ichthyoplankton, was similar to the distribution of the spotted dragonet in both time periods (Table 1, Figure 6). There were no significant differences in densities for this taxon between time periods.

On-going Research

Prior to initiating our 1994-95 study, it became apparent that ichthyoplankton surveys in Florida Bay lacked comprehensive coverage (Collins and Finucane 1984; Powell *et al.* 1989) or targeted selected species (i.e., spotted seatrout, *Cynoscion nebulosus*, and gray snapper, *Lutjanus griseus*; Rutherford *et al.* 1989). Therefore, we added additional stations in 1994-95 to compensate for the lack of comprehensive coverage (Figure 5).

The objectives of the 1994-95 study were to describe the ichthyoplankton composition throughout Florida Bay and describe the spatial and temporal spawning habits of the recreational important spotted seatrout. To accomplish these objectives, we sampled in nine months from September 1994 through August 1995 with 60 cm diameter bongo nets fitted with 0.333 mm mesh (Figure 5). Nets were towed during daylight, approximately 1 m below the surface for 5 minutes, and volume estimates were obtained from flowmeter readings. Temperature, salinity, and turbidity (nephelometer units) were obtained at each station and approximately mid-way between stations. To date, all samples have been sorted, larvae identified to mainly family level, data analysis has been accomplished, and a manuscript is in preparation.

As anticipated from our decadal study (see above), Clupeiformes (Clupeidae, Engraulidae and unidentified Clupeiformes) were a dominant component of our collections. Based on our juvenile fish collections (Thayer *et al.* 1999), we believe the majority of unidentified clupeiforms from 1994-1995 collections were bay anchovy. There were significant differences in clupeiform densities (numbers 100 m⁻³) among stations and these differences were partially attributed to the scarcity of this taxa at stations influenced by subtropical Atlantic Ocean water. On the other hand, it appeared that callionymid (*Diplogrammus pauciradiatus*) and clinid (most likely banded blenny, *Paraclinus fasciatus*; and marbled blenny, *P. marmoratus*) larvae, both abundant taxa, were, in general, more abundant in waters influenced by the Atlantic Ocean. The gobiids (most likely dominated by code goby, *Gobiosoma robustum*; and clown goby, *Microgobius gulosus*) were ubiquitous in distribution, although significant differences were observed in gobiid densities among stations. These differences could be a result of the dominance of *G. robustum* coupled with its relative rarity in northeastern Florida Bay (Sogard *et al.* 1987). The analysis of the distribution of other abundant taxa (Clinidae, Soleidae and Syngnathidae) indicated that with the exception of the syngnathids, the densities of all the abundant taxa differed significantly between stations, indicating Florida Bay is not a homogenous ecosystem.

SUMMARY

Our ichthyoplankton studies have constraints and limitations. Sampling was done during daylight hours due to the extreme difficulty of navigating at night. In addition, waters in Florida Bay are relatively clear, hence net avoidance is a major influence in collecting large larvae and juveniles. As a result, we collected mainly early stage larvae that were spawned in the bay. Compared to our concurrent juvenile sampling program, we rarely collected larger larvae of numerous taxa that spawn outside Florida Bay, but use the bay as a nursery area (e.g. gerreids, lutjanids, haemulids, sparids). In addition, those taxa with demersal eggs and larvae (batrachoidids, fundulids, cyprinodonts) are rarely collected with ichthyoplankton gear.

Still, in these studies we were able to delineate the temporal and spatial spawning habitats of the valuable spotted seatrout in Florida Bay and adjacent waters. This species has a protracted spawning period, but spawning is restricted spatially to certain portions of the bay and adjacent estuarine waters where salinities are >20-25 psu and lush seagrass habitats exist. This information is critical in evaluating the effects of a proposed Everglades National Park restoration project that would increase freshwater flows to the park. Increased freshwater inflow could cause changes in the species assemblage of both fishes and their seagrass habitats, and the spawning area for the valuable spotted seatrout.

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