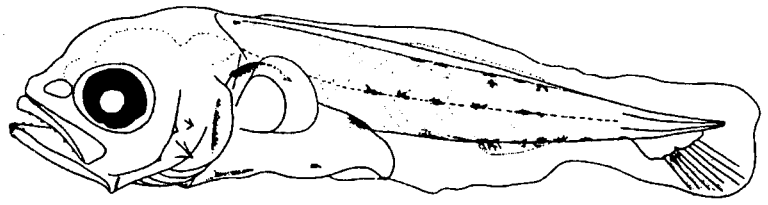
NOAA TECHNICAL MEMORANDUM NMFS-SEFSC-488

Distribution and Abundance of Ichthyoplankton in Florida Bay

Allyn B. Powell



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National Ocean Service
Center for Coastal Fisheries and Habitat Research
101 Pivers Island Road
Beaufort, NC 28516

August 2002

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August 2002

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Correct citation of this report is:

Powell, A. B. 2002. Distribution and abundance of ichthyoplankton in Florida Bay. NOAA Technical Memorandum NMFS-SEFSC- 488, 22 p.

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Abstract

Ichthyoplankton was sampled at 14 stations with 60 cm bongo nets fitted with 0.333 mm mesh in basins throughout Florida Bay in 1994-1995. In addition, I compared collections made using an epibenthic sled to those made with standard ichthyoplankton bongo nets at four stations during July 1997-November 1999 to determine if the two types of gear are complementary. In 1994-1995, in descending order of abundance, Clupeiformes, Gobiidae, Callionymidae, Sciaenidae, Labrisomidae, Soleidae and Blenniidae dominated the ichthyoplankton. Densities of clupeiforms were generally very high (> 100 larvae 100 m^{-3}) or high (10.0 - 99.9 larvae 100 m^{-3}). Gobiid larvae were ubiquitous with highest densities occurring in waters in close proximity to the Gulf of Mexico (109.7 larvae 100 m^{-3}), lowest in two of three eastern Florida Bay stations (< 1.0 larva 100 m^{-3}). Spotted seatrout, *Cynoscion nebulosus*, dominated larval sciaenid collections and the only other sciaenid identified to species was the sand seatrout, *Cynoscion arenarius*. Taxa differed markedly between collections taken by epibenthic sled and standard ichthyoplankton bongo nets. Taxa collected with standard ichthyoplankton gear were those that spawn in Florida Bay and have pelagic larvae (i.e., engraulids and gobiids). Taxa collected with the sled were small resident species that have benthic larvae (i.e., syngnathids and cyprinodonts) or taxa that spawn outside the bay, but use the bay as a nursery area (i.e., gerreids and haemulids). Recently-settled red drum, *Sciaenops ocellatus*, were collected with the epibenthic sled in November 1999, although juveniles of this important gamefish are rare in the bay.

Introduction

Florida Bay is a valuable nursery area for important commercial and recreational fishes, forage fishes, and decapod crustaceans and provides valuable habitat for small resident fishes (Costello and Allen, 1966; Davis and Dodrill, 1989; Powell et al., 1989; Rutherford et al., 1989; Tabb and Roessler, 1989; Thayer and Chester, 1989). Ecologically, Florida Bay is generally oligotrophic with the western portion of the bay supporting a greater diversity of fishes and seagrasses, and containing thick organic sediments (Thayer and Chester, 1989; Fourqurean and Robblee, 1999).

Recently, Florida Bay has received a great deal of attention because of dramatic environmental changes which occurred beginning during the late 1980's and early 1990's, including drought-induced hypersaline conditions, seagrass die-offs, increased turbidity, and algal blooms (Fourqurean and Robblee, 1999). These events prompted researchers at the NOAA Beaufort Laboratory to undertake a decadal comparison (1984-1985 compared to 1994-1995) of ichthyofauna in Florida Bay (Thayer et al., 1999). While preparing the research plan for this comparison, it became apparent that there was a lack of spatial coverage for the ichthyoplankton component. Therefore, additional fixed stations were added to the study to provide more comprehensive coverage. The objectives of this study are to provide a comprehensive account of the abundance and distribution of ichthyoplankton in Florida Bay, and to compare gear types in order to evaluate their use as complementary gear. Some data presented here were included in Thayer et al. (1999).

Materials and Methods

Sampling was conducted in basins of Florida Bay at 14 stations during nine months from September 1994 through August 1995. Sixty cm bongo nets fitted with 0.333 mm mesh were fished from the port side of a 5.4 m boat (Table 1; Fig. 1). Nets were towed during daylight, approximately 1 m below the surface for 5 min and volume estimates were obtained from flowmeter readings. Based on recommendations by the South Florida Ecosystem Restoration Prediction and Modeling (SFERPM), Program Management Committee (PMC), Florida Bay was divided into six zones (Table 1; Fig. 1).

In July 1997, I decreased our ichthyoplankton sampling coverage to monitor spawning of spotted seatrout at four stations (Table 1; stations 6, 15, 16, and 17) (Powell[1]), and also to test the efficiency of using an epibenthic sled to collect recently-settled spotted seatrout, *Cynoscion nebulosus*, as part of a concurrent otolith microstructure study (Powell et al.[2]). The analysis of other species collected with the sled allowed me to make comparisons with the standard bongo

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[1] Powell, A.B. in review. Larval abundance and distribution, and spawning habits of spotted seatrout, *Cynoscion nebulosus*, in Florida Bay, Everglades National Park, Florida. Fish. Bull.

[2] Powell, A. B., R. Cheshire, E. H. Laban, J. Colvocoresses, P. O'Donnell, and M. Davidian. unpublished manuscript. Growth, mortality and hatchdate distributions of larval and juvenile spotted seatrout, *Cynoscion nebulosus*, in Florida Bay, Everglades National Park.

nets. Stations were sampled in September 1997; March, May, June, July and September, 1998; May, July, September and November, 1999. The standard bongo nets consisted of a paired 60 cm bow-mounted push net with 0.333 mm mesh nets similar to that described by Hettler and Chester (1990). Nets were fished approximately 1 m below the surface for 3 min. The volume of water sampled was approximately 60 m^3, computed from flowmeter readings. From September 1997 through September 1998 a 0.3 x 0.7 m sled was used; thereafter, a 1.0 x 0.5 sled was employed. Both were fitted with a 0.947 mm mesh net and volume estimates were obtained from flowmeter readings. A Kruskal-Wallis non-parametric test was used to evaluate differences in the densities of total fishes between the two epibenthic sleds (Sokal and Rohlf 1981). The 1.0 m x 0.5 m sled sampled a significantly greater densities of fishes than the other sled ($p=0.05$). Therefore, no comparisons were made that would be biased by the differences in gear efficiency.

When replicate tows were processed, densities were averaged. Ichthyoplankton samples were preserved in 95% ethanol; epibenthic sled samples were preserved in 4% formalin after the removal of target species which were preserved in 95% ethanol for future otolith analysis. At all stations (1994-1999) temperature was measured with a hand-held thermometer and salinity was measured with a refractometer. Turbidity (only in 1994-1995) was measured with a portable Hach Model 2100P nephelometer and reported in turbidity units. A general description of the diverse habitats relative to my stations are described by Holmquist et al. (1989; decapod and stomatopod communities); Thayer and Chester (1989; fish distribution, seagrass distribution and abundance, sediment depth and organic content); Zieman et al. (1989; macrophyte distribution); and Fourqurean and Robblee (1999; general description of the Florida Bay ecosystem).

Because of the high coefficient of variation associated with ichthyoplankton samples (Cyr et al., 1992), I believed our sampling design was inadequate to make multi-way statistical comparisons (i.e., Analysis of Variance); therefore, we used non-parametric Kruskall - Wallis tests with $\alpha = 0.10$ (Sokal and Rohlf, 1981) and relied on patterns and trends to infer differences in the ichthyoplankton composition between stations and time periods. Ichthyoplankton densities were defined as: "very high" ($\geq$100.0 larvae 100 m^{-3}); "high" (10.0 - 99.9 larvae 100 m^{-3}); "moderate" (1.0 - 9.9 larvae 100 m^{-3}); and "low" (0.1 - 0.9 larva 100 m^{-3}).

Results

Ichthyoplankton composition 1994-1995, stations 1- 14

Clupeiformes (unidentified Clupeiformes, Clupeidae and Engraulidae) dominated ichthyoplankton collections (Table 2). In 1994-1995 these pelagic zooplantivores comprised 49% of the total ichthyoplankton. The demersal families Gobiidae (23%) and Callionymidae (17%) (spotted dragonet, *Diplogrammus pauciradiatus*) also were significant components of the ichthyoplankton.

Densities of the majority of the most abundant taxa ($\geq$1.0 larvae 100 m^{-3} in Table 2) collected in 1994-1995 differed spatially and temporally (Table 3, Fig. 2) and densities differed notably within geographic zones. Clupeiform larvae dominated collections at 10 of the 14 stations in 1994-1995 (Fig.2). "Very high" densities of clupeiform larvae occurred in the Western (station 13), Gulf Transition (station 9) and Central zones (stations 5 and 6) of Florida Bay. "High" densities occurred at numerous stations, and "moderate" and "low" densities occurred in the Atlantic Transition zone (stations 8 and 1, respectively).

Significant differences in total clupeiform densities were observed temporally (Table 3). Because numerous clupeiforms were unidentifiable to family, it was inappropriate to analyze larval clupeid and engraulid densities temporally. Clupeids and/or engraulids were most abundant in summer.

Gobiid larvae were the second most abundant taxa overall (Table 2). This demersal taxa was a dominant component at all stations, especially when clupeiforms are excluded. The highest density of gobiid larvae was observed at a Gulf Transition zone station (12), lowest at Eastern zone stations (2 and 4) (Fig. 2). Although there was a significant difference in monthly densities of gobiids, seasonal patterns were not evident, except for low densities observed in December (Table 3).

Sciaenid larvae, dominated by spotted seatrout, were collected at "high" densities in the Central (stations 5 and 6), Western (station 13) and Gulf Transition (station 10) zones; "low" densities at one station (8) in the Eastern zone; absent at stations (1, 3 and 7) in the Eastern and Central zones; and "moderate" densities at all other stations within the Eastern Central and Gulf Transition zones (Table 3). The sand seatrout, *C. arenarius*, was the only other sciaenid that was identified to species during 1994-1995 (Fig. 2). It occurred at stations 5 and 6, during September and February. Most of these larvae were recently hatched.

Labrisomid larvae, although a dominant component of the ichthyoplankton overall (Table 2), were never the dominant taxa at any one station (Fig. 2). "High" densities of this demersal taxa were observed at a station (8) in the Atlantic Transition zone, "low" densities at stations in the Central (station 14) and Gulf Transition (stations 11 and 12) zones, and were absent at two stations in the Central zone (stations 5 and 6) and one in the Western zone (station 13). "Moderate" densities were observed at all other stations (Fig. 2). Densities of labrisomid larvae were significantly different among months, and based on larval occurrences, spawning was minimal in winter (Table 3).

The soleid, *Achirus lineatus*, has a restricted distribution in Florida Bay, opposite that of the labrisomids, but similar to spotted seatrout (Fig. 2). *Achirus lineatus* was collected at "moderate" densities at Gulf Transition (stations 9, 10 and 12), Central (stations 5, 6 and 14) and Western (station 13) zones. It was absent at stations (1 and 8) in the Atlantic Transition zone and stations (2 and 3) in the Eastern zone. Based on larval occurrences, this species spawned in summer and early fall (Table 3).

Blenniid larvae were the least dominant component of the most abundant ichthyoplankton (Table 2). This demersal taxa was never the dominant taxa at any station (Fig. 2). Blenniid larvae occurred at "moderate" densities at two stations (5 and 6) in the Central zone, and at "low" densities at most other stations. Based on larval occurrences, blennies had a protracted spawning period (Table 3).

Environmental data collected during 1994-1995 indicated that mean water temperatures and their variability at all 14 stations were roughly equivalent (Fig. 3). The lowest mean water temperatures occurred in February, highest in July (Fig. 4). Mean water temperatures in November, December and April were similar. Mean salinities varied among stations more than temperature. The greatest variability within stations was observed in the Eastern zone (stations 2, 3 and 4), the least at stations in the Atlantic (station 8) and Gulf Transition zones (stations 9 and 10). The highest mean salinities were observed in September 1994, when there was little

variability among stations with salinities ranging from 34 - 39 psu. Salinities were highly variable throughout Florida Bay, and polyhaline (18 - 30 psu) to euhaline (30 - 40 psu) conditions prevailed. Mesohaline (5 - 18 psu) conditions occurred in the Central and Northern Transition zones, although salinities < 10 psu were not observed. Turbidities were relatively low in Atlantic Transition (stations 1 and 8), Eastern (station 3) and Central (station 14) zones with little seasonal differences. On the other hand, turbidity was relatively high and seasonally variable at stations 10 - 13 (Gulf Transition zone), stations influenced by water from the Gulf of Mexico (Fig. 3). In 1994-1996, turbidity was relatively low in April and July and relatively constant throughout the Florida Bay. Conversely, turbidity was high in February with considerable variation throughout the bay (Fig. 4).

Bow-mounted push net and epibenthic sled comparisons

Taxa differed markedly between collections taken by bow-mounted push net and epibenthic sled (Table 4). Push net samples were dominated by engraulids and gobiids (Table 4). These taxa were collected at "very high" densities at station 6 (Central zone) as were all other commonly collected taxa, except sciaenids (Table 5). "Very high" densities of engraulids, gobiids, callionymids, and clupeids were collected at station 6, and the highest density of sciaenids were also collected at this Central zone station. Gobiids also occurred at "very high" densities at station 16 in the Central zone. Callionymids had the most restricted distribution, and were rare to absent at all stations except station 6 (Central zone). Overall, larval fish densities were consistently higher at station 6 than in the other three sampling areas.

At least 36 species of fishes were collected with the epibenthic sled (Table 6). Two syngnathids, the dwarf seahorse, *Hippocampus zosterae* and the gulf pipefish, *Syngnathus scovelli*, dominated sled collections. "High" densities of *H. zosterae* were observed at station 16 (Central zone) and 17 (Gulf Transition zone) as well as "high" densities of *S. scovelli* at station 16; mojarras, *Eucinostomus* sp(p)., at stations 16 and 17; bay anchovy, *Anchoa mitchilli*, at station 6 (Central zone); and rainwater killifish, *Lucania parva*, at station 16 (Table 7). Pelagic larvae and recently settled larvae/juveniles of two important recreational species, spotted seatrout and red drum, *Sciaenops ocellatus*, were collected with the sled. Taxa that dominated push net samples (Table 4) for example gobiids, callionymids, and clupeids, were rarely collected with the sled at "high" densities at any one station (Table 7).

Salinities from July 1997- November 1999 at station 6 averaged 31.7 psu ± 6.9 SD [range = 21.1 (July 1997) - 41.0 (May 1999)]; station 15 averaged 18.8 psu ± 7.8 [range = 10.0 (March 1998) - 33.0 (May 1999)]; station 16 averaged 32.7 psu ± 3.4 [range = 29.0 (July 1999) - 40.0 (May 1999)]; and station 17 averaged 32.5 psu ± 3.0 [range = 29.0 (July 1999) - 39.0 (May 1999)]. Salinities, generally were lowest in July 1999 and highest in May 1999.

Discussion

Ichthyofauna collected by both bongo gear and epibenthic sled indicate that the fish assemblage in Florida Bay is mainly dominated by warm temperate taxa (e.g., sciaenids, engraulids, many syngnathids, and gerreids), while sub-tropical taxa were also encountered at relatively high densities [e.g., labrisomids (most likely *Paraclinus marmoratus*, and *P. fasciatus*;

Loftus[3]; Sogard et al., 1987)], *Diplogrammus pauciradiatus*, *Hippocampus zosterae*, *Micrognathus criniger*, and *Gobiosoma robustum*. The ichthyoplankton assemblage in Florida Bay is similar to that in Biscayne Bay, Florida (Houde and Lovdal, 1984), Apalachee Bay, Florida (Stoner, 1983) and in a western Mexican Caribbean bay system (Vásquez-Yeomans, 2000); although, there was a greater diversity of tropical species in the latter system. Using the criterion of the presence/absence of *H. zosterae*, *M. criniger*, *G. robustum*, labrisomids, and *D. pauciradiatus*, relatively few estuaries throughout Florida and the northern Gulf of Mexico exhibit a warm temperate/subtropical- larval/juvenile fish assemblage except for Biscayne Bay, Florida (Houde and Lovdal, 1984; Serafy et al., 1997) and Apalachee Bay, Florida (Stoner, 1983). None of these aforementioned species have been reported from Charlotte Harbor, Florida (Fraser, 1997), Calcasieu Estuary, Louisiana (Felley, 1987), Caloosahatchee Estuary, Florida (Gunter and Hall, 1965), or Horn Island, Mississippi (Franks, 1970). Three (*G. robustum*, *M. criniger* and *H. zosterae*) have been reported from Cedar Key, Florida (Reid, 1954), and only one (*G. robustum*) reported from Indian River Lagoon, Florida (Stoner, 1983) and Redfish Bay, Texas (Tolan et al., 1997). Of the studies above, *D. pauciradiatus* has only been reported from Biscayne Bay.

Major constraints in describing the fish assemblage from this ichthyoplankton study with standard ichthyoplankton gear are the difficulties in identifying larvae, net avoidance of larger larvae and juveniles that spawn outside the bay, and the inability to collect demersal larvae. The latter constraint was most obvious when comparing results from bongo and epibenthic sled samples (e.g., Tables 5 and 6), and comparing bongo and otter trawl samples (Thayer et al., 1999). On the other hand, standard ichthyoplankton gear was useful in determining spawning habits (e.g., *Cynoscion nebulosus*, *Diplogrammus pauciradiatus*), and depicting the ubiquitous distribution of goby larvae. Moreover, inferences about the spawning habits of *the bay anchovy, Anchoa mitchilli*, can be made, as it has been the most abundant engraulid in Florida Bay (Thayer et al., 1999)

Push net samples were dominated by those species that spawn in Florida Bay and have pelagic larvae (e.g., gobies, engraulids, callionymids and sciaenids). Sled samples were dominated by species that spawn in the bay, but have demersal larvae (e.g., syngnathids and cyprinodonts), or that spawn outside the bay and have larvae which are well developed when entering the bay, and are able to avoid standard ichthyoplankton nets (e.g., gerreids, haemulids and sparids). On the other hand, juveniles of cryptic taxa (gobies and callionymids) were not taken in high densities in the sled samples relative to their densities in push net samples.

The use of an epibenthic sled is a valuable complimentary gear when used with standard ichthyoplankton gear and an otter trawl (this study; Thayer et al., 1999). The sled provides a link between early life history stages that are most vulnerable to bongo samplers and older life history stages that are most vulnerable to otter trawls. For example, the epibenthic sled collected recently settled taxa that spawn outside Florida Bay (based on the absence of their pelagic larvae in this study's ichthyoplankton collections; Jannke, 1971; Schomer and Drew, 1982; Collins and

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[3] Loftus, W. F. undated. Inventory of fishes of Everglades National Park. National Park Service, Everglades National Park, South Florida Research Center, Homestead, FL 33030, 45 p.

Finucane, 1984), yet use the bay as a nursery area (e.g., *Eucinostomus* sp(p)., *Bairdiella chrysoura*, *Sciaenops ocellatus*). The sled also captured recently settled larvae/juveniles of taxa with pelagic larvae that spawn in the bay (e.g., *Microgobius gulosus*, *Cynoscion nebulosus*, *Gobiosoma robustum*), while also taking taxa with demersal larvae (e.g., syngnathids and *Lucania parva*).

The presence of larval *Cynoscion arenarius* in the central area of the bay (Fig. 2) is puzzling as this species is known to spawn in coastal waters (Cowan and Shaw, 1988; Shaw et al., 1988; Cowan et al., 1989). Adult *C. arenarius* are uncommon in Florida Bay (Sogard et al., 1989; Loftus unpublished report). However, *C. arenarius* have been collected in the Buttonwood Canal at Flamingo (Fig. 1) prior to the installation of a "plug" that stops the flow of Florida Bay water into the canal (Roessler, 1970) and larvae have been collected at the mouth of Little Shark River (Jannke, 1971; Fig. 1).

Red drum, *Sciaenops ocellatus*, is one of the most popular gamefish in Florida Bay (Tilmant et al., 1989), yet collections of juveniles in the bay and adjacent waters are rare (Sogard et al., 1987; Thayer et al., 1987; Sheridan et al., 1997; Matheson et al., 1999; Florida Department of Environmental Protection[4]; Schmidt[5]). Red drum spawn along the southwest coast of Florida adjacent to Everglades National Park from August to mid-February with peaks in October (Jannke, 1971; Collins and Finucane, 1984). Considerable numbers of larval red drum have been collected at the mouth of Little Shark River (Jannke, 1971). My study appears unique in that I report the first occurrence of recently-settled red drum in Florida Bay. I can document only two other collections of juvenile red drum in Florida Bay (Colvocoresses[6]). These collections were made by beach seine at East Creek, Little Madeira Bay (northeast of station 4; Fig. 1) in October (n = 1; 25 mm SL) and February (n = 9; 28 - 49 mm SL) at salinities of 0.5 and 6.2 psu, respectively. Available information suggests that juvenile red drum occupy oligohaline and mesohaline backwaters and shallow creeks, and along shorelines where trawling is impossible (Mansuetti, 1960; Perret et al., 1980; Mercer, 1984; Peters and McMichael, 1987). In south Texas estuaries, juvenile red drum occur in polyhaline habitats, particularly in stands of the seagrass, *Halodule wrightii* (Rooker and Holt, 1997). Based on salinity patterns in Florida Bay (Orlando et al., 1997), the most suitable habitat for juvenile red drum appears to be the area where juveniles have been collected (see above). However, these areas are subject to wide salinity fluctuations because of frequent freshwater run off and rainfall (Schmidt[5]). Hence, the

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[4] Florida Department of Environmental Protection. 1995. Fisheries-independent monitoring program, annual report. Florida Department of Environmental Protection, Florida Marine Research Center, 100 8th Avenue SE, St. Petersburg, FL 33701, no page numbers.

[5] Schmidt, T. W. 1979. Ecological study of fishes and the water quality characteristics of Florida Bay, Everglades National Park, Florida. Final Project Report RSP-EVER N-36. U. S. National Park Service, South Florida Research Center, Homestead, FL 33030, 145 p.

[6] Colvocoresses, J. Personal communications. 2000. Florida Marine Research Institute, 2796 Overseas Highway, Suite 119, Marathon, FL 33050.

habitat for juvenile red drum in Florida Bay might be transient and episodic. Furthermore, transport mechanisms of red drum larvae from spawning sites in the Gulf of Mexico through Florida Bay seems even more enigmatic. Larvae spawned along the southwest coast of Florida are transported into the bay by southerly currents that cross Florida Bay in a southeast direction and exit through the Florida Keys (Lee et al.[7]). However, transport of larvae or recently settled juveniles to the northeast by tidal currents is negligible, as mud banks impede circulation in the bay (Fourqurean and Robblee, 1999). A survey has recently been completed by the NOAA Beaufort Laboratory to determine the value of Florida Bay as a nursery area for red drum (Powell et al., 2002). The conclusions reached are Florida Bay is not a nursery area for this species, and the occurrence of recently-settled red drum is episodic.

Acknowledgments

Sincere appreciation is extended to Al Crosby who was field party chief and processed numerous samples. I am also indebted to other Beaufort Laboratory staff members, notably Robin Cheshire, Peter Crumley, Mike Greene, Donald Hoss, Michael Johnson, Michael Lacroix, and David Peters for their able assistance in the field; Robin Cheshire and Lisa Wood for graphics; James Waters for computer programming; and Dean Ahrenholz and Joseph Smith for valuable comments in their review of the manuscript. The staff of the Polish Sorting and Identification Center processed many of the ichthyoplankton samples. Bruce Comyns of the Gulf Coast Research Laboratory and Joanne Lyczowski-Schultz of the National Marine Fisheries Service, Pascagoula Facility verified the identification of sand seatrout, *Cynoscion arenarius*. The larvae on the cover page was illustrated by J. G. Ditty.

[7] Lee, T. N., E. Williams, E. Jones, and D. Wilson. 1999. First year results from enhanced observations of circulation and exchange processes in western Florida and connecting coastal waters, including effects of El Nino and Hurricane Georges. Abstract, p.145. Florida Bay and Adjacent Marine Systems Science Conference, November 1-5, 1999, Key Largo, Florida, 263 p.

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Table 1. Florida Bay sampling stations including zone locations as defined by the South Florida Ecosystem Restoration Prediction and Modeling Program, Program Management Committee. Stations 1-14 were sampled in 1994-95; and stations 6, 15-17 in 1997-1999. A map of these stations is provided in Table 1.

Station number	Latitude (degrees and minutes)	Longitude (degrees and minutes)	Florida Bay zones	Location
1	24 59.42	80 34.06	Atlantic Transition	Cowpens Cut
2	25 04.42	80 31.24	Eastern	Butternut Key
3	25 10.54	80 29.12	Eastern	Duck Key
4	25 09.24	80 37.12	Eastern	Eagle Key/Madeira Point
5	25 08.30	80 43.19	Central	Big Key
6	25 04.57	80 46.32	Central	Whipray Basin
7	25 03.54	80 40.12	Central	Calussa/Russel Keys
8	24 52.46	80 47.31	Atlantic Transition	Old Dan/Peterson Key Banks
9	24 55.60	80 55.40	Gulf Transition	Sprigger Bank
10	24 58.48	80 59.48	Gulf Transition	Oxfoot/Sprigger Banks
11	25 06.49	81 05.16	Gulf Transition	Cape Sable
12	25 07.22	80 55.62	Gulf Transition	Dave Foy Bank
13	24 59.98	80 55.46	Western	Blue/Ninemile Banks
14	24 59.06	80 46.54	Central	Rabbit/Gopher Keys
15	25 10.80	80 37.80	Northern	Little Madeira Bay entrance
16	25 06.00	80 52.50	Central	Palm Key Basin
17	25 07.67	80 57.32	Gulf Transition	Bradley Key

Table 2. Mean densities (numbers 100 m^{-3}) over all cruises and stations, and percent of total mean densities of all taxa collected in 1994-1995 at stations 1-14.

Taxa	Mean density	Percent
Clupeiformes (unidentified)	39.2	23.3
Gobiidae	38.0	22.7
Callionymidae	29.0	17.3
Engraulidae	26.5	15.8
Clupeidae	17.2	10.3
Sciaenidae	9.0	5.4
Labrisomidae	3.4	2.0
Soleidae	2.4	1.4
Blenniidae	1.2	0.7
Syngnathidae	0.4	0.3
Atherinidae	0.4	0.3
Tetraodontoidei (unidentified)	0.2	0.1
Exocoetidae	0.1	0.1
Carangidae	0.1	0.1
Triglidae	0.1	<0.1
Monacanthidae	0.1	<0.1
Ophidiidae	0.1	<0.1
Gobioidei (unidentified)	0.1	<0.1
Tetraodontidae	<0.1	<0.1
Gobiesocidae	<0.1	<0.1
Cynoglossidae	<0.1	<0.1

Table 3. Mean densities (numbers 100 m^{-3}) of the most abundant taxa($\geq$1.0 m^{-3}; Table 2) by month. (NS) following the taxa indicates no significant differences (Kruskal-Wallis nonparametric test) among months. Taxa are listed in alphabetical order.

Taxa	Cruise date								
	1994			1995					
	Sep	Nov	Dec	Feb	Apr	May	Jun	Jul	Aug
Blenniidae (NS)	1.2	0.8	0	3.3	2.6	0.4	0.6	0.4	1.8
Callionymidae									
Diplogrammus pauciradiatus	98.6	2.2	1.6	0.8	2.5	26.8	60.0	46.6	6.9
Clupeiforms (total)	6.3	12.1	5.6	17.2	3.3	19.0	50.4	32.8	39.6
Clupeidae	6.1	0.2	0.4	6.5	0.5	7.2	6.0	11.4	21.5
Engraulidae (NS)	8.3	27.6	11.9	17.3	2.0	6.5	21.2	11.2	14.8
Gobiidae (NS)	73.2	20.7	6.8	24.6	73.7	29.6	53.8	18.2	41.9
Labrisomidae	3.9	1.6	0.2	0.4	1.0	1.9	4.4	2.4	25.4
Sciaenidae (total)	37.7	1.8	0	1.1	1.0	5.3	18.2	4.0	12.8
Cynoscion nebulosus	15.3	0.5	0	0	0	0.6	17.1	3.4	5.8
C. arenarius	17.2	0	0	0.4	0	0	0	0	0
Soleidae									
Achirus lineatus	5.7	0.1	0	0	0.2	0.4	0.6	2.1	1.9

Table 4. Mean densities (numbers $100m^{-3}$) of larvae and small juveniles at the family level collected with a bow-mounted push net and an epibenthic sled, respectively. Collections were made July 1997 - November 1999.

Bow-mounted push net		Epibenthic sled	
Family	Density	Family	Density
Engraulidae	68.6	Syngnathidae	29.1
Gobiidae	68.5	Gerreidae	9.4
Callionymidae	29.4	Engraulidae	9.2
Clupeidae	29.1	Cyprinodontidae	6.3
Sciaenidae	11.0	Sciaenidae	4.8
Clupeiformes (unidentified)	2.9	Gobiidae	3.8
Soleidae	1.7	Clupeidae	1.0
Blenniidae	1.5	Haemulidae	0.9
Tetraodontidae	1.2	Sparidae	0.7
Syngnathidae	1.1	Monacanthidae	0.7
Labrisomidae	0.2	Diodontidae	0.2
Carangidae	0.2	Belonidae	0.1
Atherinidae	0.1	Soleidae	0.1
Gobiesocidae	0.1	Carangidae	0.1
Batrachoididae	<0.1	Cynoglossidae	0.1
Exocoetidae	<0.1	Batrachoididae	0.1
		Sphyraenidae	<0.1
		Lutjanidae	<0.1
		Ostraciidae	<0.1
		Ephippidae	<0.1
		Exocoetidae	<0.1

Table 5. Densities (numbers 100 m^{-3}) of the most commonly collected larvae (>10 larvae 100 m^{-3}; Table 7) collected by bow-mounted push net in July 1997-November 1999 by station. Families are listed by descending densities.

Family	Station			
	6	15	16	17
Engraulidae	183.8	43.0	21.2	26.5
Gobiidae	131.8	8.3	108.3	25.7
Callionymidae	117.1	0.7	0	0
Clupeidae	101.0	2.4	12.1	0.8
Sciaenidae	27.9	2.3	9.3	4.5

Table 6. Mean densities (number 100 m^{-3}) at station 6, 15, 16 and 17 combined. Collections were made July 1997 - November 1999. Species are listed by descending densities.

Species	Mean density
Hippocampus zosterae	16.8
Syngnathus scovelli	10.9
Eucinostomus sp(p).	9.2
Anchoa mitchilli	8.1
Lucania parva	6.3
Bairdiella chrysoura	2.7
Microgobius gulosus	1.9
Cynoscion nebulosus	1.4
Gobiosoma robustum	1.3
Anchoa sp(p).	1.1
Sciaenops ocellatus	0.7
Lagodon rhomboides	0.7
Monacanthus sp(p).	0.7
Syngnathus floridae	0.6
Micrognathus criniger	0.5
Orthopristis chrysoptera	0.4
Haemulon plumeri	0.4
Syngnathus louisianae	0.3
Microgobius microlepis	0.3
Harengula jaguana	0.2
Chilomycterus schoepfi	0.2
Haemulon sciurus	0.1
Strongylura notata	0.1
Achirus lineatus	0.1
Anchoa hepsetus	0.1

Table 6 (continued).

Species	Mean density
Gobionellus smaragdus	<0.1
Symphurus plagiusa	<0.1
Oligoplites saurus	<0.1
Opsanus beta	<0.1
Hippocampus erectus	<0.1
Sphyraena barracuda	<0.1
Lutjanus synagris	<0.1
Selene vomer	<0.1
Floridichthys carpio	<0.1
Lactophrys quadricornis	<0.1
Chaetodipterus faber	<0.1
Hyporamphus unifasciatus	<0.1

Table 7. Densities (numbers $100m^{-3}$) by station, median length, size range in standard length (in parenthesis), and number measured (*n*) of the most commonly collected (> 1.0 fish 100 m^{-3}, Table 7) taxa by epibenthic sled in July 1997-November 1999. Taxa are listed by descending abundance of families and species.

Family	Species	Station				Median length and size range	*n*
		6	15	16	17		
Syngnathidae	*Hippocampus zosterae*	2.5	0.1	46.0	15.0	13.0 (3.4-32.0)	197
	Syngnathus scovelli	2.9	0.1	33.6	3.2	43.5 (10.5-104.0)	154
	S. floridae	0	0	1.1	1.4	129.0 (59.0-237.0)	15
	Micrognathus criniger	0.7	0.3	0.4	0.4	30.0 (18.0-39.0)	4
	S. louisianne	0	0.2	0.4	0.5	129.0 (59.0-237.0)	15
	H. erectus	0	0	0	0.2	44.5 (43.0-46.0)	2
	unidentified	0	0.2	0	0	15.0	1
Gerreidae	*Eucinostomus* sp(p).	0	0	18.9	17.8	12.0 (4.5-42.0)	178
Engraulidae	*Anchoa mitchilli*	16.7	5.6	0.10	9.6	16.0 (8.0-40.0)	169
	Anchoa sp(p).	3.1	0.9	0	0	7.0 (5.0-11.5)	26
	A. hepsetus	0.1	0.3	0	0	–	0
Cyprinodontidae	*Lucania parva*	0.4	0	21.9	0.4	16.0 (2.8-32.0)	67
	Floridicthys carpio	0	0	0.1	0	–	0
Sciaenidae	*Bairdiella chrysoura*	0.2	0	3.6	7.5	16.5 (4.4-48.0)	66
	Cynoscion nebulosus	0.5	0.4	3.6	1.0	6.0 (1.3-37.0)	34
	Sciaenops ocellatus	<0.1	0	2.6	0	7.4 (5.2-10.8)	22
Gobiidae	*Microgobius gulosus*	3.2	0.3	3.1	0.4	8.4 (6.3-26.0)	46
	Gobiosoma robustum	3.1	<0.1	0.7	0.9	6.0 (4.4-27.0)	32
	M. microlepis	0.4	0	0.1	0.7	12.0 (6.9-20.0)	19
	Gobionellus smaragdus	0	0	0	0.2	7.6 (7.0-8.1)	2
	Unidentified	0.7	0.2	0.2	0.1	4.6 (3.7-7.4)	11
Clupeidae	*Harengula jaguana*	0.1	0	0	0.9	20.0 (17.0-20.0)	5
	Unidentified	1.9	0.3	0.4	0.3	10.0 (4.4-22.0)	50

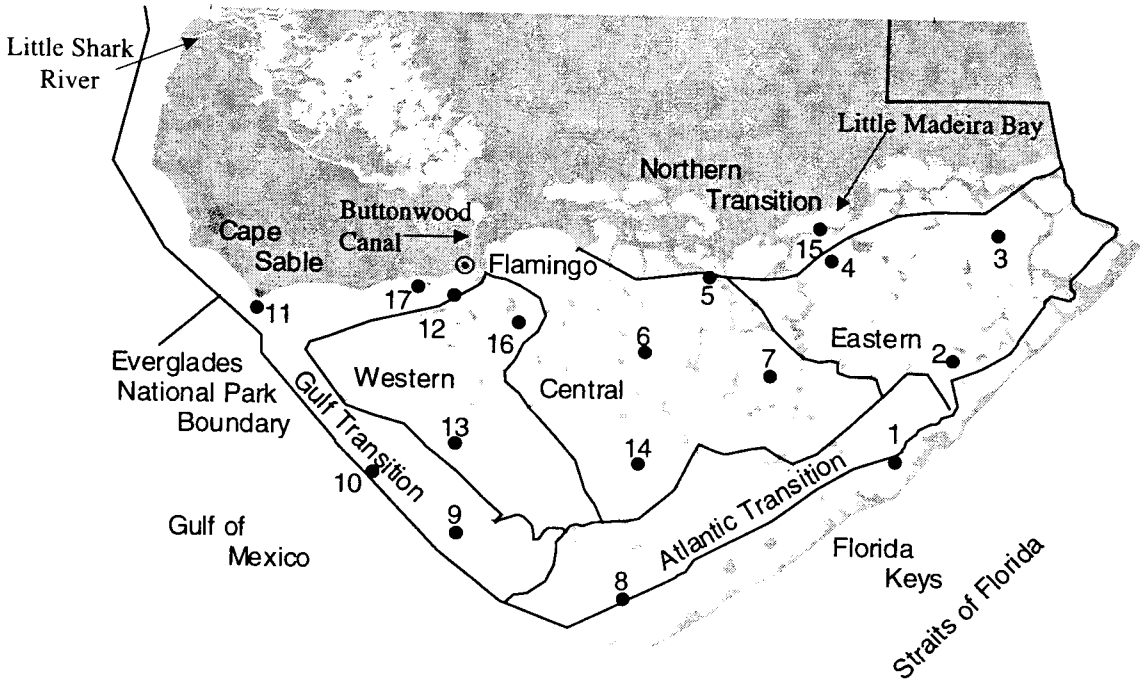

Figure 1. Location of stations in Florida Bay for ichthyoplankton sampled in 1994-1995 (station 1-14) and 1997-1999(stations 6, 15-17). Geographic locations are referenced in the text.

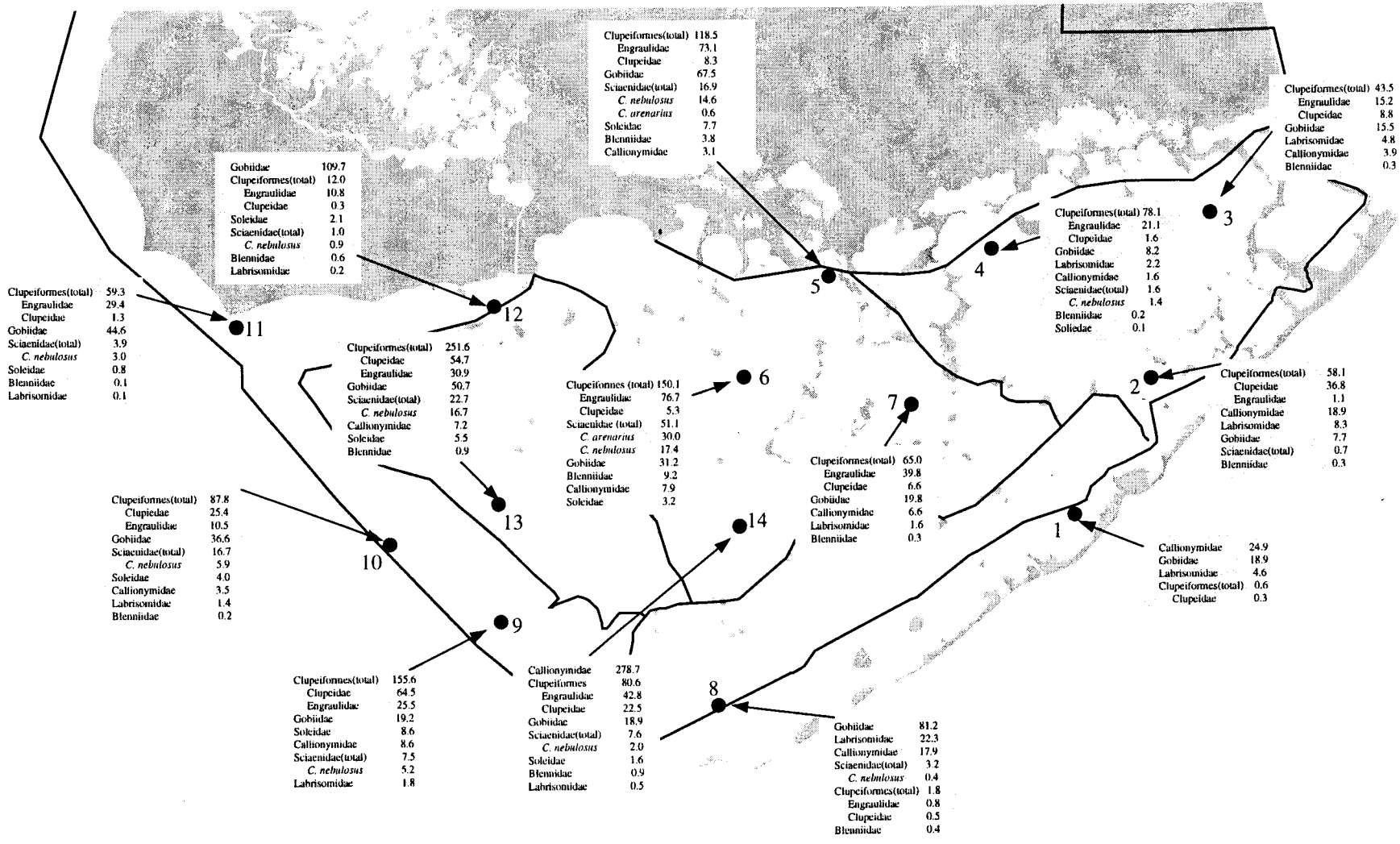

Figure 2. The dominant ichthyoplankton (>1.0 $100m^{-3}$ in Table 2) in Florida Bay in 1994-1995. There were significant differences by station for all taxa. Clupeiformes and Sciaenicae densities include unidentified specimens. Families Callionymidae and Soleidae are represented by one species - - *Dipplogrammus pauciradiatus* and *Achirus lineatus*, respectively.

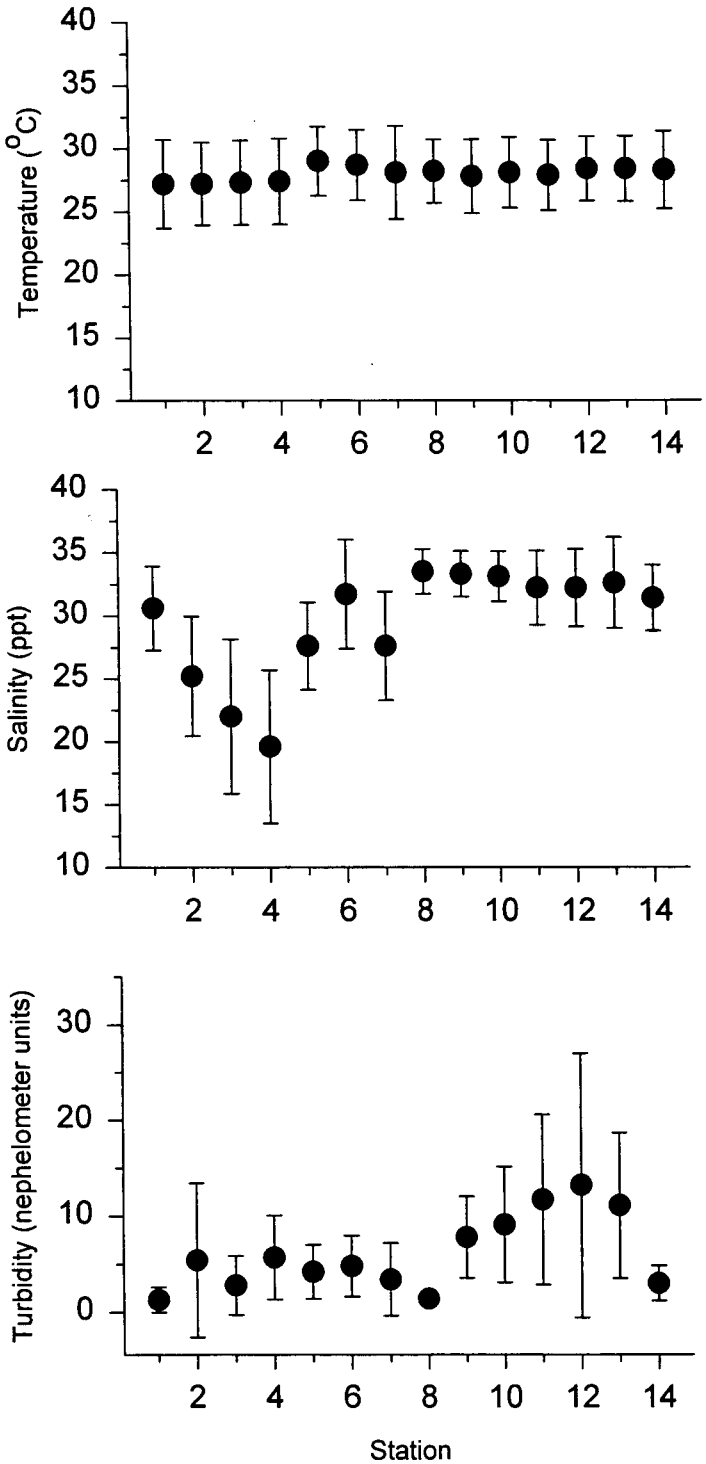

Figure 3. Mean temperatures, salinities and nephelometer units (± standard deviation) at stations 1-14 in 1994-1995.

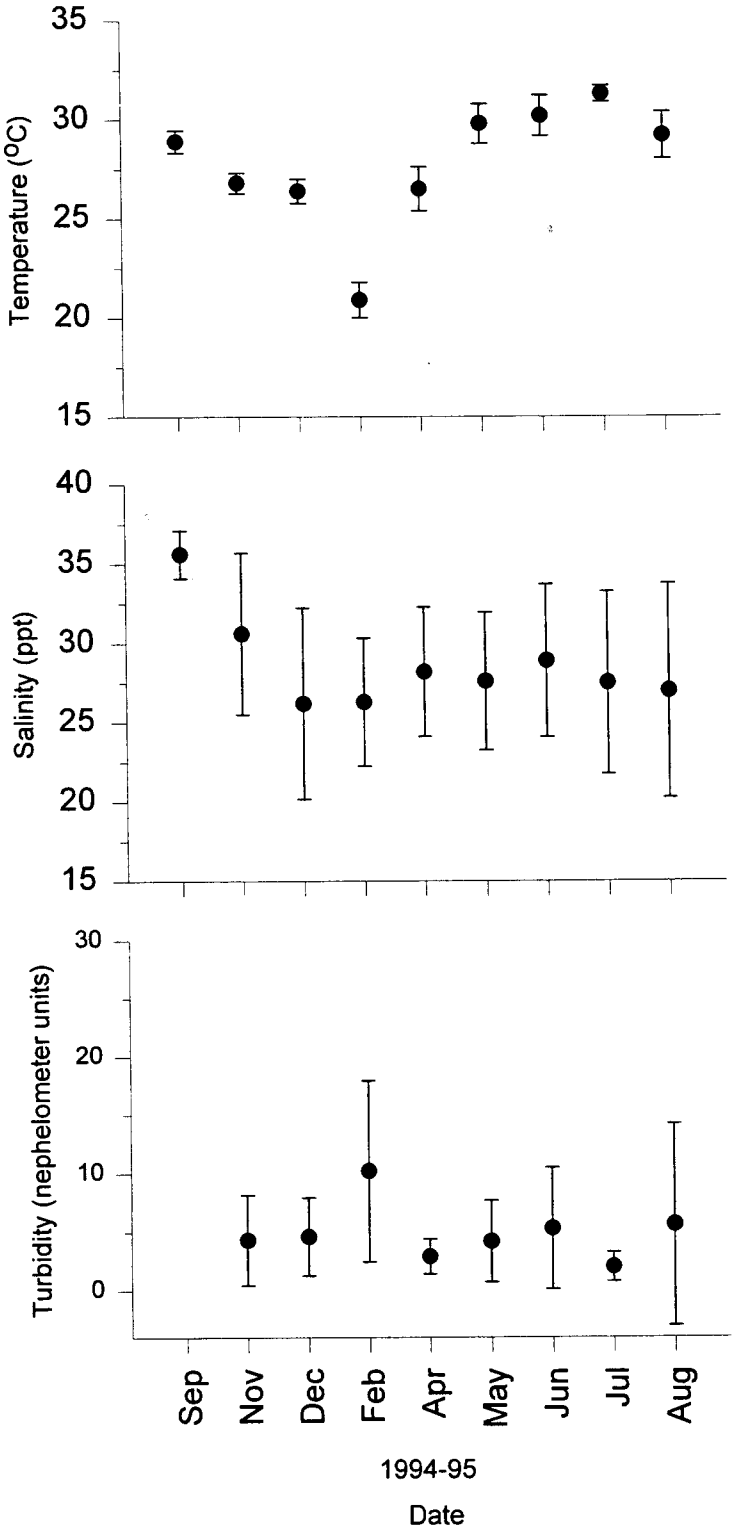

Figure 4. Mean temperatures, salinities and nephelometer turbidity units (± standard deviation) by sampling date at stations 1-14 in 1994-1995.