

Annual Report

Temporal and Spatial Distribution of Estuarine-Dependent Species in the Savannah River Estuary

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by

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Introduction

Use of the Savannah River estuarine habitats by fishes for feeding, reproduction, and refuge from predators has received little attention from the natural resource agencies of Georgia and South Carolina. The resultant lack of information on estuarine-dependent species is especially acute, given the relative size of the system and the human population base in the area. Most research and monitoring efforts have been species-specific (e.g., red drum *Sciaenops ocellatus*, seatrout *Cynoscion spp.*, striped bass *Morone saxatilis*, shortnose sturgeon *Acipenser brevirostrum*). However, in the early 1990's, two estuarine studies focused on entire assemblages in the Savannah River Estuary (SRE) (Nelson et al. 1991; Patrick 1991).

A crucial marine resource management goal is maintaining sustainable fisheries, which involves the preservation of essential fish habitat. Essential Fish Habitat within estuaries includes emergent vegetation (salt marsh and brackish marsh), estuarine shrub/scrub (mangroves), seagrass, oyster reefs and shell banks, intertidal flats, palustrine emergent and forested (freshwater wetlands), and the estuarine water column (National Marine Fisheries Service 2002). The SRE contains many of these habitats as well as federally managed estuarine species. However, the use of these habitats by estuarine fishes varies among kinds and by degree and spatially and temporally within respective habitats. Conservation efforts in the SRE are hampered because knowledge about what species are using the estuary and when and where the use occurs is unknown. Therefore, the objectives of this study are to quantify the temporal and spatial distribution of fish species that use main channel, marsh-edge, and tidal creek habitat in the SRE in different salinity zones.

Methods

Sample Stations

Eight stations/reaches in the SRE were sampled monthly for water quality and fishes. Four reaches (SR09, SR17, SR22, and SR26) were in the main Savannah River channel (i.e., Front River), two reaches were in the Middle River (MR02 and MC0.75), and two reaches were in the Back River (BR06 and BR10). Sample reaches were about 2.0-km long and included the river channel, both sides of the marsh-edge, and tidal creeks (Table 1 and Figure 1).

Salinity/Water Quality Profiles

Profiles conducted from September 2000 to August 2001 were designed to measure water column physical and chemical properties (e.g., salinity, temperature, dissolved oxygen, conductivity, and pH) during the spring and neap tides, the periods of greatest variability. A total of four samples per month (spring/high tide, spring/low tide, neap/high tide, and neap/low tide) were collected for each of the eight sample reaches. Samples were taken from surface to bottom at depth intervals ranging from 0.5 m to 3.0 m, so that at least four measurements were recorded during each profile. Analysis of profile data is ongoing; and therefore, only partial results are reported here.

Ichthyoplankton-Pushnet Surveys

The pushnet surveys, conducted September 2000 to August 2001, were designed to quantify the distribution of ichthyoplankton in the main river channels and to

determine if variation occurred along a salinity gradient, on tidal fluctuation, between day/night samples, or seasonally. Ichthyoplankton were collected with a 50-cm diameter, 500- μm mesh conical plankton net for the eight sample reaches at high tide/day, high tide/night, low tide/day, and low tide/night. Three replicate samples (about 1 meter depth from surface) were performed at each site during the four sample periods. Sample times were standardized to ensure that each tow sampled about 100 m³ of water. Temperature, salinity, dissolved oxygen, and conductivity were measured for each sample.

Marsh-Edge Ichthyofauna Survey

Drop Method

Marsh-edge fish communities were sampled from October 2000 to September 2001 by the drop method. Marsh-edge drop samples were conducted with a bottomless, cylindrical, 1.2-m², fiberglass container that was suspended from a metal boom, which extended about 1.5 m from the front of the boat. The container was dropped along the marsh-edge and then pushed into the substrate until a watertight seal was formed. The water inside the container was siphoned with a 4.0-hp water pump through a 3.7-L sampler fitted with a 500- μm mesh filter. Temperature, salinity, dissolved oxygen, and conductivity were measured for each sample.

High tidal fluctuation and steep ledges along some marsh-edges limited the areas where the drop method was effective. Preliminary experimentation to sample the marsh-edge habitat with a passive seine method (described below) was successful. The seine method captured more species (36 species vs. 22 species) and more fish (650 fish vs. 201 fish) than the drop method during the comparison period from June to September 2001.

Sampling with both seine and drop methods could not be performed efficiently during the same tidal cycle in the time period allotted each month to marsh-edge sample collection. Therefore, during Year 2 marsh-edge fishes will be sampled with seine method instead of the drop method.

Seine Method

Sampling of marsh-edge fish assemblages with the seine method began in June 2001 and will continue for the remainder of the project. Seines (0.63-cm mesh, 15.2-m in length x 1.8-m in height) were set parallel to the shoreline at slack high tide in 0.5 – 2.0 m water depth and allowed to fish for about 1.5-3.0 hrs. The seine sets were made by anchoring the lead and float lines to a pair of 5.0-cm diameter, pvc pipe that were driven about 0.5 m into the substrate. Juvenile and adult fishes were trapped behind the seine as the tide ebbed and water level dropped 1.0-2.0 m. The seines were retrieved by detaching the lead and float lines from the pvc post and pulling the lead line to shore (i.e., usually < 0.5 m). The seines were then stretched out on shore or onboard a boat, and fauna were removed by hand. Large fish (>150mm) were identified, measured, and released. All other fishes were preserved in 10% formalin and returned to the laboratory at the University of Georgia for identification and enumeration.

Tidal Creek Ichthyofauna Surveys

Sampling of tidal creek fish assemblages began in June 2001 and will continue for the remainder of the project. Two medium-sized (5.0-15.0 m width at high tide) tidal creeks were sampled with seines (0.63-cm mesh, 9.1-m long, x 2.4-m high) that

contained a 2.4-m x 2.4-m x 2.4-m bag in the center section. In June and July, a fyke net (0.3-cm mesh, 3.7-m x 3.0-m) was used to sample a second tidal creek. In August, the fyke net was replaced with a second bag seine that had the same dimensions as the first.

Bag seines were set at slack, high tide by stretching them across the mouths of tidal creeks and attaching the ends to pvc posts. The bag seines were fished with a similar method to the marsh-edge seine method. They were retrieved by detaching one end from the pvc post and pulling the free end to the other post so that it encircled the fish near the seine and forced them into the bag section. Data on fishes were collected with the same method used for marsh-edge fishes.

Data Analysis

Fish density (# fish/unit volume), species richness (# species/unit volume), and water quality (temperature and salinity) were used to evaluate the effects of habitat, season, tidal cycle, and diel variation on fish distributions in the SRE. All data were analyzed with SAS (SAS Institute 2001) and JMP (SAS Institute 2000) software. Data were tested for homogeneity of variances with an F-max test and for normality with a Shapiro-Wilk W Test (Sokal and Rohlf 1981). Variances were unequal across some of the data sets, and none of the variables were distributed normally. Transformation of values failed to achieve equal variances or a normal distribution. Therefore, group means were evaluated with a Kruskal-Wallis Test (i.e., the equivalent of a nonparametric Analysis of Variance ANOVA) at a significance level of $\alpha=0.10$.

Temperatures measured during ichthyoplankton surveys were used to quantify monthly and seasonal temperature regimes in the estuary for all fish sample types.

Minimum and maximum temperatures recorded in reaches were plotted for each month on a graph, and values showed little variability (<1.0 °C) during a sample period. Sample temperatures within each month were used to calculate mean monthly temperatures, which were used to determine seasonal groupings (i.e., fall, winter, spring, summer). Seasonal groupings with 2-4 mean monthly temperatures were tested with ANOVA, and most of the variation in temperature ($p < 0.0001$) was explained by the seasonal groupings of fall (September, October, November), winter (December, January, February), spring (March, April, May), and summer (June, July, August) (Table 2).

Salinity measurements recorded during ichthyoplankton surveys and marsh-edge drop surveys were used to group the respective samples into habitat/salinity zones. The habitat zones used were a hybridization of the Venice, Biologically-Based, and NOAA estuarine-habitat classification systems and are defined as: tidal freshwater (0.0-1.0 ppt), oligohaline (1.1-5.0 ppt), mesohaline (5.1-15.0 ppt), and polyhaline (>15.0 ppt) (NOAA 1991; Bulger et al. 1993). Because of tidal and discharge effects, samples were grouped in habitat zones based on the salinity recorded during sample time, regardless of spatial position in the estuary. This method more accurately reflected the habitat used by fishes at the time of collection.

Results

Temperature/Salinity

Mean seasonal temperatures during ichthyoplankton surveys ranged from 11.1 ± 7.9 °C in winter to 28.3 ± 1.2 °C in summer (Figure 2). Mean monthly temperatures were lowest during the winter months of December (11.6 ± 0.39 °C), January (8.5 ± 0.31 °C),

and February (13.5 ± 0.19 °C) and highest during the summer months of June (27.0 ± 0.29 °C), July (29.0 ± 0.36 °C), and August (29.2 ± 0.28 °C) (Figure 2). Mean temperature for the year was similar ($p > 0.98$) in all habitats and ranged from 19.8 ± 6.8 °C in tidal freshwater to 20.2 ± 7.5 °C in polyhaline habitat.

Salinity less than 0.1 parts per thousand (ppt) and salinity greater than 15.0 ppt were recorded in all four seasons in depth-integrated profiles (Tables 3a-3d) and pushnet surveys (Figure 3). Minimum and maximum salinity recorded in ichthyoplankton surveys displayed a bimodal pattern for the year within habitat types, and readings usually encompassed the entire range of values that defined a given habitat type (Figure 2). Decreases in minimum and maximum values occurred during periods of increased river discharge (Tables 3a-3d and Figure 4).

Fish Sampling

All gear used to sample fishes in the SRE were effective, but some were more difficult to use and less effective than others. None-the-less, use of these gears in the various habitats sampled during Year 1 have yielded fishes from 33 families comprising 75 species and 36,798 individuals.

Ichthyoplankton Pushnet Surveys

One thousand one hundred and fifty-two ichthyoplankton trawls (384 samples with 3 replicates/sample) were conducted in the SRE. Of these 384 samples, most were from either oligohaline (143) or tidal freshwater (141) salinity zones (Table 4). A total of 24 families comprising 51 species and 23,764 individuals were caught with

ichthyoplankton nets between September 2000 and August 2001 (Table 4). Bay anchovy *Anchoa mitchelli* (12,041), Atlantic menhaden *Brevortia tyrannus* (5060), Atlantic croaker *Micropogonias undulatus* (3700), and Spot *Leiostomus xanthurus* (843) were the four most abundant species and comprised 91% of the catch (Table 5 and Table 6a-6d). Peak abundance of bay anchovy (Summer/Fall), Atlantic menhaden (Spring), Atlantic croaker (Winter), and spot (Spring) occurred during different seasons and encompassed the four salinity zones (Table 5 and Table 6a-6d). Although most species collected were caught from multiple salinity zones, eight species occurred across all zones, and nine species were found exclusively in a single salinity zone (Table 5).

Mean fish density (#fish/100m³) and mean species richness (# species/100m³) did not differ among salinity zones ($p=0.12$ and $p=0.21$), but differed among season, tidal cycle, or diel cycle. Mean density was different among season, tidal cycle, and diel cycle, and mean richness was different among season and diel cycle (Table 2). Mean density ranged from 15.4 ± 7.8 in the oligohaline zone to 13.0 ± 23.5 in the polyhaline zone (Table 2 and Figure 5). Mean richness was highest in the polyhaline zone (1.8 ± 1.4) and lowest in the tidal freshwater zone (1.2 ± 0.6). Mean density (5.9 ± 6.5) and mean richness (0.9 ± 0.8) in Fall was significantly lower ($p=0.09$ and $p<0.0001$) than mean density and mean richness in other seasons. Winter, Spring, and Summer had similar mean fish density and mean species richness (Figure 6). Density (22.4 ± 26.1) and richness (1.9 ± 1.0) were highest in the Summer (Figure 6). Mean density at low tide (16.4 ± 22.1) was significantly higher ($p=0.05$) than mean density at high tide (7.9 ± 11.2), but mean richness was similar for both cycles ($p=0.61$) (Figure 7). Mean density

(22.1 ± 29.1) and mean richness (2.2 ± 1.1) in night samples was significantly greater ($p < 0.0001$) than in day samples (5.7 ± 18.6 and 0.5 ± 0.5) (Figure 8).

Marsh-Edge Ichthyofauna Surveys

Drop Method

Two hundred and four marsh-edge drops (78 samples with 2-3 replicates/sample) were conducted with the drop method. Most of these samples were either from mesohaline (27) or tidal freshwater (26) salinity zone samples (Table 7). A total of 18 families comprising 30 species and 5,793 larval and juvenile fishes were collected with the drop method. Atlantic menhaden (3,793), spot (886), bay anchovy (560), and Atlantic croaker (217) were the four most abundant species and comprised 94% of the catch (Table 8a-8d). These four species occurred in mesohaline, oligohaline, and tidal freshwater salinity zones. Three species (rough silverside *Membras martinica*, plainhead filefish *Monacanthus hispidus*, and Atlantic bumper *Chloroscombrus chrysurus*) were caught only in the polyhaline zone; none of the species were exclusive to other salinity zones (Table 9).

Mean fish density and mean species richness along the marsh edge were different among the salinity zones (Table 10). Mean density and mean richness in mesohaline (39.9 ± 80.6 and 2.5 ± 1.9), oligohaline (24.3 ± 26.7 and 3.3 ± 1.6), and tidal freshwater (16.3 ± 39.9 and 1.8 ± 1.4) salinity zones was significantly greater ($p=0.002$ and $p=0.01$) than mean density (0.5 ± 0.4) and mean richness (0.6 ± 0.6) in the polyhaline zone (Fig 9). Mean density (36.6 ± 69.9) and mean richness (2.9 ± 1.9) were highest in Spring, but these values were similar to values recorded in all four seasons (Fig 12). Mean density

was lowest in Summer (4.0 ± 3.1) and mean richness was lowest in Fall (2.0 ± 1.8) and Winter (2.0 ± 1.8) (Fig 10).

Seine Method

Marsh-edge samples collected with the seine method captured 21 families comprising 44 species and 907 individuals in 64 seine sets (32 samples with 2 replicates/sample) (Table 10). Nineteen species collected with this method were not collected in the drop method (Table 10) and nine species collected with the drop method were not found in seine samples (Table 9). Silver perch *Bairdiella chrysoura* (200), spot (99), Southern flounder *Paralichthys lethostigma* (88), and Atlantic menhaden (84) were the most abundant species caught in the seines and comprised 52% of the fishes collected with this method (Table 10).

Tidal Creek Ichthyofauna Surveys

Tidal creek surveys captured 22 families comprising 52 species and 6,334 individuals in 64 seine sets (32 samples with 2 replicates/sample) (Table 12). Bay anchovy (3746), blueback herring *Alosa aestivalis* (1026), silver perch (552), and spot (188) were the most abundant species and represent 87% of the catch (Table 11).

Discussion

Surface temperature was consistent spatially among sample reaches and across salinity zones in the SRE. Temperatures recorded at SR09 were similar to measurements at SR26, the farthest upriver site. Likewise, temperature at Back River reaches and

Middle River reaches were similar to Front River reaches. Polyhaline areas had similar temperatures to mesohaline, oligohaline, and tidal freshwater zones. These similarities suggest that temperature probably did not affect fish distribution on a short-term, temporal or spatial scale.

Temperature did vary considerably from season to season, and temporal variability has been shown to differentially effect fish distributions by increasing or decreasing abundances of some species (Hoff and Ibara 1977; Loneragan et. al., 1986; Yoklavich et. al., 1991; Rakocinski et. al., 1992; Yoklavich et. al., 1992). Seasonal comparisons showed that density and richness in the SRE was similar for all seasons except Fall. The decline in fish density and species richness probably was attributed to a decline in spawning activity in late Summer/early Fall and some movement of species to other habitats or outside the sample areas. Fishes that would contribute to Fall ichthyoplankton would come from late Summer spawners. Young-of-the-year abundances were low in Fall and did not increase in samples again until Winter with the influx of Fall drum and flatfish larvae.

Juvenile and adults of some species that were not present in Fall ichthyoplankton were caught in Fall marsh-edge and tidal creek seine samples. Some young-of-the-year had switched from main-channel habitat to marsh-edge and tidal creek habitat. Striped mullet were seen jumping around the boats frequently, but rarely were captured in sample gear most of the year. Tidal creek samples in November and December 01 have shown that mullet had moved to this habitat.

Other species caught in other seasons virtually disappeared from all sample types in Fall. Abundant silver perch, spot, jacks (Carangidae), pinfish *Lagodon rhomboides*,

and hogchokers *Trinectes maculatus* declined in late Summer/early Fall to very low abundances and did not increase again until Spring. These species probably were in the estuary, but not in sample reaches. The loss of these species contributed to the decline in density and richness across the estuary in Fall. Continued sampling with seines in these two habitats should help determine which species are year-round residents, which species move to other habitats, and which species leave at certain times of the year.

Variability of habitat use by estuarine species in sample reaches probably can be attributed to the dynamic nature of salinity distribution. Surface salinity in sample reaches varied considerably and was affected most by tidal fluctuation and to some extent river discharge. In reaches such as SR17 and BR06, salinity at high tide was at times 5.0-10.0 ppt higher than salinity at low tide, which meant that both oligohaline and mesohaline habitat occurred in a six-hour period. In reaches such as SR26 and MC0.75, salinity rarely increased above 1.0 ppt, which resulted in extended periods of freshwater habitat in these areas. High river-discharge during Spring and mid-Summer resulted in an overall decrease in salinity across the estuary.

Variation in salinity can have significant affects on species composition and abundances for estuarine fishes (Hoff and Ibara 1977; Yoklavich et. al., 1991; Paperno et. al. 2001). Most of the fishes collected seemed to be estuarine generalists that used mesohaline, oligohaline, and tidal freshwater zones throughout the year. Although present most of the year, many generalist species such as anchovy, herring, drum, and flatfish can increase dramatically in density during certain seasons and in certain habitats (Rozas and Hackney 1984; Rakocinski et. al., 1992; Witting et. al., 1999). An increase in Atlantic menhaden and bay anchovy abundance (i.e., peak spawning) occurred in

different salinity zones in the SRE. Atlantic menhaden density peaked in the tidal freshwater zone in late Winter/early Spring (January-April); whereas, bay anchovy density was highest in the mesohaline zone in Summer (July/August). These species are major prey for larger species, and temporal and spatial differences in peak abundance probably provide high biomass for year-round predators. Changes in temporal and spatial patterns for these species could result in changes in predator abundance.

Some species that range widely throughout the estuary most of the year might have specific habitat and salinity requirements during certain times of the year. Sciaenids such as Atlantic croaker, spot, star drum, silver perch, spotted seatrout *Cynoscion nebulosus*, and weakfish *Cynoscion regalis* are both predator on smaller fishes and prey for larger fishes. Larvae of these species had different temporal peaks (Table 6a-d), but juvenile and adults were collected in most habitats and salinity zones in most seasons (Table 5). Southern flounder larvae were most abundant in oligohaline and tidal freshwater zones in Winter, but juvenile and adult flounder were caught along the marsh-edge and in tidal creeks in other salinity zones in all seasons. The spatial extent of the salinity zone and habitat and the season used during these peaks might be critical to the degree of spawning success. Sampling in Year 2 should help determine if temporal and spatial patterns are similar from year to year and whether temperature and salinity might contribute to any differences.

Polyhaline conditions (i.e., salinity above 15.1 ppt) were recorded in water column profiles near the bottom during all months, but occurred rarely in surface waters in sample reaches (Table 3a-d). This result showed that surface salinity remained low in the estuary down to SR09. Only 22 out of 464 ichthyoplankton and drop samples were

collected in the polyhaline zone, and all 22 of these samples were at SR09, SR17, and BR06. The small sample size for this zone made comparisons to other salinity zones difficult to interpret. Differences in mean density and mean richness were not detected in statistical comparisons, but the number of fish and number of species collected in polyhaline areas were lower than the numbers collected in other salinity zones (Table 4 and Table 7). These trends could indicate some effects by salinity on variability or simply be a relic of low sample size.

Low river-discharge during Fall 2001 and Winter 2001-2002 resulted in more polyhaline samples for the beginning of Year 2 sampling (Figure 4). An increase in polyhaline samples could allow a more definitive analysis of density, richness, and species composition in this salinity zone in the future and help determine if higher salinity habitat occurs in the upper estuary more frequently than Year 1 results suggest.

Some less common species showed a preference to particular salinity zones. Atlantic bumper, leatherjacket *Oligoplites saurus*, sea robin *Prionotus sp.*, and striped burrfish *Chilomycterus schoepfi* were collected only in high salinity mesohaline and polyhaline zones. Fishes such as largemouth bass *Micropterus salmoides*, catfish *Ictalurus spp.*, black crappie *Pomoxis nigromaculatus*, longnose gar *Lepisosteus osseus*, minnows Cyprinidae, and sunfish *Lepomis spp.* were found in low salinity oligohaline and tidal freshwater areas. Spatial changes in salinity distribution might either extend or retract ranges where some of these species occur. Sampling in Year 2 should help determine if these species have narrow or wide salinity tolerances.

Conclusions

Methods designed to sample water quality, ichthyoplankton drift, marsh-edge fishes, and tidal creek fishes were implemented to quantify temporal and spatial fish distributions in the Savannah River Estuary. These methods have proven effective and have shown the SRE to be a diverse, productive, and complex ecosystem. Habitats sampled in the SRE have yielded fishes from 33 families comprising 75 species and 36,798 individuals.

Sampling has continued for Year 2 without anticipated changes in protocol. Statistical analysis has been an ongoing project and this report represents only results from test already performed. Correlation and ordination techniques are being employed to more definitively analyze temporal and spatial patterns in species composition. Length frequency data are being analyzed to determine salinity ranges for individual species and to determine specific habitat requirements for size classes.

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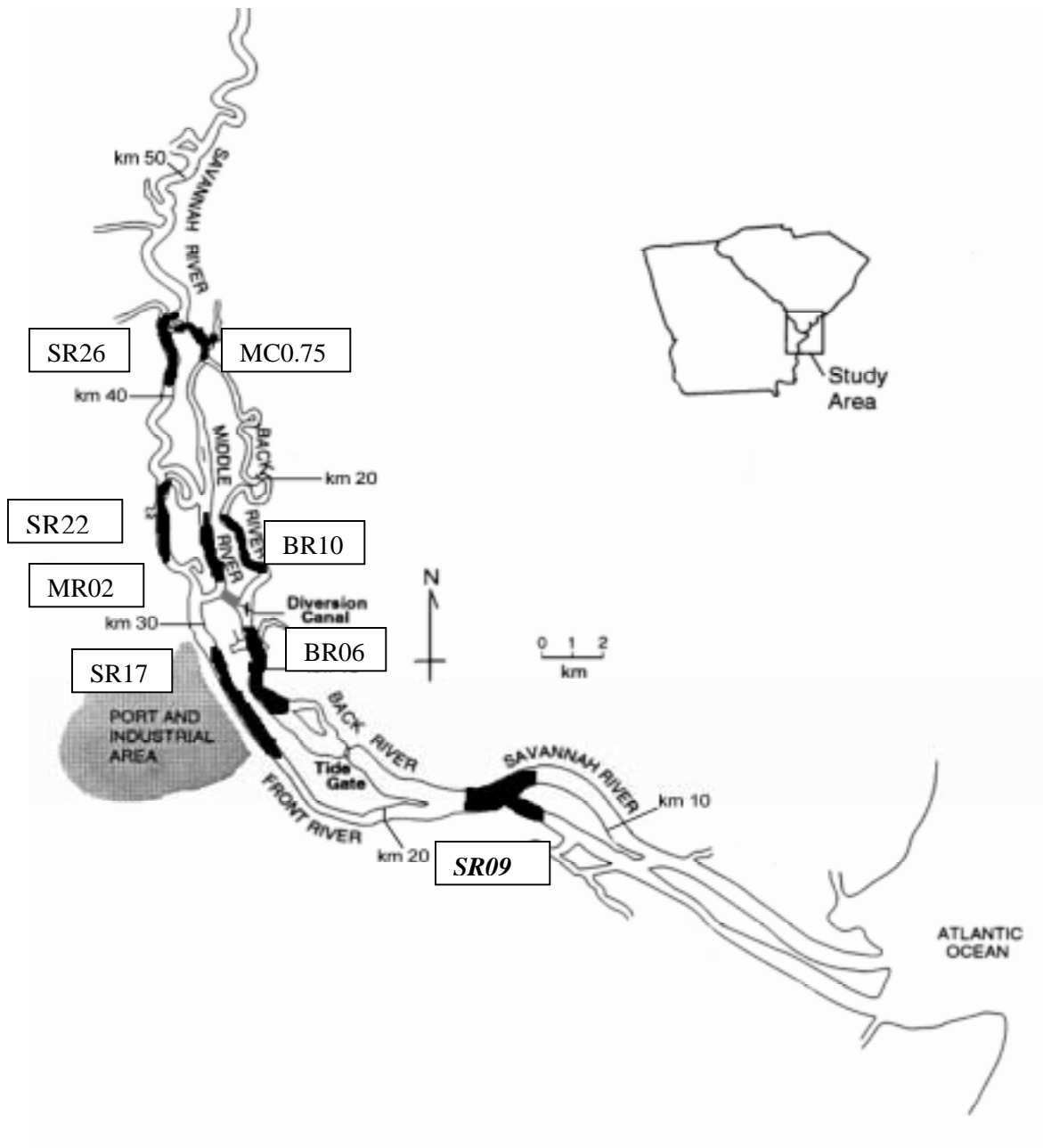


Figure 1. Map of the Savannah River Estuary, showing the location of the eight sample reaches in the three major deltaic channels (Front, Middle, Back rivers).

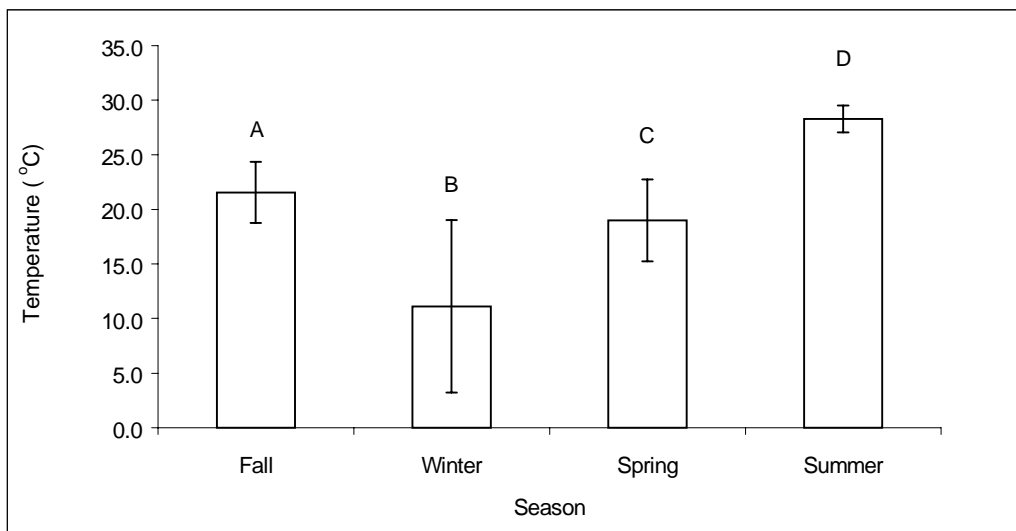
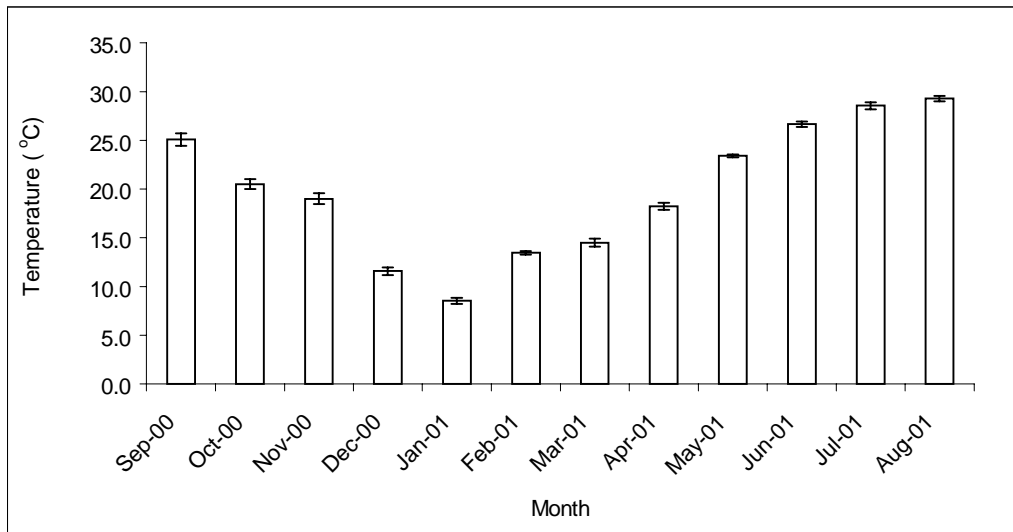


Figure 2. Mean monthly and seasonal temperatures (\pm st dev) recorded in water quality samples during ichthyoplankton pushnet surveys from September 2000 to August 2001. Different letters denote seasonal temperatures that were significantly different for Fall (Sept, Oct, Nov), Winter (Dec, Jan, Feb), Spring (Mar, Apr, May), and Summer (Jun, Jul, Aug).

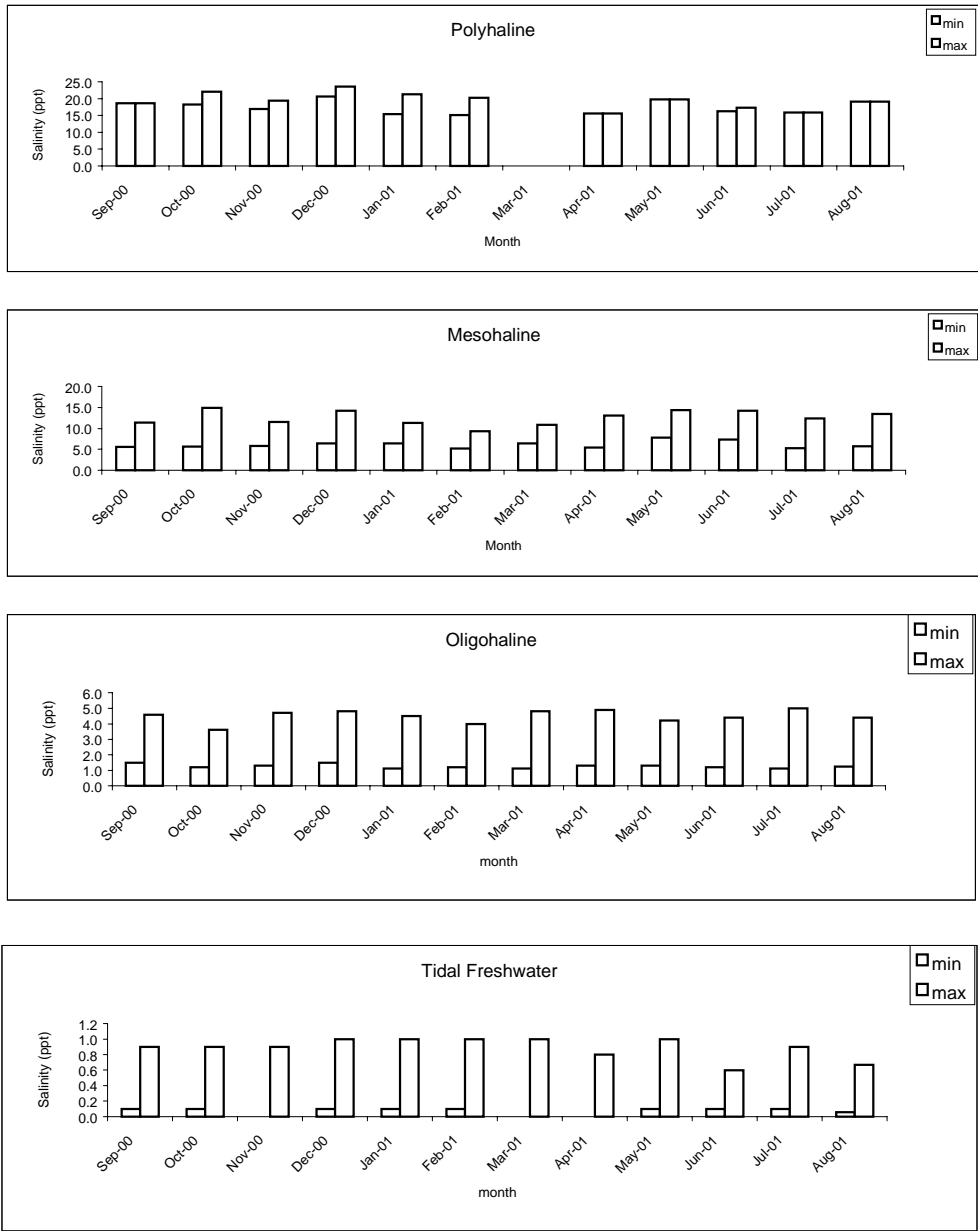


Figure 3. Minimum and maximum salinity recorded each month in the four salinity zones in water quality samples collected during ichthyoplankton pushnet surveys from September 2000 to August 2001.

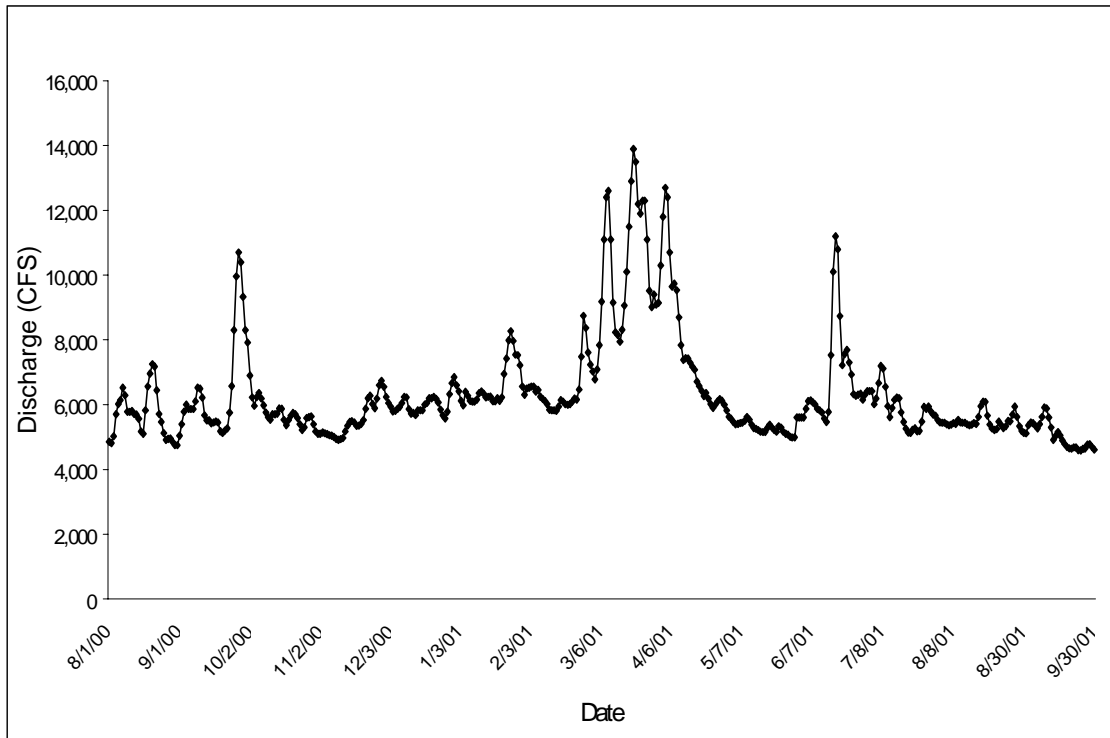


Figure 4. Mean daily discharge recorded at the USGS Savannah River gauge near Clio, Ga. from August 1, 2000 to September 30, 2001.

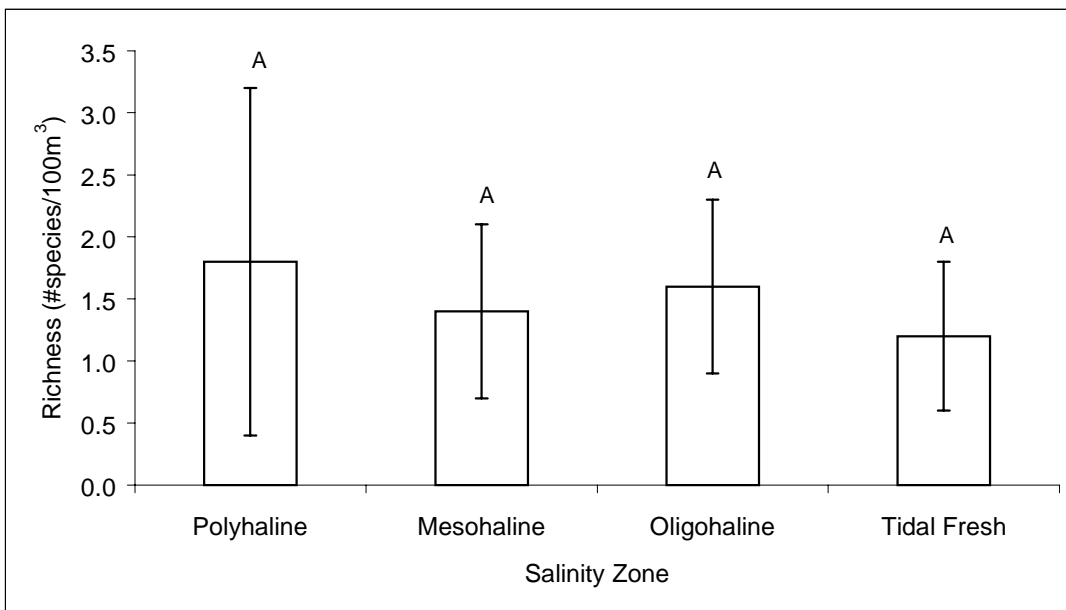
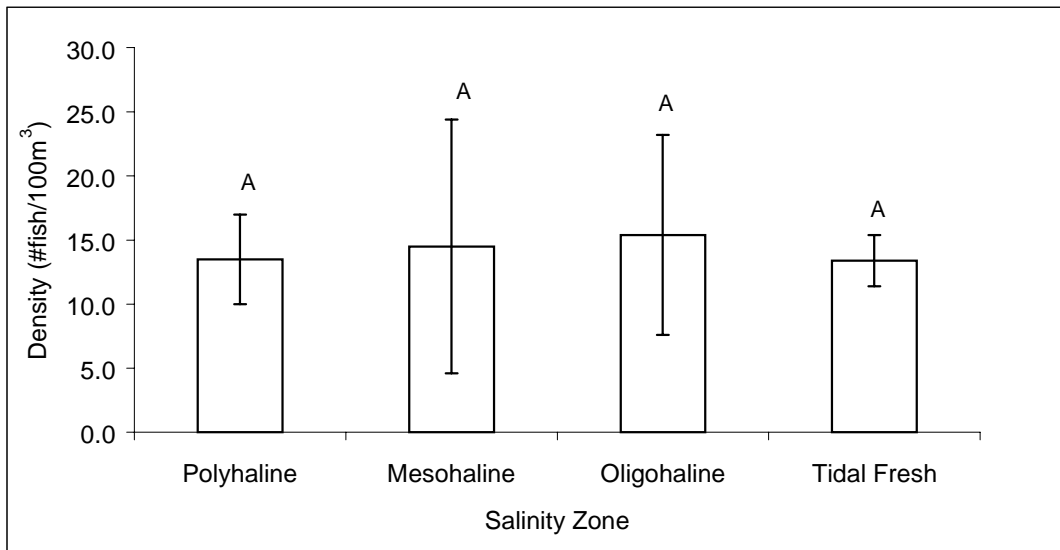


Figure 5. Mean fish density (\pm st. dev.) and species richness (\pm st. dev.) for ichthyoplankton surveys conducted in the four salinity zones from September 2000 to August 2001. Different letters denote means that were significantly different.

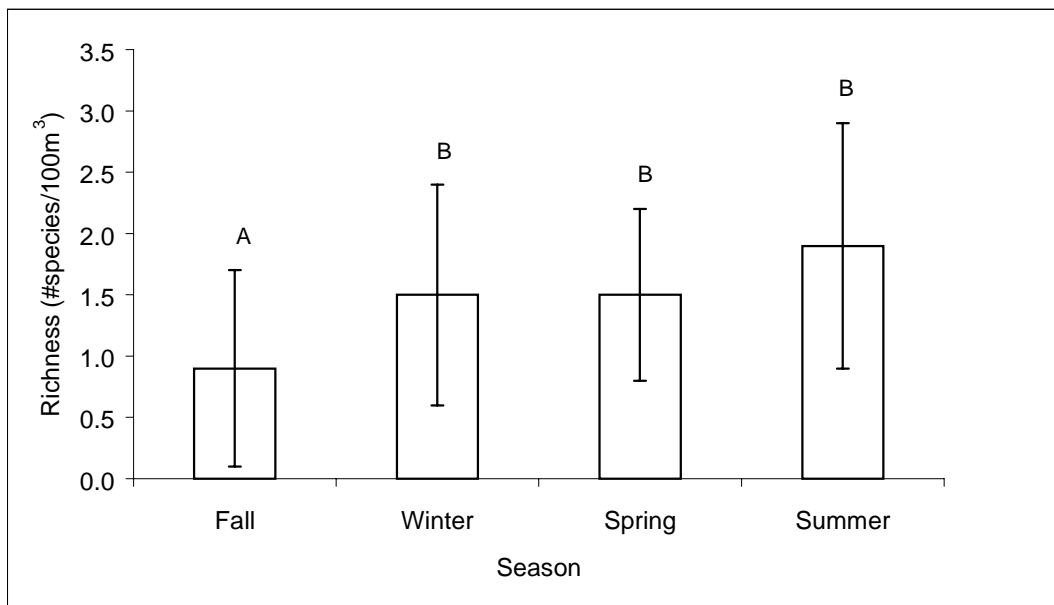
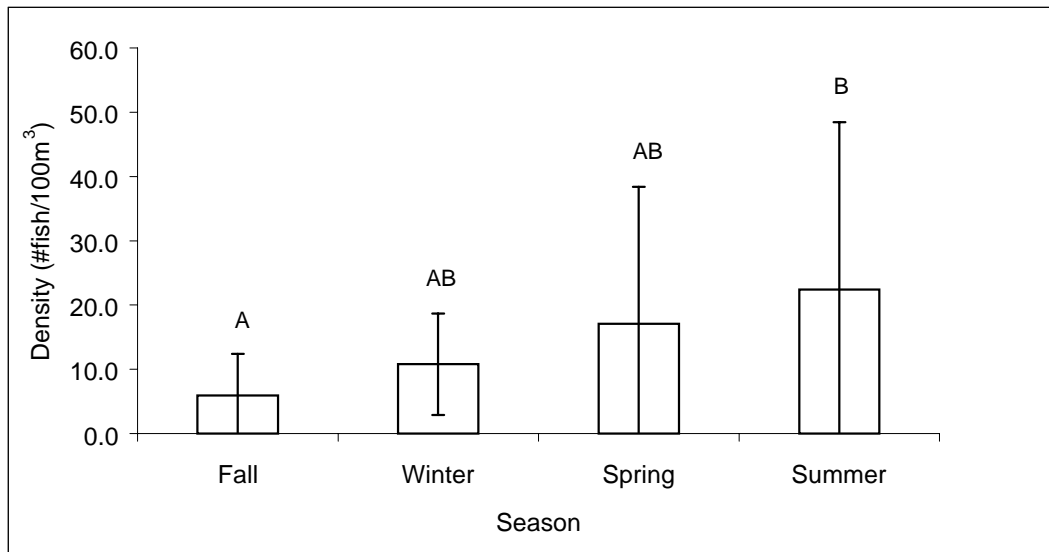


Figure 6. Mean fish density (\pm st. dev.) and species richness (\pm st. dev.) for ichthyoplankton surveys conducted in each season from September 2000 to August 2001. Different letters denote means that were significantly different.

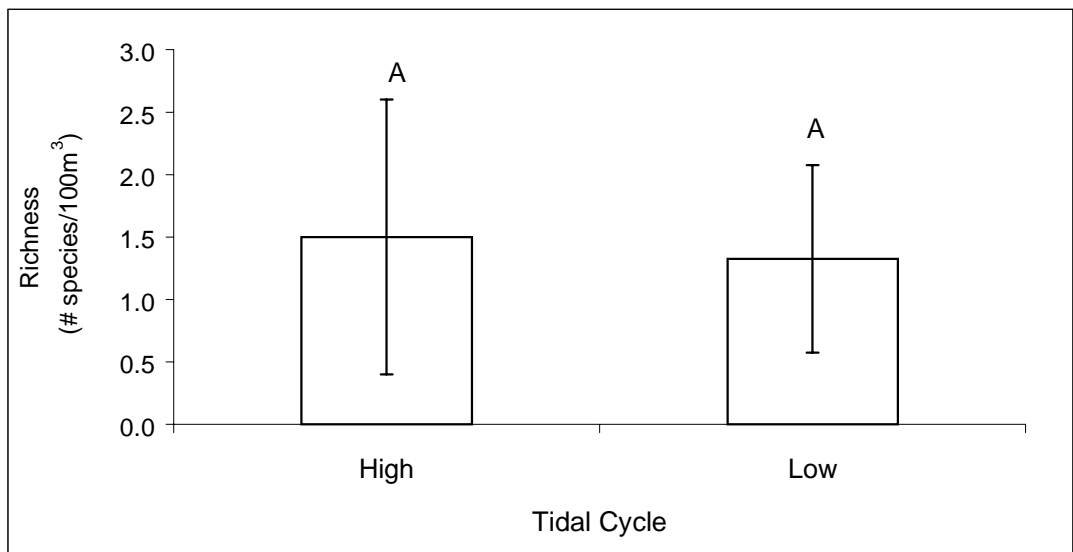
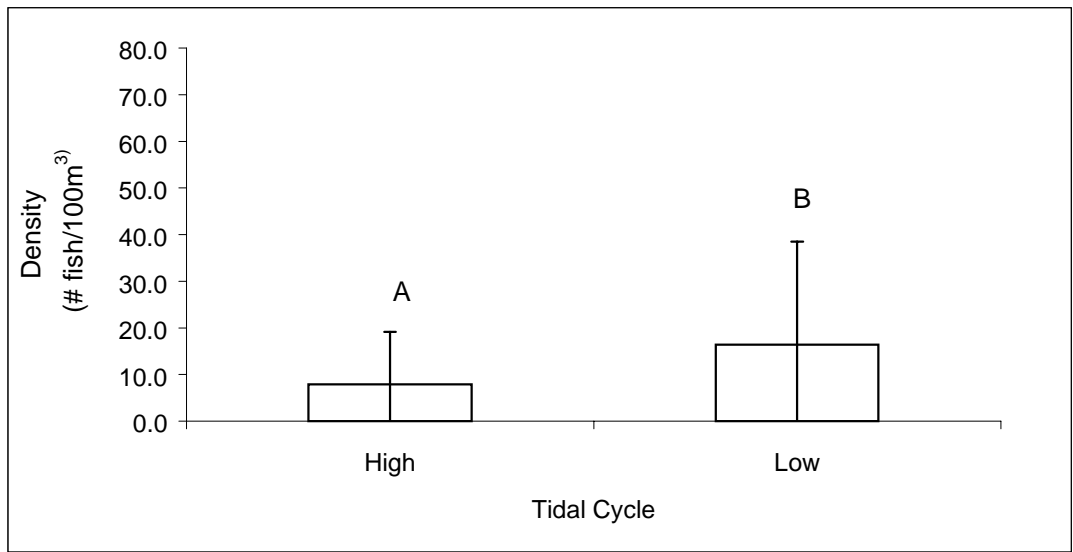


Figure 7. Mean fish density (\pm st. dev.) and species richness (+ st. dev.) for ichthyoplankton surveys conducted during high and low tides from September 2000 to August 2001. Different letters denote means that were significantly different.

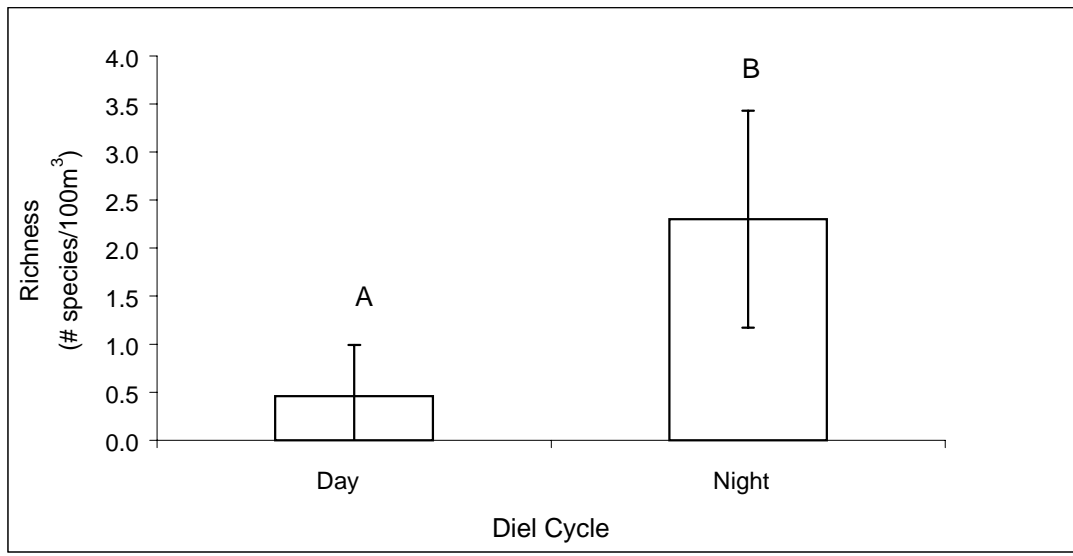
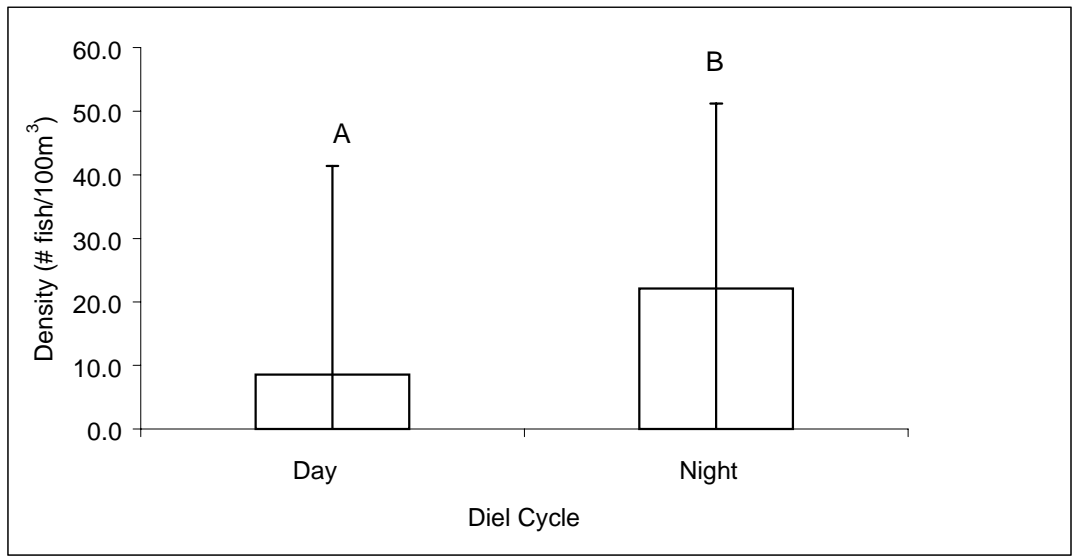


Figure 8. Mean fish density (\pm st. dev.) and species richness (+ st. dev.) for ichthyoplankton surveys conducted during day and night sampling from September 2000 to August 2001. Different letters denote means that were significantly different.

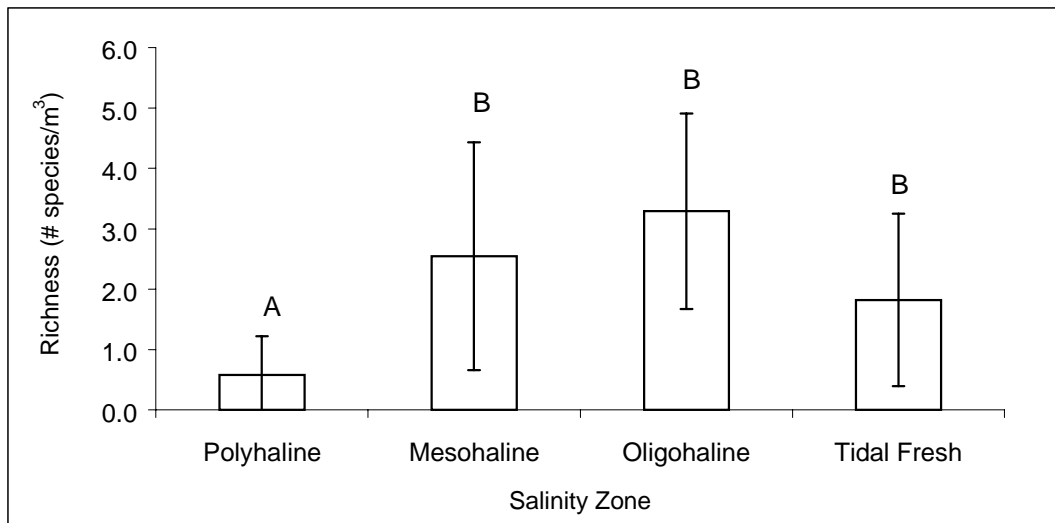
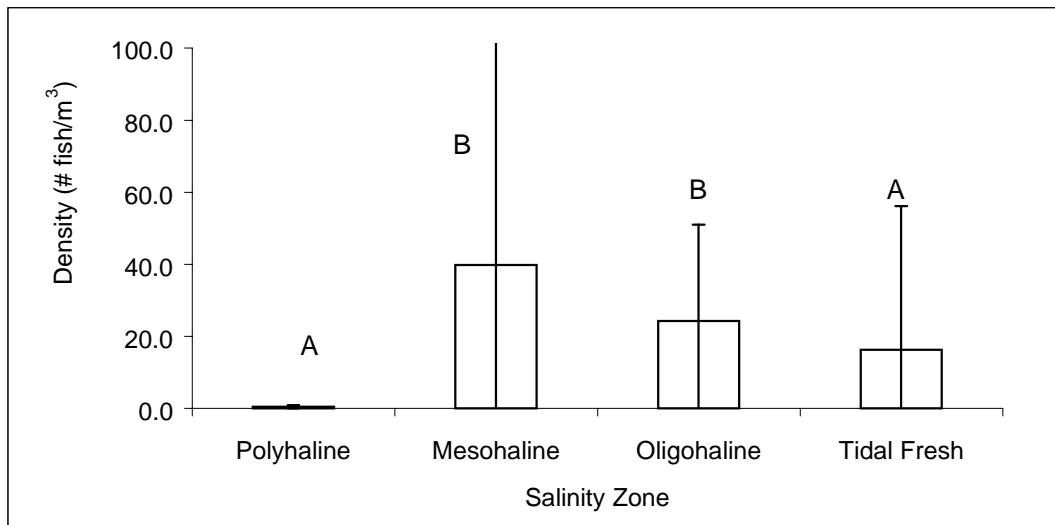


Figure 9. Mean fish density (\pm st. dev.) and species richness (\pm st. dev.) for marsh-edge drop surveys conducted in the four salinity zones from October 2000 to September 2001. Different letters denote means that were significantly different.

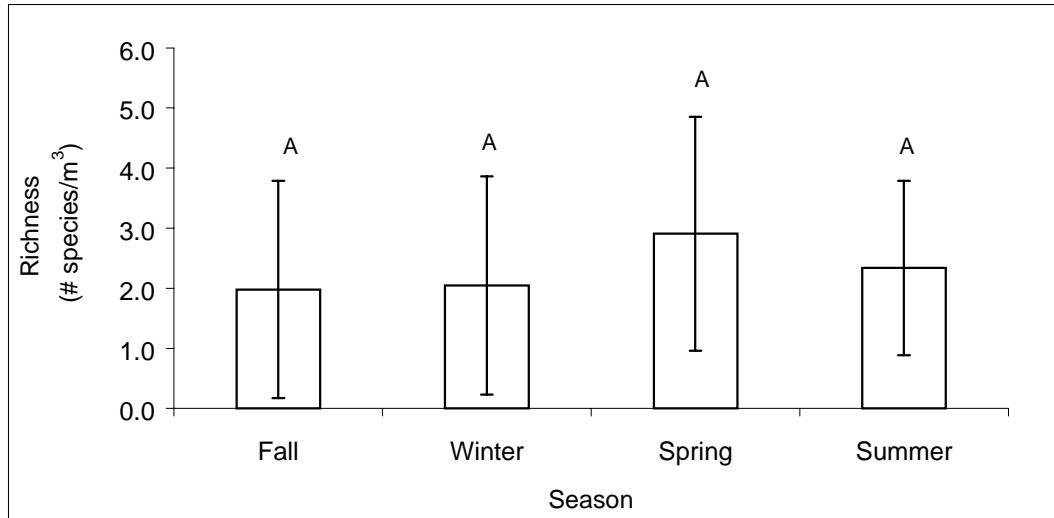
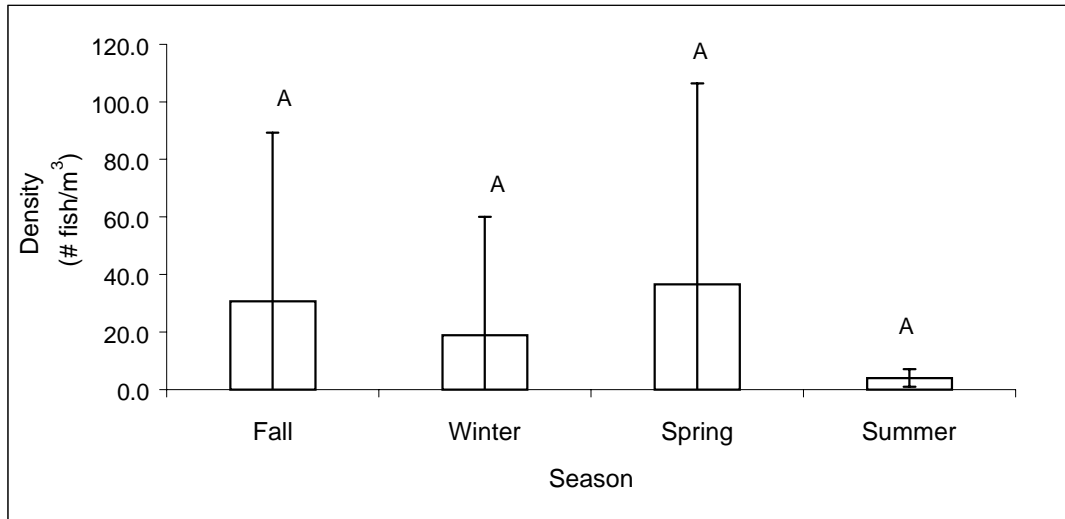


Figure 10. Mean fish density (\pm st. dev.) and species richness (\pm st. dev.) for marsh-edge drop surveys conducted in each season from October 2000 to September 2001. Different letters denote means that were significantly different.

Table 1. Upstream and downstream GPS coordinates for the eight sample reaches where water quality, ichthyoplankton, marsh-edge, and tidal creek surveys were conducted.

SITE	GPS Coordinates	
	Upstream end	Downstream end
SR09	32° 05' 49.415 N 81° 00' 46.127 W	32° 05' 29.883 N 81° 01' 46.243 W
SR17	32° 07' 37.679 N 81° 08' 04.359 W	32° 06' 08.195 N 81° 06' 45.110 W
SR22	32° 10' 38.372 N 81° 09' 19.371 W	32° 09' 42.796 N 81° 09' 08.974 W
SR26	32° 13' 29.806 N 81° 09' 10.868 W	32° 12' 41.916 N 81° 09' 10.868 W
MC0.75	32° 13' 29.806 N 81° 09' 10.868 W	n/a n/a
MR02	32° 10' 00.717 N 81° 08' 20.148 W	32° 08' 47.222 N 81° 07' 53.627 W
BR06	32° 07' 49.922 N 81° 07' 12.791 W	32° 07' 10.401 N 81° 06' 55.697 W
BR10	32° 09' 46.035 N 81° 07' 28.816 W	32° 09' 17.301 N 81° 07' 21.746 W

n/a = not available

Table 2. *P*-values for density, richness, and temperature calculated from Kruskal-Wallis nonparametric ANOVA for habitat, season, diel, and tide sources of variation.

Source of Variation	d.f.	<i>P</i> -value		
		Density	Richness	Temperature
Habitat	3	0.12	0.21	0.99
Season	3	0.09	0.02	<0.0001
Diel	1	<0.0001	<0.0001	0.54
Tide	1	0.05	0.62	0.19

Table 3a. Minimum and maximum water quality values recorded in depth-integrated profiles in the eight reaches for the fall months of September, October, and November 2000.

Reach	Month	Temperature (°C)		Salinity (ppt)		D O (mg/L)		Conductivity (ms)		pH	
		min	max	min	max	min	max	min	max	min	max
BR06	Sept	25.8	26.3	0.5	10.6	5.4	5.8	1.0	17.9	7.0	7.1
BR10	Sept	25.9	26.0	0.2	0.7	5.4	6.1	0.5	1.4	7.2	7.9
MC0.75	Sept	25.5	25.6	0.1	0.1	7.1	7.5	0.1	0.1	7.3	7.9
MR02	Sept	25.7	26.3	0.3	2.4	6.0	6.5	0.6	4.5	7.1	7.3
SR09	Sept	25.2	26.0	7.1	23.1	5.1	5.9	12.4	36.5	7.6	7.9
SR17	Sept	25.2	25.7	1.4	14.5	5.1	6.6	2.7	24.0	7.7	7.9
SR22	Sept	24.3	24.8	0.1	2.4	6.1	7.2	0.1	4.6	7.9	8.4
SR26	Sept	23.4	24.3	0.1	0.1	7.0	7.6	0.1	0.1	7.9	8.4
BR06	Oct	20.1	24.3	0.5	12.8	5.4	8.4	1.0	21.4	6.9	7.5
BR10	Oct	19.3	23.5	0.2	3.5	5.7	7.3	0.3	6.4	7.4	7.9
MC0.75	Oct	20.2	22.8	0.1	0.3	7.6	8.7	0.1	0.6	7.5	8.2
MR02	Oct	20.3	24.6	0.4	9.0	6.0	7.7	0.9	15.5	7.1	7.6
SR09	Oct	20.7	25.2	11.6	31.4	1.7	7.3	19.5	48.1	7.3	8.0
SR17	Oct	20.8	24.8	5.9	26.3	4.7	6.9	10.4	41.1	7.6	8.1
SR22	Oct	20.5	24.3	0.1	19.1	4.9	8.5	0.2	30.8	7.6	8.5
SR26	Oct	20.2	23.5	0.1	0.8	7.6	8.6	0.1	1.6	7.8	8.7
BR06	Nov	17.5	21.0	1.1	13.9	6.8	8.4	2.2	23.0	7.2	7.8
BR10	Nov	17.0	20.3	0.3	4.4	7.3	8.6	0.6	8.0	7.6	8.1
MC0.75	Nov	17.3	19.7	0.1	0.4	7.8	9.0	0.1	0.7	7.9	8.4
MR02	Nov	17.3	21.6	1.0	9.7	6.8	9.5	1.9	16.4	7.4	7.8
SR09	Nov	19.9	21.7	13.1	30.1	3.8	7.5	21.8	46.3	7.4	7.9
SR17	Nov	19.5	21.6	7.0	25.1	6.1	8.0	12.2	39.4	7.4	8.1
SR22	Nov	18.1	21.1	0.2	17.1	6.0	8.6	0.5	27.8	7.8	8.9
SR26	Nov	19.2	19.7	0.1	4.3	7.4	9.1	0.1	7.8	7.9	8.8

Table 3b. Minimum and maximum water quality values recorded in depth-integrated profiles in the eight reaches for the winter months of December, January, and February 2000-2001.

Site	Month	Temperature (°C)		Salinity (ppt)		D O (mg/L)		Conductivity (ms)		pH	
		min	max	min	max	min	max	min	max	min	max
BR06	Dec	11.0	11.6	1.4	14.5	8.6	9.9	2.8	23.9	7.8	8.0
BR10	Dec	10.7	11.4	0.1	11.4	8.9	10.2	0.2	19.2	7.9	8.6
MC0.75	Dec	10.7	11.7	0.1	1.1	10.0	11.0	0.1	2.2	8.4	8.7
MR02	Dec	11.1	11.7	1.3	8.2	9.1	10.6	2.5	14.1	7.6	8.1
SR09	Dec	11.9	13.8	12.8	31.4	8.3	9.1	21.3	48.1	7.3	8.3
SR17	Dec	11.6	14.3	2.6	27.1	3.2	9.8	4.8	42.2	8.1	8.5
SR22	Dec	11.4	14.1	0.1	20.4	7.7	11.9	0.2	32.7	8.1	9.4
SR26	Dec	11.2	11.6	0.1	2.6	9.9	10.9	0.1	4.9	8.5	9.6
BR06	Jan	6.4	11.0	0.6	13.2	9.7	11.2	1.1	22.2	6.3	8.1
BR10	Jan	5.6	9.9	0.1	8.1	10.4	11.8	0.2	14.1	6.9	8.5
MC0.75	Jan	6.6	9.6	0.1	2.0	10.8	11.1	0.1	3.8	7.6	8.6
MR02	Jan	6.6	10.1	0.5	5.7	10.3	14.2	1.0	10.1	7.2	7.9
SR09	Jan	6.7	10.7	11.5	27.2	8.9	10.8	19.5	42.8	7.6	8.3
SR17	Jan	6.7	10.8	2.9	20.4	8.9	10.7	5.3	32.7	7.9	8.7
SR22	Jan	6.9	11.0	0.1	6.7	10.3	11.7	0.1	11.8	8.2	9.4
SR26	Jan	6.9	11.1	0.1	2.1	10.6	11.5	0.1	3.9	8.4	9.2
BR06	Feb	11.8	14.5	1.1	15.3	8.2	9.9	2.2	25.1	6.3	7.3
BR10	Feb	11.8	14.3	0.2	5.3	8.6	9.6	0.4	9.4	7.1	7.8
MC0.75	Feb	11.7	14.0	0.0	0.3	9.3	10.3	0.0	0.6	7.8	8.3
MR02	Feb	12.0	14.6	1.1	7.6	8.6	10.9	2.1	13.1	6.9	7.4
SR09	Feb	12.0	14.5	9.8	25.2	7.8	9.2	16.6	39.6	7.0	8.0
SR17	Feb	12.0	14.6	2.5	18.6	7.8	13.8	4.7	30.0	7.7	8.3
SR22	Feb	12.4	14.5	0.1	9.2	7.8	11.1	0.2	15.6	7.8	8.9
SR26	Feb	12.4	14.7	0.1	0.4	9.0	11.3	0.1	0.8	8.5	8.9

Table 3c. Minimum and maximum water quality values recorded in depth-integrated profiles in the eight reaches for the spring months of March, April, and May 2001.

Site	Month	Temperature (°C)		Salinity (ppt)		D O (mg/L)		Conductivity (ms)		pH	
		min	max	min	max	min	max	min	max	min	max
BR06	Mar	14.1	14.9	0.2	10.3	7.1	8.5	0.5	17.4	7.3	8.3
BR10	Mar	13.4	14.9	0.1	2.1	7.7	8.8	0.1	4.0	7.8	8.6
MC0.75	Mar	13.0	14.1	0.0	0.1	7.9	9.0	0.1	0.1	7.9	8.6
MR02	Mar	13.3	14.8	0.1	2.4	7.8	8.8	0.1	4.6	7.7	8.6
SR09	Mar	13.9	15.1	5.0	29.8	7.1	7.7	8.9	45.9	6.5	8.2
SR17	Mar	14.0	14.7	0.8	23.1	7.0	8.3	1.5	36.6	7.3	8.7
SR22	Mar	13.3	14.3	0.1	9.6	7.2	9.1	0.1	16.4	7.9	8.7
SR26	Mar	12.8	13.6	0.0	0.1	7.8	8.8	0.1	0.1	8.3	8.8
BR06	Apr	16.6	20.5	0.2	18.3	6.6	7.6	0.5	29.5	7.0	8.2
BR10	Apr	16.5	20.7	0.1	4.6	7.0	7.8	0.2	8.2	7.4	8.9
MC0.75	Apr	16.3	20.4	0.1	0.1	7.5	8.4	0.1	0.3	7.3	8.9
MR02	Apr	16.6	20.9	0.1	15.1	6.1	8.7	0.3	24.7	7.4	8.1
SR09	Apr	15.7	20.7	6.0	30.7	5.7	7.2	10.5	47.1	7.0	8.3
SR17	Apr	15.4	21.8	0.9	26.4	5.4	7.8	1.7	41.1	7.3	8.4
SR22	Apr	15.2	22.0	0.1	22.2	5.4	7.9	0.1	35.1	7.6	8.6
SR26	Apr	15.1	21.8	0.1	0.1	7.1	8.0	0.1	0.1	7.6	9.3
BR06	May	22.1	26.0	0.8	17.8	6.7	12.1	1.6	28.9	6.7	7.3
BR10	May	22.2	26.3	0.4	3.5	7.2	13.0	0.8	6.5	7.0	8.1
MC0.75	May	22.3	25.7	0.1	0.2	6.4	8.3	0.2	0.4	7.0	8.9
MR02	May	22.1	26.3	0.8	12.6	6.1	8.7	1.7	21.0	6.8	7.7
SR09	May	22.5	25.4	10.0	30.1	5.3	7.6	17.1	46.4	6.1	7.7
SR17	May	22.4	25.2	2.8	22.4	4.8	7.1	5.1	35.6	7.0	7.5
SR22	May	22.5	25.1	0.1	5.1	6.4	8.3	0.2	9.1	6.7	8.2
SR26	May	22.7	25.0	0.1	0.2	7.4	8.1	0.2	0.5	7.0	7.8

Table 3d. Minimum and maximum water quality values recorded in depth-integrated profiles in the eight reaches for the summer months of June, July, and August 2001.

Site	Month	Temperature (°C)		Salinity (ppt)		D O (mg/L)		Conductivity (ms)		pH	
		min	max	min	max	min	max	min	max	min	max
BR06	June	27.1	27.2	0.4	0.6	4.8	5.2	0.7	1.1	7.1	7.2
BR10	June	26.8	26.9	0.2	0.2	5.0	5.1	0.4	0.4	7.0	7.3
MC0.75	June	26.4	26.4	0.1	0.1	7.6	7.6	0.1	0.1	7.0	7.1
MR02	June	26.3	26.9	0.4	0.4	6.2	7.1	0.8	0.9	7.0	7.1
SR09	June	27.0	28.0	7.7	21.5	4.3	7.1	13.4	34.4	6.8	7.6
SR17	June	26.8	27.9	2.3	13.3	4.1	7.0	4.4	22.2	7.3	7.8
SR22	June	26.1	27.9	0.0	4.3	5.1	7.7	0.1	7.8	7.3	8.2
SR26	June	26.0	27.3	0.0	0.1	7.1	9.5	0.0	0.3	7.5	8.2
BR06	July	27.4	29.4	0.6	10.7	4.6	6.6	1.2	18.1	6.9	7.9
BR10	July	27.1	29.5	0.2	1.1	5.3	6.3	0.4	2.1	7.1	8.1
MC0.75	July	27.4	28.6	0.1	0.1	6.9	9.4	0.1	0.2	7.0	8.4
MR02	July	27.5	29.4	0.3	3.3	5.6	8.6	0.6	6.1	6.9	7.7
SR09	July	28.2	29.0	6.9	26.9	4.1	5.8	12.1	42.1	7.0	7.6
SR17	July	28.3	30.1	3.1	21.7	3.7	6.4	5.7	34.7	6.6	7.9
SR22	July	27.6	28.5	0.1	6.8	4.6	9.1	0.1	12.0	7.5	8.3
SR26	July	27.5	28.4	0.1	0.2	6.8	9.5	0.1	0.4	7.8	8.5
BR06	Aug	28.0	31.3	0.0	12.7	5.1	10.4	0.1	21.2	6.6	7.9
BR10	Aug	27.5	30.6	0.0	1.4	5.8	9.5	0.0	2.7	7.6	8.0
MC0.75	Aug	27.4	29.7	0.0	0.1	7.4	7.9	0.0	0.2	7.7	8.6
MR02	Aug	28.2	31.0	0.0	6.3	5.8	8.1	0.0	11.2	7.2	7.7
SR09	Aug	28.5	30.0	0.2	26.3	4.6	7.2	0.3	41.2	6.7	7.6
SR17	Aug	28.6	30.6	0.3	19.2	3.8	6.8	0.6	31.1	7.1	7.8
SR22	Aug	27.6	30.7	0.0	11.1	4.2	8.1	0.0	18.9	7.2	8.7
SR26	Aug	27.7	29.9	0.0	0.6	7.4	8.1	0.0	1.3	7.4	8.5

Table 4. Number of species and individuals collected in ichthyoplankton surveys from polyhaline, mesohaline, oligohaline, and tidal freshwater salinity zones during the Fall, Winter, Spring, and Summer 2000-2001.

Salinity Zone (#samples)	Number of Species					Number of Individuals				
	Total	Fall	Winter	Spring	Summer	Total	Fall	Winter	Spring	Summer
Polyhaline (17)	19	4	9	5	11	498	16	108	35	339
Mesohaline (83)	35	8	11	20	20	8930	132	432	831	7535
Oligohaline (143)	34	12	16	19	24	7286	1410	2389	1772	1715
Tidal Freshwater (141)	28	9	9	18	13	7050	495	924	4977	654
Total All (384)	51	17	16	32	32	23764	2053	3853	7615	10243

Table 5. Family and species occurrence in ichthyoplankton surveys in the polyhaline, mesohaline, oligohaline, and tidal freshwater zones from September 2000 to August 2001. An X denotes the occurrence of a species in a salinity zone.

Family	Species	Common Name	Salinity Zone			
			Polyhaline	Mesohaline	Oligohaline	Tidal Fresh
Anguillidae	<i>Anguilla rostrata</i>	American Eel		x	x	x
Atherinidae	<i>Menidia beryllina</i>	Tidewater Silverside				x
	<i>Menidia menidia</i>	Atlantic Silverside		x	x	
Blenniidae	<i>Hypsoblennius hentzi</i>	Feather Blenny		x		
Bothidae	<i>Citharichthys spilopterus</i>	Bay Whiff	x	x	x	x
	<i>Paralichthys dentatus</i>	Summer Flounder			x	
	<i>Paralichthys lethostigma</i>	Southern Flounder		x	x	x
Carangidae	<i>Carangidae</i>	Unidentified Jack		x	x	
	<i>Chloroscombrus chrysurus</i>	Atlantic Bumper	x			
	<i>Oligoplites saurus</i>	Leatherjacket	x			
Centrarchidae	<i>Elassoma zonatum</i>	Banded Pygmy Sunfish				x
	<i>Lepomis sp.</i>	Unidentified Sunfish				x
Clupeidae	<i>Alosa aestivalis</i>	Blueback Herring				x
	<i>Alosa sapidissima</i>	American Shad				x
	<i>Brevoortia tyrannus</i>	Atlantic Menhaden	x	x	x	x
Cynoglossidae	<i>Symphurus plagiusa</i>	Blackcheek Tonguefish	x	x	x	
Cyprinidae	<i>Cyprinidae</i>	Unidentified Minnow				x
Elopidae	<i>Elops saurus</i>	Ladyfish	x	x	x	x
Engraulidae	<i>Anchoa hepsetus</i>	Striped Anchovy		x		
	<i>Anchoa mitchilli</i>	Bay Anchovy	x	x	x	x
Gerreidae	<i>Eucinostomus sp.</i>	Mojarra	x		x	x
Gobiidae	<i>Gobionellus boleosoma</i>	Darter Goby			x	x
	<i>Gobiosoma boscii</i>	Naked Goby	x	x	x	x
	<i>Gobiosoma ginsburgi</i>	Seaboard Goby	x	x	x	
	<i>Gobionellus hastatus</i>	Sharptail Goby		x	x	x
	<i>Gobionellus shufeldti</i>	Freshwater Goby		x	x	x
	<i>Gobiesox strumosus</i>	Skilletfish		x		
	<i>Microgobius thalassinus</i>	Green Goby			x	
Megalopidae	<i>Megalops atlanticus</i>	Tarpon		x		
Moronidae	<i>Morone saxatilis</i>	Striped Bass				x
Mugilidae	<i>Mugil cephalus</i>	Striped Mullet	x	x	x	x
	<i>Mugil curema</i>	White Mullet		x		
Ophichthidae	<i>Myrophis punctatus</i>	Speckled Worm Eel	x	x	x	x
Sciaenidae	<i>Bairdiella chrysoura</i>	Silver Perch		x	x	
	<i>Cynoscion nebulosus</i>	Spotted Seatrout		x	x	
	<i>Cynoscion regalis</i>	Weakfish	x	x	x	
	<i>Leiostomus xanthurus</i>	Spot	x	x	x	x
	<i>Menticirrhus americanus</i>	Southern Kingfish	x	x	x	x
	<i>Micropogonias undulatus</i>	Atlantic Croaker	x	x	x	x
	<i>Pogonias cromis</i>	Black Drum		x		
	<i>Sciaenops ocellatus</i>	Red Drum	x	x	x	x
	<i>Stellifer lanceolatus</i>	Star Drum	x	x	x	
Siluridae	<i>Ictalurus catus</i>	White Catfish			x	x
	<i>Ictalurus punctatus</i>	Channel Catfish			x	
Soleidae	<i>Trinectes maculatus</i>	Hogchoker		x	x	x
Sparidae	<i>Lagodon rhomboides</i>	Pinfish		x	x	x
Stromateidae	<i>Peprilus alepidotus</i>	Harvestfish		x		
Syngnathidae	<i>Syngnathus fuscus</i>	Northern Pipefish		x	x	
	<i>Syngnathus louisianae</i>	Chain Pipefish		x	x	
	<i>Syngnathus scovelli</i>	Gulf Pipefish		x	x	x
Triglidae	<i>Prionotus sp.</i>	Sea Robin	x	x		

Table 6a. All species (total number) collected in ichthyoplankton surveys during the fall months of September, October, and November 2000 from the four salinity zones.

Salinity Zone	Fall		
	Sep-00	Oct-00	Nov-00
Polyhaline	bay anchovy (9) seaboard goby (3) naked goby (2) Atlantic bumper (1)	bay anchovy (1)	none
Mesohaline	bay anchovy (29) red drum (10) Atlantic croaker (8) Gulf pipefish (4) blackcheek tonguefish (3) chain pipefish (2) pipefish (2) naked goby (2) seaboard goby (1)	Atlantic croaker (27) bay anchovy (19)	bay anchovy (17) Atlantic croaker (8)
Oligohaline	bay anchovy (408) Atlantic croaker (84) red drum (31) blackcheek tonguefish (11) naked goby (4) green goby (3) Gulf pipefish (2) hogchoker (2) mojarra (2) drums (1) weakfish (1)	bay anchovy (319) Atlantic croaker (69) darter goby (2) naked goby (1)	bay anchovy (381) Atlantic croaker (85) Gulf pipefish (1) hogchoker (1) naked goby (1) sharptail goby (1)
Tidal Fresh	bay anchovy (234) Atlantic croaker (58) naked goby (5) red drum (6) hogchoker (2) sharptail goby (3) freshwater goby (1) herring/shad (1) mojarra (1)	Atlantic croaker (113) bay anchovy (60) hogchoker (3) gobies (1)	bay anchovy (6) Atlantic croaker (2) darter/freshwater gobies (1)

Table 6b. All species (total number) collected in ichthyoplankton surveys during the winter months of December, January, and February 2000-2001 from the four salinity zones.

Winter			
Salinity Zone	Dec-00	Jan-01	Feb-01
Polyhaline	bay anchovy (4) speckled worm eel (4)	Atlantic croaker (36) bay anchovy (32) star drum (5) speckled worm eel (3) Atlantic menhaden (1) spot (1) striped mullet (1)	Atlantic menhaden (9) speckled worm eel (8) spot (2) Atlantic croaker (1) bay whiff (1)
Mesohaline	Atlantic croaker (27) bay anchovy (8) white mullet (1)	Atlantic croaker (214) bay anchovy (22) spot (12) star drum (2) striped mullet (2) Southern flounder (1) speckled worm eel (1)	Atlantic croaker (89) Atlantic menhaden (23) spot (13) speckled worm eel (5) bay anchovy (4) pinfish (3) Southern flounder (3) American eel (1)
Oligohaline	bay anchovy (694) Atlantic croaker (77) Atlantic silverside (1) darter goby (1) darter/freshwater gobies (1) Atlantic menhaden (1) pinfish (1)	Atlantic croaker (601) bay anchovy (185) Southern flounder (30) spot (30) American eel (3) Atlantic menhaden (3) freshwater goby (2) darter goby (1) pinfish (1) star drum (1) striped mullet (1) Summer flounder (1)	Atlantic croaker (425) Southern flounder (118) Atlantic menhaden (80) spot (63) pinfish (47) bay anchovy (13) American eel (3) bay whiff (2) striped mullet (1) speckled worm eel (1)
Tidal Fresh	bay anchovy (27) Atlantic croaker (11)	Atlantic croaker (487) bay anchovy (72) Southern flounder (44) spot (18) American eel (11) Atlantic menhaden (9) pinfish (8) striped mullet (4)	Southern flounder (96) Atlantic menhaden (49) Atlantic croaker (48) pinfish (28) American eel (7) spot (4) bay whiff (1)

Table 6c. All species (total number) collected in ichthyoplankton surveys during the spring months of March, April, and May 2001 from the four salinity zones.

Salinity Zone	Spring		
	Mar-01	Apr-01	May-01
Polyhaline	none	spot (12) Atlantic croaker (10) Atlantic menhaden (10) bay anchovy (1)	bay anchovy (1) pipefish (1)
Mesohaline	spot (14) Atlantic menhaden (11) bay anchovy (2) pinfish (2) Atlantic croaker (1) bay whiff (1)	bay anchovy (392) Atlantic menhaden (96) Atlantic croaker (67) spot (35) gobies (8) Atlantic silverside (3) skilletfish (3) ladyfish (2) naked goby (1) striped anchovy (1)	weakfish (129) bay anchovy (24) Southern kingfish (10) naked goby (8) searobin (4) Atlantic croaker (3) silver perch (3) black drum (2) chain pipefish (2) gulf pipefish (2) pipefish (2) Northern pipefish (1) feather blenny (1)
Oligohaline	Atlantic menhaden (196) spot (68) Atlantic croaker (41) pinfish (9) bay anchovy (4) bay whiff (3) fringed/smallmouth flounder (2) sharptail goby (1) Summer flounder (1)	Atlantic croaker (847) Atlantic menhaden (313) spot (64) bay anchovy (16) bay whiff (5) darter/freshwater gobies (1) freshwater goby (1) ladyfish (1) naked goby (1) pinfish (1) sharptail goby (1)	Atlantic menhaden (85) Atlantic croaker (38) bay anchovy (23) silver perch (17) hogchoker (15) naked goby (4) seaboard goby (4) darter goby (2) Gulf pipefish (2) drums (1) gobies (1) ladyfish (1) Northern pipefish (1) pipefish (1) weakfish (1)
Tidal Fresh	Atlantic menhaden (3713) spot (469) Atlantic croaker (194) bay anchovy (31) Southern flounder (31) pinfish (18) bay whiff (9) American eel (6) banded pygmy sunfish (6) freshwater goby (5) darter goby (2) darter/freshwater gobies (2) naked goby (1) speckled worm eel (1)	Atlantic menhaden (298) spot (38) Atlantic croaker (23) bay anchovy (6) bay whiff (3) pinfish (2) freshwater goby (1) Southern flounder (1)	Atlantic menhaden (87) bay anchovy (14) Atlantic croaker (6) Gulf pipefish (3) striped bass (2) American shad (1) ladyfish (1) pipefish (1) sharptail goby (1)

Table 6d. All species (total number) collected in ichthyoplankton surveys during the summer months of June, July, and August 2001 from the four salinity zones.

Salinity Zone	Summer		
	Jun-01	Jul-01	Aug-01
Polyhaline	bay anchovy (70) naked goby (28) blackcheek tonguefish (14) weakfish (5) mojarra (1) pipefish (1) seaboard goby (1)	bay anchovy (104) naked goby (58) blackcheek tonguefish (5) weakfish (5) pipefish (2) ladyfish (1)	bay anchovy (29) naked goby (11) red drum (1) seaboard goby (1) sea robin (1) Southern kingfish (1)
Mesohaline	bay anchovy (276) blackcheek tonguefish (127) naked goby (27) weakfish (14) silver perch (8) star drum (5) Atlantic menhaden (1) feather blenny (1) fringed/smallmouth flounder(1) gulf pipefish (1) hogchoker (1) jacks (1) pipefish (1) searobin (1)	bay anchovy (6805) naked goby (48) Atlantic menhaden (42) blackcheek tonguefish (11) weakfish (9) spotted seatrout (3) jacks (2) chain pipefish (1) Southern kingfish (1)	bay anchovy (107) naked goby (10) blackcheek tonguefish (7) weakfish (6) freshwater goby (3) Atlantic menhaden (2) hogchoker (2) seaboard goby (2) star drum (2) drums (1) harvest fish (1) jacks (1) red drum (1) Southern kingfish (1) spotted seatrout (1) tarpon (1)
Oligohaline	bay anchovy (860) naked goby (66) Atlantic menhaden (12) weakfish (9) silver perch (5) freshwater goby (4) blackcheek tonguefish (3) gulf pipefish (2) channel catfish (1) darter goby (1) fringed/smallmouth flounder(1) jacks (1) Southern kingfish (1) sharptail goby (1) white catfish (1)	bay anchovy (330) naked goby (90) hogchoker (26) weakfish (25) blackcheek tonguefish (7) Atlantic menhaden (3) pipefishes (2) darter goby (1) gobies (1) Northern pipefish (1) shad/herring (1) Southern kingfish (1) star drum (1)	bay anchovy (137) hogchoker (46) weakfish (38) naked goby (10) blackcheek tonguefish (8) red drum (6) Southern kingfish (4) chain pipefish (3) freshwater goby (2) spotted seatrout (2) green goby (1)
Tidal Fresh	bay anchovy (153) Atlantic menhaden (16) naked goby (11) freshwater goby (6) hogchoker (6) white catfish (6) blueback herring (2) darter goby (2) tidewater silverside (1)	hogchoker (151) naked goby (87) bay anchovy (37) white catfish (13) herring/shad (6) freshwater goby (3) Southern kingfish (2) darter/freshwater gobies (1)	bay anchovy (75) hogchoker (56) naked goby (9) white catfish (4) sharptail goby (2) blueback herring (1) darter/freshwater gobies (1) minnows (1) sunfish (1)

Table 7. Number of species and individuals collected in marsh-edge drop surveys from polyhaline, mesohaline, oligohaline, and tidal freshwater zones during Fall, Winter, Spring, and Summer 2000-2001.

Salinity Zone (# samples)	Number of Species					Number of Individuals				
	Total	Fall	Winter	Spring	Summer	Total	Fall	Winter	Spring	Summer
Polyhaline (5)	4	1	0	0	3	4	1	0	0	3
Mesohaline (29)	23	10	8	12	10	3478	327	96	3018	37
Oligohaline (20)	17	8	8	5	9	779	281	132	337	29
Tidal Freshwater (26)	11	6	7	6	7	1532	14	1232	265	21
Total all (80)	30	12	13	13	15	5793	623	1460	3620	90

Table 8a. All species (total number) collected in marsh-edge drop surveys during the fall months of September, October, and November 2000-2001 from the four salinity zones.

Salinity Zone	Fall		
	Oct-00	Nov-00	Sep-01
Polyhaline	silver perch (1)	none	none
Mesohaline	bay anchovy (291) Atlantic croaker (9) mummichog (5) tidewater silverside (2) freshwater goby (1) mojarra (1)	least killifish (1)	tidewater silverside (7) Southern kingfish (4) Atlantic croaker (1) bay anchovy (1) naked goby (1) red drum (1)
Oligohaline	bay anchovy (98) Atlantic croaker (30) freshwater goby (3) gray snapper (1) mummichog (1) Gulf pipefish (1)	bay anchovy (51) Atlantic croaker (3) freshwater goby (2) darter goby (1) mummichog (1)	tidewater silverside (47) bay anchovy (36) Atlantic croaker (2) red drum (2) mummichog (1) naked goby (1)
Tidal Fresh	none	pinfish (3) freshwater goby (2) Atlantic croaker (1) bay anchovy (1)	bay anchovy (5) darter goby (1) mojarra (1)

Table 8b. All species (total number) collected in marsh-edge drop surveys during the winter months of December, January, and February 2000-2001 from the salinity habitat zones.

Salinity Zone	Winter		
	Dec-00	Jan-01	Feb-01
Polyhaline	none	none	none
Mesohaline	mummichog (2)	spot (7) pinfish (2) Southern flounder (1)	spot (65) Southern flounder (15) freshwater goby (1) sailfin molly (1) Southern kingfish (1) striped mullet (1)
Oligohaline	tidewater silverside (5) Atlantic croaker (3) striped mullet (1)	star drum (23) spot (14) Atlantic croaker (4) tidewater silverside (1)	Atlantic menhaden (39) spot (30) Atlantic croaker (8) Southern flounder (3) striped mullet (1)
Tidal Fresh	freshwater goby (5) Atlantic croaker (1)	Atlantic menhaden (11) spot (5) Southern flounder (3) freshwater goby (1)	Atlantic menhaden (947) Atlantic croaker (155) spot (70) Southern flounder (27) pinfish (4) bay anchovy (3)

Table 8c. All species (total number) collected in marsh-edge drop surveys during the spring months of March, April, and May 2001 from the four salinity zones.

Salinity Zone	Spring		
	Mar-01	Apr-01	May-01
Polyhaline	none	none	none
Mesohaline	Atlantic menhaden (2375) spot (540) striped mullet (69) Southern flounder (7) freshwater goby (4) pinfish (4) bay anchovy (1) mosquitofish (1) Southern kingfish (1)	freshwater goby (2) spot (1)	Southern kingfish (5) spot (4) freshwater goby (1) largemouth bass (1) mummichog (1) spotted sucker (1)
Oligohaline	Atlantic menhaden (177) spot (19) pinfish (1)	Atlantic menhaden (68) spot (35) freshwater goby (3) naked goby (1)	spot (28) Atlantic menhaden (3) freshwater goby (2)
Tidal Fresh	freshwater goby (8) pinfish (1) Southern flounder (1)	Atlantic menhaden (173) spot (67) freshwater goby (7) pinfish (2) Southern flounder (2)	freshwater goby (3) mummichog (1)

Table 8d. All species (total number) collected in marsh-edge drop surveys during the summer months of June, July, and August 2001 from the four salinity zones.

Salinity Zone	Summer		
	Jun-01	Jul-01	Aug-01
Polyhaline	*	plainhead filefish (1) Atlantic bumper (1)	rough silverside (1)
Mesohaline	*	bay anchovy (13) pinfish (1) Gulf pipefish (1)	bay anchovy (18) chain pipefish (1) silver perch (1) spotted seatrout (1) tidewater silverside (1)
Oligohaline	*	bay anchovy (16) bay whiff (1) Southern flounder (1)	bay anchovy (10) spot (1)
Tidal Fresh	*	mummichog (3) bay anchovy (1)	bay anchovy (13) darter goby (1) freshwater goby (1) Southern flounder (1) tidewater silverside (1)

(* no samples taken in June)

Table 9. Family and species occurrence in marsh-edge drop surveys in polyhaline, mesohaline, oligohaline, and tidal freshwater zones from October 2000 to September 2001. An X denotes the occurrence of a species in a salinity zone and an asterick* denotes species not collected in seine surveys during the comparison period.

Family	Scientific name	Common Name	Salinity Zone			
			Polyhaline	Mesohaline	Oligohaline	Tidal Fresh
Atherinidae	<i>Membras martinica</i>	Rough Silverside	X			
	<i>Menidia beryllina</i>	Tidewater Silverside	*	X	X	X
Ballistidae	<i>Monacanthus hispidus</i>	Planehead Filefish	*	X		
Bothidae	<i>Citharichthys spilopterus</i>	Bay Whiff			X	
	<i>Paralichthys lethostigma</i>	Southern Flounder		X	X	X
Carangidae	<i>Chloroscombrus chrysurus</i>	Atlantic Bumper	*	X		
Catostomidae	<i>Minytrema melanops</i>	Spotted Sucker		X		
Centrarchidae	<i>Micropterus salmoides</i>	Largemouth Bass		X		
Clupeidae	<i>Brevoortia tyrannus</i>	Atlantic Menhaden		X	X	X
Cyprinodontidae	<i>Fundulus heteroclitus</i>	Mummichog		X	X	X
	<i>Heterandria formosa</i>	Least Killifish		X		
Engraulidae	<i>Anchoa mitchilli</i>	Bay Anchovy		X	X	X
Gerridae	<i>Eucinostomus sp.</i>	Mojarra		X		X
Gobiidae	<i>Gobionellus boleosoma</i>	Darter Goby	*		X	X
	<i>Gobionellus shufeldti</i>	Freshwater Goby		X	X	X
	<i>Gobiosoma boscii</i>	Naked Goby	*	X	X	
Lutjanidae	<i>Lutjanus griseus</i>	Gray Snapper	*		X	
Mugilidae	<i>Mugil cephalus</i>	Striped Mullet		X	X	
Poeciliidae	<i>Gambusia affinis</i>	Mosquitofish		X		
	<i>Poecilia latipinna</i>	Sailfin Molly		X		
Sciaenidae	<i>Bairdiella chrysoura</i>	Silver Perch	X	X		
	<i>Cynoscion nebulosus</i>	Spotted Seatrout		X		
	<i>Leiostomus xanthurus</i>	Spot		X	X	X
	<i>Menticirrhus americanus</i>	Southern kingfish		X		
	<i>Micropogonias undulatus</i>	Atlantic Croaker		X	X	X
	<i>Sciaenops ocellatus</i>	Red Drum	*	X	X	
	<i>Stellifer lanceolatus</i>	Star Drum			X	
Sparidae	<i>Lagodon rhomboides</i>	Pinfish		X	X	X
Syngnathidae	<i>Syngnathus louisianae</i>	Chain Pipefish	*	X		
	<i>Syngnathus scovelli</i>	Gulf Pipefish	*	X	X	

Table 10. Family, species, and number of individuals collected in marsh-edge seine surveys from June to September 2001. An asterick* denotes species not collected in drop surveys during the comparison period.

Family	Species	Common Name		Month			
				Jun	Jul	Aug	Sep
Anguillidae	<i>Anguilla rostrata</i>	American Eel	*	0	0	0	1
Atherinidae	<i>Membras martinica</i>	Rough Silverside		0	0	1	17
	<i>Menidia menidia</i>	Atlantic Silverside	*	0	1	1	13
Bothidae	<i>Citharichthys macrops</i>	Spotted Whiff		1	0	0	0
	<i>Citharichthys spilopterus</i>	Bay Whiff		4	6	7	3
	<i>Paralichthys dentatus</i>	Summer Flounder	*	2	1	1	0
	<i>Paralichthys lethostigma</i>	Southern Flounder		13	32	18	25
	<i>Paralichthys sp.</i>	Flounder		0	0	0	1
Carangidae	<i>Caranx hippos</i>	Jack Crevalle		1	0	0	0
	<i>Oligoplites saurus</i>	Leatherjacket	*	0	0	1	0
	<i>Selene vomer</i>	Lookdown	*	0	0	1	0
Centrarchidae	<i>Lepomis macrochirus</i>	Bluegill	*	0	1	0	0
	<i>Micropterus salmoides</i>	Largemouth Bass		1	0	0	0
Clupeidae	<i>Alosa aestivalis</i>	Blueback Herring	*	7	1	1	4
	<i>Alosa mediocris</i>	Hickory Shad		2	0	0	0
	<i>Brevoortia tyrannus</i>	Atlantic Menhaden		1	0	83	0
	<i>Dorosoma cepedianum</i>	Gizzard Shad	*	11	1	0	0
Cynoglossidae	<i>Symphurus plagiusa</i>	Blackcheek Tonguefish	*	0	0	0	1
Cyprinidae	<i>Notropis hudsonius</i>	Spottail Shiner	*	0	0	0	2
Cyprinodontidae	<i>Cyprinodon variegatus</i>	Sheepshead Minnow	*	0	0	1	0
	<i>Fundulus heteroclitus</i>	Mummichog		4	20	30	5
Dasyatidae	<i>Dasyatidae</i>	Sting Ray	*	0	0	1	0
Diodontidae	<i>Chilomycterus schoepfi</i>	Striped Burrfish	*	2	1	0	2
Engaulidae	<i>Anchoa hepsetus</i>	Striped Anchovy	*	0	0	1	1
	<i>Anchoa mitchilli</i>	Bay Anchovy		19	3	7	43
Gerreidae	<i>Diapterus auratus</i>	Irish Pompano	*	0	0	0	1
	<i>Eucinostomus argenteus</i>	Spotfin Mojarra		0	0	0	19
Gobiidae	<i>Evorthodus lyricus</i>	Lyre Goby	*	0	2	0	0
	<i>Gobionellus shufeldti</i>	Freshwater Goby		25	20	15	28
Haemulidae	<i>Orthopristis chrysoptera</i>	Pigfish	*	5	1	0	0
Moronidae	<i>Morone americana</i>	White Perch		2	0	0	0
Mugilidae	<i>Mugil cephalus</i>	Striped Mullet		0	0	1	2
Poeciliidae	<i>Gambusia affinis</i>	Mosquitofish		0	0	3	0
	<i>Poecilia latipinna</i>	Sailfin Molly		0	0	0	1
Sciaenidae	<i>Bairdiella chrysoura</i>	Silver Perch		77	38	81	41
	<i>Cynoscion nebulosus</i>	Spotted Seatrout		0	2	0	12
	<i>Cynoscion regalis</i>	Weakfish		2	0	0	0
	<i>Leiostomus xanthurus</i>	Spot		37	18	11	33
	<i>Micropogonias undulatus</i>	Atlantic Croaker		0	0	1	0
Soleidae	<i>Trinectes maculatus</i>	Hogchoker	*	5	1	2	1
Sparidae	<i>Lagodon rhomboides</i>	Pinfish		4	6	1	1
Synodontidae	<i>Synodus foetens</i>	Inshore Lizardfish	*	0	1	0	0

Table 11. Family, species, and number of individuals collected in tidal creek surveys from June to September 2001.

Family	Species	Common Name	Month			
			Jun	Jul	Aug	Sep
Atherinidae	<i>Menidia beryllina</i>	Tidewater Silverside	38	3	4	13
	<i>Membras martinica</i>	Rough Silverside	0	0	2	30
	<i>Menidia menidia</i>	Atlantic Silverside	0	0	1	3
Belonidae	<i>Strongylura marina</i>	Atlantic Needlefish	0	1	0	0
Bothidae	<i>Citharichthys spilopterus</i>	Bay Whiff	2	4	3	11
	<i>Paralichthys dentatus</i>	Summer Flounder	0	1	1	0
	<i>Paralichthys lethostigma</i>	Southern Flounder	1	10	2	10
Carangidae	<i>Paralichthys sp.</i>	Flounder	0	0	2	2
	<i>Caranx hippos</i>	Jack Crevalle	0	0	1	0
	<i>Chloroscombrus chrysurus</i>	Atlantic Bumper	0	3	102	36
	<i>Oligoplites saurus</i>	Leatherjacket	0	0	3	1
Centrarchidae	<i>Selene vomer</i>	Lookdown	0	1	2	0
	<i>Lepomis auritus</i>	Redbreast	0	0	1	0
	<i>Lepomis macrochirus</i>	Bluegill	4	0	0	3
Clupeidae	<i>Micropterus salmoides</i>	Largemouth Bass	2	0	0	2
	<i>Pomoxis nigromaculatus</i>	Black Crappie	4	6	0	5
	<i>Alosa aestivalis</i>	Blueback Herring	843	23	48	112
	<i>Alosa mediocris</i>	Hickory Shad	2	12	0	0
	<i>Alosa sapidissima</i>	American Shad	5	1	0	0
	<i>Brevoortia tyrannus</i>	Atlantic Menhaden	18	48	62	1
Cyprinidae	<i>Dorosoma cepedianum</i>	Gizzard Shad	12	10	3	3
	<i>Dorosoma petenense</i>	Threadfin Shad	2	11	9	0
	<i>Notropis hudsonius</i>	Spottail Shiner	1	0	0	0
Cyprinodontidae	<i>Fundulus heteroclitus</i>	Mummichog	1	28	43	46
	<i>Fundulus luciae</i>	Spotfin Killifish	1	1	0	0
	<i>Fundulus sp.</i>	Killifish	0	2	0	0
Diodontidae	<i>Chilomycterus schoepfi</i>	Striped Burrfish	0	0	0	2
Engraulidae	<i>Anchoa hepsetus</i>	Striped Anchovy	0	5	1	0
	<i>Anchoa mitchilli</i>	Bay Anchovy	422	567	2703	54
Gerridae	<i>Eucinostomus argenteus</i>	Spotfin Mojarra	0	0	1	3
	<i>Eucinostomus sp.</i>	Mojarra	1	0	0	0
Gobiidae	<i>Gobionellus boleosoma</i>	Darter Goby	0	0	2	1
	<i>Gobionellus shufeldti</i>	Freshwater Goby	1	0	0	0
Lepisosteidae	<i>Lepisosteus osseus</i>	Longnose Gar	0	0	0	1
Mugilidae	<i>Mugil cephalus</i>	Striped Mullet	0	3	1	3
Poeciliidae	<i>Gambusia affinis</i>	Mosquitofish	0	0	2	0
	<i>Poecilia latipinna</i>	Sailfin Molly	0	0	0	0
Pomatomidae	<i>Pomatomus saltatrix</i>	Bluefish	0	1	0	0
Sciaenidae	<i>Bairdiella chrysoura</i>	Silver Perch	1	334	187	130
	<i>Cynoscion nebulosus</i>	Spotted Seatrout	0	3	2	5
	<i>Cynoscion regalis</i>	Weakfish	2	6	0	0
	<i>Leiostomus xanthurus</i>	Spot	8	74	31	75
	<i>Micropogonias undulatus</i>	Atlantic Croaker	0	0	0	1
	<i>Stellifer lanceolatus</i>	Star Drum	0	0	0	1
Scombridae	<i>Scomberomorus maculatus</i>	Spanish Mackerel	0	0	1	0
Siluridae	<i>Ictalurus catus</i>	White Catfish	0	0	5	3
Soleidae	<i>Trinectes maculatus</i>	Hogchoker	0	1	0	0
Sparidae	<i>Archosargus probatocephalus</i>	Sheepshead	0	1	0	0
	<i>Lagodon rhomboides</i>	Pinfish	0	11	0	3
Syngnathidae	<i>Syngnathus sp.</i>	Pipefish	0	0	1	0
	<i>Syngnathus scovelli</i>	Gulf Pipefish	2	1	2	0
Triglidae	<i>Prionotus sp.</i>	Sea Robin	0	1	0	0