A COMPARISON OF SPECIES COMPOSITION AND ABUNDANCE OF DECAPOD CRUSTACEANS AND FISHES FROM THE NORTH AND SOUTH EDISTO RIVERS IN SOUTH CAROLINA

E.L. Wenner
W.P. Coon, III
P.A. Sandifer
M.H. Shealy, Jr.

Marine Resources Center
South Carolina Wildlife and Marine Resources Department
PO Box 12559
Charleston, SC 29412

Technical Report No. 78
South Carolina Marine Resources Center

January 1991

Table of Contents

List of Figures

List of Tables

List of Appendices

Abstract

Fluctuations in the distribution and abundance of fishes and decapod crustaceans collected by a 6-m otter trawl from the North and South Edisto Rivers were examined over a two-year period. Ten species which accounted for >90% of the total number of specimens and >70% of the total fish biomass in both rivers were: *Stellifer lanceolatus*, *Micropogonias undulatus*, *Ictalurus catus*, *Anchoa mitchilli*, *Leiostomus xanthurus*, *Chloroscombrus chrysurus*, *Urophycis regia*, *Brevoortia tyrannus*, *Cynoscion regalis*, and *Trinectes maculatus*. In both rivers, *Stellifer lanceolatus* was the most abundant fish species. The dominant decapod species, *Penaeus setiferus*, *P. aztecus*, *Callinectes sapidus*, and *Xiphopenaeus kroyeri*, comprised almost 94% by number and >97% of weight of the total decapod catch. *Penaeus setiferus* dominated the catch throughout the two-year period.

The two rivers differed in both salinity structure and faunal composition. The North Edisto, which lacked a distinct halocline, had a fairly uniform distribution of species among stations. Species assemblages in the North Edisto lacked a strong endemic estuarine component. Assemblages were composed of stenohaline marine species, which were generally seasonal in their appearance and not very abundant, and euryhaline transients, which were abundant but temporary inhabitants of the estuary as adults. In the South Edisto, the faunal gradient was controlled primarily by salinity, with a change in composition between the limnetic upestuary areas and the meso-euhaline areas.

Introduction

Few investigators of estuarine systems have examined species composition and abundance in hydrographically dissimilar systems. Boesch (1977) examined zonation of benthos within a relatively homiohaline tributary of Chesapeake Bay and compared results with a seasonally-poikilohaline estuary in eastern Australia. Tagatz and Dudley (1961) studied seasonality of marine fishes in four coastal habitats near Beaufort, North Carolina, while Miller and Jorgenson (1969) studied the seasonal abundance and length-frequency distribution of fishes collected from a beach habitat and two high marsh habitats in Georgia. In other Georgia studies, Dahlberg and Odum (1970) compared species occurrence, abundance, and diversity of estuarine fish populations from three ecological habitats which were separable according to amount of tidal waters; and Dahlberg (1972) compared composition and diversity of fish species collected from nine aquatic habitats along the Georgia coast. Wenner et al. (1982) examined fishes and decapod crustaceans from the North and South Santee Rivers. Similarities were found between the rivers in terms of species distribution, probably because of their hydrographic similarity. In this paper, we present information on species assemblages, abundance, and selected life history aspects of fishes and decapod crustaceans collected from a poikilohaline and a homiohaline river in coastal South Carolina.

Study Sites

The North and South Edisto Rivers are contiguous but differ considerably hydrographically. Both rivers empty into the Atlantic Ocean at their mouths. The South Edisto, which has a drainage basin that encompasses 7.7 x 10^3 sq. kilometers receives considerable freshwater inflow with runoff approximating 75 m^3s^{-1}. The upper half of the South Edisto River estuary is characteristically limnetic to mixo-oligohaline (Venice System of Salinity Classification, Symposium on the Classification of Brackish Waters, 1958), while the seaward half is mixo-mesohaline. Salt marshes of smooth cordgrass dominate the lower portion of the South Edisto while the central and upper regions at Sampson Island and Snuggedy Swamps are characterized by brackish and freshwater marshes. Tidal action and velocity are strong in this river and cause vertical mixing. The South Edisto is subject to spring freshets and floods and carries a heavy sediment load (Mathews and Shealy, 1978). Due to variations in freshwater flow, the South Edisto is a moderately fluctuating or poikilohaline estuary. Sediment composition consists of shell, coarse sand, clay, and mud, with sand predominant throughout most of the river.

The North Edisto River is a relatively short, deep estuary with a small amount of freshwater inflow which is principally the result of local upland runoff. The greatest brackish water inflow is via the Atlantic Intracoastal Waterway to the west. A number of tributaries enter the North Edisto River along its course, but water flow in these creeks is generally tidal with negligible freshwater input. Because of the absence of a significant freshwater source, waters of the North Edisto are characteristically mixo-polyhaline with no well-defined halocline present (Mathews and Shealy, 1978). Over 93 sq. kilometers of Spartina-dominated salt marsh are found along the shoreline of the North Edisto, while brackish marshes include only 1.56 sq. kilometers (Tiner, 1977). Bottom sediment composition ranges from coarse sand and shell to finer sand, clay, and mud, with sand the predominant sediment (Calder, et al, 1977).

Methods and Materials

Data Collection

Samples were collected from eight fixed stations located in the channel and representative tributaries of the North Edisto River and four fixed stations in the channel of the South Edisto River (Figure 1). The location and bottom characterization of these stations, as described by Calder et al. (1977), are as follows:

South Edisto -- D001 (Snuggedy Swamp, sand and mud); D002 (Sampson Island, mud and sand with heavy siltation); D003 (Fenwick Island, sand and shell); and D004 (Bay Point, sand with mud and clay).

North Edisto -- E001 (Yonges Island, sand with heterogeneous mixture of shells, rocks, clay, and wood debris, epifaunal community of sponges, hydroids and bryozoans); E002 (Toogoodoo Creek, sand with mud and shell); E003 (Bears Bluff, shell and mud); E004 (Dawho River, sand and mud); E005 (Steamboat Creek, sand and mud with much Leptogorgia and other sessile invertebrates); E006 (Wadmalaw Island, sand and mud); E007 (Point of Pines, sand and mud with some shell); and E008 (DeVeaux Bank, sand with shell, epifaunal invertebrate community of Leptogorgia, hydroids, and bryozoans).

Stations were sampled on a monthly basis during a two-year cycle from February 1973 through January 1975. In order to assess complete annual and seasonal trends in our data, we have grouped January 1974 data with that collected during 1973 and January 1975 data with that collected during 1974.

All collections were made with a 6-m (20-ft.) semi-balloon otter trawl composed of 2.5-cm (1-inch) stretch mesh throughout. Wenner et al. (1982) discussed the bias of this net toward selective capture of juvenile fishes. Twenty-minute tows were made against flood tide during daylight hours at a speed of 1.3 m sec^{-1} (2.5 knots), which resulted in a coverage of 1.5 $\pm$ 0.4 km during a tow.

Prior to trawling, bottom-water samples were collected at each station with 6-liter capacity Van Dorn bottles positioned 0.3 m above the bottom. Water temperature was read from stem thermometers mounted within the Van Dorn bottles, while salinity was measured with a Beckman RS7B induction salinometer in the laboratory. Dissolved oxygen was determined by the Winkler-Carpenter method (Strickland and Parsons, 1968). Turbidity was determined with a Hach Model 2100A turbidimeter. For consistency with our previous paper (Wenner et al., 1982), we defined winter as January, February, and March; spring as April, May, and June; summer as July, August, and September; and fall as October, November, and December.

Specimens collected were either processed in the field or preserved in 10% formalin and returned to the laboratory where they were identified, counted, measured (total length for fishes, carapace width measured as distance between tips of final anterolateral spines for crabs, and total length from tip of rostrum to tip of telson for shrimp) and weighed to the nearest 0.1 g. We recorded measurements for all species numbering $\leq$50 specimens per tow. At stations where the trawl caught larger numbers of organisms, we subsampled each species in the catch as follows: if $\geq$50 to $\leq$250 individuals were collected, then a minimum of 50 randomly-selected specimens were measured; if >250 to <500 individuals were caught, then a minimum of 20% were measured; when >500 were caught, a minimum of 10% were measured. Total weight and total number were recorded for all species caught during a tow, except for extremely large catches in which total number was estimated by counting specimens in a weighed subsample and extrapolating.

Data Analysis

The degree of similarity among collections and among species was determined by using the Bray-Curtis similarity coefficient (Clifford and Stephenson,

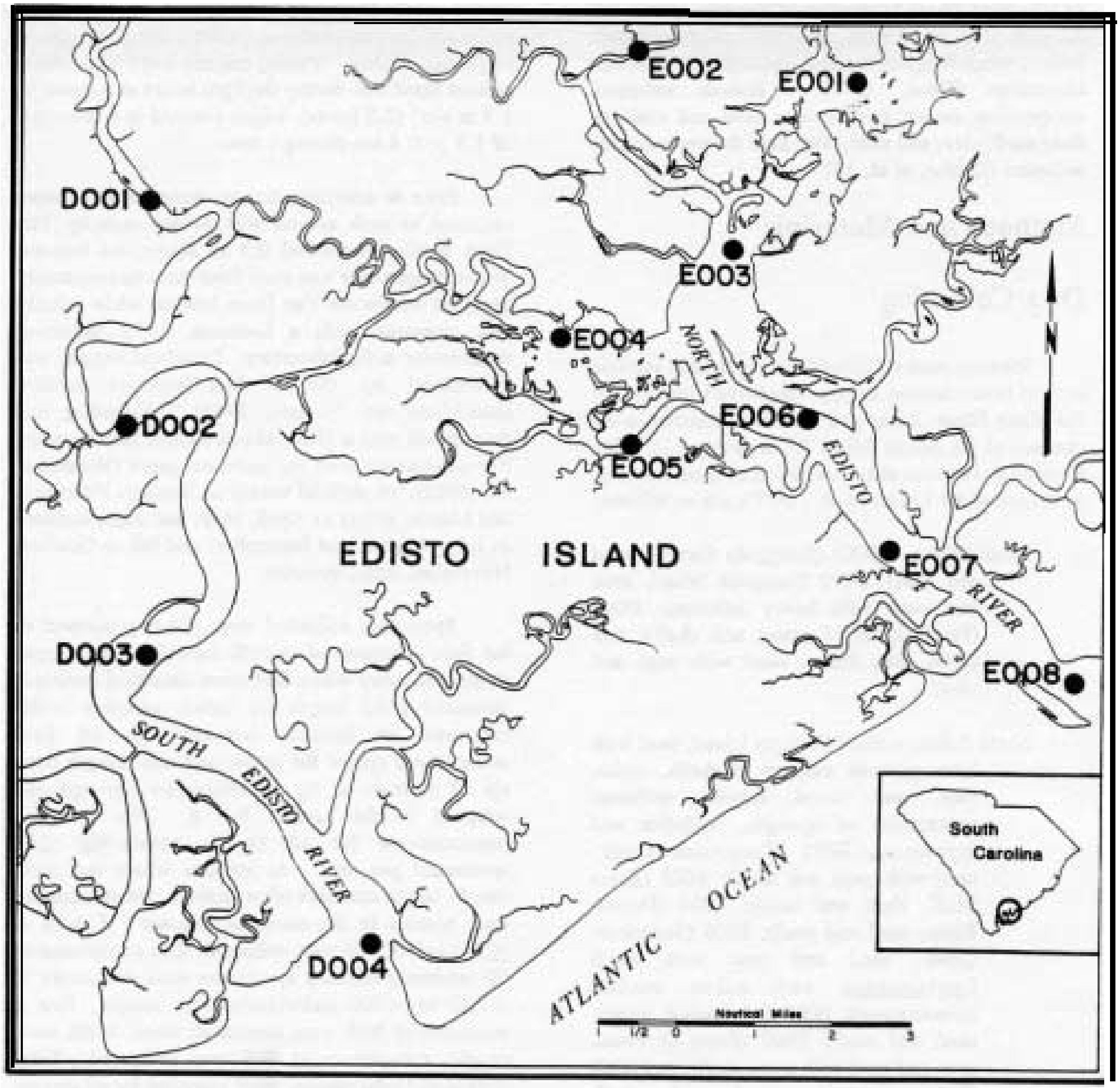


Figure 1. Location of fixed sampling locations in the North and South Edisto Rivers.

1975). Prior to calculation of similarity matrices, we eliminated species which occurred in only one or two collections taken during a sampling period and collections which contained only one species. In addition, data were logarithmically transformed by $\log_{10}(x + 1)$, where x is number of individuals for a given species, in order to emphasize less common species and decrease dominance of the matrix by extremely abundant species (Clifford and Stephenson, 1975).

Separate matrices were then constructed for each season and for each river on combined data from the two-year sampling period with site (collections) as individuals and species as attributes (normal analysis); and with species as individuals and sites as attributes (inverse analysis).

From symmetrical similarity matrices, individuals were classified into groups by means of an agglomerative hierarchical "intense" clustering strategy (Williams, 1971; Stephenson et al., 1972) using flexible sorting (Lance and Williams, 1967) with $\beta = -0.25$.

Two dendrograms were constructed for each river by season: one dendrogram indicated association of all collections by season during the two-year sampling period based on faunal content and another indicated association of all species collected each season during the 2-year sampling period based on collections of these species. We examined species group and station coincidences based on patterns of constancy and fidelity by nodal analysis (Williams and Lambert, 1961; Lambert and Williams, 1962).

We compared abundance of selected dominant species by calculating a mean of the transformed counts according to the expression (Elliott, 1977):

$$\frac{1}{n} \sum_{1}^{n} \log (x + 1)$$

where x = number of individuals of a given species and n = number of collections in a chosen time frame.

Biomass (kg/ha) and density (No./ha) estimates were determined for fishes and decapod crustaceans from computations of area swept by the 6-m trawl. Estimates of area swept (A) were determined by the following equation given by Klima (1976):

$$A = \frac{K \times M \times (0.6H)}{10{,}000 \text{ m}^2/\text{hectare}}$$

where K is speed in meters per hour, M is time in hours fished and H is headrope length in meters. The constant 0.6 denotes an effective swath of about 60% of the headrope length as determined by Roe (1967) and established by Wathne (1959). The area swept by our 6-m otter trawl was estimated to be 0.54 hectares/tow by this method.

Results

Hydrographic Variables

Observed annual bottom temperatures were similar for both years of study in the North and South Edisto Rivers (Figure 2). Seasonal temperatures were lowest in February 1973 and December 1974 in both rivers. Temperatures increased rather sharply in spring and reached a peak in August 1973 and July 1974 for the South Edisto and August-September 1973 and 1974 for the North Edisto.

Salinities were variable among seasons, and marked differences between bottom salinities at our stations were noticeable in the South Edisto only (Figure 3). Average bottom salinity in the North Edisto was highest for station E008 ($\bar{y}$ = 29.6‰) and lowest for station E001 ($\bar{y}$ = 21.9‰). Characterization of each station by the Venice System (Symposium on the Classification of Brackish Waters, 1958) yielded the following designations based on salinity extremes: E001 (14-29‰), E002 (12-28‰), E003 (16-31‰), E004 (13-29‰) and E005 (16-31‰) as meso-euhaline; E006 (18-30‰) as polyhaline; E007 (18-32‰) and E008 (22-34‰) as poly-euhaline. Bottom salinities for the North Edisto never went below 12‰ nor exceeded 33‰, confirming that bottom water of the North Edisto is meso-euhaline. Highest salinities for this river were encountered in fall and were lowest during winter and spring. Annual differences in salinity were slight for the North Edisto. In the South Edisto, salinities were more variable among stations. Station D004 had the highest salinity ($\bar{y}$ = 26.3‰) while salinities at D001 ($\bar{y}$ = .48‰) were lowest. South Edisto station D001 was characterized as limnetic-oligohaline based on extremes of 0.1-1‰; station D002 was limnetic-mesohaline (0.1-15‰); D003 was limnetic-polyhaline (10.5-30‰); and D004 was meso-euhaline (14-34‰). Bottom salinities were highest in the South

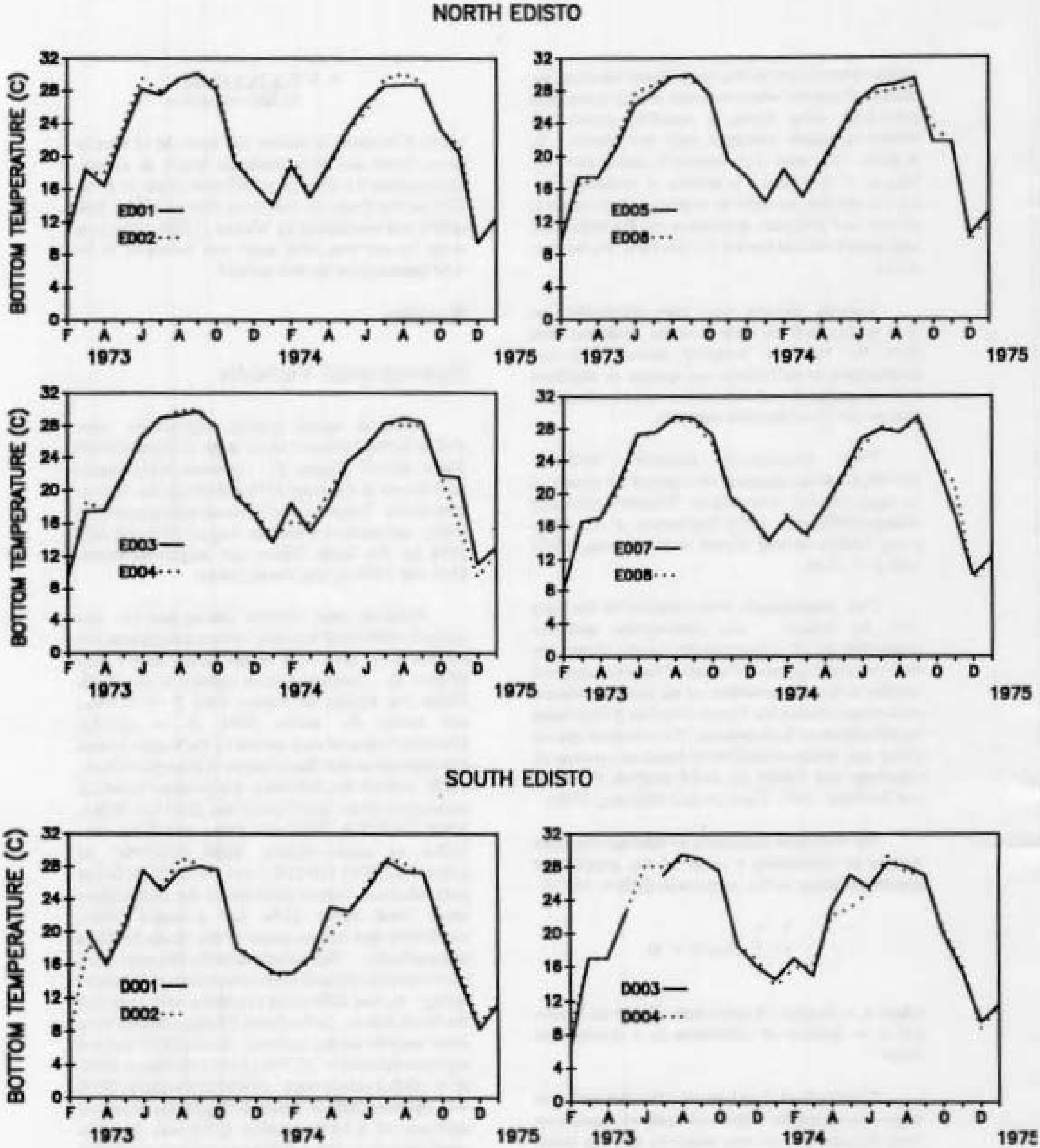
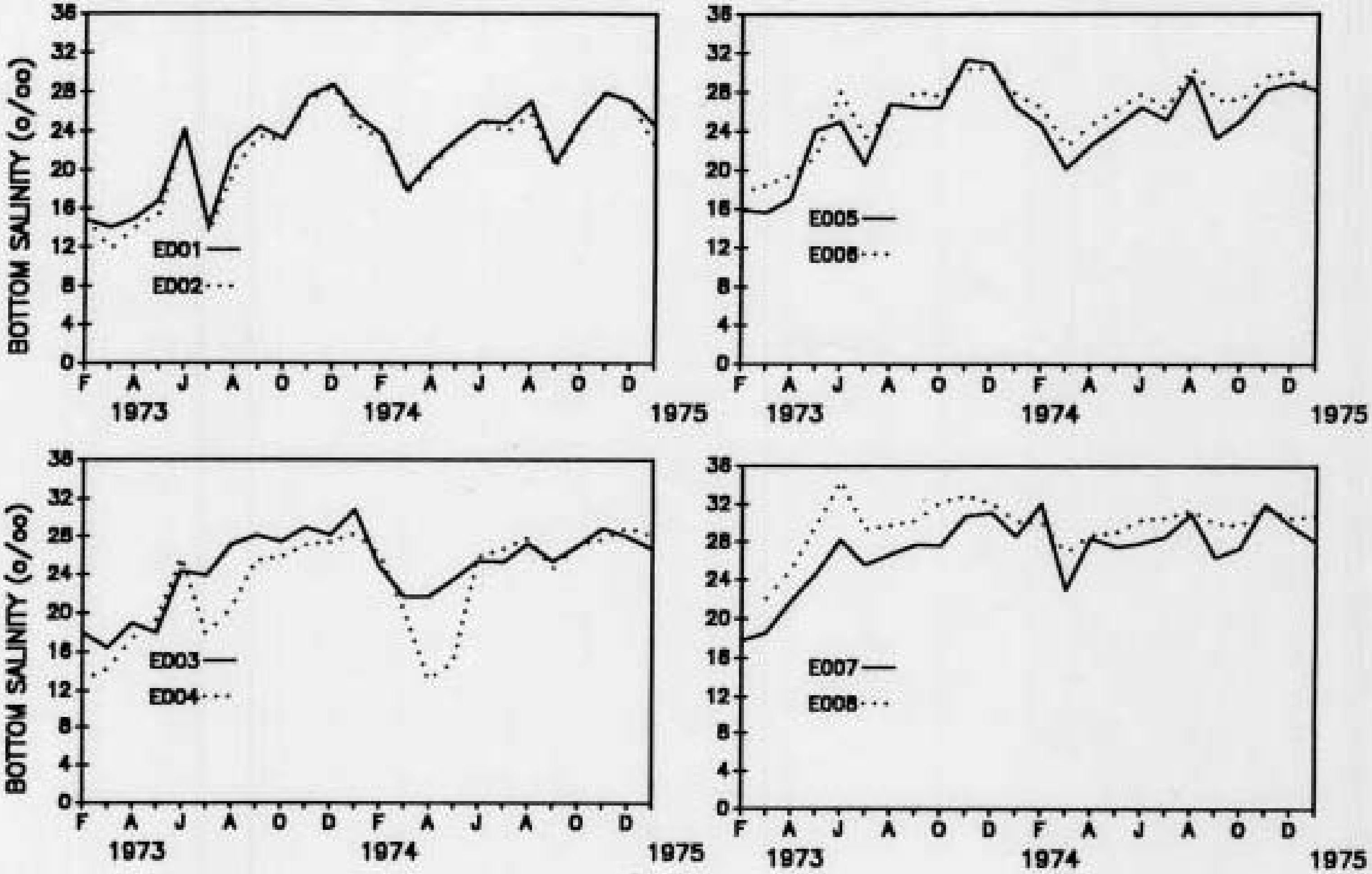


Figure 2. Average monthly water temperatures at stations sampled in the North and South Edisto Rivers.

NORTH EDISTO



SOUTH EDISTO

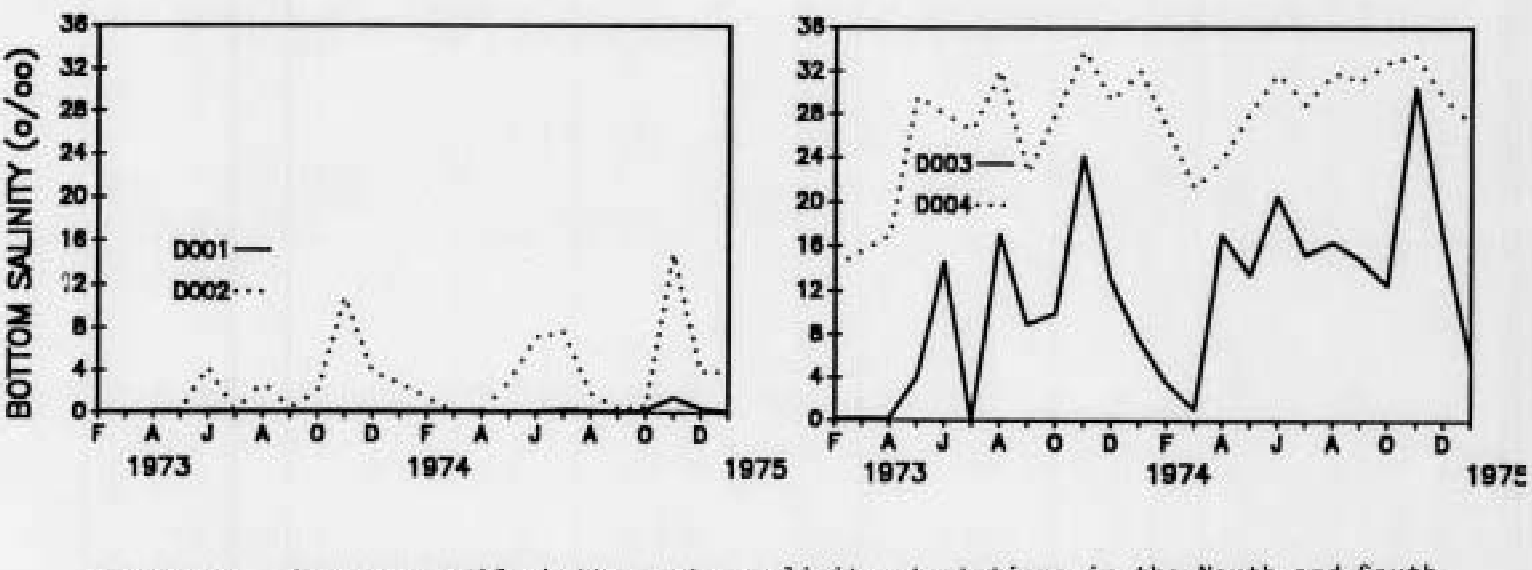


Figure 3. Average monthly bottom water salinity at stations in the North and South Edisto Rivers.

Edisto during winter and were lowest in summer with slight annual differences.

Dissolved oxygen concentrations in waters of the Edisto system were variable but never decreased to levels lower than 4.8 mg/liter. Dissolved oxygen levels were highest in winter and lowest during late summer. Depth of the channel where trawl collections were made ranged from 3-14 m in the North Edisto and 2.5-13 m in the South Edisto River.

Species Assemblages and Diversity

Eighty species of fish were collected from the North Edisto and 65 species from the South Edisto during the two-year sampling period (Tables 1 and 2). Length, salinity, and water temperature extremes, as well as relative abundance by station for all species collected are found in Appendix I. Ten species accounted for >90% of the total number of specimens and >70% of the total fish biomass collected in both rivers: Star drum (*Stellifer lanceolatus*), Atlantic croaker (*Micropogonias undulatus*), white catfish (*Ictalurus catus*), bay anchovy (*Anchoa mitchilli*), spot (*Leiostomus xanthurus*), Atlantic bumper (*Chloroscombrus chrysurus*), spotted hake (*Urophycis regia*), Atlantic menhaden (*Brevoortia tyrannus*), weakfish (*Cynoscion regalis*), and hogchoker (*Trinectes maculatus*). In both rivers, *Stellifer lanceolatus* was the most abundant demersal species, constituting ~65% and ~33% of the total catch by number for the North and South Edisto Rivers, respectively. *Stellifer* was also dominant in terms of biomass in the North Edisto but was outranked by *I. catus* in the South Edisto River.

A total of 38 decapod crustacean species was collected in the North Edisto River, while 30 species were taken from the South Edisto River (Tables 3 and 4). Not only was species richness of decapod crustaceans lower than that observed for fishes, but abundance and biomass were generally lower, with the only exception being a larger biomass for decapod crustaceans collected from the North Edisto River. The dominant decapod species in terms of abundance and biomass were white shrimp (*Penaeus setiferus*), brown shrimp (*Penaeus aztecus*), blue crab (*Callinectes sapidus*), and sea bob (*Xiphopenaeus kroyeri*). These species together comprised almost 94% by number and >97% by weight of the total decapod catch. *Penaeus setiferus* was by far the dominant decapod species collected from both rivers in terms of abundance and weight, and it maintained this dominance throughout the 2-year study period.

When the number of species collected each month was compared among stations, we found the North Edisto River supported the greatest number of species of fishes and decapod crustaceans in summer and fall (Figure 4). This pattern was especially evident at stations located upriver, whereas at station E008, richness was highest during spring and summer. In the South Edisto, the number of species present in the estuary tended to be greatest in summer and fall, although this pattern also varied depending upon station location. In both rivers, species richness of fishes and decapods was greatest at stations closest to the mouth, specifically at stations E006, E007, and E008 in the North Edisto and D004 in the South Edisto (Table 5).

The number of individuals collected followed a pattern similar to that of species richness, with abundance highest when more species were present in the river system (Figure 4). In the North Edisto, abundance of all species collected was greatest at stations in the upper to middle reaches of the river, whereas most individuals in the South Edisto were collected at stations near the mouth (Table 5).

Numerical classification analysis did not delineate collection (site) groups according to location along the salinity gradient. In the North Edisto system, considerable overlap occurred in classification of collections throughout the estuary, indicating that salinity was not a major factor affecting distribution of fishes and decapod crustaceans. In the South Edisto, site groups formed by normal cluster analysis were related more to location along the salinity gradient since collections made in upestuary, limnetic zones were faunistically least similar to those made at or near the river mouth. In order to compare seasonal species assemblages listed in Tables 6 and 7 with collections at fixed stations in the Edisto system, we constructed two-way coincidence tables for each season and cross-referenced species groups as defined by inverse cluster analysis with site groups consisting of collections made at each fixed station (Figures 5 and 6). This method intuitively appeared to facilitate more meaningful comparisons than the conventional nodal analysis which uses site groups as defined by normal classification.

In the North Edisto River, groups of stenohaline marine species were collected at station E008 nearest

TABLE 1. Total number and total weight of fishes collected from 1973 - January 1975 in the North Edisto River system. Species are listed in order of abundance and data are pooled over the two-year sampling period.

Species	Total Number	Percent Number	Total Weight	Percent Weight
Stellifer lanceolatus	39466	64.73	166.959	46.05
Anchoa mitchilli	8500	13.94	14.032	3.87
Leiostomus xanthurus	3852	6.32	34.339	9.47
Micropogonias undulatus	3587	5.88	37.661	10.39
Cynoscion regalis	1196	1.96	14.663	4.04
Urophycis regia	1196	1.47	8.212	2.27
Bairdiella chrysoura	822	1.35	13.909	3.84
Brevoortia tyrannus	427	0.70	7.126	1.97
Symphurus plagiusa	336	0.55	5.072	1.40
Menticirrhus americanus	282	0.46	5.017	1.38
Chaetodipterus faber	197	0.32	1.743	0.48
Trinectes maculatus	138	0.23	3.756	1.04
Ariopsis felis	137	0.22	13.674	3.77
Chloroscombrus chrysurus	129	0.21	0.604	0.17
Anchoa hepsetus	105	0.17	0.732	0.20
Trichiurus lepturus	78	0.13	3.646	1.01
Larimus fasciatus	75	0.12	0.600	0.17
Peprilus alepidotus	74	0.12	1.091	0.30
Alosa aestivalis	66	0.11	0.118	0.03
Hypsoblennius hentzi	63	0.10	0.598	0.16
Opisthonema oglinum	48	0.08	0.399	0.11
Opsanus tau	36	0.06	0.932	0.26
Bagre marinus	31	0.05	0.359	0.10
Pomatomus saltatrix	31	0.05	2.386	0.66
Selene setapinnis	29	0.05	0.155	0.04
Etropus crossotus	29	0.05	0.173	0.05
Peprilus triacanthus	27	0.04	0.185	0.05
Cynoscion nothus	23	0.04	0.891	0.25
Centropristis striata	23	0.04	0.462	0.13
Astroscopus y-graecum	21	0.03	0.147	0.04
Dorosoma petenense	18	0.03	0.102	0.03
Prionotus tribulus	16	0.03	0.033	0.01
Urophycis floridana	15	0.02	0.462	0.13
Alosa sapidissima	15	0.02	0.154	0.04
Urophycis earlli	13	0.02	0.305	0.08
Scophthalmus aquosus	13	0.02	0.107	0.03
Paralichthys dentatus	12	0.02	0.341	0.09
Scomberomorus maculatus	12	0.02	0.238	0.07
Paralichthys lethostigma	11	0.02	2.438	0.67
Selene vomer	11	0.02	0.094	0.03
Centropristis philadelphica	9	0.01	0.374	0.10
Gobiesox strumosus	9	0.01	0.064	0.02
Ancylopsetta quadrocellata	9	0.01	0.040	0.01
Caranx hippos	7	0.01	0.152	0.04
Ictalurus catus	5	0.01	0.485	0.13
Gymnura micrura	5	0.01	4.788	1.32
Dasyatis sabina	5	0.01	1.452	0.40
Chilomycterus schoepfi	5	0.01	0.110	0.03
Stephanolepis hispidus	4	0.01	0.005	<0.01
Prionotus carolinus	4	0.01	0.069	0.02
Cynoscion nebulosus	4	0.01	0.246	0.07
Lagodon rhomboides	4	0.01	0.099	0.03
Gobiosoma bosci	3	0.01	0.012	<0.01
Ophidion marginatum	3	<0.01	0.076	0.02
Menidia menidia	2	<0.01	0.005	<0.01
Raja eglanteria	2	<0.01	2.154	0.59
Acipenser oxyrhynchus	2	<0.01	1.780	0.49
Gobionellus hastatus	2	<0.01	0.041	0.01
Prionotus scitulus	2	<0.01	0.014	<0.01
Prionotus evolans	2	<0.01	0.021	0.01
Orthopristis chrysoptera	2	<0.01	0.088	0.02
Mugil curema	2	<0.01	0.021	0.01
Mugil cephalus	2	<0.01	0.043	0.01

Table 1 (continued)

Species	Total Number	Percent Number	Total Weight	Percent Weight
Eucinostomus argenteus	1	0.01	0.005	<0.01
Scorpaena brasiliensis	1	0.01	0.008	<0.01
Sphyraena guachancho	1	0.01	0.004	<0.01
Hypleurochilus geminatus	1	0.01	0.004	<0.01
Citharichthys spilopterus	1	0.01	0.010	<0.01
Prionotus sp.	1	0.01	0.002	<0.01
Ictalurus punctatus	1	0.01	0.281	0.08
Lepisosteus osseus	1	0.01	1.050	0.29
Anguilla rostrata	1	0.01	0.020	0.01
Rhinoptera bonasus	1	0.01	1.065	0.29
Synodus foetens	1	0.01	0.038	0.01
Caranx crysos	1	0.01	0.027	0.01
Syngnathus floridae	1	0.01	0.001	<0.01
Squalus acanthias	1	0.01	3.354	0.93
Sphyrna lewini	1	0.01	0.398	0.11
Rhizoprionodon terraenovae	1	0.01	0.117	0.03
Mustelus canis	1	0.01	0.127	0.04
	Σ= 60970		Σ= 362.556	

TABLE 2. Total number and total weight of fishes collected from 1973 - January 1975 in the South Edisto River system. Species are listed in order of abundance and data are pooled over the two-year sampling period.

Species	Total Number	Percent Number	Total Weight	Percent Weight
Stellifer lanceolatus	6537	32.88	28.663	14.14
Micropogonias undulatus	3932	19.78	24.669	12.17
Ictalurus catus	3029	15.23	59.025	29.11
Anchoa mitchilli	2229	11.21	4.148	2.05
Chloroscombrus chrysurus	575	2.89	3.635	1.79
Urophycis regia	571	2.87	6.270	3.09
Brevoortia tyrannus	526	2.65	11.019	5.43
Cynoscion regalis	469	2.36	8.338	4.11
Trinectes maculatus	449	2.26	2.090	1.03
Leiostomus xanthurus	302	1.52	3.042	1.50
Bairdiella chrysoura	274	1.38	4.121	2.03
Symphurus plagiusa	237	1.19	3.965	1.96
Ictalurus punctatus	154	0.77	4.792	2.36
Anchoa hepsetus	96	0.48	0.900	0.44
Menticirrhus americanus	90	0.45	1.031	0.51
Bagre marinus	62	0.31	0.230	0.11
Morone saxatilis	50	0.25	0.345	0.17
Ariopsis felis	48	0.24	2.726	1.34
Lepisosteus osseus	44	0.22	16.827	8.30
Alosa sapidissima	31	0.16	0.107	0.05
Larimus fasciatus	23	0.12	0.235	0.12
Alosa aestivalis	16	0.08	0.025	0.01
Acipenser oxyrhynchus	14	0.07	7.969	3.93
Selene setapinnis	11	0.06	0.026	0.01
Trichiurus lepturus	9	0.05	0.221	0.11
Paralichthys lethostigma	8	0.04	1.341	0.66
Scomberomorus maculatus	7	0.04	0.197	0.10
Citharichthys spilopterus	6	0.03	0.117	0.06
Selene vomer	6	0.03	0.022	0.01
Cynoscion nothus	6	0.03	0.129	0.06
Cynoscion nebulosus	6	0.03	0.146	0.07
Etropus crossotus	5	0.03	0.026	0.01
Peprilus triacanthus	5	0.03	0.213	0.11
Hypsoblennius hentzi	4	0.02	0.048	0.02
Opisthonema oglinum	4	0.02	0.117	0.06
Urophycis floridana	4	0.02	0.059	0.03
Menticirrhus littoralis	3	0.02	0.016	0.01
Pomatomus saltatrix	3	0.02	0.136	0.07
Stephanolepis hispidus	3	0.02	0.004	0.00
Ictalurus natalis	2	0.01	0.781	0.39
Prionotus sp.	2	0.01	0.025	0.01
Ancylopsetta quadrocellata	2	0.01	0.010	<0.01
Prionotus tribulus	2	0.01	0.002	<0.01
Paralichthys dentatus	2	0.01	0.114	0.06
Lutjanus griseus	2	0.01	0.018	0.01
Opsanus tau	2	0.01	0.063	0.03
Brevoortia smithi	2	0.01	0.564	0.28
Dasyatis sabina	2	0.01	3.766	1.86
Anguilla rostrata	1	0.01	0.077	0.04
Synodus foetens	1	0.01	0.008	<0.01
Urophycis earlli	1	0.01	0.007	<0.01
Eucinostomus argenteus	1	0.01	0.016	0.01
Orthopristis chrysoptera	1	0.01	0.027	0.01
Scophthalmus aquosus	1	0.01	0.010	<0.01
Gobionellus boleosoma	1	0.01	0.001	<0.01
Prionotus carolinus	1	0.01	0.009	<0.01
Peprilus alepidotus	1	0.01	0.028	<0.01
Gobiosoma ginsburgi	1	0.01	0.001	<0.01
Gobioides broussoneti	1	0.01	0.201	<0.01
Eucinostomus sp.	1	0.01	0.002	<0.01
Gobionellus shufeldti	1	0.01	0.002	<0.01
Dorosoma petenense	1	0.01	0.007	<0.01

Table 2 (continued)

Species	Total Number	Percent Number	Total Weight	Percent Weight
Ictalurus nebulosus	1	0.01	0.007	<0.01
Chilomycterus schoepfi	1	0.01	0.002	<0.01
Lagocephalus laevigatus	1	0.01	0.033	<0.02
	Σ= 19883		Σ= 202.771	

TABLE 3. Total number and total weight of decapod crustaceans collected from 1973 - January 1975 in the North Edisto River system. Species are listed in order of abundance and data are pooled over the two-year sampling period.

Species	Total Number	Percent Number	Total Weight	Percent Weight
Penaeus setiferus	28886	85.08	296.434	75.38
Penaeus aztecus	1787	5.26	15.851	4.03
Callinectes sapidus	1211	3.57	68.337	17.39
Callinectes similis	526	1.55	7.686	1.95
Trachypenaeus constrictus	396	1.17	0.372	0.09
Palaemonetes vulgaris	387	1.14	0.247	0.06
Lysmata wurdemanni	141	0.42	0.111	0.03
Portunus spinimanus	100	0.29	1.614	0.41
Pagurus longicarpus	94	0.28	0.040	0.01
Neopanope sayi	81	0.24	0.059	0.02
Portunus gibbesii	52	0.15	0.407	0.10
Ovalipes ocellatus	37	0.11	0.113	0.03
Penaeus duorarum	37	0.11	0.159	0.04
Panopeus herbstii	34	0.10	0.087	0.02
Libinia emarginata	30	0.09	1.082	0.28
Palaemonetes pugio	22	0.06	0.013	0.00
Pagurus pollicaris	19	0.06	0.102	0.03
Cancer irroratus	19	0.06	0.183	0.05
Alpheus heterochaelis	17	0.05	0.039	0.01
Libinia dubia	16	0.05	0.183	0.05
Palaemonetes intermedius	10	0.03	0.005	<0.01
Sicyonia laevigata	7	0.02	0.014	<0.01
Alpheus normanni	6	0.02	0.003	<0.01
Eurypanopeus depressus	5	0.01	0.003	<0.01
Hexapanopeus angustifrons	5	0.01	0.009	<0.01
Metoporhaphis calcarata	4	0.01	0.006	<0.01
Menippe mercenaria	3	0.01	0.033	0.01
Hepatus epheliticus	3	0.01	0.033	0.01
Clibanarius vittatus	3	0.01	0.003	<0.01
Sicyonia brevirostris	2	0.01	0.010	<0.01
Ovalipes stephensoni	2	0.01	0.002	<0.01
Panopeus occidentalis	2	0.01	0.002	<0.01
Rhithropanopeus harrisii	2	0.01	0.002	<0.01
Xiphopenaeus kroyeri	2	0.01	0.006	<0.01
Sicyonia dorsalis	1	<0.01	0.001	<0.01
Alpheus armillatus	1	<0.01	0.001	<0.01
Upogebia affinis	1	<0.01	0.004	<0.01
Synalpheus fritzmuelleri	1	<0.01	0.001	<0.01
	Σ= 33953		Σ= 393.253	

TABLE 4. Total number and total weight of decapod crustaceans collected from 1973 - January 1975 in the South Edisto River system. Species are listed in order of abundance and data are pooled over the two-year sampling period.

Species	Total Number	Percent Number	Total Weight	Percent Weight
Penaeus setiferus	8266	83.98	51.158	56.53
Penaeus aztecus	403	4.09	2.518	2.78
Callinectes sapidus	383	3.89	34.926	38.59
Xiphopenaeus kroyeri	212	2.15	0.263	0.29
Callinectes similis	193	1.96	1.149	1.27
Trachypenaeus constrictus	110	1.12	0.116	0.13
Palaemonetes pugio	75	0.76	0.042	0.05
Palaemonetes vulgaris	43	0.44	0.025	0.03
Rhithropanopeus harrisii	41	0.42	0.014	0.02
Ovalipes ocellatus	32	0.33	0.102	0.11
Ovalipes stephensoni	13	0.13	0.007	0.01
Pagurus longicarpus	13	0.13	0.011	0.01
Macrobrachium ohione	11	0.11	0.055	0.06
Portunus gibbesii	10	0.10	0.047	0.05
Libinia dubia	7	0.07	0.012	0.01
Panopeus herbstii	6	0.06	0.009	0.01
Palaemonetes intermedius	4	0.04	0.002	0.00
Penaeus duorarum	4	0.04	0.027	0.03
Hexapanopeus angustifrons	3	0.03	0.002	<0.01
Neopanope sayi	2	0.02	0.002	<0.01
Portunus spinimanus	2	0.02	0.003	<0.01
Pagurus pollicaris	2	0.02	0.004	<0.01
Lepidopa websteri	1	0.01	0.001	<0.01
Clibanarius vittatus	1	0.01	0.001	<0.01
Acetes americanus	1	0.01	0.001	<0.01
Lysmata wurdemanni	1	0.01	0.001	<0.01
Exhippolysmata oplophoroides	1	0.01	0.001	<0.01
Cancer irroratus	1	0.01	0.001	<0.01
Callinectes ornatus	1	0.01	0.002	<0.01
Libinia emarginata	1	0.01	0.003	<0.01
	Σ= 9843		Σ= 90.505	

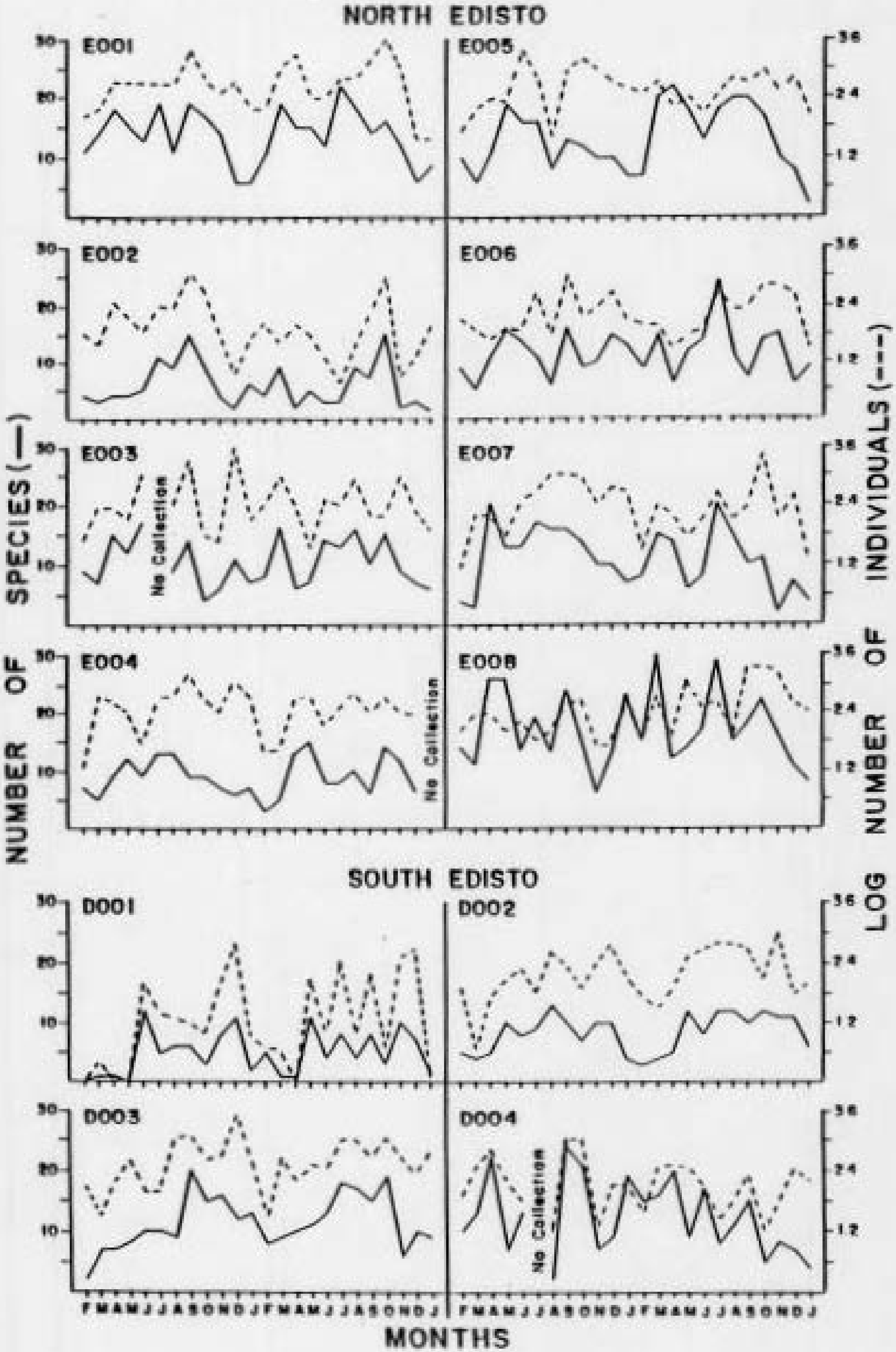


Figure 4. Number of species and individuals at stations in the North and South Edisto Rivers.

TABLE 5. Total number of individuals and species of fishes and decapod crustaceans collected at otter trawl sampling locations in the North and South Edisto Rivers, S.C. from 1973 until 1974 (January 1975 inclusive).

Sampling Site	No. of Individuals		No. of Species		No. of Collections
	Fishes	Decapods	Fishes	Decapods	
1973					
North Edisto					
E001	5178	2248	33	16	12
E002	1136	2254	20	9	12
E003	7753	934	30	11	12
E004	2565	5009	24	10	12
E005	6824	1749	28	14	12
E006	1491	1596	23	10	12
E007	1872	3863	36	15	12
E008	1775	674	35	27	12
South Edisto					
D001	1042	19	17	8	12
D002	1584	759	17	6	12
D003	4185	4215	28	10	12
D004	3238	408	35	19	11
1974					
North Edisto					
E001	10,829	1803	27	18	12
E002	606	1182	23	9	12
E003	3676	764	26	15	12
E004	1557	2181	24	9	12
E005	3210	2123	32	15	12
E006	2300	1015	36	16	12
E007	1188	5610	25	13	12
E008	9011	947	38	27	12
South Edisto					
D001	1423	21	16	7	12
D002	2244	2088	19	10	12
D003	4796	1606	22	11	12
D004	1372	727	31	16	12

TABLE 6. Groups formed from seasonal cluster analyses of fish and decapod crustacean species collected in the North Edisto River from 1973 - January 1975.

WINTER

Group A

- *Libinia emarginata*
- *Cancer irroratus*
- *Gobiesox strumosus*
- *Urophycis floridana*
- *Hypsoblennius hentzi*
- *Trachypenaeus constrictus*
- *Portunus spinimanus*
- *Lysmata wurdemanni*
- *Opsanus tau*
- *Centropristis striata*

Group B

- *Brevoortia tyrannus*
- *Dorosoma petenense*
- *Alosa sapidissima*
- *Pagurus longicarpus*

Group C

- *Paralichthys dentatus*
- *Cynoscion regalis*
- *Portunus gibbesii*
- *Libinia dubia*
- *Palaemonetes intermedius*

Group D

- *Panopeus herbstii*
- *Neopanope sayi*
- *Palaemonetes vulgaris*

Group E

- *Palaemonetes pugio*
- *Scophthalmus aquosus*
- *Bairdiella chrysoura*
- *Paralichthys lethostigma*
- *Micropogonias undulatus*
- *Penaeus aztecus*

SPRING

Group A

- *Portunus gibbesii*
- *Lysmata wurdemanni*
- *Neopanope sayi*
- *Portunus spinimanus*
- *Bairdiella chrysoura*
- *Centropristis striata*
- *Urophycis floridana*
- *Ovalipes ocellatus*
- *Pagurus longicarpus*
- *Panopeus herbstii*
- *Pagurus pollicaris*

Group B

- *Anchoa hepsetus*
- *Peprilus triacanthus*
- *Trinectes maculatus*
- *Cynoscion regalis*
- *Trichiurus lepturus*
- *Cynoscion nothus*
- *Hypsoblennius hentzi*
- *Pomatomus saltatrix*

Group C

- *Gobiosoma bosci*
- *Palaemonetes pugio*
- *Alpheus heterochaelis*
- *Opsanus tau*
- *Penaeus duorarum*

Group D

- *Scophthalmus aquosus*
- *Ancylopsetta quadrocellata*
- *Prionotus tribulus*
- *Brevoortia tyrannus*
- *Menticirrhus americanus*
- *Scomberomorus maculatus*
- *Paralichthys dentatus*

SUMMER

Group A

- *Centropristis striata*
- *Lysmata wurdemanni*
- *Lagodon rhomboides*
- *Hypsoblennius hentzi*
- *Neopanope sayi*
- *Libinia dubia*
- *Pagurus pollicaris*
- *Portunus spinimanus*
- *Portunus gibbesii*
- *Pagurus longicarpus*

Group B

- *Bairdiella chrysoura*
- *Palaemonetes vulgaris*
- *Ariopsis felis*
- *Trinectes maculatus*
- *Symphurus plagiusa*
- *Chaetodipterus faber*
- *Stellifer lanceolatus*
- *Penaeus setiferus*
- *Menticirrhus americanus*
- *Trachypenaeus constrictus*
- *Callinectes similis*
- *Micropogonias undulatus*
- *Cynoscion regalis*
- *Anchoa mitchilli*
- *Leiostomus xanthurus*
- *Callinectes sapidus*
- *Penaeus aztecus*

Group C

- *Selene setapinnis*
- *Selene vomer*
- *Anchoa hepsetus*
- *Chloroscombrus chrysurus*
- *Peprilus alepidotus*

FALL

Group A

- *Anchoa mitchilli*
- *Penaeus setiferus*
- *Stellifer lanceolatus*
- *Cynoscion regalis*
- *Bairdiella chrysoura*
- *Callinectes sapidus*

Group B

- *Menticirrhus americanus*
- *Symphurus plagiusa*
- *Trachypenaeus constrictus*
- *Callinectes similis*
- *Chaetodipterus faber*
- *Micropogonias undulatus*
- *Trinectes maculatus*
- *Leiostomus xanthurus*
- *Larimus fasciatus*

Group C

- *Pagurus longicarpus*
- *Astroscopus y-graecum*

Group D

- *Ariopsis felis*
- *Etropus crossotus*
- *Bagre marinus*
- *Chloroscombrus chrysurus*
- *Anchoa hepsetus*
- *Penaeus duorarum*
- *Opsanus tau*

Group E

- *Panopeus herbstii*
- *Portunus gibbesii*
- *Portunus spinimanus*
- *Lysmata wurdemanni*

Table 6 (continued)

Group F	Group E	Group D	Group F
Urophycis regia	*Urophycis regia*	*Opisthonema oglinum*	*Peprilus alepidotus*
Stellifer lanceolatus	*Symphurus plagiusa*	*Bagre marinus*	*Opisthonema oglinum*
Anchoa mitchilli	*Palaemonetes vulgaris*	*Etropus crossotus*	*Libinia emarginata*
Penaeus setiferus	*Micropogonias undulatus*	*Pomatomus saltatrix*	*Alpheus heterochaelis*
Callinectes sapidus	*Leiostomus xanthurus*		*Palaemonetes vulgaris*
	Anchoa mitchilli	Group E	*Stephanolepis hispidus*
Group G	*Penaeus setiferus*		
	Stellifer lanceolatus	*Penaeus duorarum*	
Symphurus plagiusa	*Callinectes sapidus*	*Opsanus tau*	
Leiostomus xanthurus	*Trachypenaeus constrictus*	*Panopeus herbstii*	
Callinectes similis	*Callinectes similis*	*Scomberomorus maculatus*	
Menticirrhus americanus	*Penaeus aztecus*	*Palaemonetes pugio*	
Trinectes maculatus	*Ariopsis felis*		
Astroscopus y-graecum		Group F	
Etropus crossotus			
Ancylopsetta quadrocellata		*Libinia emarginata*	
Ovalipes ocellatus		*Trichiurus lepturus*	
		Dasyatis sabina	
		Gymnura micrura	
		Larimus fasciatus	

TABLE 7. Groups formed from seasonal cluster analyses of fish and decapod crustacean species collected in the South Edisto River, 1973 - January 1975.

	WINTER	SPRING	SUMMER	FALL
Group A	Trachypenaeus constrictus Leiostomus xanthurus Callinectes sapidus Callinectes similis Symphurus plagiusa Urophycis regia Ovalipes ocellatus Cynoscion regalis	Callinectes similis Trachypenaeus constrictus Urophycis regia Urophycis earlii Trichiurus lepturus	Stellifer lanceolatus Cynoscion regalis Micropogonias undulatus Penaeus setiferus Anchoa mitchilli Leiostomus xanthurus Callinectes sapidus Menticirrhus americanus Bagre marinus Bairdiella chrysoura Symphurus plagiusa	Penaeus setiferus Stellifer lanceolatus Micropogonias undulatus Anchoa mitchilli Callinectes sapidus Cynoscion regalis Symphurus plagiusa Bairdiella chrysoura Xiphopenaeus kroyeri
Group B	Penaeus setiferus Stellifer lanceolatus Brevoortia tyrannus Anchoa mitchilli	Penaeus aztecus Cynoscion regalis Brevoortia tyrannus Paralichthys lethostigma	Ariopsis felis Palaemonetes vulgaris Penaeus aztecus Callinectes similis Trachypenaeus constrictus	Palaemonetes vulgaris Brevoortia tyrannus Hypsoblennius hentzi
Group C	Alosa sapidissima Palaemonetes vulgaris	Anchoa mitchilli Leiostomus xanthurus Micropogonias undulatus Callinectes sapidus Symphurus plagiusa Penaeus setiferus Stellifer lanceolatus	Anchoa hepsetus Larimus fasciatus Chloroscombrus chrysurus Selene setapinnis Selene vomer Brevoortia tyrannus Pagurus longicarpus	Callinectes similis Ariopsis felis Leiostomus xanthurus Chloroscombrus chrysurus Trachypenaeus constrictus Larimus fasciatus Anchoa mitchilli
Group D	Ictalurus catus Micropogonias undulatus Trinectes maculatus Rhithropanopeus harrisii	Palaemonetes vulgaris Ariopsis felis	Morone saxatilis Alosa sapidissima	Alosa sapidissima Acipenser oxyrhynchus
Group E		Macrobrachium ohione Lepisosteus osseus Trinectes maculatus Ictalurus catus Palaemontes pugio	Palaemonetes pugio Ictalurus catus Trinectes maculatus Rhithropanopeus harrisii Acipenser oxyrhynchus Lepisosteus osseus	Trinectes maculatus Ictalurus punctatus Ictalurus catus Morone saxatilis Palaemonetes pugio Lepisosteus osseus

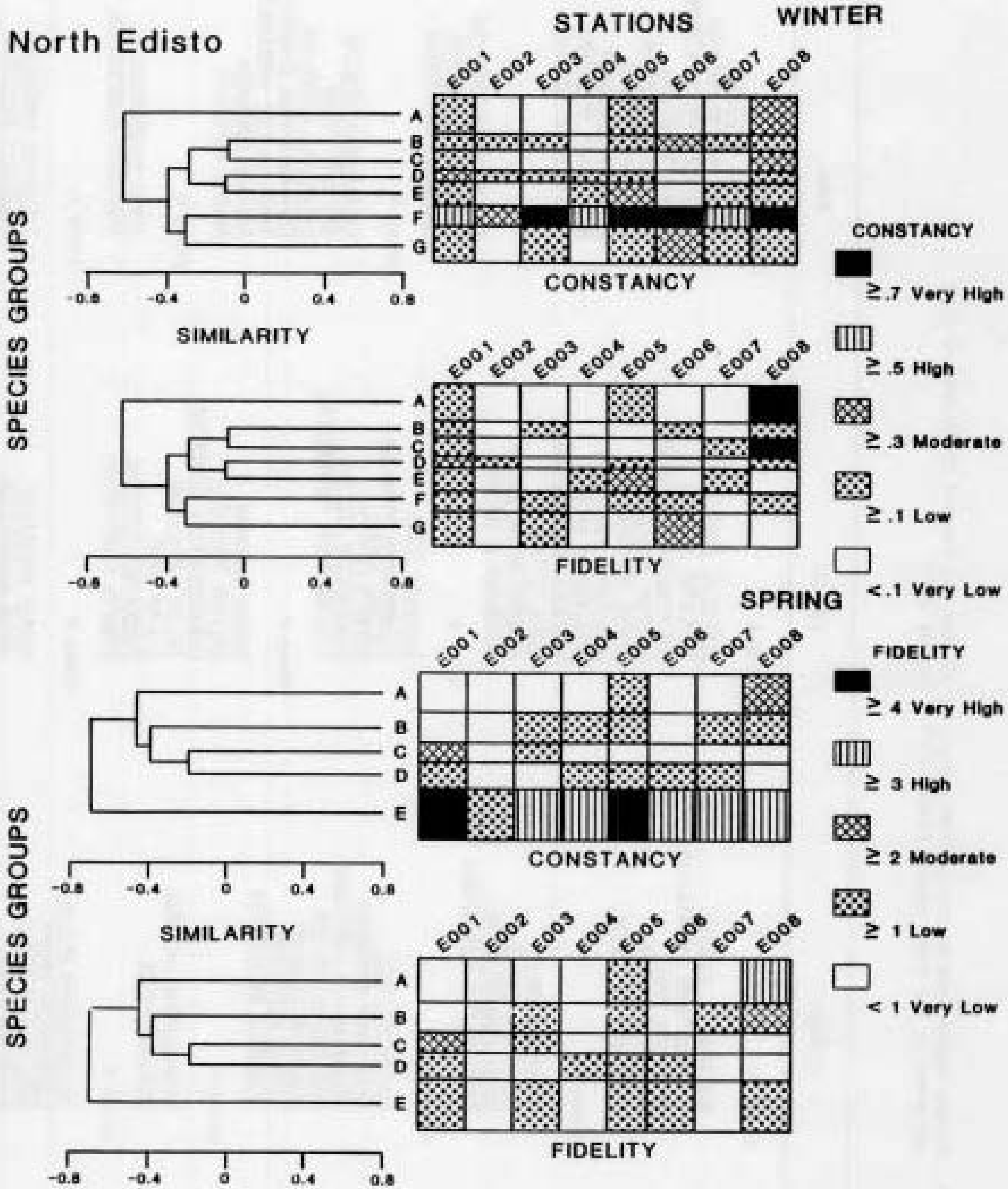
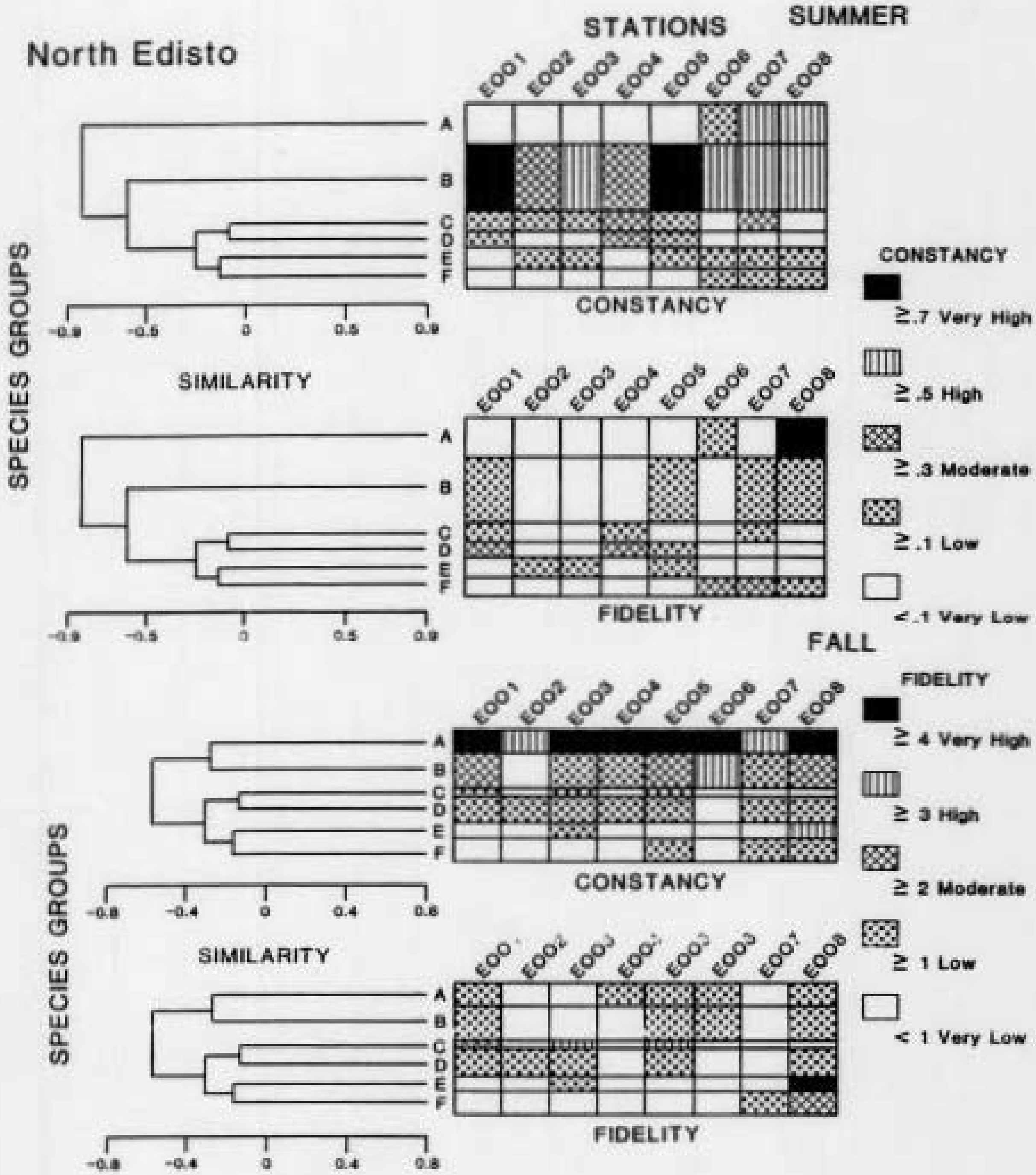


Figure 5. Two-way coincidence tables of constancy and fidelity which compare seasonal species assemblages as defined by cluster analysis with seasonal collections from fixed stations in the North Edisto River. Species comprising the alphabetically-labelled groups are listed in Table 7.


North Edisto
STATIONS
SUMMER
FALL
SPECIES GROUPS
SIMILARITY
CONSTANCY
FIDELITY
EO01 EO02 EO03 EO04 EO05 EO06 EO07 EO08
A B C D E F
-0.9 -0.5 0 0.5 0.9
-0.8 -0.4 0 0.4 0.8
CONSTANCY
≥.7 Very High
≥.5 High
≥.3 Moderate
≥.1 Low
<.1 Very Low
FIDELITY
≥ 4 Very High
≥ 3 High
≥ 2 Moderate
≥ 1 Low
< 1 Very Low

the mouth. Species restricted to this station included those forming groups A and C in winter; group A in fall and summer; and group E in fall (Figure 5). These species were also consistently collected at this station during these seasons. Station E008 was characterized by an epifaunal community dominated by Leptogorgia, hydroids, and bryozoans (Calder, et al., 1977). Species such as *Gobiesox strumosus*, *Hypsoblennius hentzi*, *Lysmata wurdemanni*, and *Centropristis striata* which formed assemblages found at E008 are frequently associated with high salinities as well as shelly bottom and epifaunal organisms. Therefore, in the absence of a distinct salinity gradient, their faithfulness to this particular station in the North Edisto possibly reflected a preference for hard or "live" bottom found at this station rather than salinity per se.

The numerically dominant species formed assemblages which displayed high constancy but low fidelity to collections from most stations in the North Edisto. In winter, species such as *Stellifer lanceolatus*, *Anchoa mitchilli*, *Penaeus setiferus*, and *Callinectes sapidus* formed species group F and were highly consistent in collections at stations throughout the river, except for those at station E002 (Figure 5). In spring, these same species and others formed group E and displayed a similar pattern of constancy and fidelity. In summer, the numerical dominants of group B were highly constant in collections throughout the river, except for those at stations E002 and E004. In fall, group A species were highly consistent in collections from every station, indicating their ubiquity and importance throughout the North Edisto. It is noteworthy that during all seasons, the dominant species displayed high or very high constancy for collections made at stations E005 and E001. In addition to catches of fishes and decapod crustaceans, collections at these stations yielded large amounts of Leptogorgia, sponges, and bryozoans. The sessile invertebrate community present at these stations probably supports large numbers of prey items which may attract and concentrate mobile megafauna such as fishes and decapods at these sites.

Other species groups formed by inverse cluster analysis generally were not consistently collected or restricted to collections made at stations in the North Edisto. Most of the species comprising these groups were either regular or transient inhabitants of the river but were not frequently encountered or restricted to collections from a particular area of the river.

Species assemblages identified by cluster analysis did not maintain their integrity throughout the year but were seasonal for the most part. For example, when we compared affinity of frequently-encountered species for the same species group during all seasons, we found that only a few year-round associations were formed and included *Symphurus plagiusa* with *Leiostomus xanthurus* and both species with *Trachypenaeus constrictus; Stellifer lanceolatus*, *Penaeus setiferus*, and *Anchoa mitchilli* with *Callinectes sapidus; Penaeus setiferus* with *Anchoa mitchilli* and both species with *Stellifer lanceolatus* (Figure 6). Other species formed associations during only one season, e.g. *Peprilus triacanthus*, *Pomatomus saltatrix*, *Trichiurus lepturus*, and *Prionotus tribulus* were included in species assemblages formed by inverse cluster analysis only during spring.

In the South Edisto River station D004, located adjacent to open coastal waters, was characterized by both numerically-dominant transient estuarine species as well as rarer stenohaline marine species (Figure 7). In winter, species in groups A and B displayed high to very high constancy for collections made at this station. Species in group B (*Penaeus setiferus*, *Stellifer lanceolatus*, *Brevoortia tyrannus*, and *Anchoa mitchilli*) were numerically dominant in the South Edisto while group A contained numerical dominants such as *Callinectes sapidus*, *Urophycis regia*, and *Cynoscion regalis* as well as other less abundant species. We noted a similar pattern for spring, when rarer species comprising group A and numerically-dominant species of group C were consistently represented in collections at station D004. In summer, species groups displayed only moderate constancy and fidelity for station D004, whereas in fall, species in group A were consistently collected at this station.

Stations D003 and D002, which were under more freshwater influence than station D004, were characterized during all seasons by multiple species assemblages but predominantly those consisting of numerically-dominant species. Species groups displaying very high constancy for one or both of these stations included group D in winter which was comprised of euryhaline species; group C in spring; and group A in summer and fall.

Estuarine endemic and transient species formed assemblages found at station D001 which fluctuated between oligohaline and limnetic salinity conditions.

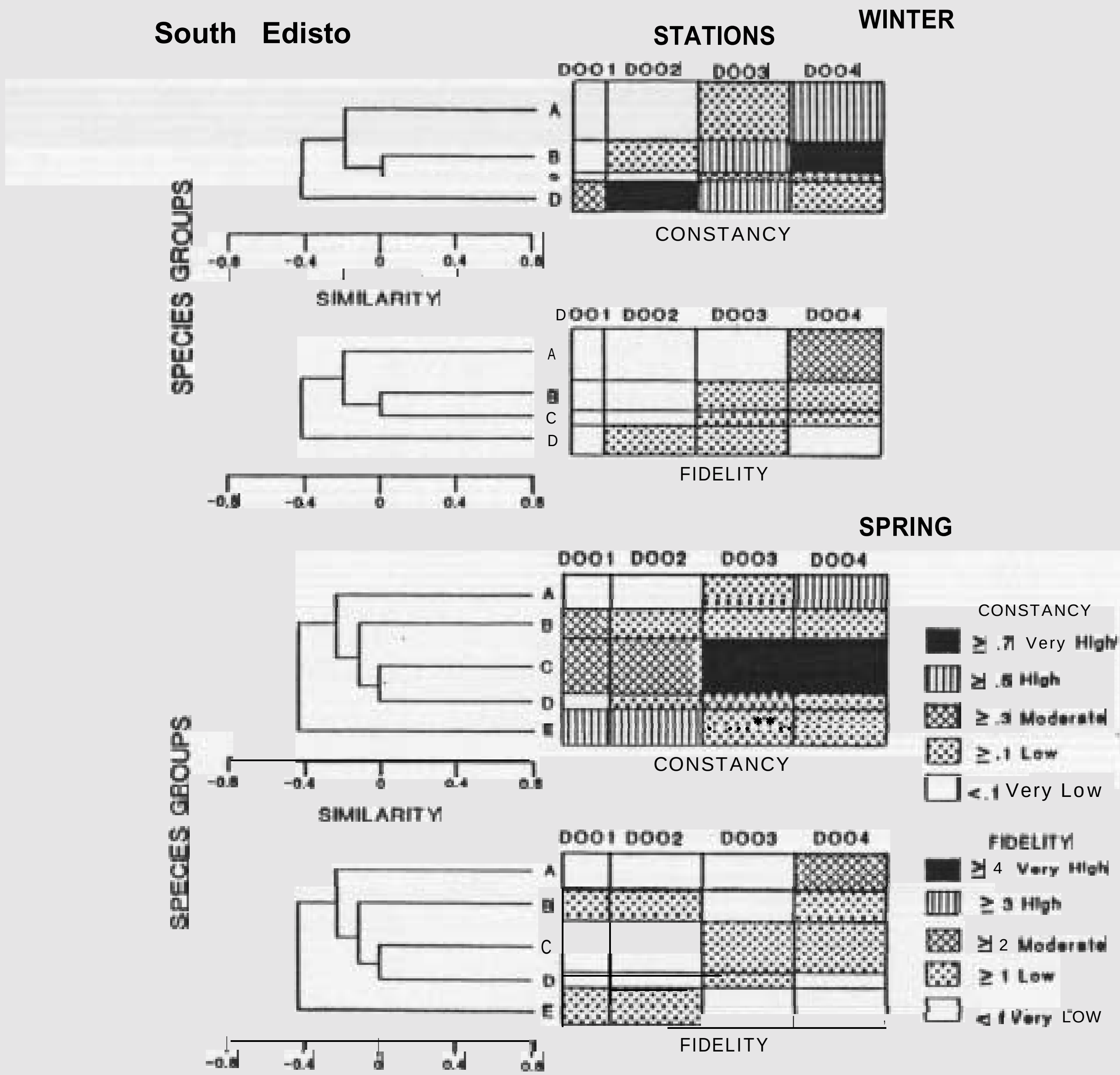
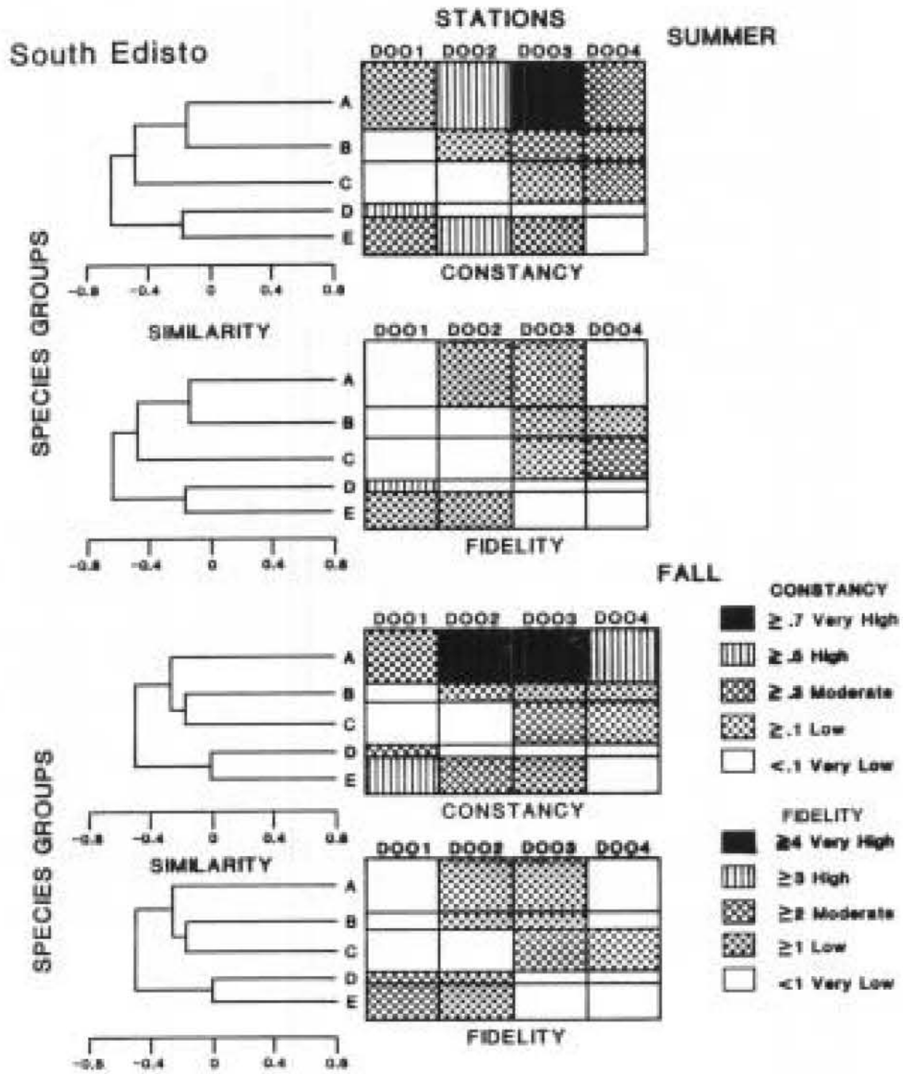


Figure 6. Two-way coincidence tables of constancy and fidelity which compare seasonal species assemblages as defined by cluster analysis with collections from fixed stations in the South Edisto River. Species comprising the alphabetically-labelled groups are listed in Table 7.


South Edisto
STATIONS
SUMMER
DOO1 DOO2 DOO3 DOO4
A
B
C
D
E
CONSTANCY
-0.8 -0.4 0 0.4 0.8
SIMILARITY
SPECIES GROUPS
FIDELITY
FALL
CONSTANCY
≥ .7 Very High
≥ .5 High
≥ .3 Moderate
≥ .1 Low
<.1 Very Low
FIDELITY
≥4 Very High
≥3 High
≥2 Moderate
≥1 Low
<1 Very Low

	Penaeus aztecus	Callinectes similis	Trachypenaeus constrictus	Callinectes sapidus	Stellifer lanceolatus	Penaeus setiferus	Anchoa mitchilli	Leiostomus xanthurus	Micropogonias undulatus	Palaemonetes vulgaris	Symphurus plagiusa	Urophycis regia	Paralichthys dentatus	Scomberomorus maculatus	Menticirrhus americanus	Brevoortia tyrannus	Prionotus tribulus	Ancylopsetta quadrocellata	Scophthalmus aquosus	Penaeus duorarum	Opsanus tau	Palaemonetes pugio	Pomatomus saltatrix	Trichiurus lepturus	Cynoscion regalis	Trinectes maculatus	Peprilus triacanthus	Anchoa hepsetus	Panopeus herbstii	Pagurus longicarpus	Ovalipes ocellatus	Centropristis striata	Bairdiella chrysoura	Neopanope sayi	Lysmata wurdemanni	Portunus gibbesi
Portunus gibbesi													1												1				10	8	2	8	2	8	9	
Lysmata wurdemanni			1																		1								10	8	2	8	2	8		
Neopanope sayi										1																			1	8	2	8	2			
Bairdiella chrysoura	7	3	3	11	11	11	11	3	7	3	3				3				1			1			11	3			2	2	2	2				
Centropristis striata			1																		1								2	8	2					
Ovalipes ocellatus		1						1			1				1			1								1			2	2						
Pagurus longicarpus																1													2							
Panopeus herbstii								1		1				3						3	3	3														
Anchoa hepsetus																				4	4		2	2	2	2	2									
Peprilus triacanthus																							2	2	2	2										
Trinectes maculatus	3	12	11	3	3	3	3	12	11	3	12				1			1					2	2	8											
Cynoscion regalis	3	3	3	11	11	11	11	11	11	3	3		1		3								2	2												
Trichiurus lepturus																							2													
Pomatomus saltatrix																																				
Palaemonetes pugio	1								1						2				1	8	8															
Opsanus tau			1												3					9																
Penaeus duorarum															3																					
Scophthalmus aquosus	1								1				2	2	2	2	2	2																		
Ancylopsetta quadrocellata		1						1			1		2	2	5	2	2																			
Prionotus tribulus													2	2	2	2																				
Brevoortia tyrannus													2	2	2																					
Menticirrhus americanus	3	12	11	3	3	3	3	12	11	3	12		2	2																						
Scomberomorus maculatus													2																							
Paralichthys dentatus																																				
Urophycis regia	2	2	2	5	5	5	5	2	2	2	2																									
Symphurus plagiusa	8	14	9	8	8	8	8	14	9	8																										
Palaemonetes vulgaris	8	8	8	8	8	8	8	8	8																											
Micropogonias undulatus	6	9	9	8	8	6	8	9																												
Leiostomus xanthurus	8	14	9	8	8	8	8																													
Anchoa mitchilli	8	8	8	14	14	14																														
Penaeus setiferus	8	8	8	14	14																															
Stellifer lanceolatus	8	8	8	14																																
Callinectes sapidus	8	8	8																																	
Trachypenaeus constrictus	8	9																																		
Callinectes similis	8																																			
Penaeus aztecus																																				

Winter	1
Spring	2
Summer	3
Fall	4
Winter/Spring	5
Winter/Spring/Summer	6
Summer/Winter	7
Spring/Summer	8
Spring/Summer/Fall	9
Spring/Fall	10
Summer/Fall	11
Summer/Fall/Winter	12
Winter/Fall	13
All Seasons	14

Figure 7. Matrix showing co-occurrences of species within the same species groups resulting from cluster analysis of: winter, spring, summer, and fall data collected from the North Edisto River. This matrix includes only those species which occurred during two or more seasons.

Species in group E in fall and spring and in group D in summer were highly constant but not restricted to collections from this upestuary station. Estuarine endemic species found at this station included *Macrobrachium ohione*, *Lepisosteus osseus*, *Ictalurus punctatus*, *Ictalurus catus*, and *Palaemonetes pugio*.

In the South Edisto, the only year-round associations we observed were *Anchoa mitchilli* and *Penaeus setiferus* with *Stellifer lanceolatus*; *Callinectes sapidus* with *Symphurus plagiusa*; *Trachypenaeus constrictus* with *Callinectes similis* and *Trinectes maculatus* with *Ictalurus catus* (Figure 8). All other species associations indicated by cluster analysis were seasonally variable. Species which occurred during one season (summer) only included *Bagre marinus*, *Selene vomer*, *Selene setapinnis* and *Pagurus longicarpus*.

Temporal and Spatial Distributions

The distribution of the ten dominant species for both the North and South Edisto Rivers varied by season and station (Figures 9 and 10).

The star drum, *Stellifer lanceolatus*, was collected at stations throughout the North Edisto River, although abundance was greatest at station E001 from March through November. Star drum were less abundant in the South Edisto River and were collected only at stations D002, D003, and D004. Although star drum were present in the South Edisto throughout the year, they were most abundant at our trawl stations from September through December. We observed no large discrepancy in catches of *S. lanceolatus* between the two annual cycles, although catches were slightly less during the first year of study in both river systems (Table 8). Length-frequency polygons (not shown) which were drawn for each species and are available from the authors, indicated that star drum ≤ 80 mm were present in the Edisto system throughout the year. The greatest number of small fish (60-70 mm modal length) were present during summer and fall in the North Edisto and during fall in the South Edisto, suggesting peaks in recruitment during those seasons. Larger fish (≥ 100 mm) which were most abundant in the estuary during spring and summer, had decreased in abundance for collections made during fall. These data may reflect migration of larger one-year-old fish from the estuary to nearshore coastal waters or avoidance by larger fish of the 6-m trawl by larger fish.

Micropogonias undulatus, the Atlantic croaker, was a numerically-dominant species in both rivers, although its abundance was greatest in the South Edisto River. Atlantic croaker were collected at all of our stations but those located in the mid-to-lower reaches of both rivers yielded the most fish (Figures 9 and 10). Abundance was greatest in both rivers during spring and summer. Differences among annual catches were slight for the South Edisto, whereas fewer individuals were caught in the North Edisto during the second year of study. Length-frequency distributions indicated that small croaker (<40 mm) were most abundant in the South Edisto River during fall and winter, suggesting recruitment at that time. By summer, no croakers <50 mm were collected in either river and modal size had increased to 90 mm in the South Edisto and 100-120 mm in the North Edisto. Larger fish (110-190 mm), which probably were one-year-old (Shealy et al., 1974), were present in low numbers during all seasons. Their scarcity is probably due to avoidance of the 6-m trawl. Decreased numbers of yearling croakers during late summer and early fall in South Carolina has been attributed to migration from the estuary (Bearden, 1964). In the Edisto system, we collected more yearling fish during these seasons, but they occurred at stations nearest the mouths of both rivers. Whether these fish were ready to migrate or would overwinter in the high-salinity waters of the estuary is not known.

Anchoa mitchilli, the bay anchovy, was ubiquitous in the Edisto system. This fish was most abundant at station D004 in the South Edisto and station E004 in the North Edisto (Figures 9 and 10). Monthly fluctuations in abundance indicated little, if any, seasonality associated with catches of bay anchovy. In addition, catches did not appreciably differ between annual cycles, although more fish were collected during the first year of our study. Modal lengths for *A. mitchilli* were in the 50-60 mm range in the North Edisto during all seasons. The few bay anchovies we collected which exceeded 100 mm were collected only in spring. In the South Edisto, *A. mitchilli* <40 mm were predominant in summer and fall. Because peak spawning in the Carolinas occurs during the summer (Kuntz, 1914), these smaller individuals are probably young-of-the-year recruits.

The remaining species of fish which were numerically dominant in the Edisto system were abundant in either the North or South Edisto but not

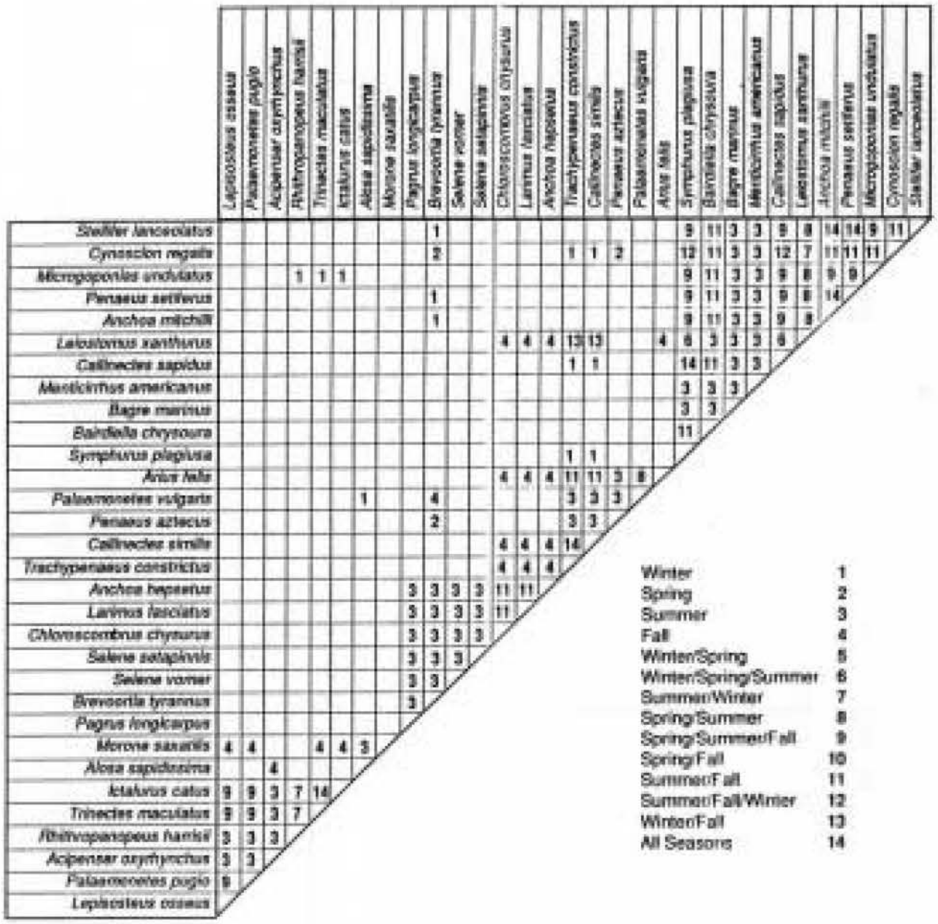


Figure 8. Same as Figure 7, except that co-occurrence of species is noted within the same species groups resulting from cluster analysis of data collected from the South Edisto River.

North Edisto 1973-1974

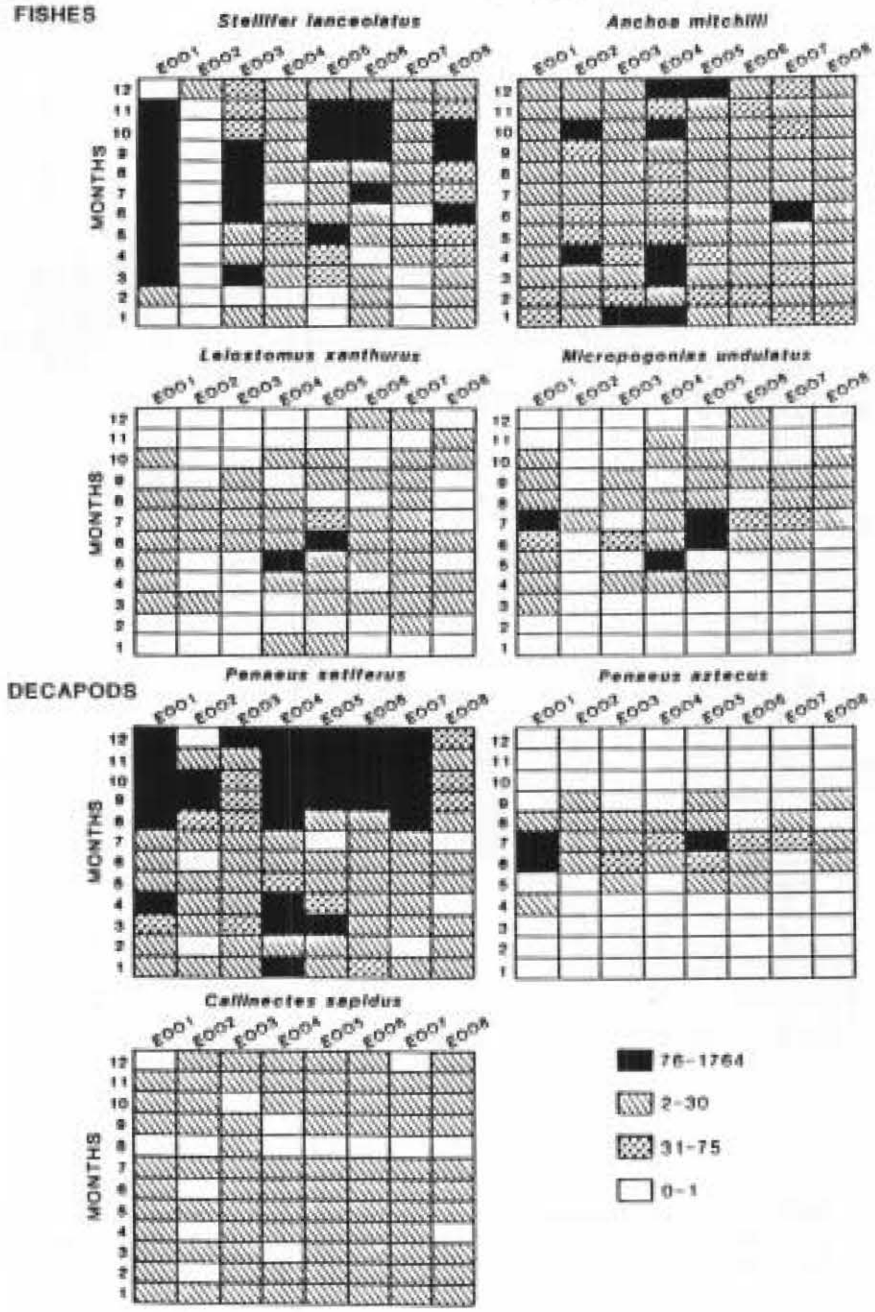


Figure 9. Abundance, expressed as the antilog of the index of abundance, for four numerically-dominant fish species and three numerically dominant decapod crustacean species collected from the North Edisto River during a two-year sampling period. Legend indicates four arbitrary levels of abundance from rare or absent (0-1) to maximum abundance (76-1764).

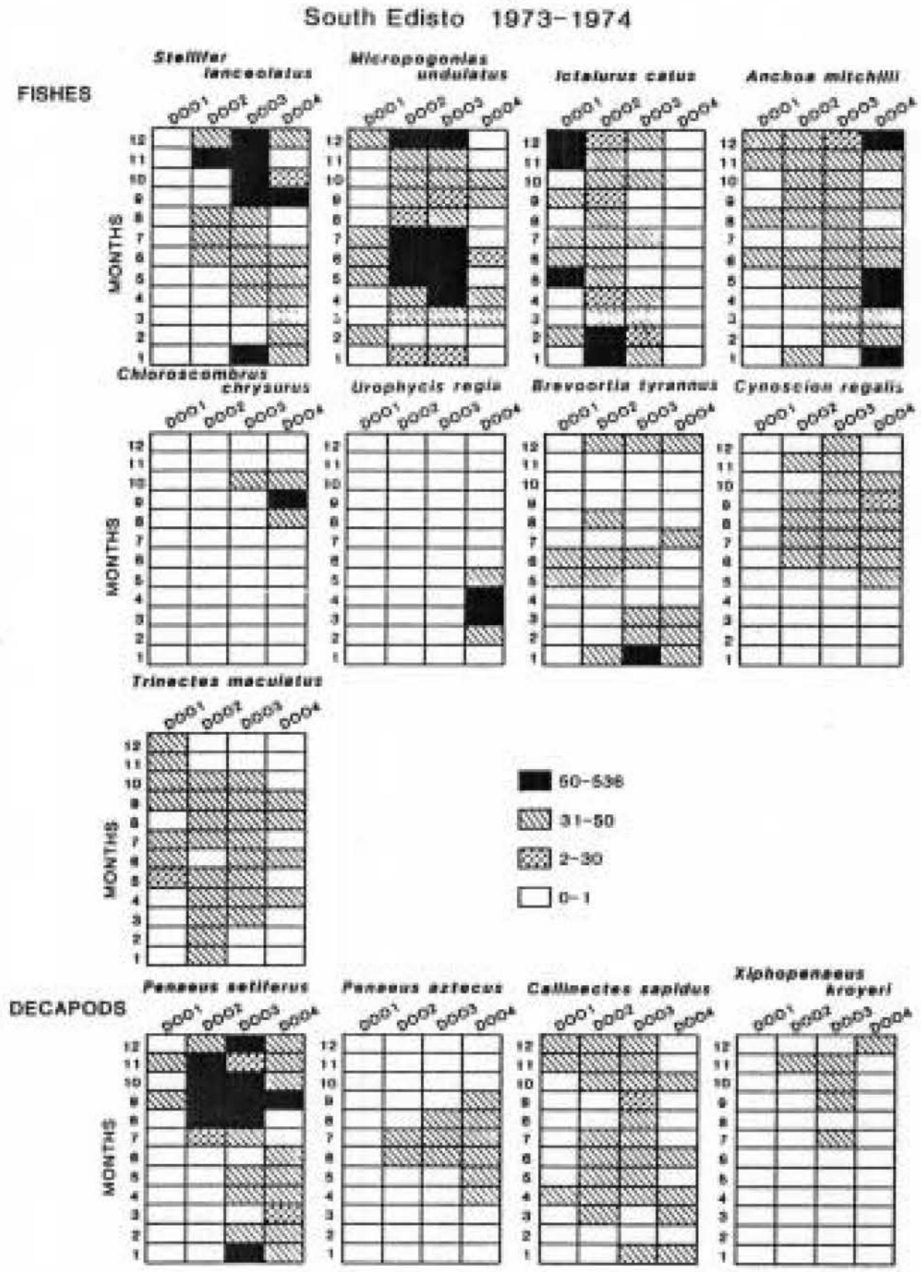


Figure 10. Abundance, expressed as the antilog of the index of abundance, for nine numerically-dominant fish species and four numerically-dominant decapod crustacean species collected from the South Edisto River during a two-year sampling period. Legend indicates four arbitrary levels of abundance from rare or absent (0-1) to maximum abundance (51-536).

TABLE 8. Annual variation in log_{10} transformed mean number of individuals for numerically-dominant species of fishes and decapod crustaceans from the Edisto system.

Fishes	North Edisto		South Edisto	
	Feb. 1973 - Jan. 1974	Feb. 1974 - Jan. 1975	Feb. 1973 - Jan. 1974	Feb. 1974 - Jan. 1974
Stellifer lanceolatus	1.000	1.280	0.572	0.706
Micropogonias undulatus	0.484	0.294	0.880	0.827
Ictalurus catus	Not Dominant		0.680	0.679
Anchoa mitchilli	1.423	1.164	0.787	0.700
Chloroscombrus chrysurus	Not Dominant		0.115	0.072
Urophycis regia	Not Dominant		0.138	0.088
Brevoortia tyrannus	Not Dominant		0.189	0.171
Leiostomus xanthurus	0.523	0.278	Not Dominant	
Cynoscion regalis	Not Dominant		0.288	0.284
Trinectes maculatus	Not Dominant		0.368	0.415
Decapod Crustaceans				
Penaeus setiferus	1.504	1.242	0.860	0.848
Penaeus aztecus	0.226	0.359	0.059	0.240
Callinectes sapidus	0.589	0.579	0.307	0.362
Xiphopenaeus kroyeri	Not Dominant		0.000	0.141

both. *Leiostomus xanthurus*, the spot, occurred throughout the North Edisto system but was most abundant at stations E004 and E005 in May and June (Figure 9). Total annual catch decreased from the first to the second year of sampling (Table 8). In the South Edisto, *Chloroscombrus chrysurus* and *Urophycis regia* were most abundant at station D004 nearest the river mouth. Both species were highly seasonal in the estuary with *C. chrysurus* occurring only from August to October and *U. regia* present from February until May (Figure 10). *Brevoortia tyrannus*, *Cynoscion regalis*, and *T. maculatus* were least abundant in winter. *Trinectes maculatus* displayed no seasonality in its abundance within the river. Annual catches for these species were fairly similar throughout the duration of our study. *Ictalurus catus*, an estuarine resident, was most abundant at stations in the upper reaches of the river (Figure 10). Catches were greatest during winter, and we observed little difference in annual catches of this species (Table 8).

The numerically-dominant decapod crustaceans, *Penaeus setiferus*, *P. aztecus*, and *Callinectes sapidus*, displayed similar patterns of seasonal abundance for both the North and South Edisto Rivers (Figures 9 and 10). *Penaeus setiferus*, white shrimp, were most abundant in the Edisto system in the fall. They occurred throughout both rivers but were least abundant at stations nearest the mouth. We also noted decreased catches of white shrimp at the extreme upriver station (D001) in the South Edisto River. Length-frequency distributions indicated that most white shrimp from the Edisto system were in the size range of 60-140 mm during all seasons. In fall, we noted the greatest influx of shrimp at modal lengths of 90 to 120 mm. Although their abundance was lower during other seasons, white shrimp with modal lengths of 70-110 mm were still present in the estuary. Brown shrimp, *P. aztecus*, were less abundant than *P. setiferus* and were highly seasonal with representation in our collections limited to the period from April through September. They were collected throughout the North Edisto River but did not occur at station D001 in the South Edisto. Sizes of *P. aztecus* ranged from 20-140 mm with modal peaks in 80-110 mm size range. Annual catches of *P. setiferus* were similar, but we noted decreased abundance of *P. aztecus* in the first year of study. Another penaeid, *Xiphopenaeus kroyeri*, was numerically important in the South Edisto River only. Individuals were collected primarily at stations located near the mouth during summer and fall. We collected no *X. kroyeri* during our first year of study. In contrast to the penaeid shrimps, *Callinectes sapidus* were ubiquitous in the Edisto system being collected at every station and displaying no apparent seasonality in occurrence. Annual catches were also similar.

A comparison of seasonal catch composition among the numerically-abundant species of the Edisto system revealed a temporal succession in their dominance (Figure 11). *Stellifer lanceolatus* and *Penaeus setiferus* dominated catches during fall in both rivers. These two species continued to be important in the North Edisto during summer, while catches in the South Edisto were overwhelmingly dominated by *P. setiferus*. By spring, *P. setiferus* was no longer an important species in our collections from the South Edisto and had been replaced by *Micropogonias undulatus* with *Anchoa mitchilli* as a secondary dominant. Catches in the North Edisto, however, continued to be dominated by *S. lanceolatus* during our second year of study. In the first year, *Leiostomus xanthurus*, *Stellifer lanceolatus*, and *M. undulatus* dominated catches during spring. Winter catches in the North Edisto were dominated by *Anchoa mitchilli* and *Penaeus setiferus* during the first year and by *S. lanceolatus* in the second year of study. In the South Edisto system, *Ictalurus catus*, *A. mitchilli*, and *Brevoortia tyrannus* were numerically important in our collections.

Biomass Estimates

Density and biomass estimates for fishes in the North Edisto generally were greatest during summer when large numbers of *Stellifer lanceolatus* dominated our catches (Table 9). Low densities of fish collected during winter were accompanied by the lowest biomass estimates observed for fishes throughout the year. Biomass was greatest at station E008 nearest the mouth where we also found fish species richness to be highest. Densities, however, were greatest at station E001 which may reflect increased concentrations of smaller fish at the upriver nursery areas. In contrast to the fishes, biomass and density of decapod crustaceans generally were greatest during fall when we caught large numbers of *Penaeus setiferus*. Densities of decapod crustaceans were highest at station E004, while biomass was greatest at station E007.

In the South Edisto, fish density and biomass estimates generally were greatest in the fall when we

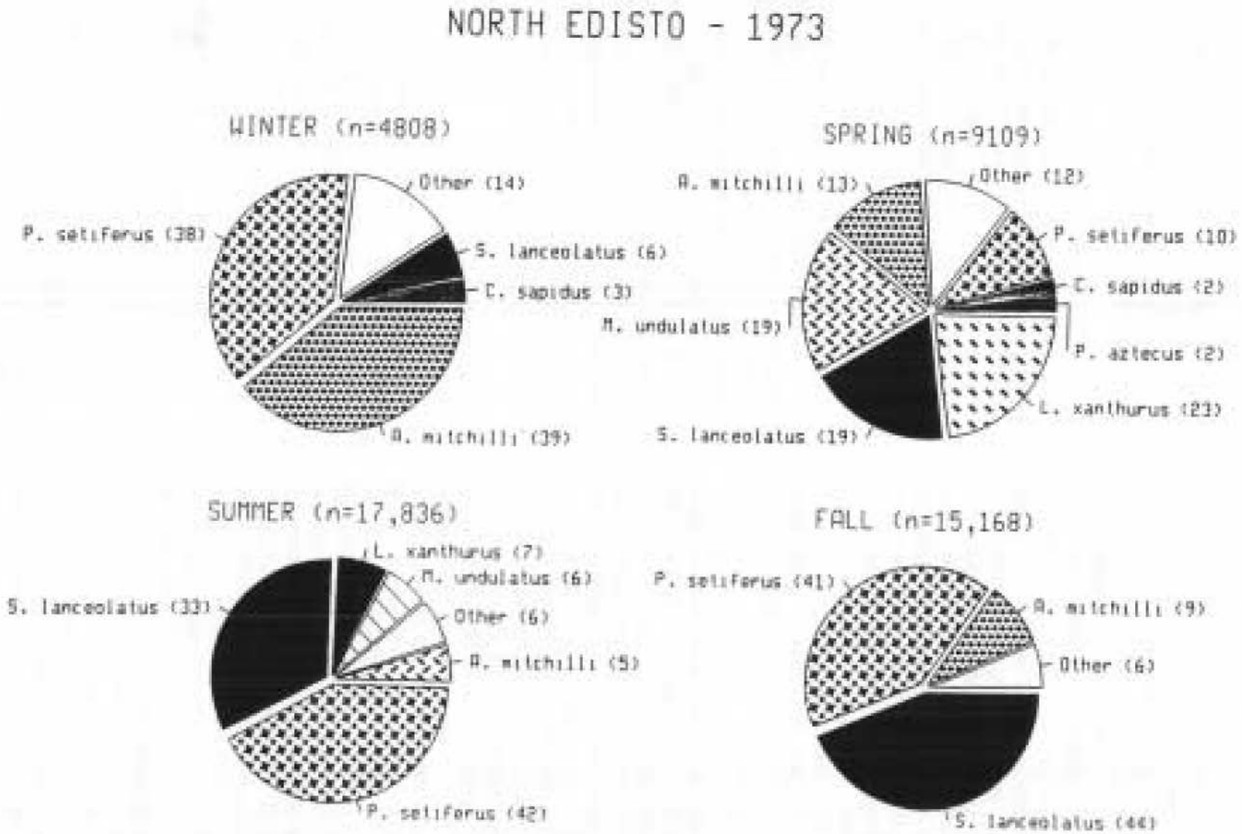
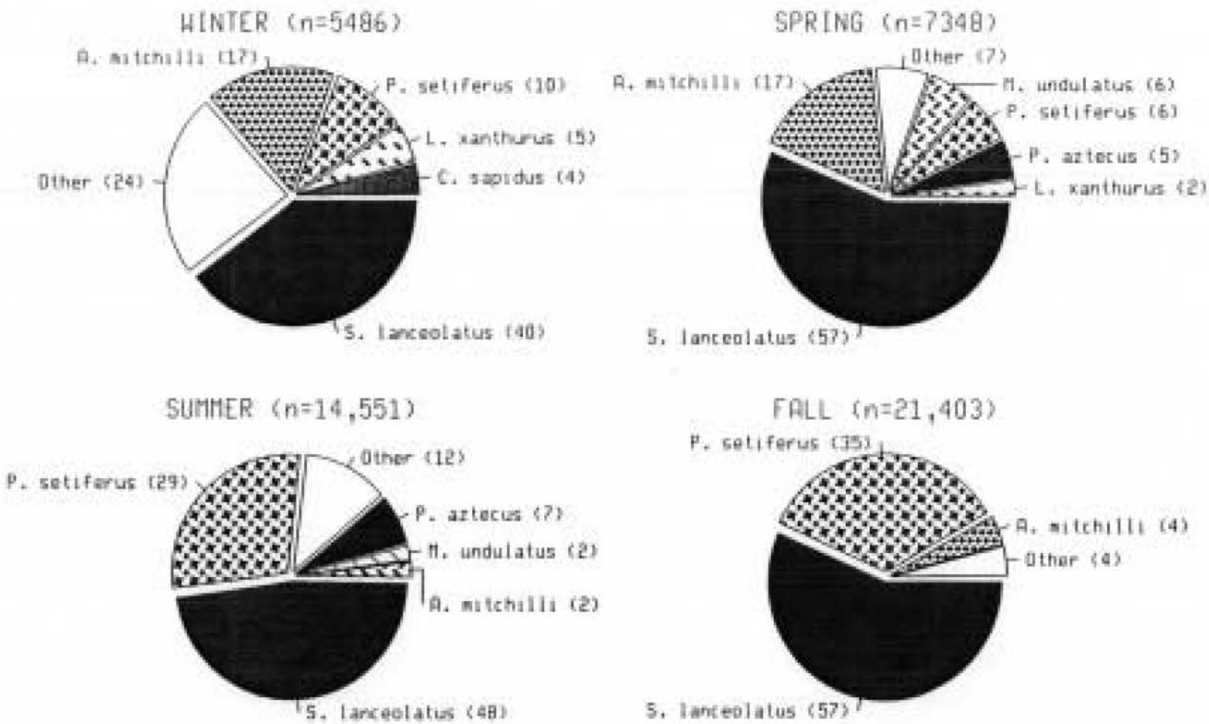
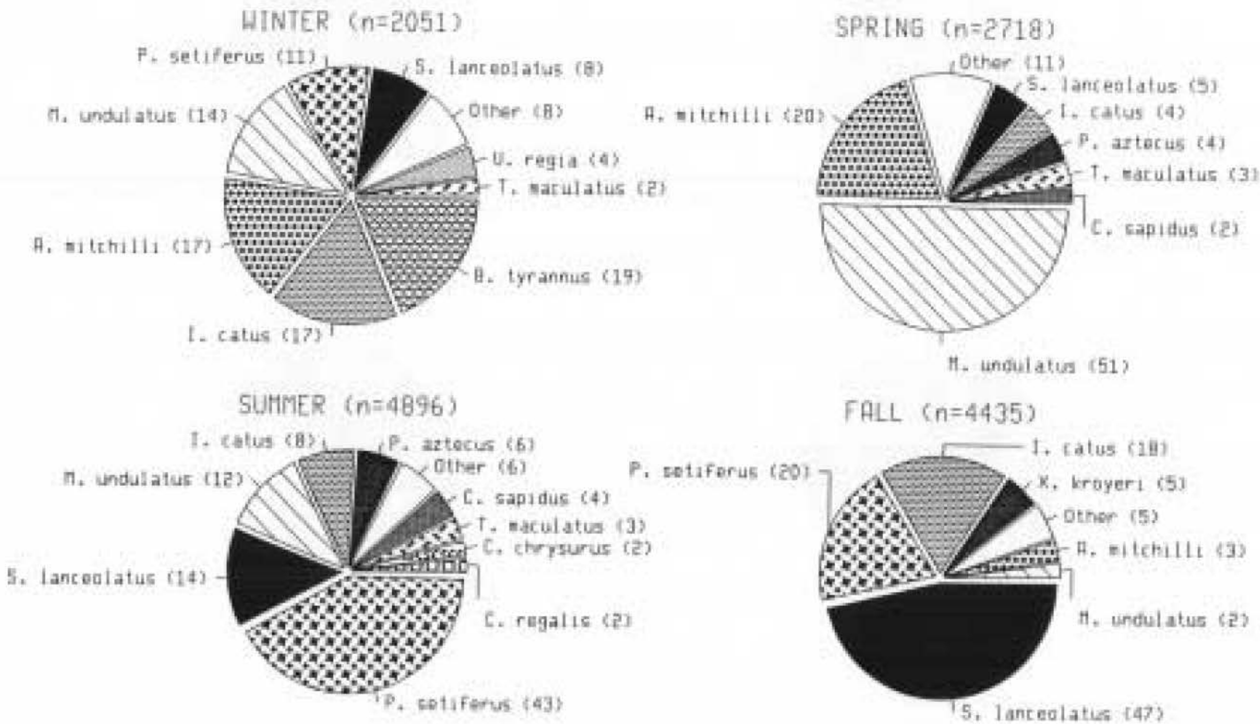


Figure 11. Seasonal and annual relative importance, expressed at $^{0}/oo$ of total catch for numerically-dominant fishes and decapod crustaceans collected in the North and South Edisto Rivers during the two-year sampling period.

NORTH EDISTO - 1974



SOUTH EDISTO - FEB. 1974-JAN. 1975



SOUTH EDISTO - FEB. 1973-JAN. 1974

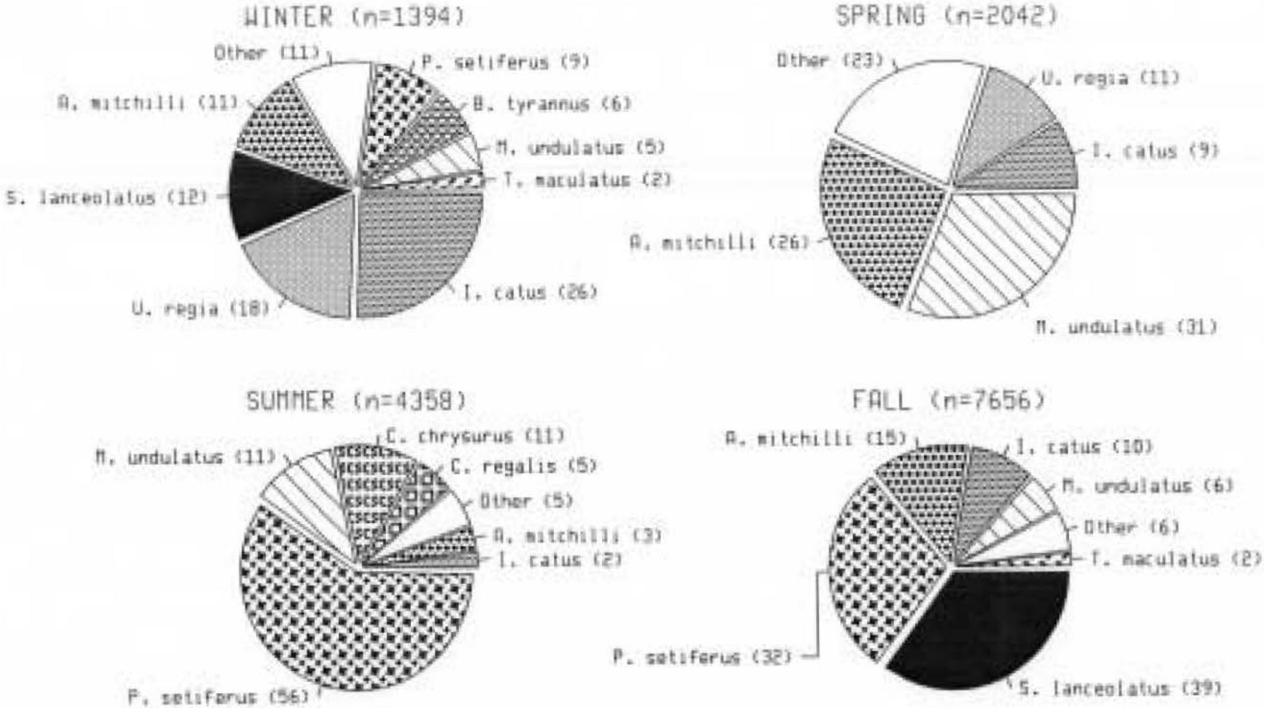


TABLE 9. Average biomass (kg/ha) and density (No./ha) of fishes and decapod crustaceans in the North (E001-E008) and South (D001-D004) Edisto estuarine systems by station and season.

	E001		E002		E003		E004		E005		E006	
	kg/ha	No./ha	kg/ha	No./ha	kg/ha	No./ha	kg/ha	No./ha	kg/ha	No./ha	kg/ha	No./ha
Fishes												
Fall	4.98	1724.7	0.72	129.3	6.4	1517.9	0.88	250.0	5.28	1065.7	2.09	453.4
Winter	1.23	327.9	0.93	126.0	1.39	344.6	0.93	270.5	1.70	218.2	0.58	123.0
Spring	6.74	1122.2	0.32	148.8	4.24	502.2	2.58	482.09	6.97	1067.9	0.74	80.2
Summer	6.47	1648.5	1.08	150.3	4.69	1436.7	2.28	304.0	5.03	723.1	3.70	496.9
Decapods												
Fall	4.93	393.5	4.49	385.2	2.5	224.1	8.46	818.2	6.16	552.8	6.16	398.8
Winter	0.46	86.01	0.19	26.5	0.65	59.5	1.80	315.12	1.98	271.9	0.41	47.9
Spring	3.14	205.2	1.14	99.4	2.4	134.9	1.93	132.4	2.48	129.6	1.21	47.5
Summer	4.4	544.8	3.66	550.9	1.36	116.2	6.5	1034.2	3.12	262.6	4.9	302.2

	E007		E008		D001		D002		D003		D004	
	kg/ha	No./ha	kg/ha	No./ha	kg/ha	No./ha	kg/ha	No./ha	kg/ha	No./ha	kg/ha	No./ha
Fishes												
Fall	0.57	156.8	8.35	1358.9	10.78	514.2	5.18	419.4	6.99	1292.3	3.17	376.5
Winter	0.56	135.5	5.82	406.1	0.08	6.37	2.73	147.9	7.06	628.8	2.40	285.8
Spring	3.60	219.8	8.67	940.1	1.21	73.8	3.51	365.1	2.53	429.9	3.26	449.7
Summer	3.63	409.3	9.30	630.6	2.01	165.8	5.32	258.3	3.92	557.7	5.38	470.2
Decapods												
Fall	18.62	1407.1	1.96	142.3	0.02	3.3	1.74	290.7	7.21	740.4	0.99	94.8
Winter	1.01	86.01	0.85	97.9	0.00	0.00	0.02	4.2	0.93	65.8	0.86	68.6
Spring	4.44	79.32	1.50	63.3	0.01	4.9	0.18	29.6	1.21	45.4	1.30	82.1
Summer	17.07	1309.6	1.42	158.3	0.03	4.0	1.89	555.5	10.98	949.7	1.04	93.9

collected large numbers of *S. lanceolatus*. *Ictalurus catus* also constituted a considerable portion of our catch during fall and no doubt influenced our estimates of biomass and density. Both parameters were greatest at station D003. Increased biomass and density were noted at this station for decapods as well as fishes; however, we found decapod density and biomass to be greatest during summer and attributed this to large catches of *P. setiferus* made then.

Total biomass and density estimates for the Edisto River system over our two-year study were:

	Biomass (kg/ha)	
	Fishes	Decapods
North Edisto	3.53	3.87
South Edisto	4.0	1.93
	Density (No./ha)	
	Fishes	Decapods
North Edisto	925	333
South Edisto	392	209

With the exception of the density estimate of fishes in the North Edisto, these estimates are lower than those reported by Wenner et al. (1982, 1984) for other South Carolina estuaries.

Discussion

Although the North and South Edisto Rivers are part of the same estuarine system, they differ in salinity structure and, to a lesser degree, in faunal composition. The North Edisto is a relatively high-salinity, homiohaline river with limited fresh-water input. The absence of a distinct halocline tends to modify faunal zonation of this river, so that many of the same species occur at all stations. More importantly, species assemblages in the North Edisto lack a strong endemic estuarine component. Assemblages were composed of stenohaline marine species, which were generally seasonal in their appearance in the North Edisto and not very abundant, and euryhaline transients, which were abundant but temporary inhabitants of the estuary as adults. The euryhaline transient species formed associations characterized by high constancy and low fidelity to stations in the North Edisto, while the stenohaline marine species, because of their lower abundance, were less constant but more restricted in their distribution.

In addition to abundance, we also attribute differences noted in patterns of constancy and fidelity between species groups found in the North Edisto to bottom type. The particular tendency for increased constancy and fidelity of species at stations characterized by hard substrate and epifaunal communities is especially interesting. Fishes are attracted to communities of epifaunal organisms which form patchy "reefs" on the continental shelf (Struhsaker, 1969; Powles and Barans, 1980; Sedberry and Van Dolah, 1984). Our results suggest that estuarine fishes often concentrate in areas which provide ample substrate, such as oyster shells, for colonization by sessile invertebrates and associated prey organisms. Our determinations of species richness validated the results of cluster analysis by showing that the most diverse assemblage of species was found at station E008 near the mouth. DeSylva (1975) has noted some relationship between engybenthic-nektonic predators and bottom sediments, and Wenner et al. (1990) noted enhanced diversity of fishes and decapod crustaceans on or near estuarine epifaunal communities in a high salinity creek of Charleston Harbor. Calder et al. (1977) reported highest diversity of macrobenthos at station E008 in the North Edisto and attributed the high diversity to stable salinity conditions and suitable substrate. In the marine environment, both Abele (1974) and Felder and Chaney (1979) found diversity higher on rocky substrates of reefs which are fouled with an epifaunal mat conducive to the development of diverse assemblages of motile benthos. The higher density of benthic organisms associated with the epifaunal mat of marine (Felder and Chaney, 1979) or estuarine environments (Calder et al., 1977) in turn supports diverse and abundant predator assemblages.

In contrast to our conclusions concerning faunal assemblages of the North Edisto, the faunal gradient of the South Edisto River appears to be controlled by salinity rather than substrate. In reality, distributional patterns, abundance, and species richness are influenced by a number of factors including dissolved oxygen, turbidity, and depth, but are represented along a temporal or spatial "gradient". The poikilohaline nature of the South Edisto and the rather uniform sandy substrate at stations in the South Edisto (Calder et al., 1977) indicates to us that distributional patterns are related to salinity. A coenoclinal change in this river was noticeable between the limnetic upestuary areas and the meso-euhaline areas of the river. In terms of species assemblages, the estuarine endemic species of the South Edisto are for the most part separated spatially from the euryhaline marine transients and the stenohaline marine species. Physiological impediments to movement by many species of fish and decapods into fresh or brackish waters (Weinstein et al., 1980) contributed to the coenoclinal nature of the South Edisto. The species assemblages present in the South Edisto are very similar to those noted by Wenner et al. (1982) for other polikilohaline estuarine systems in South Carolina. Zonation patterns in these systems follow those described by Weinstein et al. (1980) for the Cape Fear River, North Carolina in that areas of faunal change are not sharp and considerable overlap in spatial distribution for individual species occurs. However, our results contrast with those of Weinstein et al. (1980) in that many estuarine endemic forms of the South Edisto were excluded from higher salinity areas. For the most part, these species were not distributed in a manner similar to the stenohaline marine species. The differences in our observations may relate strictly to sampling methods, since several limnetic-brackish water species caught by us were not represented in Weinstein's et al. (1980) seine and rotenone collections.

Because of the occurrence of euryhaline transients and stenohaline species within similar areas of the South Edisto River, species richness and abundance were greatest at the station nearest the mouth. Enhanced species richness has been noted in high-salinity areas of other South Carolina estuaries (Wenner et al., 1982, 1984, 1990; Stender and Martore, 1990). Weinstein et al. (1980) attributed enhanced species richness of a high salinity salt marsh habitat to seasonal presence of marine species.

Undoubtedly, seasonality is a factor which affects the community structure of both rivers in the Edisto system. Seasonal changes in species richness, abundance, and dominance have been noted for numerous estuarine habitats (e.g. Dahlberg and Odum, 1970; Oviatt and Nixon, 1973; Livingston, 1976; Subrahmanyam and Drake, 1975; Subrahmanyam and Coultas, 1980). In the Edisto system, as well as in other estuaries, breeding, recruitment, and migration cycles influence community parameters. In general, we found similar time-related trends in abundance, dominance, and species richness for both rivers. Any differences which were noted are attributed to differences in species composition between the two rivers, and to unequal sampling effort, in terms of number of collections made.

Similar time-related trends in community structure are not remarkable in view of the immediate proximity of the rivers to each other but are important when the Edisto system as a whole is compared with other estuaries in South Carolina. The white shrimp, *Penaeus setiferus*, demonstrates considerable regularity in its seasonal dominance of South Carolina estuarine waters (Wenner et al. 1982, 1984, 1990; Ogburn et al. 1988; Stender and Martore, 1990). Dominant fish species during much of the year are the sciaenids, *Stellifer lanceolatus*, *Micropogonias undulatus*, and the engraulid, *Anchoa mitchilli*. We fully realize that any determination of dominance or relative importance may obscure information concerning actual importance of species based on their persistent abundance or presence in the estuary; however, species which showed some temporal regularity in the dominance hierarchy were also our most abundant species overall. This indicates that the estuary is not dominated by rare species which occur only one or two times a years (Subrahmanyam and Coultas, 1980). The importance of these observations is that the communities of both rivers maintain some stability in species composition as well as ranking of dominant species. This enables estuarine systems to "rebound" from short-term stresses such as freshets or periods of drought (Weinstein et al., 1980). Furthermore, the regular seasonal concurrence of species is thought to be of adaptive value in that competition among species for food is reduced by allowing them to compete at different times (McNaughton and Wolf, 1979; Subrahmanyam and Coultas, 1980; Weinstein et al., 1980). When species do co-occur within the estuary, other means such as bathymetric separation (Weinstein et al., 1989), and preferences for different substrate and salinity regimes, as well as prey items, are means of reducing competition. The Edisto system at present is functioning as any other estuary: though interactions of species, adequate resources of food, and regular fluctuations in composition and abundance of organisms.

Ackknowledgements

We are grateful to all persons who assisted in collection of specimens and data in the field, especially J. Miglarese, R. Richter, and J. Bishop. We thank T.D. Mathews and K.H. Austin for analysis of water samples; K. Swanson for preparation of figures; N. Kopacka and M.J. Clise for assistance with computer programming; and L. Greene for preparation of the typed manuscript. The field study and manuscript benefited from comments by our colleagues; E.B. Jospeh; V.G. Burrell, Jr., G.R. Sedberry, and C. Bearden.

The data were collected and automated by financial support from the Coastal Plains Regional Commission (Contract 10340031) as part of the Estuarine Survey Program of the South Carolina Marine Resources Center and were analyzed through funding from NOAA Office of Sea Grant (Grant 00140-93027).

Literature Cited

Abele, L.G. 1974. Species diversity of decapod crustaceans in marine habitats. Ecology 55(1):156-161.

Bearden, C.M. 1964. Distribution and abundance of Atlantic croaker, *Micropogon undulatus*, in South Carolina. Contrib. Bears Bluff Lab. No. 40, 23 p.

Boesch, D.F. 1977. A new look at the zonation of benthos along the estuarine gradient. In: Ecology of Marine Benthos, pp. 245-266. Ed. by B.C. Coull.

Calder, D.R., B.B. Boothe, Jr., and M.S. Maclin. 1977. A preliminary report on estuarine macrobenthos of the Edisto and Santee River Systems, South Carolina. S.C. Mar. Res. Center, Tech. Rep. No. 22, 50 pp.

Clifford, H.T. and W. Stephenson. 1975. An introduction to numerical classification. Academic Press, N.Y. 229 pp.

Dahlberg, M.D. 1972. An ecological study of Georgia coastal fishes. Fish. Bull. U.S. 70:323-354.

Dahlberg, M.D. and E.P. Odum. 1970. Annual cycles of species occurrence, abundance, and diversity in Georgia estuarine fish populations. Am. Midl. Nat. 83:382-392.

DeSylva, D.P. 1975. Nektonic food webs in estuaries. In. Estuarine Research, Vol. I, 420-477. Ed. by E. Cronin. New York: Academic Press.

Elliott, J.M. 1977. Some methods for the statistical analysis of samples of benthic invertebrates. Freshwater Biol. Ass. U.K. Sci. Publ. No. 25, 160 pp.

Felder, D.L. and A.H. Chaney. 1979. Decapod crustacean fauna of Seven and One-Half Fathom Reef, Texas: Species composition, abundance, and species diversity. Contrib. Mar. Sci. 22:1-29.

Klima, F.F. 1976. A review of the fishery resources in the western central Atlantic. Western Central Atlantic Fishery Commission, No. 3, 77 pp.

Kuntz, A. 1914. The embryology and larval development of *Bairdiella chrysura* and *Anchovia mitchilli*. Bull. U.S. Bur. Fish. 33:3-19.

Lambert, J.M. and W.T. Williams. 1962. Multivariate methods in plant ecology: Nodal analysis. J. Ecol. 50:775-802.

Lance, G.N. and W.T. Williams. 1967. A general theory of classificatory sorting strategies. I. Hierarchical systems. Compt. J. 9:373-380.

Livingston, R. 1976. Diurnal and season fluctuations of organisms in a north Florida estuary. Estuar. Coast. Mar. Sci. 4:373-400.

Mathews, T.D. and M.H. Shealy, Jr. 1978. Hydrography of South Carolina estuaries with emphasis on the North and South Edisto and Cooper Rivers. S.C. Mar. Res. Cent. Tech. Rep. No. 30. 148 pp.

McNaughton, S.J. and L.L. Wolf. 1979. General Ecology. Holt, Reinhart, and Winston, New York. 702 pp.

Miller, G.L. and S.C. Jorgenson. 1969. Seasonal abundance and length frequency distribution of some marine fishes in coastal Georgia. U.S. Fish Wildl. Serv., Data Rep. 35, 102 p.

Ogburn, M.V., D.M. Allen and W.K. Michener (eds.). 1988. Fishes, shrimps, and crabs in the North Inlet estuary, SC: A four-year seine and trawl survey. Baruch Institute Technical Report 88-1. Univ. of SC, Columbia, 299 pp.

Oviatt, C.A. and S.W. Nixon. 1973. The demersal fish of Narragansett Bay: An analysis of community structure, distribution, and abundance. Est. Coastal Mar. Sci. 1:361-378.

Powles, H. and C.A. Barans. 1980. Groundfish monitoring in sponge-coral areas off the southeastern United States. Mar. Fish. Rev. 42(5):21-35.

Roe, R.B. 1967. Potentially commercial nephropsids from the western Atlantic. Trans. Am. Fish. Soc. 95(1):92-98.

Sedberry, G.S. and R.F. Van Dolah. 1984. Demersal fish assemblages associated with hard bottom habitat in the South Atlantic Bight of the USA. Environ. Biol. Fishes 11:241-258.

Shealy, M.H., Jr., J.V. Miglarese, and E.B. Joseph. 1974. Bottom fishes of South Carolina estuaries - relative abundance, seasonal distribution, and length-frequency relationships. S.C. Mar. Res. Center Tech. Rep. No. 6. 189 pp.

Stender, B.W. and R.M. Martore. 1990. Finfish and invertebrate communities. In: Van Dolah, R.F., P.H. Wendt, and E.L. Wenner (eds.), A Physical and Ecological Characterization of the Charleston Harbor Estuarine System. Final Report, SC Coastal Council, Charleston, SC. 634 pp.

Stephenson, W., W.T. Williams, and S. Cooke. 1972. Computer analyses of Peterson's original data on bottom communities. Ecol. Monogr. 42:387-415.

Strickland, J.D.H. and T.R. Parsons. 1968. A practical handbook of seawater analysis. Bulletin 167, Fish. Res. Bd. Canada. 311 pp.

Struhsaker, P. 1969. Demersal fish resources: Composition, distribution, and commercial potential of the continental shelf stocks off southeastern United States. Fish. Ind. Res. 4:261-300.

Subrahmanyam, C.B. and L.L. Coultas. 1980. Studies on the animal communities, in two north Florida salt marshes Part III. Seasonal fluctuations of fish and macroinvertebrates. Bull. Mar. Sci. 30(4):79_-818. ?

Subrahmanyam, C.B. and S.H. Drake. 1975. Studies on the animal communities in two north Florida salt marshes. Part I. Fish communities. Bull. Mar. Sci. 25:445-465.

Symposium on the Classification of Brackish Waters. 1958. The Venice system for the classification of marine waters according to salinity. Oikos 9:311-312.

Tagatz, M.E. and D.L. Dudley. 1961. Seasonal occurrence of marine fishes in four shore habitats near Beaufort, North Carolina, 1957-60. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 390, 19 p.

Tiner, R.W., Jr. 1977. An inventory of South Carolina's coastal marshes. S.C. Mar. Res. Center Tech. Rept. No. 23. 33 pp.

Wathne, F. 1959. Observations on trawl-door spread and a discussion of influencing factors. Commer. Fish. Rev. 21:7-15.

Weinstein, M.P., S.L. Weiss, and M.F. Walters. 1980. Multiple determinants of community structure in shallow marsh habitats, Cape Fear River Estuary, North Carolina, U.S.A. Marine Biology 58, 227-243.

Wenner, E.L., M.H. Shealy, Jr., and P.A. Sandifer. 1982. A profile of the fish and decapod crustacean community in a South Carolina estuarine system prior to flow alteration. NOAA Tech. Rep. NMFS-SSRF-757. 17 pp.

Wenner, E.L, W.P. Coon III, M.H. Shealy, Jr., and P.A. Sandifer. 1984. A five-year study of seasonal distribution and abundance of fishes and decapod crustaceans in the Cooper River and Charleston Harbor, S.C., prior to diversion. NOAA Tech. Rept. NMFS-SSRF-782. 16 pp.

Wenner, E.L., J. Archambault, and J. Boylan. 1990. Recruitment of fishes and decapod crustaceans into nursery habitats. In: Van Dolah, R.F., P.H. Wendt, and E.L. Wenner (eds.), A Physical and Ecological Characterization of the Charleston Harbor Estuarine System., Final Report, SC Coastal Council, Charleston, SC. 634 pp.

Williams, W.T. 1971. Principles of clustering. Ann. Rev. Ecol. Syst. 2:303-326.

Williams, W.T. and J.M. Lambert. 1961. Multivariate methods in plant ecology. III. Inverse association-analysis. J. Ecol. 49:717-729.