704

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The Macrofauna of the Surf Zone Off Folly Beach, South Carolina

William D. Anderson, Jr., James K. Dias,
Robert K. Dias, David M. Cupka,
and Norman A. Chamberlain

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U.S. DEPARTMENT OF COMMERCE
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Robert M. White, Administrator
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The Macrofauna of the Surf Zone Off Folly Beach, South Carolina[1]

WILLIAM D. ANDERSON, JR.,[2] JAMES K. DIAS,[3] ROBERT K. DIAS,[4] DAVID M. CUPKA,[5] and NORMAN A. CHAMBERLAIN[2]

ABSTRACT

A seining survey of the macrofauna of the surf zone at Folly Beach, Charleston County, S.C., was conducted from October 1969 to October 1971. Eighty-seven collections were made in the surf and associated tidal pool resulting in the capture of 512 specimens of swimming invertebrates representing at least 17 species and 5,095 specimens of bony fishes representing 41 species.

The data obtained are analyzed on seasonal and yearly bases for total weights and numbers of species and specimens. Species are ranked as to importance; and prediction equations for monthly average number of specimens per collection in the surf, based on environmental variables, are developed. Length-frequency data and other aspects of the biology of selected species are presented. Length-length and length-weight relationships are given for certain species. Recommendations for the improvement of the methodology for similar surveys are made.

INTRODUCTION

Although the taxonomy of the fishes and many of the larger invertebrates inhabiting the inshore waters and estuaries of South Carolina is reasonably well known, the life histories of many of these species are incompletely known—data on the larvae and juveniles and on the seasonal variations and fluctuations of populations being especially limited. This study was initiated with the intent of filling part of this gap in our knowledge of the surf zone.

In several studies since 1940, the ichthyofauna of the surf zone has been surveyed along the Gulf and Atlantic coasts of the United States [e.g., Gunter (1945, 1958) and McFarland (1963) in Texas; Springer and Woodburn (1960) in the Tampa Bay area; Miller and Jorgenson (1969) and Dahlberg (1972) in Georgia; Cupka (1972) in South Carolina; Tagatz and Dudley (1961) in North Carolina; and Schaefer (1967) in New York], but to our knowledge no surveys have been conducted on a regular year-around basis north of North Carolina in the surf zone of unprotected beaches.

Of the many shore habitats, the surf zone of exposed beaches has been least studied. Part of the paucity of data on the surf zone is certainly due to the difficulties inherent in collecting in it. It is unfortunate that our knowledge of this environment is so meager because this rather extensive and physically well-defined habitat is not only economically important as a recreational area for sport fishermen, but also is significant as nursery grounds for certain commercial and sport species such as the pompanos, *Trachinotus* spp., mullets, *Mugil* spp., and Gulf kingfish, *Menticirrhus littoralis*. Other species inhabiting the surf undoubtedly prey upon or form a significant part of the diet of a number of economically important species. In order to adequately understand the ecology of the surf zone, basic data on the composition and seasonal variations and fluctuations of populations of both resident and transient species are necessary. With the preceding in mind, a 2-yr biweekly seining survey was initiated at Folly Beach in October 1969. A short abstract of the first year of this study was presented by Anderson et al. (1971).

DESCRIPTION OF THE STATION

Folly Beach (on Folly Island, a barrier island) is about 14 km south of the Charleston peninsula in Charleston County, S.C. The littoral zone at this beach is a high-energy environment, unprotected from the force of the open Atlantic Ocean by any physiographic feature. Collections were made in the surf (i.e., the breakers and slightly seaward) and tidal pool (when present) between the last two groins at the southwestern end of the beach (lat. 32°38.7′N, long. 79°57.6′W). The beach slopes gently in this area (about 1-1½%) and is predominantly sandy (fine sand), although considerable shell and larger shell fragments were present on about one-half of the collecting days. Tidal ranges are 5.2 feet (1.58 m) mean and 6.1 feet (1.86 m) spring. The height of the sea varied from about 0.2 to 2.1 m ($\bar{x}$ = 0.6 m).

A tidal pool[6] was present on approximately 70% of the collecting days. Its dimensions varied considerably from

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[6]A "tidal pool" is "A pool of water remaining on a beach or reef after recession of the tide" (Howell 1960).

one collection to the next. On several occasions it was limited to a small pool at the seaward end of one (or of each) groin and on others was a very long trough in excess of 200 m in length. Because the groins (of timber pilings) were well covered with encrusting invertebrates and because the currents tended to scour out the areas at the seaward ends of the groins, these man-made structures acted as unnatural foci for the concentration of motile animals. Despite this the presence of the groins affected only the catch in the tidal pool, because at the times we made the surf collections the tide had receded beyond the groins.

The minimum and maximum water temperatures observed were: surf, 6.4° and 28.6°C; tidal pool, 3.7° and 26.8°C. The salinities in the surf ranged from 23.2 to 35.0‰; those in the tidal pool, from 25.8 to 33.4‰. (For data on temperature and salinity, see Tables 1 and 2.) The lowest salinities were recorded after heavy local rains. Because the collections were made near the time of predicted low water, the maximum diluting effect of the groundwater was manifest.

MATERIALS AND METHODS

Collecting and Handling Specimens and Data

Collections were made by seine at approximately biweekly intervals (from 11 October 1969 to 10 October 1971) in the surf and tidal pool (when present) near the time of predicted low water. All except three of the collections were made in the morning (0500-1130 EST). The time required to make a collection varied from 5 to 40 min ($\bar{x}$ = 15.4) in the surf and from 1 to 25 min ($\bar{x}$ = 10.3) in the tidal pool.

The surf was seined with a 19.8- by 1.8-m, 9-mm stretch-mesh nylon bag seine with bag opening of 1.8 m in diameter and length of 1.8 m. Initially, the tidal-pool collections were made with the 19.8-m seine—later (because of ease of handling) with a 7.1- by 1.6-m, 9-mm stretch-mesh nylon bag seine with bag opening of 1.8 m in diameter and length of 1.8 m. Except when beaching and when collecting in the tidal pool was restricted to small pools at the groins, the seines were pulled parallel to the beach.

In the surf, the seine was pulled approximately 185 m, the distance between the groins. During almost all of the first year, two hauls, each about one-half the distance between the groins, were made—the first haul starting opposite one groin, the second terminating opposite the other. Later each surf collection was made with a single tow. Generally, the seine was towed with the longshore current which usually ran from northeast to southwest. The distance seined and the number of hauls in the tidal pool varied with the length and configuration of the pool, but never exceeded 185 m. The use of seines of different lengths did not affect the catch in the tidal pool because even the smaller seine was long enough to reach across the width of the pool. There were no duplicate or reciprocal tows in either the surf or tidal pool, i.e., a given area was seined only once per collecting trip. Assuming that the opening of the seine was 12 m (±2 m), the area covered in a seine haul between the groins in the surf was about 2,220 m². Surf and tidal-pool catches made on the same day were considered as different collections and were handled separately. Air and water temperatures, salinity, and turbidity were measured and observations were made on the condition of the sea, height of the breakers, wind velocity and direction, cloud cover, character of the bottom, and depth of water seined.

All material was measured and weighed after preservation. Standard length (SL), fork length (FL)—when applicable, total length (TL), and weight (W) of each fish were taken. Specimens were thoroughly blotted externally and excess moisture was squeezed out of the gill chambers of fishes before weighing. Similar techniques were used for invertebrates except that carapace length (CL) and width (CW) were measured on crabs.

Data were coded for input on 80-column Hollerith code punch cards. Four types of cards were used for each collection: 1) location data card, 2) physical data card, 3) species data card (number of specimens, total weight, and length and weight ranges), and 4) specimen data card (scientific name, sex if determined, lengths, weight, and miscellaneous data as appropriate). Data were analyzed on an IBM System 360/40 DOS computer. The software used for the analyses of the data was the Dynamic Computer Systems/Multi-purpose Information Processor and the UCLA BMD, Biomedical Computer Programs.

In this study we define the seasons as follows: October, November, December—Fall; January, February, March—Winter; April, May, June—Spring; and July, August, September—Summer.

Selectivity of Collecting Method

The method of collecting used in this study was highly selective. The material that could be collected by seining was determined by the characteristics of the net (length, configuration, and mesh size), certain environmental factors, and the speed at which the net could be pulled which is largely a reflection of environmental conditions. In the surf the environmental factors with the greatest effects were velocity of longshore current, condition and height of sea, nature of bottom, temperature, and turbidity; in the tidal pool those of greatest importance were conditions prevailing at the previous flood tide and the configuration of the pool itself which was a product of the conditions existing at the time of formation.

In the surf large individuals were not as readily collected as smaller ones; however, at times of low water temperatures the motility of larger animals was reduced greatly, thereby decreasing their chances of escaping capture. Individuals less than a certain critical size (a function of mesh size) were not retained in the net unless they became entrapped with other animals and debris in the bag of the seine.

The seine was usually pulled with the longshore current because most frequently it was impossible to make headway against it. Even though our hauls were fo the most part with the current, the time required to cover the distance between the groins varied considerably because of differences in current velocity. Our catch, then, was affected both qualitatively and quantitatively to unknown degrees by variations in the current.

In the tidal pool all individuals greater than a certain critical size would appear to be captured with ease. However, experience showed that this was not the case. Due to the configuration of the tidal pool, particularly when it was in part or entirely associated with one (or both) of the groins, animals were seen that were not collected.

RESULTS AND DISCUSSION

Collections

A total of 87 collections were made, 51 in the surf (Table 1) and 36 in the tidal pool (Table 2). Each collection in the surf yielded at least one species of fish (1-9) and all but 14 at least one swimming invertebrate species (1-6). Twenty-eight of the 36 collections in the tidal pool produced at least one species of fish (1-7), but swimming invertebrates (one species) were obtained in only eight collections. The total number of species of fishes and swimming invertebrates varied from 1 to 13 per collection in the surf and 0 to 7 in the tidal pool.

The number of fishes per collection in the surf varied from 2 to 310; the number of swimming invertebrates from 0 to 79. In the tidal pool the number of fishes per collection ranged from 0 to 759; the number of swimming invertebrates from 0 to 12. The total number of specimens of fishes and swimming invertebrates ranged from 2 to 311 per station in the surf and 0 to 759 in the tidal pool.

The weight of fishes per collection in the surf varied from 7 to 2,045 g, that of swimming invertebrates from 0 to 655 g. The weight of fishes per collection in the tidal pool varied from 0 to 817 g, that of swimming invertebrates from 0 to 7 g. The total weight of fishes and swimming invertebrates varied from 7 to 2,047 g per station in the surf, and from 0 to 817 g in the tidal pool.

Some 512 specimens of swimming invertebrates representing 4 phyla, 4 classes, 6 orders, 11 families, about 15 genera, and at least 17 species; and 5,095 specimens of bony fishes representing 7 orders, 19 families, 32 genera, and 41 species were collected and examined during this study. About 350 specimens representing at least 32 additional species of invertebrates were also collected. This group of species included nonswimming motile forms characteristic of calmer offshore waters, unattached bottom-dwellers of the surf zone (such as pelecypods and echinoderms), and detached offshore sessile organisms. Seventeen of these species (represented by 102 specimens) were collected only on 16 July 1971 shortly after a tropical storm passed near the coast of South Carolina. Because these 32 additional species of invertebrates are not ordinarily found in the surf zone or are bottom-dwellers not adequately sampled by our method of collection, they are not considered further.

Sixteen of the 17 species of swimming invertebrates were found in the surf, but only five were found in the tidal pool. Nearly all of the specimens (491 of 512) and nearly all of the mass of swimming invertebrates (4,291 of 4,300 g) were found in the surf.

All 41 species of fishes collected were found in the surf, but only 16 appeared in the tidal pool. Approximately 54% of the specimens (2,747) were seined in the surf and about 46% (2,348) in the tidal pool. Approximately 74% (12,866 g) of the ichthyomass was caught in the surf and about 26% (4,452 g) in the tidal pool. The mean weight of fishes from the surf was more than twice the mean weight of those from the tidal pool (4.68 to 1.90 g). Larger fishes tend to avoid being trapped in shallow tidal pools as the tide ebbs, whereas smaller individuals may find refuge in these relatively predator-free pools. It is conceivable that these transient pools provide havens that are important to the survival of the fry of species such as *Trachinotus carolinus* and *Mugil curema* and to individuals of most size ranges of *Fundulus majalis* and *Menidia menidia*. Individuals of the latter two species may seek these quiet waters for feeding. Although one of the effects of fishes concentrating in a tidal pool is to make them more vulnerable to some piscivorous birds, the advantages of temporary residence in an isolated pool (protection from predatory fishes and certain birds and the availability of food) may far outweigh this disadvantage. Of the most important species, the fishes *Anchoa mitchilli* and *Menticirrhus littoralis* and the decapod crustacean *Arenaeus cribrarius* were collected almost exclusively in the surf, while the fish *Fundulus majalis* was caught almost entirely in the tidal pool. Table 3 presents summaries of data on collections, size ranges, total weights, temperature, and salinity for fishes and *Arenaeus cribrarius*, and Table 4 presents the monthly size range and number collected per month for fishes and *A. cribrarius*. In both tables *A. cribrarius* is included because it was the only invertebrate species collected in sufficient numbers for analysis. Data on the other swimming invertebrates collected are presented in Table 5.

The numbers of specimens collected were quite small compared with those of some surveys. Our small catches resulted from the difficulties encountered in collecting in the surf and the limitations imposed by our sampling procedure (the absence of replicate tows and collecting sites and the use of a small beach seine). The similarities in the two years in the compositions of the collections and the seasonal trends indicate that our methodology was adequate for giving an estimate of some of the environmental and population parameters of the area.

Comparisons of Yearly and Seasonal Abundance of Fishes

Comparisons of numbers of species and specimens and total weights of fishes are presented in Table 6. These are discussed in this section. In the section on the Analysis of Abundance of Fishes, the statistics of the data given in Table 6 are examined.

Table 1.—List of collections made in the surf during survey of Folly Beach, S.C. (Oct. 1969-Oct. 1971). F = Fish; I = Swimming invertebrates. Plus indicates imcomplete data; dash indicates no data taken; < indicates weights of 0.5 g or less.

Date	Temperature (°C)	Salinity (‰)	No. of species F	No. of species I	No. of specimens F	No. of specimens I	Total weight (g) F	Total weight (g) I
1969								
11 Oct.	24.5	33.0	5	3	25	20	56	354
18 Oct.	21.0	32.8	6	1	77	4	180	135
1 Nov.	17.5	31.2	2	1	3	2	11	39
16 Nov.	11.4	32.9	5	0	54	0	312	0
2 Dec.	11.0	31.4	2	0	3	0	75	0
17 Dec.	9.3	29.0	6	0	195	0	461	0
1970								
2 Jan.	8.8	32.8	4	0	97	0	307	0
15 Jan.	6.7	27.7	7	2	39	6	1,252	39
1 Feb.	7.4	32.2	2	0	47	0	121	0
14 Feb.	8.9	32.1	2	1	58	2	162	<
1 Mar.	9.9	33.2	1	0	15	0	50	0
15 Mar.	11.1	32.6	1	0	9	0	32	0
31 Mar.	15.3	26.4	2	1	130	1	520	5
12 Apr.	16.0	23.2	2	0	14	0	63	0
25 Apr.	21.5	31.8	7	2	37	3	162	14
11 May	22.5	32.6	3	2	7	6	16	103
26 May	23.2	32.6	4	2	12	4	24	—
9 June	23.8	28.0	7	4	21	19	1,294	276
23 June	27.2	31.2	6	1	51	44	188	166+
11 July	26.7	31.2	9	4	45	8	96	16+
25 July	28.3	35.0	7	2	16	6	289	207+
8 Aug.	26.0	32.3	3	1	25	79	166	56+
24 Aug.	28.6	33.9	6	2	21	13	102	7
9 Sept.	25.6	30.2	5	2	15	8	58	108
23 Sept.	26.9	29.6	5	1	113	2	2,045	2+
10 Oct.	23.0	31.2	3	1	7	3	8	31+
24 Oct.	20.4	31.2	5	1	46	8	486	16
7 Nov.	15.3	32.3	9	0	71	0	193	0
22 Nov.	14.6	29.1	2	1	4	1	19	<
6 Dec.	13.0	29.6	4	0	74	0	229	0
22 Dec.	13.3	34.5	2	0	2	0	7	0
1971								
4 Jan.	10.2	28.0	1	0	8	0	26	0
21 Jan.	6.4	31.2	6	1	310	1	571	<
6 Feb.	9.0	27.0	5	0	244	0	626	0
20 Feb.	10.8	26.4	3	0	132	0	472	0
8 Mar.	10.9	30.2	5	1	39	1	63	—
21 Mar.	11.0	31.8	4	2	78	6	156	13
6 Apr.	14.2	30.2	5	2	13	10	186	22
17 Apr.	15.3	31.2	5	2	34	4	184	80
2 May	19.0	28.0	5	4	14	10	212	95
16 May	21.1	28.0	3	2	3	11	29	152
30 May	21.6	29.1	6	1	15	1	21	19
14 June	24.9	33.4	7	1	81	9	293	165
28 June	27.2	32.8	4	3	28	8	85	204
16 July	27.4	33.4	7	6	80	47	128	446
30 July	27.8	31.5	6	2	66	13	126	19
13 Aug.	26.8	29.6	9	1	38	1	206	1
28 Aug.	27.0	32.3	4	1	41	34	112	341
12 Sept.	26.2	32.8	8	5	161	61	319+	655
26 Sept.	24.2	29.2	3	1	12	5	14	67
10 Oct.	23.5	27.5	5	2	17	30	53+	438

Surf.—More species and more specimens of fishes were caught in the surf during the second year than in the first year, but the weight of fishes caught in the second year was only 60% of those caught in the first year (see Table 6). A considerable portion of this difference was due to the capture during the first year of 20 *Mugil cephalus* with a total weight in excess of 1.5 kg and a single specimen of *Pogonias cromis* which weighed more than 1.2 kg.

Comparisons of seasonal catches between the two years show close similarities in numbers of species in corresponding seasons except summer. The summer of the second year produced almost half again as many species as that of the first year. Winter, spring, and summer in

Table 2.—List of collections made in the tidal pool (when present) during survey of Folly Beach, S.C. (Oct. 1969-Oct. 1971). F = Fish; I = Swimming invertebrates. Plus indicates incomplete data; dash indicates no data taken; < indicates weights of 0.5 g or less.

Date	Temperature (°C)	Salinity (‰)	No. of species		No. of specimens		Total weight (g)	
			F	I	F	I	F	I
1969								
11 Oct.	26.8	—	6	1	130	2	365+	<
18 Oct.	17.0	—	5	0	14	0	38	0
16 Nov.	11.2	32.0	1	0	14	0	41	0
2 Dec.	10.8	32.0	3	1	58	12	809	—
17 Dec.	7.9	28.1	1	0	1	0	5	0
1970								
2 Jan.	8.0	32.5	1	0	5	0	22	0
15 Jan.	6.2	26.2	1	0	4	0	16	0
1 Feb.	7.3	30.7	0	0	0	0	0	0
15 Mar.	8.4	32.4	1	0	5	0	21	0
11 May	21.6	31.6	3	0	76	0	268	0
26 May	21.1	31.8	6	0	251	0	817	0
9 June	22.8	28.0	7	0	759	0	295	0
23 June	24.8	28.0	3	1	366	1	236	7
11 July	23.4	28.5	4	1	73	1	215	<
25 July	26.3	32.3	2	1	5	1	9	1
8 Aug.	24.6	30.7	4	1	159	1	239	<
9 Sept.	24.2	29.6	2	0	3	0	5	0
23 Sept.	25.6	28.5	1	0	5	0	1	0
10 Oct.	24.3	31.2	3	0	51	0	1	0
7 Nov.	14.6	31.2	5	0	52	0	149	0
22 Nov.	14.2	31.2	2	0	132	0	461	0
6 Dec.	10.7	29.6	0	0	0	0	0	0
22 Dec.	14.0	32.3	1	0	50	0	218	0
1971								
4 Jan.	11.2	25.8	3	0	17	0	67	0
21 Jan.	3.7	28.5	0	0	0	0	0	0
6 Feb.	11.0	27.0	1	0	1	0	<	0
17 Apr.	14.9	30.2	3	0	49	0	14	0
2 May	18.0	25.8	1	0	4	0	14	0
16 May	19.8	28.0	1	0	4	0	13	0
30 May	18.5	29.1	0	0	0	0	0	0
14 June	24.0	33.4	0	0	0	0	0	0
28 June	25.1	31.2	0	0	0	0	0	0
16 July	24.5	31.2	0	0	0	0	0	0
13 Aug.	24.2	29.6	0	0	0	0	0	0
12 Sept.	25.5	32.3	4	1	46	1	73	—
10 Oct.	23.0	28.0	4	1	14	2	28	1

the second year each yielded more specimens than in the first year, with winter and summer each being a great deal more productive. In each season of the first year a greater total mass of fishes was collected than in the same season in the second year.

A comparison of data for seasons for both years combined shows that more species were caught in summer than in any other season and that diversity was least in winter. In contrast, most specimens and greatest mass were obtained in winter, whereas the least number of individuals and smallest mass appeared in the spring and fall catches, respectively. For the most part, the individual years followed the same pattern. The high diversity in the warmer months was expected, but the large number of individuals and great mass caught during the winter was not anticipated. The large winter catch, relative to other seasons, may be due to at least two factors—motility and preferences for particular temperature regimes. Most of the larger, faster fishes that were caught in cold water could have easily avoided the seine when the water was warm. *Menidia menidia*, the most abundant species, was caught over a wide range of temperature (6.4°-28.3°C), but was most plentiful at the lower end of that range, whereas *Trachinotus carolinus* and *Mugil curema* (two of the most common species of fishes) were not collected at temperatures less than 14.6° and 14.9°C, respectively.

Tidal pool.—More species, more individuals, and greater mass of fishes were collected in the tidal pool during the first year than in the second year (see Table 6). These differences appear to be largely due to chance. A tidal pool was present on 18 of the collecting days each year, but only 1 of the 18 yielded no fishes or invertebrates in the first year; in contrast 7 produced no specimens in the second year. The absence of fishes from a particular collection in the tidal pool was apparently not entirely related to temperature because three collections which produced none were made in December, January, and February (water temperature: 3.7-10.7°C)

Table 3.—Summary data for *Arenaeus cribrarius* and fishes collected during survey of Folly Beach, S.C. (Oct. 1969-Oct. 1971).

Species	Number collected and times (in parentheses) surf	tidal pool	total	Size range (mm SL)	Total weight (g)	Temperature range (°C)	Salinity range (°/₀₀)
Portunidae (Decapoda, Crustacea)							
Arenaeus cribrarius	417(32)	5(3)	422(35)	[1]7-141	3,218+	11.0-28.6	27.5-35.0
Elopidae							
Elops saurus	1(1)	0	1(1)	220	111	26.2	32.8
Clupeidae							
Alosa aestivalis	22(5)	0	22(5)	42-62	29	6.4-10.9	27.7-32.8
Brevoortia smithi	1(1)	0	1(1)	89	13	6.7	27.7
Brevoortia tyrannus	18(3)	0	18(3)	49-99	87	6.4-9.3	27.0-31.2
Dorosoma petenense	1(1)	0	1(1)	73	7	28.6	33.9
Opisthonema oglinum	15(1)	0	15(1)	63-80	78	26.8	29.6
Engraulidae							
Anchoa hepsetus	22(7)	3(1)	25(8)	36-78	70	15.3-28.6	29.6-33.9
Anchoa mitchilli	362(29)	10(1)	372(30)	20-60	365	6.4-28.6	27.5-35.0
Ariidae							
Arius felis	1(1)	1(1)	2(2)	229-237	347	19.0-23.4	28.0-28.5
Cyprinodontidae							
Cyprinodon variegatus	2(1)	2(2)	4(3)	26-32	4	9.3-11.2	25.8-32.0
Fundulus heteroclitus	1(1)	3(1)	4(2)	25-38	3	11.4-14.6	31.2-32.9
Fundulus majalis	3(3)	341(15)	344(18)	26-84	744	6.2-26.8	25.8-33.0
Fundulus sp.	0	2(2)	2(2)	57	8	6.2-22.8	26.2-28.0
Atherinidae							
Membras martinica	14(8)	0	14(8)	44-83	42	9.0-26.8	23.2-33.4
Menidia beryllina	22(10)	4(4)	26(14)	46-75	53	6.4-22.8	26.4-32.9
Menidia menidia	1,485(36)	630(18)	2,115(54)	21-89	6,226	6.4-28.3	23.2-35.0
Pomatomidae							
Pomatomus saltatrix	2(2)	0	2(2)	93-122	38	23.8-26.7	28.0-31.2
Carangidae							
Caranx hippos	2(2)	0	2(2)	28-34	2	26.8-28.3	29.6-35.0
Chloroscombrus chrysurus	6(3)	0	6(3)	20-54	6	26.2-27.8	29.6-32.8
Trachinotus carolinus	266(29)	710(13)	976(42)	12-93	1,519	14.6-28.6	27.5-35.0
Trachinotus falcatus	7(5)	41(7)	48(12)	12-59	47	15.3-26.8	28.0-33.0
Trachinotus goodei	4(3)	0	4(3)	18-91	23	21.0-26.0	31.2-32.8
Gerreidae							
Eucinostomus sp.	1(1)	2(1)	3(2)	14-28	1	24.3-24.5	31.2-33.0
Sparidae							
Archosargus probatocephalus	1(1)	0	1(1)	118	70	6.7	27.7
Sciaenidae							
Bairdiella chrysura	1(1)	0	1(1)	93	17	15.3	32.3
Larimus fasciatus	4(1)	0	4(1)	15-34	4	26.2	32.8
Leiostomus xanthurus	2(2)	0	2(2)	38-102	26	21.1-21.5	28.0-31.8
Menticirrhus littoralis	291(34)	3(2)	294(36)	19-149	843	6.7-28.6	26.4-35.0
Menticirrhus saxatilis	3(2)	1(1)	4(3)	33-50	5	22.8-27.2	28.0-33.4
Menticirrhus sp.	3(2)	1(1)	4(3)	27-38	2	14.6-26.2	31.2-33.0
Pogonias cromis	1(1)	0	1(1)	328	1,228	23.8	28.0
Stellifer lanceolatus	1(1)	0	1(1)	51	3	14.2	30.2
Mugilidae							
Mugil cephalus	26(8)	47(3)	73(11)	17-328	2,426	6.4-28.3	27.0-35.0
Mugil curema	121(9)	545(7)	666(16)	19-130	2,709	14.9-28.6	28.0-35.0
Scombridae							
Scomberomorus maculatus	1(1)	0	1(1)	106	11	27.4	33.4
Triglidae							
Prionotus sp.	2(2)	0	2(2)	24-26	1	26.2-27.4	32.8-33.4
Bothidae							
Paralichthys squamilentus	17(9)	2(1)	19(10)	34-115	82	15.3-27.4	27.5-33.4
Scophthalmus aquosus	1(1)	0	1(1)	81	14	15.3	32.3
Soleidae							
Trinectes maculatus	1(1)	0	1(1)	100	45	21.5	31.8
Balistidae							
Monacanthus hispidus	6(4)	0	6(4)	16-22	2	15.3-27.0	29.1-32.3
Tetraodontidae							
Sphoeroides maculatus	5(2)	0	5(2)	14-18	2	27.2-27.8	31.5-32.8
Sphoeroides spengleri	1(1)	0	1(1)	16	<1	23.5	27.5
Diodontidae							
Chilomycterus?	2(1)	0	2(1)	12-16	1	27.4	33.4

[1]Carapace width in millimeters.

Table 4.—Number collected per month (in parentheses) and size range (mm SL) for *Arenaeus cribrarius* and fishes collected during survey of Folly Beach, S.C. (Oct. 1969-Oct. 1971).

Species	January	February	March	April	May	June	July	August	September	October	November	December
Portunidae (Decapoda, Crustacea)												
Arenaeus cribrarius[1]	0	0	(1)28	(13)28-98	(25)17-70	(76)21-102	(57)16-140	(126)14-141	(55)7-134	(66)17-103	(3)23-79	0
Elopidae												
Elops saurus	0	0	0	0	0	0	0	0	(1)220	0	0	0
Clupeidae												
Alosa aestivalis	(15)42-55	0	(6)44-62	0	0	0	0	0	0	0	0	(1)49
Brevoortia smithi	(1)89	0	0	0	0	0	0	0	0	0	0	0
Brevoortia tyrannus	(1)83	(1)99	0	0	0	0	0	0	0	0	0	(16)49-69
Dorosoma petenense	0	0	0	0	0	0	0	(1)73	0	0	0	0
Opisthonema oglinum	0	0	0	0	0	0	0	(15)63-80	0	0	0	0
Engraulidae												
Anchoa hepsetus	0	0	0	0	0	0	(8)36-58	(2)61-72	(9)56-69	(3)68-76	(3)72-78	0
Anchoa mitchilli	(5)42-46	0	(33)34-57	(13)39-51	(21)40-59	(45)42-57	(55)32-54	(4)39-46	(126)20-54	(54)32-60	(15)38-52	(1)29
Ariidae												
Arius felis	0	0	0	0	(1)237	0	(1)229	0	0	0	0	0
Cyprinodontidae												
Cyprinodon variegatus	(1)26	0	0	0	0	0	0	0	0	0	0	(3)30-32
Fundulus heteroclitus	0	0	0	0	0	0	0	0	0	0	(4)25-38	0
Fundulus majalis	(5)46-67	(1)38	0	0	(9)63-84	(24)26-74	(58)26-48	(143)31-61	(44)34-62	(2)47-63	(6)49-65	(52)45-81
Fundulus sp.	(1)57	0	0	0	0	(1)57	0	0	0	0	0	0
Atherinidae												
Membras martinica	0	(1)58	(1)44	(2)77-83	0	(2)78-80	(1)69	(2)52-54	(2)56-61	0	0	(3)48-71
Menidia beryllina	(9)52-70	(4)60-75	(3)53-62	(1)73	(2)46-63	(1)65	0	0	0	0	(2)52-61	(4)53-62
Menidia menidia	(423)49-85	(470)51-87	(226)55-89	(58)58-82	(277)57-86	(20)21-84	(4)67-87	(1)31	(1)57	(92)51-73	(248)54-82	(295)47-83
Pomatomidae												
Pomatomus saltatrix	0	0	0	0	0	(1)93	(1)122	0	0	0	0	0
Carangidae												
Caranx hippos	0	0	0	0	0	0	(1)34	(1)28	0	0	0	0
Chloroscombrus chrysurus	0	0	0	0	0	0	(1)20	(4)21-54	(1)34	0	0	0
Trachinotus carolinus	0	0	0	(1)13	(26)14-47	(695)12-75	(59)22-90	(45)19-93	(13)14-61	(121)13-77	(16)34-69	0
Trachinotus falcatus	0	0	0	0	0	(3)14-25	0	(1)52	(5)15-35	(38)12-59	(1)58	0
Trachinotus goodei	0	0	0	0	0	0	0	(1)91	0	(3)18-30	0	0
Gerreidae												
Eucinostomus sp.	0	0	0	0	0	0	0	0	0	(3)14-28	0	0
Sparidae												
Archosargus probatocephalus	(1)118	0	0	0	0	0	0	0	0	0	0	0
Sciaenidae												
Bairdiella chrysura	0	0	0	0	0	0	0	0	0	0	(1)93	0
Larimus fasciatus	0	0	0	0	0	0	0	0	(4)15-34	0	0	0
Leiostomus xanthurus	0	0	0	(1)38	(1)102	0	0	0	0	0	0	0
Menticirrhus littoralis	(1)60	(4)83-145	(5)60-75	(18)46-112	(1)82	(12)26-103	(57)19-149	(54)25-104	(71)22-94	(37)22-76	(29)28-103	(5)62-102
Menticirrhus saxatilis	0	0	0	0	0	(4)33-50	0	0	0	0	0	0
Menticirrhus sp.	0	0	0	0	0	0	0	0	(2)33-38	(1)27	(1)36	0
Pogonias cromis	0	0	0	0	0	(1)328	0	0	0	0	0	0
Stellifer lanceolatus	0	0	0	(1)51	0	0	0	0	0	0	0	0
Mugilidae												
Mugil cephalus	(17)102-229	(1)24	(2)25-26	(47)17-211	0	0	(2)175-198	0	0	0	(1)195	(3)130-328
Mugil curema	0	0	0	(2)20-21	(36)20-25	(492)19-30	(26)21-69	(9)85-100	(75)86-130	(26)20-112	0	0
Scombridae												
Scomberomorus maculatus	0	0	0	0	0	0	(1)106	0	0	0	0	0
Triglidae												
Prionotus sp.	0	0	0	0	0	0	(1)26	0	(1)24	0	0	0

Table 4.—Continued.

Species	January	February	March	April	May	June	July	August	September	October	November	December
Bothidae												
Paralichthys squamilentus	0	0	0	(2)34-38	(11)42-58	(4)46-56	(1)82	0	0	(1)115	0	0
Scophthalmus aquosus	0	0	0	0	0	0	0	0	0	0	(1)81	0
Soleidae												
Trinectes maculatus	0	0	0	(1)100	0	0	0	0	0	0	0	0
Balistidae												
Monacanthus hispidus	0	0	0	0	(1)16	0	(2)16	(1)22	0	0	(2)18-19	0
Tetraodontidae												
Sphoeroides maculatus	0	0	0	0	0	(1)18	(4)14-18	0	0	0	0	0
Sphoeroides spengleri	0	0	0	0	0	0	0	0	0	(1)16	0	0
Diodontidae												
Chilomycterus ?	0	0	0	0	0	0	(2)12-16	0	0	0	0	0

[1]Measurements = carapace width in millimeters.

and five were made in May, June, July, and August (water temperature: 18.5°-25.1°C). Several of the pools from which no specimens were collected were for the most part extremely shallow (0.1 m or less in depth) or were oriented at the seaward end of a groin in a manner which made it impossible to make a good seine haul. Considerable portions of the discrepancies in numbers and weights between the two years were the result of the capture of large numbers of small *Fundulus majalis*, *Trachinotus carolinus*, and *Mugil curema* in the tidal pool during the first year.

Comparisons of seasonal catches between the two years show close similarities in numbers of species in all seasons except spring. The spring of the first year produced 3 times as many species as the spring of the second year. Fall and winter of the second year each yielded more specimens than their counterparts of the first year, but spring and summer of the second year each had very few specimens as compared to the corresponding season in the first year. In each season of the first year except winter a greater mass of fishes was collected than in the same season in the second year.

A comparison of data for seasons for both years combined demonstrates that species diversity was greatest in fall and spring and least in winter, that number of specimens collected was greatest in spring and least in winter, and that greatest mass was obtained in fall and least in winter. Because the first year dominated the combined catch for both years, it followed essentially the same pattern, but the second year differed considerably.

Surf and tidal pool combined.—When the surf and tidal pool were considered as a unit, the second year produced more species, but fewer specimens and less weight than the first year (see Table 6).

Comparisons of seasonal catches between the two years show close similarities in numbers of species in corresponding seasons except summer. The summer of the second year produced almost a third more species than that of the first year. With regard to numbers of specimens, fall and summer of the first year were very similar to the same seasons in the second year, but the winter of the second year produced about twice as many individuals as that of the first year and the spring of the first year 6.5 times as many as that of the second year. In each season of the first year a greater mass of fishes was collected than in the same season of the second year.

A comparison of data for seasons for both years combined shows that more species were caught in summer than in any other season, and that diversity was less in fall and spring and much less in winter. The greatest number of specimens were collected in spring and the least in summer. The greatest mass appeared in winter, but spring produced almost as much and summer and fall were not far behind. The individual years followed different patterns of seasonal distribution.

Comparison of surf with tidal pool.—During both years more species and a greater mass of fishes were

Table 5.—Summary data for swimming invertebrates (except *Arenaeus cribrarius*) collected during survey of Folly Beach, S.C. (Oct. 1969-Oct. 1971).

Species	Number collected and times (in parentheses): surf	tidal pool	total	Season(s) collected: fall	winter	spring	summer	Temperature range (°C)	Salinity range (°/oo)
Cnidaria									
Scyphozoa									
One (?) unidentified species (damaged)	2(2)	0	2(2)		X	X		10.9-19.0	28.0-30.2
Mollusca									
Cephalopoda									
Lolliguncula brevis	1(1)	0	1(1)	X				23.5	27.5
Annelida									
Polychaeta									
Nereis succinea	3(2)	1(1)	4(3)				X	25.5-27.4	32.3-33.4
Arthropoda									
Crustacea									
Isopoda									
Aegathoa oculata	1(1)	0	1(1)				X	28.6	33.9
Decapoda									
Acetes americanus carolinae	3(1)	0	3(1)				X	26.2	32.8
Callinectes ornatus	0	1(1)	1(1)				X	26.3	32.3
Callinectes sapidus	9(8)	12(1)	21(9)	X		X	X	10.8-28.3	28.0-35.0
Emerita talpoida	3(3)	2(2)	5(5)			X	X	19.0-26.7	28.0-31.2
Emerita sp., fragment	1(1)	0	1(1)			X		23.2	32.6
Ogyrides alphaerostris	1(1)	0	1(1)			X		27.2	32.8
Ovalipes ocellatus	14(8)	0	14(8)		X	X		11.0-23.8	26.4-31.8
Palaemonetes pugio	5(3)	0	5(3)		X		X	6.4-26.7	31.2-32.1
Penaeus setiferus	21(4)	0	21(4)		X		X	6.7-27.4	27.7-33.4
Portunus anceps	5(1)	0	5(1)				X	27.4	33.4
Portunus gibbesii	1(1)	0	1(1)				X	27.4	33.4
Trachypenaeus constrictus	1(1)	0	1(1)	X				24.5	33.0
Stomatopoda									
Squilla empusa	2(1)	0	2(1)		X			6.7	27.7
One unidentified species (larva)	1(1)	0	1(1)				X	26.7	31.2

collected in the surf than in the tidal pool (see Table 6). In the first year more specimens were captured in the tidal pool than in the surf, but in the second year the opposite was true. Captures of large numbers of small fishes in the tidal pool during the spring of the first year accounts for most of this variation between years.

Considering the first and second years combined, more species, greater numbers, and a greater mass were collected in the surf than in the tidal pool. In the surf as compared with the tidal pool, species diversity was

Table 6.—Numbers of species and specimens and total weights of fishes (in grams) collected in the surf, tidal pool, and surf and tidal pool combined at Folly Beach, S.C. (Oct. 1969-Oct. 1971).

		Surf: Number species collected[1]	Number specimens collected	Total weight collected	Tidal pool: Number species collected[1]	Number specimens collected	Total weight collected	Surf and tidal pool combined: Number species collected[1]	Number specimens collected	Total weight collected
First year	fall	14	357	1,095	9	217	1,258	16	574	2,353
	winter	9	395	2,445	2	14	58	9	409	2,503
	spring	14	142	1,748	9	1,452	1,617	15	1,594	3,365
	summer	13	235	2,755	6	245	469	16	480	3,224
Total		28	1,129	8,043	14	1,928	3,402	29	3,057	11,445
Second year	fall	12	204	942	8	285	842	17	489	1,784
	winter	8	811	1,914	4	18	67	11	829	1,981
	spring	14	188	1,010	3	57	40	14	245	1,050
	summer	19	415	957	5	60	101	21	475	1,058
Total		31	1,618	4,823	11	420	1,050	35	2,038	5,873
First and second years comb.	fall	20	561	2,037	11	502	2,100	20	1,063	4,137
	winter	11	1,206	4,359	4	32	125	12	1,238	4,484
	spring	19	330	2,758	10	1,509	1,657	20	1,839	4,415
	summer	24	650	3,712	6	305	570	26	955	4,282
Total		41	2,747	12,866	16	2,348	4,452	41	5,095	17,318

[1]Total figure accounts for only one occurrence of each species.

greater in all seasons, number of specimens was larger in all seasons except spring, and mass was greater in all seasons except fall. The seasonal patterns for the individual years were quite similar to the preceding.

The surf zone and tidal pool are related, but quite different habitats. Their ecological relationship can be described as that of a severe, but seasonally relatively stable, environment (the surf zone) with a depauperate fauna which "regularly" contributes segments of its populations in a partly random fashion to a transient, unstable environment (the tidal pool) which reappears at predictable intervals unless certain conditions, whose appearances are largely unpredictable, intervene.

Analysis of Abundance of Fishes

Abundance in terms of numbers of species and specimens and total weight per collection was analyzed by season, year, and sampling location. A two-factor randomized complete-block design was used as the experimental model for each of the dependent variables of interest: number of species, number of specimens, and total weight of fishes per collection. Analysis of variance was employed for each of the three dependent variables in testing the null hypothesis that the effects of sampling location (factor 1, 2 levels; surf, tidal pool), season (factor 2, 4 levels; fall, winter, spring, summer), interaction between sampling location and season, and year (block, 2 levels; October 1969 through September 1970, October 1970 through September 1971) were nonsignificant. Throughout "nonsignificant" means $P>0.05$; "significant," $0.01<P<0.05$; and "highly significant," $P<0.01$. The number of collections (observations) made for the various treatment combinations was:

	Fall	*Winter*	*Spring*	*Summer*
Year 1:				
Surf	6	7	6	6
Tidal pool	5	4	4	5
Year 2:				
Surf	6	6	7	6
Tidal pool	5	3	6	3

It should be noted that the surf and tidal pool collections made on 10 October 1971 (the start of a third year) were not included in these analyses. Because the cell frequencies were unequal, an unweighted-means analysis was used as the computational procedure with the harmonic mean ($\bar{n}_h = 4.97$) of the number of observations being used as the effective number of observations per cell for computation of main effects and interactions (Winer 1962).

One of the underlying assumptions of the analysis of variance is that of homogeneity of variance. Each set of data was examined for correlation between treatment means and their within-treatment variances. This examination suggested transformations producing homogeneity. An analysis of variance was then conducted.

The within-cell means and variances of the number of species per collection for the various treatment combinations were examined for correlations, but none were found. The within-cell variances for the number of species per collection ranged from 0.25 to 6.97. Bartlett's test for homogeneity of variance gave a χ^2 value of 11.04 for 15 df which was not significant. We then proceeded with the analysis of variance on the original data, X = number of species of fishes per collection.

Similar examinations were conducted for the number of specimens and total weight of fishes per collection. In both cases it was apparent that the variances were proportional to the means and were also heterogeneous. Bartlett's test was employed to test the hypothesis of equal within-cell variances for both the number of specimens and total weight of fishes per collection. The results of Bartlett's test were $\chi^2_{15\mathrm{df}} = 93.19$ and $\chi^2_{15\mathrm{df}} = 99.78$, respectively. Both χ^2 values were highly significant and we therefore rejected the hypothesis of homogeneity. It appeared that the heterogeneity was of the regular type for both the number of specimens and total weight of fishes per collection, i.e., the variability within the several treatments was proportional to the treatment means. For this reason the logarithmic transformation, log $(X + 1)$, was used to make the means and variances independent and to stabilize the within-cell variances. The logarithmic transformation was made on the number of specimens of fishes per collection, and Bartlett's test was conducted to determine if this transformation homogenized the variances. The result of Bartlett's test on the within-cell variances for X = log (number of specimens of fishes per collection + 1) was $\chi^2_{15\mathrm{df}} = 13.78$. Since this was nonsignificant and it appeared that no relationship remained between the means and variances of the transformed data, we then conducted the analysis of variance on the transformed data, X = log (number of specimens of fishes per collection + 1). The logarithmic transformation was also used for the total weight of fishes per collection. Bartlett's test resulted in $\chi^2_{15\mathrm{df}} = 12.85$ for the within-cell variances of the transformed data. This was nonsignificant and the analysis of variance was then conducted on the transformed data, X = log (total weight of fishes per collection + 1).

The results of the analysis of variance for the number of species of fishes per collection (Table 7) indicate that the block or year effect is not significant. The nonsignificant location-by-season interaction shown in Table 7 indicates that the surf and tidal pool differences in number of species per collection are constant across season. The location-by-season means of number of species of fishes

Table 7.—Analysis of variance of X = number of species of fishes per collection. (* Significant, $P<0.05$; ** highly significant, $P<0.01$; ns not significant, $P>0.05$.)

Source	SS	df	MS	F
Blocks (years)	4.92	1	4.92	1.248 ns
Location	124.85	1	124.85	31.669 **
Season	39.60	3	13.20	3.348 *
Location by season	17.04	3	5.68	1.441 ns
Error	299.61	76	3.94	
Total	486.02	84		

per collection averaged over both years are (number of collections in parentheses):

	Fall	Winter	Spring	Summer	Overall
Surf	4.25(12)	3.31(13)	4.92(13)	6.00(12)	4.60(50)
Tidal pool	2.70(10)	1.00(7)	2.40(10)	2.12(8)	2.14(35)
Overall	3.55(22)	2.50(20)	3.82(23)	4.45(20)	3.59(85)

The surf and tidal pool collections differ significantly with respect to number of species per collection when averaged over both years and all seasons (Table 7). The results of the analysis of variance also indicate a significant seasonal effect. Student-Newman-Keuls' test was used to determine which of the overall seasonal means were significantly different (Sokal and Rohlf 1969). The results indicate that only winter and summer differ significantly in number of species per collection; all other comparisons were nonsignificant.

The results of the analysis of variance for the number of specimens per collection are presented in Table 8, indicating that neither the year effect nor the main effect of season is significant. On the other hand, both the main effect of location and the location-by-season interaction are highly significant. The back-transformed location-by-season means (means expressed in the original units of measurement) for both years combined are (number of collections in parentheses):

Table 8.—Analysis of variance for X = log (number of specimens of fishes per collection + 1). (Highly significant, $P < 0.01$; ns not significant, $P > 0.05$.)**

Source	SS	df	MS	F
Blocks (years)	1.4906	1	1.4906	3.565 ns
Location	3.5807	1	3.5807	8.563 **
Season	0.6739	3	0.2246	0.537 ns
Location by season	6.4340	3	2.1447	5.129 **
Error	31.7783	76	0.4181	
Total	43.9575	84		

	Fall	Winter	Spring	Summer
Surf	20.66(12)	56.00(13)	18.88(13)	38.69(12)
Tidal pool	23.02(10)	2.50(7)	18.19(10)	8.84(8)

In view of the highly significant interaction of location and season, an examination of this interaction was undertaken to determine location differences within season; results of t-tests for surf versus tidal pool are: fall 0.16, $P > 0.05$; winter 4.00, $P < 0.01$; spring 0.06, $P > 0.05$; summer 2.05, $P < 0.05$. These single degree-of-freedom comparisons are not independent, but are warranted because the interaction is highly significant. They indicate that there is a highly significant difference between the average number of specimens per collection in the surf and the average number of specimens per collection in the tidal pool for those collections made in winter, a significant difference for summer, and a nonsignificant difference for both fall and spring.

Table 9 gives the results of the analysis of variance for total weight per collection which indicate a highly significant difference between years for the total weight of fishes per collection. This is due in part to the capture during the first year of 20 *Mugil cephalus* with a total weight in excess of 1.5 kg and a single specimen of *Pogonias cromis* which weighed more than 1.2 kg. A variation in seining technique (see section on Materials and Methods) may have contributed to the capture of these large specimens because two short tows may have been more effective in collecting large individuals than a single long tow. The main effect of season is not significant. Both the main effect of location and the location-by-season interaction were found to be significant. The back-transformed location-by-season means (in grams) for both years combined are (number of collections in parentheses):

Table 9.—Analysis of variance for X = log (total weight of fishes per collection + 1). (*Significant, $P < 0.05$; **highly significant, $P < 0.01$; ns not significant, $P > 0.05$.)

Source	SS	df	MS	F
Blocks (years)	4.4421	1	4.4421	8.288 **
Location	12.5504	1	12.5504	23.416 **
Season	1.2729	3	0.4243	0.792 ns
Location by season	5.8823	3	1.9608	3.658 *
Error	40.7355	76	0.5360	
Total	64.8832	84		

	Fall	Winter	Spring	Summer
Surf	75.87(12)	184.60(13)	101.24(13)	146.66(12)
Tidal pool	59.56(10)	5.84(7)	22.37(10)	11.34(8)

Single degree-of-freedom comparisons of location differences within season show that the surf does not differ significantly from the tidal pool for those collections made in the fall, but surf and tidal pool collections differ significantly for each of the other seasons with respect to the average total weight of fishes per collection (results of t-tests are: fall 0.33, $P > 0.05$; winter 4.18, $P < 0.01$; spring 2.08, $P < 0.05$; summer 3.23, $P < 0.01$).

Ranking of Species

The more common species (represented by at least 100 specimens) were *Arenaeus cribrarius*, *Anchoa mitchilli*, *Fundulus majalis*, *Menidia menidia*, *Trachinotus carolinus*, *Menticirrhus littoralis*, and *Mugil curema*. The six species of fishes accounted for 94% of the specimens of fishes collected (4,767 of 5,095) and 72% of the ichthyomass (12,406 of 17,318 g). One species, *Areneaus cribrarius*, made up 82% of the swimming invertebrate specimens (422 of 512) and 75% of the mass of swimming invertebrates (3,218 of 4,300 g). These species were ranked to determine their relative importance. Of the seven most important species, one (*F. majalis*) was not a significant part of the catch in the surf, and three (*A. cribrarius*, *A. mitchilli*, and *M. littoralis*) were of little consequence in the tidal pool.

We developed a seasonal index to allow ordering of species by seasonal occurrence. It is defined as:

$$\text{Seasonal index} = 1 + \log N \cdot \sum_{i=1}^{4} \frac{D_i\, C_i}{M_i}$$

where N = total number collected,
D_i = days collected in the i^{th} season,
C_i = months collected in the i^{th} season,
M_i = number of months in the i^{th} season.

Although arbitrary in its design, this index does contain the elements implicit in the meaning of seasonality, and the lower the seasonal index for a species the more seasonal is its occurrence.

Species were ranked by number of specimens, frequency of appearance (number of days collected), weight, and seasonality (seasonal index). For each of these categories the values were ordered and the highest value was given a rank of one, the second highest a rank of two, etc. In determining rank of importance, the individual ranks for each species were weighted equally and summed. The ordered sums were then ranked as "importance" (Table 10). In the surf and tidal pool combined, *M. menidia* was the most important species, followed by *A. cribrarius*, *T. carolinus*, *M. littoralis* and *M. curema*, *A. mitchilli*, and *F. majalis*.

Relationships Between Environmental Variables and Occurrence

A major objective of this study was to determine the relationships of the occurrence of the fauna to certain environmental variables using multiple regression techniques. The collections made in the surf were chosen for more detailed analyses. Effects of environmental variables on collections made in the tidal pool were not examined because conditions at the time of pool formation were not known.

Five of the most important species in the surf were selected to determine which environmental variables are important to their occurrence. The species chosen were *Arenaeus cribrarius*, *Anchoa mitchilli*, *Menidia menidia*, *Trachinotus carolinus*, and *Menticirrhus littoralis*. *Mugil curema* was not chosen because it was present in only 9 of the 51 surf collections. Five variables (duration of effort, water temperature, salinity, height of sea, and visibility of Secchi disc) were chosen for analysis. We used stepwise regression techniques to choose the "best" equation (Draper and Smith 1966) for each of the five selected species in the following manner:

1. Occurrence was plotted versus environmental variables and the data were linearized, where necessary;
2. Simple correlation coefficients between occurrence and the environmental variables were computed;
3. Using the multiple regression model, $Y = \beta + \beta_1 Z_1 + \beta_2 Z_2 + \ldots + \beta_p Z_p + \epsilon$, where Y = occurrence, and Z_i is some function of one of the five selected environmental variables, $X_1, X_2, \ldots, X_5$, a stepwise regression was preformed to identify those parameters which account for the attributable variations in the model; and
4. For each final regression equation residuals were analyzed.

Variation within months, which we did not consider significant, was removed by using monthly averages for all data. Only temperature showed a marked seasonal effect. The mean number of specimens per collection was plotted for each species versus mean water temperature (by months). The pattern for *A. cribrarius* (Fig. 1) was typical of all species except *M. menidia* (Fig. 2). *Menidia menidia* was much more abundant at the lower water temperatures, while the converse was true for the other species. Figures 1 and 2 indicate the possible utility of the square of water temperature as an additional independent variable because the relationships appear to be curvilinear functions.

Table 10.—Rank of the seven most important species collected during Folly Beach survey (Oct. 1969-Oct. 1971). Ranks are in parentheses. Appearance equals number of days collected (because of this the number of days collected in surf and tidal pool combined does not equal number of days collected in surf plus number of days collected in tidal pool).

	Species	Number	Appearance	Weight (g)	Seasonal index	Sum of ranks	Importance
Surf:	*Menidia menidia*	1,485(1)	36(1)	4,025(1)	109.7(1)	4	1
	Arenaeus cribrarius	417(2)	32(3)	3,209(2)	76.6(2)	9	2
	Menticirrhus littoralis	291(4)	34(2)	831(5)	72.9(3)	14	3
	Anchoa mitchilli	362(3)	29(4.5)	350(6)	63.7(4)	17.5	4
	Trachinotus carolinus	266(5)	29(4.5)	1,018(4)	62.0(5)	18.5	5
	Mugil curema	121(6)	9(6)	2,591(3)	11.7(6)	21	6
Tidal pool:	*Menidia menidia*	630(2)	18(1)	2,201(1)	31.2(1)	5	1
	Trachinotus carolinus	710(1)	13(3)	501(3)	21.8(2)	9	2
	Fundulus majalis	341(4)	15(2)	734(2)	20.9(3)	11	3
	Mugil curema	545(3)	7(4)	118(4)	8.5(4)	15	4
Surf and tidal pool combined:	*Menidia menidia*	2,115(1)	40(1)	6,226(1)	126.9(1)	4	1
	Arenaeus cribrarius	422(4)	35(2)	3,218(2)	76.7(2)	10	2
	Trachinotus carolinus	976(2)	29(5)	1,519(4)	76.2(3)	14	3
	Menticirrhus littoralis	294(7)	34(3)	843(5)	73.0(4)	19	4.5
	Mugil curema	666(3)	14(7)	2,709(3)	29.2(6)	19	4.5
	Anchoa mitchilli	372(5)	30(4)	365(7)	66.5(5)	21	6
	Fundulus majalis	344(6)	16(6)	744(6)	23.0(7)	25	7

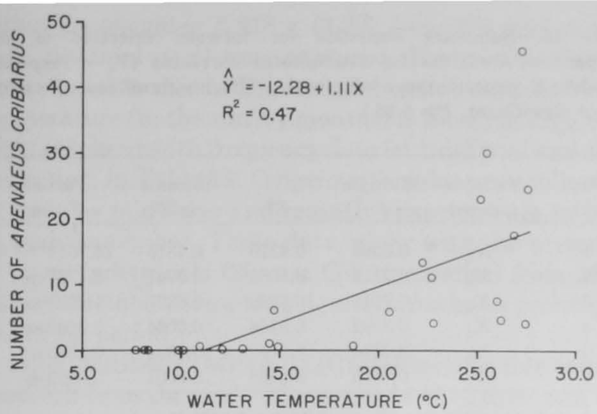

Figure 1.—Mean number of *Arenaeus cribrarius* per collection versus mean water temperature for surf collections (by months).

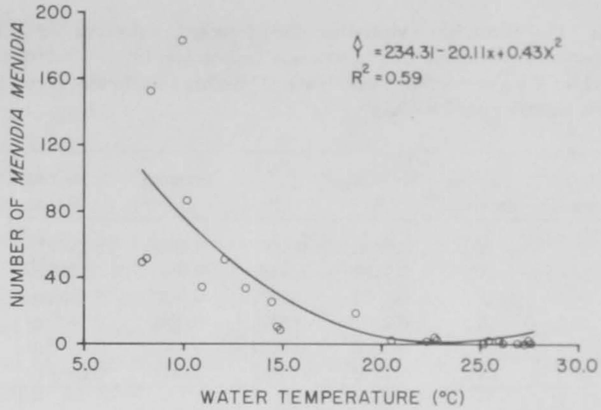

Figure 2.—Mean number of *Menidia menidia* per collection versus mean water temperature for surf collections (by months).

Simple correlation coefficients of monthly averages of environmental variables and monthly average number of specimens per collection in the surf are given in Table 11. Water temperature and its square correlated significantly with number of specimens for all species. Height of sea was significantly correlated with occurrence for *A. mitchilli* and *M. littoralis*. A significant negative correlation existed between salinity and number of specimens for *M. menidia*. No other correlations were significant.

Stepwise regression was then undertaken for each species. The list of variables and notation used is contained in Table 12. In addition to the stepwise procedure, all independent variables were forced to enter the equation (forward selection) to assess the percentage reduction of the sum of squares of deviations of Y from its mean attributed to regression.

An examination of residuals ($e_i = Y_i - \hat{Y}_i$) was conducted using the methods of Draper and Smith (1966). In conducting the regression analyses, assumptions were made about e_i: errors were independent, had zero mean and a constant variance, and followed a normal distribution. Residuals were examined to see if these assumptions were violated and to suggest possible transformations of the variables (e.g., squares and cross products of the independent variables). Residuals for the final equations selected for each species were plotted overall, in time sequence, against the fitted values $\hat{Y}_i$, and against the independent variables X_{ji}, for $j = 1, 2, \ldots, k$. Our assumptions apparently were not violated, with one exception. There appeared to be a time sequence effect for some species when the residuals were ordered by month, i.e., long runs of positive residuals followed by runs of negative residuals. A one-sample runs test was used to examine this time sequence effect. Results were not significant. It was concluded that our final equations did not violate the assumptions and no other transformations seemed relevant.

Table 12.—List of variables and notation for stepwise multiple regression.

Response variables Monthly average number of specimens per collection in the surf		Independent variables Monthly average in the surf	
Y_1	*Arenaeus cribrarius*	X_1	duration of effort (min)
Y_2	*Anchoa mitchilli*	X_2	water temperature (°C)
Y_3	*Menidia menidia*	X_3	salinity (°/₀₀)
Y_4	*Trachinotus carolinus*	X_4	height of sea (m)
Y_5	*Menticirrhus littoralis*	X_5	visibility of Secchi disc (m)
		X_6	square of water temperature

The summary statistics for the forward selection of six independent variables are given in Tables 13 through 17 along with the final equation selected by the stepwise procedure.

Water temperature (or the square of water temperature) was more highly correlated with occurrence than any of the other independent variables (Table 11). The stepwise procedure was modified to enter water temperature before its square. This modification had little effect on the results because the correlation between water temperature and its square was high ($r = 0.992$).

Table 11.—Simple correlation coefficients of monthly averages ($N = 24$) of environmental variables and monthly average number of specimens per collection in the surf for five selected species. (*Significant correlation, $P < 0.05$; **highly significant correlation, $P < 0.01$.)

Species	Duration (min)	Water temperature (°C)	Salinity (‰)	Height of sea (m)	Visibility of Secchi disc (m)	Square of water temperature (°C)²
Arenaeus cribrarius	0.080	0.683**	0.275	0.296	0.082	0.706**
Anchoa mitchilli	−0.104	0.405*	0.242	0.402*	−0.329	0.405*
Menidia menidia	−0.232	−0.711**	−0.495*	−0.167	0.056	−0.667**
Trachinotus carolinus	0.237	0.657**	0.370	0.002	0.149	0.674**
Menticirrhus littoralis	−0.219	0.497*	0.208	0.464*	−0.113	0.506*

Table 13.—Summary statistics for forward selection of six independent variables for *Arenaeus cribrarius* (Y_1 = response variable; R = correlation coefficient). (**Highly significant, $P<0.01$; ns not significant, $P>0.05$.)

Step number	Variable entered	Multiple R	R^2	Increase in R^2	Partial F-test
1	X_2	0.6830	0.4665	0.4665	19.2372**
2	X_6	0.7199	0.5182	0.0517	2.2557 ns
3	X_1	0.7273	0.5290	0.0107	0.4558 ns
4	X_5	0.7301	0.5330	0.0040	0.1627 ns
5	X_3	0.7309	0.5343	0.0013	0.0494 ns
6	X_4	0.7310	0.5343	0.0000	0.0011 ns

Step 1 prediction equation: $\hat{Y}_1 = -12.2821 + 1.1120\,X_2$

Table 14.—Summary statistics for forward selection of six independent variables for *Anchoa mitchilli* (Y_2 = response variable; R = correlation coefficient). (*Significant, $P<0.05$; ns not significant, $P>0.05$.)

Step number	Variable entered	Multiple R	R^2	Increase in R^2	Partial F-test
1	X_2	0.4046	0.1637	0.1637	4.3065*
2	X_5	0.5740	0.3295	0.1658	5.1926*
3	X_4	0.6063	0.3675	0.0380	1.2030 ns
4	X_3	0.6249	0.3905	0.0230	0.7159 ns
5	X_1	0.6558	0.4301	0.0396	1.2519 ns
6	X_6	0.6596	0.4350	0.0049	0.1471 ns

Step 2 prediction equation: $\hat{Y}_2 = 7.3141 + 0.7816\,X_2 - 34.4694\,X_5$

Table 15.—Summary statistics for forward selection of six independent variables for *Menidia menidia* (Y_3 = response variable; R = correlation coefficient). (*Significant, $P<0.05$; **highly significant, $P<0.01$; ns not significant, $P>0.05$.)

Step number	Variable entered	Multiple R	R^2	Increase in R^2	Partial F-test
1	X_2	0.7105	0.5048	0.5048	22.4299**
2	X_6	0.7694	0.5920	0.0872	4.4892*
3	X_3	0.8409	0.7070	0.1150	7.8503*
4	X_5	0.8553	0.7316	0.0246	1.7395 ns
5	X_4	0.8619	0.7430	0.0113	0.7943 ns
6	X_1	0.8624	0.7437	0.0007	0.0494 ns

Step 3 prediction equation:

$\hat{Y}_3 = 566.8066 - 23.2452\,X_2 - 10.3017\,X_3 + 0.5368\,X_6$

The final regression equation for *M. menidia* contained water temperature, the square of water temperature, and salinity as predictor variables. Water temperature accounted for 50% of the variation in Y due to regression (R^2 = 0.50). The addition of salinity and the square of water temperature as independent variables increased R^2 to 71%. Forcing the addition of the remaining variables increased R^2 to only 74%. For all other species, except *A. mitchilli*, water temperature was the only variable selected. The final regression equation selected for *A. mitchilli* contained water temperature and visibility of Secchi disc as independent variables. The best fit (R^2) was obtained for *M. menidia* (R^2 = 0.71), followed by *A. cribrarius* (R^2 = 0.47), *T. carolinus* (R^2 = 0.43), *A. mitchilli* (R^2 = 0.33), and *M. littoralis* (R^2 = 0.25).

Table 16.—Summary statistics for forward selection of six independent variables for *Trachinotus carolinus* (Y_4 = response variable; R = correlation coefficient). (**Highly significant, $P<0.01$; ns not significant, $P>0.05$.)

Step number	Variable entered	Multiple R	R^2	Increase in R^2	Partial F-test
1	X_2	0.6569	0.4315	0.4315	16.7013**
2	X_4	0.7115	0.5063	0.0747	3.1787 ns
3	X_6	0.7348	0.5399	0.0337	1.4634 ns
4	X_3	0.7392	0.5464	0.0064	0.2698 ns
5	X_5	0.7414	0.5497	0.0034	0.1340 ns
6	X_1	0.7415	0.5498	0.0001	0.0029 ns

Step 1 prediction equation: $\hat{Y}_4 = -7.6441 + 0.7025\,X_2$

Table 17.—Summary statistics for forward selection of six independent variables for *Menticirrhus littoralis* (Y_5 = response variable; R = correlation coefficient). (*Significant, $P<0.05$; ns not significant, $P>0.05$.)

Step number	Variable entered	Multiple R	R^2	Increase in R^2	Partial F-test
1	X_2	0.4969	0.2469	0.2469	7.2144*
2	X_1	0.5909	0.3492	0.1022	3.2991 ns
3	X_4	0.6372	0.4060	0.0568	1.9124 ns
4	X_3	0.6697	0.4485	0.0426	1.4664 ns
5	X_6	0.6835	0.4672	0.0187	0.6313 ns
6	X_5	0.6993	0.4890	0.0218	0.7249 ns

Step 1 prediction equation: $\hat{Y}_5 = -4.6371 + 0.5718\,X_2$

Ordering the regression equations on the basis of R^2 for the five selected species resulted in the same ranking as the "importance" for surf and tidal pool combined (Table 10) with the exception of a reversal of order between *A. mitchilli* and *M. littoralis*.

Livingston et al. (1976) performed similar regression analyses for species collected in a study of Apalachicola Bay, Fla. The only species analyzed in both their study and ours was *Anchoa mitchilli*. Of the independent variables examined for this species by Livingston et al. only chlorophyll a and visibility of Secchi disc were significant contributors to R^2 (with chlorophyll a being more important). Their R^2 for *A. mitchilli* was 0.38. Clarity of water (by visibility of Secchi disc), then, is an important factor in determining the presence of *A. mitchilli*.

Annotated List of Selected Species

The seven species included in the section on ranking and several others are considered below in some detail. Temperature and salinity ranges for these species are presented in Table 3; and numbers and size ranges by month are given in Table 4.

Arenaeus cribrarius (Lamarck) (Crustacea, Decapoda, Portunidae). This species was collected in spring, summer, and fall of both years and in winter (one specimen in March) of the second year. In 35 collections (32 from the surf and 3 from the tidal pool), 422 specimens of 7 to 141 mm CW (417, 7-141 mm CW, from the surf and 5, 17-59 mm CW, from the tidal pool) of *A.*

cribrarius weighing 3,218 g (3,209 from the surf and 9 from the tidal pool) were captured. The relationship of mean number per collection and mean station water temperature (in the surf by months) is shown in Figure 1; and carapace width frequency data for tidal pool and surf combined, in Table 18. Ovigerous females were collected as early as mid-June and recently spawned ones as late as mid-September. These data, along with the presence of small individuals (20 mm CW or smaller) from May through October, show that *A. cribrarius* has a prolonged spawning period.

Alosa aestivalis (Mitchill) (Clupeidae). In five collections (all from the surf), 22 specimens of 42 to 62 mm SL of *Alosa* were collected. As Berry (1964) pointed out, it is difficult to identify small specimens of *Alosa* using any description or key. The characters which appear to be most useful in identifying the species of the Atlantic drainage (*A. sapidissima*, *A. mediocris*, *A. aestivalis*, and *A. pseudoharengus*) are the number of gill rakers on the lower limb of the anterior gill arch and total number of vertebrae (Hildebrand 1963; Berry 1964). Our specimens have lower-limb gill raker counts of 36 to 41 ($\bar{x}$ = 37.82) and vertebral counts of 49 to 51 ($\bar{x}$ = 50.00). The high gill raker counts eliminate *Alosa mediocris* and the low vertebral counts remove *A. sapidissima* from further consideration. According to Hildebrand (1963), *Alosa aestivalis* has 49 to 53 vertebrae, whereas *A. pseudoharengus* has 46 to 50. Both *A. aestivalis* and *A. pseudoharengus* show an increase in number of gill rakers with growth until adult sizes are reached (Hildebrand 1963). Hildebrand (1963) gave lower-limb gill raker counts as follows: *A. aestivalis*, specimens of 30 to 49 mm SL—28 to 36, specimens of 50 to 69 mm SL—30 to 39; *A. pseudoharengus*, specimens of 30 to 49 mm SL—25 to 33, specimens of 50 to 69 mm SL—32 to 36. Our material, then, is more similar to *Alosa aestivalis* (Mitchill) than to *Alosa pseudoharengus* (Wilson). We have, therefore, considered our specimens of *Alosa* as *A. aestivalis*.

Dorosoma petenense (Günther) (Clupeidae). One specimen of 73 mm SL of *Dorosoma petenense* was collected in the surf on 24 August 1970. Although *D. petenense* has been introduced into freshwater reservoirs in the southeast, we have found no record published prior to 1974 of its occurring in the estuarine or marine waters of South Carolina. According to Miller (1963), it has been collected from the Gulf Coast of the United States and southward to northern Guatemala and British Honduras. Donald C. Scott (University of Georgia) stated (pers. commun.) that in addition to its having been introduced into reservoirs in Georgia, there was a native stock of *D. petenense* present at least as far back as 1955 in the Satilla River which drains into the Atlantic, and, at present, it is widespread along the coast having been taken in beach collections at Sapelo and near Brunswick and Savannah. Miller and Jorgenson (1969) reported this species from collections made in the surf at St. Simons Island, Ga. In addition to the specimen collected at Folly Beach, one was collected on 9 February 1970 near Dewees Inlet at the northeast end of the Isle of Palms, in Charleston County (lat. 32°48.8′N, long. 79°43.0′W). Shealy et al. (1974) collected numerous specimens in 1973-74 during a survey of South Carolina's estuaries.

Anchoa mitchilli (Valenciennes) (Engraulidae). This species was collected in all seasons of both years, least commonly in winter. In 30 collections (29 from the surf and 1 from the tidal pool), 372 specimens of 20 to 60 mm SL (362, 20-60 mm SL, from the surf and 10, 47-58 mm SL, from the tidal pool) of *A. mitchilli* weighing 365 g (350 from the surf and 15 from the tidal pool) were collected.

Table 18.—Carapace width frequencies (%) by month for *Arenaeus cribrarius* collected in tidal pool and surf combined during the Folly Beach survey. One specimen of 140.8 mm CW, collected in August 1971, is denoted by an asterisk.

	Carapace width (mm)														
Month	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-110	111-120	121-130	131-140	*N*
1969															
Oct.		13.0		34.8	4.3	8.7	17.4	4.3	13.0		4.3				23
Nov.					50.0			50.0							2
1970															
Apr.				100.0											1
May		12.5	25.0	12.5	12.5	25.0	12.5								8
June		1.7	15.3	42.4	23.7	3.4	11.9	1.7							59
July		25.0	12.5	25.0	12.5	12.5		12.5							8
Aug.		4.4	86.8	8.8											91
Sept.		11.1	33.3	44.4			11.1								9
Oct.		27.3	27.3	18.2	9.1	9.1		9.1							11
Nov.			100.0												1
1971															
Mar.			100.0												1
Apr.			41.7	33.3	8.3		8.3			8.3					12
May			20.0	6.7	13.3		60.0								15
June			46.7	20.0			6.7			20.0	6.7				15
July		20.4	51.0	10.2	10.2	2.0			4.1					2.0	49
Aug.		60.0	20.0	5.7	2.9	2.9	2.9			2.9				2.9*	35
Sept.	4.3	6.5	50.0	23.9	2.2		2.2	2.2	2.2			2.2	2.2	2.2	46
Oct.		3.2		12.9	12.9	35.5	12.9	12.9	6.5	3.2					31
															417

Fundulus majalis (Walbaum) (Cyprinodontidae). Although this species was collected in all seasons of both years except the spring of the second year, 71% of the specimens were obtained during the summer. In 18 collections (3 from the surf and 15 from the tidal pool), 344 specimens of 26 to 84 mm SL (3, 38-67 mm SL, from the surf, and 341, 26-84 mm SL, from the tidal pool) of *F. majalis* weighing 744 g (10 from the surf and 734 from the tidal pool) were collected.

Menidia spp. (Atherinidae). Rubinoff and Shaw (1960) separated *Menidia beryllina* (Cope) collected in Massachusetts from *M. menidia* (Linnaeus) collected in Massachusetts and New York mainly on the basis of number of soft rays in the anal fin. Their 251 specimens of *M. beryllina* had a range of 14 to 19, usually 15 to 17, anal soft rays ($\bar{x}$ = 15.6), whereas their 134 specimens of *M. menidia* had a range of 20 to 29, usually 22 to 25 ($\bar{x}$ = 23.5). In Rubinoff and Shaw's collections only one specimen had 19 anal soft rays and only one had 20. They assigned these specimens to species on the basis of size and total number of lateral scales.

Robbins (1969) examined *M. beryllina* collected from Massachusetts to Vera Cruz, Mexico, and *M. menidia* from Prince Edward Island to northeastern Florida. In 1,952 specimens of *M. beryllina*, he found a range of 12 to 21, usually 15 to 18, anal soft rays ($\bar{x}$ = 16.37), and in 1,504 specimens of *M. menidia* a range of 19 to 29, usually 21 to 26 ($\bar{x}$ = 23.60).

The distribution of counts of anal soft rays for 1,658 of our 2,141 specimens of *Menidia* is:

	N	%
16	1	0.1
17	0	0.0
18	3	0.2
19	16	1.0
20	94	5.7
21	292	17.6
22	511	30.8
23	415	25.0
24	223	13.4
25	85	5.1
26	16	1.0
27	1	0.1
28	1	0.1

Because the distribution appears almost normal there may be only one species of this genus represented in our collections. A contrary interpretation, and the one that we prefer, is that both *Menidia beryllina* and *M. menidia* are present, but due to overlap in ranges of counts of anal soft rays there is no clear line of demarcation between the species using this character. On a number of specimens, representing the entire range of counts of anal fin rays recorded, we counted total vertebrae and lateral scales. These counts were of little help in separating the two species. Weighing the preceding, we arbitrarily considered specimens of *Menidia* with 19 or fewer anal soft rays as *M. beryllina* and those with 20 or more as *M. menidia*.

In 14 collections (10 from the surf and 4 from the tidal pool), 26 specimens of 46 to 75 mm SL (22, 52-75 mm SL, from the surf and 4, 46-65 mm SL, from the tidal pool) of *M. beryllina* weighing 53 g (44 from the surf and 9 from the tidal pool) were obtained. This species was collected in the autumn and winter of both years and in the spring of the first year.

In 54 collections (36 from the surf and 18 from the tidal pool), 2,115 specimens of 21 to 89 mm SL (1,485, 21-89 mm SL, from the surf and 630, 31-86 mm SL, from the tidal pool) of *M. menidia* weighing 6,226 g (4,025 from the surf and 2,201 from the tidal pool) were obtained. This species was collected in all seasons of both years. However, 53% of the specimens were seined in winter and less than 0.5% in summer. The relationship of mean number per collection and mean station water temperature (in the surf by months) is shown in Figure 2. Small individuals of *M. menidia* utilize habitats other than those of the surf zone. Only about 0.4% of the specimens collected were 50 mm SL or smaller (Table 19). We do not believe that the virtual absence of *M. menidia* less than 50 mm SL is an artifact of the collecting method because we collected numbers of small individuals of similarly shaped species. Ripe individuals were noted from late March to early June. Cupka (1972) found sexually mature specimens from mid-March through early June.

Trachinotus carolinus (Linnaeus) (Carangidae). This species was collected in both years in all seasons except winter, but 68% of the specimens were seined in the spring of the first year. Most of those caught in that season were less than 30 mm SL and from the tidal pool (Table 20). Almost 61% of the total number were obtained from the tidal pool on two successive collecting days in June 1970. A prolonged spawning period is indicated for this species because small specimens (22 mm SL or smaller) were caught from mid-April through late October (specimens 14 mm SL or smaller in April, May, June, September, and October). This is similar to the findings of several other authors (Fields 1962; Finucane 1969; Bellinger and Avault 1970; Cupka 1972). In 42 collections (29 from the surf and 13 from the tidal pool), 976 specimens of 12 to 93 mm SL (266, 12-93 mm SL, from the surf and 710, 12-66 mm SL, from the tidal pool) of *T. carolinus* weighing 1,519 g (1,018 from the surf and 501 from the tidal pool) were obtained.

Menticirrhus littoralis (Holbrook) (Sciaenidae). Although this species was collected in all seasons of both years, 62% of the specimens were obtained in summer, but only about 3% in winter. In 36 collections (34 from the surf and 2 from the tidal pool), 294 specimens of 19 to 149 mm SL (291, 19-149 mm SL, from the surf and 3, 31-76 mm SL, from the tidal pool), of *M. littoralis* weighing 843 g (831 from the surf and 12 from the tidal pool) were collected. Hildebrand and Cable (1934) suggested that spawning starts near Cape Lookout, N.C., no later than 1 May and continues into August. The capture of individuals measuring less than 30 mm SL from June through November during our survey indicates a similar situation off South Carolina with spawning probably extending into September (Table 21). Tagatz and Dudley

Table 19.—Standard length frequencies (%) by month for *Menidia menidia* collected in the tidal pool (T) and surf (S) during the Folly Beach survey.

	Standard length (mm)												
	21-30		41-50		51-60		61-70		71-80		81-90		
Month	T	S	T	S	T	S	T	S	T	S	T	S	*N*
1969													
Oct.			1.1		50.0	1.1	37.5	6.8	3.4				88
Nov.					6.3	14.1	15.6	53.1		10.9			64
Dec.				1.3	3.1	38.6	14.9	31.6	5.3	3.9	0.9	0.4	228
1970													
Jan.				1.0	1.0	36.9	1.0	51.5	1.9	5.8	1.0		103
Feb.						20.8		67.3		11.9			101
Mar.						3.8	1.3	46.5	1.9	44.6		1.9	157
Apr.						2.8		36.1		61.1			36
May					3.1		42.0	0.8	51.1	0.4	2.7		262
June							43.8	12.5	31.2	6.3	6.3		16
July								50.0		25.0		25.0	4
Aug.	100.0												1
Oct.								100.0					2
Nov.					11.4	1.6	51.6	3.8	26.6	3.3	1.6		184
Dec.						35.3		55.9		7.4		1.5	67
1971													
Jan.				0.3		49.1	1.9	40.9	2.5	5.0	0.3		320
Feb.						10.6		57.5		30.5		1.4	367
Mar.						23.2		60.9		15.9			69
Apr.						4.5	4.5	36.4	9.1	40.9		4.5	22
May							20.0	26.7	33.3	20.0			15
June		25.0						25.0		50.0			4
Sept.					100.0								1
Oct.					50.0		50.0						2
													2,113

(1961) also reported specimens of similar size taken from June through November near Cape Lookout, N.C.

Mugil cephalus Linnaeus (Mugilidae). Although this species was collected in fall (1969), winter (1970 and 1971), spring (1971), and summer (1970), most specimens were collected in winter (27%) and spring (64%). In 11 collections (8 from the surf and 3 from the tidal pool), 73 specimens of 17 to 328 mm SL (26, 25-229 mm SL from the surf and 47, 17-328 mm SL from the tidal pool) of *M. cephalus* weighing 2,426 g (1,786 from the surf and 640 from the tidal pool) were obtained. Even though *Mugil cephalus* outranks four of the seven most impor-

Table 20.—Standard length frequencies (%) by month for *Trachinotus carolinus* collected in the tidal pool (T) and surf (S) during the Folly Beach survey.

	Standard length (mm)																
	11-20		21-30		31-40		41-50		51-60		61-70		71-80	81-90	91-100	
Month	T	S	T	S	T	S	T	S	T	S	T	S	S	S	S	*N*
1969																
Oct.		1.3	30.7	8.0	17.3	5.3	6.7	6.7	9.3	5.3	5.3	2.7	1.3			75
Nov.						50.0				50.0						2
1970																
May	5.6	5.6	55.5	22.1		5.6		5.6								18
June	37.3	0.3	36.5	1.7	13.0	1.2	3.1	2.0	1.7	0.9		2.0	0.2			646
July			3.0	21.2		21.2	3.0	36.4	3.0	9.1				3.0		33
Aug.		5.9	29.4	5.9	11.8			8.8		14.7		8.8	11.8	2.9		34
Sept.	37.5	12.5	25.0			12.5				12.5						8
Oct.	25.0	5.6	33.3	11.1		13.9		5.6		2.8		2.8				36
Nov.					7.1		28.6	7.1		42.9		14.3				14
1971																
Apr.		100.0														1
May		12.5		62.5		25.0										8
June		4.1		2.0		8.2		18.4		38.8		22.4	6.1			49
July				26.9		23.1		38.5		11.5						26
Aug.				27.3				27.3		9.1		18.2	9.1		9.1	11
Sept.	20.0	20.0	20.0							20.0		20.0				5
Oct.			44.4	11.1			11.1			22.2		11.1				9
																975

Table 21.—Standard length frequencies (%) by month for *Menticirrhus littoralis* collected in the surf during the Folly Beach survey.

Month	Standard length (mm) 11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-110	111-120	141-150	*N*
1969													
Oct.		16.7	27.8	22.2	16.7	5.6	11.1						18
Nov.				50.0	50.0								2
1970													
Jan.					100.0								1
Apr.								100.0					1
June		12.5	50.0		25.0		12.5						8
July	50.0			50.0									2
Aug.			21.1	21.1	36.8	10.5	10.5						19
Sept.		25.0	8.3	33.3	8.3		8.3		16.7				12
Oct.			11.1	33.3	33.3	22.2							9
Nov.		37.0	33.3	18.5	7.4					3.7			27
Dec.						60.0	20.0			20.0			5
1971													
Feb.								25.0	25.0	25.0		25.0	4
Mar.					20.0	60.0	20.0						5
Apr.				23.5	11.8	23.5	5.9	17.6	11.8		5.9		17
May								100.0					1
June			25.0	50.0						25.0			4
July	3.6	23.6	30.9	18.2	5.5	10.9	3.6	1.8				1.8	55
Aug.		17.1	22.9	42.9	11.4	2.9				2.9			35
Sept.		11.9	23.7	30.5	20.3	8.5	5.1						59
Oct.		14.3	71.4	14.3									7
													291

tant species in weight (Table 10), it was not considered with that group because it was represented by a relatively small number of specimens.

Mugil curema Valenciennes (Mugilidae). This species was collected in both years in all seasons except winter. Seventy-nine percent of the specimens (all less than 30 mm SL) were caught in the first spring, whereas 15% (most between 86 and 130 mm SL) were caught during the first summer (Table 22). In 16 collections (9 from the surf and 7 from the tidal pool), 666 specimens of 19 to 130 mm SL (121, 22-130 mm SL, from the surf and 545, 19-73 mm SL, from the tidal pool) of *M. curema* weighing 2,709 g (2,591 from the surf and 118 from the tidal pool) were obtained.

Paralichthys squamilentus Jordan and Gilbert (Bothidae). This species was collected in spring of both years (89% of total), summer of the second year, and in October 1971. In 10 collections (9 from the surf and 1 from the tidal pool), 19 specimens of 34 to 115 mm SL (17, 34-115 mm SL, from the surf and 2, 44-58 mm SL, from the tidal pool) of *P. squamilentus* weighing 82 g (76 from the surf and 6 from the tidal pool) were collected. Bearden (1971) noted that few records of juvenile *Paralichthys squamilentus* have appeared in the

Table 22.—Standard length frequencies (%) by month for *Mugil curema* collected in the tidal pool (T) and surf (S) during the Folly Beach survey.

	Standard length (mm)											
	11-20	21-30		61-70	71-80		81-90	91-100	101-110	111-120	121-130	
Month	T	T	S	S	T	S	S	S	S	S	S	*N*
1969												
Oct.	100.0											1
1970												
May	23.5	76.5										34
June	0.8	99.2										492
July	5.0	75.0	10.0	10.0								20
Aug.								100.0				3
Sept.							2.7	36.0	41.3	18.7	1.3	75
Oct.						8.3	25.0	45.8	12.5	8.3		24
1971												
Apr.	100.0											2
May		100.0										2
July			100.0									6
Aug.							66.7	33.3				6
Oct.					100.0							1
												666

literature. He reported 60 juvenile specimens (25-88 mm SL) of *P. squamilentus* caught in shallow water (0.3-1.3 m) at nine open ocean beach stations in South Carolina in May and June 1969. Cupka (1972) collected two specimens (56-97 mm SL, one in May 1971 and one in August 1971) from the surf zone in South Carolina. Bearden (1971) offered two possible explanations for the appearance of *P. squamilentus* off the beaches of South Carolina in 1969: 1) 1969 may have been a year when spawning was unusually successful, or 2) the juveniles of *P. squamilentus* may have been misidentified or overlooked previously. Because we collected juveniles of *P. squamilentus* in the two succeeding years, the appearance of juveniles of this species in 1969 does not seem unusual. A more plausible interpretation of the data is that the apparent absence of juveniles of *P. squamilentus* in the waters of South Carolina before 1969 is the result for the most part of inadequate collecting.

Sphoeroides spengleri (Bloch) (Tetraodontidae). One specimen, 16 mm SL, of *S. spengleri* was collected from the surf on 10 October 1971. Shipp and Yerger (1969) stated that *S. spengleri* is "Widespread in the western Atlantic and adjacent waters, in shallow water." Our specimen was identified by Robert L. Shipp (University of South Alabama) who wrote one of us (24 March 1972) that *S. spengleri* wanders as far north as Massachusetts and is fairly common at Bermuda, but to his knowledge this is the first record from South Carolina.

Chilomycterus ? (Diodontidae). Two specimens, 12 to 16 mm SL, of a diodontid were collected from the surf on 16 July 1971 after the passage of a tropical storm. These fish resemble *Lyosphaera globosa* as shown in pl. 267 of Jordan and Evermann (1900). According to Fraser-Brunner (1943), *Lyosphaera* is a junior synonym of *Chilomycterus*.

Relationships of Lengths and Lengths to Weight

The relationships of carapace length to carapace width and these measurements to weight are presented in Table 23 for the decapod crustacean *Arenaeus cribrarius*. The relationships of lengths and lengths to weight are presented in Tables 24 through 31 for the following fishes: *Anchoa mitchilli*, *Fundulus majalis*, *Menidia menidia*, *Trachinotus carolinus*, *Trachinotus falcatus*, *Menticirrhus littoralis*, *Mugil cephalus*, and *Mugil curema*. All lengths of fishes were measured from the tip of the snout: standard length, to the structural base of the caudal fin; fork length, to the bifurcation of the caudal fin; and total length, to the distal tip of the longest caudal ray.

Equations of length to length relationships were derived by the method of least squares and are of the form $Y = a + bX$ (where Y = dependent variable or predicted length, a = Y intercept, b = coefficient of regression, and X = independent variable or observed length). Equations of length to weight were also obtained by the method of least squares after a $\log_{10}$ -$\log_{10}$ transformation of the original data, and are of the form $Y = a + bX$ (where Y = log weight and X = log length). This transformation was used to convert the analyses from curvilinear to simple linear regression. For each regression analysis we have included the sum of squares and cross products of deviations for ease of comparison with other data. In Tables 23 through 31 the following notations are used: N = sample size, X = independent variable, Y = dependent variable, a = Y intercept, b = coefficient of regression, r = product-moment correlation coefficient, Σx^2 = sum of squares of deviations of X, Σy^2 = sum of squares of deviations of Y, and Σxy = sum of cross products of deviations of X and Y.

RECOMMENDATIONS

Several ways in which a collecting program such as ours might be improved and provide better sampling and understanding of the area studied are:

1. Collect additional physical data, such as current velocity;
2. Make replicate tows through the collecting site (preserving the material from each tow separately);
3. Establish replicate collecting sites nearby;
4. Use a larger seine for longer tows in deeper water to supplement the collecting;
5. Collect at several stages of the tide, at midday and at night, and during various phases of the moon;
6. Sample for a longer period of time;
7. Make a special effort to gather additional biological data, such as information on spawning, fecundity, food habits, incidence of ectoparasitism; and
8. Use field and laboratory data sheets from which data can be key punched directly without transcription.

A program incorporating the methods used in this study and the above recommendations should provide

Table 23.—Carapace length-carapace width, carapace length-weight, and carapace width-weight regression statistics for N = 352 specimens of *Arenaeus cribrarius*.

X	Y	a	b	r	Σx^2	Σy^2	Σxy
CW	CL	−1.1686	0.4659	0.996	160,001.63990	34,989.03111	74,550.70835
CL	CW	2.7690	2.1307	0.996	34,989.03111	160,001.63990	74,550.70835
log CW	log W	−4.7894	3.3004	0.977	15.95073	181.96342	52.64344
log CL	log W	−3.4380	3.1801	0.983	17.38521	181.96342	55.28680

	CW (mm)	CL (mm)	W (g)
Mean	38.59	16.81	7.99
Range	7.0-140.8	4.0-65.6	0.07-222.9

Table 24.—Length-length and length-weight regression statistics for N = 215 specimens of *Anchoa mitchilli*.

X	Y	a	b	r	Σx^2	Σy^2	Σxy
SL	FL	3.7405	1.0208	0.980	7,021.48493	7,610.26633	7,167.23298
SL	TL	2.3699	1.1657	0.963	7,021.48493	10,290.75656	8,185.22423
FL	SL	−1.7622	0.9418	0.980	7,610.26633	7,021.48493	7,167.23298
FL	TL	−1.0110	1.1243	0.967	7,610.26633	10,290.75656	8,556.17275
TL	SL	1.4286	0.7954	0.963	10,290.75656	7,021.48493	8,185.22423
TL	FL	4.1155	0.8314	0.967	10,290.75656	7,610.26633	8,556.17275
log SL	log W	−6.0330	3.6360	0.951	0.66723	9.75842	2.42602
log FL	log W	−6.4963	3.8170	0.951	0.60589	9.75842	2.31271
log TL	log W	−6.2989	3.6100	0.941	0.66381	9.75842	2.39633

	SL (mm)	FL (mm)	TL (mm)	W (g)
Mean	45.53	50.22	55.45	1.08
Range	27.5-59.9	30.9-64.4	33.4-77.0	0.20-2.78

Table 25.—Length-length and length-weight regression statistics for N = 341 specimens of *Fundulus majalis*.

X	Y	a	b	r	Σx^2	Σy^2	Σxy
SL	TL	1.7211	1.1722	0.999	39,435.90452	54,339.91062	46,226.10678
TL	SL	−1.3361	0.8507	0.999	54,339.91062	39,435.90452	46,226.10678
log SL	log W	−5.1305	3.2532	0.995	3.31912	35.50605	10.79770
log TL	log W	−5.5353	3.3303	0.995	3.16801	35.50605	10.55051

	SL (mm)	TL (mm)	W (g)
Mean	45.05	54.52	2.19
Range	26.0-84.1	31.8-98.5	0.25-12.25

Table 26.—Length-length and length-weight regression statistics for N = 500 specimens of *Menidia menidia*.

X	Y	a	b	r	Σx^2	Σy^2	Σxy
SL	FL	3.4715	1.0872	0.997	27,732.99210	33,001.74800	30,151.30480
SL	TL	5.7405	1.1396	0.991	27,732.99210	36,673.69960	31,604.49710
FL	SL	−2.7378	0.9136	0.997	33,001.74800	27,732.99210	30,151.30480
FL	TL	2.2339	1.0464	0.993	33,001.74800	36,673.69960	34,533.23480
TL	SL	−3.7872	0.8618	0.991	36,673.69960	27,732.99210	31,604.49710
TL	FL	−1.0206	0.9416	0.993	36,673.69960	33,001.74800	34,533.23480
log SL	log W	−5.0377	3.0341	0.929	1.25294	13.36788	3.80155
log FL	log W	−5.4685	3.1716	0.934	1.15954	13.36788	3.67758
log TL	log W	−5.7295	3.2553	0.943	1.12077	13.36788	3.64845

	SL (mm)	FL (mm)	TL (mm)	W (g)
Mean	64.72	73.83	79.49	3.00
Range	30.8-88.9	35.4-96.7	38.0-107.0	0.24-7.48

Table 27.—Length-length and length-weight regression statistics for N = 500 specimens of *Trachinotus carolinus*.

X	Y	a	b	r	Σx^2	Σy^2	Σxy
SL	FL	1.2582	1.1215	0.999	116,132.82810	146,309.33380	130,241.53720
SL	TL	−0.6558	1.3240	0.998	116,132.82810	204,204.72070	153,753.67220
FL	SL	−1.0732	0.8902	0.999	146,309.33380	116,132.82810	130,241.53720
FL	TL	−2.1288	1.1802	0.999	146,309.33380	204,204.72070	172,666.97750
TL	SL	0.5817	0.7529	0.998	204,204.72070	116,132.82810	153,753.67220
TL	FL	1.8689	0.8456	0.999	204,204.72070	146,309.33380	172,666.97750
log SL	log W	−4.9662	3.2714	0.996	20.71864	223.58965	67.77955
log FL	log W	−5.3659	3.3869	0.996	19.34027	223.58965	65.50392
log TL	log W	−5.2538	3.2184	0.996	21.41597	223.58965	68.92533

	SL (mm)	FL (mm)	TL (mm)	W (g)
Mean	27.94	32.59	36.33	1.42
Range	11.8-93.0	14.1-104.1	15.7-123.9	0.03-24.88

Table 28.—Length-length and length-weight regression statistics for N = 45 specimens of *Trachinotus falcatus*.

X	Y	a	b	r	Σx^2	Σy^2	Σxy
SL	FL	1.6501	1.0962	0.9997	5,485.89911	6,596.88311	6,013.79711
SL	TL	0.1357	1.2980	0.9988	5,485.89911	9,264.20800	7,120.66133
FL	SL	−1.4883	0.9116	0.9997	6,596.88311	5,485.89911	6,013.79711
FL	TL	−1.8078	1.1837	0.9989	6,596.88311	9,264.20800	7,808.62933
TL	SL	−0.0483	0.7686	0.9988	9,264.20800	5,485.89911	7,120.66133
TL	FL	1.5879	0.8429	0.9989	9,264.20800	6,596.88311	7,808.62933
log SL	log W	−4.0249	2.7452	0.9429	1.17563	9.96602	3.22731
log FL	log W	−4.4235	2.8910	0.9393	1.05202	9.96602	3.04141
log TL	log W	−4.3651	2.7614	0.9468	1.17158	9.96602	3.23522

	SL (mm)	FL (mm)	TL (mm)	W (g)
Mean	24.00	27.96	31.29	1.03
Range	12.1-59.4	14.3-66.8	16.2-75.9	0.09-8.66

Table 29.—Length-length and length-weight regression statistics for N = 291 specimens of *Menticirrhus littoralis*.

X	Y	a	b	r	Σx^2	Σy^2	Σxy
SL	TL	1.2032	1.2172	0.998	114,966.97810	171,061.35680	139,935.44470
TL	SL	−0.7740	0.8180	0.998	171,061.35680	114,966.97810	139,935.44470
log SL	log W	−4.7160	2.9514	0.992	7.60448	67.38193	22.44407
log TL	log W	−5.0851	3.0019	0.991	7.34690	67.38193	22.05480

	SL (mm)	TL (mm)	W (g)
Mean	48.96	60.79	2.88
Range	19.2-149.1	24.4-181.2	0.10-45.90

Table 30.—Length-length and length-weight regression statistics for N = 48 specimens of *Mugil cephalus*.

X	Y	a	b	r	Σx^2	Σy^2	Σxy
SL	FL	1.6494	1.1462	0.9997	287,624.41670	378,110.61480	329,671.25420
SL	TL	−0.2732	1.2703	0.9997	287,624.41670	464,347.77310	365,360.01750
FL	SL	−1.3811	0.8719	0.9997	378,110.61480	287,624.41670	329,671.25420
FL	TL	−2.0735	1.1080	0.9998	378,110.61480	464,347.77310	418,941.18560
TL	SL	0.2608	0.7868	0.9997	464,347.77310	287,624.41670	365,360.01750
TL	FL	1.9075	0.9022	0.9998	464,347.77310	378,110.61480	418,941.18560
log SL	log W	−5.1821	3.2163	0.9995	9.39197	97.25856	30.20757
log FL	log W	−5.5090	3.2681	0.9995	9.09758	97.25856	29.73201
log TL	log W	−5.4259	3.1764	0.9996	9.63288	97.25856	30.59741

	SL (mm)	FL (mm)	TL (mm)	W (g)
Mean	87.69	102.16	111.12	49.31
Range	18.2-328.0	21.8-370.0	22.3-413.0	0.07-586.0

Table 31.—Length-length and length-weight regression statistics for N = 394 specimens of *Mugil curema*.

X	Y	a	b	r	Σx^2	Σy^2	Σxy
SL	FL	0.5761	1.1722	0.9985	470,299.87390	648,206.35520	551,308.74100
SL	TL	−0.7066	1.2848	0.9997	470,299.87390	776,685.93360	604,216.83340
FL	SL	−0.3563	0.8505	0.9985	648,206.35520	470,299.87390	551,308.74100
FL	TL	−1.1853	1.0931	0.9986	648,206.35520	776,685.93360	708,547.91860
TL	SL	0.5739	0.7780	0.9997	776,685.93360	470,299.87390	604,216.83340
TL	FL	1.2302	0.9123	0.9986	776,685.93360	648,206.35520	708,547.91860
log SL	log W	−5.1563	3.2558	0.9984	30.99242	329.57610	100.90500
log FL	log W	−5.4521	3.2860	0.9979	30.39528	329.57610	99.87731
log TL	log W	−5.4166	3.2148	0.9986	31.79767	329.57610	102.22395

	SL (mm)	FL (mm)	TL (mm)	W (g)
Mean	44.79	53.08	56.83	6.66
Range	19.1-130.4	23.0-155.5	24.1-168.0	0.10-49.60

adequate data for developing basic models of either the shallow-water estuarine or surf-zone ichthyofauna occurring over shell-hash, sandy, or muddy bottoms and should be useful both in identifying natural perturbations and artificial stresses and in predicting their effects.

CONCLUSIONS AND SUMMARY

1. Fifty-one collections were made in the surf and 36 in the tidal pool from which some 512 specimens of swimming invertebrates representing at least 17 species and 5,095 specimens of bony fishes representing 41 species were collected.

2. The surf and tidal pool collections differ significantly with respect to number of species per collection when averaged over both years and all seasons.

3. Winter and summer differ significantly in number of species per collection.

4. Both the main effect of location and the location-by-season interaction show highly significant differences in number of specimens per collection.

5. There is a highly significant difference between the average number of specimens per collection in the surf versus the tidal pool for those collections made in winter and a significant difference for summer.

6. There is a highly significant difference between years for the total weight of fishes per collection. This is due in part to the capture during the first year of a number of comparatively large specimens of *Mugil cephalus* and a single specimen of *Pogonias cromis* weighing more than 1.2 kg.

7. The main effect of location shows a highly significant difference in total weight of fishes per collection and the location-by-season interaction is significant.

8. There is a highly significant difference between surf and tidal pool in average total weight of fishes per collection for winter and summer and a significant difference for spring.

9. Six species of fishes (*Anchoa mitchilli*, *Fundulus majalis*, *Menidia menidia*, *Trachinotus carolinus*, *Menticirrhus littoralis*, and *Mugil curema*) accounted for 94% of the specimens of fishes collected and 72% of the ichthyomass. One species, *Arenaeus cribrarius*, made up 82% of the swimming invertebrate specimens and 75% of the mass of swimming invertebrates.

10. Species were ranked as to "importance." In the surf and tidal pool combined the order of decreasing "importance" for the most abundant species was *Menidia menidia*, *Arenaeus cribrarius*, *Trachinotus carolinus*, *Menticirrhus littoralis* and *Mugil curema*, *Anchoa mitchilli*, and *Fundulus majalis*.

11. Water temperature and its square correlated significantly with number of specimens for each of five of the most important species (*Arenaeus cribrarius*, *Anchoa mitchilli*, *Menidia menidia*, *Trachinotus carolinus*, and *Menticirrhus littoralis*) collected in the surf. Height of sea was significantly correlated with occurrence for *A. mitchilli* and *M. littoralis*; and a significant negative correlation existed between salinity and number of specimens for *M. menidia*.

12. The prediction equation for monthly average number of specimens per collection contained water temperature, the square of water temperature, and salinity as independent variables for *Menidia menidia*, but only water temperature appeared in the equations for all other species examined except *Anchoa mitchilli*, which contained visibility of Secchi disc (in addition to water temperature) as an independent variable.

13. *Arenaeus cribrarius* has a prolonged spawning period; ovigerous females were collected as early as mid-June, recently spawned females as late as mid-September, and small specimens (20 mm CW or smaller) from May through October.

14. Ripe specimens of *Menidia menidia* were observed from late March to early June. Specimens of *M. menidia* 50 mm SL or smaller were rarely collected. Because this virtual absence of small individuals of *M. menidia* does not appear to be related to the method of collection, this species presumably occupies a habitat other than the surf zone during its early life history.

15. *Trachinotus carolinus* has a prolonged spawning period; specimens 22 mm SL or smaller appeared in the catch from mid-April through late October.

16. Specimens of *Menticirrhus littoralis* less than 30 mm SL were collected from June through November indicating an extended spawning period.

17. The apparent absence of juveniles of *Paralichthys squamilentus* in the waters of South Carolina before 1969 is a result for the most part of inadequate collecting.

18. *Sphoeroides spengleri* is reported for the first time from the waters of South Carolina.

19. Relationships of carapace length to carapace width and these measurements to weight are presented for the decapod crustacean *Arenaeus cribrarius*; and the relationships of lengths and lengths to weight are presented for eight species of fishes.

20. Recommendations for improving surveys similar to the one reported herein are given.

21. Stochastic effects seem to be important in determining the catch in the surf and associated tidal pools of sandy beaches.

22. Species inhabiting the surf zone must be able to cope with wide ranges in turbulence, turbidity, quantities of suspended particles in the medium, current velocity, and bottom characteristics. In addition to the above factors, a number of meteorological and seasonal changes are superimposed producing variations in temperature and salinity. Highly motile species may move into or out of the surf zone depending upon prevalent conditions. This may account in part for some of the variations in catch.

23. The macrofauna of the tidal pool is a depauperate derivative of the surf zone.

24. Species collected in the tidal pool were probably attracted there to some degree by their different ecological requirements and tolerances. In addition, larger individuals tend to avoid being trapped in these pools, whereas smaller ones (of species such as

Trachinotus carolinus and *Mugil curema*) may actively seek them as havens which are relatively free of predators. Species inhabiting tidal pools are subjected to sudden fluctuations in temperature and salinity.

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