Beach Fauna Study of the CERC Field Research Facility, Duck, North Carolina

by
James F. Matta

MISCELLANEOUS REPORT NO. 77-6
APRIL 1977

Approved for public release;
distribution unlimited.

Prepared for
U.S. ARMY, CORPS OF ENGINEERS
COASTAL ENGINEERING
RESEARCH CENTER
Kingman Building
Fort Belvoir, Va. 22060

Reprint or republication of any of this material shall give appropriate credit to the U.S. Army Coastal Engineering Research Center.

Limited free distribution within the United States of single copies of this publication has been made by this Center. Additional copies are available from:

National Technical Information Service
ATTN: Operations Division
5285 Port Royal Road
Springfield, Virginia 22151

Contents of this report are not to be used for advertising, publicatio ... mes does not constitut ... se of such commer

The ... n official Departm ... by other authoriz

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER MR 77-6	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) BEACH FAUNA STUDY OF THE CERC FIELD RESEARCH FACILITY, DUCK, NORTH CAROLINA		5. TYPE OF REPORT & PERIOD COVERED Miscellaneous Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) James F. Matta		8. CONTRACT OR GRANT NUMBER(s) DACW72-75-C-0019
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of Biological Sciences Old Dominion University Norfolk, Virginia 23508		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS G31531
11. CONTROLLING OFFICE NAME AND ADDRESS Department of the Army Coastal Engineering Research Center (CERRE-CE) Kingman Building, Fort Belvoir, Virginia 22060		12. REPORT DATE April 1977
		13. NUMBER OF PAGES ~~102~~ 100 p.
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Beach fauna
CERC Field Research Facility
Dare County, North Carolina
Ecology
Macrofauna
Meiofauna
Ocean beach
Sound beach

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the results of a location intensive seasonal study of the beach fauna of a barrier island in Dare County, North Carolina. The study area includes the beach face from the margin of the swash zone to 60 meters offshore on the ocean beach and from the swash zone to 300 meters offshore on the sound beach. A simple quantitative sampling device was developed for use in the surf zone and was used throughout this study.

(Continued)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

The dominant species on the ocean beach were *Emerita talpoida*, *Scolelepis squamata*, *Donax* sp., and *Parahaustorius longimerus*. Three communities were defined on the beach by a factor analysis of physical and biological parameters measured. The *Emerita* community was confined to the swash zone and the inner edge of the surf zone on the beach. It was characterized by high-stress conditions, high densities of *E. talpoida*, and low densities of all other species. The *Scolelepis* community ranged outward from the margin of the surf zone to approximately 45 to 50 meters offshore. It was characterized by high densities of *S. squamata* and also had high densities of other organisms including *P. longimerus* and *Donax* sp. The *Parahaustorius* community extended from 50 to 60 meters offshore to an undetermined offshore point. It was characterized by high densities of *P. longimerus* and lowered densities of *S. squamata*. *Donax* sp. and *Bathyporeia quoddyensis* also attained their highest densities in this area. Species diversities on the beach were low.

The sound beach was characterized by three distinct faunistic communities. The *Scolecolepides* community was characterized by high densities of *Scolecolepides viridis*, Chironomid larvae, and *Peloscolex* sp. and the presence of *Rangia cuneata*. It extended from 90 to 140 meters to at least 300 meters offshore, with the nearshore boundary the edge of the wind tide exposed beach and the offshore boundary probably the margin of the dense stands of *Rupea* in deep water. The zone between the beach margin and the edge of the *Scolecolepides* community was characterized by the burrowing amphipod *Lepidactylus dysticus*. This was the only abundant species in this zone which was frequently exposed by wind tides. A small developing marsh community, characterized by higher organic content, higher temperatures, lower salinities, increased numbers of species and higher species densities was the third community on the site. Species diversities were low as is characteristic of most oligohaline areas.

PREFACE

This report is published to provide base-line data on the beach faunas of a barrier island at Duck, North Carolina. The work was carried out under the coastal ecology research program of the U.S. Army Coastal Engineering Research Center (CERC).

The report was prepared by Dr. James F. Matta, Associate Professor of Biological Sciences, Old Dominion University, Norfolk, Virginia, under CERC Contract No. DACW72-75-C-0019.

The author expresses appreciation to Drs. A.J. Provenzano and H.G. Marshall, Institute of Oceanography and Department of Biological Sciences, Old Dominion University, for assistance in designing the research program and in taking the samples, and to W.W. Willis, graduate student, Institute of Oceanography, and W.W. Robinson and C.E. McKinley, graduate students in the Department of Biological Sciences, for their assistance in the field and in the sorting and identification of collections. The assistance of A.K. Hurme of CERC throughout the project, and particularly in selecting favorable collecting days, is gratefully acknowledged.

A.K. Hurme was the CERC contract monitor for the report, under the general supervision of R.M. Yancey, Chief, Coastal Ecology Branch, Research Division.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

JOHN H. COUSINS
Colonel, Corps of Engineers
Commander and Director

CONTENTS

TABLES

CONTENTS

TABLES-Continued

CONTENTS

TABLES-Continued

CONTENTS

TABLES-Continued

FIGURES

CONTENTS

FIGURES-Continued

CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI)
UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.39	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.8532	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.1745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1]To obtain Celsius (C) temperature readings from Farenheit (F) readings, use formula: C = (5/9) (F -32).

To obtain Kelvin (K) readings, use formula: K = (5/9) (F -32) + 273.15.

BEACH FAUNA STUDY OF THE CERC FIELD RESEARCH FACILITY, DUCK, NORTH CAROLINA

by

James F. Matta

I. INTRODUCTION

The Outer Banks of North Carolina are a series of offshore sandy barrier islands extending from the Virginia-North Carolina border to Cape Fear. The barrier islands, rarely more than 6 kilometers wide, are separated from the shore by shallow sounds of varying widths and are occasionally connected to the mainland or pierced by inlets to the Atlantic Ocean.

These islands provide an inhospitable environment to both plants and animals. Strong winds, salt spray, and scouring sands have limited plant and animal communities to a few dominant, well-adapted species.

The CERC Field Research Facility (FRF) is located on a narrow section of Currituck Bank (North Bank), about 48 kilometers south of the Virginia-North Carolina State line and 2 kilometers north of Duck, Dare County, North Carolina (Fig. 1). Currituck Bank extends southward about 91 kilometers from the State line to Oregon Inlet, the first break in the Outer Banks south of Chesapeake Bay. At the FRF site, the ocean and sound beaches are approximately 914 meters long.

Barrier island beaches offer several different habitats for invertebrates. The swash zone and surf zone are severe habitats, where the main limiting environmental factors are the stress of wave action and the periodic exposure and submergence caused by the tidal cycle.

The ocean beach at the FRF site is a high-energy beach with a steep, narrow beach face bordered by 7-meter-high foredunes. The foredunes were stabilized in 1935 by the Works Progress Administration (WPA) and the Civilian Conservation Corps (CCC) in a project which involved the area between Virginia Beach, Virginia, and the middle of Ocracoke Island, North Carolina (Stratton and Hollowell, 1940). According to Dolan (1972) and Dolan, Godfrey, and Odum (1973), this stabilization narrowed the beach and increased the oceanside slope on the dune face and the beach.

The beach face slopes down to an abrupt topographic step at 50 to 100 centimeters below mean sea level (MSL). This step is the line of demarkation between the coarse bottom material of the lower swash zone and surf zone, and the fine sand of the buildup zone and the outer part of the surf zone. Three wave zones and five bottom zones were defined

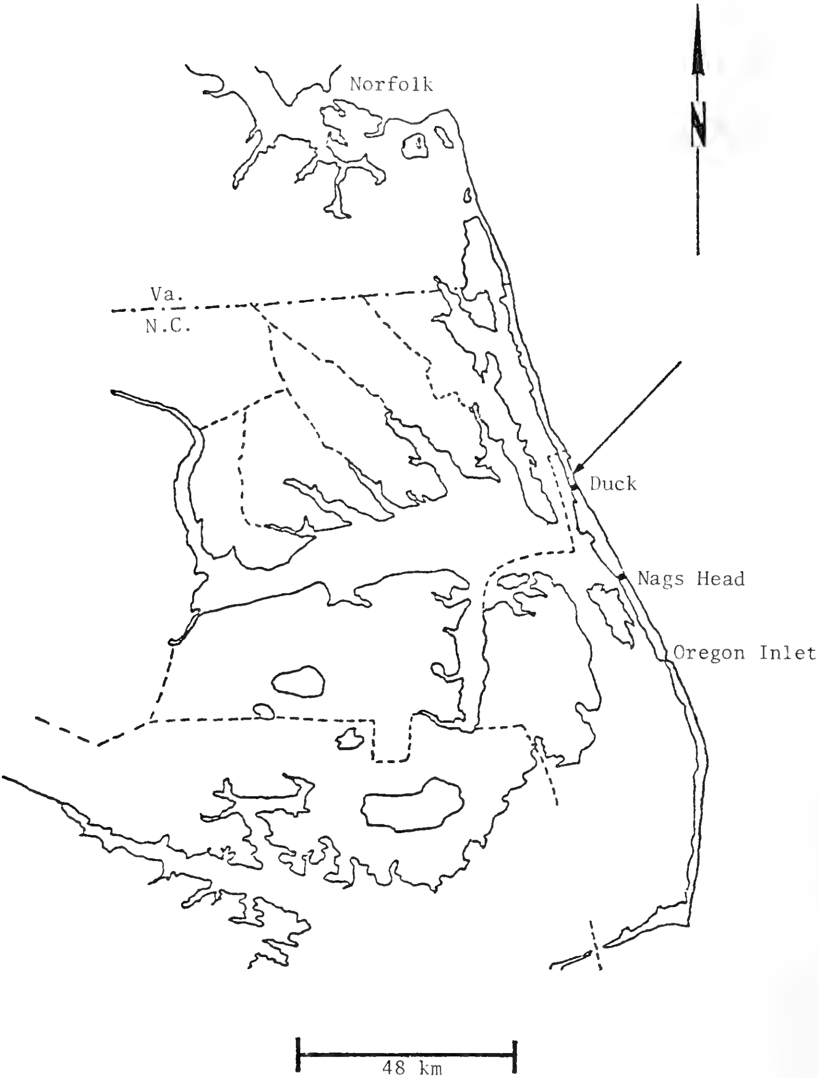

Figure 1. Location of the CERC Field Research Facility.

for this type of beach (Clifton, Hunter, and Phillips, 1971). Waves pass through the buildup zone and become higher and steeper until they break. After breaking, the waves progress through the surf zone and terminate in the swash zone. An asymmetric ripple facies occurs offshore and merges with a megaripple area in the buildup zone. The inner buildup zone and part of the surf zone cover the outer planar facies, while the inner rough facies occurs under the rest of the surf zone. The inner planar facies is in the swash zone. All of these zones occur at the FRF beach, and the line of demarkation between the outer planar facies and the inner rough facies is very abrupt.

The sound beach is wide and sloping, and periodically exposed or covered by wind tides. The major features of the beach are a small riprapped promontory at the southern end which was created by erosion at the edge of the riprap, an eroded and steeply banked shoreline, a small natural marsh bordering the riprapped area, and a large area of submerged and emergent vegetation which was planted near the natural marsh by CERC personnel to stop erosion. Levy (1976) found 22 species of wetlands plants in this area; *Scirpus americanus*, *Aster tenuifolius*, *Distichlis spicata*, *Elocharis* sp., and *Hydrocotyle umbellata* are the most common species.

Most of the beach is barren 500 to 800 feet from shore. Here, small *Vallisneria* plants occur which are gradually replaced by a solid stand of *Ruppia* at about 1,000 to 1,200 feet. The water in the area is oligohaline, varying from a salinity of 0.5 to 5.0 parts per thousand.

The first comprehensive study of benthic communities was performed in the North Sea by Peterson (1924). He established the major benthic communities and discussed the environmental factors limiting their distribution.

The earliest comprehensive study of marine sandy beach fauna in the eastern United States was conducted at Beaufort, North Carolina, by Pearse, Humm, and Wharton (1942). They examined the species composition of beach communities from the foreshore slope to deep water, and gave the zonal distributions for several animals. *Emerita talpoida* was abundant in the intertidal region, and *Donax* sp. was also found in this region. The burrowing amphipod, *Haustorius*, was most abundant on inundated shoals. This study provided information on sand beach fauna, but quantitative sampling and a systematic sampling plan were not used.

Cerame-Vivas and Gray (1966) studied the distributional pattern of benthic invertebrates of the Continental Shelf off North Carolina, but did not include beach fauna.

There have been no quantitative studies on benthic communities of high-energy beaches on the east coast of the United States. These beaches are difficult to sample, and earlier research has focused on the benthic communities of protected and easily sampled beaches.

Community structure was studied at Morehead City, North Carolina, on an intertidal sandy beach in an ocean inlet inside Beaufort Inlet (Dexter, 1969). The community was typified by low diversity, low density, and a few dominant species, especially haustorid amphipods and polychaetes. The four most abundant species were *Neohausterius schmitzi* (803.96 individuals per square meter), *Acanthohaustorius millsi* (60.28 individuals per square meter), *Donax variabilis* (31.01 individuals per square meter), and *Scolelepis squamata* (14.23 individuals per square meter).

Croker (1967) discussed the niche diversity of five haustorid amphipods occurring on sandy beaches. The distribution and niche diversity of haustorid amphipods in North Carolina were studied by Dexter (1967). *Amphiporeia virginiana* was most abundant on surf-swept beaches on the barrier islands; *Parahaustorus longimerus* was most abundant in the inlet environment; and *Lepidactylus dytiscus* occurred in various habitats in the sound.

McDougall (1943) discussed the sessile marine invertebrates around Beaufort and focused on population variations in pile-dwelling organisms. Carriker (1967) reviewed estuarine benthic invertebrates, and emphasized the need for work on all aspects of estuarine ecology.

Several studies on estuarine benthic invertebrates were conducted in North Carolina. Brett (1963) studied the relationship between invertebrate distribution and sediment type. Tenore, Horton, and Duke (1968) reported the distribution of the bivalve, *Rangia cuneata*, in the Pamlico River estuary and Pamlico Sound. Tenore (1970) studied the macrobenthos of the Pamlico River estuary. He divided the estuary into an oligohaline zone dominated by *R. cuneata* and *Nereis succinea*, a mesohaline zone with a *Macroma balthica-Heteromastus filliformis-Mereis succinea* association, and a polyhaline zone with a *Macoma phenax-Mulinia lateralis-Glycera dibranchiata* association.

This is an intensive, seasonal study of the benthic invertebrate communities on a high-energy barrier island beach and on the estuarine beach of the same strand. Species were characterized by location and density, and communities are defined and related to the limiting physical parameters. The species diversity of the communities is determined and seasonal changes in densities and diversity are discussed.

II. METHODS AND MATERIALS

1. Transect Location.

Three transects were established on both the ocean and sound beaches (Fig. 2). On the ocean beach, transect II was due east of bench mark 16, and 47 meters north of the pier on the FRF site.

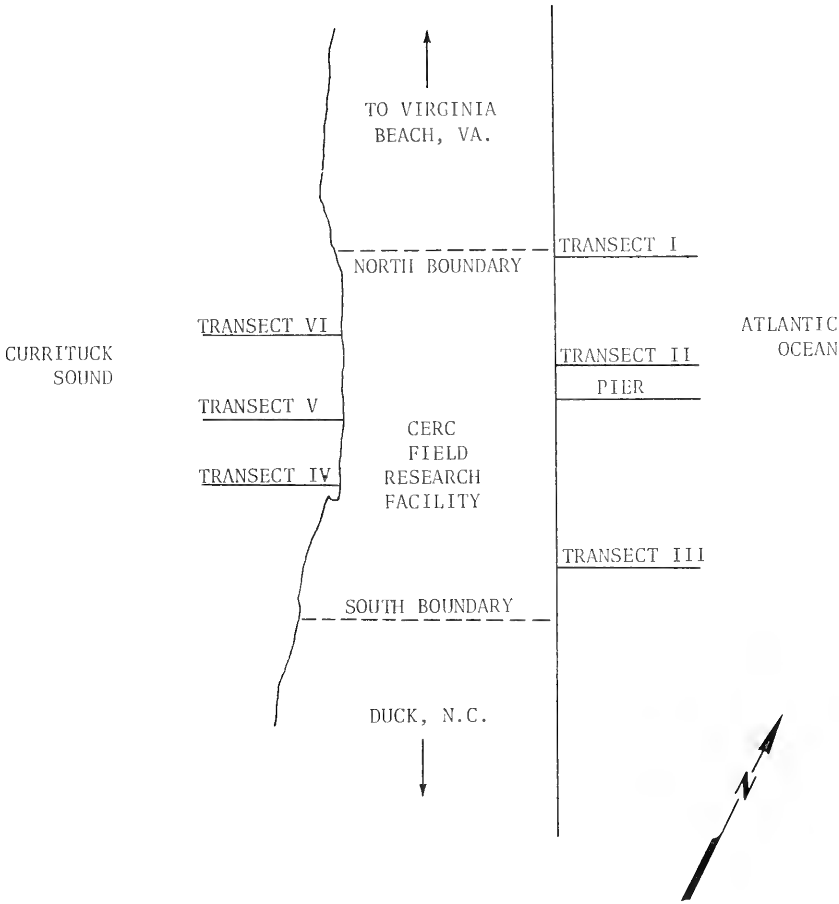

Figure 2. Location of transects on the study site.

Transect I was 305 meters north of transect II, and transect III was 305 meters south of transect II.

On the sound beach, transect IV was 118 meters south of bench mark 64. This site was selected because it included a small marsh. Transect V was 34 meters north of bench mark 64, and 152 meters north of transect IV. This site was selected because a shallow east-to-west depression caused the transect to be in deeper water than the surrounding area. Transect VI was 200 meters north of transect V in a barren sand area with little slope which was typical of the sound beach.

2. Sampling Device.

Preliminary tests conducted with two grab sampling devices which were considered unsuitable for the project are discussed in Appendix A. The device used in the project (Fig. 3) was a corer constructed of a 6-millimeter (1/4 inch) circular steelplate with a 1-centimeter hole in the center welded to a 15-centimeter section of 8.55-centimeter-diameter (3-3/8 inches) steel electrical conduit. A 2.54-centimeter (1 inch) pipe coupling was welded to the plate over the hole, and a 2.54-centimeter steel pipe was tightly screwed into the coupling. The leading edge of the steel conduit was sharpened to aid penetration. A long handle (about 50 centimeters) was used in the shallow areas, and a short handle (about 15 centimeters) was used in the deep areas that required diving.

The corer was pushed into the substrate, then extracted with the hole at the top of the handle covered. The core sample usually remained in the corer until the sample was placed in a bag, but on the deep sites the open end was covered to prevent the sample from washing out.

The corer was easy to use, fast, and unaffected by the varying particle sizes on the beach, and there were no moving parts to rust or jam. It was relatively safe to use in the surf zone where sampling is dangerous. The corer sampled a large area (57.7 square centimeters) compared to commercially available corers.

3. Sampling Plan.

The sampling plan was changed to improve the efficiency of the sampling and the quality of the data (App. B). In the final plan on the ocean beach, the zero point on each transect was the landward margin of the swash zone. Thus, the sites were in the same relative position with reference to the wave activity, but changed position between sampling series with reference to a fixed point onshore. Sites one to nine were respectively established seaward of the zero point at 3.3, 7.6, 10.6, 13.6, 15.2, 22.7, 30.4, 45.6, and 60.8 meters (horizontal distance)(Fig. 4). When possible, samples were collected during low tide so the sites were relatively the same distance from MSL over the sampling series. However, the main criterion in determining sampling times was sea conditions.

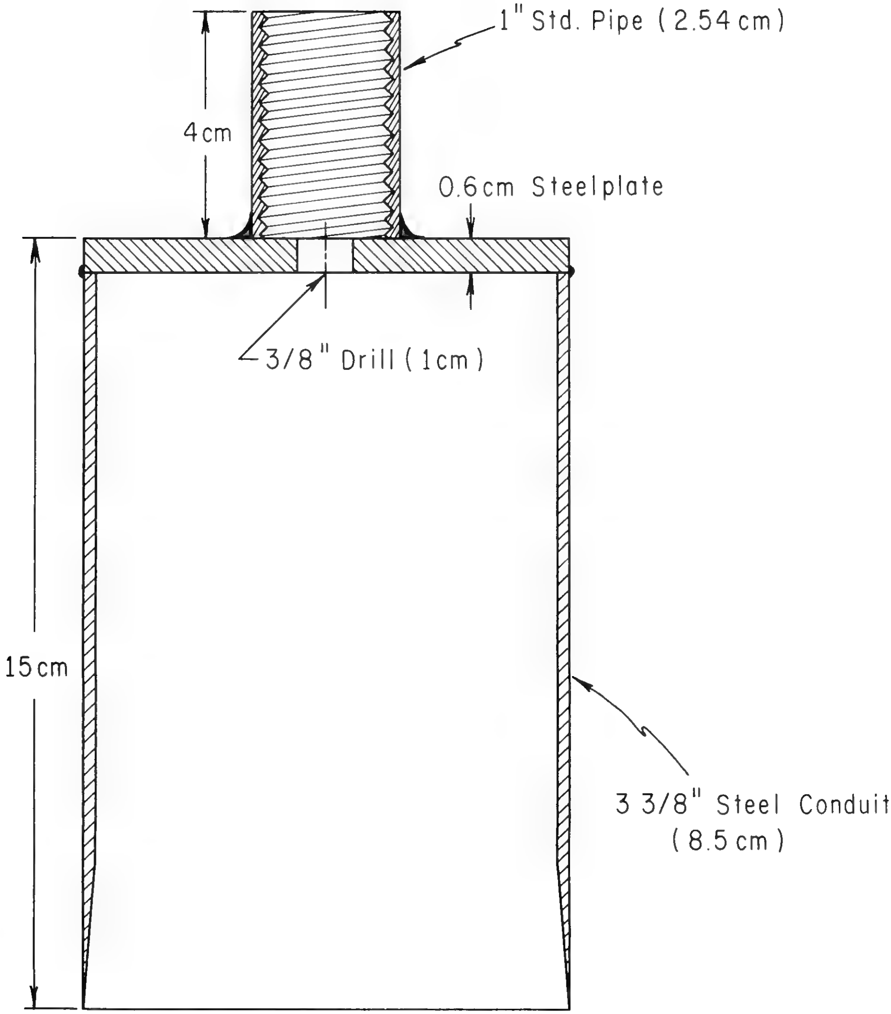

Figure 3. Cross section of the corer used as a sampling device.

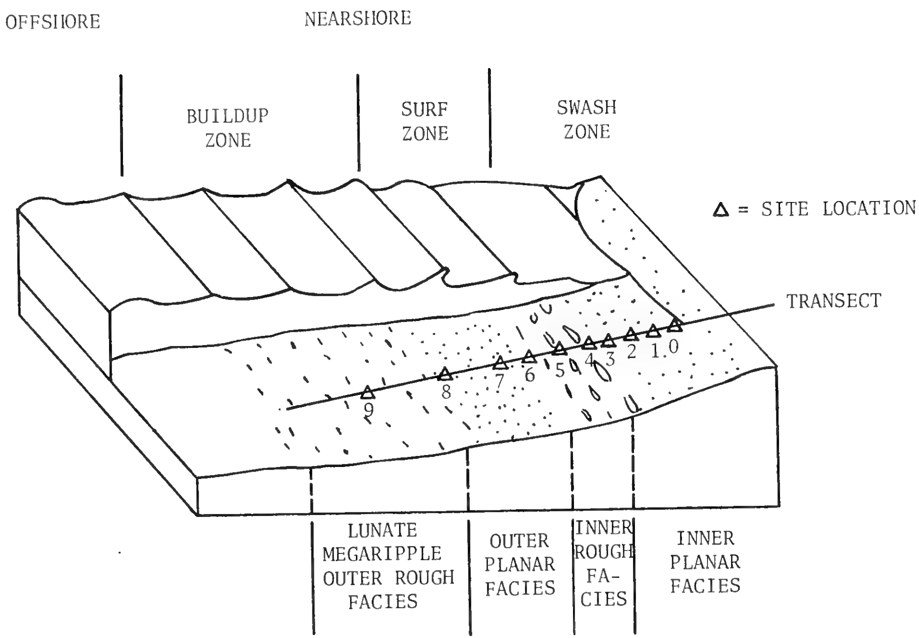

Figure 4. The approximate location of the sampling sites with respect to the zonation of wave activity and sedimentary structures. Δ0 is the zero point on the transect (modified from Clifton, Hunter, and Phillips, 1971).

Three samples, each consisting of two cores, were taken at each site (total area sampled 1.15 X 10^{-2} square meters by 10 centimeters deep). Samples were placed in prelabeled plastic bags, stored at 1° to 4° Celsius, and returned to the laboratory for extraction.

A magnesium chloride ($MgCl_2$) and seawater rinsing technique was used to extract the organisms from the core samples (Cox, 1976); rose bengal was added to a 4-percent Formalin solution to aid in the sorting. All organisms, 0.5 millimeter or larger, were separated by species, identified, and counted. Some smaller groups (mostly microcrustacea) were also counted, but were not identified below the order level.

Core samples for grain-size analysis were taken at each site, rather than at every other site, to increase the chance of detecting a correlation between organism density and grain-size distribution.

The ocean beach was not sampled during unfavorable sea conditions, and usually no more than two transects were sampled per day. Thus, sampling during the late fall and early spring lasted as much as 1 month. The first sampling series was taken in August 1975 (App. C), the second series on 23 October (transects I and II) and 20 November 1975 (transect III), the third series on 7 March (transect I) and 8 April 1976 (transects II and III), the fourth series on 8 June (transect II) and 10 June 1976 (transects I and III), and the fifth series on 16 July (transect I) and 22 July 1976 (transects II and III).

After the October-November sampling was completed, a change in the sampling procedure was requested by CERC. The number of samples per site was increased from three to four to increase the accuracy of the variance estimates of the common species populations and to increase the chance of collecting rare species. Sampling at sites 4 and 6 was eliminated to keep the total number of samples collected at a manageable level.

In the final plan on the south beach transects, the zero point was the sound margin. Sampling sites 1 to 8 were respectively placed 15.2, 38.0, 51.8, 61.0, 68.6, 76.2, 152.4, and 304.8 meters soundward of the zero point. The coring and extraction techniques used were identical to the methods used on the ocean material (Cox, 1976), but tapwater was substituted for the $MgCl_2$-seawater solution. Core samples were also taken at each site for grain-size analyses.

The first sampling series for the sound beach was taken in July 1975 (App. D), the second series on 11 October 1976, the third series on 7 March 1976, the fourth series on 24 May 1976, and the fifth series on 16 July (transect VI) and 31 July 1976 (transects IV and V).

4. <u>Measurement of Physical Parameters</u>.

Sites were located by stretching a precalibrated nylon line, which was anchored to the shore, over the transect. The vertical distance from MSL was determined by relating the water depth to a point of known elevation on shore using a level and elevation rod. Temperature and salinity were measured near the bottom at each site using an inductive salinometer with a 300-foot cable.

Taylor series sieves (phi interval) and a ROTAP[R] were used for grain-size analyses. About 50 ± 2 grams of material were sieved on the ROTAP[R] for 10 minutes. Material retained on each sieve was weighed, and a computer program for sediment-size analysis (Darby and Wobus, 1976) was used to determine mean, sorting, skewness, and kurtosis.

The total organic content of each sediment sample was determined by the incineration method and the total carbonate content of each sediment sample by the hydrochloric acid (HCI) method (Carver, 1971).

III. RESULTS AND CONCLUSIONS

1. The Ocean Beach.

a. Preliminary Sampling. Because different sampling and extraction techniques were used, samples taken in August 1975 were not directly comparable to the other four sets of samples and will not be discussed here (see App. C).

b. Faunistics. Twenty-three species of macrofauna in five phyla and 19 families were collected (Table 1). All but four of the macrofaunal species were polychaetes or crustaceans. Several species of meiofauna were also quantitated, but were not identified to the species level.

c. Species Abundance. The mean number of individuals per square meter at each site during each season was calculated for all species constituting more than 1 percent of the total macrofauna, and for the total macrofauna (Tables 2 to 16). The total macrofauna ranged from 0 (site 3, transect II, October 1975) to 24,152 individuals per square meter (site 8, transect II, June 1976).

The swash zone fauna was dominated by *E. talpoida*, an organism uniquely adapted to the constant wave action and shifting bottom. The polychaete, *S. squamata*, was abundant in the deep parts of the swash zone and between the swash zone and the surf zone (sites 3 and 4) during June and July 1976. *Donax* sp. occasionally occurred in large numbers in this area, especially during July 1976.

The outer surf zone and the inner buildup zone, including the inner rough and the outer planar bottom types (sites 5, 6, 7, and 8) were dominated by *S. squamata* with up to 10,000 to 12,000 individuals per square meter. Most species were collected in this area, and small specimens of *Donax* sp. occasionally occurred with up to 6,000 individuals per

Table 1. Faunistic list of the ocean beach at the CERC Field Research Facility.

Phylum NEMERTEA
- *Tubulanus pellucidus*

Phylum ANNELLIDA
- Class Polychaeta
  - Family Spionidae
    - *Scolelepis squamata*
    - *Spiophanes bombyx*
  - Family Nephtyidae
    - *Nephtys bucera*
  - Family Megalonidae
    - *Megalona rosea*
  - Family Hesionidae
    - *Microphthalmus sczelkowii*
  - Family Opheliidae
    - *Travisia carnea*
  - Family Phyllodocidae
    - *Eteone heteropoda*
  - Family Glyceridae
    - *Glycera* sp.

Phylum MOLLUSCA
- Class Bivalvia
  - Order Heterodoatida
    - Family Donacidae
      - *Donax* sp. (probably *variablis*)
    - Family Solenidae
      - *Ensis* sp.
  - Order Prionodontida
    - Family Arcidae
      - *Anadara ovalis*

Phylum ARTHROPODA
- Class Crustacea
  - Order Amphipoda
    - Family Haustoriidae
      - *Parahaustorius longimerus*
      - *Amphiporeia virginiana*
      - *Bathyporeia quoddyensis*

Table 1. Faunistic list of the ocean beach at the CERC Field Research Facility.--Continued

Family Ischyroceridae
Jassa falcata

Order Mysidacea
Metamysidopsis mexicana

Order Cumacea
Family Leuconidae
Leucon americanus
Eudorellopsis deformis

Family Pseudocumidae
Petalosarsia declivis

Order Decapoda
Family Paguridae
Pagurus longicarpus

Family Portunidae
Ovalipes ocellatus

Family Hippidae
Emerita talpoida

Microcrustacea
Subclass Ostracoda
Order Myodacopoda
Species A

Order Podocopa
Species A

Subclass Copepoda
Order Harpacticoida
Species A
Species B

Phylum CNIDARIA
Class Anthozoa
Order Actiniaria
Species A (immature)

Table 2. Mean number of total macrofauna per square meter on the ocean beach.[1]

Season[2]	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	434.78	1,072.46	173.91	500.0	1,000.0	869.57	413.04	739.13	413.04	4,086.96	1,978.26	3,108.70
2	202.90	318.84	753.62	978.26	217.39	1,086.96	2,065.22	1,130.43	630.43	934.78	3,434.78	2,369.57
3	28.99	0	695.65	1,630.43	43.48	369.57	1,521.74	869.57	804.35	1,086.96	5,086.96	2,739.13
4	202.90	144.93	86.96	---	---	---	---	---	---	---	---	---
5	405.80	202.90	115.94	1,608.70	65.22	43.48	891.3	10,891.3	1,043.48	4,065.22	8,152.17	5,000.0
6	2,550.72	202.90	57.97	---	---	---	---	---	---	---	---	---
7	318.84	753.62	231.88	608.7	304.35	3,913.04	9,956.52	12,065.22	5,239.13	19,630.43	3,413.04	5,413.04
8	753.62	115.94	260.87	3,260.87	1,108.7	1,260.87	8,782.61	24,152.17	7,760.87	9,260.87	5,195.65	3,739.13
9	260.87	608.70	898.55	2,086.96	1,043.48	1,847.83	5,065.22	1,413.04	17,586.96	7,673.91	6,108.70	5,586.96

[1] Sample size equals 1.15×10^{-2} square meters.

[2] Three samples per site taken October - November 1975. Four samples taken on other dates.

Table 3. Mean number of *Emerita talpoida* per square meter on the ocean beach.[1]

Season[2]	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	434.78	1,072.46	115.94	500	934	630	130	43	0	3,239	609	2,195
2	202.9	289.86	753.62	108	195.65	1,000	1,304	239	152	870	565	1,696
3	0	0	666.67	21	21	326	1,000	130	348	783	478	239
4	0	0	86.96	---	---	---	---	---	---	---	---	---
5	115.94	0	28.99	65	21	0	65	0	0	65	13	0
6	0	0	0	---	---	---	---	---	---	---	---	---
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0

[1] Sample size equals 1.15×10^{-2} square meters.

[2] Three samples per site taken October - November 1975. Four samples taken on other dates.

Table 4. Mean number of *Scolelepis squamata* per square meter on the ocean beach.[1]

Season[2]	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	0	0	28.99	0	6	0	130	261	43	43	652	500
2	0	0	0	0	0	43	370	543	239	43	2,261	413
3	0	0	28.99	0	0	22	326	630	304	239	3,891	2,413
4	115.94	0	0	---	---	---	---	---	---	---	---	---
5	115.94	0	28.99	0	22	22	522	10,652	500	2,478	7,457	4,848
6	1,681.16	0	57.97	---	---	---	---	---	---	---	---	---
7	57.97	86.96	86.96	609	130	2,761	8,000	9,304	4,370	3,739	1,283	1,217
8	0	0	0	2,957	43	370	5,565	12,696	630	2,022	109	152
9	0	0	0	1,173	43	217	2,630	283	3,717	173	152	196

1 Sample size equals 1.15×10^{-2} square meters.

2 Three samples per site taken October - November 1975. Four samples taken on other dates.

Table 5. Mean number of *Parahaustorius longimerus* per square meter on the ocean beach.[1]

Season[2]	October - November 1975			March - April 1976			June 1976			July 1976		
Transect / Site	I	II	III	I	II	III	I	II	III	I	II	III
1	0	0	0	0	0	195	0	43	0	152	283	130
2	0	0	0	0	21	43	21	21	0	0	43	0
3	28.99	0	0	0	0	0	43	0	22	0	130	22
4	57.97	0	0	---	---	---	---	---	---	---	---	---
5	0	0	57.97	0	0	0	86	21	152	109	435	109
6	0	0	0	---	---	---	---	---	---	---	---	---
7	28.99	57.97	57.97	0	130	1,065	652	500	195	174	478	109
8	28.99	28.99	144.93	217	956	782	847	4,087	4,043	1,522	3,543	3,283
9	0	550.72	521.74	630	673	1,369	891	891	8,196	4,522	2,609	3,621

1 Sample size equals 1.15×10^{-2} square meters.

2 Three samples per site taken October - November 1975. Four samples taken on other dates.

Table 6. Mean number of *Donax* sp. per square meter on the ocean beach.[1]

Season[2]	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	0	0	0	0	0	0	0	109	0	217	87	22
2	0	0	0	0	0	0	109	43	0	0	457	130
3	0	0	0	0	0	0	22	0	0	43	522	43
4	0	0	0	---	---	---	---	---	---	---	---	---
5	0	0	0	0	0	0	65	65	22	826	0	22
6	0	28.99	0	---	---	---	---	---	---	---	---	---
7	57.97	28.99	0	0	0	0	1,000	1,587	239	5,847	1,283	4,022
8	28.99	28.99	0	0	0	43	2,065	6,326	565	3,869	848	0
9	0	0	57.97	0	174	22	1,087	130	3,674	1,696	1,869	652

[1] Sample size equals 1.15×10^{-2} square meters.

[2] Three samples per site taken October - November 1975. Four samples taken on other dates.

Table 7. Mean number of *Bathyporeia quoddyensis* per square meter on the ocean beach.[1]

Season[2]	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	0	0	0	0	0	0	0	0	0	21.74	0	0
2	0	28.99	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	21.74	21.74	0	0	21.74	0	0	0
4	28.99	0	0	---	---	---	---	---	---	---	---	---
5	144.93	57.97	0	0	21.74	0	0	0	43.48	217.39	65.22	0
6	869.57	57.97	0	---	---	---	---	---	---	---	---	---
7	57.97	0	0	0	43.48	43.48	21.74	0	21.74	0	130.43	0
8	0	0	0	0	65.22	21.74	86.96	21.74	43.48	173.91	326.09	21.74
9	28.99	0	260.87	43.48	108.70	130.43	108.70	21.74	739.13	760.87	108.70	630.43

1 Sample size equals 1.15×10^{-2} square meters.

2 Three samples per site taken October - November 1975. Four samples taken on other dates.

Table 8. Mean number of *Megalona rosea* per square meter on the ocean beach.[1]

Season[2]	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	0	0	0	0	0	0	0	0	0	0	0	21.74
2	0	0	0	0	0	0	21.74	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	---	---	---	---	---	---	---	---	---
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	28.99	0	---	---	---	---	---	---	---	---	---
7	0	0	0	0	0	0	0	0	0	0	21.74	0
8	0	0	0	0	0	0	0	21.74	43.48	21.74	0	21.74
9	0	57.97	0	0	0	0	0	0	65.22	21.74	456.52	21.74

1 Sample size equals 1.15×10^{-2} square meters.

2 Three samples per site taken October - November 1975. Four samples taken on other dates.

Table 9. Mean number of *Spiophanes bombyx* per square meter on the ocean beach.[1]

Season[2]	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	22	0	0	0	0	0
4	0	0	0	---	---	---	---	---	---	---	---	---
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	---	---	---	---	---	---	---	---	---
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	22	0	22	22
9	0	0	0	0	0	0	0	0	22	0	456	0

1 Sample size equals 1.15×10^{-2} square meters.

2 Three samples per site taken October - November 1975. Four samples taken on other dates.

Table 10. Mean number of *Petalosarsia declivis* per square meter on the ocean beach.[1]

Season[2]	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	0	0	0	0	0	21.74	43.48	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	86.96	0	0	0	0	0	0	0	0
4	0	0	0	---	---	---	---	---	---	---	---	---
5	869.57	0	0	21.74	0	21.74	0	0	0	0	0	0
6	0	28.99	0	---	----	---	---	---	---	---	---	---
7	0	57.97	0	0	0	43.48	0	0	0	0	0	0
8	57.97	28.99	0	0	21.74	0	0	0	0	0	0	0
9	28.97	0	0	21.74	0	86.96	0	0	108.7	0	0	0

1 Sample size equals 1.15×10^{-2} square meters.

2 Three samples per site taken October - November 1975. Four samples taken on other dates.

Table 11. Mean number of *Eteone heteropoda* per square meter on the ocean beach.[1]

Season[2]	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	43	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	---	---	---	---	---	---	---	---	---
5	0	0	0	0	0	0	0	22	0	0	0	0
6	0	0	0	---	---	---	---	---	---	---	---	---
7	0	0	0	0	0	0	65	326	261	22	65	0
8	0	0	0	0	0	0	87	435	87	22	0	22
9	0	0	0	0	0	0	43	0	0	0	130	43

1 Sample size equals 1.15×10^{-2} square meters.

2 Three samples per site taken October - November 1975. Four samples taken on other dates.

Table 12. Mean number of *Glycera* sp. per square meter on the ocean beach.[1]

Season[2]	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	0	0	0	0	0	0	0	21.74	86.96	0	0	0
2	0	0	0	0	0	0	0	0	108.70	0	0	0
3	0	0	0	0	0	0	21.74	0	0	0	0	0
4	0	0	0	---	---	---	---	---	---	---	---	---
5	0	0	0	0	0	0	0	21.74	0	0	0	0
6	0	0	0	---	---	---	---	---	---	---	---	---
7	0	0	0	0	0	0	0	21.74	0	0	0	0
8	0	0	0	0	0	0	0	21.74	108.7	0	43.48	21.74
9	0	0	0	0	0	0	43.48	43.48	65.22	0	65.22	0

[1] Sample size equals 1.15×10^{-2} square meters.

[2] Three samples per site taken October - November 1975. Four samples taken on other dates.

Table 13. Mean number of *Metamysidopsis mexicana* per square meter on the ocean beach.[1]

Season[2]	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	0	0	28.99	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	21.74	0
4	0	86.96	0	---	---	---	---	---	---	---	---	---
5	0	144.93	0	0	0	0	0	0	21.74	65.22	86.96	21.74
6	0	57.97	0	---	---	---	---	---	---	---	---	---
7	0	57.97	28.99	0	0	0	0	0	0	43.48	65.22	0
8	0	0	28.99	0	0	0	0	0	0	0	0	0
9	0	0	57.97	0	0	0	0	0	0	0	43.48	0

[1] Sample size equals 1.15×10^{-2} square meters.

[2] Three samples per site taken October - November 1975. Four samples taken on other dates.

Table 14. Mean number of *Amphiporeia virginiana* per square meter on the ocean beach.[1]

Season[2]	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	0	0	0	0	0	0	0	0	0	347.83	304.35	239.13
2	0	0	0	0	0	0	0	0	0	0	43.48	0
3	0	0	0	0	0	0	0	0	0	21.74	21.74	0
4	0	0	0	---	---	---	---	---	---	---	---	---
5	0	0	0	0	0	0	0	0	0	21.74	43.48	0
6	0	0	0	---	---	---	---	---	---	---	---	---
7	0	0	0	0	0	0	0	0	0	65.22	0	43.48
8	0	0	0	0	0	0	0	0	0	0	21.74	0
9	0	0	0	0	0	0	0	0	0	21.74	0	65.22

1 Sample size equals 1.15×10^{-2} square meters.

2 Three samples per site taken October - November 1975. Four samples taken on other dates.

Table 15. Mean number of *Leucon americanus* per square meter on the ocean beach.[1]

Season[2]	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	21.74
4	0	0	0	---	---	---	---	---	---	---	---	---
5	0	0	0	0	0	0	0	21.74	65.22	0	21.74	0
6	0	0	0	---	---	---	---	---	---	---	---	---
7	0	0	0	0	0	0	43.48	65.22	0	0	43.48	21.74
8	0	0	0	0	0	0	65.22	130.43	21.74	152.17	108.70	0
9	0	0	0	0	0	0	21.74	0	86.96	152.17	86.96	195.65

[1] Sample size equals 1.15×10^{-2} square meters.

[2] Three samples per site taken October - November 1975. Four samples taken on other dates.

Table 16. Mean number of *Microphthalmus sczelkowii* per square meter on the ocean beach.[1]

Season[2]	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	0	0	0	0	0	0	0	0	86.96	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	130.43
3	0	0	0	0	0	0	0	0	43.48	0	21.74	0
4	0	0	0	---	---	---	---	---	---	---	---	---
5	0	0	0	0	0	0	0	0	0	108.70	0	0
6	0	0	0	---	---	---	---	---	---	---	---	---
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	21.74	0	43.48	0
9	0	0	0	0	0	0	0	0	0	0	21.74	0

1 Sample size equals 1.15×10^{-2} square meters.

2 Three samples per site taken October - November 1975. Four samples taken on other dates.

square meter. The haustorid amphipod, *P. longimerus*, occurred with up to 4,000 individuals per square meter (particularly on site 8).

Site 9 was farthest from shore and was located in the middle of the buildup zone where megaripples occur in the rough facies. *Parahaustorius longimerus* was dominant in this area with up to 8,000 individuals per square meter; however, both *S. squamata* and *Donax* sp. occurred in large numbers. A second haustorid amphipod, *Bathyporeia quoddyensis*, also occurred in the area with up to 750 individuals per square meter. No other significant species were collected. Eight crustaceans and five polychaetes occurred over the sites but did not dominate any area.

d. Analyses of Variance. Three-way analyses of variance were performed using site number, transect number, and season as the independent variables, and total macrofauna and major macrofaunal species as the dependent variables (Table 17). The two-way interactions between site and transect, site and season, and transect and season were often highly significant. The three-way interaction between site, transect, and season was usually significant. When interaction terms are significant, interpretation of the main effects is difficult because the level of the measured variable (number of individuals collected) is affected nonadditively by the levels of the two or more independent variables. An interpretation was made after re-examining the data and determining the direction and magnitude of the interaction effects.

All species showed a significant difference in density due to season (probability, $p < 0.05$), and most showed a highly significant difference ($p < 0.001$). Densities generally increased from October to June and decreased in July. An exception was the seasonal distribution of *Donax* sp., which showed no significant change in total numbers between June and July. Clam spats (probably *Donax*) were numerous in June, but were reduced considerably in July. This indicated that a reduction in the *Donax* populations between the two samplings was counteracted by maturation of some juveniles. About 50 percent of the major species showed a significant difference in density between transects. Three of the four most abundant species were significantly different between transects ($p < 0.01$), but total macrofauna was not significantly different. Although macrofaunal species composition varied, the total number of organisms at a site did not vary significantly among transects (excluding temporal variation).

All the major species except *Microphtholmus sczelkowii*, *Glycera* sp., and *Petalosarsia declivis* showed a significant difference in density between sites. *A posteriori* tests (Student-Newman Keuls' procedure for differences between means at the 5-percent level) were performed on the species showing a significant difference between sites. *Emerita talpoida* was most abundant on sites 1 and 2; *P. longimerus* was most abundant on sites 8 and 9; and *S. squamata* was most abundant on site 7, but its densities on sites 5 and 8 were also significantly different from other sites. Juvenile *Donax* sp. were significantly more abundant on

Table 17. Three-way analyses of variance between the major macrofaunal species of the ocean beach and site, transect, and season.

Species	Probability of a greater F value						
				Interactions			
	Site	Transect	Season	Site-transect	Site-season	Transect-season	Site-transect-season
Total macrofauna	0.001	NS[1]	0.001	0.001	0.001	0.001	0.001
Emerita talpoida	0.001	0.003	0.001	NS	0.001	0.001	0.001
Scolelepis squamata	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Parahaustoris longimerus	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Bathyporeia quoddyensis	0.001	NS	0.001	0.001	0.001	0.023	0.001
Spiophanes sp.	0.002	0.030	0.007	0.001	0.001	0.001	0.001
Microphthalmus sczelkowii	NS	NS	0.003	NS	NS	NS	0.001
Glycera sp.	NS	NS	0.001	NS	NS	0.010	NS
Nephtys bucera	0.001	0.009	0.001	0.001	0.001	0.011	0.001
Amphiporeia virginiana	0.001	NS	0.001	NS	0.001	NS	NS
Metamysidopsis mexicana	0.022	0.022	0.005	NS	NS	NS	NS
Petalosarsia declivis	NS	NS	0.045	NS	NS	NS	NS
Megalona rosea	0.001	0.039	0.004	0.001	0.001	0.005	0.001
Leucon americanus	0.001	NS	0.001	0.021	0.001	NS	NS
Eteone heteropoda	0.001	0.039	0.001	NS	0.001	NS	NS
Donax sp.	0.001	NS	0.001	0.008	0.001	0.001	0.001

[1] Not significant.

sites 7, 8, and 9. The haustorid amphipod, *B. quoddyensis*, was most abundant on site 9. The other, less abundant species did not yield interpretable results in the *a posteriori* tests.

e. Physical Data. Water temperatures were recorded at each site (Table 18). Bottom temperature varied from 10.3° Celsius in March to 24.9° Celsius in July. Temperature usually decreased as the distance from shore increased. The greatest temperature range, 2.3° Celsius between sites 1 and 9, occurred in June.

Salinities were recorded on the bottom at each site (Table 19), and ranged from 30.1 parts per thousand in June to 35.8 parts per thousand in March. Salinity gradually increased with increased distance from shore because of the diluting effect of ground water nearshore. The greatest salinity range was 2.37 parts per thousand between sites 1 and 9 in October.

The vertical distance from a site to MSL varied between samplings (Table 20). The method of locating the zero point on the transects caused the site location to depend upon the level of the tide and the sea conditions during sampling. The site elevations were affected by seasonal changes in the slope of the beach face, especially at the deep sites. The greatest elevational change was at site 1 on transect III; the elevation was 0.24 meter below MSL on 20 November 1975 and 1.4 meters above MSL on 8 April 1976.

The mean grain size (in phi), sorting, skewness, and kurtosis of the sediments were determined for each site (Tables 21 to 24). The bottom material generally was fine but poorly sorted at sites 7, 8, and 9, and coarse but well sorted at sites 1, 2, and 3. Site 5 was in a transitional area between the coarse inner beach sediments and the fine deepwater sediments, and grain-size statistics were variable for this site.

The total organic content of the sediments (in grams per 100 grams) was determined for each site (Table 25). Organic content was generally low, and ranged from 0.00 to 2.17 grams per 100 grams with both the low and the high values occurring in the October 1975 sampling. Although a clear pattern of organic content distribution did not emerge, organic content was slightly higher at the deep sites than at the swash zone sites.

The total carbonate content (in grams per 100 grams) of the sediments was determined for each site (Table 26), and was usually high on sites 1, 2, and 3 and low on sites 7, 8, and 9. The highest carbonate content was 26.15 grams per 100 grams on site 5, where the concentration was often high because broken shells accumulated at the interface between the outer planar facies and the inner rough facies. Carbonate content on the inshore sites ranged from 2.19 to 17.78 grams per 100 grams; concentrations on the deep sites (7, 8, and 9) ranged from 0.28 to 2.83 grams per 100 grams. There was no pattern in the distribution of carbonate within the two groups of sites.

Table 18. Water temperatures (° Celsius) recorded on the ocean beach.

Season	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	22.63	22.91	---	11.9	12.5	12.5	20.1	18.7	21.9	24.9	21.2	23.26
2	22.79	22.76	22.84	12.2	12.4	12.3	19.8	18.7	20.9	24.9	20.9	23.9
3	22.35	22.72	22.72	11.3	12.3	12.4	18.9	18.6	20.5	25.3	21.6	22.4
4	22.83	22.72	22.86	---	---	---	---	---	---	---	---	---
5	22.9	22.42	22.80	11.4	12.2	12.4	19.4	18.5	20.1	24.2	19.6	23.0
6	22.42	22.48	22.85	---	---	---	---	---	---	---	---	---
7	22.63	22.40	22.93	10.3	12.2	12.4	18.3	18.4	20.7	24.2	19.3	22.8
8	22.82	22.42	22.92	10.3	12.2	12.4	18.2	18.5	20.7	24.2	19.0	20.2
9	22.74	22.32	22.84	10.3	12.2	12.4	17.8	18.7	20.6	24.2	19.5	20.9

Table 19. Salinity levels (parts per thousand) recorded on the ocean beach.

Season	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	33.91	33.80	---	34.4	31.6	32.0	32.8	30.1	31.7	31.8	32.92	33.43
2	34.08	34.04	34.19	34.6	31.9	31.2	33.2	30.1	32.5	31.7	32.92	33.45
3	34.35	34.30	34.26	34.3	32.1	32.1	32.1	30.9	32.1	31.7	32.6	33.40
4	34.61	34.50	34.09	---	---	---	---	---	---	---	---	---
5	34.90	34.82	34.12	34.6	30.9	32.1	32.5	31.1	33.2	33.4	34.56	34.48
6	35.09	35.10	34.00	---	---	---	---	---	---	---	---	---
7	35.12	35.10	34.02	35.8	32.4	32.2	33.9	31.3	34.0	33.3	34.44	34.37
8	35.12	35.08	34.13	35.8	32.4	32.2	33.8	31.1	33.9	33.3	34.78	34.65
9	35.15	35.17	34.44	35.8	32.4	32.2	33.8	31.7	34.0	33.3	34.41	34.47

Table 20. Vertical distance (in meters) from MSL of sites on the ocean beach.

Season	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	-0.03	-0.06	-0.24	0.31	1.25	1.37	0.27	0.12	0.21	0.43	0.49	0.67
2	-0.21	-0.43	-0.46	0.15	1.00	1.19	0.15	0	0.12	0.40	0.43	0.61
3	-0.43	-0.73	-0.52	-0.08	0.85	0.31	-0.31	-0.31	0	0.34	0.21	0.40
4	-0.64	-1.19	-0.67	---	---	---	---	---	---	---	---	---
5	-0.91	-1.37	-0.76	-0.31	0.40	0.67	-0.46	-0.91	-0.46	-0.31	-0.55	-0.06
6	-1.34	-1.68	-0.91	---	---	---	---	---	---	---	---	---
7	-1.68	-1.98	-1.07	-1.22	-0.67	-0.09	-1.07	-1.52	-1.22	-1.07	-0.70	-0.82
8	-2.59	-2.62	-1.37	-1.83	-2.04	-1.16	-1.37	-2.44	-2.74	-1.52	-1.46	-2.04
9	-2.74	-3.23	-1.98	-2.44	-2.80	-2.53	-2.13	-3.20	-3.66	-1.98	-2.22	-3.26

Table 21. Mean grain size (in phi) of sediments on each site on the ocean beach.

Season	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	-2.300	-1.3996	-1.9353	0.0995	1.0369	0.9910	1.0331	-0.7658	-0.8832	0.646	1.6174	1.4580
2	-2.1750	-1.7069	-1.8023	0.4756	0.5223	1.1581	-0.8441	-0.0733	-1.2189	-0.1403	0.5773	1.0330
3	1.8913	-2.1512	-1.6346	-0.646	0.2768	0.5971	-1.0079	-0.2182	-1.0912	0.1984	-1.1411	0.4131
4	1.9609	2.5580	-1.7889	---	---	---	---	---	---	---	---	---
5	2.1604	2.660	1.4654	-0.5384	-0.2768	-0.9269	-0.4354	-1.0340	-1.4606	-1.3565	1.3791	-0.2615
6	2.3880	2.5139	2.4280	---	---	---	---	---	---	---	---	---
7	2.5715	2.7230	2.1894	2.2524	1.5612	2.5326	1.9126	2.1275	1.7465	2.2498	1.5479	1.6662
8	2.5909	2.5841	2.4906	2.4468	2.2528	2.1548	1.9529	1.6453	1.5067	2.1166	1.3594	1.6340
9	2.5343	2.6109	2.1973	2.4872	2.026	2.6440	1.7246	1.5048	1.5668	1.8236	1.4849	1.6516

Table 22. Sorting of sediments on each site on the ocean beach.

Season	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	0.887	0.483	0.736	1.411	1.228	1.522	1.410	2.310	1.448	1.656	1.103	1.305
2	0.793	0.626	0.600	1.548	1.306	1.361	2.301	1.692	2.067	1.632	1.830	1.433
3	1.600	0.758	0.577	1.200	1.374	1.356	1.866	1.590	1.567	1.773	2.277	1.547
4	1.653	0.575	0.643	---	---	---	---	---	---	---	---	---
5	1.123	0.615	1.794	1.633	1.492	2.076	2.298	1.581	1.577	1.855	2.058	1.656
6	0.724	0.736	0.809	---	---	---	---	---	---	---	---	---
7	0.611	0.642	0.871	0.886	1.555	0.051	0.551	0.523	0.526	0.608	0.665	0.900
8	0.805	0.576	0.594	0.420	0.649	1.826	0.786	0.405	0.295	0.715	0.756	1.087
9	0.566	0.602	0.812	0.441	1.067	0.769	0.535	0.697	0.320	0.613	0.462	0.454

Table 23. Skewness of sediments at each site on the ocean beach.

Season	October - November 1975			March - April 1976			June 1976			July 1976		
Site / Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	0.086	-0.020	-0.343	0.928	-0.037	-0.312	-0.286	0.267	0.401	-0.174	-1.006	-0.800
2	0.345	-0.798	-0.709	0.287	0.637	-0.312	0.507	0.278	0.901	0.485	-0.380	-0.264
3	-1.535	0.154	0.464	1.916	0.317	0.308	0.101	0.467	1.124	-0.137	0.731	0.237
4	-1.682	-0.371	-0.589	---	---	---	---	---	---	---	---	---
5	-2.280	-0.288	-1.294	1.072	0.887	0.771	0.672	0.440	1.488	1.006	-1.636	0.412
6	-2.736	-1.210	-2.051	---	---	---	---	---	---	---	---	---
7	-1.014	-1.317	-1.747	-2.039	-0.768	-1.997	-0.223	-1.115	-0.943	-3.280	-2.627	-2.011
8	-1.868	-0.004	-0.319	-1.892	-0.445	-1.670	-1.860	0.649	-3.324	-3.084	-1.516	-2.960
9	-0.705	0.007	-2.524	-1.269	-2.201	-0.011	-0.050	-1.514	0.242	-0.940	-5.257	-0.063

Table 24. Kurtosis of sediments at each site on the ocean beach.

Season	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	3.287	8.612	4.641	2.624	1.668	1.918	1.713	1.452	2.034	1.698	3.220	2.402
2	5.568	7.207	5.556	1.940	2.048	2.110	1.607	2.193	2.431	1.982	1.950	1.777
3	5.340	5.400	13.664	6.235	2.172	1.879	2.456	2.270	3.823	2.162	1.880	1.836
4	5.146	5.380	5.600	---	---	---	---	---	---	---	---	---
5	9.219	6.372	3.443	2.894	2.685	2.571	2.009	3.306	4.489	3.00	4.401	2.584
6	16.386	8.245	11.728	---	---	---	---	---	---	---	---	---
7	8.651	11.721	8.854	9.503	2.685	12.827	5.075	5.428	11.932	18.484	16.334	8.548
8	11.421	7.787	7.623	18.296	5.576	5.643	8.501	8.041	49.958	16.930	6.842	13.310
9	8.222	7.458	15.203	12.910	11.910	8.114	5.597	10.938	21.752	6.817	49.550	10.862

Table 25. Organic content of sediments (in grams per 100 grams) on the ocean beach.

Season	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	0.42	1.17	0.42	0.17	0.37	0.63	0.12	0.14	0.19	0.11	0.09	0.08
2	0.36	0.57	0	0.20	0.51	0.83	0.13	0.11	0.15	0.15	0.08	0.10
3	0.38	1.09	1.11	0.15	0.46	0.68	0.13	0.11	0.16	0.16	0.14	0.09
4	0.09	2.17	0	---	---	---	---	---	---	---	---	---
5	0	1.56	1.45	0.31	0.53	0.49	0.12	0.11	0.14	0.10	0.13	0.10
6	0	1.73	1.60	---	---	---	---	---	---	---	---	---
7	0	0	0	0.51	0.58	0.81	0.14	0.21	0.21	0.21	0.22	0.14
8	0.25	0.48	0	0.49	0.83	0.97	0.15	0.28	0.25	0.25	0.19	0.18
9	0	1.14	0	0.40	0.87	1.07	0.15	0.17	0.26	0.26	0.21	0.23

Table 26. Carbonate concentration (in grams per 100 grams) on the ocean beach.

Season	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	13.69	4.02	3.24	3.32	4.73	4.93	2.40	8.63	9.04	2.82	2.84	2.19
2	4.94	2.73	7.17	3.38	2.42	3.48	17.78	4.31	9.73	3.57	3.17	2.89
3	3.36	6.53	4.70	14.55	2.46	7.46	5.57	4.11	6.00	4.77	7.20	2.84
4	1.88	1.84	5.28	---	---	---	---	---	---	---	---	---
5	0.43	1.28	1.38	2.76	3.33	26.15	2.25	7.04	3.52	3.68	7.26	4.27
6	1.86	1.73	1.25	---	---	---	---	---	---	---	---	---
7	0.74	1.52	1.57	1.22	1.88	1.08	1.7	1.49	1.77	1.52	2.03	1.75
8	2.57	2.10	1.49	1.30	1.40	1.74	2.46	1.81	1.78	1.66	2.83	1.47
9	1.86	1.76	1.12	1.10	1.83	1.07	1.59	1.85	1.85	1.84	1.27	0.28

f. Correlation Analyses. A correlation matrix was developed, using the physical parameters and the major species. Twenty-nine variables were used, producing 406 nonredundant correlations (Table 27). The correlation coefficients from the comparison of major species with season, transect, site, and horizontal distance from shore, generally agreed with the results of the variance analysis. The correlation between *E. talpoida*, *Donax* sp., *A. virginiana*, *L. americanus*, or *M. sczelkowii* and temperature was significant, but no species showed a significant correlation with salinity. Temperature and salinity changed gradually with increased distance from shore, thus the correlations between a species and temperature reflect the seasonal effect.

Emerita talpoida had a strong negative correlation with mean grain size, indicating an affinity for the coarse sediments of the upper swash zone. *Emerita talpoida* correlated with sorting, skewness, and kurtosis because of the partial correlation of these variables with mean grain size. The burrowing amphipods, *P. longimerus* and *B. quoddyensis*, had a strong, positive correlation with mean grain size, indicating an affinity for the fine sediments of the deep sites.

A principal factor analysis with iteration and varimax rotation (Nei, et al., 1975) was performed on the correlation matrix. The extracted factors, eigenvalues, and the percent of variance explained are presented in Table 28. Nine factors were extracted, but the first five, interpreted below, explained over 80 percent of the variance:

(a) Factor 1. This factor loaded heavily with month of collection (loading 0.94165), indicating that the largest source of variance was seasonal variation which accounted for about one-third of the variance.

(b) Factor 2. This factor loaded heavily and positively with site, horizontal distance from shore, mean grain size, and kurtosis. It loaded heavily and negatively with vertical distance from MSL and the sorting, skewness, and carbonate content of the sediments. Since the other variables were strongly correlated (positively or negatively) with site, this factor depended on location on the transect, and accounted for 20 percent of the variance.

(c) Factor 3. The factor loaded heavily with two selective surface deposit-feeding polychaetes, *Spiophanes bombyx* and *Megalona rosea*. These species occurred sporadically in the collections. Their occurrence was very highly correlated, but they did not correlate strongly with other variables. *Scolelepis squamata*, another selective surface deposit-feeding polychaete, was abundant on most sites, but did not fall into this factor.

(d) Factor 4. The factor loaded with the burrowing amphipod, *P. longimerus* and with an omnivorous fast-burrowing polychaete, *Nephytes bucera*. It is also loaded with a third variable, the kurtosis of the sediments, and with a second burrowing, omnivorous polychaete,

Table 27. Matrix of correlation coefficients among physical parameters and major species for the ocean beach.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1. Season	----																												
2. Site	019	----																											
3. Transect	028	005	----																										
4. Mean	-163	707	-133	----																									
5. Sorting	132	-561	023	-535	----																								
6. Skewness	212	-530	034	-656	464	----																							
7. Kurtosis	017	516	221	366	-464	-624	----																						
8. Hor. Dist.	-060	780	064	479	-467	-444	402	----																					
9. Temperature	199	-014	-033	-100	027	-021	068	-034	----																				
10. Salinity	014	268	-174	262	-089	-137	177	194	410	----																			
11. Vert. Dist.	-050	-752	165	-528	468	363	-513	-576	-021	-159	----																		
12. Depth	396	682	060	381	-388	-310	540	535	-185	107	-159	----																	
13. *Emerita*	198	-458	014	-270	270	205	-211	-326	154	-058	338	-275	----																
14. *H. mexicana*	-005	064	016	088	-061	-018	-021	-018	108	018	-009	-047	-086	----															
15. *S. squamata*	274	201	-045	056	-125	071	-002	044	036	-008	-179	-008	-119	002	----														
16. *S. bombyx*	126	134	010	051	-068	-108	088	141	015	039	-127	180	-035	062	-039	----													
17. *N. bucera*	186	274	117	137	-233	-116	470	260	083	027	-376	491	-087	-046	204	043	----												
18. *E. heteropoda*	127	179	026	137	-173	-061	093	078	018	-020	-183	234	-080	-010	405	114	088	----											
19. *Glycera* sp.	129	075	121	-009	-041	071	214	089	050	-003	-158	212	-074	-032	016	143	314	003	----										
20. *Donax* sp.	303	295	-073	207	-241	-049	095	189	152	019	-273	018	-101	051	450	107	326	305	078	----									
21. *P. longimerus*	265	456	135	256	-329	-191	511	431	056	066	-511	066	-139	-045	172	121	730	070	258	388	----								
22. *A. virginiana*	234	177	-033	-065	086	068	-088	-129	165	-005	110	-069	373	-029	-033	-016	-011	-019	-034	013	-021	----							
23. *B. quoddyensis*	105	275	-021	182	-180	-110	192	246	107	077	-273	300	-098	-016	018	003	212	0	064	180	392	035	----						
24. *L. americanus*	290	310	-005	148	-218	-035	145	273	110	042	-312	437	-115	-034	163	180	203	223	140	361	427	031	403	----					
25. *M. acsalkowii*	178	-074	076	-122	130	087	-031	-063	124	006	058	-026	013	095	-039	114	008	-027	049	004	007	-161	009	-027	--				
26. *P. declivis*	-092	-115	018	123	-089	036	073	115	-100	044	-164	059	-073	-015	-037	-021	066	042	035	145	134	-041	244	-042	-035	---			
27. Organic	-300	045	239	104	-181	-019	-026	166	-202	-025	-032	-105	-066	120	-112	-028	-062	-048	-062	-079	-030	-087	-086	-071	065	056			
28. Carbonate	-005	-427	033	-541	-427	455	-302	-354	-093	-084	351	-200	-118	-055	-056	-059	-124	-101	035	-148	208	050	135	137	035	032	039		
29. *M. rosea*	118	311	004	136	-173	-061	093	078	018	-620	-183	-145	-080	049	465	114	115	113	154	305	194	012	000	222	093	011	019	101	

Note: All samples for collections 2 to 5 are included--total of 333. Decimal points are omitted, all absolute values over 0.108 are significant at the 5-percent level; all absolute values over 0.141 are significant at the 1-percent level.

Table 28. Principal factors with eigenvalues and percent of variance predicted by each factor, ocean beach.

Factor	Eigenvalue	Pct of Variance	Cumulative Pct Variance
1	6.12413	34.7	34.7
2	3.58640	20.3	55.1
3	1.95403	11.1	66.1
4	1.50980	8.6	74.7
5	1.30912	7.4	82.1
6	0.92319	5.2	87.4
7	0.89462	5.1	92.4
8	0.73495	4.2	96.6
9	0.59845	3.4	100.0

Glycera sp., but not as strongly as the other variables (0.3758). The factor includes organisms that burrow through the fine, leptokurtotic sands of the deepwater sites.

(e) Factor 5. The factor loaded heavily with the deposit-feeding polychaete, *S. squamata*, *Donax* sp., and the carnivorous polychaete, *Eteone heteropoda*. These animals were characteristic of deepwater sites, but sometimes moved shoreward and were found in low numbers on all sites.

g. Species Diversity. Species diversity for each sample was calculated, using the Shannon-Weaver index:

$$H' = -\sum_{1}^{s} (N_i/N) \log_2 (N_i/N) \ ,$$

where N_i is the number of individuals per taxon, N is the total number of organisms, and s is the number of taxa. The species diversity was calculated for each site (Table 29). A three-way analysis of variance was performed on these data with site, transect, and season as the independent variables.

The two-way interaction terms were significant, but the three-way interaction term was not significant. There was no significant difference in diversity between transects. There was a highly significant difference between both sites and seasons. Diversity was lowest during October and increased during March, June, and July. Diversities in October ranged from 0 to 1.27 and in July from 0.29 to 1.80. The deep sites had the highest diversities with the highest diversity (1.85) occurring on transect III, site 9 in June 1976.

2. The Sound Beach.

a. Preliminary Sampling. Samples taken during 26 and 27 July 1975 are not comparable to the other four sets of samples because different extraction techniques were used, and will not be discussed here (see App. D).

b. Faunistics. Twenty-three species of macrofauna in four phyla and 23 families were collected (Table 30). The phylum Arthropoda dominated the macrofauna with 14 families and at least 14 species. The phylum Annellida, represented by five species, was most numerous. Larval Diptera were not identified below the family level; several species may have been represented, particularly in the family Chironomidae.

c. Species Abundance. The mean number of individuals per square meter was calculated for each site and season for the total fauna, and

Table 29. Average diversity per site on the ocean beach.

Season	October - November 1975			March - April 1976			June 1976			July 1976		
Site \ Transect	I	II	III	I	II	III	I	II	III	I	II	III
1	0	0	0.60	0	0.30	0.81	1.46	1.38	1.18	1.01	1.74	1.24
2	0	0	0	0.05	0.25	0.38	1.41	1.56	0.95	0.29	1.27	0.88
3	0	0	0.20	0.18	0	0.31	1.30	1.10	1.71	0.77	1.17	0.58
4	0.24	0	0	---	---	---	---	---	---	---	---	---
5	0.82	0.22	0.31	0.34	0.25	0	1.40	0.18	1.46	1.42	0.53	0.45
6	0.32	1.19	0	---	---	---	---	---	---	---	---	---
7	1.27	0.95	1.0	0	0.87	0.97	0.97	1.11	1.05	1.30	1.63	1.01
8	0.83	0.67	0.63	0.49	0.89	1.19	1.55	1.61	1.76	1.79	1.45	0.69
9	0.38	0	0.79	0.98	1.44	1.21	1.54	1.31	1.85	1.67	1.80	1.78

1 Sample size equals 1.15×10^{-2} square meters.

2 For October - November 1975 $N = 3$; for all other dates $N = 4$.

Table 30. Faunistic list of the sound beach at the CERC Field Research Facility. Species above 0.5 millimeter only.

Phylum NEMATODA
- Order Dorylaimida

Phylum ANNELLIDA
- Class Polychaeta
  - Order Spionida
    - Family Spionidae
      - *Scolecolepides viridis*
  - Order Phyllodocida
    - Family Nereidae
      - *Laeonereis culveri*
  - Order Terebellidae
    - Family Ampharetidae
      - *Lysippides grayi*
- Class Oligochaeta
  - Order Prosopora
    - Family Lumbriculidae
      - *Lumbriculus* sp.
  - Order Plesiopora
    - Family Tubifisidae
      - *Peloscolex* sp.

Phylum MOLLUSCA
- Class Bivalvia
  - Family Mactridae
    - *Rangia cuneata*
- Class Gastropoda
  - Order Pulmonata
    - Family Physidae
      - *Physa* sp.
    - Family Ancylidae
      - *Ferrissia* sp ?

Phylum ARTHROPODA
- Class Crustacea
  - Order Amphipoda
    - Family Haustoridae
      - *Lepidactylus dysticus*

Table 30. Faunistic list of the sound beach at the CERC Field Research Facility. Species above 0.5 millimeter only.--Continued

Family Gammaridae
Gammarus sp.

Family Photidae
Leptocheirus plumulosus

Family Oedicerotidae
Monoculodes sp.

Order Isopoda
Family Anthuridae
Cyathura polita

Family Idoteidae
Chiridotea sp.

Order Decapoda
Family Cambaridae
Cambarus sp ? (immature)

Family Portunidae
Callinectes sapidus

Class Insecta
Order Odonata
Family Coenagrionidae
Enallagma sp.

Order Collembola
Species A

Order Coleoptera
Family Dytiscidae
Uvarus sp.

Order Diptera
Family Tabanidae
Species A (immature)

Family Chironomidae
(Immatures)

Family Cerotopogonidae
(Immatures)

for each species constituting more than 1 percent of the total macrofauna (Tables 31 to 42). The total fauna, including both macrofauna and larger meiofauna, varied from 230 (site 3, transect VI, October 1975) to 132,700 individuals per square meter (site 1, transect IV, July 1976). Densities were generally highest on transect IV and lowest on transect VI and meiofauna species, primarily copepods, had the highest densities.

The burrowing amphipod, *L. dysticus*, was abundant with 0 to 3,300 individuals per square meter. Another amphipod, *Monoculodes* sp., was common with 0 to 1,360 individuals per square meter. Two other amphipods, *Leptocheirus plumulosus* and *Gammarus* sp., were collected on the beach, but their densities were low and their occurrence was sporadic.

The burrowing polychaete, *Scolecolepides viridis*, was found on all sites, but was most abundant in deep waters with 0 to 435 individuals per square meter. Two other polychaetes, *Lysippides grayi* and *Laeonereis culveri*, occurred sporadically and in low numbers, but their frequency of occurrence was highest during July 1976.

Chironomid larvae and the oligochaete, *Peloscolex* sp., were usually abundant with 0 to 2,579 and 0 to 41,480 individuals per square meter, respectively. They were most abundant on transect IV and on site 8 of all transects.

The last major species was the brackish water clam, *R. cuneata*, which was commonly collected on the deep sites with 0 to 115 individuals per square meter.

d. Analyses of Variance. Three-way analyses of variance were performed on the total macrofauna and on all major species, using site, season, and transect as the independent variables (Table 43). The two-way interactions between site and season, transect and site, and season and site were often highly significant. The three-way interaction between site, transect, and season was also usually significant. Significant interactions make interpretation of the main effects difficult, because the levels of the measured variables are affected nonadditively by the levels of two or more independent variables. The interpretations were made after re-examining the original data and determining the direction and magnitude of the interaction term. The total fauna showed significantly different densities for site, transect, and season. Total fauna increased on all sites during May and July 1976, but greatly increased on sites 1 and 2 of transect IV because of marsh development.

Scolecolepides viridis showed highly significantly different densities for site and season but no significant difference in densities for transect. This species was most abundant on the deep sites with a significant difference in density between samplings with an increase during March and May.

Table 31. Mean number of all organisms per square meter on the sound beach.[1]

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	11,304.35	782.61	434.78	4,057,97	1,536.23	2,028.99	20,492.75	4,666.67	4,492.75	132,724.64	3,710.14	3,971.01
2	6,811.59	1,536.23	434.78	2,115.94	2,376.81	1,333.33	14,318.84	7,507.25	7,014.49	10,753.62	9,159.42	3,333.33
3	3,768.12	608.70	231.88	1,391.30	1,304.35	1,014.49	16,028.99	5,014.49	5,159.42	11,681.16	5,304.35	3,971.01
4	1,768.12	1,391.30	405.80	927.54	1,739.13	1,159.42	18,666.67	6,811.59	7,130.43	4,811.59	5,275.36	3,710.14
5	1,594.20	1,072.46	289.86	1,565.22	1,449.28	869.57	14,231.88	5,797.10	5,275.36	2,550.72	2,405.8	2,405.8
6	3,710.14	405.80	115.94	1,333.33	1,536.23	898.55	16.289.86	7,304.35	4,463.77	4,927.54	9,739.13	3,188.41
7	202.9	405.80	608.70	956.52	985.51	753.62	5,304.35	4,898.55	7,043.48	2,898.55	2,202.9	3,217.39
8	434.78	463.77	347.83	1,652.17	1,449.28	1,768.12	8,115.94	4,289.86	4,057.97	3,855.07	3,362.32	17,304.35

[1] Sample size equals 1.15×10^{-2} square meters; N equals 3 .

Table 32. Mean number of *Lepidactylus dysticus* per square meter on the sound beach.[1]

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	0	231.88	405.80	0	492.75	724.64	405.80	318.84	1,536.23	0	1,478.26	1,420.29
2	86.96	1,449.28	289.86	0	1,246.38	724.64	608.70	3,188.41	1,536.23	173.91	3,304.35	1,536.23
3	289.86	492.75	173.91	144.93	579.71	579.71	1,449.28	2,028.99	1,362.32	463.77	724.64	1,217.39
4	376.81	956.52	347.83	173.91	811.59	521.74	550.72	3,217.39	1,072.46	463.77	724.64	753.62
5	86.96	608.7	231.88	260.87	811.59	434.78	550.72	1,623.19	1,333.33	376.81	782.61	695.65
6	231.88	231.88	57.97	695.65	666.67	289.86	782.61	1,710.14	869.57	260.87	927.54	1,333.33
7	0	231.88	376.81	0	173.91	86.96	579.71	608.7	956.52	28.99	57.97	66.67
8	144.93	115.94	0	0	86.96	0	86.96	376.81	28.99	0	0	86.96

[1] Sample size equals 1.15×10^{-2} square meters; *N* equals 3 .

Table 33. Mean number of *Scolecolepides viridis* per square meter on the sound beach.[1]

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	0	0	28.99	0	28.99	28.99	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	28.99	28.99	0
3	0	0	28.99	57.97	57.97	28.99	0	0	28.99	0	28.99	86.96
4	0	0	28.99	28.99	115.94	86.96	0	0	57.97	28.99	0	57.97
5	57.97	115.94	57.97	28.99	28.99	0	0	57.97	28.99	0	0	86.96
6	144.93	28.99	28.99	86.96	57.97	57.97	28.99	57.97	57.97	0	57.97	28.99
7	115.94	86.96	202.90	289.86	86.96	173.91	144.93	115.94	115.94	28.99	28.99	86.96
8	202.90	115.94	260.87	231.88	405.80	289.86	347.83	405.80	434.78	86.96	115.94	260.87

[1] Sample size equals 1.15×10^{-2} square meters; N equals 3 .

Table 34. Mean number of *Peloscolex* sp. per square meter on the sound beach.[1]

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	3,942.03	28.99	0	521.74	115.94	86.96	15,217.39	57.97	86.96	41,478.26	86.96	144.93
2	3,188.41	0	0	840.88	0	0	3,884.06	434.78	86.96	5,710.14	898.55	231.88
3	2,289.86	28.99	0	289.86	28.99	0	7,391.30	173.91	202.90	5,739.13	579.71	376.81
4	811.59	115.94	0	463.77	173.91	0	4,898.55	463.77	318.84	2,869.51	521.74	811.59
5	782.61	115.94	0	115.94	28.99	86.96	9,623.19	144.93	231.88	1,217.39	231.88	173.91
6	2,202.90	28.99	0	28.99	0	289.97	6,724.64	956.52	202.90	2,000.0	637.68	115.94
7	28.99	0	0	115.94	115.94	144.93	2,289.86	1,333.33	1,652.17	1,826.09	782.61	1,043.48
8	0	115.94	0	144.93	231.88	869.57	4,202.90	1,623.19	782.61	3,333.33	2,289.86	6,869.57

[1] Sample size equals 1.15×10^{-2} square meters; N equals 3 .

Table 35. Mean number of Chironomidae larvae per square meter on the sound beach.[1]

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	7,159.42	521.74	0	2,579.71	492.75	869.57	1,130.43	57.97	86.96	1,681.16	115.94	492.75
2	3.101.45	57.97	86.96	347.83	376.81	57.97	753.62	173.91	115.94	1,507.25	144.93	405.80
3	956.52	57.97	0	202.90	115.94	0	231.88	86.96	289.86	1,739.13	260.87	347.83
4	289.86	173.91	0	0	86.96	28.99	376.81	202.90	376.81	521.74	347.83	260.87
5	492.75	231.88	0	260.87	202.90	0	173.91	260.87	579.71	115.94	86.96	202.90
6	753.62	86.96	0	57.97	115.94	57.97	347.83	202.90	289.86	202.90	492.75	0
7	28.99	86.96	28.99	115.94	202.90	57.97	260.87	202.90	289.86	231.88	202.90	289.86
8	0	115.94	86.96	695.65	579.71	231.88	1,130.43	289.86	985.51	86.96	144.93	2,144.93

[1] Sample size equals 1.15×10^{-2} square meters; N equals 3 .

Table 36. Mean number of *Leptocheirus plumulosus* per square meter on the sound beach.[1]

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	0	0	0	0	0	0	2.67	0.67	1.33	0	0	0.33
2	0	0	0	0	0	0	1.67	2.33	0	0	0	0
3	0	0	0	0	0	0	0.67	1.67	0.33	0	0	0
4	0	0	0	0	0	0	1.33	0.67	2.0	0	0	0
5	0	0	0	0	0	0	1.33	0.67	4.33	0.33	0	0
6	0	0	0	0	0	0	2.67	1.00	1.00	0.67	0	0
7	0	0	0	0	0	0	4.0	2.00	2.33	0.67	0	0.33
8	0	0	0	0	0	0	8.67	7.00	11.00	1.00	3.33	1.67

[1] Sample size equals 1.15×10^{-2} square meters; N equals 3 .

Table 37. Mean number of *Monoculodes* sp. per square meter on the sound beach.[1]

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	0	0	0	0	115.94	144.93	0	28.99	28.99	0	0	144.93
2	0	28.99	57.97	144.93	347.83	260.87	28.99	260.87	0	0	28.99	0
3	0	28.99	28.99	434.78	463.77	173.91	173.91	231.88	115.94	144.93	144.93	86.96
4	0	115.94	28.97	202.90	289.86	318.84	57.97	144.93	144.93	115.94	144.93	57.97
5	86.96	0	0	202.90	173.91	289.86	0	202.9	260.87	86.96	144.93	115.94
6	28.99	0	28.99	231.88	405.80	231.88	260.87	463.77	260.87	57.97	115.94	86.96
7	0	0	0	28.99	347.83	173.91	289.86	1,362.32	376.81	0	28.99	57.97
8	28.99	0	0	144.93	28.99	86.96	231.88	115.94	86.96	28.99	0	115.94

[1] Sample size equals 1.15×10^{-2} square meters; N equals 3 .

Table 38. Mean number of *Gammarus* sp. per square meter on the sound beach.[1]

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	0	0	0	0	0	0	28.99	57.97	0	0	0	57.97
2	0	0	0	0	0	0	202.90	115.94	0.67	28.99	0	202.90
3	0	0	0	0	0	0	28.99	0	0	434.78	0	28.99
4	0	0	0	0	0	0	0	86.96	0	115.94	0	115.94
5	0	0	0	0	0	0	28.99	0	0	57.97	0	28.99
6	0	0	0	0	0	0	0	0	0	28.99	28.99	28.99
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	28.99	521.74

[1] Sample size equals 1.15×10^{-2} square meters; N equals 3 .

Table 39. Mean number of *Cyathura polita* per square meter on the sound beach.[1]

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	0	0	0	1.67	0	0	0.33	0	0.67	1.00	0	0.67
2	3.00	0	0	5.33	0.33	0	5.67	1.00	1.67	0	0	0
3	1.67	0	0	1.00	0	0	2.33	1.00	1.33	1.33	.33	1.00
4	1.33	0	0	0.33	0	0	1.00	1.00	0.67	0	0	0
5	0.33	0	0	1.33	0	0	1.00	0	0.67	0	0	0
6	2.67	0.33	0	0	0	0	2.33	0.67	1.00	0	0	0
7	0.33	0	0	0	0	0	0	0.33	0.33	0	0	0
8	0.33	0	0	0	0	0	0.33	0.33	0.33	1.00	1.00	3.00

1 Sample size equals 1.15×10^{-2} square meters; N equals 3 .

Table 40. Mean number of *Rangia cuneata* per square meter on the sound beach.[1]

Season	October 1975			March 1976			May 1976			July 1976		
Site / Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	28.99
3	0	0	0	28.99	0	0	28.99	0	0	0	0	28.99
4	0	0	0	0	0	0	0	0	0	0	0	0
5	28.99	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	28.99	0	0	0	0	115.94	0	0	0
8	0	0	0	28.99	0	28.99	0	28.99	0	28.99	0	0

[1] Sample size equals 1.15×10^{-2} square meters; N equals 3 .

Table 41. Mean number of *Laeonereis culveri* per square meter on the sound beach.[1]

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	115.94	0	0
3	0	0	0	0	0	0	0	0	0	57.97	0	0
4	0	0	0	0	0	0	0	0	0	28.99	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	86.96	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	2,434.78

[1] Sample size equals 1.15×10^{-2} square meters; N equals 3 .

Table 42. Mean number of *Lysippides grayi* per square meter on the sound beach.[1]

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	0	0	0	0	0	0	0	0	0	0	1.13	1.75
2	57.97	0	0	86.96	0	0	0	0	0	28.99	1.46	1.60
3	57.97	0	0	0	0	0	0	0	0	57.97	1.52	2.17
4	0	0	0	0	0	0	0	0	0	0	1.56	1.98
5	0	0	0	0	0	0	0	0	0	0	1.37	1.95
6	0	0	0	0	0	0	0	0	0	0	1.15	1.41
7	0	0	0	0	0	0	0	0	0	0	1.44	2.08
8	0	0	0	0	0	0	0	0	28.99	0	1.30	2.18

[1] Sample size equals 1.15×10^{-2} square meters; N equals 3 .

Table 43. Three-way analyses of variance between the major macrofaunal species of the sound beach and site, transect, and season.

Species	Probability of a greater F value						
				Interactions			
	Site	Season	Transect	Site-season	Site-transect	Season-transect	Site-season-transect
Total fauna	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Scolecolepides viridis	0.001	0.002	NS[1]	0.001	NS	NS	NS
Lepidactylus dysticus	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Leptocheirus plumulosis	0.001	0.001	NS	0.001	NS	NS	NS
Monoculodes sp.	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cyathura polita	0.001	0.001	0.001	0.001	0.001	0.001	0.045
Peloscolex sp.	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Rangia cuneata	0.032	NS	NS	NS	NS	NS	0.001
Chironomid Larvae	0.001	NS	0.001	0.006	0.001	0.001	0.012
Lysippides grayi	0.001	0.012	0.034	0.001	0.001	0.002	0.001

1 Not significant.

The results for *L. plumulosus* were identical to those for *S. viridis*, but *L. plumulosus* was less abundant and was collected in large numbers only during May 1976.

Lepidactylus dysticus showed highly significant differences in density for all factors. This species was found on all sites but was least abundant on the deepwater sites of all transects and the marsh sites of transect IV. A general increase occurred in October, March, and May, and a small decrease occurred in July 1976. *Lepidactylus dysticus* and *Monoculodes* sp. had similar distributions.

Chironomid larvae showed no significant difference in density between seasons, but highly significant differences between sites and transects. Chironomids were most abundant on transect IV, and also attained high densities on sites 1, 2, 7, and 8 of the other transects. They were least abundant on transect VI and on sites 3, 4, 5, and 6 on transect V.

The oligochaete, *Peloscolex* sp., showed highly significant differences in density for all factors; densities increased with each season. It was most abundant in the marsh area of transect IV and on sites 7 and 8 of all transects.

e. Physical Data. Water temperatures were recorded at each site (Table 44). Bottom temperatures varied from 17.7° Celsius in March to 35.1° Celsius in July. The temperature decreased as the distance from shore increased with the greatest temperature range (4.1° Celsius) between sites 1 and 8. Transect IV was usually one or two degrees warmer than the other transects on the nearshore sites, probably because it was insulated by the marsh.

Salinity levels ranging from 0.7 to 4.0 parts per thousand were recorded at each site (Table 45). Salinities were lowest during October and March, increased during May, and decreased slightly during July. Salinities increased with distance from shore with the greatest range (2.25 parts per thousand) between sites 1 and 8. The salinities were lowest on the inner sites of transect IV, probably because the marsh reduced the mixing of the freshwater runoff with the brackish waters of the sound.

The vertical distance from MSL was recorded for each site (Table 46). The beach has little slope for the first 75 to 90 meters, and minor changes in elevation are caused by small undulations in the sand surface. The beach is stable, and elevations are constant from season to season.

The descriptive statistics are reported for grain-size distribution, mean, sorting, skewness, and kurtosis (Tables 47 to 50, respectively). Grain-size statistics remained stable during most of the study, but in May the average particle size increased by approximately 1 phi. This may have been caused by winter storms on the beach. Average grain size remained relatively constant at different distances from shore and between sites.

Table 44. Water temperature (° Celsius) recorded at each site on the sound beach.

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	30.2	27.60	29.18	23.1	23.1	19.4	---	---	23.5	35.1	33.4	33.0
2	27.5	26.86	27.46	21.4	20.9	20.1	---	20.8	23.5	32.8	31.5	32.52
3	26.78	26.24	26.78	20.4	21.1	20.2	23.7	20.8	---	32.5	31.3	31.72
4	26.2	26.22	26.46	20.2	20.6	19.9	23.32	21.9	---	32.0	31.1	31.43
5	26.06	26.32	26.42	19.9	20.1	19.8	---	21.9	22.4	32.0	31.1	31.0
6	26.0	25.56	26.32	19.3	20.2	19.4	23.98	---	22.2	32.2	30.6	30.81
7	25.19	24.78	25.31	18.8	19.1	18.5	21.3	19.5	21.5	31.8	30.1	30.07
8	24.9	23.46	24.65	17.8	17.7	17.6	17.9	28.45	17.7	31.0	30.1	29.36

Table 45. Salinity (parts per thousand) recorded at each site on the sound beach.

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	0.7	1.30	1.42	0.94	1.4	1.8	---	---	1.0	1.1	2.1	2.3
2	1.52	1.46	1.72	1.6	1.9	1.9	---	2.5	1.0	2.3	2.6	2.3
3	1.58	1.68	1.82	1.8	1.9	1.8	3.8	2.5	---	2.4	2.4	3.0
4	1.50	1.70	1.80	1.9	1.9	1.5	3.95	3.6	---	2.4	2.4	2.7
5	1.60	1.86	1.82	1.8	1.9	2.0	---	3.6	3.69	2.4	2.5	2.9
6	1.70	1.96	1.86	1.9	1.9	1.9	4.04	---	3.6	2.4	2.5	2.9
7	2.07	1.96	1.98	2.0	1.9	1.9	3.6	3.5	3.7	2.5	2.5	2.9
8	1.89	1.96	1.91	2.1	1.9	2.1	3.3	3.4	3.25	2.6	2.6	2.7

Table 46. Vertical distance (in meters) from MSL for each site on the sound beach.

Season	October 1975			March 1976			May 1976			July 1976		
Site / Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	0.27	0.24	0.24	0.24	0.04	0.24	0.18	0.21	0.32	0.24	0.21	0.09
2	0.18	0.29	0.09	0.21	0.12	0.12	0.03	0.18	0.17	0.09	0.09	0
3	0.15	0.31	0.01	0.12	0.18	0.09	-0.03	0.06	0.11	-0.12	-0.03	-0.06
4	-0.01	0.23	0.07	0.12	0.12	0.06	-0.05	0.12	0.21	-0.15	0	-0.06
5	-0.03	0.21	0.04	0.09	0.06	0.06	-0.06	0.11	-0.11	-0.12	0.03	0
6	-0.09	0.17	-0.02	0.09	0.09	0.03	-0.06	0.05	-0.11	-0.12	-0.09	-0.06
7	-0.23	-0.28	-0.14	-0.09	0.03	-0.12	-0.23	-0.14	-0.20	-0.27	-0.21	-0.18
8	-0.50	-0.55	-0.58	-0.49	-0.43	-0.55	-0.53	-0.53	-0.93	-0.58	-0.67	-0.88

Table 47. Mean grain size (in phi) of sediments at each site on the sound beach.

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	2.3707	2.5002	2.3644	2.2346	2.4375	2.3689	1.4285	1.4356	1.3832	2.2071	2.507	2.3529
2	2.3967	2.4918	2.3583	2.4955	2.4723	1.9339	1.4271	1.4080	1.2627	2.3895	2.4946	2.2859
3	2.3816	2.3811	2.4279	2.3831	2.4722	2.4059	1.4338	1.767	1.3036	2.1331	2.4516	2.2519
4	2.3593	2.4963	2.4429	2.4801	2.4733	2.3829	1.4032	1.4136	1.3776	2.1827	2.4918	2.3876
5	2.4504	2.437	2.4419	2.337	2.3865	2.4210	1.4311	1.4376	1.4055	2.4983	2.4712	2.4275
6	2.3643	2.4554	2.4143	2.3847	2.4468	2.4251	1.3953	1.4708	1.4460	2.4413	2.4575	2.4511
7	2.4668	2.5061	2.4571	2.4349	2.4667	2.4347	1.4987	1.4837	1.4461	2.4297	2.450	2.3707
8	2.727	2.4811	2.3667	2.4867	2.4488	2.3047	1.4532	1.4527	1.3732	2.3047	2.4028	2.3540

Table 48. Sorting of sediments at each site on the sound beach.

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	0.638	0.628	0.591	0.692	0.663	0.621	0.589	0.596	0.610	0.700	0.587	0.636
2	0.562	0.487	0.702	0.643	0.664	1.650	0.632	0.544	1.010	0.615	0.564	0.760
3	0.551	0.617	0.716	0.587	0.595	0.732	0.731	1.199	0.788	0.830	0.615	0.740
4	0.941	0.454	0.565	0.614	0.600	0.713	0.702	0.763	0.529	0.855	0.574	0.532
5	0.507	0.604	0.595	0.720	0.831	0.656	0.596	0.480	0.613	0.527	0.466	0.548
6	0.689	0.618	0.603	0.602	0.618	0.635	0.742	0.545	0.612	0.662	0.530	0.508
7	0.558	0.488	0.529	0.577	0.502	0.546	0.560	0.544	0.540	0.567	0.487	0.549
8	0.430	0.471	0.467	0.456	0.492	0.522	0.434	0.470	0.420	0.477	0.430	0.530

Table 49. Skewness of sediments at each site on the sound beach.

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	-1.541	-2.001	-1.160	-1.10	-1.161	-1.631	-0.683	-0.985	-0.825	-0.907	-0.830	-0.944
2	-0.821	-0.400	-1.046	-1.718	-2.890	-2.470	-0.781	-0.832	-2.690	-1.252	-0.642	-1.245
3	-0.857	-2.461	-2.370	-0.920	-1.889	-2.289	-2.622	-2.608	-2.024	-1.504	-0.868	-0.790
4	-3.833	-1.067	-0.841	-0.630	-2.629	-1.083	-2.760	-2.851	-0.345	-1.212	-0.864	-0.332
5	-0.700	-1.491	-0.843	-2.945	-2.918	-1.129	-0.523	-0.080	-0.875	-0.370	-0.126	-0.844
6	-1.717	-2.564	-1.118	-0.994	-1.470	-1.203	-2.630	-0.482	-0.916	-1.30	-0.552	-0.301
7	-0.964	-0.434	-0.720	-0.836	-0.527	-0.612	-0.301	-0.543	-0.460	-0.742	-0.285	-0.525
8	-0.812	-0.518	-1.278	-0.721	-0.661	-1.181	-0.301	-0.356	-1.233	-1.015	-0.617	-0.306

Table 50. Kurtosis of sediments at each site on the sound beach.

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	8.929	14.922	6.496	5.570	7.146	11.325	6.027	6.887	7.129	5.064	7.481	5.779
2	6.100	7.109	7.103	12.291	22.485	8.50	7.225	8.750	11.716	7.848	6.516	6.028
3	6.225	19.939	15.807	6.932	15.6214	14.931	19.533	10.677	11.891	5.488	6.681	4.656
4	23.396	13.407	7.027	5.832	22.527	6.653	19.685	20.034	5,343	4.821	7.819	5.342
5	7.336	9.170	6.706	19.946	17.341	7.440	6.258	6.150	6.169	5.882	5.355	7.201
6	11.040	20.656	7.431	6.572	10.718	8.001	18.601	7.582	7.254	7.800	6.327	5.118
7	7.781	7.581	7.230	6.777	6.752	6.307	6.818	8.372	6.885	5.883	5.570	4.727
8	10.00	7.624	7.750	9.471	7.035	6.034	7.393	7.010	8.161	6.191	7.910	4.886

The total carbonate and organic content (in grams per 100 grams) of the sediments were recorded at each site (Tables 51 and 52). The carbonate content was low, ranging from 0.02 to 0.15 percent. There was no significant difference between sites or sampling dates.

The total organic content was also low, ranging from 0.11 to 0.97 percent. Organic content increased during the study, and was significantly higher on site 1 of transect IV at the last sampling because of the gradual marsh development on transect IV.

f. Correlation Analyses. A correlation matrix was developed, using the physical parameters and the major species. Twenty-seven variables produced 351 nonredundant correlations (Table 53). The correlation coefficients with season, transect, and site support the analyses of variance.

Scolecolepides viridis was highly correlated with water depth and horizontal distance from shore and *R. cuneata* was also correlated with these variables. Both species were most abundant on the deep sites. When wind tides exposed large areas of beach surface, shore birds congregated in the area and fed on the exposed bottom. Several freshly opened *R. cuneata* were discovered in the feeding area. The low densities of *R. cuneata* and *S. viridis* on the inner sites are probably due to predation, rather than to the species' inability to withstand exposure. *Leipdactylus dysticus* preferred the shallow, inshore sites and was negatively correlated with depth and horizontal distance from shore.

A principal factor analysis with iteration and varimax rotation (Nei, et al., 1975) was performed on the correlation matrix; the nine extracted factors, eigenvalues, and percent of variance explained are presented in Table 54.

The three major factors are interpreted below:

(a) Factor 1. The factor loaded heavily for organic content, oligochaetes, total organisms, tabanidae, and the dytiscid beetle, *Uvarus* sp. These variables suggested that the marsh area was a cohesive community and responsible for a major part of the variance in the collections.

(b) Factor 2. The factor loaded heavily for site, horizontal distance from shore, water depth, and the polychaete, *S. viridis*, and is primarily a location factor. The heavy loading of *S. viridis* indicated the organism's dependence on location, primarily distance from shore.

(c) Factor 3. The factor loaded heavily for season, carbonate content, temperature, and salinity. Factor 3 was a time and physical parameter factor, because seasonal changes, marked by changes in temperature and salinity, caused a large part of the variance in the correlation matrix.

Table 51. Carbonate concentration (in grams per 100 grams) at each site on the sound beach.

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	0.088	0.039	0.085	0.047	0.027	0.037	0.05	0.08	0.08	0.85	0.18	0.25
2	0.112	0.081	0.094	0.064	0.124	0.067	0.09	0.20	0.10	0.31	0.44	0.21
3	0.069	0.065	0.126	0.021	0.029	0.055	0.11	0.16	0.09	0.16	0.27	0.64
4	0.113	0.092	0.083	0.049	0.060	0.059	0.10	0.11	0.14	0.38	0.20	0.81
5	0.078	0.088	0.100	0.058	0.067	0.070	0.10	0.07	0.10	0.62	0.37	0.31
6	0.153	0.078	0.095	0.087	0.091	0.122	0.08	0.10	0.14	0.41	0.20	0.42
7	0.072	0.030	0.104	0.074	0.050	0.122	0.18	0.11	0.08	0.66	0.55	0.32
8	0.091	0.087	0.142	0.106	0.096	0.071	0.09	0.13	0.11	0.42	0.57	0.47

Table 52. Organic concentration (in grams per 100 grams) at each site on the sound beach.

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	0.150	0.165	0.110	0.172	0.141	0.149	0.30	0.11	0.11	0.97	0.18	0.26
2	0.259	0.133	0.147	0.223	0.158	0.174	0.22	0.15	0.13	0.27	0.37	0.19
3	0.183	0.149	0.154	0.211	0.247	0.177	0.17	0.13	0.15	0.17	0.28	0.16
4	0.181	0.193	0.149	0.237	0.185	0.374	0.21	0.16	0.15	0.20	0.19	0.17
5	0.202	0.178	0.184	0.143	0.188	0.184	0.16	0.16	0.15	0.21	0.19	0.18
6	0.221	0.147	0.160	0.213	0.190	0.237	0.18	0.16	0.19	0.20	0.20	0.16
7	0.218	0.191	0.184	0.188	0.214	0.237	0.22	0.18	0.20	0.26	0.24	0.21
8	0.227	0.234	0.249	0.236	0.231	0.224	0.22	0.22	0.26	0.28	0.26	0.60

Table 53. Matrix of correlation coefficients among physical parameters and major species for the sound beach.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1. Season	----																										
2. Transect	0	----																									
3. Site	0	0	----																								
4. Depth	206	028	774	----																							
5. Temperature	669	-075	-257	092	----																						
6. Salinity	870	049	124	288	584	----																					
7. Hor. Dist.	0	0	838	900	-224	084	----																				
8. Mean	-282	-024	057	-148	-517	088	034	----																			
9. Sorting	008	063	-419	-327	015	-099	-425	-220	----																		
10. Skewness	263	062	293	273	184	320	291	065	-624	----																	
11. Kurtosis	-320	-141	135	-216	-218	-366	-178	-047	280	-875	----																
12. Organic	255	-153	075	196	118	292	203	143	-109	188	-222	----															
13. Carbonate	656	-024	081	234	476	796	084	178	-103	289	-330	486	----	----													
14. Vert. Dist.	-222	-032	-791	-992	-021	-275	-918	136	311	-259	206	-204	-217	----													
15. *L. dysticus*	293	209	-304	-222	333	162	-334	-366	194	-104	122	-177	025	212	----												
16. *S. viridis*	-068	077	584	614	-250	-060	703	-025	-323	231	-157	145	-059	-639	-254	----											
17. *Monoculodes* sp.	083	047	119	-046	-119	-076	-003	-215	040	006	078	-059	-165	006	140	006	----										
18. *C. polita*	046	-256	-143	008	145	-063	-077	-230	123	-152	106	118	-022	-001	-031	-090	-003	----									
19. Chironomidae	-024	-216	-187	-045	116	-066	-063	007	-003	013	-090	160	024	060	-139	-019	-097	168	----								
20. Oligochaetes	215	-274	-134	-015	308	143	-060	-135	034	037	-079	657	327	026	-125	-073	-082	216	240	----							
21. *L. grayi*	109	090	-119	260	029	129	194	040	-045	059	-077	325	138	-263	-072	060	-007	260	212	107	----						
22. *R. cuneata*	051	017	123	127	-011	027	146	-080	-060	084	-061	-003	-016	-135	006	202	060	-009	-041	-024	-018	----					
23. Cerotopogonidae	026	-072	129	017	057	-014	-018	-097	-009	050	-036	-026	-023	-016	-050	-035	-038	119	-005	281	-005	-012	----				
24. *Uvarus* sp.	136	-133	-157	-107	180	128	-097	-014	049	041	-092	692	351	112	-081	-067	-066	033	113	623	-010	-022	051	----			
25. Tabanidae	130	-125	-156	-107	179	112	-090	-017	038	042	-089	706	347	112	-090	-056	-069	028	121	732	-009	-021	-006	956	----		
26. *Gammarus* sp.	238	003	-027	151	184	243	036	-036	046	044	-115	158	164	-148	044	-065	-022	169	182	095	655	047	-012	029	-023	- -	
27. *L. plumulosus*	205	-002	262	456	273	026	371	-523	-159	134	-073	039	-026	-453	012	352	132	040	041	074	-012	005	008	032	-006	-035	----

Note: All samples for collections 1 to 5 are included--total of 288. Decimal points are omitted; all absolute values over 0.116 are significant at the 5-percent level; all absolute values over 0.144 are significant at the 5-percent level.

Table 54. Factors, eigenvalues, and variance explained for factor analysis on the sound beach correlation matrix.

Factor	Eigenvalue	Pct of Variance	Cumulative Pct
1	5.25363	26.8	26.8
2	4.82872	24.6	51.4
3	2.70715	13.8	65.3
4	2.06814	10.6	75.8
5	1.55056	7.9	83.7
6	1.25773	6.4	90.1
7	0.85644	4.4	94.5
8	0.58851	3.0	97.5
9	0.48931	2.5	100.0

The three factors accounted for over 65 percent of the variance; other factors were not interpretable for biologic effects. None of the organisms, except those characteristic of the marsh and *S. viridis*, was associated with the major factors. Thus, their distributions were not dependent on the measured parameters. Other physical and chemical parameters determined both population levels and distributions for these species.

g. Species Diversity. Species diversity at each site was calculated using a Shannon-Weaver index (see Section III, 1, g)(Table 55). The total fauna (including meiofauna) was used to compute the diversity index. Diversity ranged from 0.33 to 2.33. The diversities in the May and July samples were significantly higher than those in the October and March samples; diversity was generally higher on the deepwater sites (sites 7 and 8) than on the nearshore sites.

IV. DISCUSSION

1. The Ocean Beach.

The ocean beach has one distinct faunal community. This community was located in the swash zone and was dominated by *E. talpoida*. Pearse, Humm, and Wharton (1942) report that *Donax* sp. occur in this zone and move up and down the beach with the tidal cycle as does *E. talpoida*; however, densities of adult *Donax* were low in the swash zone at the FRF.

Donax sp. has been observed in large numbers in the swash zone at Virginia Beach, Virginia. This beach presents a reduced stress situation compared to the beach at the FRF because of the gently sloping beach face and milder wave conditions. *Donax* did not remain in the swash zone at the FRF in winter because of the high storm waves. Since the density of juveniles was high in deep water, *Donax* probably recolonized the swash zone each spring.

There were two other strongly integrated communities in the deep water, dominated by *S. squamata* and *P. longimerus*, respectively. Significant numbers of these species were also present in the swash zone, but their densities were low compared to the deepwater sites.

The second community on the ocean beach is the *S. squamata* community. These deposit-feeding polychaetes are found on all sites but are most abundant on sites 5, 6, 7, and 8. Their density was high on site 5, just seaward of the interface between the outer plane facies and the inner course facies. The third community is the *P. longimerus* community on site 9. The two communities appear to integrate strongly in the area of site 8. The *S. squamata* community represents an inshore community extending over the megaripple area, and the *P. longimerus* community represents the margin of a large community inhabiting the asymmetric ripple area in the offshore zone.

Table 55. Average diversity per site on the sound beach.

Season	October 1975			March 1976			May 1976			July 1976		
Site \ Transect	IV	V	VI	IV	V	VI	IV	V	VI	IV	V	VI
1	1.04	1.01	0.33	1.72	1.88	1.42	1.17	0.69	1.30	1.03	1.13	1.75
2	1.39	0.27	0.84	1.99	1.74	1.54	1.70	1.70	1.43	1.58	1.46	1.60
3	1.35	0.79	0.57	2.08	1.71	1.18	1.56	1.59	1.75	2.00	1.52	2.17
4	1.47	0.88	0.51	1.76	2.02	1.70	1.24	1.62	1.70	1.79	1.56	1.98
5	1.70	1.07	0.32	1.95	1.56	1.38	0.79	1.62	2.05	1.81	1.37	1.95
6	1.77	1.40	0.33	1.84	1.86	2.01	1.54	1.87	2.04	1.62	1.15	1.41
7	0.83	1.19	0.92	1.66	2.01	2.07	1.88	2.06	2.22	1.22	1.44	2.08
8	1.39	1.25	0.24	1.78	1.65	1.76	1.87	2.24	2.33	0.72	1.30	2.18

Several nondominant species occurred in these communities. Densities of *Donax* sp. were high on sites 7, 8, and 9. A second burrowing amphipod and several polychaete species (*Glycera* sp., *M. rosea*, and *S. bombyx*) were common, but their densities were not high.

Lie (1968) recorded diversities for benthic fauna in offshore areas of the Oregon coast and Boesch (1972) recorded diversities for offshore Virginia waters; however, species diversities have not been reported for the high-energy beach zone. Diversities were low on the study area; 15 sites had a diversity of zero, with no organisms on 1 site and only one species on 14 sites. The low diversity was caused by the high-stress conditions on the beach. The few species adapted to the beach face had high densities, and the relatively large numbers of the dominant species resulted in low species diversities.

2. The Sound Beach.

The community structure on the sound beach was easily defined, and was delineated in both the analyses of variance and the factor analysis. The sample area was divided into three communities (Fig. 5). The marsh community occupies a small area at the base of transect IV, and is characterized by high densities of the oligochaete, *Peloscolex* sp., by the insect groups, Tabanidae, Ceratopogonidae, and *Uvarus* sp., and by high densities of chironomid larvae. There were more individuals and more species per sample than in other areas. Species diversity was low because the *Peloscolex* and the meiofaunal species were dominant in the marsh.

The two other communities cover the rest of the study site. The *S. viridis* community begins between 90 and 140 meters from shore and extends outward at least 300 meters from shore. No sampling was done beyond this point; however, the bottom beyond site 8 was covered by dense stands of *Rupea* sp. and the benthic fauna possibly changed. Although *S. viridis* characterized this community, other organisms were significant. The density of oligochaetes (*Peloscolex* sp.) and chironomid larvae was higher than on inshore sites. Although the brackish water clam, *R. cuneata*, was not present in large numbers, it was significant in terms of biomass and was limited to this community. The shoreward boundary of the community probably depended on exposure by wind tides, and the community started where wind tides seldom exposed the bottom. Shore birds fed at the margin of the community during an extreme tide, and preyed on *R. cuneata*. Predation may have limited *R. cuneata* and *S. viridis* in the nearshore area.

The third community extended 90 to 140 meters from shore on transects V and VI and into a narrow zone between the marsh and the *S. viridis* community on transect IV. The community was exposed by wind tides and characterized by the burrowing amphipod, *L. dysticus*. During exposure, *L. dysticus* escaped predation by remaining under the sand surface; it scurried over the bottom when water covered the community.

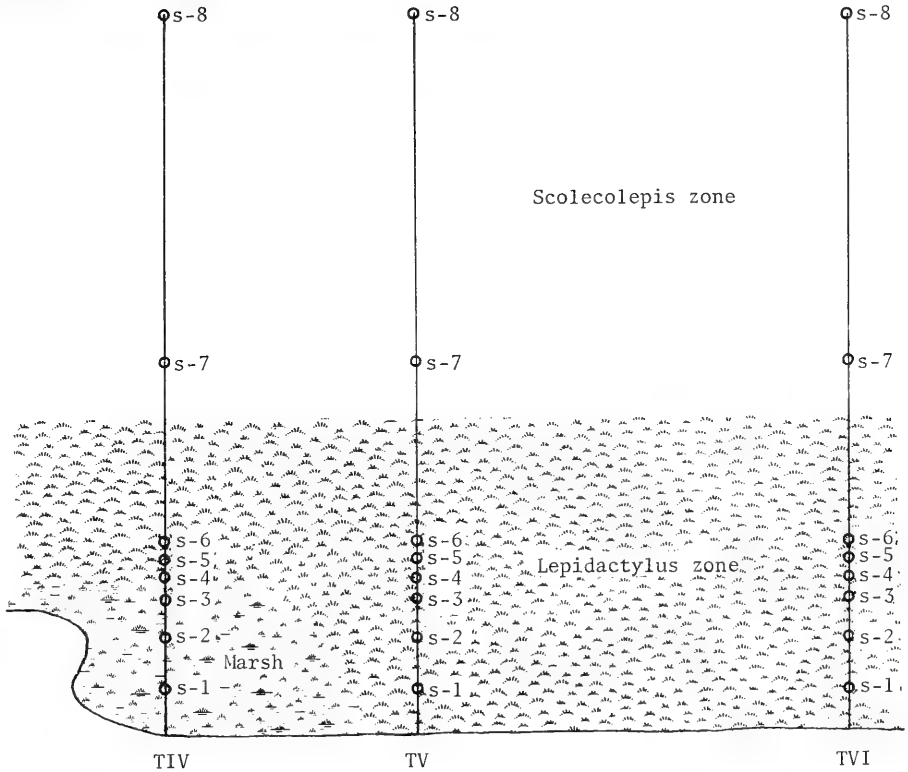

Figure 5. Approximate location of the three major communities on the sound beach (s- indicates site locations).

The species diversities were low on the sound beach, averaging between 1.0 and 2.0. Boesch (1972) recorded species diversities for marine and estuarine habitats in Virginia. The estuarine systems of the York and Pamunkey Rivers ranged from 1.5 to 2.8, with the lowest diversities in the low salinity areas (0 to 5 parts per thousand) of the upper Pamunkey. Caspers (1967) indicated that species diversities are low in estuaries, and Day (1951) stated that a complex of changing parameters limited the number of colonizing organisms.

The low diversities on the sound sites were caused by stress. The oligohaline salinity of the zone and the periodic exposure by wind tides resulted in the very low diversities on the nearshore sites of transects IV and V.

The oligohaline environment limited the diversity at the deep sites, but the marsh area on transect IV decreased stress, and diversities were slightly higher in that area. As the marsh develops and expands, the export from the marsh should increase diversity in the surrounding area. The species diversities within the marsh should rise as additional species colonize the area.

LITERATURE CITED

BOESCH, D.F., "Species Diversity of Marine Macrobenthos in the Virginia Area," *Chesapeake Science*, Vol. 13, No. 3, Sept. 1972, pp. 206-211.

BRETT, C.E., "Relationships between Marine Invertebrate Infauna Distribution and Sediment Type Distribution in Bogue Sound, N.C.," unpublished Ph.D. Thesis, University of North Carolina, Chapel Hill, N.C., 1963.

CARRIKER, M.R., "The Ecology of Estuarine Benthic Invertebrates: A Perspective," *Estuaries*, American Association for the Advancement of Science Publication, No. 83, 1967, pp. 442-487.

CARVER, R.E., *Procedures in Sedimentary Petrology*, Wiley-Interscience, New York, 1971.

CASPERS, H., "Estuaries: Analysis of Definitions and Biological Considerations," *Estuaries*, American Association for the Advancement of Science, Publication No. 83, 1967, pp. 6-8.

CERAME-VIVES, M.J., and GRAY, I.E., "The Distributional Pattern of Benthic Invertebrates of the Continental Shelf off North Carolina," *Ecology*, Vol. 47, No. 2, 1966, pp. 260-270.

CLIFTON, H.E., HUNTER, R.E., and PHILLIPS, R.L., "Depositional Structures and Processes in the Non-Barred High Energy Near Shore," *Journal of Sedimentary Petrology*, Vol. 41, No. 3, Sept. 1971, pp. 651-670.

COX, J.L., "Sampling Variation in Sandy Beach Littoral and Nearshore Meiofauna and Macrofauna," TP 76-14, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Sept. 1976.

CROKER, R.A., "Niche Diversity in Five Sympatric Species of Intertidal Amphipods (Crustacea:Haustoriidae)," *Ecological Monographs*, Vol. 37, 1967, pp. 173-200.

DARBY, D.A., and WOBUS, H.B., "A Versatile Computer Program for Sediment Size Analysis," Technical Report PGS-TR-GE-76-25, Old Dominion University Research Foundation, Norfolk, Va., Mar. 1976.

DAY, J.H., "The Ecology of South African Estuaries I. A Review of Estuarine Conditions in General," *Transactions of the Royal Society of South Africa*, Vol. 33, 1951, pp. 53-91.

DEXTER, D.M., "Distribution and Niche Diversity of Haustoriid Amphipods in North Carolina," *Chesapeake Science*, Vol. 8, No. 3, Sept. 1967, pp. 187-192.

DEXTER, D.M., "Structure of an Intertidal Sandy-beach Community in North Carolina," *Chesapeake Science*, Vol. 10, No. 2, 1969, pp. 93-98.

DOLAN, R., "Barrier Dune System Along the Outer Banks of North Carolina: A Reappraisal," *Science*, Vol. 176, No. 4032, Apr. 1972, pp. 286-288.

DOLAN, R., GODFREY, P.J., and ODUM, W.E., "Man's Impact on the Barrier Islands of North Carolina," *American Scientist*, Vol. 61, No. 2, Mar.-Apr. 1973, pp. 152-162.

LEVY, G.F., "Vegetative Study at the Duck Field Research Facility, Duck, North Carolina," MR 76-6, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Apr. 1976.

LIE, U., "A Quantitative Study of Benthic Infauna in Puget Sound," Norges almenuitenskapelige forskningsrad, Sec. D, Vol. 14, No. 5, 1968, pp. 229-556.

McDOUGALL, K.D., "Sessile Marine Invertebrates of Beaufort, North Carolina," *Ecological Monographs*, Vol. 13, 1943, pp. 321-374.

NEI, N.H., et al., *Statistical Package for the Social Sciences*, McGraw-Hill, New York, 1975.

PEARSE, A.S., HUMM, H.J., and WHARTON, G.W., "Ecology of Sand Beaches at Beaufort," *Ecological Monographs*, Vol. 12, 1942, pp. 135-190.

PETERSON, C.G.J., "A Brief Survey of the Animal Communities in Danish Waters, Based upon Quantitative Samples Taken with a Bottom Sampler," *American Journal of Science*, Series 5, Vol. 7, No. 41, 1924, pp. 343-354.

SHANNON, C.E., and WEAVER, W., "The Mathematical Theory of Communication," University of Illinois Press, Urbana, Ill., 1963.

STRATTON, A.C., and HOLLOWELL, J.R., "Sand Fixation and Beach Erosion Control," National Park Service Report, Office of Natural Scientific Studies, National Park Service, Washington, D.C., unpublished, 1940.

TENORE, K.R., "The Macrobenthos of the Pamlico River Estuary, North Carolina," Water Resources Research Institute Report No. 40, 1970.

TENORE, K.R., HORTON, D.B., and DUKE, I.W., "Effects of Bottom Substrate on the Brackish Water Bivalve, *Rangia cuneata*," *Chesapeake Science*, Vol. 9, No. 4, 1968, pp. 238-248.

APPENDIX A

PRELIMINARY TESTS OF SAMPLING DEVICES

The surf zone of the ocean beach was difficult to sample. The shallow water and the severe turbulence of the high-energy beach precluded the use of a boat or a research vessel, and thus eliminated most bottom sampling gear used in marine benthic sampling.

Preliminary tests were conducted on two grab samplers which were light enough to handle in the surf zone. A petit ponar grab sampler was tested in the surf zone at Sandbridge, Virginia, on a beach similar to the beach at the FRF site. This grab penetrated less than 3 centimeters in areas of compact sand, and produced samples which were shallow and inadequate for the analysis. In the surf zone, the grab turned over as each wave passed. Adequate samples were taken in the coarse material of the surf zone when the grab was dropped, closed, and retrieved between passing waves, but this restrictive sampling procedure made the grab inefficient.

A pole-mounted Echman grab sampler was tested, but was unsuitable. Although it was stable in the surf, it could not penetrate hard-packed sand. The jaws jammed open on shells and rocks, and usually lost part of the sample. During periods of severe wave conditions, the sampler was dangerous to handle in the surf.

Several lightweight, commercially available corers with sample retention devices were tested in the surf zone. However, samples taken by the corer were small (generally less than 15 square centimeters) and unsuitable for the study.

The device selected for use in this study is described in Section II, 2 of the text.

APPENDIX B

DEVELOPMENT OF SAMPLING PLAN

1. Ocean Beach Sampling.

Initially, in August 1975, six sampling sites were established on each of the three ocean beach transects. Sampling sites on these transects were placed with respect to MSL. Site 1 was 7.6 meters (horizontal distance) shoreward of the MSL point (zero point), and sites 2 to 6 were 7.6, 15.2, 30.4, 45.6, and 60.8 meters seaward from the MSL point. Three samples, each consisting of two cores, were taken at each site (total area sampled 1.15×10^{-2} square meters by 10 centimeters deep). Samples were placed in prelabeled plastic bags, stored at 1° to 4° Celsius, and returned to the laboratory for extraction. Samples were sieved, and the organisms retained on the 0.6- or 0.4-millimeter sieves were collected. Organisms were preserved in 4-percent Formalin for later identification.

Salinity and temperature readings were taken at all sites, and an additional core sample was taken at odd-numbered sites on each transect for analysis of grain size and for determination of organic and carbonate content. The results of the initial sampling are discussed in Appendix C.

In the October-November and subsequent samplings the zero point on the transects was moved from MSL to the landward margin of the swash zone. Site 1 was abandoned and four new sites (sites 1, 3, 4, and 6, respectively) were established at 3.3, 10.6, 13.6, and 22.7 meters seaward of the zero point. An improved technique was used to extract the organisms from the core samples and core samples for grain size analysis were taken at all sites rather than every other site. In the March-April and subsequent samplings the number of samples per site was increased from three to four and sampling at sites 4 and 6 was eliminated. These changes and the resulting final plan are discussed in detail in the text in Section II, 3.

2. Sound Beach Sampling.

Initially in July 1975, six sampling sites on each of the three sound beach transects were placed with reference to the sound margin (zero point) at 15.2, 38.0, 51.8, 61.0, 68.6, and 76.2 meters from the shoreline. The procedures for sampling and sample extraction were the same as described for the August 1975 ocean beach samplings.

Salinity and temperature readings were taken at all sites, and an additional core sample was taken at odd-numbered sites on each transect for analysis of grain size and for determination of organic and carbonate content. The results of the initial sampling are discussed in Appendix D.

In the October and subsequent samplings two additional sites were established 152.4 and 304.8 meters from the zero point, resulting in eight sampling sites per transect. Core samples for grain size analysis were taken at all sites, rather than at every other site. The final extraction technique used was identical to the final technique used on the ocean material but tapwater was substituted for the $MgCl_2$-seawater solution. These changes and the resulting final plan are discussed in detail in the text in Section II, 3.

APPENDIX C

RESULTS OF THE AUGUST 1975 SAMPLING ON THE OCEAN BEACH

The sieving technique used to extract the August 1975 samples was less sensitive to small organisms than the $MgCl_2$-seawater extraction method used on subsequent samples. Thus, the August 1975 samples were not compared to subsequent samples.

The average number of *E. talpoida*, *P. longimerus*, *S. squamata*, and total organisms per square meter was determined for each site (Table C-1). Physical data, mean grain size, and sorting of the sediments, and total organic and carbonate contents of the sediments were also determined (Tables C-2, C-3, and C-4, respectively).

The results of the August sampling supported the previous conclusions on community distribution. The three major species that defined the ocean beach communities had high densities. *Donax* sp. was not collected; the occurrence of a severe storm before the sampling may have reduced the *Donax* population.

Table C-1. Average number of *Emerita talpoida*, *Parahaustorius longimerus*, *Scolelepis squamata*, and of total organisms per square meter on the ocean beach sites, August 1975.

Species	Transect \ Site	1	2	3	4	5	6
Emerita talpoida	I	0.0	782.61	0.0	0.0	0.0	0.0
	II	0.0	376.81	434.78	0.0	0.0	0.0
	III	0.0	782.61	28.99	0.0	0.0	0.0
Parahaustorius longimerus	I	0.0	0.0	0.0	0.0	289.86	0.0
	II	0.0	28.99	0.0	57.97	260.87	202.9
	III	0.0	0.0	0.0	57.97	57.97	28.99
Scolelepis squamata	I	0.0	0.0	86.96	492.75	86.96	0.0
	II	0.0	0.0	0.0	0.0	0.0	0.0
	III	0.0	0.0	0.0	231.88	0.0	115.94
Total	I	0.0	782.61	86.96	492.75	376.81	0.0
	II	0.0	405.80	434.78	86.96	260.87	231.88
	III	0.0	782.61	28.99	289.86	57.97	144.93

Table C-2. Physical data for ocean beach sites, August 1975.

Site	x (m)[1]	Water Temperature °C[2]			Salinity ‰[2]			Vertical Distance From MSL (m)		
		Transect			Transect			Transect		
		I	II	III	I	II	III	I	II	III
1	+7.6	--	--	--	--	--	--	+0.3	+0.3	+0.3
2	-7.6	--	--	--	--	--	--	-0.15	-0.15	-0.15
3	-15.2	22.9	--	22.8	33.0	--	32.9	-0.91	-0.3	-0.46
4	-30.0	22.6	24.0	22.8	33.1	33.2	33.1	-2.1	-1.5	-3.0
5	-47.7	21.8	23.2	22.8	33.1	33.1	33.3	-2.7	-2.4	-3.4
6	-61.0	21.2	22.6	22.3	33.0	33.3	33.3	-2.7	-2.4	-4.0

[1] x = horizontal distance from MSL.

[2] Water temperature and salinity readings were not taken at sites 1 and 2 on all transects and at site 3 on transect II. These sites were dry during either all or part of the sampling period.

Table C-3. Mean grain size and sorting of sediments for odd-numbered ocean beach sites, August 1975.

Transect	I			II			III		
Site	1	3	5	1	3	5	1	3	5
Mean	0.88	0.88	2.44	0.58	-0.31	2.46	0.53	-0.47	2.41
Sorting	1.45	1.45	0.43	1.24	1.38	0.41	1.59	1.41	0.47

Table C-4. Total organic and carbonate content of sediment samples from the odd-numbered ocean beach sites, August 1975.

Transect / Site	Carbonate content (pct)			Organic content (pct)		
	I	II	III	I	II	III
1	0.01	0.00	0.00	2.39	2.19	4.86
3	0.01	0.03	0.00	0.93	19.89	4.30
5	0.01	0.00	0.00	0.00	1.46	1.69

APPENDIX D

RESULTS OF THE JULY 1975 SAMPLING ON THE SOUND BEACH

The sieving technique used to extract the July 1975 samples was less sensitive to small and medium-size organisms than the rinsing flotation technique used on subsequent samples. Thus, the July 1975 samples were not compared to subsequent samples.

The average number of *Monoculodes* sp., *S. viridis* *L. dysticus*, *Peloscolex* sp., chironomid larvae, *Gammarus* sp., *Cyathura polita*, and total organisms per square meter was determined (Table D-1). Physical data, mean grain size and sorting, and total organic and carbonate content of the sediments were measured (Tables D-2, D-3, and D-4).

The results of the July sampling supported the general conclusions in the text. Two communities were present, the marsh community on transect IV and the *L. dysticus* community on transects IV and V. Sites 7 and 8 were not measured, but included the *S. viridis* community. *Scolecolepidis viridis* increased in number with increased distance from shore, but had low densities on transect VI. The marsh community was poorly developed in July 1975, and few characteristics species were present.

Table D-1. Average number of *Monoculodes* sp., *S. viridis*, *L. dysticus*, *Peloscolex* sp., chironomid larvae, *Gammarus* sp., *C. polita*, and total organisms per square meter on the sound beach sites, July 1975.

Species	Transect \ Site	1	2	3	4	5	6
Monoculodes sp.	IV	0.0	0.0	0.0	57.97	202.90	115.94
	V	0.0	28.99	57.97	28.99	57.97	28.99
	VI	0.0	0.0	0.0	0.0	0.0	86.96
Scolecolepides viridis	IV	0.0	57.97	57.97	115.94	115.94	86.96
	V	57.97	28.99	173.91	115.94	202.90	260.87
	VI	0.0	0.0	28.99	57.97	28.99	0.0
Lepidactylus dysticus	IV	28.99	173.91	782.61	376.81	144.93	608.70
	V	376.81	434.78	811.59	724.64	202.90	724.64
	VI	347.83	782.61	724.64	840.58	666.97	608.70
Peloscolex sp.	IV	28.99	28.99	28.99	608.70	231.88	144.93
	V	0.0	0.00	0.0	0.0	0.0	0.0
	VI	0.0	0.0	0.00	0.0	0.0	0.0
Chironomid larvae	IV	1,536.23	115.94	86.96	0.0	695.65	1,333.33
	V	0.0	0.0	0.0	115.94	202.90	28.99
	VI	0.0	0.0	0.0	0.0	0.0	0.0

Table D-1. Average number of *Monoculodes* sp., *S. viridis*, *L. dysticus*, *Peloscolex* sp., chironomid larvae, *Gammarus* sp., *C. polita*, and total organisms per square meter on the sound beach sites, July 1975.--Continued

Species	Transect \ Site	1	2	3	4	5	6
Gammarus sp.	IV	0.0	58.26	145.22	0.0	58.26	666.97
	V	0.0	0.0	0.0	0.0	86.96	0.0
	VI	0.0	0.0	0.0	0.0	0.0	0.0
Cyanthura polita	IV	0.0	86.96	28.99	28.99	86.96	0.0
	V	0.0	0.0	28.99	0.0	28.99	0.0
	VI	0.0	0.0	0.0	0.0	28.99	28.99
Total	IV	1,594.20	521.74	1,130.43	1,188.41	1,536.23	2,956.52
	V	434.78	492.75	1,072.46	985.51	782.61	1,043.48
	VI	347.83	782.61	753.62	898.55	724.64	724.64

Table D-2. Physical data for the sound beach sites, July 1975.

Site	x (m)[1]	Water Temperature (°C)			Salinity ($^o/oo$)			Vertical Distance From MSL (m)		
		Transect			Transect			Transect		
		IV	V	VI	IV	V	VI	IV	V	VI
1	15.2	24.2	26.0	31.2	0.2	0.4	1.7	0.49	0.31	0.37
2	38.1	26.9	26.9	28.5	1.2	2.4	2.4	0.38	0.11	0.34
3	51.8	25.2	27.1	28.4	2.3	2.7	2.6	0.35	0.18	0.37
4	61.0	24.4	27.3	27.8	2.6	2.7	2.7	0.27	0.11	0.40
5	68.6	24.1	27.2	27.6	2.7	2.7	2.7	0.37	0.12	0.38
6	76.2	24.1	27.4	27.4	2.7	2.7	2.7	0.32	0.06	0.37

[1] x = horizontal distance from the shoreline.

Table D-3. Mean grain size and sorting of sediments for the sound beach sites, July 1975.

Transect	IV			V			VI		
Site	1	3	5	1	3	5	1	3	5
Mean	2.67	2.47	2.37	2.41	2.46	2.43	2.36	2.41	2.44
Sorting	0.67	0.62	0.81	0.59	0.50	0.61	0.67	0.64	0.61

Table D-4. Total organic and carbonate content of sediment samples for the odd-numbered sound beach sites, August 1975.

Site \ Transect	Carbonate content (pct)			Organic content (pct)		
	IV	V	VI	IV	V	VI
1	0.067	0.070	0.166	0.157	0.132	0.101
3	0.091	0.053	0.216	0.166	0.143	0.143
5	0.129	0.065	0.222	0.161	0.139	0.159

Matta, James F.
Beach fauna study of the CERC Field Research Facility, Duck, North Carolina / by James F. Matta. -- Fort Belvoir, Va. : U.S. Coastal Engineering Research Center, 1977.
102 pp. : ill. (Miscellaneous report - U.S. Coastal Engineering Research Center ; 77-6) Also (Contract - U.S. Coastal Engineering Research Center ; DACW72-75-C-0019)
The results of an intensive seasonal study of the beach fauna of a barrier island in Dare County, North Carolina, are presented. Study areas include the beach face from margin of the swash zone to 60 meters offshore on the ocean beach, and from swash zone to 300 meters offshore on the sound beach. A simple quantitative sampling device was also developed for use in the surf zone.
1. Coastal fauna. 2. Duck, North Carolina. I. Title. II. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 77-6. III. Series: U.S. Coastal Engineering Research Center. Contract DACW72-75-C-0019.

TC203 .U581mr no. 77-6 627

Matta, James F.
Beach fauna study of the CERC Field Research Facility, Duck, North Carolina / by James F. Matta. -- Fort Belvoir, Va. : U.S. Coastal Engineering Research Center, 1977.
102 pp. : ill. (Miscellaneous report - U.S. Coastal Engineering Research Center ; 77-6) Also (Contract - U.S. Coastal Engineering Research Center ; DACW72-75-C-0019)
The results of an intensive seasonal study of the beach fauna of a barrier island in Dare County, North Carolina, are presented. Study areas include the beach face from margin of the swash zone to 60 meters offshore on the ocean beach, and from swash zone to 300 meters offshore on the sound beach. A simple quantitative sampling device was also developed for use in the surf zone.
1. Coastal fauna. 2. Duck, North Carolina. I. Title. II. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 77-6. III. Series: U.S. Coastal Engineering Research Center. Contract DACW72-75-C-0019.

TC203 .U581mr no. 77-6 627

Matta, James F.
Beach fauna study of the CERC Field Research Facility, Duck, North Carolina / by James F. Matta. -- Fort Belvoir, Va. : U.S. Coastal Engineering Research Center, 1977.
102 pp. : ill. (Miscellaneous report - U.S. Coastal Engineering Research Center ; 77-6) Also (Contract - U.S. Coastal Engineering Research Center ; DACW72-75-C-0019)
The results of an intensive seasonal study of the beach fauna of a barrier island in Dare County, North Carolina, are presented. Study areas include the beach face from margin of the swash zone to 60 meters offshore on the ocean beach, and from swash zone to 300 meters offshore on the sound beach. A simple quantitative sampling device was also developed for use in the surf zone.
1. Coastal fauna. 2. Duck, North Carolina. I. Title. II. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 77-6. III. Series: U.S. Coastal Engineering Research Center. Contract DACW72-75-C-0019.

TC203 .U581mr no. 77-6 627

Matta, James F.
Beach fauna study of the CERC Field Research Facility, Duck, North Carolina / by James F. Matta. -- Fort Belvoir, Va. : U.S. Coastal Engineering Research Center, 1977.
102 pp. : ill. (Miscellaneous report - U.S. Coastal Engineering Research Center ; 77-6) Also (Contract - U.S. Coastal Engineering Research Center ; DACW72-75-C-0019)
The results of an intensive seasonal study of the beach fauna of a barrier island in Dare County, North Carolina, are presented. Study areas include the beach face from margin of the swash zone to 60 meters offshore on the ocean beach, and from swash zone to 300 meters offshore on the sound beach. A simple quantitative sampling device was also developed for use in the surf zone.
1. Coastal fauna. 2. Duck, North Carolina. I. Title. II. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 77-6. III. Series: U.S. Coastal Engineering Research Center. Contract DACW72-75-C-0019.

TC203 .U581mr no. 77-6 627

Matta, James F.
Beach fauna study of the CERC Field Research Facility, Duck, North Carolina / by James F. Matta. -- Fort Belvoir, Va. : U.S. Coastal Engineering Research Center, 1977.
102 pp. : ill. (Miscellaneous report - U.S. Coastal Engineering Research Center ; 77-6) Also (Contract - U.S. Coastal Engineering Research Center ; DACW72-75-C-0019)
The results of an intensive seasonal study of the beach fauna of a barrier island in Dare County, North Carolina, are presented. Study areas include the beach face from margin of the swash zone to 60 meters offshore on the ocean beach, and from swash zone to 300 meters offshore on the sound beach. A simple quantitative sampling device was also developed for use in the surf zone.
1. Coastal fauna. 2. Duck, North Carolina. I. Title. II. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 77-6. III. Series: U.S. Coastal Engineering Research Center. Contract DACW72-75-C-0019.

TC203 .U581mr no. 77-6 627

Matta, James F.
Beach fauna study of the CERC Field Research Facility, Duck, North Carolina / by James F. Matta. -- Fort Belvoir, Va. : U.S. Coastal Engineering Research Center, 1977.
102 pp. : ill. (Miscellaneous report - U.S. Coastal Engineering Research Center ; 77-6) Also (Contract - U.S. Coastal Engineering Research Center ; DACW72-75-C-0019)
The results of an intensive seasonal study of the beach fauna of a barrier island in Dare County, North Carolina, are presented. Study areas include the beach face from margin of the swash zone to 60 meters offshore on the ocean beach, and from swash zone to 300 meters offshore on the sound beach. A simple quantitative sampling device was also developed for use in the surf zone.
1. Coastal fauna. 2. Duck, North Carolina. I. Title. II. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 77-6. III. Series: U.S. Coastal Engineering Research Center. Contract DACW72-75-C-0019.

TC203 .U581mr no. 77-6 627

Matta, James F.
Beach fauna study of the CERC Field Research Facility, Duck, North Carolina / by James F. Matta. -- Fort Belvoir, Va. : U.S. Coastal Engineering Research Center, 1977.
102 pp. : ill. (Miscellaneous report - U.S. Coastal Engineering Research Center ; 77-6) Also (Contract - U.S. Coastal Engineering Research Center ; DACW72-75-C-0019)
The results of an intensive seasonal study of the beach fauna of a barrier island in Dare County, North Carolina, are presented. Study areas include the beach face from margin of the swash zone to 60 meters offshore on the ocean beach, and from swash zone to 300 meters offshore on the sound beach. A simple quantitative sampling device was also developed for use in the surf zone.
1. Coastal fauna. 2. Duck, North Carolina. I. Title. II. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 77-6. III. Series: U.S. Coastal Engineering Research Center. Contract DACW72-75-C-0019.

TC203 .U581mr no. 77-6 627

Matta, James F.
Beach fauna study of the CERC Field Research Facility, Duck, North Carolina / by James F. Matta. -- Fort Belvoir, Va. : U.S. Coastal Engineering Research Center, 1977.
102 pp. : ill. (Miscellaneous report - U.S. Coastal Engineering Research Center ; 77-6) Also (Contract - U.S. Coastal Engineering Research Center ; DACW72-75-C-0019)
The results of an intensive seasonal study of the beach fauna of a barrier island in Dare County, North Carolina, are presented. Study areas include the beach face from margin of the swash zone to 60 meters offshore on the ocean beach, and from swash zone to 300 meters offshore on the sound beach. A simple quantitative sampling device was also developed for use in the surf zone.
1. Coastal fauna. 2. Duck, North Carolina. I. Title. II. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 77-6. III. Series: U.S. Coastal Engineering Research Center. Contract DACW72-75-C-0019.

TC203 .U581mr no. 77-6 627