Quantitative Composition and Distribution of the Macrobenthic Invertebrate Fauna of the Continental Shelf Ecosystems of the Northeastern United States

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ABSTRACT

From the mid-1950's to the mid-1960's a series of quantitative surveys of the macrobenthic invertebrate fauna were conducted in the offshore New England region (Maine to Long Island, NewYork). The surveys were designed to 1) obtain measures of macrobenthic standing crop expressed in terms of density and biomass; 2) determine the taxonomic composition of the fauna (ca. 567 species); 3) map the general features of macrobenthic distribution; and 4) evaluate the fauna's relationships to water depth, bottom type, temperature range, and sediment organic carbon content. A total of 1,076 samples, ranging from 3 to 3,974 m in depth, were obtained and analyzed.

The aggregate macrobenthic fauna consists of 44 major taxonomic groups (phyla, classes, orders). A striking fact is that only five of those groups (belonging to four phyla) account for over 80% of both total biomass and number of individuals of the macrobenthos. The five dominant groups are Bivalvia, Annelida, Amphipoda, Echninoidea, and Holothuroidea.

Other salient features pertaining to the macrobenthos of the region are the following: substantial differences in quantity exist among different geographic subareas within the region, but with a general trend that both density and biomass increase from northeast to southwest; both density and biomass decrease with increasing depth; the composition of the bottom sediments significantly influences both the kind and quantity of macrobenthic invertebrates, the largest quantities of both measures of abundance occurring in the coarser grained sediments and diminishing with decreasing particle size; areas with marked seasonal changes in water temperature support an abundant and diverse fauna, whereas a uniform temperature regime is associated with a sparse, less diverse fauna; and no detectable trends are evident in the quantitative composition of the macrobenthos in relation to sediment organic carbon content.

Introduction

The broad continental shelf off the northeastern coast of the United States is a particularly significant topographic feature of the continental margin because of its influence on the marine life of the region. Water masses overlying this large shelf, and neritic waters generally, are noted for their abundance of plankton, fishes, and associated organisms, some endangered. Noteworthy of the offshore New England waters, including Georges Bank, are the rich harvests of fish that have been taken each year since pre-Colonial days. The marine life inhabiting New England offshore waters has been the subject of studies conducted from time to time throughout the past century. This has resulted in the acquisition of a considerable body of knowledge on the fishes and plankton in this region, but information about the benthic invertebrates has been rather limited, espe-

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cially regarding quantitative aspects. Because of the key role played by macrobenthic invertebrates in the ecological dynamics of the marine environment, their usefulness to man as a food resource, their potential as concentrators of toxic substances that could be transmitted through the food chain, and their usefulness as indicators of environmental change, the National Marine Fisheries Service (formerly the Bureau of Commercial Fisheries) of the U.S. Department of Commerce, NOAA, in cooperation with the U.S. Geological Survey and the Woods Hole Oceanographic Institution conducted a quantitative survey of the benthos of the entire continental margin of the eastern United States. The investigation of the macrobenthic invertebrates was an integral part of a broad program of study of the Atlantic continental margin (Emery and Schlee, 1963; Emery, 1966b).

This report is the second of two which describe the quantitative distribution of macrobenthic invertebrates of the Atlantic continental shelf and slope. The first (Wigley and Theroux, 1981) describes the quantitative distribution of major taxonomic groups of macrobenthic invertebrates inhabiting the continental shelf and slope between Cape Cod, Massachusetts, and Cape Hatteras, North Carolina. Their distribution in relation to geographic location, water depth, bottom sediments, range in bottom water temperature, and sediment organic carbon content is considered.

The present report describes the quantitative distribution of the principal groups of macrobenthic invertebrates inhabiting offshore New England waters. The area studied extends from the mouth of the Bay of Fundy eastward to Nova Scotia (longitude 64° West) and southward to central New Jersey. The quantity of each major taxonomic group is considered in relation to the same environmental variables. Only the broad distributional aspects of major groups are presented and evaluated here. Other aspects of the benthic fauna derived from these samples, such as community composition, trophic zonation, faunal dominance and diversity, and similar topics will be the subjects of future reports.

The large database generated by the Continental Margin Program contains a wealth of valuable geological, faunal, and environmental information of historical as well as current significance. In addition to providing input for a variety of descriptive studies, as described above, the potential exists for information contained in the database for ecosystem modeling tasks; paleoecological and global climate change studies; and benthic production estimates (Cohen et al. 1978, 1982; Cohen and Wright 1979; Warwick 1980; Rowe et al. 1986, 1988; Bourne 1987; Cohen and Grosslein 1987; Steimle 1987, 1990a, 1990b; Rowe et al., 1991; and others).

Order of Discussion

The first section of this report briefly describes the principal physical features of the region, providing a general background for understanding the distribution of the various faunal groups. This section is followed by the main body of data describing the quantitative distribution of 44 faunal groups in relation to the five environmental parameters: 1) geography, 2) bathymetry, 3) bottom sediments, 4) bottom water temperatures, and 5) sediment organic carbon. Quantitative data for geographic distribution are presented at two different levels: a detailed evaluation based on calculations for each of several hundred unit areas (20 min in latitude by 20 min in longitude); and a less detailed evaluation based on six large geographical subareas within the region studied. Faunal groups are chiefly phyla, classes, and orders of macrobenthos presented in phylogenetic order. The final section is a summary of the environmental relationship of the dominant taxonomic components.

Previous Studies

One of the earliest studies in marine benthic ecology dealt with populations inhabiting the Woods Hole-Vineyard Sound area off southeastern Massachusetts (Verrill et al., 1873). This well-known study is not only the first comprehensive report dealing with the New England marine benthos but also one of the earliest ecological accounts of marine zoobenthos in all scientific literature. Included in the report are descriptions of new species, an annotated catalog of animals found in Vineyard Sound and vicinity, and, significantly, a large part of the report is devoted to descriptions of the benthic communities and the biotopes they inhabit. Although a small number of published reports on New England natural history observations and taxonomic studies were available as sources of information to supplement their study (Gould 1841, 1870; Desor 1851; Stimpson 1851, 1853; Verrill 1867; and others), by far the bulk of all information contained in the report by Verrill et al. is based on original collections and observations.

Between 1871 and 1887 nearly 2,000 benthic fauna samples were collected in waters off the northeastern United States by the U.S. Fish Commission in cooperation with the U.S. Revenue Service, U.S. Coast Survey, and zoologists from American universities. Dredging and trawling were the principal methods of collecting samples. A large proportion of the samples were collected in coastal areas between New Haven, Connecticut, and Eastport, Maine; only a moderate number of collections were from offshore areas. Inshore operations were conducted from the vessels *Moccasin, Mosswood, Bache, Speedwell, Blue Light,* and to some extent the *Blake* and *Fish Hawk*; however, the latter two also operated in offshore areas, as did the *Albatross* and the chartered fishing schooner, *Josie Reeves* (Packard, 1874, 1876: Agassiz, 1881; Smith and Rathbun, 1882; Tanner, 1882; Smith and Rathbun, 1889; Townsend, 1901).

This early sampling was primarily exploratory in nature. The participating zoologists faced a vast unstudied fauna and a multitude of species new to science. Scientists most active in this work were chiefly systematists; consequently the results were largely taxonomic accounts of various groups. The following are typical examples: Smith, 1879, 1884; Harger,1880, 1883; Rathbun, 1880; Wilson, 1880; Fewkes, 1881; Verrill ,1881, 1884; Agassiz, 1883, Webster and Benedict, 1884; Bush, 1885; Bigelow, 1891). Professor Addison E. Verrill of Yale College, who collaborated closely with U.S. Fish Commission scientists, was undoubtedly the most productive systematist of this, or perhaps any era. He described over one thousand species representing most major invertebrate groups. A very large percentage of these new species descriptions was based on specimens collected off New England. Although several preliminary ecological studies of the offshore benthos were reported (Smith and Harger, 1874; Verrill, 1874a, 1874b; Agassiz 1888a, 1888b) and the reports on systematics of various groups contain ecological information, no comprehensive ecological reports pertaining to the fauna of this region were published.

The second milestone in ecological research of the New England marine benthos was a comprehensive report by Summer et al. (1913). This report is based on three years of intensive sampling in Vineyard Sound and Buzzards Bay by the Bureau of Fisheries in 1903, 1904, and 1905. This useful publication not only lists the species occurring in the Woods Hole region but includes species distribution charts and discusses some physical conditions (temperature, depth, and sediments) that influence the distribution of animals. To this day, this remains the most thorough ecological study of the New England marine benthos.

After the investigation by Sumner et al. (1913), there was a 30-year hiatus during which ecological research on New England marine benthos—particularly that concerned with offshore invertebrates—proceeded at an exceedingly slow pace. Belding (1914), Allee (1922a, 1922b, 1923a, 1923b, 1923c), Pytherch (1929), Stauffer (1937), Ayers (1938), and others contributed valuable information on inshore populations. Rather few ecologically oriented works such as Procter (1933a, 1933b) and Bigelow and Schroeder (1939) pertaining to offshore zoobenthos appeared during this period. In addition to the foregoing, however, many studies of a taxonomic nature containing valuable ecological information were issued during this time span (Rathbun, 1905, 1925; Koehler, 1914; Nutting, 1915; Pilsbry, 1916; Heath, 1918; Bartsch, 1922; Deichmann, 1930, 1936; and others). Ecological interests of marine scientists conducting field studies in this region centered on plankton and fishes. It was not until the 1940's that renewed activities in benthic ecology attained a significant level. Beginning in that decade a number of investigations were undertaken concerning inshore populations (Dexter, 1944, 1947; Lee, 1944; Phleger and Walton, 1950; Swan 1952a, 1952b; Parker, 1952; Pratt, 1953; Burbanck et al., 1956; Parker and Athern, 1959; Stickney, 1959; Rhoads, 1963; and others). Ecological studies pertaining to the offshore populations commenced somewhat later, for example the reports by: Parker (1948); Northrup (1951); Phleger (1952); Clarke (1954); Schroeder (1955, 1958); Taylor et al. (1957); Wigley (1959); Wieser (1960); Wigley (1960b); Chamberlin and Stearns (1963); and Wigley and Emery (1968), are notable examples.

Perhaps the most significant event of this period, relative to the present work, was the inauguration of quantitative benthos investigations of the New England marine fauna (Lee, 1944). Lee's work was a study of the macrobenthic invertebrate fauna of Menemsha Bight, an embayment of Vineyard Sound, Massachusetts. Years later, quantitative studies were made of the benthos of Long Island Sound (Sanders, 1956; Richards and Riley, 1967), Buzzards Bay (Sanders, 1958, 1960; Wieser, 1960), Barnstable Harbor (Sanders et. al., 1962), Greenwich Bay, Rhode Island (Stickney and Stringer, 1957), Sheepscot Estuary (Hanks, 1964), Narragansett Bay (Phelps, 1965), Rand's Harbor, Massachusetts (Burbanck et al., 1956), and other locales. In recent years, due to increased interest in potential impacts of man's activities in outer continental shelf (OCS) development and exploitation and in understanding the dynamics of marine ecosystems, quantitative studies of the benthic fauna in the New England region have undergone a marked increase, as have studies in other associated disciplines. Studies such as Wigley (1961b); Sanders et. al. (1962); Wigley and McIntyre (1964); Emery et al. (1965); Nesis (1965); Sanders et al. (1965); Owen et al. (1967); Wigley and Emery (1967); Wigley (1968); Mills (1969); Wigley and Theroux (1970); Haedrich, et al. (1975); Rowe et al. (1975); Wigley et al. (1975); Uzmann et al. (1977); Pearson and Rosenberg (1978); Maurer and Leathem (1980, 1981a, 1981b); Valentine et al. (1980); Magnuson et. al. (1981); Wigley and Theroux (1981); Maurer and Wigley (1982, 1984); Steimle (1982); Caracciolo and Steimle (1983); Lear and O'Malley (1983); Steimle (1985); Rowe et al. (1986); Maciolek and Grassle (1987); Michael (1987); Theroux and Grosslein (1987); Langton et al. (1988); Langton and Uzmann (1988); Sherman et al. (1988); Langton and Uzmann 1989, Langton et. al. (1990); and Rowe et. al. (1991), and as well as others have provided much needed insights into the complex ecosystems of the region.

Several published indexes and bibliographies include many references to the general literature pertaining to benthic invertebrates and allied subjects. Many of the historical as well as the modern reports are included among the citations in these bibliographies.

The interested reader may wish to consult the following:

1 Fishery Publication Index, 1920–1954. U.S. Fish & Wildlife Service Circular 36, published in 1955.
2 Publications of the United States Bureau of Fisheries 1871–1940. Compiled by Barbara B. Aller and published in 1958.
3 A Preliminary Bibliography with KWIC Index on the Ecology of Estuaries and Coastal Areas of the Eastern United States. Compiled by Robert Livingston Jr. and published in 1965.
4 Marine and Estuarine Environments, Organisms and Geology of the Cape Cod Region, an Indexed Bibliography, 1665–1965. Compiled by Anne E. Yentsch, M. R. Carriker, R. H. Parker, and V .A. Zullo, published in 1966.
5 Fishery Publication Index, 1955–64. U.S. Fish & Wildlife Service, Bur. Comm. Fish. Circ. 296, published in 1969.
6 The Effects of Waste Disposal in the New York Bight. Compiled by the National Marine Fisheries Service, Middle Atlantic Coastal Fisheries Center, Sandy Hook, New Jersey, published in 1972.
7 Coastal and Offshore Environmental Inventory: Cape Hatteras to Nantucket Shoals. Edited by Saul B. Saila and published in 1973.
8 Bibliography of the New York Bight: Part 1—List of Citations; Part 2— Indices. Compiled by the National Oceanic and Atmospheric Administration, Marine Ecosystems Analysis Program, Stony Brook, N.Y, published in 1974.
9 Fishery Publication Index, 1965–74. Compiled by M. E. Engett and L. C. Thorson, U.S. Dep. Commerce, NOAA Tech. Rep. NMFS Circ. 400, published in 1977.
10 A Summary and Analysis of Environmental Information on the Continental Shelf from the Bay of Fundy to Cape Hatteras (1977). Vol. II, Master Bibliography, Index, Acknowledgements. Prepared for the Bureau of Land Management by Center for Natural Areas, published in 1977.
11 The Bay Bib: Rhode Island Marine Bibliography, Revised Edition. Coordinated by C. Q. Dunn and L. Z. Hale, edited by A. Bucci, Coastal Resources Center, Northeast Regional Coastal Information Center, Marine Advisory Service, National Sea Grant Depository, Univ. of Rhode Island Mar. Tech. Rep. 70, published in 1979.
12 An Ecological Characterization of Coastal Maine (North and East of Cape Elizabeth). Vol. 5, Data Source Appendix. Compiled by S. E. Fefer and P. A. Schetting for Biol. Serv. Program, Interagency Energy/Environment Res. and Dev. Program, Office of Res. and Dev., U.S. Environmental Protection Agency, published in 1980.
13 Benthic Productivity and Marine Resources of the Gulf of Maine. I. Babb and M. DeLuca (eds.). National Undersea Research Program, Research Report 88-3, published in 1988.

Another result of increased OCS activity is the large volume of information relating to benthic fauna appearing in the so-called "gray" literature. Included in this category are completion reports of field study contracts, environmental impact statements, public and private agency investigation reports, annual reports, and other similar special documents. Many appear in irregular series, or are one-of-a-kind reports, often in photocopied or mimeographed form and, as such, are not always listed in the usual literature sources (e.g. Maurer, 1983; Michael et. al., 1983; Pratt, 1973; also see Literature Cited).

In addition to Wigley and Theroux (1981) there are several taxonomically or ecologically oriented reports based wholly or in part on the samples forming the basis of the Northeast Fisheries Science Center (NEFC) benthic database. Such reports include Wigley (1960a, 1960b, 1961a, 1961b, 1963a, 1963b, 1965, 1966a, 1966b, 1968, 1970, and 1973); Pettibone (1961, 1962, 1963); Chamberlin and Stearns (1963); Emery and Merrill (1964); Wigley and McIntyre (1964); Emery et al. (1965); Trumbull (1965); Merrill et al. (1965); Wigley and Shave (1966); Wigley and Emery (1967); Schopf (1968b); Haynes and Wigley (1969); Plough (1969); Hazel (1970); Merrill (1970); Wigley and Theroux (1970); Kraeuter (1971); Wigley and Burns (1971); Wigley and Theroux (1971); Bousfield (1973); Cutler (1973, 1977); Wigley and Stinton (1973); Murray (1974); Wigley et al. (1975); Wigley and Messersmith (1976); Wigley et al. (1976); Williams and Wigley (1977); Kinner (1978); Merrill et al. (1978); Plough (1978); Brodeur (1979); Watling (1979a); Dickinson et al. (1980); Franz and Merrill (1980b); Dickinson and Wigley (1981); Franz et al. (1981); Maurer and Wigley (1982, 1984); Maurer (1983); Shepard and Theroux (1983); Theroux[1]; Theroux and Wigley (1983); Rowe et al. (1986); Shepard et al. (1986); Bousfield (1987); Rowe (1987); Theroux and Grosslein (1987); Langton and Uzmann (1988); Langton et al. (1988); Rowe et al. (1988); Sherman et al. (1988); Langton and Uzmann (1989); Langton et al. (1990);

[1] Theroux, R. B. 1983. Collection data for the U.S. east coast gastropod mollusks in the Northeast Fisheries Center Specimen Reference Collection, Woods Hole, Massachusetts. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Northeast Fish. Cntr., Woods Hole Lab. Ref. Doc. No. 8327, 280 p. Unpubl. manuscript.

and Rowe et al. (1991); Burns and Wigley[2]; Wigley et al.[3]; Theroux and Wigley[4]; Maurer and Wigley[5]; Theroux, et al.[6]; Theroux and Schmidt-Gengenback.[7]

Other uses to which the data have proven useful in the past, as well as in the present, have been varied. Included have been environmental impact statements prepared by various public agencies (Dep. Interior, Minerals Management Service; U.S. Army Corps of Engineers; NOAA, etc.) relating to OCS activities (e.g. oil and gas exploration, mining, dredging, dumping, etc.); international litigation (i.e. US/Canada Boundary Case); marine sanctuary designation proposals (e.g. Stellwagen Bank, Norfolk Canyon); and others.

Several specially targeted programs initiated in the latter 1970's and terminated in the mid- to late 1980's have provided additional impetus for an increase in attention devoted to the macrobenthos of the region. During that period many studies were conducted by public and private agencies and academic institutions (e.g. NOAA's Northeast Monitoring and Ocean Pulse Programs; the Northeast Fisheries Center's Marine Resources Mapping, Assessment, and Prediction program (Sherman, 1980); the Marine Ecosystem Analysis Program (MESA) (see Pearce et al., 1981); the Woods Hole Oceanographic Institution's Georges Bank Study program, and many others). Those studies, in both inshore and offshore areas, were designed to establish baselines for assessing environmental quality and to monitor the impacts of present and future activities related to oil and gas exploration and production, marine mining, ocean dumping, other waste disposal, and natural environmental change. The results of those programs covered a broad spectrum of interdisciplinary topics which expanded our understanding of the marine environment (e.g. Pearce, 1971, 1972, 1974, 1975; Pratt, 1973; Pearce et al., 1976a, 1976b, 1976c, 1976d, 1977a, 1977b, 1977c, 1978, 1981; Caracciolo et al., 1978; Pearson and Rosenberg, 1978; Reid et al., 1979; Steimle and Radosh, 1979; Warwick, 1980; Schaffner and Boesch, 1982; Steimle, 1982; Boehm, 1983; Caracciolo and Steimle, 1983; Lear and O'Malley, 1983; Steimle, 1985; Steimle and Terranova, 1985; Duinker and Beanlands, 1986; Howart,1987; Neff, 1987; Reid et al., 1987; Steimle, 1990a, 1990b; Steimle et al., 1990).

Materials and Methods

Macrofauna Samples

This report is based on 1,076 quantitative samples of macrobenthic fauna collected during 22 cruises by 5 research vessels between 1956 and 1965 (Table 1). The geographic locality of sampling sites is illustrated in Figure 1, and sampling density is illustrated in Figure 2 in which the number of samples in each geographic unit area is indicated (dimension of each unit area is 20 minutes latitude by 20 minutes longitude). Collection data (including cruise, station, and collection num-

Table 1
Research vessels, cruise numbers, date of collections, and number of samples obtained.

Vessel	Cruise number	Date	Number of samples
Albatross III	80	August 1956	35
Albatross III	101	August 1957	165
Delaware	59-9	August 1959	75
Delaware	61-10	June 1961	75
Delaware	62-7	June 1962	123
Gosnold	10	April 1963	7
Gosnold	11	April 1963	3
Gosnold	12	May 1963	38
Gosnold	13	May 1963	29
Gosnold	20	July 1963	1
Gosnold	22	August 1963	93
Gosnold	24	August–September 1963	32
Gosnold	28	October 1963	9
Gosnold	29	October 1963	84
Gosnold	49	August 1964	72
Gosnold	51	September 1964	7
Asterias	1	April 1964	8
Asterias	2	July–August 1964	62
Albatross IV	64-12	October 1964	24
Albatross IV	64-13	October–November 1964	10
Albatross IV	65-11	August 1965	123
Total			1,076

[2] Burns, B. R., and R. L. Wigley. 1970. Collection and biological data pertaining to mysids in the collection at the BCF Biological Laboratory, Woods Hole. U.S. Bur. Comm. Fish. Biol. Lab. Woods Hole, Mass., Lab. Ref. 70-3, 36 p. (mimeo). Unpubl. manuscript.

[3] Wigley, R. L., R. B. Theroux, and H. E. Murray. 1976. Marine macrobenthic invertebrate fauna of the Middle Atlantic Bight region. Part 1. Collection data and environmental measurements. Northeast Fisheres Center, Woods Hole Lab. Ref. Doc. 7618, 34 p. (mimeo). Unpubl. Manuscript.

[4] Theroux, R. B., and R. L. Wigley. 1979. Collection data for U.S. east coast bivalve mollusks in the Northeast Fisheries Center Specimen Reference Collection, Woods Hole, Massachusetts. Northeast Fisheries Center, Woods Hole Laboratory, National Marine Fisheries Serv., NOAA, Northeast Fisheries Center.,Woods Hole Lab. Ref. Doc. 79-29, 471 p. (mimeo). Unpubl. Manuscript.

[5] Maurer, D., and R. L. Wigley. 1981. Distribution of biomass and density of macrobenthic invertebrates on the continental shelf off Martha's Vineyard, Massachusetts. National Marine Fisheries Service, Northeast Fisheries Center, Woods Hole Laboratory, NOAA, Woods Hole Lab. Ref. Doc. 81-15, 97 p. (mimeo). Unpubl. manuscript.

[6] Theroux, R. B., R. L. Wigley, and H. E. Murray. 1982. Marine macrobenthic invertebrate fauna of the New England Region: Collection data and environmental measurements. Nat. Mar. Fish. Serv., NOAA, Northeast Fish. Center, Woods Hole Lab. Ref.Doc. 82-40, MARMAP Contrib. MD/NEFC 82-67, 74 p. (mimeo). Unpubl. Manuscript.

[7] Theroux, R. B., and J. Schmidt-Gengenbach. 1984. Collection data and environmental measurements for U.S. east coast Cumacea (Arthropoda, Crustacea) in the Northeast Fisheries Center Specimen Reference Collection Woods Hole, Massachusetts. Nat. Mar. Fish. Serv., Northeast Fisheries Center, Woods Hole Lab. Ref. Doc. 84-27, MARMAP Contr. MED/NEFC 83-46, 114 p. (mimeo). Unpubl. Manuscript.

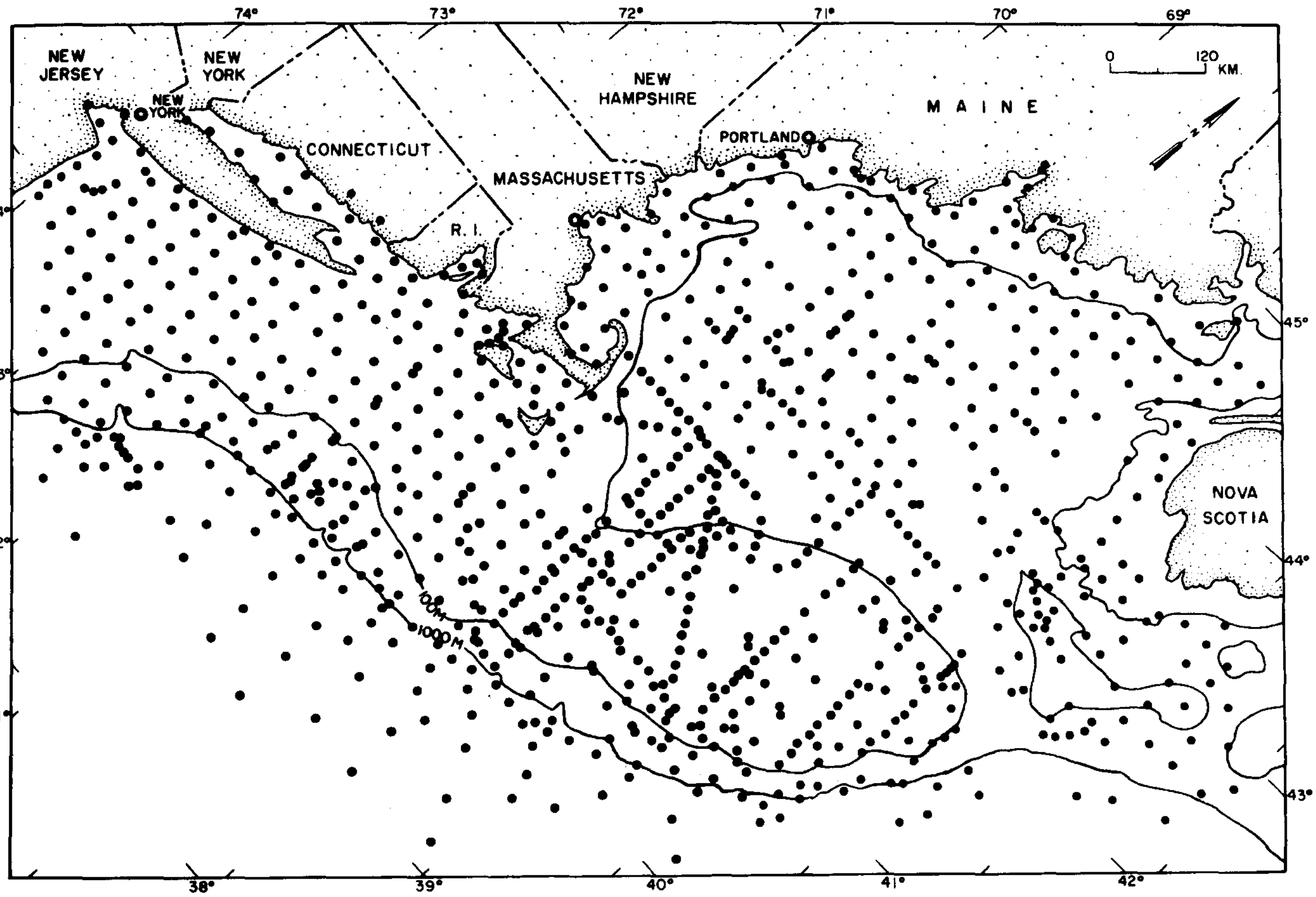

Figure 1

Chart of the study area showing the location of stations where quantitative samples of macrobenthic invertebrates were obtained.

bers, number of samples, latitude, longitude, date of sampling, and type of gear used) and environmental measurements (including water depth in meters, bottom type, geographic subarea, temperature range [°C], and percent organic carbon) for each sampling site are contained in Theroux et al.[6]).

Sampling stations were located in all sections of the study area, but somewhat more intensive coverage was given to the offshore continental shelf region than to the inshore bays and sounds or to the deep water region beyond the continental shelf. Table 2 lists the number of samples and occurrence frequency for each parameter grouping. A moderate number of samples, however, were taken in the major bays and estuaries, and in deep water. Ninety-two samples were collected at depths less than 24 m, and 93 samples from depths greater than 500 m. The continental rise was only sparsely sampled because of its great depth and the correspondingly increased time required to obtain samples. Minimum and maximum depths at which samples were taken were 3 and 3,975 m.

Sampling Gear

The samples consisted of bottom sediments with the constituent fauna collected with a Smith-McIntyre spring-loaded grab sampler (Smith and McIntyre, 1954) illustrated in Figure 3, or a Campbell grab sampler (Menzies et al., 1963) illustrated in Figure 4. The bottom area sampled by the Smith-McIntyre sampler was 0.1 m^2 which had a capacity of approximately 15 liters (L). Area sampled by the Campbell sampler was 0.56 m^2, which had a volume capacity of about 200 L. The Campbell grab was equipped with a 35-mm camera and electronic flash, housed within the buckets, to obtain photographs of the bottom immediately before impact (Emery and Merrill, 1964; Emery et al., 1965; Wigley and Emery, 1967; Theroux, 1984).

Sample Processing

Aboard ship, the material obtained at each sampling site by each sampler was processed and preserved as a

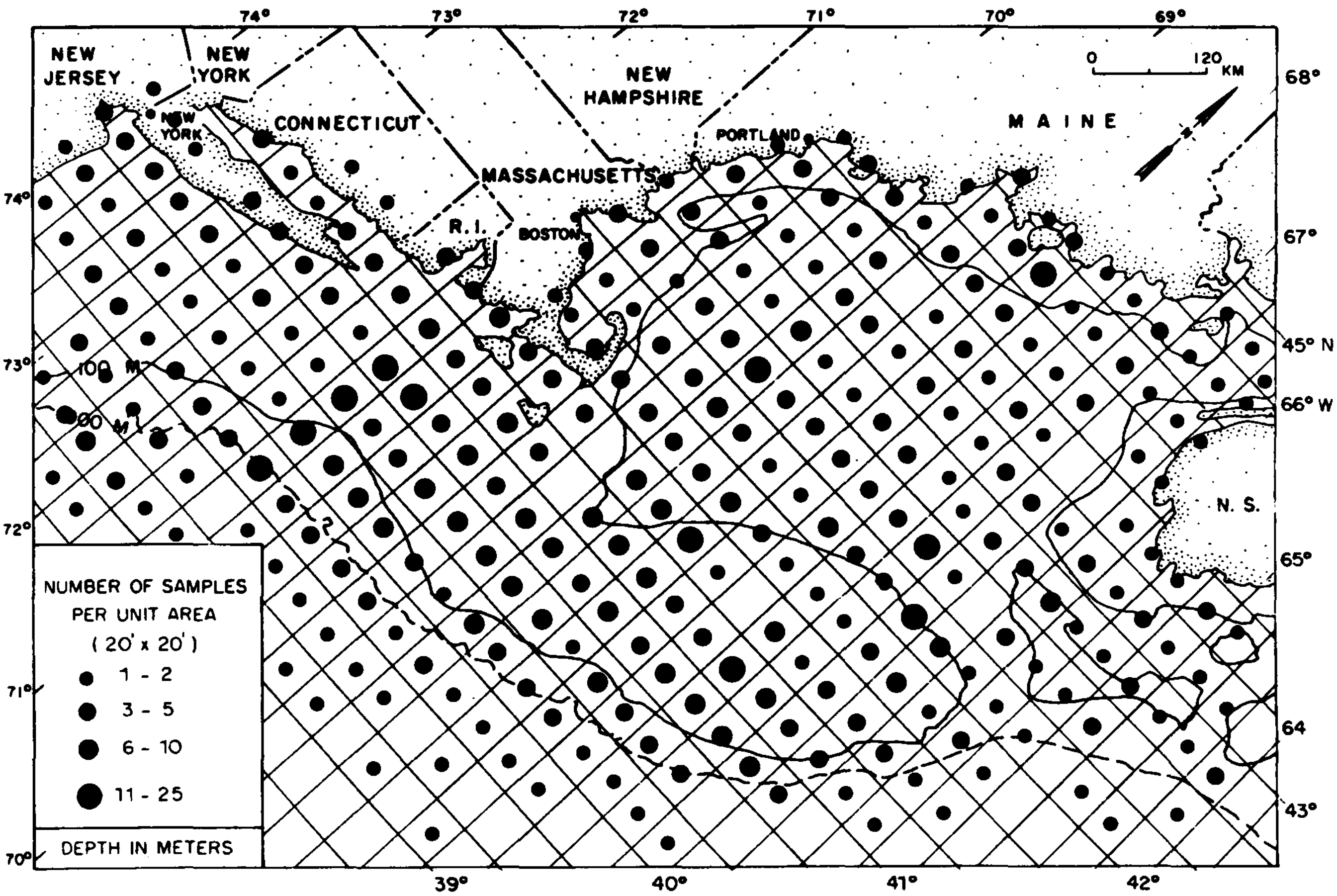

Figure 2

Chart showing sampling intensity within each standard unit area (20 min. latitude by 20 min. longitude). All samples within each unit area have been added to indicate sampling density.

separate sample. The contents of the sampler were emptied into a bucket or tub calibrated in liters, or directly into a wash-box (volume measured by means of a calibrated rule) from which two small subsamples were removed prior to washing. One of these subsamples was for meiofauna, and the other for sediment analysis. Total quantity removed ranged from 0.25 to 1.0 L, depending upon the total volume of material obtained. The quantities of both samples and subsamples were measured and recorded on sample log sheets. Generally, the remaining material was washed through a 1-mm-aperture mesh-sieving screen. Material remaining on the screen after washing, consisting of benthic animals, tubes, shells, shell hash, and coarse sediments, was preserved in a buffered seawater solution of formaldehyde and brought to the laboratory ashore for further processing.

Laboratory processing involved separating the preserved organisms from the mineral debris, sorting them to major taxonomic groups, identifying them to the lowest practicable taxonomic level, counting, and weighing. Weights are damp formalin weight, the "rough weight" of Petersen (1918), herein referred to as wet weight inasmuch as the superficial fluid on the specimens was removed by blotting before being weighed on a Mettler precision balance to the nearest 0.01 g. Weights include shells and skeletal materials that constitute an integral part of the living animal, i.e. shells of living mollusks, brachiopods, and skeletal structures of bryozoans, barnacles, and similar organisms. Materials omitted in the weighing procedure were: tubes of polychaetous worms, gastropod and scaphopod shells inhabited by pagurid crabs or sipunculid worms, and other similar nonintegral structures or nonliving animal remains. Counts of the number of specimens were made for all groups. Colonial animals were treated as individuals; that is, one sponge colony, or a colony of bryozoans was each counted as an individual specimen; colonies are much more comparable in size to individuals of noncolonial animals than are the zooids making up the colony. Also, the disparity in size from smallest to largest colonial organisms was only slightly greater than the size differential between small and large individuals of noncolonial species.

Specimens of each taxon were bottled separately in 70% ethanol and labeled. Subsequently, specimens were assembled by taxonomic groups and sent to cooperating systematists for species determinations. There were more than 40 specialists from the United States and from other countries cooperating in this part of the study.

Data Treatment

Information pertaining to the location, collecting methods, physical and chemical characteristics of the environment, and the number and weight of the biological components of each sample was recorded on preprinted data forms. The coded information and quantitative data from the records were entered on automatic data-processing cards. Data were summarized by computer in a form similar to that presented in the tables appearing in the body of this report.

The principal units used for expressing the quantity of benthic invertebrates (quantity per unit area) are: 1) density—number of individual specimens per square meter of bottom area, and 2) biomass—wet weight, in grams, per square meter of bottom.

Faunal density values used in constructing quantitative geographic distribution charts for the various taxonomic groups (Figs. 12, 27, 33, 39, 45, etc.) are mean values for all samples within each unit area as shown in Figure 2.

Qualitative and quantitative differences between seasons and between years were sufficiently small to permit the consolidation of all samples for purposes of this report. Some seasonal and yearly differences in taxonomic composition and quantity of animals were detected within specific geographic localities that were repeatedly sampled. With few exceptions, however, the dissimilarities were relatively minor in comparison to the differences from one geographic locality to another. One of the chief reasons for the temporal stability was the presence of many animals having a long (one year to a century or more) life span. The common occurrence of sessile forms and nonmigratory motile forms also contributed to the observed constancy in biomass. Similar conditions were reported by Zatsepin (1968, in Steele, 1973) in reference to macrobenthos samples taken in the Barents Sea and Norwegian Sea over a 30-year period. He found that a comparison of samples taken in the same regions in different years "... showed no substantial changes in the quantitative distribution of the bottom fauna." Several recent reports also allude to the temporal persistence of certain dominant components of the macrobenthos of the region (Steimle, 1990a, 1990b; Maurer[8]; Michael et al.[9]).

Table 2
Numbers of samples and occurrence frequency in each of the various parameter groupings used in this report.

Parameter	Number of samples	Frequency (%) of occurrence
Geographic area		
Nova Scotia	85	7.9
Gulf of Maine	303	28.2
Georges Bank	211	19.6
Southern New England Shelf	344	32.0
Georges Slope	52	4.8
Southern New England Slope	81	7.5
Depth range (m)		
0–24	92	8.6
25–49	160	14.9
50–99	319	29.6
100–199	246	22.9
200–499	166	15.4
500–999	22	2.0
1000–1999	34	3.2
2000–3999	37	3.4
Sediment type		
Gravel	148	13.8
Till	22	2.0
Shell	6	0.6
Sand	455	42.2
Sand-silt	211	19.6
Silt-clay	234	21.8
Temperature range (°C)		
0–3.9	335	31.1
4–7.9	158	14.7
8–11.9	336	31.2
12–15.9	157	14.6
16–19.9	62	5.8
20–23.9	28	2.6
Sediment organic carbon (%)		
0.00	5	0.5
0.01-0.49	418	38.8
0.50-0.99	167	15.5
1.00-1.49	84	7.8
1.50-1.99	43	4.0
2.00-2.99	13	1.2
3.00-4.99	4	0.4
5.00+	1	0.1
missing data	341	31.7

Geographic Areas

For purposes of detecting and reporting regional differences in faunal composition the region has been

[8] Maurer, D. 1983. Review of benthic invertebrates of Georges Bank in relation to gas and oil exploration with emphasis on management implications. Natl. Mar. Fish, Serv., Northeast Fisheries Center, Woods Hole, Massachusetts, Woods Hole Lab. Ref. Doc. 83-16, 329 p. (mimeo). Unpubl. manuscript.

[9] Michael, A. D., C. D. Long, D. Maurer, and R. A. McGrath. 1983. Georges Bank benthic infauna historical study. Final report to U.S. Dep. Interior, Minerals Management Service, Washington, DC, Rep. 83-1 by Taxon Inc. Salem, MA 01970, 171 p.

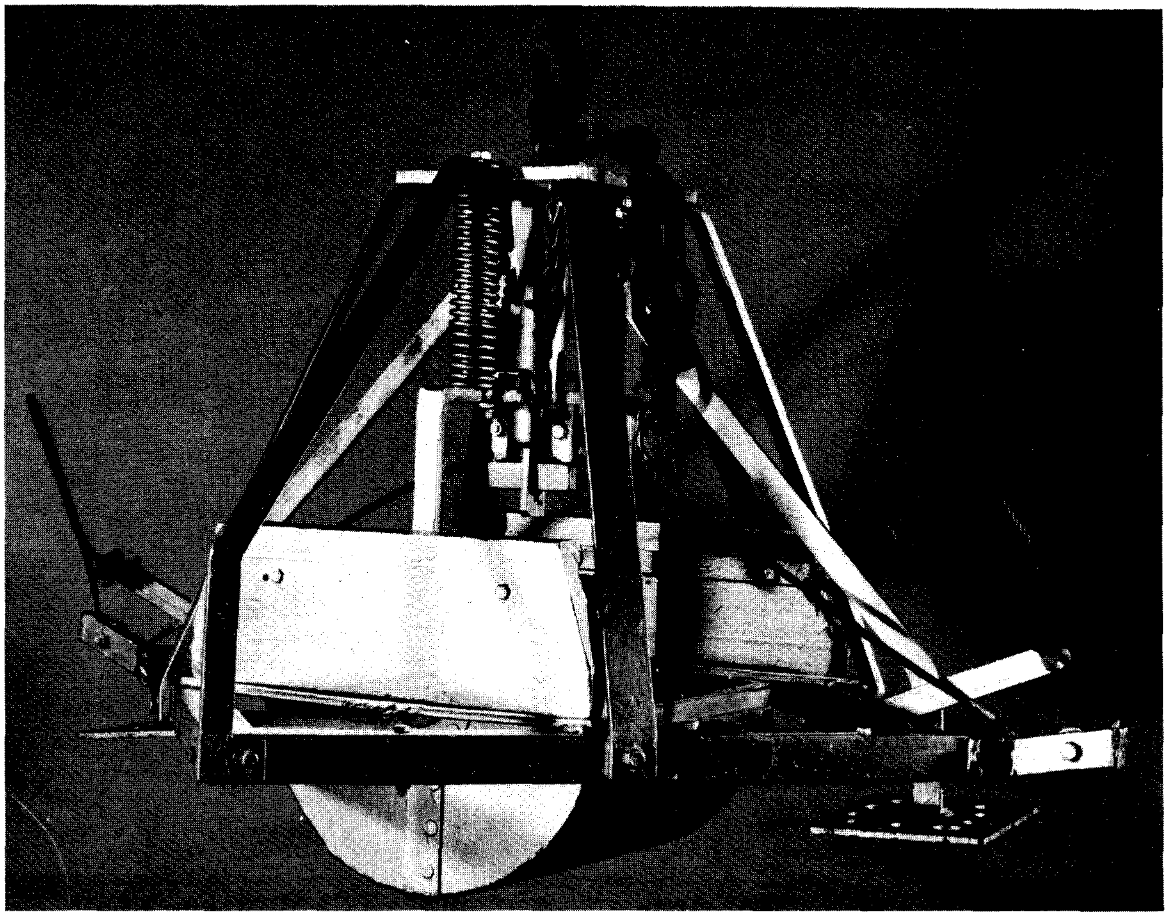

Figure 3
Side view of the Smith-McIntyre spring-loaded bottom sampler in the closed position. Lead weights on each side are set vertically to impede rotation of the sampler during descent and ascent. Vertical distance from frame base to top plate is 52 cm.

divided geographically into six subareas (Fig. 5). These are: 1) Nova Scotia, containing 44,816 km^2 (13,049 mi^2)—encompassing southwestern Bay of Fundy, eastern gulf of Maine, Browns Bank, and the Nova Scotian continental shelf; 2) Gulf of Maine—all of the Gulf of Maine except the eastern sector encompassing an area of 80,067 km^2 (23,313 mi^2); 3) Georges Bank—consisting only of Georges Bank proper with an area of 39,211 km^2 (11,417 mi^2); 4) Southern New England Shelf occupying 73,318 km^2 (21,348 mi^2)—including the continental shelf from Great South Channel southwestward to central New Jersey; 5) Georges Slope—the continental slope from Great South Channel northeasterly to off the Scotian Banks, an area of 50,706 km^2 (14,764 mi^2); 6) Southern New England Slope—the continental slope from Great South Channel southwesterly to southwest of Hudson Canyon, occupying 62,570 km^2 (18,218 mi^2). Each subarea has specific biotopic and biogeographic faunal characteristics. These are discussed in the section entitled "Description of the Region" and in the "Geographic Distribution" section for each of the major taxonomic groups.

Bottom Sediments

Bottom sediments from the samples have been analyzed for particle size, composition, and color. In addition, a selected series of these samples was further analyzed for carbonate content (Hülsemann, 1966), quantity of organic matter (Hülsemann, 1967) and minerology (Ross, 1970b). Detailed particle size analyses of approximately 75% of the samples were made by John Schlee, U.S. Geological Survey (Schlee, 1973).

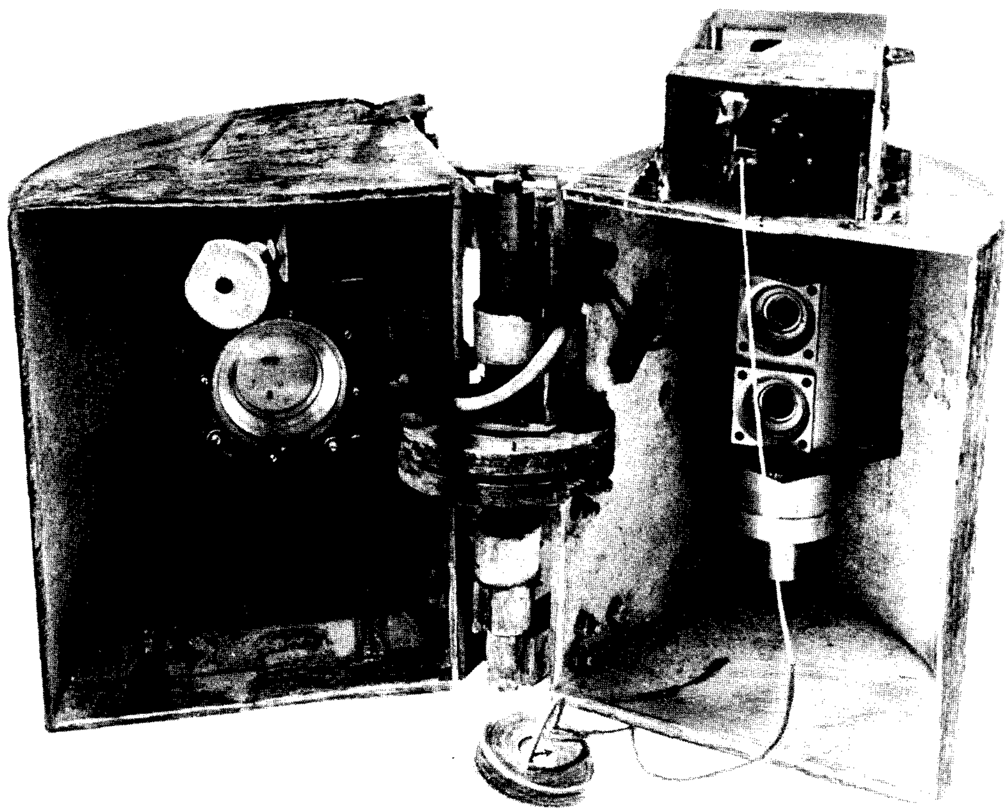

Figure 4
Bottom view of Campbell grab sampler. Camera housing is installed in right-hand bucket and strobe light is in the left-hand bucket. Shutter trip weight is in foreground. Width of the buckets (vertical dimension in photograph) is 57 cm.

Approximately 20% of the samples were analyzed by the New York Soil Testing Laboratory (Wigley, 1961a). The remaining 5% were classified using field techniques by K.O. Emery of the Woods Hole Oceanographic Institution or by National Marine Fisheries Service personnel. For additional information concerning sediment analyses, methodology, and detailed results, see references listed by Emery (1966b) and the section of this report titled "Description of the Region."

Bathymetry

Water depths, in meters, were obtained by means of echo sounders and precision depth recorders and corrected for hydrophone/transducer depth and temperature effects on the velocity of sound in water.

Temperature

Water temperature and salinity data were based primarily on the hydrographic report prepared by John B. Colton et al. (1968), which gives detailed information obtained on eight quarterly (March, May, September, and December) hydrographic survey cruises from 1964 to 1966. Each cruise covered the entire area from Nova Scotia to New York. We also used several thousand bottom temperature records obtained on seventeen bottom trawl survey cruises of the research vessels *Albatross III*, *Albatross IV*, and *Delaware*, conducted by the Bureau of Commercial Fisheries Biological Laboratory, Woods Hole, during the years 1956 through 1965. Additional sources of reference and temperature-salinity data are: Townsend (1901); Sumner, et al. (1913); Bigelow (1927, 1933); Edwards et al. (1962); Hathaway

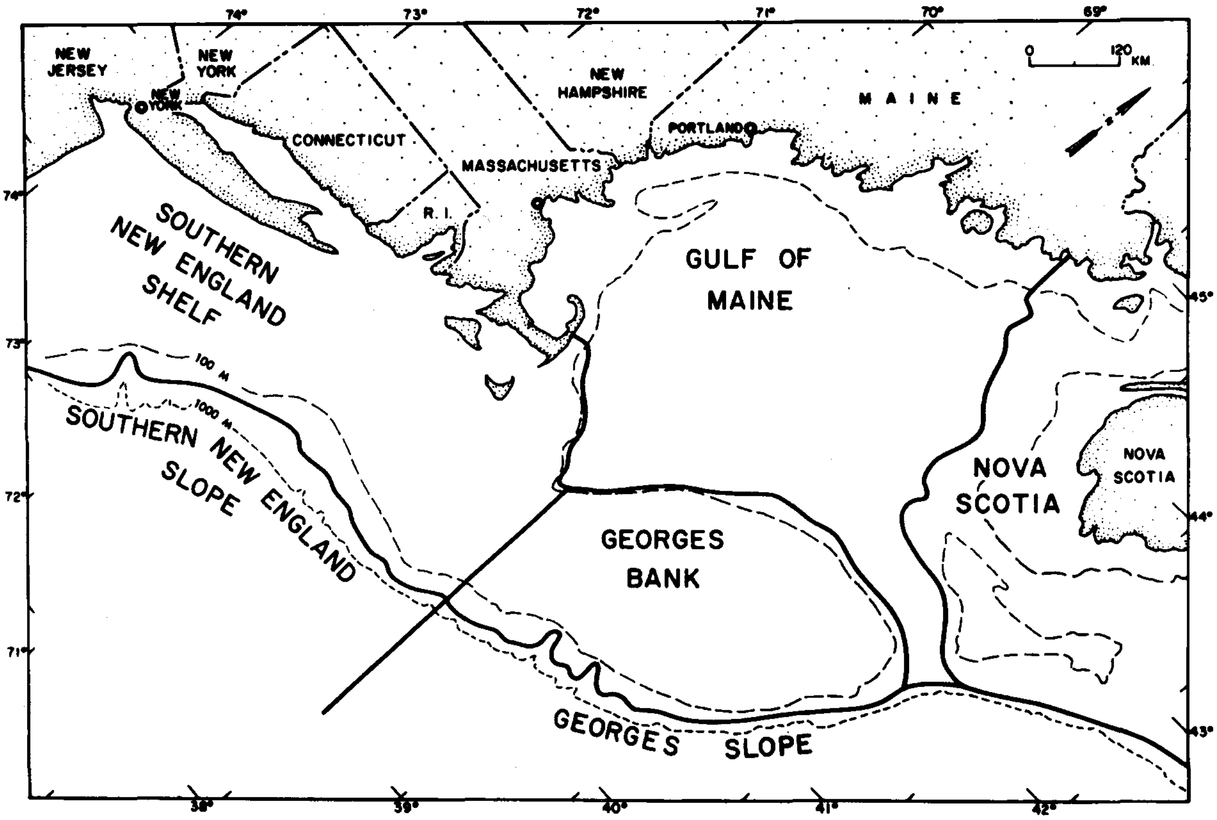

Figure 5
Chart of the study area showing the location of the six standard geographic subareas used for analytical purposes: Nova Scotia, Gulf of Maine, Georges Bank, Georges Slope, Southern New England Shelf, and Southern New England Slope.

(1966); Schopf (1967); and Schopf and Colton (1966); and Mountain and Holzwarth (1989).

Sediment Organic Carbon

Organic carbon in bottom sediments was measured by gasometric method in samples after removal of $CaCO_3$ by acid treatment. Data are contained in Hathaway (1971).

Description of the Region

Topography

Relief of the sea bottom off the New England region has been studied most recently by the U.S. Geological Survey and the Woods Hole Oceanographic Institution (Austin et al., 1980; Emery, 1965a, 1966b; Emery and Ross, 1968; Emery and Uchupi, 1972; Gibson et al. 1968; Klitgord and Behrendt, 1979; Klitgord et al., 1982. Schlee et al., 1976; Sheridan, 1974; Uchupi, 1965b, 1966a, 1966b, 1966c, 1968; Uchupi and Emery, 1967; Uchupi et al., 1977; Uchupi and Austin, 1979; Valentine, 1981). Figure 6 is based on, and has been derived from, a much larger more detailed chart by Uchupi (1965a), U.S.G.S. Map I-451, scale 1:1,000,000.

Topographically, the New England offshore area consists of several large, grossly different geological features. The largest and most complex feature is the Gulf of Maine, an immense, nearly oval-shaped glacially eroded depression on the continental shelf. The topography in this depression is very irregular, resulting in numerous basins separated by ridges, swales, and banks. These topographic irregularities are due in part to deposition, gouging, erosion, and related actions during the Pleistocene period of glaciation. Greatest depth in the gulf is 377 m, in Georges Basin; shallowest offshore depth in the gulf is 9 m, at Amen Rock on Cashes Ledge in the west central part of the Gulf of Maine (see Ballard and Uchupi, 1975; Austin et al., 1980; Klitgord et al., 1982; Schlee et al., 1976).

Georges Bank is another striking topographic feature. It is an enormous (120 km by 240 km) submarine cuestalike bank situated at the mouth of the Gulf of

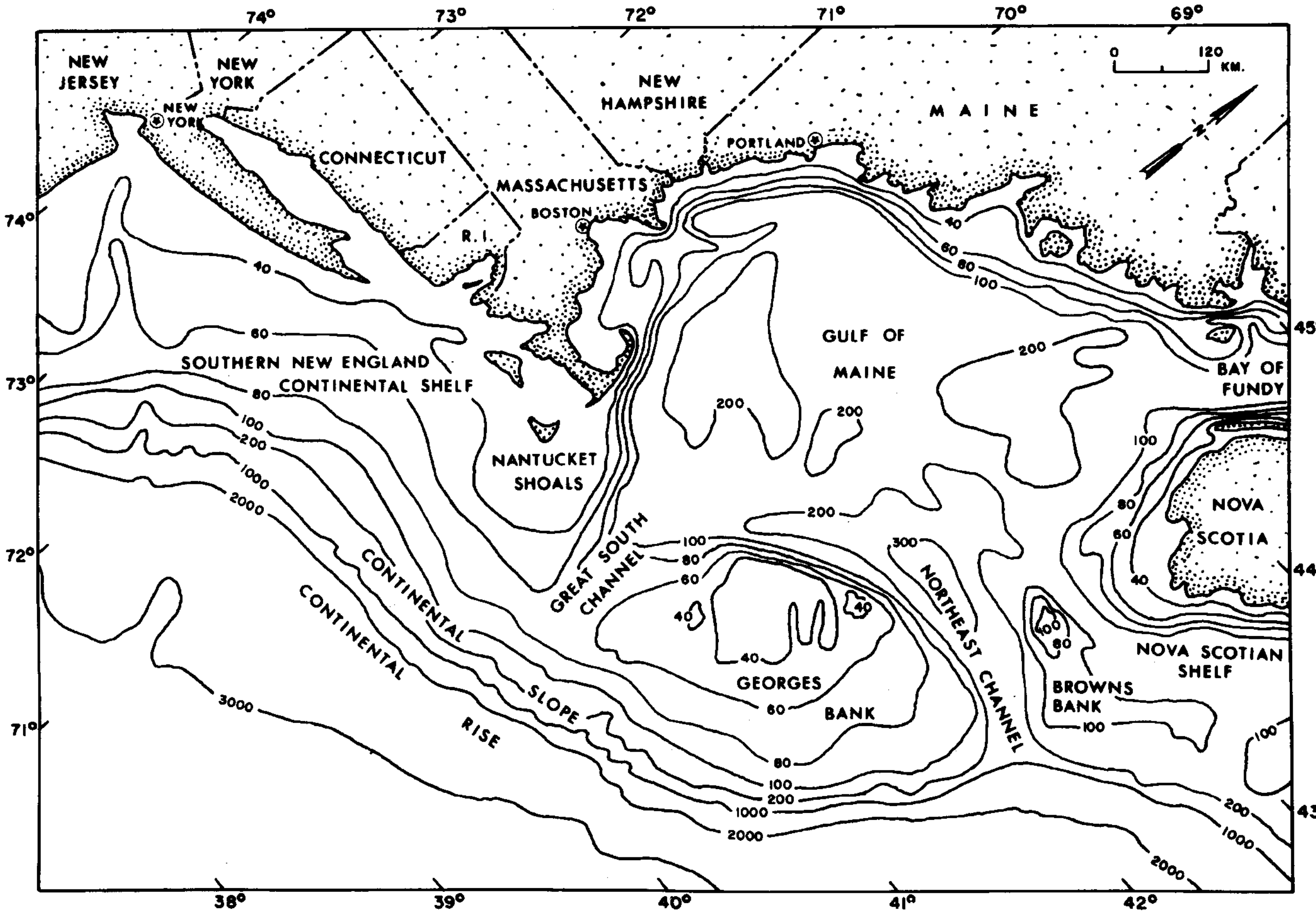

Figure 6

Chart of the study area showing bathymetric and geographical features. Depth contours are in meters (adapted from Uchupi 1965).

Maine. The bank slopes gently to the southeast and south and its surface is relatively smooth except for a series of sand ridges in the shallow northwest and north-central sections. The sand ridges are formed by exceptionally strong tidal currents that prevail in this region. Tidal currents generally flow with greatest velocity in the northwest and southeast directions. Further details relating to Georges Bank are contained in Emery and Uchupi (1965); Uchupi et al. (1977); Valentine (1981); Butman (1982, 1987); Butman et al. (1982, 1987); Backus (1987); Bourne (1987); Butman and Beardsley (1987); Cohen and Grosslein (1987); Cooper et al. (1987); Emery (1987); Flagg (1987); Howart (1987); Klitgord and Schlee (1987); Maciolek and Grassle (1987); Michael (1987); Neff (1987); Twichell et al. (1987); Uchupi and Austin (1987).

Nantucket Shoals is a relatively shallow and topographically uneven area southeast of Nantucket Island, Massachusetts. Principal irregularities are large swales and ridges extending in north-south and northeast-southwest directions.

The southern New England continental shelf is a gently seaward-sloping region with rather smooth topography. Width of the shelf is approximately 100 km and the shelf break occurs at a depth of about 120 m. See Garrison and McMaster (1966) for more details.

The continental slope is a narrow zone along the outer margin of the shelf extending from the shelf break to a depth of 2,000 m. This zone has a comparatively steep gradient, but less than 5°, and the relief is moderately smooth except where it is cut by submarine canyons. The continental rise (2,000–6,000 m) is generally similar to the slope in having only gradual changes in surficial topography. However, the overall gradient is substantially less than that for the continental slope. Consult Emery (1965a), Emery and Ross (1968), Gibson et al. (1968), Schlee et al. (1979), Sheridan (1974), and Uchupi et al. (1977) for details of topography of this region.

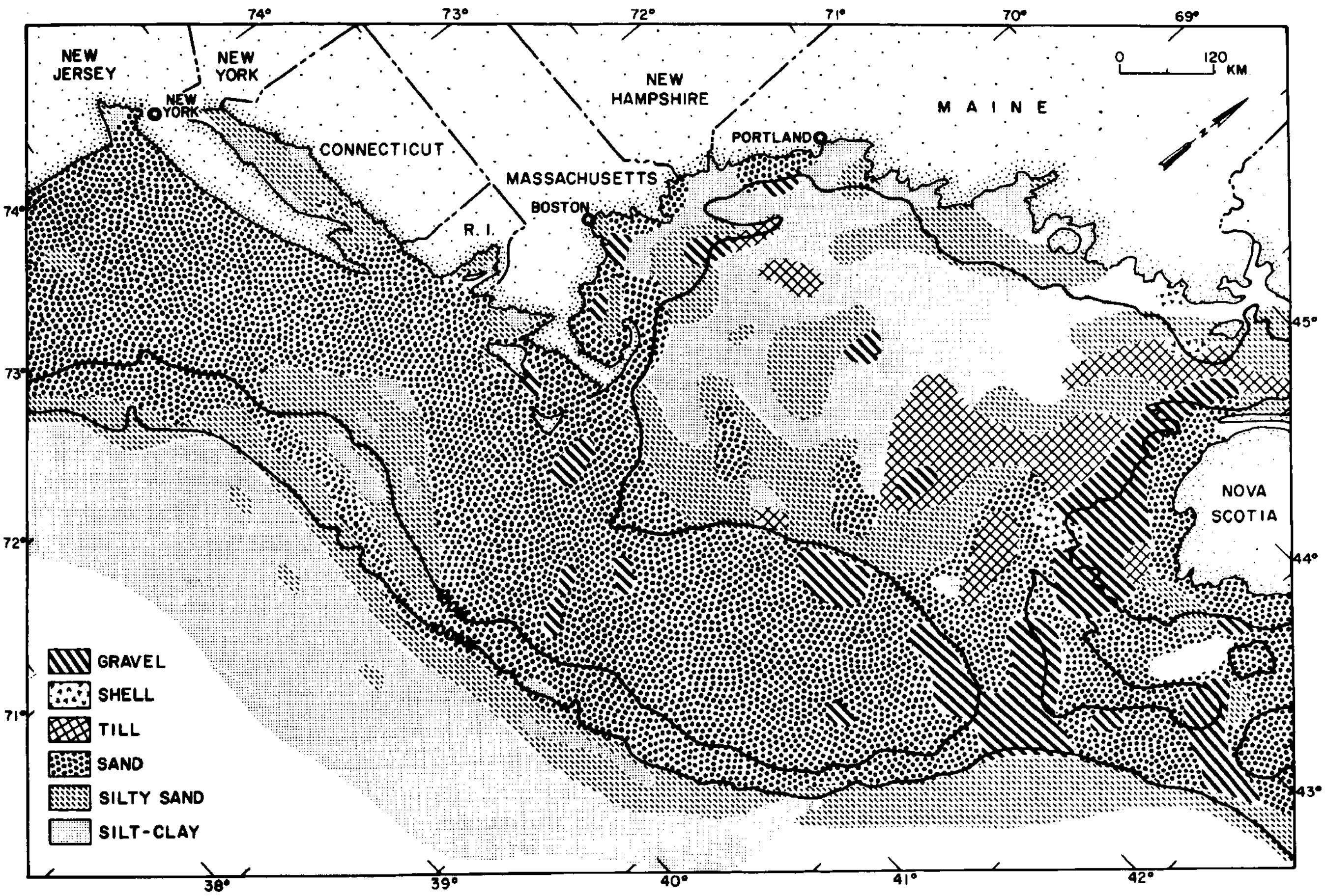

Figure 7
Geographical distribution of bottom-sediment types in the study area.

Bottom Sediments

The composition of sediments blanketing the sea floor throughout the study area is well known. Detailed studies have included sedimentological aspects of general lithology, particle size composition, calcium carbonate content, organic carbon content, nitrogen content, minerology, sand and gravel fractions, and other components. A representative selection of publications dealing with the bottom sediments of New England marine waters includes: Shepard, et al. (1934); Shepard and Cohee (1936); Stetson (1936, 1938, 1949); Shepard (1939); Hough (1940, 1942); Wigley (1961a); Uchupi (1963, 1965b, 1966a, 1966b, 1966c, 1968, 1969); Emery (1965a, 1965b, 1966a, 1966b, 1968); Emery et al. (1965); Rvachev (1965); Garrison and McMaster (1966); Hülsemann (1966, 1967); McMaster and Garrison (1966); Ross (1967, 1970a, 1970b); Uchupi and Emery (1967); Emery and Ross (1968); Schlee (1968, 1973); Schlee and Pratt (1970); Emery and Uchupi (1972); Trumbull (1972); Milliman (1973); Wigley and Stinton (1973); Sheridan (1974); Austin et al. (1980); Twichell et al. (1981); Butman (1982, 1987); Klitgord et. al. (1982); and Valentine et al. (1980).

Relict glacial sediments are the major constituents covering most of the study area, particularly on the continental shelf. Quartz and feldspar sands and granite and gneiss gravels are particularly common in the shallower areas and on the topographically high elevations in deeper water. Fine-textured sediments, mainly silts and clays, that mantle the continental slope, continental rise, and protected pockets and basins on the continental shelf are predominantly present-day detrital sediments.

Large areas in the deeper part of the Gulf of Maine are floored with unsorted glacial till, whereas the shallow banks and ridges are commonly covered with gravel or sand of glacial origin that remained after washing action removed the finer particles. In some deep parts of the Gulf, where water currents are minimal, the till is overburdened with layers of silt and clay. In Long Island Sound, Buzzards Bay, and many of the smaller bays along the coast, the sediments are composed largely of silts and clays, with sand and gravel common in the nearshore zones.

The sediment chart prepared for this report (Fig. 7) is based on sediment samples taken from the same grab hauls from which the fauna was obtained.

Sediment organic carbon

The distribution of organic carbon in the bottom sediments of the region is depicted in Figure 8. Values for sediment organic carbon content from samples were low to moderate, ranging from less than 0.5% to slightly over 7% (7.04). The major portion of the continental shelf contains small amounts (< 0.5%) of organic carbon in sediments, with only small, discrete patches, especially in the Southern New England shelf area, of slightly greater amounts (0.5–1.99%). Organic carbon content of sediments in the two slope subareas, Georges Slope and Southern New England Slope, was somewhat higher than on the shelf with values between 0.50 and 0.99% prevailing and with small areas on the Southern New England slope containing from 1.00 to 1.99% organic carbon. The sediments in both the Gulf of Maine and Long Island Sound contain comparatively larger amounts of carbon, primarily in the 1.00 to 1.99% range over most of their respective areas. Highest organic carbon content (from 2.00 to 7.04%) was almost exclusively restricted to the major embayments and estuaries within the study area; only offshore exceptions to this were two small areas on Stellwagen Bank and in the area known as Georges Basin, where organic carbon contents in that range were found.

Hydrography

A substantial amount of information has been amassed over the years concerning the hydrography of the offshore New England region. Some of the first hydrographic data collected were temperature measurements taken by Benjamin Franklin's nephew in 1789. Since that time numerous studies have been conducted primarily by government organizations, such as the U.S. Fish Commission (subsequently named the U.S. Bureau of Commercial Fisheries, and currently called the National Marine Fisheries Service), the U.S. Coast Survey (now the National Ocean Survey), U.S. Coast Guard, Tidal Survey of Canada, Biological Board of Canada (Fisheries Research Board of Canada), coastal states organizations, Bigelow Laboratory, Woods Hole Oceanographic Institution, Harvard University, Massachusetts Institute of Technology, University of

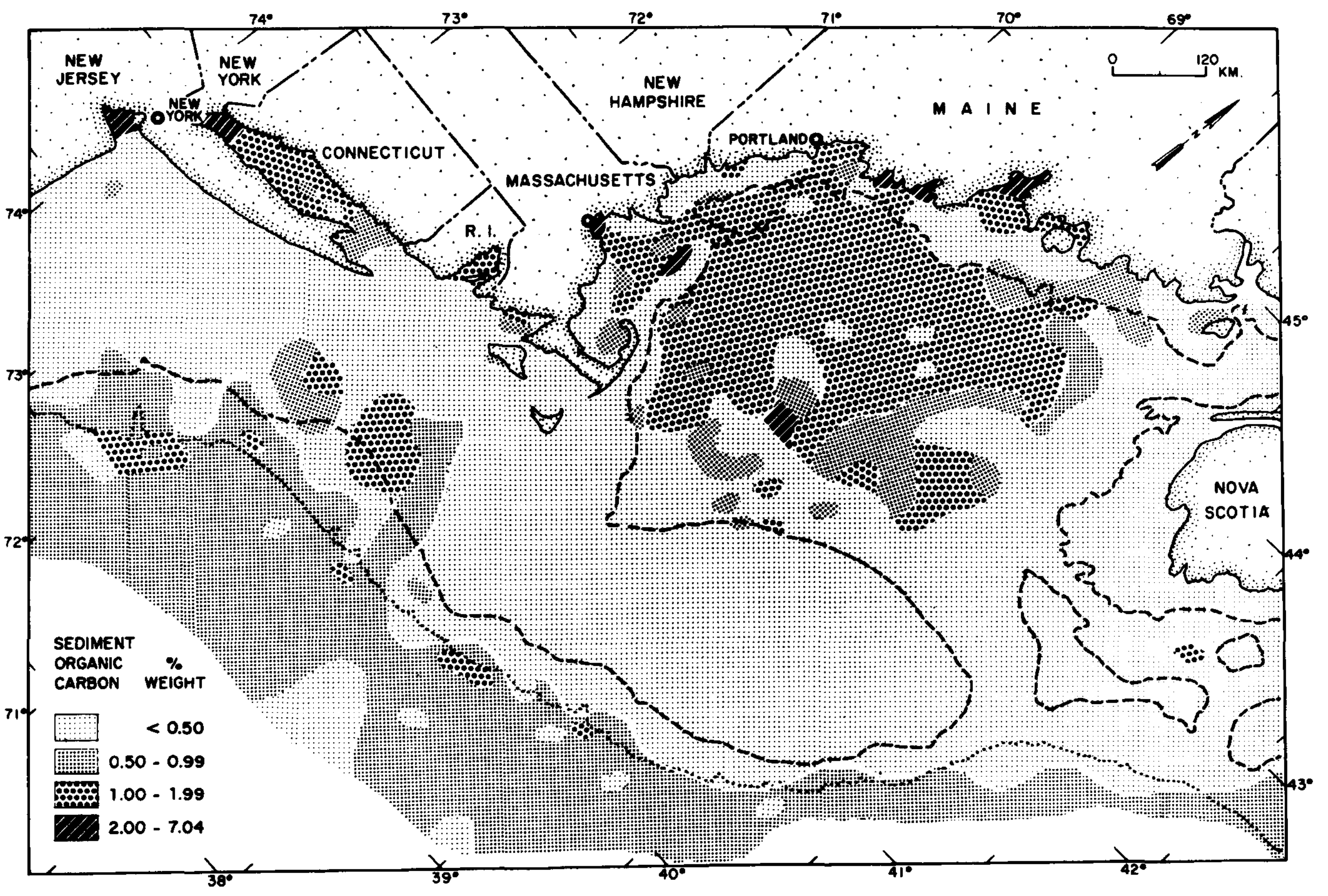

Figure 8
Geographic distribution of organic carbon in the bottom sediments.

Rhode Island, and other private and governmental organizations.

One of the most comprehensive reports on this subject is the monograph entitled "Physical Oceanography of the Gulf of Maine" by Henry B. Bigelow (1927). He describes the essential features of water temperature, salinity, tidal and nontidal circulation, and seasonal variation in these hydrographic features. Much detailed information was added in succeeding years particularly by John B. Colton and his associates at the Bureau of Commerical Fisheries Biological Laboratory at Woods Hole, Massachusetts, and by Dean F. Bumpus and his colleagues at the Woods Hole Oceanographic Institution (Stetson, 1937; Bumpus, 1960, 1961; Colton, 1964; Bumpus and Lauzier, 1965; Bumpus et al., 1973; Butman et al., 1980, 1982; Dorkins, 1980; Ramp et al., 1980, Moody et. al., 1984, Mountain and Holzwarth, 1989, among others). Discussions of early oceanographic research in this region and references to the literature are given by Colton (1964), Schopf (1968a), and Wright (1987).

In brief, the main features pertaining to water circulation in the study area are as follows: 1) cold water on the Nova Scotian Shelf flows southwestwardly along that feature and turns northward into the Gulf of Maine; 2) Gulf of Maine waters form a large nontidal counterclockwise gyre; 3) waters overlying Georges Bank form a clockwise gyre; 4) nontidal currents generally flow southwestwardly and westward across Nantucket Shoals and on the Southern New England continental shelf; 5) freshwater runoff from land empties by means of large New England and Canadian rivers into the northern and western sections of the study area; 6) incursions of relatively warm high-salinity slope water enter the Gulf of Maine by way of Northeast Channel; 7) tidal amplitude is exceptionally large in the Bay of Fundy region, and tidal currents are strong throughout the entire New England continental shelf area; 8) the Gulf Stream flows northeastward in deep water south of the New England continental shelf (usually the Gulf Stream's northern edge is more than one hundred miles south of the continental shelf in the region south of Nantucket Island); and 9) below the Gulf Stream in the vicinity of the ocean bottom, the Western Boundary Current flows southwestwardly.

Oceanic waters in the vicinity of the Gulf Stream maintain a relatively constant salinity of about 35‰. Most of the waters overlying the continental shelf have a salinity range from 32 to 34‰. Salinity of inshore waters, which are more strongly influenced by runoff, fluctuate seasonally and drop to 28‰ in late spring when river discharge is maximum.

Temperature of water in deep oceanic areas beyond the continental shelf is typically homostenothermal. Waters are warm (20°C) at the surface and cold at the bottom (2.5 to 5°C), and both surface and bottom temperatures remain relatively stable throughout the year. Conversely,the inshore waters along the coast are characteristically heteroeurythermal. They are cold (0°C) in winter and warm in summer, and because of the shallowness and general turbulence of the water, the temperature differential between surface and bottom is relatively small. Also, there is considerable latitudinal effect on inshore waters; in southern areas the temperature does not drop as low in winter and rises higher in summer than it does in northern areas. Midshelf waters—those between the oceanic and inshore zones—are generally intermediate in their temperature regime. Temperature diversity between the surface and bottom is moderate. Seasonal changes in temperature are greater in offshore shallow areas (such as Nantucket Shoals and Georges Bank) than in basins and other deep water areas, but the range is less than that in coastal waters. Annual fluctuation in temperature of bottom water is considerably less than that of surface waters. Latitudinal effect on shelf water masses is pronounced; Nova Scotian water is substantially colder than other water masses within the study area, and the temperature generally increases to the west and south (Bigelow, 1933; McLellan, 1954; Edwards et al., 1962; Colton et al., 1968; Schopf and Colton, 1966; Schopf, 1967; Colton, 1968a, 1968b, 1969; Colton and Stoddard, 1972, 1973; Mountain and Holzwarth, 1989; Colton et al.[10]; Colton et al.[11]; Colton et al.[12]; Colten et al.[13]).

Thermal extremes, rather than means, are believed to have a marked influence on the presence or absence of various kinds of benthic animals. In order to detect the possible influence of thermal extremes as a limiting factor, we have analyzed the invertebrate fauna distribution in relation to the approximate annual minimum and maximum water temperatures, and the range in water temperature, to which the various taxa are

[10] Colton, J. B., Jr., R. R. Marak, and S. R. Nickerson. 1965a. Environmental observations on continental shelf Nova Scotia to Long Island, March 1965, *Albatross IV* cruise 65-3. U.S. Bur. Commer. Fish. Biol. Lab. Woods Hole, Mass., Lab. Ref. 65-15, 3 p., 9 figs. (mimeo). Unpubl. manuscript.

[11] Colton, J. B., Jr., R. R. Marak, and S. R. Nickerson. 1965b. Environmental observations on continental shelf Nova Scotia to Long Island, September 1965, *Albatross IV* cruise 65-12. U.S. Bur. Commer. Fish. Biol. Lab. Woods Hole, Mass., Lab. Ref. 65-19, 3 p., 9 figs. (mimeo). Unpubl. manuscript.

[12] Colton, J. B., Jr., R. R. Marak, and S. R. Nickerson. 1966a. Environmental observations on continental shelf Nova Scotia to Long Island, March 1966, *Albatross IV* cruise 66-2. U.S. Bur. Commer. Fish. Biol. Lab. Woods Hole, Mass., Lab. Ref. 66-6, 3 p., 10 figs. (mimeo). Unpubl. manuscript.

[13] Colton, J. B., Jr., R. R. Marak, S. R. Nickerson, and R. R. Stoddard. 1966b. Environmental observations on continental shelf Nova Scotia to Long Island, May–June 1966. *Albatross IV* cruise 66-7. U.S. Bur. Commer. Fish. Biol. Lab., Woods Hole, Mass., Lab. Ref. 66-7, 3 p., 10 figs. (mimeo). Unpubl. manuscript.

subjected. Charts were constructed to illustrate the isotherms of maximum bottom water temperature (Fig. 9) minimum bottom water temperature (Fig. 10), and annual range in bottom water temperature (Fig. 11). Data for these charts were extracted from temperature records taken during the sampling period when biological data were collected, August 1956 through August 1965, and from the literature (see above citations). Temperature patterns depicted in these charts are intended to provide a general scheme of annual temperature change. Higher or lower temperatures may have existed for short periods in some areas and may have been missed because of the opportunistic nature of the sampling. Extremes of this kind, however, are not considered usual or of great magnitude.

These charts disclose a wide annual temperature range in coastal bays and in shallow offshore areas, such as Georges Bank and Nantucket Shoals. Very little change occurs in deep water. At depths below 500 meters the annual variation in temperature is roughly 0–3.9°C. Bottom water in the Gulf of Maine is relatively cold, 4 to 8°C and changes very little throughout the year. Bottom water on the Scotian Shelf and Browns Bank is particularly cold in the spring and warms up only to moderate levels in the fall and early winter. Annual average temperature of bottom water for some of the major areas calculated by Schopf and Colton (1966) and Schopf (1967) are: Georges Bank 8.6°C, Nantucket Shoals 7.8°C, Gulf of Maine 5.7°C, Browns Bank 5.0°C, and the Nova Scotian Shelf 4.6°C.

Zoogeography

The topographic, hydrographic, climatic, and faunal complexities of the sublittoral portion of the study area cause considerable difficulty in the definition of definitive zoogeographic boundaries in the Northwest Atlantic. Until recently, the traditional view among biogeographers was that the region embraced portions of two major zoogeographic provinces: 1) The Boreal Province, sometimes referred to as Acadian or Nova Scotian, which extends from Newfoundland to Cape Cod, and 2) The Trans-Atlantic or (Warm Temperate) Province

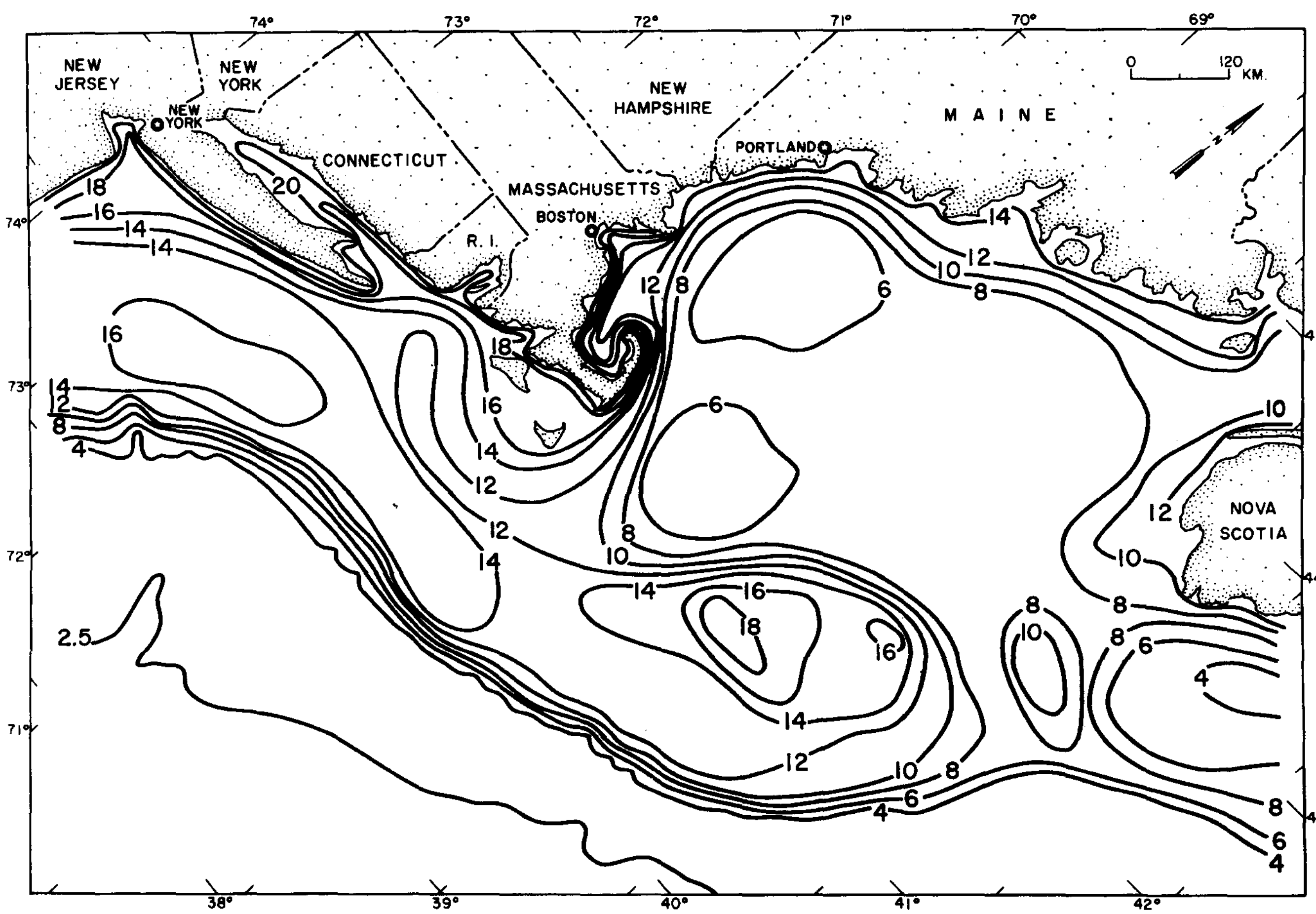

Figure 9
Distribution of maximum reported bottom water temperatures (in degrees Celsius) in the study area.

of which the Virginian subprovince extends from Cape Cod southward to Cape Hatteras (Ekman, 1953; Hedgpeth, 1957). Although these views postulated the highly visible physical features of Cape Cod and Cape Hatteras as the boundaries between these provinces (a credible hypothesis topographically and hydrographically), no definitive consensus of opinion among biogeographers of the period prevailed as to the precise placement of the boundaries in the Northwest Atlantic. Indeed, the plethora of varying definitions and terms led to a rather confusing semantic problem that exists to this day. Further, these views resulted from studies based almost solely on biological and physical data from inshore or nearshore areas.

Hazel (1970) reviewed the historical development of faunal provinces for North America and Europe based on the work of 17 authors from 1838 to 1966 and noted that during that period essentially three biogeographic schemes evolved to characterize the Northwest Atlantic down to Cape Hatteras: 1) Cape Cod acts as a boundary between the cold temperate Nova Scotian or Boreal Province to the north, and the warm temperate Virginian subprovince to the south, with Cape Hatteras forming the boundary between the Virginian and Carolinian subprovinces, which together formed the Trans-Atlantic Province down to present day Cape Kennedy; 2) a region of overlap or transition, lacking a unique fauna of its own (low endemism) with no provincial status, between the Nova Scotian and Carolinian Provinces; and 3) A cold temperate Boreal Province extending from Newfoundland to Cape Hatteras.

Although more recent biogeographic studies, based mostly on offshore fauna within the region, such as those of Bousfield (1960), Coomans (1962), Schopf (1968b), Franz (1970), Hazel (1970), Bousfield (1973), Franz (1975), Bowen et al. (1979), Kinner (1978), Watling (1979), Franz and Merrill (1980a, 1980b), and Franz et al. (1981) have expressed concern over the boundary's existence and have attempted to resolve the semantic problem of terminology through revision and simplification, they have not, for the most part, significantly altered the three biogeographic concepts of earlier workers. These recent works, however, have provided some new insights concerning the placement of

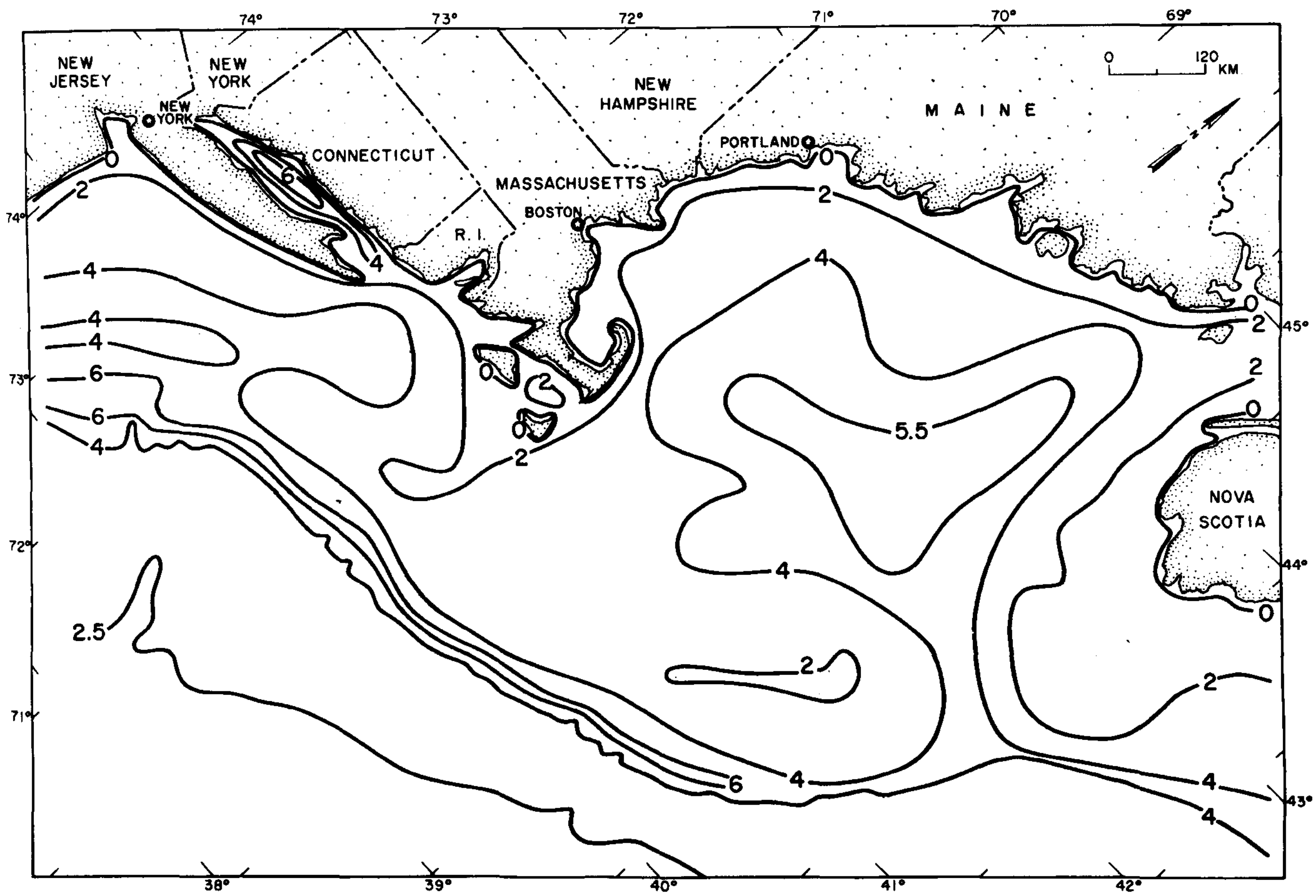

Figure 10
Distribution of minimum reported bottom water temperatures (in degrees Celsius) in the study area.

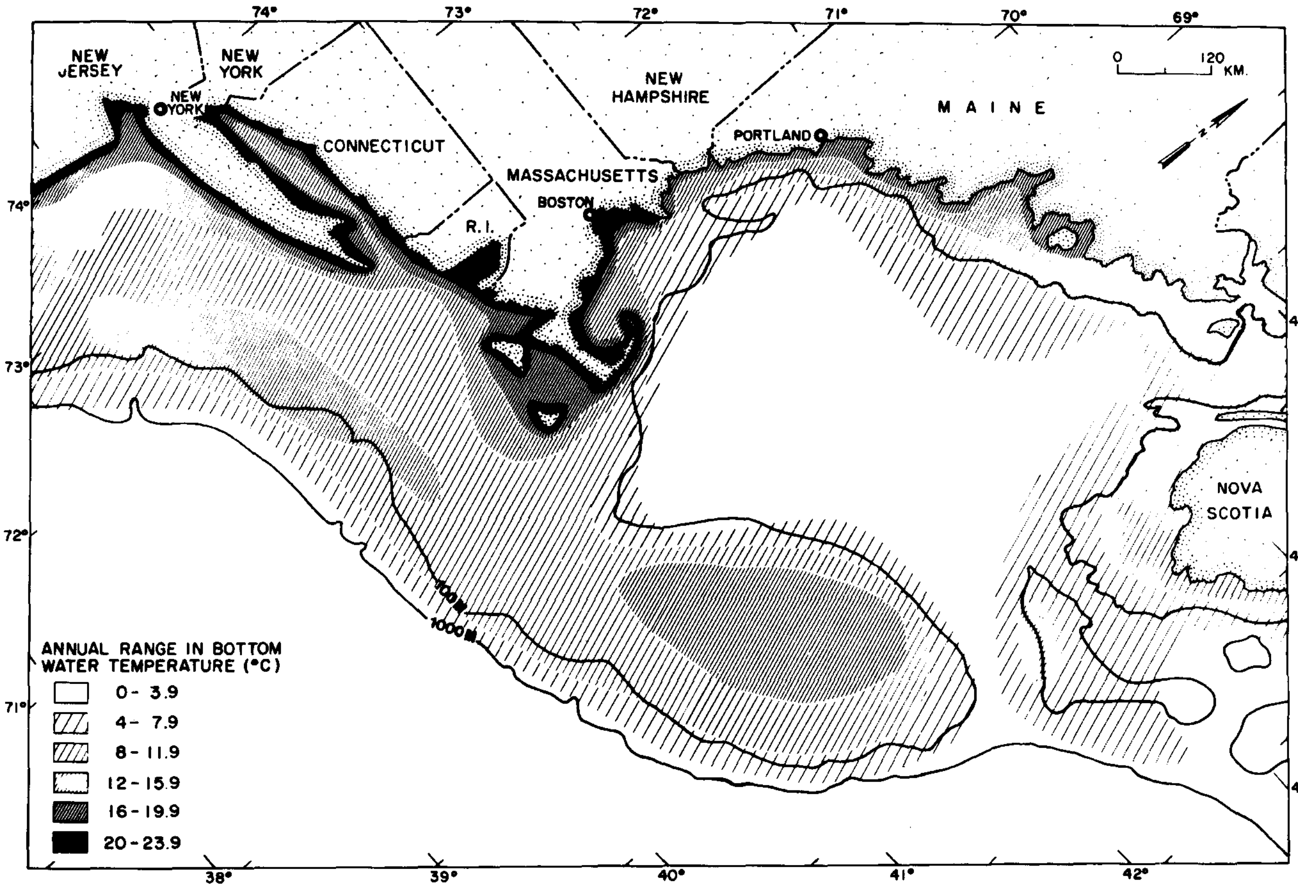

Figure 11

Distribution of the annual range (difference between maximum and minimum reported values) in bottom water temperature (in degrees Celsius) in the study area.

more meaningful zoogeographic boundaries for regulating the distribution of benthic taxa within the region.

Boundaries of the geographical area considered in this report were purposely selected so that they did not terminate at the margin of a perceived zoogeographical barrier. Cape Cod, lying roughly in the center of the study area, is of course the main physical feature historically considered to mark the separation between the Boreal and Trans-Atlantic Provinces. The recent work of Schopf (1968b), Hazel (1970), Watling (1979b), Franz et al. (1981), and other reports (Wigley and Burns, 1971; Williams and Wigley, 1977; Theroux and Wigley, 1983; and Theroux and Grosslein, 1987) based on the same data as, and including, the present report corroborate the fact that Cape Cod is indeed a zoogeographic boundary. However, the seaward extension of this boundary, at least as it pertains to benthic animals, does not traverse the continental shelf over Nantucket Shoals and the southwestern terminus of Great South Channel as previously supposed. Rather, the boundary appears to lie along an easterly path across the northern end of Great South Channel at depths of 50 to 100 m and to continue along the northern margin of Georges Bank and thence southeasterly along the western boundary of Northeast Channel.

In bathyal and abyssal depths there are at least two other zoogeographic provinces. Along the continental slope, at depths between 150 and 2,000 m, is the Atlantic Transitional Province (Cutler, 1977), and at depths between 2,000 and 4,000 m is the Atlantic Bathyal-Abyssal Province. Because of the interdigitating distributional patterns resulting from the southward submergence of Boreal species and the ascendency of Transitional and Bathyal-Abyssal species in their northward extension, the delineation of these provinces is imprecise and only partially aligned with topographic features.

A great deal more work of a zoogeographic nature on the many remaining unstudied taxa of benthic invertebrates inhabiting the area needs to be performed before precise zoogeographic boundaries may be drawn, if at all possible.

Faunal Composition

The macrobenthic invertebrate fauna of the New England region is moderate in variety. A modest number of species (567 in the present study), in combination with a graded abundance of individuals composed of a variety of dominants and codominants, is characteristic of the fauna, and is generally typical of Boreal-Temperate faunal assemblages.

Taxa reported on in this study represent 13 phyla and 28 lesser groups such as subphyla, classes, subclasses, and orders. The majority of species are Boreal forms, followed closely in abundance by Virginian (or warm-temperate) forms. Additionally, there is a small contingent of Arctic and Subarctic species, particularly in the Gulf of Maine. Also, a few tropical and subtropical species occur chiefly in the Southern New England and Georges Bank areas.

The ecological importance of these groups, judged primarily from their numerical abundance and biomass, ranges from minor (components that account for less than 0.1% in number of individuals and biomass) to dominant components that make up 20% or more in number of individuals or biomass. The 44 major taxonomic groups, with the percentage of total number of individuals and percentage of total biomass for each, are listed in Table 3. Also, they are classified into four dominance categories, I to IV.

Over 80% of both the biomass and number of individuals in the macrobenthos is formed by only five taxonomic groups. These are classified in dominance category I in Table 3. Bivalvia is the dominant contributor (44.1%) to the biomass and is also a major component (10.8%) in terms of numbers of individuals. Amphipoda, on the other hand, is numerically dominant (43.4%) but contributes only 2.3% of the biomass. Conversely, Echinoidea and Holothuroidea are important components of the biomass, but are numerically sparse. Annelida is a major contributor in both measures of quantity.

Table 3
Rank order of major taxonomic groups according to percentage composition of the total macrobenthic fauna in terms of biomass and number of specimens.

Dominance category	Taxa	Percentage of total biomass	Taxa	Percentage of total number specimens
I	Bivalvia	44.1	Amphipoda	43.4
	Echinoidea	20.0	Annelida	28.1
	Annelida	9.5	Bivalvia	10.8
	Holothuroidea	7.0		
	Total	80.6	Total	82.3
II	Zoantharia	3.5	Ophiuroidea	2.9
	Amphipoda	2.3	Echinoidea	1.9
	Ascidiacea	2.2	Cumacea	1.7
	Cirripedia	1.9	Zoantharia	1.5
	Ophiuroidea	1.8	Cirripedia	1.5
	Gastropoda	1.2	Gastropoda	1.2
	Asteroidea	1.2	Ascidiacea	1.1
	Porifera	1.2	Bryozoa	1.0
	Total	15.3	Total	12.8
III	Decapoda	0.8	Isopoda	0.8
	Bryozoa	0.7	Nemertea	0.5
	Brachiopoda	0.5	Decapoda	0.5
	Nemertea	0.4	Hydrozoa	0.4
	Sipunculida	0.4	Sipunculida	0.4
	Hydrozoa	0.3	Brachiopoda	0.3
	Scaphopoda	0.2	Scaphopoda	0.3
	Echiura	0.2	Holothuroidea	0.3
	Isopoda	0.2	Nematoda	0.2
	Alcyonaria	0.1	Mysidacea	0.2
	Polyplacophora	0.1	Porifera	0.1
	Cumacea	0.1	Alcyonaria	0.1
			Polyplacophora	0.1
			Asteroidea	0.1
	Total	4.0	Total	4.3
IV	Turbellaria	<0.1	Turbellaria	<0.1
	Priapulida		Priapulida	
	Nematoda		Cephalopoda	
	Cephalopoda		Echinoidea	
	Arachnida		Arachnida	
	Pycnogonida		Pycnogonida	
	Ostracoda		Ostracoda	
	Copepoda		Copepoda	
	Mysidacea		Tanaidacea	
	Tanaidacea		Crinoidea	
	Crinoidea		Pogonophora	
	Pogonophora		Hemichordata	
	Hemichordata		Echiura	
	Total	<1.0	Total	<1.0

Category II, in Table 3, consists of eight taxa that contribute moderate biomass (1.2 to 2.3% of the total fauna) and number of individuals (1.0 to 2.9% of the total fauna). Categories III and IV contain those taxa that contribute small to very small quantities to the total biomass and density.

The New England region macrobenthos is dominated by members of four phyla: Annelida, Mollusca, Arthropoda, and Echinodermata. These groups will be discussed in more detail in the following sections. Table 4 lists the components of the macrobenthic invertebrate fauna inhabiting the New England region, and Table 5 lists the quantitative measures of abundance (mean and total weights and numbers per square meter), number of samples, and frequency of occurrence for each taxonomic group considered in this report.

Table 4
List of macrobenthic invertebrate species contained in quantitative samples obtained within the study area.

PORIFERA
- Demospongiae
  - Hadromerida
    - Suberitidae
      - *Polymastia* sp.

COELENTERATA
- Hydrozoa
  - *Hydractinia echinata* Fleming, 1828
  - *Hydractinia* sp.
- Anthozoa
  - Alcyonaria
    - Alcyonacea
      - *Alcyonium* sp.
    - Gorgonacea
      - *Acanella* sp.
      - *Paragorgia arborea* (Linnaeus, 1767)
      - *Primnoa reseda* (Pallas, 1766)
    - Pennatulacea
      - *Pennatula aculeata* Danielssen and Koren, 1858
      - *Pennatula* sp.
      - *Stylatula elegans* (Danielssen, 1860)
  - Zoantharia
    - Zoanthidea
      - *Epizoanthus incrustatus* (Verrill, 1864)
      - *Epizoanthus* sp.
  - Actiniaria
    - *Tealina felina* (Linnaeus, 1767)
    - *Edwardsia sulcata* (T. Pennant, 1777)
    - *Edwardsia* sp.
    - *Actinostola callosa* Verrill, 1882
    - *Antholoba perdix* (Verrill, 1882)
  - Madreporaria
    - *Astrangia* sp.
    - *Flabellum goodei* Verrill, 1878
    - *Flabellum* sp.
  - Ceriantheria
    - *Cerianthus borealis* Verrill, 1878
    - *Cerianthus* sp.
    - *Ceriantheopsis americanus* Verrill, 1866

Annelida
- Polychaeta
  - Amphinomida
    - Amphinomidae
      - *Paramphinome jeffreysii* (McIntosh, 1868)
  - Capitellida
    - Capitellidae
      - *Capitella* sp.
    - Maldanidae
      - *Asychis biceps* (Sars, 1861)
      - *Maldane* sp.
  - Cossurida
    - Cossuridae
      - *Cossura longicirrata* Webster and Benedict, 1883
      - *Cossura* sp.
  - Eunicida
    - Arabellidae
      - *Arabella iricolor* (Montagu, 1804)
      - *Arabella* sp.
      - *Drilonereis longa* Webster, 1879
      - *Drilonereis* sp.
      - *Notocirrus* sp.
    - Eunicidae
      - *Eunice pennata* (Müller, 1776)
      - *Eunice* sp.
      - *Marphysa* sp.
    - Lumbrineridae
      - *Lumbrinerides acuta* (Verrill, 1875)
      - *Lumbrineris fragilis* (Müller, 1776)
      - *Lumbrineris* sp.
      - *Ninoe* sp.
    - Onuphidae
      - *Diopatra cuprea* (Bosc, 1802)
      - *Diopatra* sp.
      - *Hyalinoecia tubicola* (Müller, 1776)
      - *Hyalinoecia* sp.
      - *Nothria conchylega* Sars, 1835
      - *Onuphis eremita* Audoin and Milne-Edwards, 1833
      - *Onuphis opalina* (Verrill, 1873)
      - *Onuphis quadricuspis* Sars, 1872
      - *Onuphis sp.*
      - *Paradiopatra* sp.
  - Flabelligerida
    - Flabelligeridae
      - *Brada* sp.
      - *Flabelligera* sp.
      - *Pherusa* sp.
  - Opheliida
    - Opheliidae
      - *Ophelia* sp.
      - *Ophelina aulogaster* (H. Rathke, 1843)
      - *Ophelina* sp.
      - *Travisia carnea* Verrill, 1873
      - *Travisia* sp.
    - Scalibregmidae
      - *Scalibregma inflatum* Rathke, 1843
      - *Scalibregma* sp.
  - Orbiniida
    - Orbiniidae
      - *Orbinia ornata* (Verrill, 1873)
      - *Orbinia swani* Pettibone, 1957
      - *Orbinia* sp.
      - *Scoloplos robustus* (Verrill, 1873)
      - *Scoloplos* sp.
      - *Aricidea jeffreysii* (McIntosh, 1879)
      - *Aricidea* sp.
    - Paraonidae
      - *Paraonis* sp.
  - Oweniida
    - Oweniidae
      - *Owenia fusiformis* delle Chiaje, 1844
      - *Owenia* sp.
  - Phyllodocida
    - Aphroditidae
      - *Aphrodita hastata* Moore, 1905
      - *Aphrodita* sp.
      - *Laetmonice* sp.
    - Glyceridae
      - *Glycera americana* Leidy, 1855
      - *Glycera capitata* Oersted, 1843
      - *Glycera dibranchiata* Ehlers, 1868
      - *Glycera* sp.

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Table 4 (continued)

Goniadidae
Goniada maculata (Oersted, 1843)
Goniada sp.
Goniadella sp.
Ophioglycera gigantea Verrill, 1885
Ophioglycera sp.
Hesionidae
Nereimyra punctata (O.F. Müller, 1776)
Nephtyidae
Aglaophamus circinata (Verrill, 1874)
Aglaophamus sp.
Nephtys bucera Ehlers, 1869
Nephtys incisa Malmgren, 1865
Nephtys picta Ehlers, 1868
Nephtys sp.
Nereidae
Ceratocephale loveni Malmgren, 1867
Ceratocephale sp.
Nereis sp.
Phyllodocidae
Eteone sp.
Eumida sanguinea (Oersted, 1843)
Phyllodoce arenae Webster, 1879
Phyllodoce sp.
Pilargiidae
Ancistrosyllis sp.
Polynoidae
Harmothoe sp.
Lepidonotus squamatus (Linnaeus, 1758)
Sigalionidae
Leanira sp.
Pholoe minuta (Fabricius, 1780)
Sigalion arenicola Verrill, 1879
Sigalion sp.
Sphaerodoridae
Sphaerodorum gracilis (Rathke, 1843)
Syllidae
Exogone verugera (Clarapede, 1868)
Exogone sp.
Tomopteridae
Tomopteris sp.
Sabellida
Sabellidae
Chone infundibuliformis Krøyer, 1856
Chone sp.
Euchone sp.
Potamilla neglecta (Sars, 1850)
Potamilla reniformis (Linnaeus, 1788)
Potamilla sp.
Sabella sp.
Serpulidae
Filograna sp.
Spirorbidae
Spirorbis sp.
Spionida
Chaetopteridae
Spiochaetopterus sp.
Cirratulidae
Chaetozone sp.
Cirratulus sp.
Tharyx sp.
Spionidae
Diospio uncinata Hartman, 1951
Laonice cirrada (Sars, 1851)
Laonice sp.
Polydora concharum Verrill, 1880
Polydora sp.
Priospio sp.
Spio setosa Verrill, 1873
Spio sp.
Spiophanes bombyx (Clarapede, 1870)
Sternaspida
Sternaspidae
Sternaspis scutata (Renier, 1807)
Sternaspis sp.
Terebellida
Ampharetidae
Ampharete acutifrons (Grube, 1860)
Ampharete sp.
Melinna cristata (Sars, 1851)
Melinna sp.
Pectinariidae
Pectinaria gouldii (Verrill, 1873)
Pectinaria sp.
Terebellidae
Amphitrite sp.
Streblosoma spiralis (Verrill, 1874)
Steblosoma sp.
POGONOPHORA
Siboglinidae
Siboglinum angustum Southward and Brattegard, 1968
Siboglinum atlanticum Southward and Southward, 1958
Siboglinum ekmani Jagerston, 1956
Siboglinum holmei Southward ,1963
Siboglinum pholidotum Southward and Brattegard, 1968
Siboglinum sp.
Polybrachiidae
Crassibranchia sandersi Southward, 1968
Diplobrachia similis Southward and Brattegard, 1968
Polybrachia sp.
SIPUNCULIDA
Aspidosiphon zinni Cutler, 1969
Golfingia catharinae (Müller, 1789)
Golfingia elongata (Keferstein, 1869)
Golfingia eremita (Sars, 1851)
Golfingia flagrifera (Selenka, 1885)
Golfingia margaritacea (Sars, 1851)
Golfingia minuta (Keferstein, 1865)
Golfingia murinae murinae Cutler, 1969
Onchnesoma steenstrupi Koren and Danielssen, 1875
Phascolion strombi (Montague, 1804)
Phascolopsis gouldi (Pourtales, 1851)
Sipunculus norvegicus Koren and Danielssen, 1875
ECHIURA
Bonellia thomensis (Gmelin, 1788)
Echiurus echiurus (Pallas, 1774)
Echiurus sp.
Ikedella akaeta (Zenkevitch, 1958)
Maxmuelleria lankesteri (Herdman, 1898)
Prometor grandis (Zenkevitch, 1957)
Protobonellia sp.
Sluiterina sibogae (Sluiter, 1902)
Sluiterina sp.

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Table 4 (continued)

MOLLUSCA
- Polyplacophora
- Gastropoda
  - Prosobranchia
    - Archaeogastropoda
      - Fissurelidae
        - *Puncturella noachina* (Linnaeus, 1771)
      - Lepetidae
        - *Lepeta caeca* (Müller, 1776)
      - Trochidae
        - *Calliostoma occidentalis* (Mighels and Adams, 1842)
        - *Margarites costalis* (Gould, 1841)
        - *Margarites groenlandicus* (Gmelin, 1791)
        - *Margarites helicinus* (Phipps, 1774)
        - *Margarites* sp.
        - *Solariella lamellosa* Verrill and Smith, 1880
        - *Solariella obscura* (Couthouy, 1838)
        - *Solariella* sp.
    - Mesogastropoda
      - Littorinidae
        - *Littorina obtusata* (Linnaeus, 1758)
      - Rissoidae
        - *Alvania brychia* (Verrill, 1884)
        - *Alvania pelagica* (Stimpson, 1851)
        - *Alvania areolata* Stimpson, 1851
        - *Alvania* sp.
      - Turritellidae
        - *Tachyrhynchus erosus* (Couthouy, 1838)
        - *Turritellopsis acicula* (Stimpson, 1851)
      - Cerithiidae
        - *Cerithiella* sp.
        - *Diastoma alternatus* (Say, 1822)
      - Epitoniidae
        - *Epitonium dallianum* Verrill and Smith, 1880
        - *Epitonium greenlandicum* (Perry, 1811)
      - Melanellidae
        - *Couthouyella striatula* (Couthouy, 1839)
      - Aclididae
        - *Aclis verrilli* Bartsch, 1911
      - Trichotropidae
        - *Trichotropis borealis* Broderip and Sowerby, 1829
      - Crepidulidae
        - *Crepidula fornicata* Linnaeus, 1767
        - *Crepidula plana* Say, 1822
        - *Crucibulum striatum* Say, 1824
      - Aporrhaidae
        - *Aporrhais occidentalis* Beck, 1836
      - Velutinidae
        - *Velutina velutina* (Müller, 1776)
        - *Velutina undata* (Brown, 1839)
        - *Velutina* sp.
      - Naticidae
        - *Lunatia heros* (Say, 1822)
        - *Lunatia triseriata* (Say, 1826)
        - *Lunatia pallida* (Broderip, and Sowerby, 1829)
        - *Lunatia* sp.
        - *Natica clausa* Broderip and Sowerby, 1829
        - *Natica pusilla* Say, 1822
        - *Polinices duplicatus* (Say, 1822)
        - *Polinices immaculatus* (Totten, 1835)
        - *Polinices* sp.
    - Neogastropoda
      - Muricidae
        - *Boreotrophon clathratus* (Linnaeus, 1758)
        - *Eupleura caudata* (Say, 1822)
      - Columbellidae
        - *Amphissa haliaeeti* (Jeffreys, 1867)
        - *Anachis lafresnayi* (Fischer and Bernardi, 1856)
        - *Anachis* sp.
        - *Mitrella lunata* (Say, 1826)
        - *Mitrella pura* (Verrill, 1882)
        - *Mitrella rosacea* (Gould, 1841)
        - *Mitrella* sp.
      - Buccinidae
        - *Buccinum undatum* Linnaeus, 1758
        - *Buccinum* sp.
        - *Colus caelatus* (Verrill and Smith, 1880)
        - *Colus obesus* (Verrill, 1884)
        - *Colus parvus* (Verrill and Smith, 1882)
        - *Colus pygmaeus* (Gould, 1841)
        - *Colus* sp.
        - *Neptunea decemcostata* (Say, 1826)
        - *Neptunea despecta* (Linnaeus, 1758)
        - *Neptunea* sp.
      - Melongenidae
        - *Busycon canaliculatus* (Linnaeus, 1758)
      - Nassariidae
        - *Ilyanassa obsoleta* (Say, 1822)
        - *Nassarius trivittatus* (Say, 1822)
        - *Nassarius vibex* (Say, 1822)
      - Cancellariidae
        - *Admete couthouyi* (Jay, 1839)
      - Turridae
        - *Oenopota decussata* (Couthouy, 1839)
        - *Oenopota harpularia* (Couthouy, 1838)
        - *Oenopota incisula* (Verrill, 1882)
        - *Pleurotomella agassizi agassizi* Verrill and Smith, 1880
        - *Pleurotomella blakeana* (Dall, 1889)
        - *Pleurotemella curta curta* (Verrill, 1884)
        - *Pleurotomella packardi packardi* (Verrill, 1872)
        - *Propebela elegans* (Möller, 1842)
        - *Propebela exarata* (Möller, 1842)
        - *Propebela turricula* (Montagu, 1803)
      - Pyramidellidae
        - *Odostomia dealbata* (Stimpson, 1851)
        - *Odostomia dux* Dall and Bartsch, 1906
        - *Odostomia* sp.
        - *Turbonilla bushiana* Verrill, 1882
        - *Turbonilla elegantula* Verrill, 1882
        - *Turbonilla nivea* (Stimpson, 1851)
        - *Turbonilla polita* (Verrill, 1872)
        - *Turbonilla* sp.
  - Opisthobranchia
    - Acteonidae
      - *Acteon* sp.
    - Ringiculidae
      - *Ringicula nitida* Verrill, 1873
    - Actiocinidae
      - *Acteocina canaliculata* (Say, 1822)
      - *Retusa obtusa* (Montagu, 1807)

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Table 4 (continued)

Scaphandridae
Cylichna alba (Brown, 1827)
Cylichna gouldi (Couthouy, 1839)
Cylichna vortex (Dall, 1881)
Cylichna sp.
Scaphander punctostriatus Mighels, 1841
Philinidae
Philine lima (Brown, 1827)
Philine quadrata (S. Wood, 1839)
Philine sp.
Akeridae
Haminoea sp.
Pleurobranchidae
Pleurobranchaea sp.
Nudibranchia
Dendronotidae
Dendronotus frondosus (Ascanius, 1774)
Bivalvia
Palaeotoxodonta
Nuculoida
Nuculidae
Nucula delphinodonta Mighels and Adams, 1842
Nucula proxima Say, 1822
Nucula tenuis Montagu, 1808
Nucula sp.
Malletiidae
Malletia obtusa G.O. Sars, 1872
Saturnia subovata Verrill, and Bush, 1897
Nuculanidae
Nuculana acuta (Conrad, 1831)
Nuculana pernula (Müller, 1771)
Nuculana tenuisulcata (Couthouy, 1838)
Nuculana sp.
Portlandia fraterna (Verrill and Bush, 1898)
Portlandia frigida (Torrell, 1859)
Portlandia inconspicua (Verrill and Bush 1898)
Portlandia inflata (Verrill, and Bush, 1897)
Portlandia iris (Verrill and Bush, 1897)
Portlandia lenticula (Möller, 1842)
Portlandia lucida (Loven, 1846)
Yoldia limatula (Say, 1831)
Yoldia myalis (Couthouy, 1838)
Yoldia regularis Verrill, 1884
Yoldia sapotilla (Gould,1841)
Yoldia thraciaeformis Storer, 1838
Yoldia sp.
Cryptodonta
Solemyoida
Solemyacidae
Solemya velum Say, 1822
Pteriomorphia
Arcoida
Arcidae
Anadara ovalis (Bruguière, 1789)
Anadara transversa (Say, 1822)
Bathyarca anomala (Verrill and Bush, 1898)
Bathyarca pectunculoides (Scacchi, 1833)
Bathyarca sp.
Limopsidae
Limopsis affinis Verrill, 1885
Limopsis cristata Jeffreys, 1876
Limopsis minuta Philippi, 1836
Limopsis sulcata Verrill and Bush, 1898
Limopsis sp.
Mytiloida
Mytilidae
Crenella decussata (Montagu, 1808)
Crenella glandula (Totten, 1834)
Crenella sp.
Dacrydium vitreum (Holböll in Möller, 1842)
Modiolus modiolus (Linnaeus, 1758)
Musculus corrugatus (Stimpson, 1851)
Musculus discors (Linnaeus, 1767)
Musculus niger (Gray, 1824)
Musculus sp.
Mytilus edulis Linnaeus, 1758
Mytilus sp.
Pterioida
Pectinidae
Chlamys islandica (Müller, 1776)
Cyclopecten pustulosus Verrill, 1873
Placopecten magellanicus (Gmelin, 1791)
Anomiidae
Anommia simplex Orbigny, 1842
Anomia squamula Linnaeus, 1758
Anomia sp.
Limidae
Limatula subauriculata (Montagu, 1808)
Limatula sp.
Heterodonta
Veneroida
Lucinidae
Lucinoma blakeana Bush, 1883
Lucinoma filosa (Stimpson, 1851)
Lucinoma sp.
Thyasiridae
Thyasira equalis Verrill and Bush, 1898
Thyasira ferruginea Winckworth, 1932
Thyasira flexuosa (Montagu, 1803)
Thyasira flexuosa forma *gouldii* Philippi, 1845
Thyasira pygmaea Verrill and Bush, 1898
Thyasira subovata Jeffreys, 1881
Thyasira trisinuata Orbigny, 1842
Thyasira sp.
Lasaeidae
Aligena elevata (Stimpson, 1851)
Leptonidae
Montacuta sp.
Carditidae
Cyclocardia borealis Conrad, 1831
Cyclocardia sp.
Astartidae
Astarte borealis (Schumacher, 1817)
Astarte castanea (Say, 1822)
Astarte crenata subequilatera Sowerby, 1854
Astarte elliptica (Brown, 1827)
Astarte montagui (Dillwyn, 1817)
Astarte nana Dall, 1886
Astarte quadrans Gould, 1841
Astarte smithii Gould, 1841
Astarte undata Gould, 1841
Astarte sp.

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Table 4 (continued)

Cardiidae
Cerastoderma pinnulatum (Conrad, 1831)
Laevicardium mortoni (Conrad, 1830)
Mactridae
Mulinia lateralis (Say, 1822)
Spisula solidissima (Dillwyn, 1817)
Mesodesmatidae
Mesodesma sp.
Solenidae
Ensis directus Conrad, 1843
Siliqua costata Say, 1822
Tellinidae
Macoma calcarea (Gmelin, 1791)
Macoma sp.
Tellina agilis Stimpson, 1858
Tellina sp.
Arcticidae
Arctica islandica (Linnaeus, 1767)
Veneridae
Gemma gemma (Totten, 1834)
Mercenaria mercenaria (Linnaeus, 1758)
Pitar morrhuanus Linsley, 1845
Myoida
Myidae
Mya arenaria Linnaeus, 1758
Corbulidae
Corbula contracta C.B. Adams, 1852
Corbula sp.
Hiatellidae
Cyrtodaria siliqua (Spengler, 1793)
Hiatella arctica (Linnaeus, 1767)
Hiatella striata (Fleuriau, 1802)
Hiatella sp.
Panomya arctica (Lamarck, 1818)
Panomya sp.
Anomalodesmata
Pholadomyoida
Pandoridae
Pandora gouldiana Dall, 1886
Pandora inflata Boss and Merrill, 1965
Pandora inornata Verrill and Bush, 1898
Pandora sp.
Lyonsiidae
Lyonsia arenosa Möller, 1842
Lyonsia hyalina Conrad, 1830
Lyonsia sp.
Periplomatidae
Periploma fragile (Totten, 1835)
Periploma leanum (Conrad, 1830)
Periploma papyratium (Say, 1822)
Periploma sp.
Thraciidae
Thracia myopsis Möller, 1842
Thracia sp.
Cuspidariidae
Cardiomya perrostrata (Dall, 1881)
Cuspidaria glacialis (G.O. Sars, 1878)
Cuspidaria obesa (Lovén, 1846)
Cuspidaria parva Verrill and Bush, 1898
Cuspidaria pellucida Stimpson, 1853
Cuspidaria sp.
Scaphopoda
Dentaliidae
Bathoxiphus ensiculus (Jeffreys, 1877)
Cadulus agassizii Dall, 1881
Cadulus cylindratus Jeffreys, 1877
Cadulus pandionis Verrill and Smith, 1880
Cadulus rushii Pilsbry and Sharp, 1898
Cadulus sp.
Dentalium entale stimpsoni Henderson, 1920
Dentalium meridionale Pilsbry and Sharp, 1897
Dentalium occidentale Stimpson, 1851
Dentalium sp.
Cephalopoda
Octopus sp.
Rossia sp.
ARTHROPODA
Pycnogonida
Achelia scabra Wilson, 1880
Achelia spinosa (Stimpson, 1853)
Anoplodactylus lentus Wilson, 1878
Nymphon brevitarse Krøyer, 1844
Nymphon grossipes (O. Fabricius?) Krøyer, 1780
Nymphon hirtipes Bell, 1853
Nymphon macrum Wilson, 1880
Nymphon stroemi Krøyer, 1844
Paranymphon spinosum Caullery, 1896
Pycnogonium littorale (Strom, 1762)
Crustacea
Cirripedia
Balanus sp.
Lepas sp.
Copepoda
Calanus sp.
Caligus sp.
Cumacea
Brachydiastylis resima (Krøyer, 1846)
Campylaspis affinis Sars, 1870
Campylaspis rubicunda (Lilljeborg, 1855)
Cyclaspis longicaudata G.O. Sars, 1864
Diastylis cornuifer (Blake, 1929)
Diastylis polita S.I. Smith, 1879
Diastylis quadrispinosa G.O. Sars, 1871
Diastylis rathkei (Krøyer, 1841)
Diastylis sculpta G.O. Sars, 1871
Diastylis sp.
Eudorella emarginata (Krøyer, 1846)
Eudorella hispida Sars, 1871
Eudorella truncatula (Bate, 1855)
Eudorella sp.
Eudorellopsis deformis (Krøyer, 1846)
Eudorellopsis sp.
Hemilamprops cristata (Sars, 1870)
Lamprops quadriplicata S.I. Smith, 1879
Lamprops fuscata Sars, 1865
Lamprops sp.
Leptostylis longimana (Sars, 1865)
Leptostylis macrura G.O. Sars, 1869
Leptostylis sp.
Leucon americanus Zimmer, 1943
Leucon nasicoides Lilljeborg, 1855
Oxyrostylis smithi Calman, 1912

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Table 4 (continued)

Cumacea, continued
- *Petalosarsia declivis* (G.O. Sars, 1865)
- *Pseudoleptocuma minor* (Calman, 1912)

Isopoda
- *Calathura branchiata* (Stimpson, 1853)
- *Calathura* sp.
- *Chiridotea arenicola* Wigley, 1960
- *Chiridotea tuftsi* (Stimpson, 1883)
- *Chiridotea* sp.
- *Cirolana concharum* (Stimpson, 1853)
- *Cirolana impressa* (Harger, 1818)
- *Cirolana polita* (Stimpson, 1853)
- *Cirolana* sp.
- *Cyathura polita* (Stimpson, 1855)
- *Cyathura* sp.
- *Edotea acuta* (Richardson, 1905)
- *Edotea triloba* (Say, 1818)
- *Erichsonella filiformis* (Say, 1818)
- *Idotea phosphorea* (Harger, 1873)
- *Janira alta* (Stimpson, 1853)
- *Pseudarachna* sp.
- *Ptilanthura tenuis* (Harger, 1879)
- *Ptilanthura* sp.

Amphipoda
- Caprellidea
  - Caprellidae
    - *Aeginina longicornis* (Krøyer, 1842-43)
    - *Aeginina* sp.
    - *Caprella linearis* (Linnaeus, 1767)
    - *Caprella penantis* Leach, 1814
    - *Caprella septentrionalis* Krøyer, 1838
    - *Caprella unica* Mayer, 1903
    - *Caprella* sp.
    - *Luconacia incerta* Mayer, 1903
    - *Mayerella limicola* Huntsman, 1915
    - *Proaeginina norvegica* (Stephensen, 1931)
- Hyperiidea
  - Hyperiidae
    - *Hyperia* sp.
    - *Parathemisto gaudichaudii* (Milne-Edwards, 1840)
    - *Parathemisto* sp.
    - *Phronima sedentaria* (Forskal, 1775)
    - *Vibilia* sp.
- Gammaridea
  - Acanthonotozomatidae
    - *Acanthonotozoma serratum* (Fabricius, 1780)
  - Ampeliscidae
    - *Ampelisca abdita* Mills, 1964
    - *Ampelisca agassizi* (Judd, 1896)
    - *Ampelisca declivitatus* Mills, 1967
    - *Ampelisca eschrichti* Krøyer, 1842
    - *Ampelisca macrocephala* Lilljeborg, 1852
    - *Ampelisca vadorum* Mills, 1963
    - *Ampelisca verrilli* Mills, 1967
    - *Ampelisca* sp.
    - *Byblis gaimardi* (Krøyer, 1846)
    - *Byblis serrata* (Smith, 1873)
    - *Byblis* sp.
    - *Haploops tubicola* Lilljeborg, 1856
    - *Haploops* sp.

Amphilochidae
- *Amphilochoides odontyx* (Boeck, 1871)
- *Gitanopsis arctica* G.O. Sars, 1895

Amphithoidae
- *Amphithoe rubricata* (Montagu, 1808)

Aoridae
- *Lembos smithi* Holmes, 1905
- *Lembos* sp.
- *Leptocheirus pinguis* (Stimpson, 1853)
- *Leptocheirus* sp.
- *Microdeutopis gryllotalpa* Costa, 1853
- *Pseudunciola obliqua* (Shoemaker, 1949)
- *Unciola dissimilis* Shoemaker, 1945
- *Unciola inermis* Shoemaker, 1945
- *Unciola irrorata* Say, 1818
- *Unciola leucopis* (Krøyer, 1845)
- *Unciola serrata* Shoemaker, 1945
- *Unciola spicata* Shoemaker, 1945
- *Unciola* sp.

Argissidae
- *Argissa hamatipes* (Norman, 1869)

Bateidae
- *Batea catharinensis* Müller, 1865

Calliopiidae
- *Calliopius laeviusculus* (Krøyer, 1838)
- *Haliragesfulvocinctus* (M. Sars, 1854)
- *Haliragoides inermis* (G.O. Sars, 1882)
- *Hippomedon serratus* Holmes, 1905

Corophiidae
- *Corophium crassicorne* Bruzelius, 1859
- *Corophium insidiosum* Crawford, 1937
- *Corophium volutator* (Pallas, 1766)
- *Corophium* sp.
- *Siphonocetes smithianus* Rathbun, 1908
- *Siphonocetes* sp.

Eusiridae
- *Eusirus cuspidatus* Krøyer, 1845
- *Rhachotropis distincta* (Holmes, 1908)
- *Rhachotropis inflata* (G.O. Sars, 1882)
- *Rhachotropis oculata* (Hansen, 1887)
- *Gammarus annulatus* Smith, 1873
- *Gammarus pallustris* Bousfield, 1969
- *Gammarus* sp.

Haustoriidae
- *Acanthohaustorius intermedius* Bousfield, 1965
- *Acanthohaustorius millsi* Bousfield, 1965
- *Acanthohaustorius similis* Frame, 1980
- *Acanthohaustorius spinosus* Bousfield, 1962
- *Haustorius arenarius* (Slabber, 1769)
- *Haustorius* sp.
- *Parahaustorius attenuatus* Bousfield, 1965
- *Parahaustorius holmesi* Bousfield, 1965
- *Parahaustorius longimerus* Bousfield, 1965
- *Protohaustorius deichmannae* Bousfield, 1965
- *Protohaustorius wigleyi* Bousfield, 1965
- *Pseudohaustorius borealis* Bousfield, 1965

Ischyroceridae
- *Ericthonius brasiliensis* (Dana, 1853)
- *Ericthonius rubricornis* Smith, 1873
- *Ericthonius* sp.
- *Ischyroceros anguipes* Krøyer, 1838

continued on next page

Table 4 (continued)

Ischyroceridae, continued
- *Ischyroceros megacheir* (Boeck, 1871)
- *Ischyroceros* sp.

Lysianassidae
- *Anonyx debruynii* Hoek, 1882
- *Anonyx lilljeborgi* Boeck, 1871
- *Anonyx nugax* (Phipps, 1774)
- *Anonyx sarsi* Steele and Brunel, 1968
- *Anonyx* sp.
- *Hippomedon propinguus* Sars, 1895
- *Hippomedon serratus* Holmes, 1905
- *Hippomedon* sp.
- *Lysianopsis alba* Holmes, 1905
- *Orchomene groenlandica* (Hansen, 1887)
- *Orchomene minuta* Krøyer, 1846
- *Orchomene pinguis* Boeck, 1861
- *Orchomene* sp.
- *Psammonyx nobilis* Stimpson, 1853
- *Tmetonyx cicada* O. Fabricius, 1780
- *Tmetonyx* sp.
- *Tryphosella nanoides* Lilljeborg, 1865

Melitidae
- *Casco bigelowi* (Blake, 1929)
- *Eriopisa elongata* (Bruzelius, 1859)
- *Maera danae* Stimpson, 1853
- *Maera loveni* (Bruzelius, 1859)
- *Maera* sp.
- *Melita dentata* Krøyer, 1842
- *Melita palmata* (Montagu, 1894)
- *Melita* sp.

Melphidippidae
- *Melphidippa goesi* Stebbing, 1899
- *Melphidippa* sp.

Oedicerotidae
- *Bathymedon sausserei* (Boeck, 1871)
- *Monoculodes edwardsi* Holmes, 1908
- *Monoculodes intermedius* Shoemaker, 1930
- *Monoculodes latimanus* (Goes, 1866)
- *Monoculodes longicornis* (Boeck, 1871)
- *Paroediceros* sp.
- *Synchelidium americanum* Bousfield, 1973
- *Westwoodilla megalops* (G.O. Sars, 1882)

Paramphithoidae
- *Epimeria loricata* G.O. Sars, 1879

Pardaliscidae
- *Halice abyssi* Boeck, 1871
- *Pardalisca cuspidata* Krøyer, 1842

Photidae
- *Gammaropsis maculatus* (Johnson, 1827)
- *Photis dentata* Shoemaker, 1945
- *Photis macrocoxa* Shoemaker, 1945
- *Photis reinhardi* Krøyer, 1842
- *Photis* sp.
- *Podoceropsis nitida* (Stimpson, 1853)
- *Protomedia fasciata* Krøyer, 1842

Pleustidae
- *Neopleustes pulchellus* Krøyer, 1846
- *Parapleustes* sp.
- *Pleustes panoplus* Krøyer, 1838
- *Pleustes glaber* Boeck, 1861
- *Stenopleustes gracilis* Holmes, 1905
- *Stenopleustes inermis* Shoemaker, 1949
- *Stenopleustes latipes* (M. Sars, 1895)

Podoceridae
- *Dyopedus articus* (Murdoch, 1884)
- *Dyopedus monacantha* (Metzger, 1875)
- *Dulichia porrecta* (Bate, 1857)
- *Dulichia tuberculata* Boeck, 1870
- *Dulichia* sp.
- *Paradulichia typica* Boeck, 1870
- *Paradulichia* sp.

Pontogeneidae
- *Pontogeneia inermis* (Krøyer, 1842)
- *Pontogeneia* sp.

Pontoporeiidae
- *Amphiporea gigantea* Bousfield, 1973
- *Amphiporea lawrenciana* Shoemaker, 1929
- *Amphiporea virginiana* Shoemaker, 1933
- *Bathyporeia quoddyensis* Shoemaker, 1949

Stegocephalidae
- *Anadaniopsis nordlandica* (Boeck, 1871)
- *Stegocephalus inflatus* Krøyer, 1842

Stenothoidae
- *Stenothoe minuta* Holmes, 1905
- *Stenula peltata* (Smith, 1873)

Synopiidae
- *Syrrhoe crenulata* Goes, 1866
- *Syrrhoe spiniferum* (Stimpson, 1853)

Mysidacea
- *Erythrops erythrophthalma* (Goes, 1864)
- *Erythrops* sp.
- *Mysidopsis bigelowi* Tattersall, 1926
- *Neomysis americana* (S.I. Smith, 1873)
- *Neomysis* sp.

Decapoda

Caridea
- *Crangon septemspinosa* Say, 1818
- *Dichelopandalus leptocerus* (Smith, 1881)
- *Eualus pusiolus* (Krøyer, 1841)
- *Pandalus montagui* Leach, 1813 or 1814
- *Pandalus propinquus* G.O. Sars, 1869
- *Pandalus* sp.
- *Pontophilus brevirostris* Smith, 1881
- *Spirontocaris lilljeborgii* (Danielssen, 1859)
- *Spirontocaris* sp.

Astacidea
- *Homarus americanus* H. Milne-Edwards, 1837

Anomura
- *Axius serratus* Stimpson, 1852
- *Callianassa atlantica* Rathbun, 1926
- *Callianassa biformis* Biffar, 1971
- *Calocaris templemani* (Squires, 1965)
- *Catapagurus gracilis* (Smith, 1881)
- *Munida iris* A. Milne-Edwards, 1880
- *Munida valida* Smith, 1883
- *Pagurus acadianus* Benedict, 1901
- *Pagurus annulipes* Stimpson, 1860
- *Pagurus arcuatus* Squires, 1964
- *Pagurus longicarpus* Say, 1817
- *Pagurus politus* (Smith, 1882)
- *Pagurus pollicaris* Say, 1817
- *Pagurus pubescens* Krøyer, 1838

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Table 4 (continued)

Anomura, continued
- *Upogebia affinis* (Say, 1817)

Brachyura
- *Cancer borealis* Stimpson, 1859
- *Cancer irroratus* Say, 1817
- *Euprognatha rastellifera* Stimpson, 1871
- *Geryon quinquedens* Smith, 1897
- *Hexapanopeus angustifrons* (Benedict and Rathbun, 1891)
- *Hyas coarctatus* Leach, 1815
- *Hyas* sp.
- *Libinia dubia* H. Milne-Edwards, 1834
- *Libinia* sp.
- *Neopanope texana sayi* (Smith, 1869)
- *Ocypode* sp.
- *Pelia mutica* (Gibbes, 1850)
- *Pinnixa chaetopterana* Stimpson, 1860
- *Pinnixa sayana* Stimpson, 1860
- *Pinnixa* sp.

BRYOZOA
- Ctenostomata
  - Alcyonidiidae
    - *Alcyonidium mamillatum* Alder, 1857
    - *Alcyonidium* sp.
  - Flustrellidae
    - *Flustrellidra* sp.
- Cyclostomata
  - Crisiidae
    - *Crisia cribraria* Stimpson, 1853
    - *Crisia denticulata* (Lamarck, 1816)
  - Oncousoeciidae
    - *Oncousoecia canadensis* Osburn, 1933
    - *Oncousoecia diastoporoides* (Norman, 1868)
    - *Oncousoecia* sp.
  - Tubuliporidae
    - *Idmonea atlantica* Johnston, 1847
    - *Idmonea* sp.
    - *Tubulipora liliacea* (Pallas, 1766)
    - *Tubulipora lobulata* Hassall, 1841
    - *Tubulipora* sp.
  - Diaperoeciidae
    - *Diaperoecia harmeri* Osburn, 1933
    - *Diplosolen obelium* (Johnston, 1838)
    - *Entalophora* sp.
  - Frondiporidae
    - *Defrancia* sp.
- Cheilostomata
  - Alderinidae
    - *Amphiblestrum flemingii* (Busk, 1854)
    - *Amphiblestrum trifolium* (Searles Wood, 1850)
    - *Cauloramphus cymbaeformis* (Hincks, 1887)
  - Bugulidae
    - *Bugula elongata* Nordgaard, 1906
    - *Bugula turrita* (Desor, 1848)
    - *Bugula* sp.
    - *Dendrobeania murrayana* (Johnston, 1847)
    - *Dendrobeania* sp.
  - Calloporidae
    - *Callopora aurita* (Hincks, 1877)
    - *Callopora craticula* (Alder, 1857)
    - *Callopora lineata* (Linnaeus, 1767)
    - *Callopora whiteavesi* Norman, 1903
    - *Callopora* sp.
  - Cellariidae
    - *Cellaria* sp.
  - Celliporidae
    - *Cellepora canaliculata* Busk, 1884
    - *Cellepora* sp.
  - Cheiloporinidae
    - *Cryptosula pallasiana* (Moll, 1803)
  - Cribrilinidae
    - *Cribrilina punctata* (Hassall, 1842)
    - *Cribrilina* sp.
  - Electridae
    - *Electra hastingsae* Marcus, 1938
    - *Electra pilosa* (Linnaeus, 1767)
    - *Pyripora catenularia* (Jameson, 1814)
  - Eucrateidae
    - *Eucratea loricata* (Linnaeus, 1758)
  - Hippoporinidae
    - *Hippodiplosia americana* (Verrill, 1875)
    - *Hippodiplosia pertusa* (Esper, 1794-97)
    - *Hippoponella hippopus* (Smitt, 1867)
  - Hippothoidae
    - *Hippothoa hyalina* (Linnaeus, 1767)
  - Membraniporidae
    - *Conopeum reticulum* (Linnaeus, 1767)
    - *Membranipora* sp.
  - Microporellidae
    - *Microporella ciliata* (Pallas, 1766)
  - Mucronellidae
    - *Mucronella immersa* (Fleming, 1847)
    - *Mucronella ventricosa* (Hassall, 1842)
    - *Palmicellaria skenei* (Ellis and Solander, 1786)
    - *Porella plana* (Dawson, 1859)
    - *Porella proboscidea* Hincks, 1888
    - *Porella propinqua* (Smitt, 1867)
    - *Pseudoflustra* sp.
    - *Rhamphostomella bilaminata* (Hincks, 1877)
    - *Rhamphostomella ovata* (Smitt, 1867)
    - *Rhamphostomella* sp.
    - *Smittina bella* (Busk, 1860)
    - *Smittina reduplicata* Osburn, 1933
    - *Smittina rigida* Lorenz, 1886
    - *Smittina trispinosa* (Johnston, 1838)
    - *Smittina* sp.
  - Schizoporellidae
    - *Schizomavella auriculata* (Hassall, 1842)
    - *Schizoporella biaperta* (Michelin, 1841-42)
    - *Schizoporella unicornis* (Johnston, 1847)
  - Scrupariinidae
    - *Haplota clavata* (Hincks, 1857)
  - Scrupocellariidae
    - *Caberea ellisii* (Fleming, 1828)
    - *Scrupocellaria scabra* (Fabricius, 1780)
    - *Tricellaria gracilis* (Van Beneden, 1848)
    - *Tricellaria* sp.
  - Gigantoporidae
    - *Tessaradoma gracile* (M. Sars, 1851)
  - Stomachetosellidae
    - *Escharopsis sarsi* (Smitt, 1868)
    - *Stomachetosella* sp.

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Table 4 (continued)

BRACHIOPODA
Terebratulina sp.
ECHINODERMATA
Holothuroidea
Apodida
Chirodota sp.
Labidoplax buskii (McIntosh, 1866)
Myritrochus sp.
Synapta sp.
Trochoderma sp.
Aspidochirotida
Astichopus sp.
Dendrochirotida
Cucumaria planci Marenzeller, 1893
Cucumaria sp.
Havelockia scabra (Verrill, 1873)
Psolus fabricii Duben and Koren, 1846
Psolus phantapus (Strussenfeldt, 1765)
Psolus valvatus Østergren in Grieg, 1913
Psolus sp.
Stereoderma unisemita (Stimpson, 1851)
Thyone fusus (Müller, 1788)
Thyone sp.
Thyonidium pellucidum Duben and Koren, 1844
Molpadiida
Caudina arenata (Gould, 1841)
Molpadia oolitica (Pourtales, 1851)
Molpadia sp.
Dactylochirotida
Echinocucumis sp.
Echinoidea
Camarodonta
Strongylocentrotus droebachiensis (Müller, 1776)
Clypeastroidea
Echinarachnius parma (Lamarck, 1816)
Echinocyamus grandiporus Mortensen, 1907
Spatangoida
Aceste bellidifera Wyville Thompson, 1877
Aeropsis rostrata Norman, 1876
Brisaster fragilis (Duben and Koren, 1844)
Brissopsis atlantica Mortensen, 1907
Schizaster orbignyanus A. Agassiz, 1883
Schizaster sp.
Ophiuroidea
Amphilepididae
Amphilepis ingolfiana Mortensen, 1933
Amphiuridae
Amphilimna olivacea (Lyman, 1869)
Amphilimna sp.
Amphioplus abditus (Verrill, 1872)
Amphioplus macilentus (Verrill, 1882)
Amphioplus sp.
Amphiura otteri Ljungman, 1871
Amphiura fragilis (Verrill, 1885)
Amphiura grandisquama Lyman, 1869
Amphiura sp.
Axiognathus squamatus (delle Chiaje, 1828)
Axiognathus sp.
Ophiacanthidae
Ophiacantha abyssicola (E. Forbes, 1843)
Ophiacantha bidentata (Retzius, 1805)
Ophiacantha sp.
Ophiochiton tenuispinus (Verrill, 1884)
Ophiocten scutatum Koehler, 1896
Ophiocten sericeum (Forbes, 1852)
Ophiomusium lymani Thompson, 1873
Ophiura ljungmani (Lyman, 1878)
Ophiura robusta (Ayres, 1852)
Ophiura sarsi Lütken, 1858
Ophiura sp.
Asteroidea
Asteriidae
Asterias forbesi (Desor, 1848)
Asterias vulgaris (Verrill, 1866)
Asterias sp.
Leptasterias sp.
Astropectinidae
Astropecten americana (Verrill, 1880)
Astropecten sp.
Goniopectinidae
Ctenodiscus crispatus (Retzius, 1805)
Ctenodiscus sp.
Echinasteridae
Henricia sanguinolenta (Sars, 1844)
Henricia sp.
Solasteridae
Solaster sp.
HEMICHORDATA
Enteropneusta
Balanoglossus sp.
CHORDATA
Ascidiacea
Amaroucium sp.
Bostrichobranchus sp.
Molgula sp.

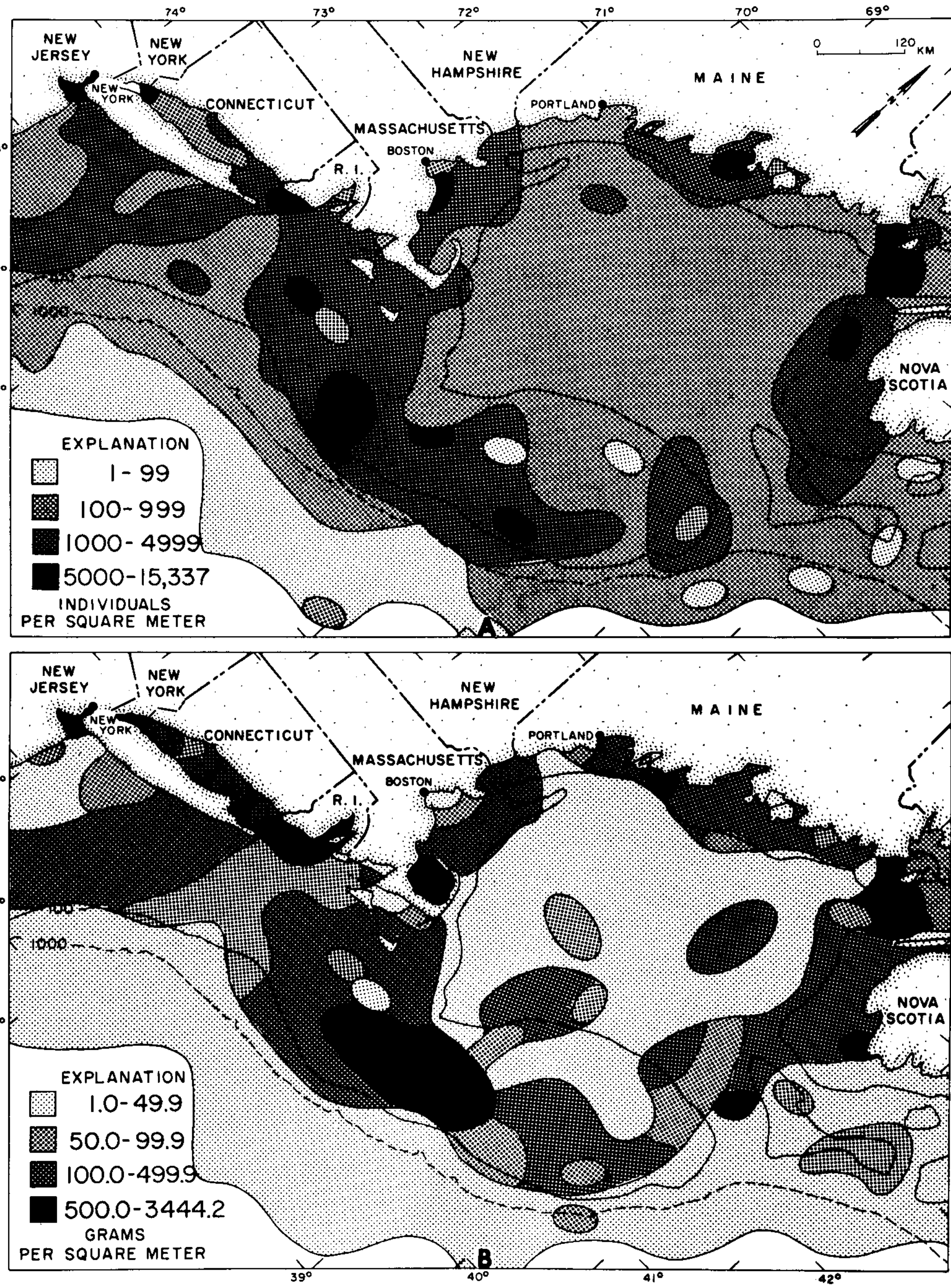
Total Macrobenthos — All Taxonomic Groups Combined

Geographic Distribution

Macrobenthic invertebrates showed clear geographic trends in abundance (Fig. 12). Both density and biomass of organisms exhibited similar patterns. Density was generally highest (1,000 to 15,000/m^2) in the coastal regions of the Gulf of Maine, on Georges Bank, and on most of the continental shelf region off Southern New England. Density was generally low (less than 100 individuals/m^2) over most of the continental rise, and moderately low (100 to 1,000/m^2) in the central Gulf of Maine, on the southeastern Scotian Shelf area, and along the continental slope. The distribution of biomass was similar to that for density. High biomass (100 to 3,400 g/m^2) was distributed around the periphery of the Gulf of Maine, on Georges Bank, on most of the continental shelf off Southern New England, and in

Table 5
Mean number and weight per square meter, total number and weight, number of samples, and percent frequency of occurrence of each taxonomic group, based on 1,076 samples.

Taxon	Mean		Total		Number of samples	Frequency of occurrence %
	No./m^2	Wt./m^2	No.	Wt.		
PORIFERA	1.5	2.24	1,566	2,415.82	71	6.6
COELENTERATA	32.1	7.33	34,513	7,884.63	449	41.7
Hydrozoa	6.4	0.52	6,878	560.32	126	11.7
Anthozoa	25.7	6.81	27,635	7,324.31	323	30.0
Alcyonaria	0.8	0.20	902	219.89	63	5.9
Zoantharia	22.6	6.39	24,322	6,871.85	265	24.6
Unidentified	2.2	0.22	2,411	232.57	100	9.3
PLATYHELMINTHES	0.4	0.01	381	6.44	16	1.5
Turbellaria	0.4	0.01	381	6.44	16	1.5
NEMERTEA	8.2	0.71	8,806	765.70	405	37.6
ASCHELMINTHES	2.8	0.01	3,047	8.19	98	9.1
Nematoda	2.8	0.01	3,047	8.19	98	9.1
ANNELIDA	425.0	17.41	457,283	18,727.37	1,034	96.1
POGONOPHORA	0.6	<0.01	618	3.22	56	5.2
SIPUNCULIDA	5.9	0.75	6,358	802.87	249	23.1
ECHIURA	0.1	0.30	105	327.78	17	1.6
PRIAPULIDA	<0.1	<0.01	10	4.60	4	0.4
MOLLUSCA	188.0	83.64	202,250	89,998.88	946	87.9
Polyplacophora	1.5	0.14	1,608	148.66	84	7.8
Gastropoda	17.8	2.23	19,165	2,396.85	470	43.7
Bivalvia	163.1	80.95	175,535	87,105.74	893	83.0
Scaphopoda	5.1	0.32	5,458	339.69	218	20.3
Cephalopoda	0.4	0.01	376	7.34	5	0.5
Unidentified	0.1	<0.01	108	0.60	2	0.2
ARTHROPODA	726.2	9.41	781,348	10,125.53	936	87.0
Pycnogonida	0.3	0.01	369	8.45	25	2.3
Arachnida	<0.1	<0.01	3	0.03	1	0.1
Crustacea	725.8	9.40	780,976	10,117.05	910	84.6
Ostracoda	<0.1	<0.01	19	0.19	5	0.5
Cirripedia	21.8	3.39	23,511	3,648.00	41	3.8
Copepoda	<0.1	<0.01	26	0.18	4	0.4
Cumacea	25.8	0.11	27,758	120.97	390	36.3
Tanaidacea	<0.1	<0.01	50	0.66	15	1.4
Isopoda	12.1	0.29	12,966	1,313,24	390	36.3
Amphipoda	655.8	4.16	705,612	4,478.71	862	80.1
Mysidacea	2.5	0.01	2,642	12.33	41	3.8
Decapoda	7.5	1.43	8,039	1,540.72	246	22.9
Unidentified	0.3	<0.01	353	2.07	18	1.7
BRYOZOA	15.7	1.29	16,915	1,391.00	119	11.1
BRACHIOPODA	4.5	0.89	4,793	955.31	54	5.0
ECHINODERMATA	79.3	55.00	85,331	59,182.14	772	71.8
Crinoidea	<0.1	<0.01	13	0.18	2	0.2
Holothuroidea	4.3	12.87	4,633	13,849.69	202	18.8
Echinoidea	29.3	36.75	31,512	39,540.94	293	27.2
Ophiuroidea	44.2	3.26	47,565	3,504.18	487	45.3
Asteroidea	1.5	2.13	1,608	2,287.15	144	13.4
HEMICHORDATA	0.1	0.02	101	18.67	4	0.4
CHORDATA	16.3	4.10	17,520	4,415.19	181	16.8
Ascidiacea	16.3	4.10	17,520	4,415.19	181	16.8
UNIDENTIFIED	5.8	0.27	6,199	294.42	261	24.3
Total	1,512.2	183.39	1,627,144	197,327.78		



ALL TAXA COMBINED

Figure 12

Geographic distribution of the density (A) and biomass (B) of all taxonomic groups combined. Density is expressed as number of individuals per square meter of bottom area; biomass is expressed as wet (damp) weight per square meter of bottom area.

coastal areas south of New York. Low biomass (less than 50 g/m^2) was prevalent in the central Gulf of Maine, on the southeastern Scotian Shelf, and along the continental slope and continental rise.

A few areas were characterized by a very high density (5,000/m^2 or greater) and an unusually high biomass (500 g/m^2 or more). One of these exceedingly rich areas was located at the mouth of the Bay of Fundy;

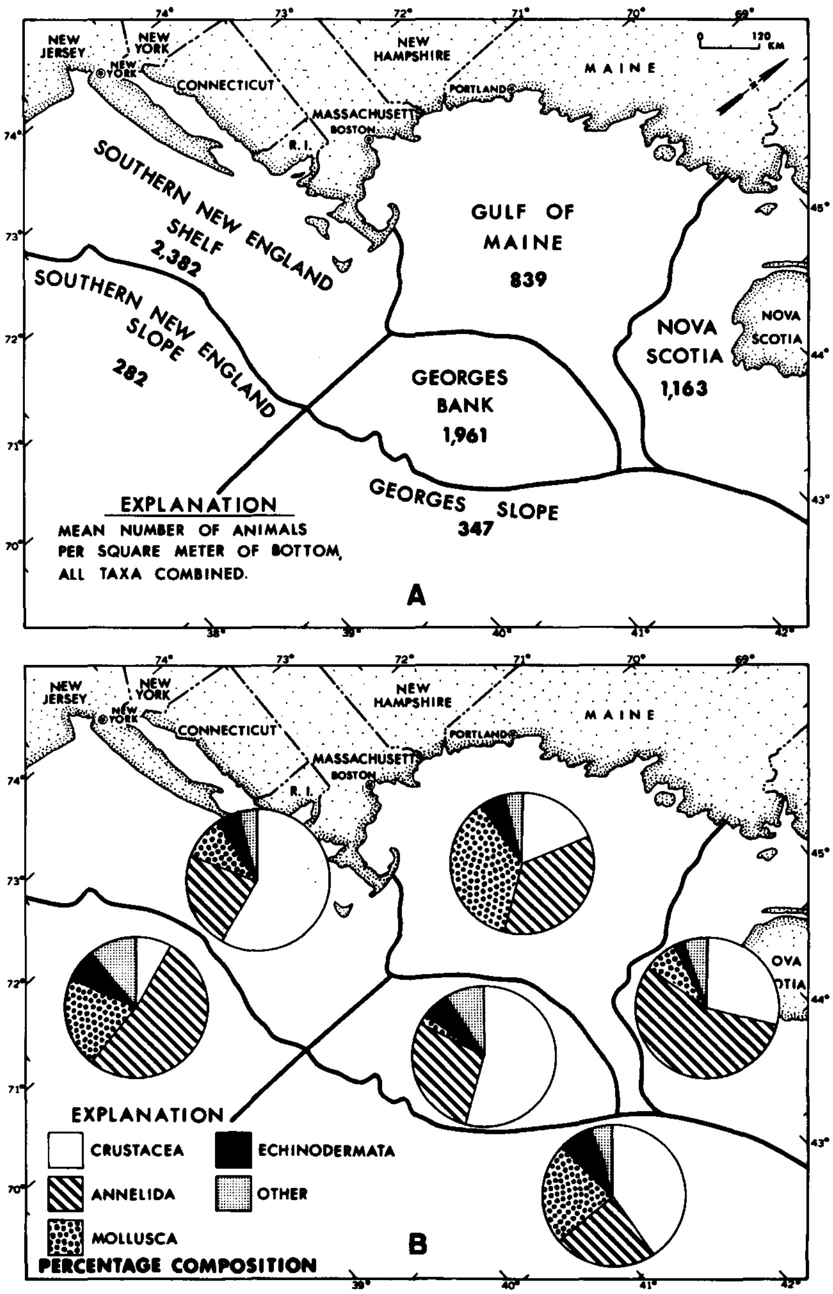


Figure 13

Quantitative composition of the total macrobenthic invertebrate fauna in relation to the six standard geographic subareas. A.—Mean number of individuals per square meter of bottom area; B.—Percentage composition, by density, of the major taxonomic groups.

another was located in the vicinity of the southern end of Great South Channel and southwestern Georges Bank. Several smaller rich areas were encountered in the coastal region of Rhode Island and New York. Generally, they occurred around the periphery of the Gulf of Maine and off southern New England.

Substantial differences in both biomass and density existed among the six geographic areas (Tables 6, 7; Fig. 13A). Average density was highest (2,382 and 1,961/m^2) on the Southern New England Shelf and on Georges Bank, intermediate in Nova Scotia and the Gulf of Maine, and lowest (about 300/m^2) on Georges Slope.

Table 6
Mean number of specimens of each taxon per square meter in relation to geographic area.

Taxon	Geographic areas						
	Nova Scotia	Gulf of Maine	Georges Bank	Southern New England Shelf	Georges Slope	Southern New England Slope	All areas
PORIFERA	4.8	2.7	0.6	0.5	0.3	0.2	1.5
COELENTERATA	22.2	9.2	99.7	22.6	6.7	8.5	32.1
Hydrozoa	11.5	3.3	6.8	9.9	0.1	0.8	6.4
Anthozoa	10.7	5.9	92.9	12.7	6.6	7.7	25.7
Alcyonaria	0.7	0.9	—	1.2	1.0	1.5	0.8
Zoantharia	8.2	3.6	92.5	7.3	3.0	4.3	22.6
Unidentified	1.8	1.4	0.4	4.2	2.6	1.9	2.2
PLATYHELMINTHES	0.2	<0.1	0.2	0.9	0.4	—	0.4
Turbellaria	0.2	<0.1	0.2	0.9	0.4	—	0.4
NEMERTEA	3.0	4.1	22.7	6.8	1.2	1.6	8.2
ASCHELMINTHES	0.9	3.1	1.7	4.0	2.3	2.3	2.8
Nematoda	0.9	3.1	1.7	4.0	2.3	2.3	2.8
ANNELIDA	648.4	291.3	545.6	530.8	79.9	148.6	425.0
POGONOPHORA	0.3	<0.1	—	—	3.1	5.3	0.6
SIPUNCULIDA	9.3	4.6	4.4	7.2	1.2	8.7	5.9
ECHIURA	—	0.1	—	0.1	0.4	0.2	0.1
PRIAPULIDA	—	—	—	—	0.1	0.1	<0.1
MOLLUSCA	77.2	306.2	46.8	244.2	83.1	57.9	188.0
Polyplacophora	1.9	3.6	0.1	0.9	0.6	0.2	1.5
Gastropoda	15.0	15.2	11.2	28.8	8.4	6.9	17.8
Bivalvia	50.6	276.0	34.4	212.3	69.5	45.8	163.1
Scaphopoda	9.6	11.4	1.2	1.0	4.5	4.8	5.1
Cephalopoda	<0.1	—	<0.1	1.0	0.1	0.1	0.4
Unidentified	—	—	—	0.3	<0.1	—	0.1
ARTHROPODA	329.8	150.4	1,052.4	1,386.0	137.6	21.5	726.2
Pycnogonida	0.8	0.1	0.3	0.6	0.1	—	0.3
Arachnida	—	—	<0.1	—	—	—	<0.1
Crustacea	329.0	150.3	1,052.1	1,385.4	137.5	21.5	725.9
Ostracoda	0.1	<0.1	—	—	<0.1	<0.1	<0.1
Cirripedia	35.7	6.4	2.7	52.2	—	—	21.8
Copepoda	—	—	—	<0.1	—	0.2	<0.1
Cumacea	7.3	15.0	45.0	37.0	2.5	3.0	25.8
Tanaidacea	—	—	—	—	0.4	0.4	<0.1
Isopoda	3.9	9.5	18.0	17.0	1.3	1.0	12.1
Amphipoda	280.0	118.2	952.9	1,269.3	133.7	17.1	655.8
Mysidacea	<0.1	0.2	10.6	1.0	—	<0.1	2.5
Decapoda	2.1	0.5	22.3	8.7	—	0.1	7.5
Unidentified	—	0.5	0.5	0.2	<0.1	—	0.3
BRYOZOA	16.3	6.9	27.9	21.9	0.4	—	15.7
BRACHIOPODA	22.4	9.5	—	—	<0.1	—	4.5
ECHINODERMATA	23.6	43.3	121.0	122.7	18.8	18.7	79.3
Crinoidea	—	<0.1	—	—	<0.1	—	<0.1
Holothuroidea	2.5	7.8	0.2	4.7	2.2	3.4	4.3
Echinoidea	3.6	4.6	105.6	21.8	0.2	0.3	29.3
Ophiuroidea	17.0	29.5	14.0	93.7	15.8	14.8	44.2
Asteroidea	0.4	1.5	1.1	2.5	0.6	0.2	1.5
HEMICHORDATA	—	—	—	0.3	—	0.1	0.1
CHORDATA	2.8	2.3	33.8	26.8	2.6	1.3	16.3
Ascidiacea	2.8	2.3	33.8	26.8	2.6	1.3	16.3
UNIDENTIFIED	1.7	4.9	4.3	7.6	9.4	7.2	5.8
Total	1,162.6	838.7	1,961.0	2,382.4	347.4	281.9	1,512.2

Table 7
The number of specimens of each taxon, expressed as a percentage of the total benthic invertebrate fauna, in relation to geographic area.

Taxon	Geographic areas						
	Nova Scotia	Gulf of Maine	Georges Bank	Southern New England Shelf	Georges Slope	Southern New England Slope	All areas
PORIFERA	0.4	0.3	<0.1	0.1	0.1	0.1	0.1
COELENTERATA	1.9	1.1	5.1	1.0	1.9	3.0	2.1
Hydrozoa	1.0	0.4	0.4	0.4.	<0.1	0.3	0.4
Anthozoa	0.9	0.7	4.7	0.6	1.9	2.7	1.7
Alcyonaria	0.1	0.1	—	<0.1	0.3	0.5	0.1
Zoantharia	0.7	0.4	4.7	0.3	0.9	1.5	1.5
Unidentified	0.2	0.2	<0.1	0.2	0.8	0.7	0.2
PLATYHELMINTHES	<0.1	<0.1	<0.1	<0.1	0.1	—	<0.1
Turbellaria	<0.1	<0.1	<0.1	<0.1	0.1	—	<0.1
NEMERTEA	0.3	0.5	1.2	0.3	0.3	0.6	0.5
ASCHELMINTHES	0.1	0.4	0.1	0.2	0.7	0.8	0.2
Nematoda	0.1	0.4	0.1	0.2	0.7	0.8	0.2
ANNELIDA	55.8	34.7	27.8	22.3	23.0	52.7	28.1
POGONOPHORA	<0.1	<0.1	—	—	0.9	1.9	<0.1
SIPUNCULIDA	0.8	0.6	0.2	0.3	0.3	3.1	0.4
ECHIURA	—	<0.1	—	<0.1	0.1	0.1	<0.1
PRIAPULIDA	—	—	—	—	<0.1	<0.1	<0.1
MOLLUSCA	6.6	36.5	2.4	10.2	23.9	20.5	12.4
Polyplacophora	0.2	0.4	<0.1	<0.1	0.2	0.1	0.1
Gastropoda	1.3	1.8	0.6	1.2	2.4	2.5	1.2
Bivalvia	4.4	32.9	1.8	8.9	20.0	16.3	10.8
Scaphopoda	0.8	1.4	0.1	<0.1	1.3	1.7	0.3
Cephalopoda	<0.1	—	<0.1	<0.1	<0.1	<0.1	<0.1
Unidentified	—	—	—	<0.1	<0.1	—	<0.1
ARTHROPODA	28.4	17.9	53.7	58.2	39.6	7.6	48.0
Pycnogonida	0.1	<0.1	<0.1	<0.1	<0.1	—	<0.1
Arachnida	—	—	<0.1	—	—	—	<0.1
Crustacea	28.3	17.9	53.7	58.2	39.6	7.6	48.0
Ostracoda	<0.1	<0.1	—	—	<0.1	<0.1	<0.1
Cirripedia	3.1	0.8	0.1	2.2	—	—	1.4
Copepoda	—	—	—	<0.1	—	0.1	<0.1
Cumacea	0.6	1.8	2.3	1.6	0.7	1.1	1.7
Tanaidacea	—	—	—	—	0.1	0.1	<0.1
Isopoda	0.3	1.1	0.9	0.7	0.4	0.4	0.8
Amphipoda	24.1	14.1	48.6	53.3	38.5	6.0	43.4
Mysidacea	<0.1	<0.1	0.5	<0.1	—	<0.1	0.2
Decapoda	0.2	0.1	1.1	0.4	—	<0.1	0.5
Unidentified	—	0.1	<0.1	<0.1	<0.1	—	<0.1
BRYOZOA	1.4	0.8	1.4	0.9	0.1	—	1.0
BRACHIOPODA	1.9	1.1	—	—	<0.1	—	0.3
ECHINODERMATA	2.0	5.2	6.2	5.2	5.4	6.6	5.2
Crinoidea	—	<0.1	—	—	<0.1	—	<0.1
Holothuroidea	0.2	0.9	<0.1	0.2	0.6	1.2	0.3
Echinoidea	0.3	0.5	5.4	0.9	<0.1	0.1	1.9
Ophiuroidea	1.5	3.5	0.7	3.9	4.6	5.2	2.9
Asteroidea	<0.1	0.2	<0.1	0.1	0.2	0.1	0.1
HEMICHORDATA	—	—	—	<0.1	—	<0.1	<0.1
CHORDATA	0.2	0.3	1.7	1.1	0.7	0.5	1.1
Ascidiacea	0.2	0.3	1.7	1.1	0.7	0.5	1.1
UNIDENTIFIED	0.1	0.6	0.2	0.3	2.7	2.5	0.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 8
Mean wet weight of specimens of each taxon (grams per square meter) in relation to geographic area.

Taxon	Geographic areas: Nova Scotia	Gulf of Maine	Georges Bank	Southern New England Shelf	Georges Slope	Southern New England Slope	All areas
PORIFERA	15.49	3.15	0.47	0.09	0.24	0.03	2.24
COELENTERATA	20.23	11.87	3.68	4.62	2.42	0.99	7.33
Hydrozoa	0.49	0.12	1.61	0.41	<0.01	0.03	0.52
Anthozoa	19.74	11.75	2.07	4.21	2.42	0.96	6.81
Alcyonaria	0.03	0.43	—	0.21	0.14	0.07	0.20
Zoantharia	19.54	10.90	2.04	3.84	1.90	0.70	6.39
Unidentified	0.16	0.41	0.03	0.15	0.38	0.19	0.22
PLATYHELMINTHES	<0.01	0.01	<0.01	0.01	0.01	—	0.01
Turbellaria	<0.01	0.01	<0.01	0.01	0.01	—	0.01
NEMERTEA	0.56	0.54	0.83	1.04	0.11	0.20	0.71
ASCHELMINTHES	<0.01	0.01	0.01	0.01	0.01	0.01	0.01
Nematoda	<0.01	0.01	0.01	0.01	0.01	0.01	0.01
ANNELIDA	18.50	15.51	7.93	29.60	4.86	4.32	17.41
POGONOPHORA	<0.01	<0.01	—	—	0.01	0.03	<0.01
SIPUNCULIDA	1.65	0.37	0.46	0.74	1.01	1.83	0.75
ECHIURA	—	0.01	—	0.07	5.18	0.40	0.03
PRIAPULIDA	—	—	—	—	0.01	0.05	<0.01
MOLLUSCA	54.40	31.59	79.54	170.90	2.65	1.18	83.64
Polyplacophora	0.10	0.19	<0.01	0.24	0.01	0.01	0.14
Gastropoda	2.47	0.90	1.98	4.29	0.32	0.05	2.23
Bivalvia	50.81	29.84	77.40	166.34	2.11	1.04	80.95
Scaphopoda	1.03	0.66	0.15	0.02	0.20	0.08	0.32
Cephalopoda	<0.01	—	0.01	0.01	<0.01	<0.01	0.01
Unidentified	—	—	—	<0.01	<0.01	—	<0.01
ARTHROPODA	16.49	2.43	9.75	17.11	0.64	0.13	9.41
Pycnogonida	0.02	0.02	<0.01	<0.01	<0.01	—	0.01
Arachnida	—	—	<0.01	—	—	—	<0.01
Crustacea	16.49	2.41	9.75	17.11	0.64	0.13	9.40
Ostracoda	<0.01	<0.01	—	—	<0.01	<0.01	<0.01
Cirripedia	12.71	0.47	0.35	6.84	—	—	3.39
Copepoda	—	—	—	<0.01	—	<0.01	<0.01
Cumacea	0.03	0.05	0.20	0.17	0.04	0.02	0.11
Tanaidacea	—	—	—	—	0.01	<0.01	<0.01
Isopoda	0.09	0.34	0.30	0.40	0.02	0.02	0.29
Amphipoda	1.36	0.94	5.55	8.34	0.57	0.08	4.16
Mysidacea	<0.01	<0.01	0.05	0.01	—	<0.01	0.01
Decapoda	2.27	0.61	3.29	1.36	—	0.02	1.43
Unidentified	—	<0.01	<0.01	<0.01	<0.01	—	<0.01
BRYOZOA	6.32	0.17	2.64	0.71	0.02	—	1.29
BRACHIOPODA	3.68	2.12	—	—	<0.01	—	0.89
ECHINODERMATA	39.44	56.42	119.99	36.06	3.89	10.01	55.00
Crinoidea	—	<0.01	—	—	<0.01	—	<0.01
Holothuroidea	0.77	27.55	0.50	14.65	1.28	2.75	12.87
Echinoidea	32.75	23.54	117.19	12.89	1.77	4.62	36.75
Ophiuroidea	1.46	3.30	1.26	5.41	0.79	2.62	3.26
Asteroidea	4.45	2.03	1.04	3.11	0.05	0.02	2.13
HEMICHORDATA	—	—	—	0.05	—	<0.01	0.02
CHORDATA	0.79	2.62	8.41	5.13	0.17	0.11	4.10
Ascidiacea	0.79	2.62	8.41	5.13	0.17	0.11	4.10
UNIDENTIFIED	0.12	0.23	0.08	0.52	0.12	0.17	0.27
Total	177.64	127.03	233.79	266.64	21.34	19.46	183.39

Table 9
The wet weight of specimens of each taxon, expressed as a percentage of the total benthic invertebrate fauna, in relation to geographic area.

	Geographic areas						
Taxon	Nova Scotia	Gulf of Maine	Georges Bank	Southern New England Shelf	Georges Slope	Southern New England Slope	All areas
PORIFERA	8.7	2.5	0.2	0.1	1.1	0.2	1.2
COELENTERATA	11.4	9.4	1.6	1.7	11.3	5.1	4.0
Hydrozoa	0.3	0.1	0.7	0.2	<0.1	0.2	0.3
Anthozoa	11.1	9.3	0.9	1.5	11.3	4.9	3.7
Alcyonaria	<0.1	0.3	—	0.1	0.7	0.4	0.1
Zoantharia	11.0	8.6	0.9	1.4	8.9	3.6	3.5
Unidentified	0.1	0.3	<0.1	0.1	1.8	1.0	0.1
PLATYHELMINTHES	<0.1	<0.1	<0.1	<0.1	0.1	—	<0.1
Turbellaria	<0.1	<0.1	<0.1	<0.1	0.1	—	<0.1
NEMERTEA	0.3	0.4	0.4	0.4	0.5	1.0	0.4
ASCHELMINTHES	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nematoda	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
ANNELIDA	10.4	12.2	3.4	11.1	22.8	22.2	9.5
POGONOPHORA	<0.1	<0.1	—	—	<0.1	0.2	<0.1
SIPUNCULIDA	0.9	0.3	0.2	0.3	4.7	9.4	0.4
ECHIURA	—	<0.1	—	<0.1	24.3	2.0	0.2
PRIAPULIDA	—	—	—	—	0.1	0.2	<0.1
MOLLUSCA	30.6	24.9	34.0	64.1	12.4	6.0	45.6
Polyplacophora	0.1	0.2	<0.1	0.1	0.1	<0.1	0.1
Gastropoda	1.4	0.7	0.8	1.6	1.5	0.3	1.2
Bivalvia	28.6	23.5	33.1	62.4	9.9	5.3	44.1
Scaphopoda	0.6	0.5	0.1	<0.1	0.9	0.4	0.2
Cephalopoda	<0.1	—	<0.1	<0.1	<0.1	<0.1	<0.1
Unidentified	—	—	—	<0.1	<0.1	—	<0.1
ARTHROPODA	9.3	1.9	4.2	6.4	3.0	0.6	5.1
Pycnogonida	<0.1	<0.1	<0.1	<0.1	<0.1	—	<0.1
Arachnida	—	—	<0.1	—	—	—	<0.1
Crustacea	9.3	1.9	4.2	6.4	3.0	0.6	5.1
Ostracoda	<0.1	<0.1	—	—	<0.1	<0.1	<0.1
Cirripedia	7.2	0.4	0.2	2.6	—	—	1.8
Copepoda	—	—	—	<0.1	—	<0.1	<0.1
Cumacea	<0.1	<0.1	0.1	0.1	0.2	0.1	0.1
Tanaidacea	—	—	—	—	<0.1	<0.1	<0.1
Isopoda	<0.1	0.3	0.1	0.2	0.1	0.1	0.2
Amphipoda	0.8	0.7	2.4	3.1	2.7	0.4	2.3
Mysidacea	<0.1	<0.1	<0.1	<0.1	—	<0.1	<0.1
Decapoda	1.3	0.5	1.4	0.5	—	0.1	0.8
Unidentified	—	<0.1	<0.1	<0.1	<0.1	—	<0.1
BRYOZOA	3.6	0.1	1.1	0.3	0.1	—	0.7
BRACHIOPODA	2.1	1.7	—	—	<0.1	—	0.5
ECHINODERMATA	22.2	44.4	51.3	13.5	18.2	51.5	30.0
Crinoidea	—	<0.1	—	—	<0.1	—	<0.1
Holothuroidea	0.4	21.7	0.2	5.5	6.0	14.2	7.0
Echinoidea	18.4	18.5	50.1	4.8	8.3	23.7	20.0
Ophiuroidea	0.8	2.6	0.5	2.0	3.7	13.5	1.8
Asteroidea	2.5	1.6	0.4	1.2	0.2	0.1	1.2
HEMICHORDATA	—	—	—	<0.1	—	<0.1	<0.1
CHORDATA	0.4	2.1	3.6	1.9	0.8	0.6	2.2
Ascidiacea	0.4	2.1	3.6	1.9	0.8	0.6	2.2
UNIDENTIFIED	0.1	0.2	<0.1	0.2	0.6	0.9	0.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 10
Frequency of occurrence (%) of each taxonomic group in the samples in each geographic area.

	Geographic areas					
Taxon	Nova Scotia	Gulf of Maine	Georges Bank	Southern New England Shelf	Georges Slope	Southern New England Slope
PORIFERA	19	9	4	3	10	5
COELENTERATA	61	33	39	43	64	46
Hydrozoa	29	8	15	13	4	1
Anthozoa	32	25	24	30	60	45
Alcyonaria	4	3	—	7	27	17
Zoantharia	31	22	28	25	17	21
PLATYHELMINTHES	2	<1	1	3	2	—
Turbellaria	2	<1	1	3	2	—
NEMERTEA	28	32	32	52	35	25
ASCHELMINTHES	8	9	5	6	39	15
Nematoda	8	9	5	6	39	15
ANNELIDA	97	98	89	99	96	99
POGONOPHORA	2	1	—	—	35	42
SIPUNCULIDA	42	20	13	24	25	36
ECHIURA	—	<1	—	1	15	7
PRIAPULIDA	—	—	—	—	4	3
MOLLUSCA	91	90	73	92	92	95
Polyplacophora	24	11	1	5	15	6
Gastropoda	54	43	35	43	58	53
Bivalvia	80	87	64	89	89	94
Scaphopoda	46	35	7	4	35	33
Cephalopoda	1	—	<1	<1	2	1
ARTHROPODA	95	71	100	95	85	74
Pycnogonida	8	1	3	2	6	—
Arachnida	—	—	1	—	—	—
Crustacea	95	71	100	95	85	74
Ostracoda	2	<1	—	—	2	1
Cirripedia	15	4	2	4	—	—
Copepoda	—	—	—	1	—	3
Cumacea	31	24	44	49	31	19
Tanaidacea	—	—	—	—	15	9
Isopoda	35	21	48	48	29	20
Amphipoda	94	58	94	92	73	63
Mysidacea	1	1	10	4	—	1
Decapoda	18	6	46	33	—	3
BRYOZOA	19	12	13	11	6	—
BRACHIOPODA	21	12	—	—	2	—
ECHINODERMATA	69	79	67	67	81	75
Crinoidea	—	<1	—	—	2	—
Holothuroidea	22	25	2	17	40	27
Echinoidea	26	19	51	28	8	9
Ophiuroidea	55	64	22	35	62	59
Asteroidea	9	13	9	19	14	6
HEMICHORDATA	—	—	—	1	—	1
CHORDATA	20	12	14	23	14	16
Ascidiacea	20	12	14	23	14	16

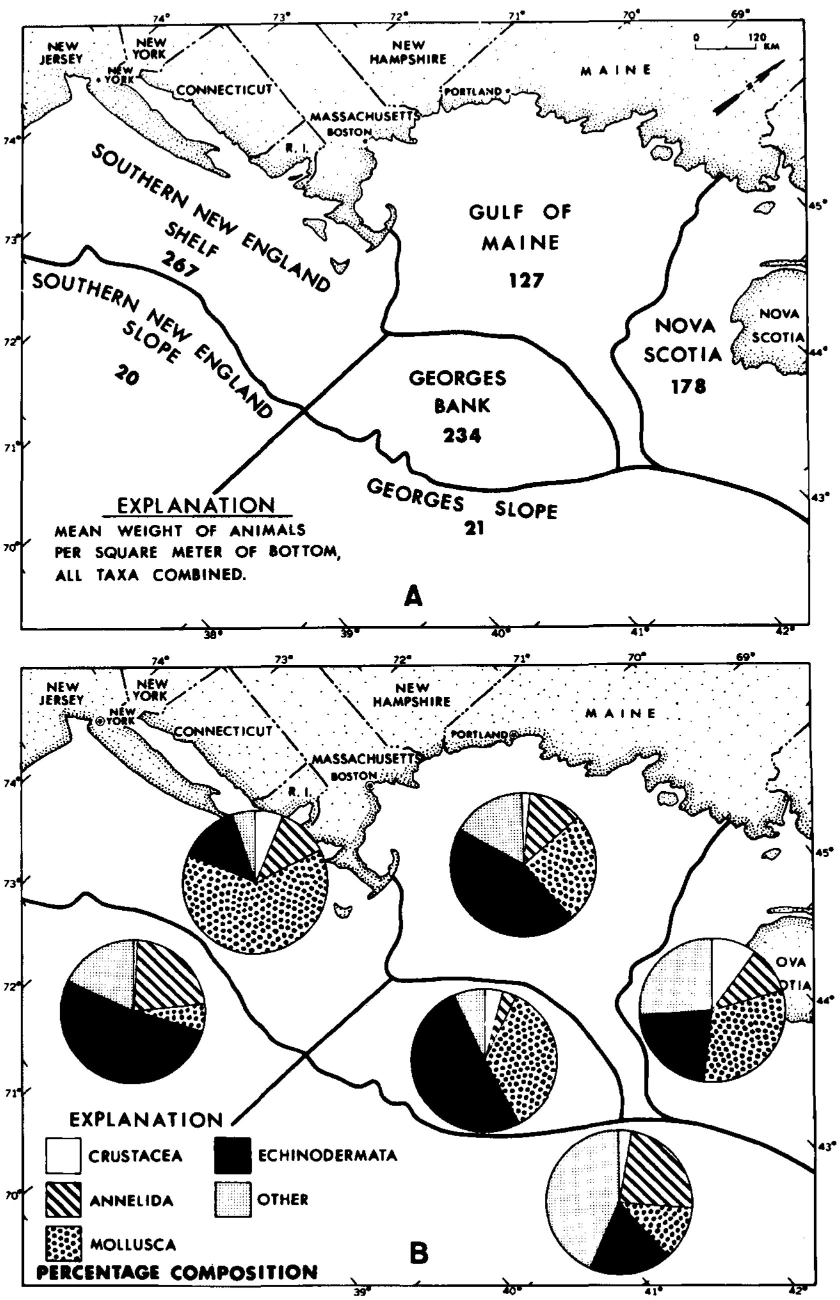


Figure 14
Quantitative composition of the total macrobenthic- invertebrate fauna in relation to the six standard geographic subareas. A.—Mean wet weight of animals per square meter of bottom area; B.—Percentage composition, by biomass, of the major taxonomic groups.

A gradient was evident in the density distribution. In the three shallow water areas—Nova Scotia, Georges Bank, and Southern New England Shelf—average density increased in the order listed from the northeast to the southwest. The Southern New England Shelf area (2,382/m^2) had about twice the density of the Nova Scotian area (1,163/m^2). The Gulf of Maine averaged 839/m^2, and the two slope areas had average densities of about 300/m^2.

Biomass distribution followed precisely the same rank order as density, and the magnitudes of differences in biomass from one area to another were roughly the

Table 11
Mean number of specimens of each taxon per square meter in relation to water depth.

Taxon	Water depth (m)								
	0–24	25–49	50–99	100–199	200–499	500–599	1,000–1,999	2,000–3,999	All depths
PORIFERA	1.3	2.8	0.8	1.3	2.5	0.3	0.3	0.1	1.5
COELENTERATA	56.7	96.8	28.6	11.6	9.0	6.0	4.3	1.6	32.1
Hydrozoa	36.8	5.1	5.9	2.5	1.0	—	0.1	0.1	6.4
Anthozoa	19.9	91.7	22.7	9.1	8.0	6.0	4.2	1.5	25.7
Alcyonaria	—	—	0.9	0.9	1.9	1.1	1.2	0.4	0.8
Zoantharia	5.6	91.3	21.1	6.8	4.4	2.0	0.4	0.2	22.6
Unidentified	14.3	0.4	0.7	1.4	1.7	2.9	2.7	1.0	2.2
PLATYHELMINTHES	2.6	<0.1	0.3	—	0.2	—	—	—	0.4
Turbellaria	2.6	<0.1	0.3	—	0.2	—	—	—	0.4
NEMERTEA	4.2	27.2	7.8	3.8	3.4	0.5	1.5	0.7	8.2
ASCHELMINTHES	6.8	0.8	3.2	1.4	4.4	4.2	1.4	1.7	2.8
Nematoda	6.8	0.8	3.2	1.4	4.4	4.2	1.4	1.7	2.8
ANNELIDA	719.3	436.8	51.9	455.9	240.6	106.5	30.2	9.1	425.0
POGONOPHORA	—	—	—	0.1	1.3	6.8	3.2	3.5	0.6
SIPUNCULIDA	1.8	5.8	6.2	7.5	8.1	1.5	0.7	1.2	5.9
ECHIURA	0.3	—	—	0.2	—	—	0.5	0.6	0.1
PRIAPULIDA	—	—	—	—	—	—	0.2	0.1	<0.1
MOLLUSCA	570.2	205.0	197.3	135.7	91.0	121.5	55.7	27.2	188.0
Polyplacophora	0.8	4.0	1.1	0.4	2.5	0.2	0.5	0.2	1.5
Gastropoda	64.1	18.4	15.2	11.3	12.1	23.7	3.9	1.1	17.8
Bivalvia	505.1	182.2	179.2	113.1	62.6	86.7	50.1	25.8	163.1
Scaphopoda	0.2	0.4	1.5	9.5	13.8	10.8	1.2	0.1	5.1
Cephalopoda	—	—	—	1.5	0.1	—	—	—	0.4
Unidentified	—	—	0.3	—	—	0.1	—	—	0.1
ARTHROPODA	1,039.4	1,255.7	1,351.6	168.8	67.0	14.6	13.2	6.6	726.2
Pycnogonida	0.6	0.6	0.3	0.5	—	0.2	0.1	—	0.3
Arachnida	—	—	<0.1	—	—	—	—	—	<0.1
Crustacea	1,038.8	1,255.1	1,351.3	168.3	67.0	14.4	13.1	6.6	725.9
Ostracoda	—	—	<0.1	<0.1	0.1	0.1	—	0.1	<0.1
Cirripedia	214.2	13.7	2.9	2.3	0.7	—	—	—	21.8
Copepoda	—	—	<0.1	—	<0.1	0.5	—	—	<0.1
Cumacea	33.1	39.8	50.3	6.8	2.9	1.6	0.7	1.7	25.8
Tanaidacea	—	—	—	—	0.1	—	0.1	1.0	<0.1
Isopoda	22.4	37.9	11.1	2.9	3.1	1.3	0.4	1.9	12.1
Amphipoda	746.4	1,148.6	1,273.8	147.4	59.1	11.1	12.0	2.9	655.8
Mysidacea	4.0	6.5	3.8	0.1	<0.1	—	—	—	2.5
Decapoda	18.0	8.2	9.1	8.6	0.3	—	0.1	—	7.5
Unidentified	0.6	0.4	0.2	0.2	0.8	—	—	—	0.3
BRYOZOA	38.6	29.4	18.9	7.8	4.3	—	—	0.5	15.7
BRACHIOPODA	—	—	1.2	6.5	17.0	0.1	—	—	4.5
ECHINODERMATA	47.4	133.2	87.4	94.6	48.1	6.5	4.4	7.3	79.3
Crinoidea	—	—	—	—	0.1	—	0.1	—	<0.1
Holothuroidea	1.5	1.3	4.9	4.0	9.8	1.2	1.9	0.7	4.3
Echinoidea	44.4	127.4	19.1	2.0	2.6	—	0.1	0.3	29.3
Ophiuroidea	0.8	2.0	61.5	86.7	35.0	5.2	2.0	6.2	44.2
Asteroidea	0.7	2.5	1.9	1.8	0.5	0.1	0.3	0.1	1.5
HEMICHORDATA	—	—	0.3	<0.1	—	0.5	—	—	0.1
CHORDATA	9.0	32.0	29.8	6.2	2.7	0.1	1.0	1.7	16.3
Ascidiacea	9.0	32.0	29.8	6.2	2.7	0.1	1.0	1.7	16.3
UNIDENTIFIED	6.0	6.6	5.1	5.3	5.6	3.5	5.8	13.1	5.8
Total	2,503.3	2,232.0	2,256.9	906.6	505.1	272.4	122.2	74.9	1,512.2

Table 12
The number of specimens of each taxon, expressed as a percentage of the total benthic invertebrate fauna, in relation to water depth.

	Depth zones (m)								
Taxon	0–24	25–49	50–99	100–199	200–499	500–599	1,000–1,999	2,000–3,999	All depths
PORIFERA	0.1	0.1	<0.1	0.2	0.5	0.1	0.2	0.1	0.1
COELENTERATA	2.3	4.3	1.3	1.3	1.8	2.2	3.5	2.1	2.1
Hydrozoa	1.5	0.2	0.3	0.3	0.2	—	<0.1	0.1	0.4
Anthozoa	0.8	4.1	1.0	1.0	1.6	2.2	3.5	2.0	1.7
Alcyonaria	—	—	<0.1	0.1	0.4	0.4	1.0	0.6	0.1
Zoantharia	0.2	4.1	0.9	0.8	0.9	0.7	0.3	0.2	1.5
Unidentified	0.6	<0.1	<0.1	0.2	0.3	1.0	2.2	1.3	0.2
PLATYHELMINTHES	0.1	<0.1	<0.1	—	<0.1	—	—	—	<0.1
Turbellaria	0.1	<0.1	<0.1	—	<0.1	—	—	—	<0.1
NEMERTEA	0.2	1.2	0.4	0.4	0.7	0.2	1.2	0.9	0.5
ASCHELMINTHES	0.3	<0.1	0.1	0.2	0.9	1.5	1.1	2.3	0.2
Nematoda	0.3	<0.1	0.1	0.2	0.9	1.5	1.1	2.3	0.2
ANNELIDA	28.7	19.6	23.0	50.3	47.6	39.1	24.7	12.2	28.1
POGONOPHORA	—	—	—	<0.1	0.2	2.5	2.6	4.6	<0.1
SIPUNCULIDA	0.1	0.3	0.3	0.8	1.6	0.5	0.6	1.6	0.4
ECHIURA	<0.1	—	—	<0.1	—	—	0.4	0.8	<0.1
PRIAPULIDA	—	—	—	—	—	—	0.2	0.1	<0.1
MOLLUSCA	22.8	9.2	8.7	15.0	18.0	44.6	45.6	36.3	12.4
Polyplacophora	<0.1	0.2	<0.1	<0.1	0.5	0.1	0.4	0.3	0.1
Gastropoda	2.6	0.8	0.7	1.2	2.4	8.7	3.2	1.5	1.2
Bivalvia	20.2	8.2	7.9	12.5	12.4	31.8	41.0	34.4	10.8
Scaphopoda	<0.1	<0.1	0.1	1.0	2.7	4.0	1.0	0.1	0.3
Cephalopoda	—	—	—	0.2	<0.1	—	—	—	<0.1
Unidentified	—	—	<0.1	—	—	<0.1	—	—	<0.1
ARTHROPODA	41.5	56.3	59.9	18.6	13.3	5.4	10.8	8.8	48.0
Pycnogonida	<0.1	<0.1	<0.1	<0.1	—	0.1	<0.1	—	<0.1
Arachnida	—	—	<0.1	—	—	—	—	—	<0.1
Crustacea	41.5	56.2	59.9	18.6	13.3	5.3	10.8	8.8	48.0
Ostracoda	—	—	<0.1	<0.1	<0.1	<0.1	—	0.1	<0.1
Cirripedia	8.6	0.6	0.1	0.2	0.1	—	—	—	1.4
Copepoda	—	—	<0.1	—	<0.1	0.2	—	—	<0.1
Cumacea	1.3	1.8	2.2	0.8	0.6	0.6	0.6	2.3	1.7
Tanaidacea	—	—	—	—	<0.1	—	<0.1	1.4	<0.1
Isopoda	0.9	1.7	0.5	0.3	0.6	0.5	0.3	2.5	0.8
Amphipoda	29.8	51.5	56.4	16.3	11.7	4.1	9.8	3.9	43.4
Mysidacea	0.2	0.3	0.2	<0.1	<0.1	—	—	—	0.2
Decapoda	0.7	0.4	0.4	1.0	0.1	—	<0.1	—	0.5
Unidentified	<0.1	<0.1	<0.1	<0.1	0.2	—	—	0.1	<0.1
BRYOZOA	1.5	1.3	0.8	0.9	0.8	—	—	0.7	1.0
BRACHIOPODA	—	—	<0.1	0.7	3.4	<0.1	—	—	0.3
ECHINODERMATA	1.9	6.0	3.9	10.4	9.5	2.4	3.6	9.8	5.2
Crinoidea	—	—	—	—	<0.1	—	<0.1	—	<0.1
Holothuroidea	0.1	0.1	0.2	0.4	1.9	0.4	1.5	0.9	0.3
Echinoidea	1.8	5.7	0.8	0.2	0.5	—	0.1	0.4	1.9
Ophiuroidea	<0.1	0.1	2.7	9.6	6.9	1.9	1.6	8.3	2.9
Asteroidea	<0.1	0.1	0.1	0.2	0.1	<0.1	0.3	0.1	0.1
HEMICHORDATA	—	—	<0.1	<0.1	—	0.2	—	—	<0.1
CHORDATA	0.4	1.4	1.3	0.7	0.5	<0.1	0.8	2.2	1.1
Ascidiacea	0.4	1.4	1.3	0.7	0.5	<0.1	0.8	2.2	1.1
UNIDENTIFIED	0.2	0.3	0.2	0.6	1.1	1.3	4.7	17.4	0.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

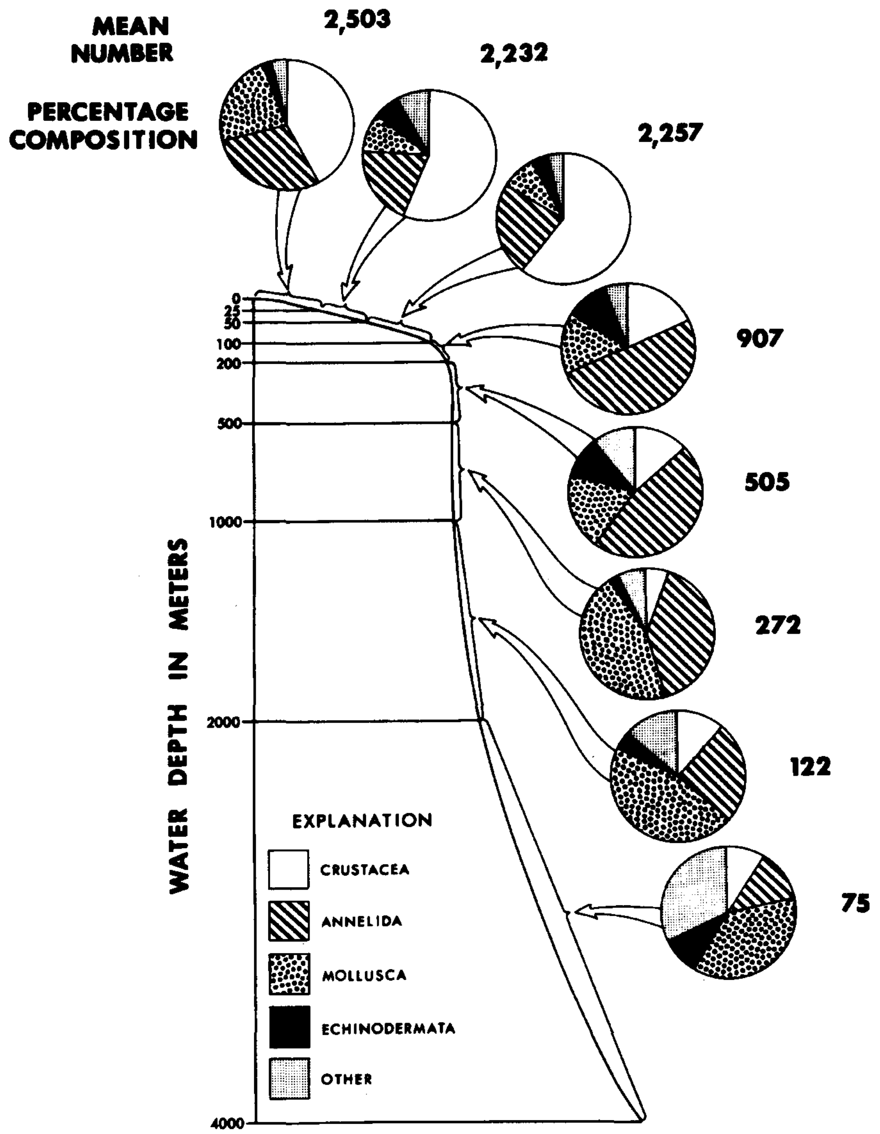


Figure 15
Quantitative composition of the total macrobenthic invertebrate fauna in relation to water depth. Mean number of individuals per square meter of bottom area, and percentage composition, by density, of the major taxonomic groups are shown.

same as the changes in density (Tables 8, 9; Fig. 14A). Southern New England Shelf and Georges Bank had the highest average biomasses (267 and 234 g/m^2); biomass was intermediate (178 and 127 g/m^2) in Nova Scotia and the Gulf of Maine, and low (21 and 20 g/m^2) on Georges Slope and Southern New England Slope.

The percentage occurrence of each taxonomic group in the samples in each geographic area is presented in Table 10.

Bathymetric Distribution

One of the most striking relationships in the New England region was the pronounced diminution in quantity of macrobenthic invertebrates from shallow to deep water (Tables 11, 12; Fig. 15). In the shallowest waters sampled (0–24 m) the average density was 2,503/m^2, whereas in the deepest water (2,000–3,999 m) the density averaged only 75/m^2. The decrease from one depth range to an-

Table 13
Mean wet weight of specimens of each taxon (grams per square meter) in relation to water depth.

	Water depth (m)								
Taxon	0–24	25–49	50–99	100–199	200–499	500–599	1,000–1,999	2,000–3,999	All depths
PORIFERA	0.06	1.23	2.90	3.08	3.12	0.54	0.02	0.03	2.24
COELENTERATA	3.63	1.49	3.38	18.95	9.13	0.36	0.72	0.69	7.33
Hydrozoa	1.21	0.22	1.17	0.16	0.02	—	<0.01	<0.01	0.52
Anthozoa	2.42	1.27	2.21	18.79	9.11	0.36	0.72	0.69	6.81
Alcyonaria	—	—	0.16	0.33	0.47	0.04	0.25	0.01	0.20
Zoantharia	2.08	1.22	1.99	18.28	8.05	0.19	0.18	0.19	6.39
Unidentified	0.35	0.05	0.06	0.18	0.59	0.13	0.29	0.49	0.22
PLATYHELMINTHES	0.02	<0.01	0.01	—	<0.01	—	—	—	0.01
Turbellaria	0.02	<0.01	0.01	—	<0.01	—	—	—	0.01
NEMERTEA	1.00	1.44	0.99	0.23	0.40	0.01	0.06	0.12	0.71
ASCHELMINTHES	<0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Nematoda	<0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
ANNELIDA	27.22	16.24	25.20	14.76	10.70	4.76	1.41	0.76	17.41
POGONOPHORA	—	—	—	<0.01	0.01	0.03	0.02	0.01	<0.01
SIPUNCULIDA	0.22	0.57	0.82	0.77	0.54	3.93	1.38	0.53	0.75
ECHIURA	0.22	—	—	0.01	—	—	5.04	3.52	0.30
PRIAPULIDA	—	—	—	—	—	—	0.12	0.01	<0.01
MOLLUSCA	257.88	106.89	132.14	20.67	10.80	3.26	1.44	0.58	83.64
Polyplacophora	0.84	0.07	0.02	0.02	0.29	0.01	0.01	<0.01	0.14
Gastropoda	4.85	1.82	4.23	1.07	0.18	0.29	0.15	0.17	2.23
Bivalvia	252.18	104.94	127.80	18.56	10.04	2.79	1.07	0.41	80.95
Scaphopoda	<0.01	0.07	0.09	0.98	0.29	0.17	0.22	<0.01	0.32
Cephalopoda	—	—	—	0.03	<0.01	—	—	—	0.01
Unidentified	—	—	<0.01	—	—	0.01	—	—	<0.01
ARTHROPODA	37.04	15.64	9.31	2.40	3.89	0.09	0.08	0.10	9.41
Pycnogonida	0.01	<0.01	<0.01	0.03	—	<0.01	<0.01	—	0.01
Arachnida	—	—	<0.01	—	—	—	—	—	<0.01
Crustacea	37.03	15.64	9.31	2.37	3.89	0.09	0.08	0.10	9.40
Ostracoda	—	—	<0.01	<0.01	<0.01	<0.01	—	<0.01	<0.01
Cirripedia	27.08	3.89	0.29	0.10	2.53	—	—	—	3.39
Copepoda	—	—	<0.01	—	<0.01	0.10	—	—	<0.01
Cumacea	0.08	0.11	0.26	0.04	0.02	0.01	0.01	0.05	0.11
Tanaidacea	—	—	—	—	<0.01	—	<0.01	0.01	<0.01
Isopoda	0.15	0.66	0.27	0.15	0.42	0.02	0.01	0.02	0.29
Amphipoda	6.39	9.77	6.38	0.97	0.31	0.06	0.03	0.02	4.16
Mysidacea	0.03	0.02	0.02	<0.01	<0.01	—	—	—	0.01
Decapoda	3.32	1.19	2.10	1.12	0.61	—	0.03	—	1.43
Unidentified	0.01	<0.01	<0.01	<0.01	<0.01	—	—	<0.01	<0.01
BRYOZOA	0.96	0.92	2.88	0.87	0.14	—	—	0.02	1.29
BRACHIOPODA	—	—	0.11	1.05	3.98	0.01	—	—	0.89
ECHINODERMATA	105.93	166.80	33.95	34.23	19.18	1.72	3.16	4.62	55.00
Crinoidea	—	—	—	—	<0.01	—	<0.01	—	<0.01
Holothuroidea	36.59	12.76	19.23	6.47	3.57	0.24	1.24	2.15	12.87
Echinoidea	65.74	153.88	9.24	16.16	11.11	—	1.13	1.78	36.75
Ophiuroidea	0.29	0.06	2.49	7.50	4.49	1.48	0.75	0.66	3.26
Asteroidea	3.30	0.11	2.99	4.10	0.01	<0.01	0.04	0.04	2.13
HEMICHORDATA	—	—	0.05	0.01	—	0.01	—	—	0.02
CHORDATA	3.85	5.20	8.93	1.03	0.72	<0.01	<0.01	0.21	4.10
Ascidiacea	3.85	5.20	8.93	1.03	0.72	<0.01	<0.01	0.21	4.10
UNIDENTIFIED	0.19	0.58	0.28	0.23	0.12	0.19	0.23	0.15	0.27
Total	438.26	317.01	220.95	98.30	62.72	14.91	13.66	11.36	183.39

Table 14
The wet weight of specimens of each taxon, expressed as a percentage of the total benthic invertebrate fauna, in relation to water depth.

	Depth zones (m)								
Taxon	0–24	25–49	50–99	100–199	200–499	500–599	1,000–1,999	2,000–3,999	All depths
PORIFERA	<0.1	0.4	1.3	3.1	5.0	3.6	0.1	0.3	1.2
COELENTERATA	0.8	0.5	1.5	19.3	14.6	2.4	5.3	6.1	4.0
Hydrozoa	0.3	0.1	0.5	0.2	<0.1	—	<0.1	<0.1	0.3
Anthozoa	0.5	0.4	1.0	19.1	14.6	2.4	5.3	6.1	3.7
Alcyonaria	—	—	0.1	0.3	0.8	0.3	1.8	0.1	0.1
Zoantharia	0.5	0.4	0.9	18.6	12.8	1.2	1.3	1.7	3.5
Unidentified	0.1	<0.1	<0.1	0.2	0.9	0.9	2.1	4.3	0.1
PLATYHELMINTHES	<0.1	<0.1	<0.1	—	<0.1	—	—	—	<0.1
Turbellaria	<0.1	<0.1	<0.1	—	<0.1	—	—	—	<0.1
NEMERTEA	0.2	0.5	0.4	0.2	0.6	0.1	0.4	1.0	0.4
ASCHELMINTHES	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	<0.1
Nematoda	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	<0.1
ANNELIDA	6.2	5.1	11.4	15.0	7.0	32.0	10.3	6.7	9.5
POGONOPHORA	—	—	—	<0.1	<0.1	0.2	0.1	0.1	<0.1
SIPUNCULIDA	<0.1	0.2	0.4	0.8	0.8	26.3	10.1	4.7	0.4
ECHIURA	0.1	—	—	<0.1	—	—	36.9	31.0	0.2
PRIAPULIDA	—	—	—	—	—	—	0.9	0.1	<0.1
MOLLUSCA	58.8	33.7	59.8	21.0	17.2	21.9	10.6	5.1	45.6
Polyplacophora	0.2	<0.1	<0.1	<0.1	0.5	<0.1	<0.1	<0.1	0.1
Gastropoda	1.1	0.6	1.9	1.1	0.3	1.9	1.1	1.5	1.2
Bivalvia	57.5	33.1	57.8	18.9	16.0	18.7	7.8	3.6	44.1
Scaphopoda	<0.1	<0.1	<0.1	1.0	0.5	1.2	1.6	<0.1	0.2
Cephalopoda	—	—	—	<0.1	<0.1	—	—	—	<0.1
Unidentified	—	—	<0.1	—	—	0.1	—	—	<0.1
ARTHROPODA	8.4	4.9	4.2	2.4	6.2	0.6	0.6	0.9	5.1
Pycnogonida	<0.1	<0.1	<0.1	<0.1	—	<0.1	<0.1	—	<0.1
Arachnida	—	—	<0.1	—	—	—	—	—	<0.1
Crustacea	8.4	4.9	4.2	2.4	6.2	0.6	0.6	0.9	5.1
Ostracoda	—	—	<0.1	<0.1	<0.1	<0.1	—	<0.1	<0.1
Cirripedia	6.2	1.2	0.1	0.1	4.0	—	—	—	1.8
Copepoda	—	—	<0.1	—	<0.1	<0.1	—	—	<0.1
Cumacea	<0.1	<0.1	0.1	<0.1	<0.1	0.1	0.1	0.4	0.1
Tanaidacea	—	—	—	—	<0.1	—	<0.1	0.1	<0.1
Isopoda	<0.1	0.2	0.1	0.2	0.7	0.1	<0.1	0.2	0.2
Amphipoda	1.5	3.1	2.9	1.0	0.5	0.4	0.2	0.2	2.3
Mysidacea	<0.1	<0.1	<0.1	<0.1	<0.1	—	—	—	<0.1
Decapoda	0.8	0.4	1.0	1.1	1.0	—	0.2	—	0.8
Unidentified	<0.1	<0.1	<0.1	<0.1	<0.1	—	—	<0.1	<0.1
BRYOZOA	0.2	0.3	1.3	0.9	0.2	—	—	0.2	0.7
BRACHIOPODA	—	—	<0.1	1.1	6.3	<0.1	—	—	0.5
ECHINODERMATA	24.2	52.6	15.4	34.8	30.6	11.5	23.0	40.7	30.0
Crinoidea	—	—	—	—	<0.1	—	<0.1	—	<0.1
Holothuroidea	8.4	4.0	8.7	6.6	5.7	1.6	9.0	18.9	7.0
Echinoidea	15.0	48.5	4.2	16.4	17.7	—	8.2	15.7	20.0
Ophiuroidea	0.1	<0.1	1.1	7.6	7.2	9.9	5.5	5.8	1.8
Asteroidea	0.8	<0.1	1.4	4.2	<0.1	<0.1	0.3	0.3	1.2
HEMICHORDATA	—	—	<0.1	1.0	—	<0.1	—	—	<0.1
CHORDATA	0.9	1.6	4.0	1.0	1.2	<0.1	<0.1	1.8	2.2
Ascidiacea	0.9	1.6	4.0	1.0	1.2	<0.1	<0.1	1.8	2.2
UNIDENTIFIED	<0.1	0.2	0.1	0.2	0.2	1.3	1.6	1.3	0.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

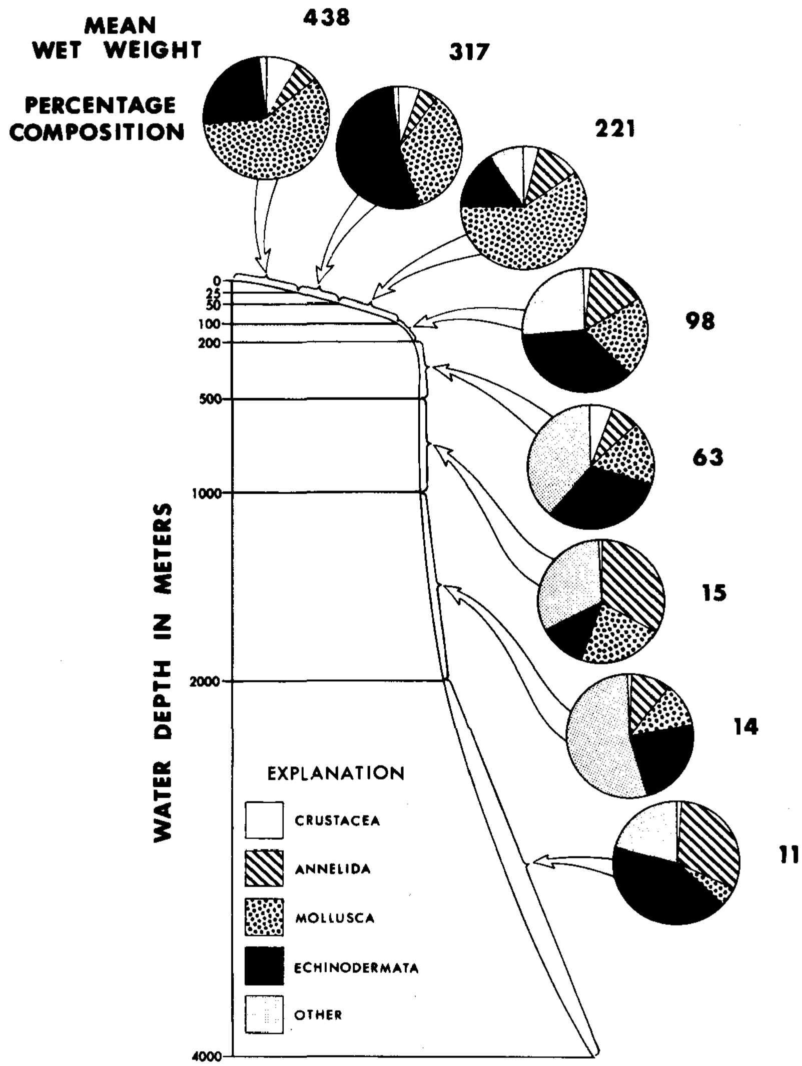


Figure 16
Quantitative composition of the total macrobenthic invertebrate fauna in relation to water depth. Mean wet weight per square meter of bottom area, and percentage composition, by biomass, of the major taxonomic groups are shown.

other was not uniform over the entire depth spectrum. There was a 60% drop in density from 50–99 m to 100–199 m and the largest drop in density occurred between 100 and 200 m depth.. Another way of expressing this change is to say there was a decrease in density per meter increase in depth. In the vicinity of 100 m the average density decreased by 18 specimens with each 1-m increase in water depth. In shallower water the rate of decrease was as high as 10 specimens per 1 m of water depth increase, but the percentage change was substantially lower. In deep water (below 200 m) the diminution rate was less than one specimen per meter change in water depth. Differences in density in depth ranges between 1,000 and 1,999 m and between 2,000 and 3,999 m decreased an average of 0.05 per meter increase in depth.

Biomass diminished with depth from an average of 438 g/m^2 in shallow water to 11 g/m^2 on the continental rise (Tables 13, 14; Fig. 16). The biomass remained rather high (221 g or more) in shallow water out to 100 meters. In the vicinity of 100 m the biomass was 56% lower than in the shallowest water, and 76% lower in the vicinity of 500 m depth.

The relatively high biomass, averaging 11 g/m^2, at water depths between 2,000 and 3,999 m was due in

Table 15
Frequency of occurrence (%) of each taxonomic group in the samples in each depth range class.

	Water depth (m)							
Taxon	0–24	25–49	50–99	100–199	200–499	500–599	1,000–1,999	2,000–3,999
PORIFERA	5	3	5	8	12	9	12	3
COELENTERATA	36	36	50	40	33	46	65	41
Hydrozoa	21	16	15	10	4	—	3	3
Anthozoa	15	20	35	30	29	46	62	38
Alcyonaria	—	—	5	5	8	23	29	22
Zoantharia	16	21	33	29	19	9	18	8
PLATYHELMINTHES	2	1	4	—	1	—	—	—
Turbellaria	2	1	4	—	1	—	—	—
NEMERTEA	35	51	47	30	28	18	33	24
ASCHELMINTHES	2	6	8	5	15	32	18	35
Nematoda	2	6	8	5	15	32	18	35
ANNELIDA	96	93	96	98	97	100	97	95
POGONOPHORA	—	—	—	1	5	50	53	43
SIPUNCULIDA	3	13	26	32	25	32	21	22
ECHIURA	2	—	—	<1	—	—	21	19
PRIAPULIDA	—	—	—	—	—	—	9	3
MOLLUSCA	92	82	85	91	89	100	97	87
Polyplacophora	1	4	10	7	11	9	18	8
Gastropoda	52	42	43	37	44	77	74	30
Bivalvia	88	76	81	85	84	100	97	81
Scaphopoda	1	1	9	35	43	59	35	3
Cephalopoda	—	—	—	1	1	—	—	—
ARTHROPODA	88	99	100	80	71	82	53	78
Pycnogonida	2	2	2	4	—	9	3	—
Arachnida	—	—	<1	—	—	—	—	—
Crustacea	88	99	100	80	71	82	53	78
Ostracoda	—	—	<1	<1	1	5	—	3
Cirripedia	13	4	3	3	4	—	—	—
Copepoda	—	—	1	—	1	5	—	—
Cumacea	27	41	56	30	15	36	15	22
Tanaidacea	—	—	—	—	1	—	3	35
Isopoda	29	69	46	20	20	18	12	43
Amphipoda	80	95	98	72	58	77	44	54
Mysidacea	13	11	3	<1	1	—	—	—
Decapoda	37	39	35	13	4	—	3	—
BRYOZOA	19	13	11	10	12	—	—	5
BRACHIOPODA	—	—	2	10	14	5	—	—
ECHINODERMATA	39	68	71	78	84	64	65	92
Crinoidea	—	—	—	—	1	—	3	—
Holothuroidea	9	8	20	17	33	14	29	27
Echinoidea	21	57	31	16	22	—	6	16
Ophiuroidea	10	9	40	66	72	59	44	76
Asteroidea	9	9	20	16	6	5	12	5
HEMICHORDATA	—	—	1	<1	—	5	—	—
CHORDATA	14	24	19	14	12	5	15	24
Ascidiacea	14	24	19	14	12	5	15	24

Table 16
Mean number of specimens of each taxon per square meter in relation to bottom sediments.

Taxon	Bottom sediments						
	Gravel	Till	Shell	Sand	Sand-silt	Silt-clay	All types
PORIFERA	3.9	4.5	0.3	0.4	2.5	0.7	1.5
COELENTERATA	45.0	16.0	7.8	50.0	15.4	6.3	32.1
Hydrozoa	20.3	6.9	5.2	6.0	2.9	1.5	6.4
Anthozoa	24.7	10.9	2.6	44.0	12.5	4.8	25.7
Alcyonaria	1.6	—	—	0.2	0.9	1.6	0.8
Zoantharia	13.7	3.4	2.3	43.1	9.3	2.7	22.6
Unidentified	9.3	5.6	0.3	0.7	2.3	0.4	2.2
PLATYHELMINTHES	1.7	—	—	0.2	—	0.1	0.4
Turbellaria	1.7	—	—	0.2	—	0.1	0.4
NEMERTEA	4.9	0.9	27.5	13.3	5.1	3.4	8.2
ASCHELMINTHES	8.7	1.0	—	1.2	2.4	3.0	2.8
Nematoda	8.7	1.0	—	1.2	2.4	3.0	2.8
ANNELIDA	504.8	289.5	442.5	558.1	309.7	231.9	425.0
POGONOPHORA	—	—	—	<0.1	0.8	1.9	0.6
SIPUNCULIDA	4.0	4.4	6.0	7.1	5.3	5.5	5.9
ECHIURA	—	—	—	—	0.2	0.3	0.1
PRIAPULIDA	—	—	—	—	<0.1	<0.1	<0.1
MOLLUSCA	83.7	103.0	228.5	98.6	276.0	353.8	188.0
Polyplacophora	2.0	2.5	—	0.3	3.8	1.3	1.5
Gastropoda	40.3	9.1	82.7	11.2	22.0	11.9	17.8
Bivalvia	39.4	78.3	180.3	85.0	242.1	329.6	163.1
Scaphopoda	2.0	13.1	25.5	1.8	6.4	10.9	5.1
Cephalopoda	<0.1	—	—	<0.1	1.7	—	0.4
Unidentified	—	—	—	0.2	<0.1	—	0.1
ARTHROPODA	712.0	58.8	124.2	1,336.0	275.5	33.9	726.2
Pycnogonida	2.1	0.1	—	0.1	0.1	0.1	0.3
Arachnida	—	—	—	<0.1	—	—	<0.1
Crustacea	709.9	58.7	124.2	1,335.9	275.4	33.8	725.9
Ostracoda	<0.1	—	—	—	0.1	<0.1	<0.1
Cirripedia	28.7	1.0	5.0	16.4	55.5	0.2	21.8
Copepoda	—	—	—	0.1	0.1	0.1	0.1
Cumacea	10.5	1.2	7.5	45.3	18.3	7.0	25.8
Tanaidacea	—	—	—	—	0.1	0.1	<0.1
Isopoda	5.8	7.1	4.2	22.4	5.2	3.0	12.1
Amphipoda	639.7	49.5	98.8	1,237.6	193.0	23.1	655.8
Mysidacea	0.9	—	—	5.0	0.9	0.1	2.5
Decapoda	24.0	—	8.7	8.7	1.9	0.2	7.5
Unidentified	0.3	—	—	0.4	0.6	—	0.3
BRYOZOA	75.1	5.6	331.0	4.9	5.4	1.5	15.7
BRACHIOPODA	13.6	48.2	37.0	1.2	2.3	2.0	4.5
ECHINODERMATA	23.0	67.0	27.8	94.9	103.7	65.0	79.3
Crinoidea	—	—	—	—	0.1	<0.1	<0.1
Holothuroidea	3.7	25.4	2.0	2.2	7.4	4.1	4.3
Echinoidea	2.8	3.4	0.3	67.2	0.6	1.5	29.3
Ophiuroidea	15.8	38.0	25.5	23.8	94.3	57.8	44.2
Asteroidea	0.8	0.2	—	1.8	1.3	1.7	1.5
HEMICHORDATA	—	—	—	0.1	0.2	<0.1	0.1
CHORDATA	29.3	5.1	4.3	22.4	11.4	1.9	16.3
Ascidiacea	29.3	5.1	4.3	22.4	11.4	1.9	16.3
UNIDENTIFIED	2.9	5.6	—	5.8	6.4	7.0	5.8
Total	1,512.5	609.6	1,236.9	2,243.5	1,002.4	718.2	1,512.2

Table 17
The number of specimens of each taxon, expressed as a percentage of the total benthic invertebrate fauna, in relation to bottom sediments.

	Bottom sediments						
Taxon	Gravel	Till	Shell	Sand	Sand-silt	Silt-clay	All types
PORIFERA	0.3	0.7	<0.1	<0.1	0.2	0.1	0.1
COELENTERATA	3.0	2.6	0.6	2.3	1.5	0.9	2.1
Hydrozoa	1.3	1.1	0.4	0.3	0.3	0.2	0.4
Anthozoa	1.7	1.5	0.2	2.0	1.2	0.7	1.7
Alcyonaria	0.1	—	—	<0.1	0.1	0.2	0.1
Zoantharia	0.9	0.6	0.2	2.0	0.9	0.4	1.5
Unidentified	0.6	0.9	<0.1	<0.1	0.2	0.1	0.2
PLATYHELMINTHES	0.1	—	—	<0.1	—	<0.1	<0.1
Turbellaria	0.1	—	—	<0.1	—	<0.1	<0.1
NEMERTEA	0.3	0.2	2.1	0.6	0.5	0.5	0.5
ASCHELMINTHES	0.6	0.2	—	<0.1	0.2	0.4	0.2
Nematoda	0.6	0.2	—	<0.1	0.2	0.4	0.2
ANNELIDA	33.4	47.5	34.1	25.4	30.3	32.3	28.1
POGONOPHORA	—	—	—	<0.1	0.1	0.3	<0.1
SIPUNCULIDA	0.3	0.7	0.5	0.3	0.5	0.8	0.4
ECHIURA	—	—	—	—	<0.1	<0.1	<0.1
PRIAPULIDA	—	—	—	—	<0.1	<0.1	<0.1
MOLLUSCA	5.5	16.9	22.2	4.5	27.0	49.3	12.4
Polyplacophora	0.1	0.4	—	<0.1	0.4	0.2	0.1
Gastropoda	2.7	1.5	6.4	0.5	2.2	1.6	1.2
Bivalvia	2.6	12.8	13.9	3.9	23.7	45.9	10.8
Scaphopoda	0.1	2.2	2.0	0.1	0.6	1.5	0.3
Cephalopoda	<0.1	—	—	<0.1	0.2	—	<0.1
Unidentified	—	—	—	<0.1	<0.1	—	<0.1
ARTHROPODA	47.1	9.6	9.6	60.9	27.0	4.7	48.0
Pycnogonida	0.1	<0.1	—	<0.1	<0.1	<0.1	<0.1
Arachnida	—	—	—	<0.1	—	—	<0.1
Crustacea	46.9	9.6	9.6	60.9	27.0	4.7	48.0
Ostracoda	<0.1	—	—	—	<0.1	<0.1	<0.1
Cirripedia	1.9	0.2	0.4	0.8	5.4	<0.1	1.4
Copepoda	—	—	—	<0.1	<0.1	<0.1	<0.1
Cumacea	0.7	0.2	0.6	2.1	1.8	1.0	1.7
Tanaidacea	—	—	—	—	<0.1	<0.1	<0.1
Isopoda	0.4	1.2	0.3	1.0	0.5	0.4	0.8
Amphipoda	42.3	8.1	7.6	56.4	18.9	3.2	43.4
Mysidacea	0.1	—	—	0.2	0.1	<0.1	0.2
Decapoda	1.6	—	0.7	0.4	0.2	<0.1	0.5
Unidentified	<0.1	—	—	<0.1	0.1	—	<0.1
BRYOZOA	5.0	0.9	25.5	0.2	0.5	0.2	1.0
BRACHIOPODA	0.9	7.9	2.8	<0.1	0.2	0.3	0.3
ECHINODERMATA	1.5	11.0	2.2	4.3	10.2	9.0	5.2
Crinoidea	—	—	—	—	<0.1	<0.1	<0.1
Holothuroidea	0.2	4.2	0.2	0.1	0.7	0.6	0.3
Echinoidea	0.2	0.6	<0.1	3.1	0.1	0.2	1.9
Ophiuroidea	1.0	6.2	2.0	1.1	9.2	8.0	2.9
Asteroidea	<0.1	<0.1	—	0.1	0.1	0.2	0.1
HEMICHORDATA	—	—	—	<0.1	<0.1	<0.1	<0.1
CHORDATA	1.9	0.8	0.3	1.0	1.1	0.3	1.1
Ascidiacea	1.9	0.8	0.3	1.0	1.1	0.3	1.1
UNIDENTIFIED	0.2	0.9	—	0.3	0.6	1.0	0.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

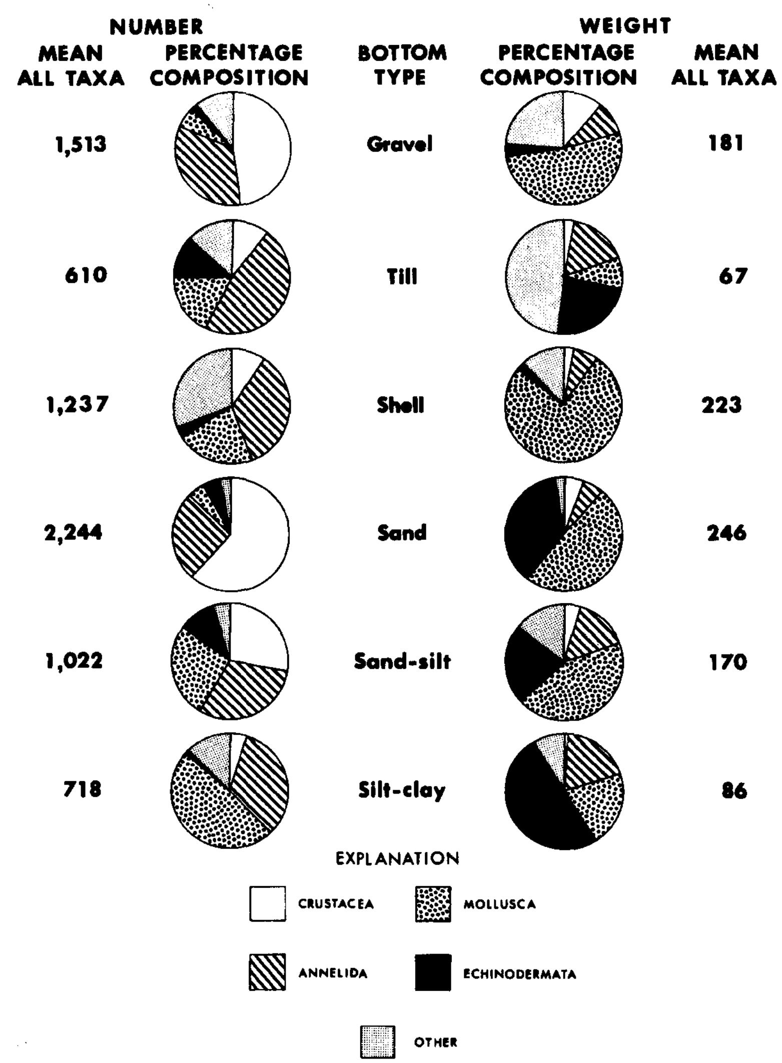


Figure 17
Quantitative composition of the total macrobenthic invertebrate fauna in relation to bottom type. Mean number of individuals and mean wet weight, per square meter of bottom area, and percentage composition, by density and biomass, of the major taxonomic groups are shown.

large part to occasional large animals. Those groups that contributed large specimens at those depths were Sipunculida, Echiura, Echinoidea, and Holothuroidea.

The percentage occurrence of each taxonomic group in samples in each depth range class is presented in Table 15.

Relation to Bottom Sediments

A marked disparity in the average density and biomass of benthic invertebrates was found among the various kinds of bottom sediments in the New England Region (Tables 16, 17; Fig. 17). Sand ranked far above the other sediment types in density, with an average of 2,244 individuals/m^2. Three sediment types—gravel, shell, and sand-silt—supported a moderate number of animals; their average densities ranged from 1,022 to 1,513/m^2. Lower densities (610 and 718/m^2) were found in till and silt-clay sediments.

Distribution of biomass (Tables 18, 19; Fig. 17) was similar to that of density. Sand and shell supported high (246 and 223 g/m^2) biomasses. Moderate quantities (170 and 181 g/m^2) occurred in gravel and sand-silt. Relatively low quantities were encountered in silt-clay and till sediments.

Table 18
Mean wet weight of specimens of each taxon (grams per square meter) in relation to bottom sediments.

	Bottom sediments						
Taxon	Gravel	Till	Shell	Sand	Sand-silt	Silt-clay	All types
PORIFERA	8.62	12.69	5.77	0.34	3.05	0.12	2.24
COELENTERATA	15.29	1.81	0.93	2.00	18.22	3.52	7.33
Hydrozoa	2.60	0.32	0.14	0.34	0.05	0.01	0.52
Anthozoa	12.69	1.49	0.79	1.66	18.17	3.51	6.81
Alcyonaria	0.09	—	—	0.22	0.29	0.20	0.20
Zoantharia	12.36	1.09	0.68	1.37	17.25	3.22	6.39
Unidentified	0.24	0.39	0.12	0.07	0.62	0.10	0.22
PLATYHELMINTHES	0.01	—	—	0.01	—	0.01	0.01
Turbellaria	0.01	—	—	0.01	—	0.01	0.01
NEMERTEA	0.52	0.06	6.09	0.81	0.83	0.46	0.71
ASCHELMINTHES	0.01	0.01	—	<0.01	0.01	0.01	0.01
Nematoda	0.01	0.01	—	<0.01	0.01	0.01	0.01
ANNELIDA	15.52	10.67	15.30	15.00	25.96	16.25	17.41
POGONOPHORA	—	—	—	<0.01	0.01	0.01	<0.01
SIPUNCULIDA	0.58	0.29	0.16	0.89	0.81	0.57	0.75
ECHIURA	—	—	—	—	0.79	0.69	0.30
PRIAPULIDA	—	—	—	—	<0.01	0.02	<0.01
MOLLUSCA	94.44	5.96	167.76	120.99	73.56	18.43	83.64
Polyplacophora	0.72	0.29	—	0.01	0.06	0.07	0.14
Gastropoda	3.25	0.21	2.13	3.32	1.60	0.22	2.23
Bivalvia	90.22	4.66	165.13	117.44	71.62	17.58	80.95
Scaphopoda	0.25	0.80	0.50	0.22	0.26	0.56	0.32
Cephalopoda	<0.01	—	—	0.01	0.02	—	0.01
Unidentified	—	—	—	<0.01	<0.01	—	<0.01
ARTHROPODA	20.32	1.93	6.26	11.92	6.95	0.62	9.41
Pycnogonida	0.05	<0.01	—	<0.01	<0.01	0.01	0.01
Arachnida	—	—	—	<0.01	—	—	<0.01
Crustacea	20.27	1.93	6.26	11.92	6.95	0.61	9.40
Ostracoda	<0.01	—	—	—	<0.01	<0.01	<0.01
Cirripedia	11.06	0.02	0.45	2.36	4.41	0.01	3.39
Copepoda	—	—	—	<0.01	<0.01	<0.01	<0.01
Cumacea	0.06	0.01	0.08	0.20	0.06	0.03	0.11
Tanaidacea	—	—	—	—	<0.01	<0.01	<0.01
Isopoda	0.21	1.36	0.04	0.44	0.14	0.09	0.29
Amphipoda	3.39	0.54	0.92	7.73	1.91	0.18	4.16
Mysidacea	0.01	—	—	0.02	0.01	<0.01	0.01
Decapoda	5.56	—	4.78	1.16	0.41	0.32	1.43
Unidentified	<0.01	—	—	<0.01	<0.01	—	<0.01
BRYOZOA	7.39	0.25	16.78	0.37	0.05	0.05	1.29
BRACHIOPODA	2.44	15.87	0.22	0.24	0.33	0.28	0.89
ECHINODERMATA	5.66	15.24	3.39	88.43	36.59	42.87	55.00
Crinoidea	—	—	—	—	<0.01	<0.01	<0.01
Holothuroidea	2.10	4.73	0.40	3.11	25.00	28.74	12.87
Echinoidea	1.98	4.73	2.25	80.68	3.43	7.26	36.75
Ophiuroidea	1.23	5.27	0.74	2.67	5.80	3.26	3.26
Asteroidea	0.34	0.50	—	1.98	2.27	3.61	2.13
HEMICHORDATA	—	—	—	0.02	0.04	<0.01	0.02
CHORDATA	9.70	1.98	0.09	4.35	2.36	1.95	4.10
Ascidiacea	9.70	1.98	0.09	4.35	2.36	1.95	4.10
UNIDENTIFIED	0.45	0.21	—	0.23	0.31	0.24	0.27
Total	180.94	66.97	222.75	245.60	169.88	86.10	183.39

Table 19

The wet weight of specimens of each taxon, expressed as a percentage of the total benthic invertebrate fauna, in relation to bottom sediments.

	Bottom sediments						
Taxon	Gravel	Till	Shell	Sand	Sand-silt	Silt-clay	All types
PORIFERA	4.8	19.0	2.6	0.1	1.8	0.1	1.2
COELENTERATA	8.5	2.7	0.4	0.8	10.7	4.1	4.0
Hydrozoa	1.4	0.5	0.1	0.1	<0.1	<0.1	0.3
Anthozoa	7.1	2.2	0.3	0.7	10.7	4.1	3.7
Alcyonaria	<0.1	—	—	0.1	0.2	0.2	0.1
Zoantharia	6.8	1.6	0.3	0.6	10.2	3.7	3.5
Unidentified	0.1	0.6	<0.1	<0.1	0.4	0.1	0.1
PLATYHELMINTHES	<0.1	—	—	<0.1	—	<0.1	<0.1
Turbellaria	<0.1	—	—	<0.1	—	<0.1	<0.1
NEMERTEA	0.3	0.1	2.7	0.3	0.5	0.5	0.4
ASCHELMINTHES	<0.1	<0.1	—	<0.1	<0.1	<0.1	<0.1
Nematoda	<0.1	<0.1	—	<0.1	<0.1	<0.1	<0.1
ANNELIDA	8.6	15.9	6.9	6.1	15.3	18.9	9.5
POGONOPHORA	—	—	—	<0.1	<0.1	<0.1	<0.1
SIPUNCULIDA	0.3	0.4	0.1	0.4	0.5	0.7	0.4
ECHIURA	—	—	—	—	0.5	0.8	0.2
PRIAPULIDA	—	—	—	—	<0.1	<0.1	<0.1
MOLLUSCA	52.2	8.9	75.3	49.3	43.3	21.4	45.6
Polyplacophora	0.4	0.4	—	<0.1	<0.1	0.1	0.1
Gastropoda	1.8	0.3	1.0	1.4	0.9	0.3	1.2
Bivalvia	49.9	7.0	74.1	47.8	42.2	20.4	44.1
Scaphopoda	0.1	1.2	0.2	0.1	0.2	0.6	0.2
Cephalopoda	<0.1	—	—	<0.1	<0.1	—	<0.1
Unidentified	—	—	—	<0.1	<0.1	—	<0.1
ARTHROPODA	11.2	2.9	2.8	4.8	4.1	0.7	5.1
Pycnogonida	<0.1	<0.1	—	<0.1	<0.1	<0.1	<0.1
Arachnida	—	—	—	<0.1	—	—	<0.1
Crustacea	11.2	2.9	2.8	4.8	4.1	0.7	5.1
Ostracoda	<0.1	—	—	—	<0.1	<0.1	<0.1
Cirripedia	6.1	<0.1	0.2	1.0	2.6	<0.1	1.8
Copepoda	—	—	—	<0.1	<0.1	<0.1	<0.1
Cumacea	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	0.1
Tanaidacea	—	—	—	—	<0.1	<0.1	<0.1
Isopoda	0.1	2.0	<0.1	0.2	0.1	0.1	0.2
Amphipoda	1.9	0.8	0.4	3.2	1.1	0.2	2.3
Mysidacea	<0.1	—	—	<0.1	<0.1	<0.1	<0.1
Decapoda	3.1	—	2.2	0.5	0.2	0.4	0.8
Unidentified	<0.1	—	—	<0.1	<0.1	—	<0.1
BRYOZOA	4.1	0.4	7.5	0.2	<0.1	0.1	0.7
BRACHIOPODA	1.4	23.7	0.1	0.1	0.2	0.3	0.5
ECHINODERMATA	3.1	22.8	1.5	36.0	21.6	49.8	30.0
Crinoidea	—	—	—	—	<0.1	<0.1	<0.1
Holothuroidea	1.2	7.1	0.2	1.3	14.8	33.4	7.0
Echinoidea	1.1	7.1	1.0	32.8	2.0	8.4	20.0
Ophiuroidea	0.7	7.9	0.3	1.1	3.4	3.8	1.8
Asteroidea	0.2	0.8	—	0.8	1.3	4.2	1.2
HEMICHORDATA	—	—	—	<0.1	<0.1	<0.1	<0.1
CHORDATA	5.4	3.0	<0.1	1.8	1.4	2.3	2.2
Ascidiacea	5.4	3.0	<0.1	1.8	1.4	2.3	2.2
UNIDENTIFIED	0.2	0.3	—	0.1	0.2	0.3	0.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 20
Frequency of occurrence (%) of each taxonomic group in the samples in each sediment type.

	Bottom sediments					
Taxon	Gravel	Till	Shell	Sand	Sand-silt	Silt-clay
PORIFERA	16	41	17	3	8	3
COELENTERATA	47	59	50	38	53	35
Hydrozoa	23	27	33	14	6	4
Anthozoa	24	32	17	24	47	31
Alcyonaria	4	—	—	1	10	12
Zoantharia	29	27	33	22	35	17
PLATYHELMINTHES	2	—	—	2	—	1
Turbellaria	2	—	—	2	—	1
NEMERTEA	28	14	50	42	47	29
ASCHELMINTHES	12	5	—	4	13	13
Nematoda	12	5	—	4	13	13
ANNELIDA	97	100	100	94	100	97
POGONOPHORA	—	—	—	<1	8	16
SIPUNCULIDA	20	23	17	25	28	18
ECHIURA	—	—	—	—	3	5
PRIAPULIDA	—	—	—	—	1	1
MOLLUSCA	75	96	100	86	94	93
Polyplacophora	14	27	—	3	11	9
Gastropoda	43	50	83	44	45	42
Bivalvia	68	96	100	79	92	91
Scaphopoda	17	46	33	10	30	31
Cephalopoda	1	—	—	1	1	—
ARTHROPODA	95	91	100	96	82	68
Pycnogonida	11	5	—	1	1	1
Arachnida	—	—	—	<1	—	—
Crustacea	95	91	100	96	82	68
Ostracoda	1	—	—	—	1	<1
Cirripedia	13	9	17	2	3	1
Copepoda	—	—	—	<1	1	<1
Cumacea	26	14	17	50	34	22
Tanaidacea	—	—	—	—	2	5
Isopoda	32	50	17	51	28	16
Amphipoda	93	77	100	94	74	51
Mysidacea	4	—	—	6	3	1
Decapoda	35	—	33	37	7	4
BRYOZOA	27	32	50	8	10	4
BRACHIOPODA	14	41	17	2	3	3
ECHINODERMATA	51	86	50	72	78	78
Crinoidea	—	—	—	—	1	<1
Holothuroidea	16	50	17	8	36	23
Echinoidea	14	32	17	47	8	15
Ophiuroidea	40	68	33	29	64	62
Asteroidea	8	9	—	14	16	14
HEMICHORDATA	—	—	—	<1	1	<1
CHORDATA	22	32	17	19	15	11
Ascidiacea	22	32	17	19	15	11