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Biomass and Density of Macrobenthic Invertebrates on the U. S. Continental Shelf off Martha's Vineyard, Mass., in Relation to Environmental Factors

Don Maurer and Roland L. Wigley

July 1984

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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741. Distribution of gammaridean Amphipoda (Crustacea) in the Middle Atlantic Bight region. By John J. Dickinson, Roland L. Wigley, Richard D. Brodeur, and Susan Brown-Leger. October 1980, iv + 46 p., 26 figs., 52 tables.

742. Water structure at Ocean Weather Station V, northwestern Pacific Ocean, 1966-71. By D. M. Husby and G. R. Seckel. October 1980, 18 figs., 4 tables.

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John V. Byrne, Administrator
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William G. Gordon, Assistant Administrator for Fisheries

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Biomass and Density of Macrobenthic Invertebrates on the U.S. Continental Shelf off Martha's Vineyard, Massachusetts, in Relation to Environmental Factors[1]

DON MAURER[2] and ROLAND L. WIGLEY[3]

ABSTRACT

The mean density and mean biomass of macrobenthic invertebrates on the U.S. continental shelf off Martha's Vineyard, Mass., were 3,008/m² and 245.7 g/m², respectively. The latter estimate was considerably higher than values from the North Sea, Scotian Shelf, and Middle-Atlantic Bight. Molluscs (pelecypods and gastropods) and echinoderms (echinoids and ophiuroids) greatly influenced patterns of total biomass distribution. The ocean quahog, *Arctica islandica*, was the dominant species in terms of biomass. Total density was dominated by crustaceans (amphipods), polychaetous annelids, molluscs (small pelecypods), and echinoderms (ophiuroids).

Mean density of mollusca was positively associated with sediment size. Mean biomass and density of crustacea were negatively associated with depth, grain size, and bottom temperature, whereas the same parameters for the Echinodermata were positively associated with those environmental factors.

Three faunal assemblages emerged which were analagous to those described from earlier studies on Georges Bank (sand fauna, silt-sand fauna, muddy-basin fauna). The fauna from the Mud Patch most closely resembled the silty-sand fauna.

INTRODUCTION

Research on the northeastern U.S. continental shelf has accelerated because of a wide variety of human activities ranging from fishing and recreation to transportation, mineral recovery, waste disposal, and oil and gas exploration (Grosslein et al. 1979). These activities are not always compatible, and managers face important decisions attempting to reconcile diverse uses of this valuable resource—the continental shelf. Before decisions can be made, the resource must be assessed in a variety of ways.

Any assessment of the shelf should involve benthic invertebrates, an important component of the shelf ecosystem (Mills and Fournier 1979). The benthos are important in their own right and as a measure of the health of the ecosystem, and play a critical role in trophic relationships providing a major source of energy to economically and ecologically important groundfish (Cohen et al.[4]). In addition, the benthos play a supporting role in nutrient exchange, providing a mechanism for flux of nutrients initially trapped in sediments to the water column (Zeitzschel 1980). The purpose of this account is to report on the distribution of biomass and density of macrobenthic invertebrates off Martha's Vineyard.

Georges Bank off southern New England has been the scene of intensive fishing activity for over 300 yr (Wigley 1961). The Georges Bank area is bounded on the southwest by Martha's Vineyard and Nantucket Island. Directly south of Martha's Vineyard is an area about 80-100 m deep termed the Mud Patch, consisting of fine-grain sediment. This sediment type is relatively rare on the northeastern shelf which normally consists of sand. The origin of the Mud Patch is uncertain, but it may be an active site of deposition (Milliman et al.[5]). If so, then processes controlling deposition of fine-grain sediment must be considered in assessing their effect on benthic biota. Presumably, benthos living in the Mud Patch would be exposed to relatively higher levels of particulate contaminants (trace metals, hydrocarbons) than benthos living on the surrounding, relatively dynamic, sand bottoms. Assuming this relationship, bioaccumulation of contaminants by the benthos might provide opportunity for biomagnification through food webs. The trophic relationship between demersal fish and benthos is well documented for Georges Bank (Wigley 1965).

In the early 1960's benthic research was conducted on the shelf south of Martha's Vineyard and Nantucket I. Some of these data were reported (Wigley 1963; Wigley and McIntyre 1964; Wigley and Stinton 1973), but the largest portion was placed in a data file report pending further analysis and synthesis (Maurer and Wigley[6]). The report contains maps of biomass and density distribution. With the advent of gas and oil exploration, together with other diverse activities on Georges Bank, documentation of the benthos in and around the Mud Patch would seem to be of special interest to man-

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[2]Southern California Ocean Studies Consortium, California State University, Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840.

[3]35 Wilson Road, Woods Hole, MA 02543.

[4]Cohen, E. B., M. D. Grosslein, M. P. Sissenwine, and F. Steimle. 1979. An energy budget of Georges Bank. Workshop on Multispecies Approaches to Fisheries Management, St. John's, Newfoundland, 26-30 November 1979, p. 1-37. National Marine Fisheries Service Woods Hole Lab., Woods Hole, Mass.

[5]Milliman, J. D., M. H. Bothner, and C. M. Parmenter. 1980. Seston in New England Shelf and Slope Waters, 1976-1977. *In* J. M. Aaron (editor), Environmental geological studies in the Georges Bank area, United States northeastern Atlantic Outer Continental Shelf, 1975-1977, p. 1-1 to 1-73. Final Report submitted to the Bureau of Land Management. U.S.G.S., Woods Hole, Mass.

[6]Maurer, D., and R. L. Wigley. 1981. Distribution of biomass and density of macrobenthic invertebrates on the U.S. Continental Shelf off Martha's Vineyard. Lab. Ref. Doc. 81-15 (unpubl.), 97 p. Northeast Fisheries Center, NMFS, NOAA, Woods Hole, Mass.

agers because of its proximity to the coast and its potential as a depositional sink of contaminants. Although there are a number of review documents dealing with benthos off southern New England (Pratt 1973; TRIGOM-PARC[7]; Wigley and Theroux[8,9]; Maurer[10]), no study has featured the fauna of the Mud Patch.

MATERIALS AND METHODS

Field and Laboratory

Samples were collected 11-20 June 1962 by the National Marine Fisheries Service vessel RV *Delaware* at 64 stations south of Martha's Vineyard, Mass. (Fig. 1, Appendix Table 1). Stations were spaced at intervals of 16 km on a grid pattern with eight north-south transects at right angles to the depth contours. At each station (except station 7) two quantitative bottom samples were collected with a Smith-McIntyre grab. This instrument effectively sampled a 0.1 m^2 area of bottom to a depth of 10-17 cm. At sea, grab samples for macrobenthic studies were washed through a 1.0 mm mesh screen. Macrobenthos remaining on the screen after washing were removed and preserved in a solution of neutral Formalin.

In the laboratory macrobenthos were sorted, identified, counted, and weighed. External moisture was removed from specimens by blotting. Shells, internal skeletons, and exoskeletons were included in the values expressed as wet weight biomass (g/m^2).

Sediment samples were collected with a Dietz-LaFond grab at each station and at two localities equally spaced between stations along the cruise. The locations of sediment samples used in conjunction with biological analyses are depicted in Figure 1. Terminology follows the Wentworth Particle Size Classification (Twenhofel and Tyler 1941), and nomenclature follows the classification of Shepard (1954) and Emery (1960). Determinations were made of median sediment size (ϕ), percent sand, percent silt, percent clay, percent Kjeldahl nitrogen, percent organic carbon measured, and carbon/nitrogen ratio of the sediments (Hathaway [11]). Standard sieving procedures were used to measure sediment size. Based on sediment analyses, a composite sediment-type map was made (Fig. 2). Appendix Table 1 lists environmental data per station.

[7]TRIGOM-PARC. 1974. A socio-economic and environmental inventory of the North Atlantic Region, Vol. 1, Book 3, 198 p. Report to the Bureau of Land Management, South Portland, Me.

[8]Wigley, R. L., and R. B. Theroux. 1976. Macrobenthic invertebrate fauna of the Middle Atlantic Bight region. Part II: Faunal composition and quantitative distribution. Northeast Fisheries Center, NMFS, Woods Hole, Mass., 395 p.

[9]Wigley, R. L., and R. B. Theroux. Reconnaissance survey of the quantitative distribution of macrobenthic invertebrates in the offshore New England region. Manuscr. in prep. Northeast Fisheries Center, NMFS, Woods Hole, Mass.

[10]Maurer, D. 1982. Review of benthic invertebrates of Georges Bank in relation to gas and oil exploration with emphasis on management implications. Report to Northeast Fisheries Center, Woods Hole, Mass., and Sandy Hook Laboratory, Highlands, N.J., 329 p.

[11]Hathaway, J. C. (editor). 1971. Data file, continental margin program, Atlantic Coast of the United States. Vol. 2. Sample collection and analytical data. Ref. No. 71-15, 496 p. Woods Hole Oceanographic Institution, Woods Hole, Mass.

Analysis

Wet weight and number per taxon by station and gear were punched on cards and a computer listing was prepared. Based on the listing, the average biomass and density per station of major taxa (Amphipoda, Pelecypoda, Asteroidea, etc.) were determined and distribution maps plotted by computer (Maurer and Wigley footnote 6). In some cases, maps were also made of particularly important genera and species. Correlation coefficients (R) were computed for average weight and number transformed ($\log_e (N + 1)$) of major taxa in relation to environmental variables.

ENVIRONMENTAL SETTING

Physiography

The Georges Bank area off New England is a submerged northeast extension of the Atlantic Coastal Plain (Aaron[12]). The Bank, which encompasses about 42,000 km^2, is covered by up to 200 m of water. The study area for this account (Fig. 1) lies immediately southwest of the Bank.

The study area encompasses about 130 km^2 and extends across the continental shelf to the upper portion of the continental slope. Bottom topography is moderately smooth. Water depths increase gradually and rather uniformly from shore outward to the shelf break, about 120 m. The average gradient of the continental slope off the Middle Atlantic Bight varies from 2° to 7° (Milliman 1973); beyond the shelf break in the study area, the depth gradient is relatively steep, averaging 4° (Wigley and Stinton 1973). The most distinguishing feature on the shelf break is the number of gullies and canyons that transect the slope (Fig. 1).

Sediment Composition

Six major sediment types occurred in the study area (Fig. 2). Sand, silty sand, and sandy silt occurred over a large area, whereas gravel-sand, sand-silt-clay, and silt were much less widespread. Sand with some gravel (stations 1, 45, 47) covered more than half the area, mainly in shallow water (0 to 60-80 m) except in the eastern sector and in a narrow (6 km) band parallel to and just below the outer periphery of the continental shelf. In shallow water the sands were silt free and occasionally mixed with large quantities of shell (mollusks and echinoderm plates). Admixtures of silt occurred with the sand over most of the remaining area.

A large area (80 × 100 km) of fine-grain sediment (Mud Patch) occurred in the southwestern sector (Fig. 2). A relatively circular area of sand-silt-clay near its center was surrounded by an inner band of sandy silt which grades to an outer band of silty sand. Illite is normally the most important clay mineral, and organic carbon is higher here than in the surrounding sand (Appendix Table 1). This is the largest known natural area of fine-grain sediment on the Middle Atlantic Shelf. Sediments on the continental slope were dominated by silt and clay.

[12]Aaron, J. M. 1980. A summary of environmental geologic studies in the Georges Bank area, United States northeastern Atlantic outer continental shelf, 1975-1977. Executive Summary of the Final Report submitted to the Bureau of Land Management. U.S.G.S., Woods Hole, Mass., 22 p.

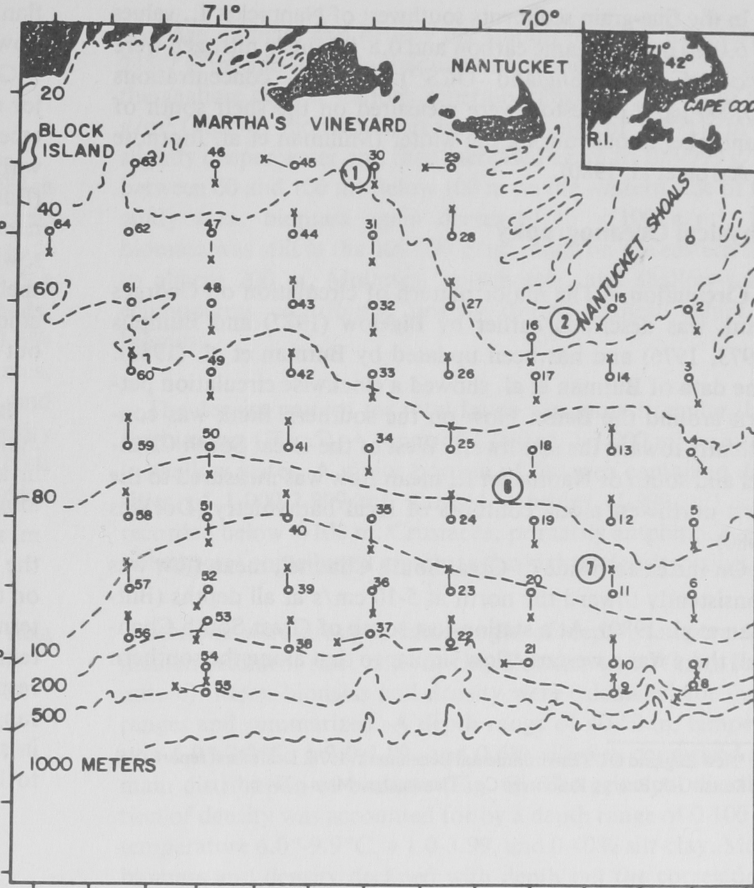

Figure 1.—Location of stations of bottom samples for fauna (o) and sediment (x) off Martha's Vineyard, Mass., June 1962. Stations 1, 2, 6, and 7 are from the 1977 BLM study.

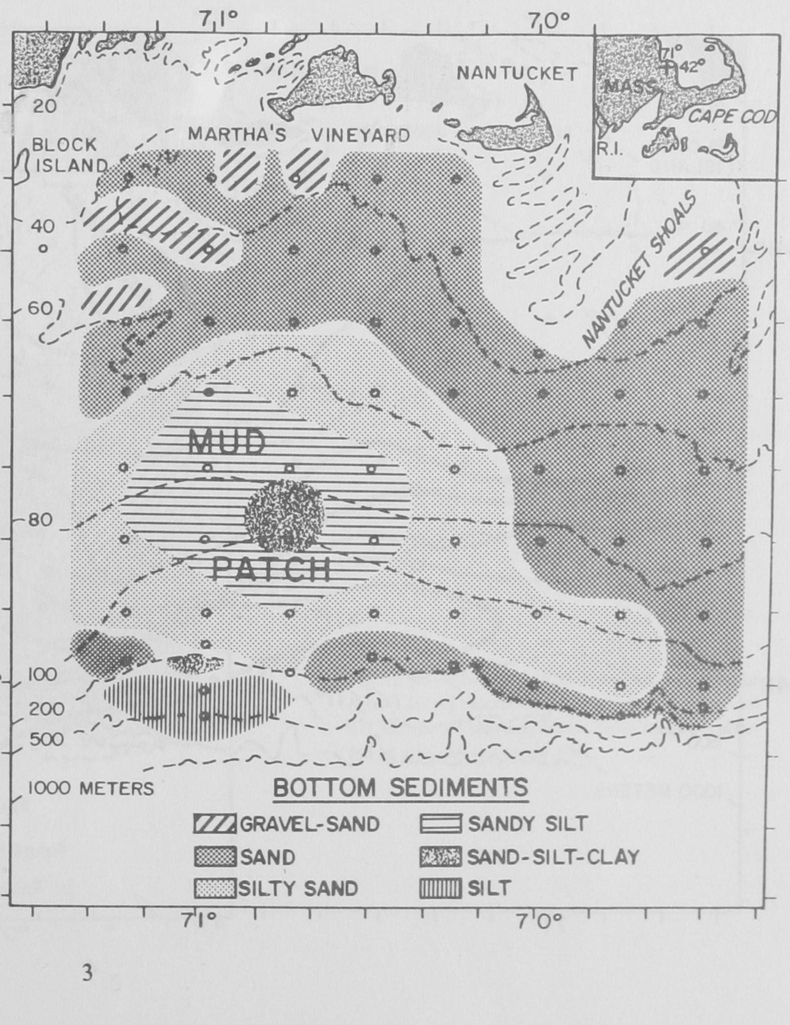

Figure 2.—Bottom-sediment types off Martha's Vineyard, Mass., from samples collected at stations (o), June 1962.

In the fine-grain sediments southwest of Nantucket I., values of 6.0-10 mg/g organic carbon and 0.8-1.2 mg/g nitrogen were recorded (New England OCS[13]). Highest concentrations (15,000 μg/l) of seston were measured on the shelf south of Nantucket Shoals during the winter (Milliman et al. footnote 5; Aaron et al. 1980).

Physical Oceanography

Circulation.—The major pattern of circulation on Georges Bank was described earlier by Bigelow (1927) and Bumpus (1973, 1976) and has been updated by Butman et al. (1980). The data of Butman et al. showed a clockwise circulation pattern around the Bank. Flow on the southern flank was consistently toward the southwest. West of the Great South Channel and south of Nantucket I., mean flow was measured to the west-northwest along contours of local bathymetry (Dorkins 1980).

On the eastern side of Great South Channel, mean flow was consistently toward the north at 5-10 cm/s at all depths (Butman et al. 1980). At a station just south of Great South Channel, there was a westerly flow similar to that along the southern flank. On the western side of Great South Channel, little net flow was measured.

Great South Channel has been historically considered a major exit for Gulf of Maine waters (Schlitz in press). However, recent water current measurements indicate that mean flow within the channel is directed mainly toward the Gulf of Maine (Butman et al. 1980). Schlitz et al. (1977) showed that a permanent front exists across the channel from Nantucket Shoals toward Georges Bank, separating the Gulf of Maine from the shelf to the south. According to Schlitz (in press), a small amount of water flows southward through Nantucket Shoals, but this probably does not contribute a significant volume.

Bottom temperature.—When the study was conducted in June 1962, a cell of cold bottom water (6.1°-6.9°C) extended in an east-west band from the New York Bight eastward to long. 69°30′W (Fig. 3). This cell occurred at depths of 40-80 m, roughly the mid-shelf region. The cold cell was bounded on the north by higher coastal water temperatures (<12°C) and on the south by values of 10-12°C near the shelf break. Long-term (1940-66) annual maximum and minimum bottom-water temperatures near the shelf break were 16°-17°C and 1°-2°C, respectively (Colton and Stoddard 1973). However, the annual range here is normally 2°C. Offshore shelf waters, particularly in shallow portions, may range from 3°C in February-March to 14°C in September-November (Wigley and Stinton 1973).

[13]New England OCS Environmental Benchmark. 1978. Draft final report, Vol. V, Sects. G-J. Energy Resources Co., Cambridge, Mass., 224 p.

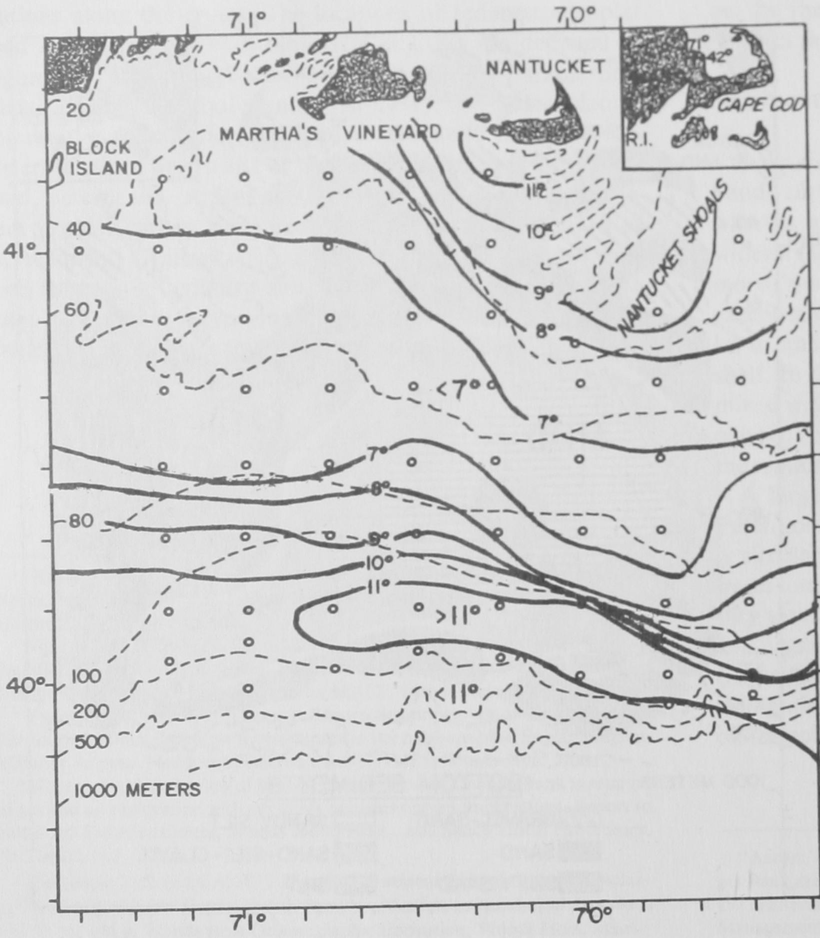

Figure 3.—Bottom temperature (°C) off Martha's Vineyard, Mass., from measurements taken at stations (o), June 1962.

RESULTS

Faunal Composition

A total 214 taxa were identified (Appendix Table 2). Since some taxa were identified only to phylum (Porifera, Nemertea) and since some taxa identified to genus may include several species, the total number of taxa is conservative. Of the number of taxa, ~24.3% were molluscs, 27.1% arthropods, 24.3% polychaetous annelids, 10.7% echinoderms, and 13.6% miscellaneous taxa, including sipunculids, coelenterates, nemerteans, ectoprocts, ascidiaceans, pogonophorans, and hemichordates. Biomass (wet weight g/m^2) and density ($no./m^2$) are presented in Appendix Tables 3 and 4. About 190,000 individuals and 15,500 g of specimens were collected.

Total Faunal Biomass and Density

Biomass and density were distributed among the major taxa as follows:

	Biomass (g/m^2)	*Density* ($no./m^2$)
Annelida	10.9%	20.3%
Mollusca	56.7%	5.9%
Crustacea	4.1%	62.5%
Echinodermata	21.3%	7.0%
Misc. taxa	7.0%	4.3%

Average biomass and density per station for total fauna were 245.7 g/m^2 and 3,008 individuals/m^2, respectively. Biomass in the shallow central stations generally ranged from 100 to 999 g/m^2 (Fig. 4). Biomass decreased to a range of 1-100 g/m^2 in slightly deeper water and then increased again to 100-999 g/m^2 between 60 and 100 m. Below 100 m on the western side of the study area, biomass again decreased to <100 g/m^2, but biomass was still in the 100-999 g/m^2 range on the eastern side to almost 200 m. Molluscs, polychaetes, and shallow-water echinoderms contributed heavily to the highest values of biomass.

The density pattern for total fauna was more irregular than for biomass (Fig. 5). A range of 1,000 to $>3{,}000$ m^2 occurred in shallow water. A major portion of the area contained densities of 1,000-2,999/m^2. Lowest densities (1-999/m^2) were recorded below ~100 m. Crustacea, primarily amphipods, and polychaetes contributed greatly to the highest density values.

Stations were grouped into ranges of depth, temperature, median sediment size, and silt-clay (Maurer and Wigley footnote 6). Mean biomass and density were calculated for those ranges and summarized. A depth range of 40-80 m, temperature 6.0°-7.9°C, ϕ 2.0-3.99, and 0.6% silt-clay comprised the main distribution of biomass (Fig. 6). The principal distribution of density was accounted for by a depth range of 0-100 m, temperature 6.0°-9.9°C, ϕ 1.0-3.99, and 0-40% silt-clay. Mean biomass and density declined with depth but the correlations were low ($R = -0.20$).

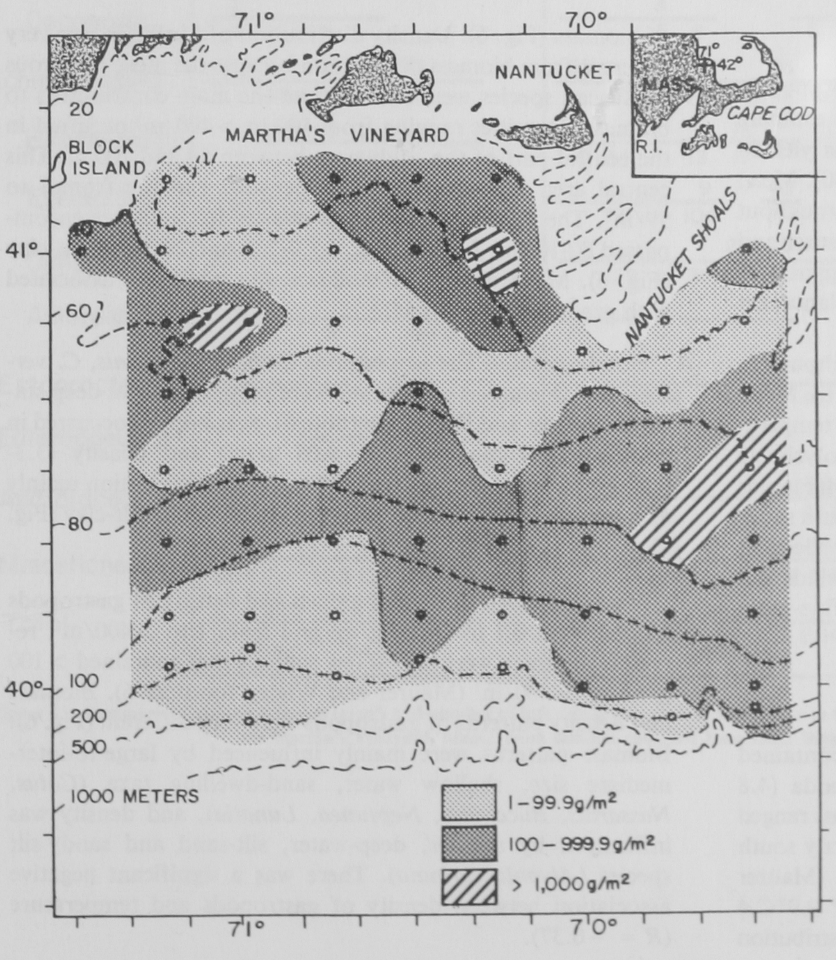

Figure 4.—Quantitative distribution of biomass (g/m^2) for all macrobenthic invertebrates combined off Martha's Vineyard, Mass., from samples collected at stations (o), June 1962.

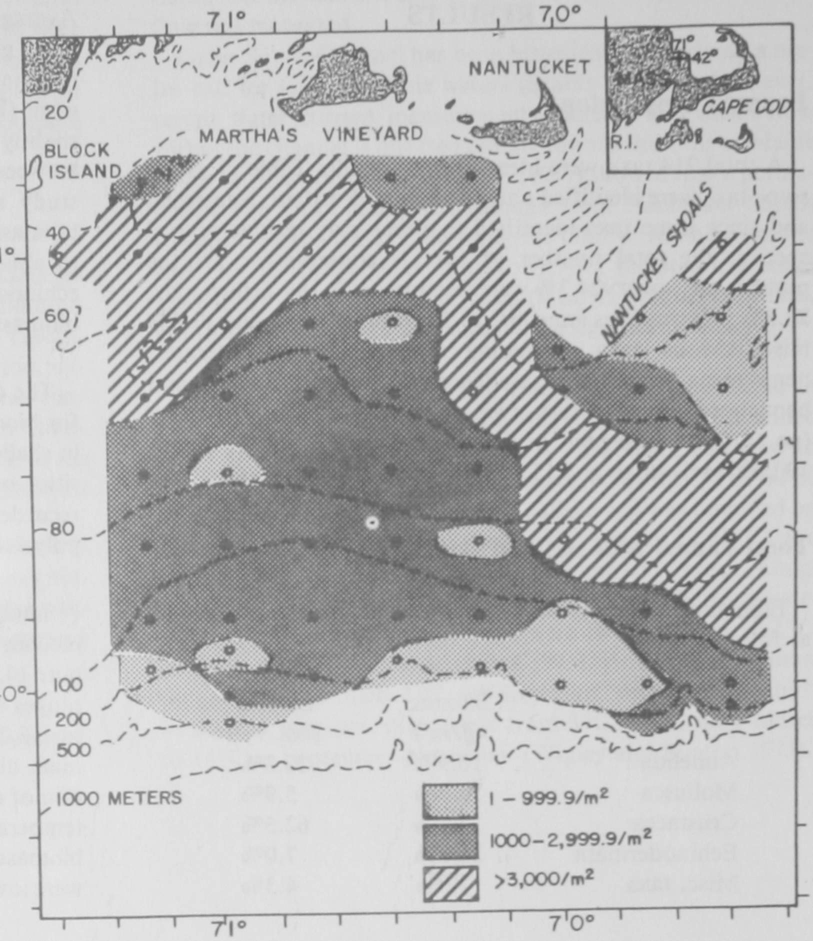

Figure 5.—Quantitative distribution of individuals (no./m²) for all macrobenthic invertebrates combined off Martha's Vineyard, Mass., from samples collected at stations (o), June 1962.

Polychaetous Annelids

Many species of polychaetes were identified (Appendix Table 2). The number of species is a conservative estimate because recent work with a 0.5 mm mesh sieve has yielded higher numbers of species (Maurer and Leathem 1980). Mean biomass of polychaetes ranged from 0.1-39 g/m² throughout most of the area to >100 g/m² at a few stations (Maurer and Wigley footnote 6). A biomass range of 40-99 g/m² was measured directly south of Nantucket I. and Nantucket Shoals.

Polychaetes were more evenly distributed throughout environmental ranges than any of the major taxa (Fig. 6). Mean biomass and density were negatively associated with temperature ($R = -0.39$, $R = -0.39$). A number of polychaete species showed marked differential distribution. Maldanids and *Scalibregma inflatum* occurred in shallow water and sand. The latter species showed the same relationship over Georges Bank (Maurer and Leathem 1980). In contrast, terebellids and *Sternapis scutata* occurred in deeper water with fine-grain sediment.

Mollusca

In terms of mean biomass and density, Mollusca contained Scaphopoda (0.1 and 0.6%, respectively), Gastropoda (4.8 and 15.2%), and Pelecypoda (95.1 and 84.2%). Biomass ranged from 0.1 to >100 g/m² with the highest values directly south of Nantucket Shoals and southwest of Nantucket I. (Maurer and Wigley footnote 6). A depth range of 20-80 m, 6.0°-9.9°C, ϕ 2.0-3.9, and 0-20% silt-clay comprised the main distribution of biomass (Fig. 6). Density distribution of Mollusca was very different from biomass distribution because the most numerous molluscan species were smaller than the main contributors to biomass. Densities ranging from 100 to >400/m² occurred in the central part of the study area between 60 and 100 m. This central area was surrounded by densities ranging from 1 to 99/m². The main distribution of density for molluscs encompassed 80-100 m, 7.0°-10.9°C, ϕ 3.0-5.9, and 20-100% silt-clay (Fig. 6). Mean density of mollusca was positively associated with grain size ($R = 0.44$).

Scaphopoda.—The scaphopods *Cadulus pandionis*, *C. verrilli*, and *Dentalium occidentale* were sampled only at deep stations (Maurer and Wigley footnote 6). Scaphopods occurred in relatively low biomass (0.05-0.08 g/m²) and density (3.3-7.5/m²) in water deeper than 200 m. Their distribution mainly encompassed 10.0°-12°C, ϕ 4.0-5.9, and 40-80% silt-clay (Fig. 6).

Gastropoda.—Although biomass and density of gastropods ranged from 0.1 to >100 g/m² and from 1 to >400/m², respectively, there were only a few stations that contained >100 g/m² or >400/m² (Maurer and Wigley footnote 6). Biomass and density patterns of gastropods were very different (Fig. 6). Biomass patterns were mainly influenced by large-to-intermediate size, shallow water, sand-dwelling taxa (*Colus*, *Nassarius*, *Buccinum*, *Neptunea*, *Lunatia*), and density was influenced by smaller, deep-water, silt-sand and sandy-silt species (*Alvania carinata*). There was a significant negative association between density of gastropods and temperature ($R = -0.37$).

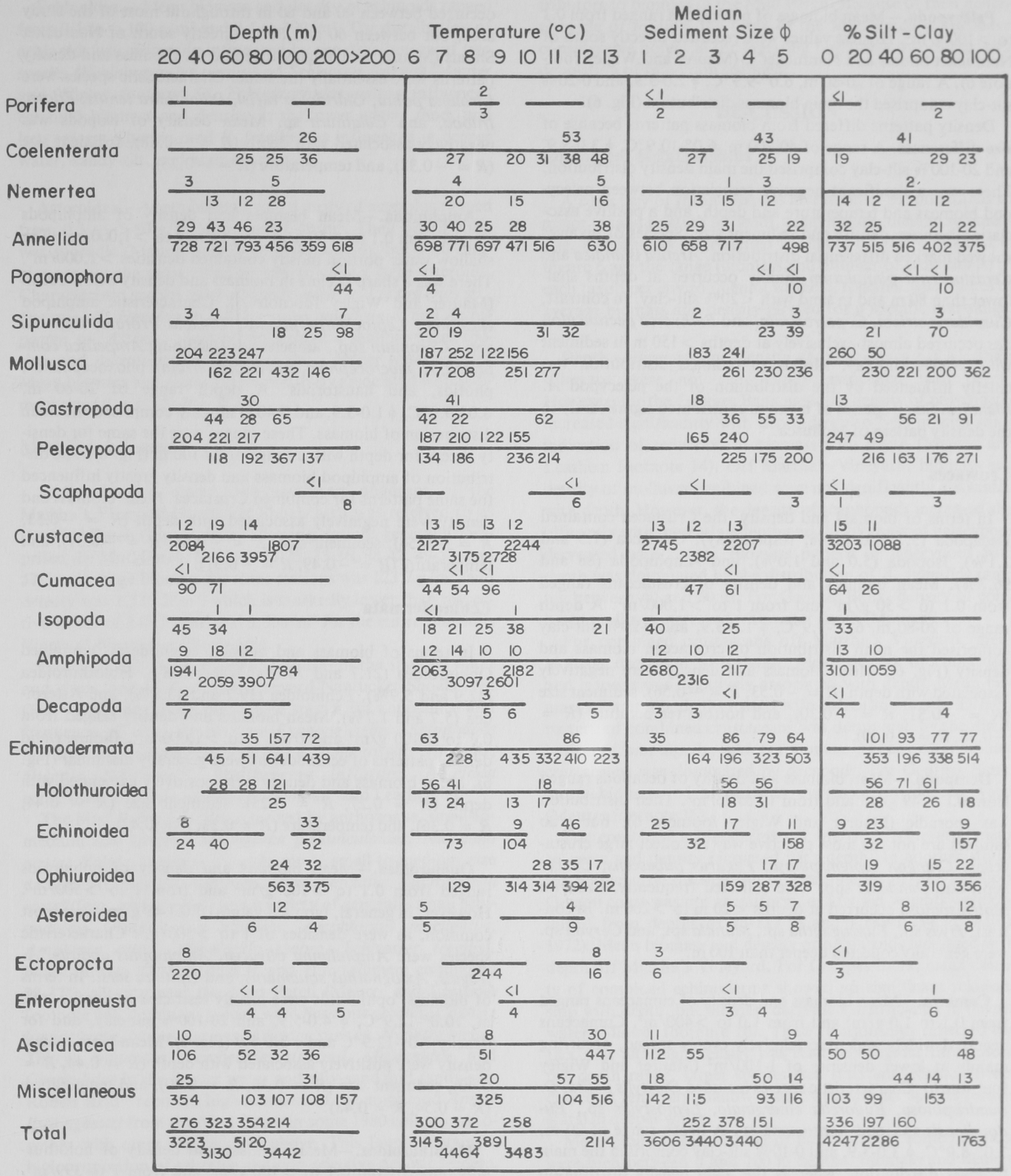

Figure 6.—Summary of average biomass (g/m²) and number of individuals (no./m²) of major taxa in relation to depth, temperature, median sediment size, and silt-clay, off Martha's Vineyard, Mass., from samples collected June 1962. Biomass above line; number below line.

Pelecypoda.—Mean biomass of pelecypods ranged from 0.1 to >100 g/m². Highest values were recorded directly south of Nantucket Shoals and Nantucket I. (Maurer and Wigley footnote 6). A range of 20-80 m, 6.0°-9.9°C, ϕ 2.0-3.9, and 0-20% silt-clay comprised the main biomass distribution (Fig. 6).

Density patterns differed from biomass patterns because of size differences. A range of 40-200 m, 6.0°-10.9°C, ϕ 3.0-5.9, and 20-100% silt-clay comprised the main density distribution. There was a significant negative association between pelecypod biomass and temperature and depth, and a positive association between density and sediment size. Species of bivalves showed marked differential distribution. *Arctica islandica* and *Cerastoderma pinnulatum* mainly occurred at depths shallower than 80 m and in sand with <20% silt-clay. In contrast, *Cuspidaria striata*, *C. perrostrata*, and *Bathyarca pectunculoides* occurred almost exclusively at depths >150 m in sediment wit.. >50% silt-clay. Molluscan biomass distribution was chiefly influenced by the distribution of the pelecypod *A. islandica*. Small species of bivalves contributed significantly to the density pattern of Mollusca.

Crustacea

In terms of biomass and density, the Crustacea contained Decapoda (5.7 and 0.2%, respectively), Cumacea (1.3 and 2.1%), Isopoda (5.0 and 1.0%), and Amphipoda (88 and 96.7%). Mean biomass and density of crustaceans ranged from 0.1 to >50 g/m² and from 1 to >1,000/m². A depth range of 20-80 m, 6.0°-9.9°C, ϕ 1.0-3.9, and 0-20% silt-clay comprised the main distribution of crustacean biomass and density (Fig. 6). Mean biomass and density were negatively associated with depth ($R = -0.53$, $R = -0.56$), sediment size ($R = -0.31$, $R = -0.30$), and bottom temperature ($R = -0.48$, $R = -0.50$).

Decapoda.—Mean biomass and density of decapods ranged from 0.1 to 49 g/m² and from 10 to 25/m². Their distribution was sporadic (Maurer and Wigley footnote 6), but grab samples are not the most effective way to collect large crustaceans. *Crangon septemspinosa*, *Pagurus pubescens*, *Cancer* spp., and *Pandalus* spp. were collected frequently. *Crangon septemspinosa* occurred at depths <20 m to >200 m. In contrast, *Hyas* sp., *Euprognatha* sp., *Munida* sp., and *Geryon* sp. were generally collected deeper than 100 m.

Cumacea.—Mean biomass and density of cumaceans ranged from 0.1 to 1.0 g/m² and from 1.0 to >400/m². Cumaceans occurred widely and were relatively evenly spread, occurring mainly at lower densities of 1-100/m² (Maurer and Wigley footnote 6). Characteristic species included *Diastylis polita*, *D. quadrispinosa*, *Eudorella emarginata*, *Leptostyllis* sp., *Eudorellopsis* sp., and *Leptocuma* sp. A depth range of 20 m, 7.0°-8.9°C, ϕ 3.0-3.9, and 0-10% silt-clay comprised the main biomass distribution, whereas the main density distribution was most accurately contained in a depth range of 20-40 m, 6.0°-8.9°C, ϕ 2.0-3.9, and 0-20% silt-clay (Fig. 6). Mean biomass and density of cumaceans were negatively associated with depth ($R = -0.36$, $R = -0.52$), and density with temperature ($R = -0.29$).

Isopoda.—Mean biomass and density ranged from 0.1 to 10 g/m² and from 1 to >100/m². The greatest numbers of isopods occurred between 40 and 60 m throughout most of the study area, but between 60 and 80 m directly south of Nantucket Shoals (Maurer and Wigley footnote 6). Biomass and density patterns were essentially the same. Characteristic species were *Cirolana polita*, *Chiridotea tuftsi*, *Ptilanthura tenuis*, *Edotea triloba*, and *Calathura* sp. Mean density of isopods was negatively associated with depth ($R = -0.38$), sediment size ($R = -0.38$), and temperature ($R = -0.26$).

Amphipoda.—Mean biomass and density of amphipods ranged from 0.1 to >50 g/m² and from 1 to >1,000/m². The shallow water portion mostly contained densities >1,000/m². There was a sharp decline in biomass and density below 100 m (Maurer and Wigley footnote 6). Characteristic amphipod taxa were *Leptocheirus pinguis*, *Unciola irrorata*, *Caprella* spp., *Coropium* spp., ampelescids (including *Ampelisca compressa*, *A. macrocephala*, and *Byblis serrata*), phoxocephalids, photids, and haustoriids. A depth range of 20-80 m, 6.0°-9.9°C, ϕ 1.0-3.9, and 0-40% silt-clay comprised the main distribution of biomass. These ranges were the same for density except for depth with a range of 20-100 m (Fig. 6). The distribution of amphipod biomass and density greatly influenced the same patterns for combined Crustacea. Mean biomass and density were negatively associated with depth ($R = -0.53$, $R = -0.54$), sediment size ($R = -0.31$, $R = -0.31$), and temperature ($R = -0.49$, $R = -0.51$).

Echinodermata

In terms of biomass and density, echinoderms contained Ophiuroidea (21.7 and 78.6%, respectively), Holothuroidea (52.9 and 5.9%), Echinoidea (19.7 and 13.8%), and Asteroidea (5.7 and 1.7%). Mean biomass and density ranged from 0.1 to >100 g/m² and from 1 to >1,000/m². Biomass and density patterns of echinoderms were generally dissimilar (Fig. 6). Mean biomass and density were positively associated with depth ($R = 0.27$, $R = 0.25$), sediment size ($R = 0.44$, $R = 0.36$), and temperature ($R = 0.33$, $R = 0.42$).

Ophiuroidea.—Mean biomass and density of ophiuroids ranged from 0.1 to >100 g/m² and from 1 to >500/m². However, in general, biomass values of 0.1-49 g/m² were most common, as were densities of 1 to >500/m². Characteristic species were *Amphilimna olivacea*, *Amphioplus abditus*, *A. fragilis*, *Axiognathus squamatus*, and *Ophiura sarsi*. In terms of biomass, ophiuroids were mainly restricted to depths >80 m, 10.0°-12.9°C, ϕ 4.0-5.9, and 20-100% silt-clay, and for density 7.0°-12.9°C and ϕ 3.0-5.9 (Fig. 6). Mean biomass and density were positively associated with depth ($R = 0.44$, $R = 0.40$), sediment size ($R = 0.36$, $R = 0.40$), and temperature ($R = 0.54$, $R = 0.48$).

Holothuroidea.—Mean biomass and density of holothurians ranged from 0.1 to >100 g/m² and from 1 to 399/m². Holothurians were almost exclusively collected in the deeper portion of the study area below 80 m (Maurer and Wigley footnote 6). Characteristic species were *Synapta* sp., *Astichopus* sp., *Molpadia* sp., and *Havelockia scabra*. A depth range of 40-100 m, 6.0°-7.9°C, ϕ 3.0-4.9, and 20-80% silt-clay comprised the main biomass distribution, whereas a depth range of 80-100 m and 6.0°-10.9°C comprised the main density distribution (Fig. 6).

Echinoidea.—Mean biomass and density of echinoids ranged from 0.1 to >100 g/m² and 0.1 to 399/m². The distribution of echinoids was primarily influenced by the distribution of two species (*Echinarachnius parma* and *Schizaster fragilis*) (Maurer and Wigley footnote 6). *Echinarachnius parma* influenced echinoid biomass and density in shallower water, sand, and low percent silt-clay, and *S. fragilis* was influenced in deeper water, sandy-silt, and high silt-clay.

Asteroidea.—Mean biomass and density of asteroids ranged from 0.1 to >50 g/m² and from 1-49/m². Their distribution was sporadic (Maurer and Wigley footnote 6), but grab samples are not the most effective way to collect large asteroids. Characteristic species were *Asterias vulgaris*, *Leptasterias* sp., *Porania* sp., *Henricia* sp., *Astropecten americanus*, and *Astropecten* sp. *Asterias vulgaris* represented a shallow-water species, and *Astropecten americanus* was a deeper water species. Mean biomass and density were positively associated with sediment size ($R = 0.32$, $R = 0.26$).

Mud Patch Fauna

Earlier in this report, the southwest quadrant of the Martha's Vineyard-Nantucket Shoals area was referred to as the Mud Patch (Fig. 2). The following stations generally comprised the Mud Patch: Stations 23-25, 33-36, 38-42, 49-53, and 57-59. Average biomass for these stations was 123.7 g/m², and density was 1,536.2/m², which is markedly lower than respective values of 245.7 g/m² and 3,008/m² for the entire Martha's Vineyard-Nantucket Shoals area.

Based on two BLM stations (1 and 2) in the shallow water and clean sand of Martha's Vineyard-Nantucket Shoals area (Fig. 1), the dominant polychaete species (in abundance and frequency of occurrence) were *Exogone hebes*, *Spiophanes bombyx*, *Parapionosyllis longicirrata*, *Sphaerosyllis erinaceus*, *Owenia fusiformis*, *Scalibregma inflatum*, *Aricidea catherinae*, and *Spio pettiboneae* (Maurer and Leathem[14]).

The Mud Patch was characterized by anthozoans, small-to-medium size bivalves (*Bathyarca pectunculoides*, *Nuculana acuta*, *Yolida sapotilla*, *Nucula* spp.), small-to-medium size decapods (*Catapagurus sharreri*, *Hyas coarctatus*, *Euprognatha rastellifera*, *Munida iris*), and a variety of generally small echinoderms (*Amphilimna olivacea*, *Amphioplus macilentus*, *Amphiura otteri*, *Havelockia scabra*, *Schizaster fragilis*). Based on two BLM stations (6 and 7) in sediment containing 32-37% silt-clay near the Mud Patch (Maurer and Leathem footnote 14), dominant species were *Paraonis gracilis*, *Cossura longocirrata*, *Ninoe nigripes*, *Aricidea suecica*, *Nephtys incisa*, *Tharyx annulosus*, *Terebellides stroemii*, *Maldanidae*, and *Cirratulidae* in the deeper water and silty-sand and sandy-silt. Robert Reid[15] reported high numbers of the amphipod *Ampelisca agassizi* from the Mud Patch in some 1980 collections together with other species cited above. This fauna contains a high proportion of selective and non-selective deposit feeders, both surface and buried, representing a typical soft-bottom community. Echinoderms were particularly important as contributors to biomass in the Mud Patch. Because of their general mode of feeding, the biota of the Mud Patch would have considerable potential for ingesting pollutants associated with deposition of fine-grain sediment.

[14]Maurer, D., and W. Leathem. 1980. Ecological distribution of polychaetous annelids of Georges Bank. CMS-1-80. College of Marine Studies, Univ. of Delaware, Lewes, Del., 181 p.

[15]Robert Reid, Northeast Fisheries Center Sandy Hook Laboratory, National Marine Fisheries Service, NOAA, Highlands, NJ 07732, pers. commun. 1981.

DISCUSSION

Ecological Relationships

A summary of mean biomass and number of individuals of major taxa in relation to depth, temperature, median sediment size, and silt-clay is presented in Figure 6. Also contained in Figure 6 age the range (biomass and number of individuals) of each taxon per environmental variable, together with values of average biomass and density plotted for a specific mid-range.

Depth.—Biomass and density of polychaetes off Martha's Vineyard were not significantly associated with depth. However, for the Georges Bank area, the density of polychaetes increased significantly with depth down to ~80 m with some indication of reduction in biomass with depth (Maurer and Leathem footnote 14). Off Martha's Vineyard, biomass and density of molluscs combined were not significantly associated with depth. However, the density of scaphopods increased significantly with increasing depth and the biomass of pelecypods decreased with depth. Biomass pattern of pelecypods with depth was dominated by the distribution of *A. islandica* ranging between 40 and 60 m. For Georges Bank, density of combined molluscs increased with water depth (Maurer[16]).

For combined crustaceans off Martha's Vineyard, mean biomass decreased with depth. Mean density of cumaceans and isopods was negatively associated with depth. Mean biomass of amphipods decreased with increasing depth. Density pattern of combined crustaceans was dominated by the distribution of amphipods, whereas biomass pattern of combined crustaceans was dominated by decapods. For Georges Bank, mean biomass of amphipods decreased in deeper water (Maurer footnote 16).

For combined echinoderms off Martha's Vineyard, mean biomass and density increased with depth. In another study, the bathymetric distribution of echinoderms off the northern Oregon coast was not as uniform, as low wet weights were obtained from depths of 86-139 m and 1,189-1,234 m (Alton 1972). Mean biomass and density of ophiuroids increased with depth off Martha's Vineyard. For Georges Bank, mean density of combined echinoderms showed no significant relationship with depth, but biomass decreased significantly in deeper water (Maurer footnote 16). These relationships reflected the fact that although density was relatively regular throughout the depth range, larger species (sea stars and echinoids) occurred in relatively shallow water, with smaller species (brittle stars) in deeper water.

Mean biomass and number of individuals of combined taxa were high between 0 and 100 m depths. Biomass and density decreased with increasing depth, although these relationships were not statistically significant. Off southern New England, there was a marked reduction in density and biomass with

[16]Maurer, D. 1982. Review of benthic invertebrates of Georges Bank in relation to gas and oil exploration with emphasis on management implications. Report to Northeast Fisheries Center, NMFS, Woods Hole, Mass., and Sandy Hook Laboratory, Highlands, N.J., 329 p.

depth (Wigley and Theroux 1981). Total biomass was dominated by molluscs (pelecypods and gastropods) and echinoderms (echinoids and ophiuroids), and density pattern was dominated by amphipods, polychaetes, small bivalves, and ophiuroids. According to Parsons et al. (1977), a number of studies have demonstrated decreased macrofaunal numbers and biomass with increased water depth. Abrupt faunal discontinuities tended to occur at 100-300 m. These changes generally corresponded to the vertical distribution of other environmental factors, such as organic carbon, nitrogen, and total particulates which decrease rapidly with increasing depth. Depth-related decreases in macrobenthos are more closely linked to suspended living biomass than to total particulate matter (Parsons et al. 1977).

Parsons et al. (1977) cited examples of higher mean biomass in regions of higher phytoplankton production. This relationship suggests that benthic biomass in inshore coastal areas may be strongly influenced by sedimentation of organic matter produced during a bloom. This process undoubtedly contributes to macrobenthos at shallow depths of continental shelves. The shallow depths of Georges Bank and Nantucket Shoals fit these conditions.

Data from other studies on benthic biomass with depth are presented in Table 1. Mean biomass was generally highest in the 50-99 m stratum. Moreover, mean biomass was higher off New England than the New York Bight. Off the Scotian Shelf, wet weight biomass was 24 g/m^2 at 0-90 m depth and 22.1 g/m^2 at 90-180 m (Mills 1980). The inverse relationship between benthic biomass and depth is probably more related to the geographic position of zones of primary productivity and sedimentation on shelves rather than to absolute values of depth per se. This relationship has been recognized for some time (Rowe 1971; Sokolova 1972).

Another aspect related to depth involves substratum stability. Sediments in shallow coastal waters and the inner shelf are subject to vigorous current action. Wave base to 80-85 m depth is not uncommon during the winter on Georges Bank (Aaron et al. 1980). Accordingly during times of high energy flow, sediment stability decreases, impeding colonization by many infaunal organisms. Specialized species such as haustoriid amphipods and rapidly burrowing bivalves commonly dominate these sites. Nantucket Shoals represents an area of high seasonal sediment instability.

Temperature.—Although there were some quantitative relationships between biomass and density of various taxa and bottom temperature, the presence of a cold-water cell bounded by warmer water on the north and south made it difficult to interpret distribution according to temperature (Fig. 3). In this case, there was a shallow-water (0-50 m) and deep-water (80-100 m) zone both containing water ranging from 7° to 12°C. Although the maximum biomass of certain taxa (Ophiuroidea) was associated with shallow water and deep water (Maurer and Wigley footnote 6), their maximum biomass was similar according to temperature (11.0°-12.9°C). The Coelenterata, another deep-water taxon, had its highest biomass in 11.0°-11.9°C (Maurer and Wigley footnote 6), temperatures normally associated with depths of about 40 m for this time of year. Thus it is important to bear in mind the relative position of the cold-water cell in relation to depth when comparing distribution according to temperature.

Off Atlantic City, N.J., Boesch et al.[17] concluded that temperature was the principal hydrographic factor affecting macrobenthic distribution. Temperatures were more variable on the inner and central shelf and more constant on the outer shelf. Differences in temperature regime were probably the prime cause of the sharper faunal change at the outer shelf/shelf-break transition.

Sediment and related environmental variables.—Off Martha's Vineyard, the pattern of biomass and number of individuals were relatively even throughout a range of median sediment size and percent silt-clay (Fig. 6). For Georges Bank, density of infauna increased significantly with percent gravel (Maurer and Leathem footnote 14). In addition, there were some significant relationships between the density of several dominant polychaete species and sediment parameters (percent silt-clay, percent silt, percent carbon, percent nitrogen, microbial biomass, and bacterial biomass) (Maurer and Leathem footnote 14).

Off Martha's Vineyard, polychaetes were ubiquitous in regard to sediment type and were major contributors to both average density and biomass of all benthic organisms in each sediment type (Maurer and Wigley footnote 6). This apparent lack of correlation with a sediment type may partly be due to differences in sieve size, wherein some of the smaller taxa known to occur abundantly on the shelf were probably missed with a 1.0 mm mesh net. In a related study off southern New England, greatest amounts of polychaetes were found in shell and sand-gravel (750 and 555/m^2, respectively), somewhat lesser amounts in sand, silty sand, gravel, and silt (433, 331, 289, and 118/m^2), and lowest (23 and 9/m^2) in sand-shell and clay (Wig-

[17]Boesch, D., J. N. Kraeuter, and D. K. Serafy. 1977. Benthic ecological studies: Megabenthos and macrobenthos. *In* Middle Atlantic Outer Continental Shelf Environmental Studies, Chap. 6, 111 p. Draft Rep. to Bureau of Land Management.

Table 1.—Comparison of wet-weight biomass (g/m^2) of macrobenthos (Annelida, Mollusca, Crustacea, Echinodermata) in relation to bathymetric stratum at locations off the U.S. northeastern Atlantic coast.

Depth (m)	Georges Bank[1] (0.5 mm sieve)	Southern New England[2] (1.0 mm sieve)	Martha's Vineyard/ Nantucket Shoals (1.0 mm sieve)	New York Bight[3] (1.0 mm sieve)	(0.5 mm sieve)
25-49	140.6	308.6	230.4	121.0	78.0
50-99	460.0	230.1	314.3	156.4	96.6
100-199	24.2	60.4	75.6	27.2	33.2

[1]Maurer, see text footnote 16.
[2]Wigley and Theroux, see text footnote 8.
[3]Boesch et al., see text footnote 17.

ley and Theroux 1981). Wet-weight biomass values between 20 and 30 g/m² occurred in four sediment types: Shell, silty sand, gravel, and sand in order of decreasing amounts. Silt and sand-gravel contained 7 and 116 polychaetes/m², respectively, and sand-shell and clay had the smallest biomass with 1.7 and 0.45 g/m². In general, there were no correlations between density of annelids and sediment organic carbon for the southern New England area of the New York Bight. The highest biomass values (45.4 and 37.4 g/m²) occurred in sediment with 1.5-1.9% and 2.0-2.9% organic content, respectively.

Off Martha's Vineyard, mean density of combined Mollusca was positively associated with sediment size (ϕ) as was that of pelecypods. For Georges Bank, mean density of combined molluscs increased with percent carbon in the sediment (Maurer footnote 16). Franz (1976) reported three molluscan-sediment groups in northeastern Long Island Sound. One group consisted of very fine sand and contained species similar to that of the Mud Patch. A second and third group consisted of medium sand and coarse sand and contained molluscan species very similar to the sand bottom off Martha's Vineyard. Based on mean grain diameter, sorting, silt-clay content, and fauna, Driscoll and Brandon (1973) identified four facies in Buzzards Bay. In addition, the density of particular molluscan-sediment relationships emerged with certain feeding types. Similar relationships have been reported elsewhere (Maurer 1967a, b). Because of the variety of feeding types in many major taxa, it is difficult to correlate major taxa with sedimentary variables. This exercise is most accurately accomplished at the species level.

Mean biomass and density of combined crustaceans were negatively associated with sediment size off Martha's Vineyard. This pattern was primarily influenced by amphipods and, to a lesser extent, isopods. For Georges Bank, mean density and biomass of amphipods were positively associated with percent sand, and mean biomass declined with percent gravel (Maurer footnote 16). The number of amphipod species increased significantly with percent sand and decreased with percent gravel, percent silt, percent silt-clay, percent carbon, and percent nitrogen. In Long Island Sound, there was a strong correlation in summer between Shannon-Weaver diversity of benthic amphipods and sediment texture, with diversity increasing due to decreasing species dominance, and, most importantly, to increasing species richness as sediments became coarser (Biernbaum 1979). Increased sediment instability caused by winter storms resulted in marked diversity decrease. The response to seasonal sediment stability by the benthic biota, including amphipods, must be a critical feature influencing recruitment, maintenance, and production on shallow portions of Georges Bank, including Nantucket Shoals in this study area.

Mean biomass and density of combined echinoderms were positively associated with sediment type off Martha's Vineyard. This relationship was recorded for ophiuroids and holothurians. According to Tyler and Banner (1977) there was a significant relationship off the Bristol Channel between the density of adult dominant ophiuroids and percent fine material with a weaker relationship between density and organic matter in the sediment. They concluded that distribution of both larvae and adults correlated with the energy distribution of the hydrodynamic regime. In view of the hydrodynamic regime off Martha's Vineyard influencing, on the one hand, deposition in the Mud Patch, and, on the other hand, extensive scouring on Nantucket Shoals, their findings might be applied to echinoderms and the entire benthic community in the study area.

The association between benthic animals and sediment is not a simple causal relationship (Rhoads 1974). Sediment composition and associated physical properties (grain size, sorting, porosity, mechanical strength) are primarily controlled by geologic processes. In turn, geologic and physical oceanographic processes exert considerable control over chemical properties of sediment (nutrients, oxygen tension, geochemistry). Finally, chemical properties catalyze and interact with biological properties of sediment (algal sheaths, feces, organic film, bacterial and fungal slime). Because of these properties, sediment provides a substratum for colonization, a medium in which reside temporarily or permanently, material for tube and burrow construction, and a source of nutrition. Thus quantitative relationships between benthos and sediment parameters deserve attention; however, because of the varied histories and origins of the sediment parameters, the relationships are not always immediately obvious in terms of their ecological significance. Without quantitative chemical measures of sediment properties (Johnson 1974), sediment might be considered an integrative environmental factor to which the benthos are responding.

Faunal assemblage

Since identification to species level was not always possible, it was not feasible to quantitatively define communities in the study area. Accordingly, the less formal term "assemblage" was used here to designate a recurring group of organisms living within broadly defined and repetitive environmental conditions. Based on studies in the Gulf of Maine and Georges Bank, four major benthic assemblages were tentatively outlined (Wigley[18]): Sand fauna, silty-sand fauna, gravel fauna, and muddy basin. Pratt (1973) elaborated on Wigley's scheme and suggested that these assemblages extend along the Middle Atlantic Bight. Characteristic species were recommended for the sand assemblage off the Delmarva Peninsula (Maurer et al. 1976) which confirmed Wigley's (1968) and Pratt's (1973) projections. Examination of sediment data (Appendix Table 1), species list (Appendix Table 2), and the distribution maps presented here indicates that almost half the study area contained the sand fauna (*Echinarachnius parma*, *Crangon septemspinosa*, *Chiridotea tuftsi*, *Pagurus acadianus*, *Leptocuma minor*, Haustoriidae, *Phoxocephalus holbolli*, *Paraphoxus* sp., *Lunatia heros*, *Nassarius trivittatus*, *Spisula solidissima*, *Molgula* spp.).

The fauna of the southwestern quadrat and south central portion of this study—the Mud Patch—compares well with the silty-sand fauna recognized earlier by Wigley (1968) from other areas on Georges Bank. The silty-sand bottom and Mud Patch both contained *Havelockia scabra*, ampeliscids, *Dichelopandalus leptocerus*, *Diastylis* spp., *Edotea triloba*, *Scalibregma inflatum*, *Nephtys incisa*, *Cerianthus*, *Nucula* spp., *Nuculana* sp., *Amphioplus* spp., and *Amphilimna olivacea*. A muddy-basin fauna between fishing banks was also identified earlier (Wigley 1968). The deeper stations in this study (7-10, 21, 22, 37, 38, 52, 53, 56, 57), contained species that are in common with the muddy-basin fauna. For example,

[18]Wigley, R. L. 1958. Bottom ecology. *In* Annual Report, U.S.D.I., Bur. Comm. Fish., Woods Hole Laboratory, Woods Hole, Mass., p. 55-58.

Schizaster fragilis, *Ophiura sarsi*, *Ophiura robusta*, *Amphiura otteri*, *Cadulus* spp., *Dentalium* sp., *Sternaspis scutata*, *Amphitrite* sp., *Onuphis* spp., and *Leanira* sp. were characteristic of muddy-basin fauna and the deep stations off Martha's Vineyard.

In the most comprehensive benthic survey of the U.S. Middle Atlantic Shelf, five faunal zones were recognized (Boesch et al. footnote 17). Faunal changes were mainly gradual rather than abrupt. The faunal zones included: Inner shelf (to 30 m), central shelf (38-50 m), outer shelf (50-100 m), shelf break (100-200 m), and continental slope (>200 m). According to Boesch et al. (footnote 17), the inner and central shelf assemblages were relatively similar, and outer shelf assemblages contained both inshore and offshore species overlapping in distribution. In contrast, shelf break and continental slope assemblages were more discrete.

Comparison of the faunal assemblages of the Martha's Vineyard study with Boesch et al. (footnote 17) is difficult for several reasons. The study by Boesch et al. used a 0.5 mm sieve, and their quantitative (cluster analysis) determination of species and site groups emphasized polychaetes and peracarid crustaceans which were missed or deemphasized in earlier studies with coarser sieves.

Another difficulty lies in the presence of the Mud Patch off Martha's Vineyard. Transects from the east side of the study area (Fig. 2) would be more comparable to transects studied by Boesch et al. (footnote 17). The Mud Patch affords the opportunity for colonization in shallower depths by species normally encountered in mud bottoms at deeper depths further out on the central and outer shelf. Coincidental with this expansion into shallower water is the response of deeper dwelling mud-bottom species to a different temperature regime. Species considered characteristic of a zone normally <11°C (Fig. 3) and with a smaller seasonal range would be colonizing a site with a wider temperature fluctuation. It might be expected that the Mud Patch would consist of a fauna containing both inner and outer shelf components.

Based on bathymetry and sediment type, the fauna off Martha's Vineyard could be conveniently arranged into the faunal zones proposed by Boesch et al. (footnote 17). The added complication of the Mud Patch must also be considered. These qualitative comparisons are primarily offered as suggestions for testing rather than as formal community designations.

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Appendix Table 1. Station Location and Environmental Variables off Martha's Vineyard, Massachusetts.

Station	Station location		Water	Water	Bottom Sediment Parameters							
						Median	Composition			Nitrogen	Organic	Carbon
	Lat. (N)	Long. (W)	depth	temperature	Type	diameter	Sand	Silt	Clay	(Kjeldahl)	carbon	Nitrogen
			m	°C		ϕ	%	%	%	%	%	
1	40°58'	69°30'	46	8.6	Sand-gravel	--	--	--	--	--	--	--
2	40°51'	69°31'	46	8.6	Sand	1.00	100.0	0.0	0.0	0.003	0.050	17.0
3	40°40'	69°31'	51	7.7	Sand	2.35	100.0	0.0	0.0	0.010	0.11	11.1
4	40°30'	69°29'	62	7.1	Sand	2.54	100.0	0.0	0.0	0.019	0.13	6.9
5	40°21'	69°30'	76	9.4	Sand	3.47	81.0	12.7	6.3	0.070	0.46	6.6
6	40°10'	69°31'	91	8.6	Sand	2.23	90.0	10.0	0.0	0.034	0.26	7.7
7	40°00'	69°30'	128	11.9	Sand	2.79	84.5	10.2	5.3	0.031	0.24	7.8
8	39°57'	69°30'	183	11.9	Sand	2.89	86.0	9.8	4.2	0.022	0.12	5.5
9	39°56'	69°45'	201	8.9	Sand	2.70	85.0	10.7	4.2	0.035	0.22	6.3
10	40°00'	69°45'	139	11.7	Silty-Sand	3.85	57.0	33.4	9.5	0.037	0.61	7.0
11	40°10'	69°45'	95	7.3	Silty-Sand	3.70	69.0	23.6	7.5	0.064	0.41	6.5
12	40°20'	69°46'	79	6.7	Sand	3.48	85.5	9.2	5.4	0.059	0.41	7.0
13	40°30'	68°45'	73	7.2	Sand	2.63	95.0	1.9	3.2	0.026	0.17	6.6
14	40°40'	69°45'	59	7.5	Sand	2.24	100.0	0.0	0.0	0.004	0.03	7.9
15	40°50'	69°45'	37	9.2	Sand	2.05	100.0	0.0	0.0	0.003	0.02	8.0
16	40°46'	70°00'	38	8.1	Sand	2.67	100.0	0.0	0.0	0.018	0.03	4.6
17	40°39'	69°59'	49	7.5	Sand	3.27	81.0	10.3	8.7	0.072	0.39	5.5
18	40°30'	70°00'	73	6.8	Sand	3.65	67.0	25.3	7.7	0.082	0.55	6.8
19	40°20'	49°59'	91	6.7	Sand	3.79	62.0	31.4	6.7	0.069	0.48	6.9
20	40°10'	70°00'	117	11.4	Sand	4.12	45.0	44.8	10.2	0.080	0.58	7.2
21	40°00'	70°00'	165	(11.4)	Sand	3.35	66.0	23.9	10.1	0.058	0.48	8.4
22	40°03'	70°15'	183	10.8	Silty-sand	2.18	66.8	23.6	9.6	0.060	0.59	9.9
23	40°10'	70°15'	113	11.6	Silty-sand	4.31	36.2	53.4	10.4	0.092	0.70	7.6
24	40°20'	70°15'	90	7.8	Silty-sand	4.12	47.0	38.9	14.1	0.133	0.92	6.9
25	40°30'	70°15'	70	6.6	Sand	3.83	58.8	30.7	10.5	0.076	0.52	6.8
26	40°40'	70°15'	51	7.2	Sand	3.37	85.9	10.2	3.8	0.048	0.19	4.0
27	40°50'	70°15'	44	8.1	Sand	3.43	86.1	9.3	4.5	0.035	0.20	5.7
28	41°00'	70°15'	33	9.4	Sand	3.35	90.7	4.2	4.7	0.033	0.13	4.0
29	41°11'	70°16'	27	12.2	Sand	1.35	100.0	0.0	0.0	0.011	0.07	6.9
30	41°10'	70°30'	38	8.3	Sand	2.03	100.0	0.0	0.0	0.018	0.11	6.2
31	41°00'	70°30'	48	7.5	Sand	2.81	79.5	14.1	6.4	0.044	0.28	6.3
32	40°50'	70°30'	59	6.9	Sand	3.30	67.5	24.1	3.5	0.073	0.51	7.0
33	40°40'	70°30'	62	6.7	Silty-Sand	3.48	60.0	25.3	14.7	0.137	0.84	6.2
34	40°30'	70°30'	73	7.5	Sandy-silt	4.54	33.2	49.0	17.8	0.148	1.03	6.9
35	40°20'	70°30'	97	10.0	Sandy-silt	4.67	12.3	72.3	15.4	0.146	1.12	7.6

Appendix Table 1 (cont.)

Station	Station location		Water	Water	Bottom Sediment Parameters								
						Median	Composition			Nitrogen	Organic	Carbon
	Lat. (N)	Long. (W)	depth	temperature	Type	diameter	Sand	Silt	Clay	(Kjeldahl)	carbon	Nitrogen
			m	°C		ϕ	%	%	%	%	%	
36	40°10'	70°30'	128	12.1	Silty-sand	2.26	82.8	10.2	7.0	0.046	0.41	8.9
37	40°04'	70°29'	220	9.4	Sand	1.79	88.8	6.2	5.0	0.038	0.28	7.5
38	40°02'	70°44'	194	10.8	Silty-sand	3.61	53.6	31.8	14.6	0.113	0.63	5.6
39	40°10'	70°45'	132	11.7	Silty-sand	5.02	14.5	66.4	19.1	0.183	1.05	5.7
40	40°20'	70°46'	106	9.2	Sand-silt-clay	5.01	14.0	61.6	24.5	0.212	1.46	6.9
41	40°30'	70°45'	79	6.7	Sandy-silt	4.86	19.3	62.6	18.1	0.194	1.03	5.3
42	40°40'	70°45'	66	6.4	Silty-sand	3.42	55.8	29.7	14.5	0.112	0.69	6.2
43	40°50'	70°45'	55	6.8	Sand	2.37	85.5	7.8	6.7	0.054	0.22	4.1
44	41°00'	70°45'	51	6.7	Sand	1.48	100.0	0.0	0.0	0.008	0.07	8.7
45	41°10'	70°45'	38	8.6	Sand-gravel	1.00	100.0	0.0	0.0	0.006	0.06	10.6
46	41°10'	71°00'	40	9.7	Sand	1.59	100.0	0.0	0.0	0.007	0.08	11.2
47	41°00'	71°00'	51	6.4	Sand-gravel	2.53	85.1	6.8	8.1	-	-	-
48	40°50'	71°00'	59	6.1	Sand	2.30	83.4	8.5	7.7	0.046	0.23	5.0
49	40°40'	71°00'	70	6.3	Sandy-silt	5.09	16.4	61.0	22.6	0.220	1.09	5.0
50	40°30'	71°00'	84	6.3	Clayey-silt	5.84	3.1	69.3	27.6	0.245	1.24	5.0
51	40°21'	71°00'	99	9.4	Sandy-silt	4.77	31.2	49.0	19.8	0.150	0.94	6.3
52	40°10'	71°00'	146	10.8	Silty-sand	2.35	70.0	17.5	11.5	0.067	0.45	6.7
53	40°06'	71°00'	179	10.8	Silty-sand	4.77	24.1	54.1	21.8	0.124	1.04	8.4
54	39°59'	71°00'	366	(6.1)	Silt	5.16	25.2	66.8	8.0	0.112	0.88	7.9
55	39°56'	71°00'	567	(6.1)	Silt	4.39	42.7	36.3	21.0	0.160	1.17	7.3
56	40°03'	71°16'	183	10.3	Sand	2.18	86.0	8.4	5.6	0.050	0.21	4.1
57	40°10'	71°15'	110	10.8	Silty-sand	2.68	66.0	23.6	10.4	0.099	0.74	7.5
58	40°20'	71°15'	91	9.0	Silty-sand	3.29	52.0	35.3	12.7	0.136	0.81	5.9
59	40°30'	71°15'	77	6.7	Silty-sand	2.95	69.5	19.5	11.0	0.086	0.32	3.7
60	40°40'	71°15'	62	6.2	Sand	2.38	76.6	16.1	7.3	0.060	0.29	4.9
61	40°50'	71°15'	62	6.4	Sand	3.00	87.9	6.5	5.6	0.044	0.20	4.5
62	41°01'	71°16'	48	6.7	Sand	1.63	100.0	0.0	0.0	0.009	0.06	7.1
63	41°10'	71°15'	38	8.1	Sand	2.14	100.0	0.0	0.0	0.003	0.06	7.9
64	41°00'	71°30'	55	6.9	Sand	2.38	89.4	6.1	4.5	0.042	0.24	5.6

Appendix Table 2.--List of Macrobenthic Invertebrates off Martha's Vineyard, Massachusetts.

Porifera

Cnidaria
Hydrozoa
Hydractinia echinata
Anthozoa
Cerianthus sp.
Edwardsia sp.
Epizoanthus americanus
Pennatula aculeata
Stylatula elegans

Nemertea

Annelida
Aglaophamus circinata
Ammotrypane aulogaster
Amphitrite sp.
Ancistrosyllis sp.
Aphrodita hastata
Arabella iricolor
Aricidea jeffreysii
Asychis biceps
Brada sp.
Capitella sp.
Ceratocephale loveni
Chaetozone sp.
Chone infundibuliformis
Cossura longocirrata
Drilonereis longa
Eunice pennata
Flabelligera sp.
Glycera robusta
Glycera tesselata
Goniada brunnea
Goniada maculata
Harmothoe extenuata
Hyalinoecia tubicola
Laonice cirrata
Leanira sp.
Lumbrineris fragilis
Lumbrineris tenuis
Melinna cristata
Nephtys bucera
Nephtys incisa
Nereis pelagica
Ninoe nigripes
Notocirrus sp.
Onuphis conchylega
Onuphis opalina
Onuphis quadricuspis
Orbinia ornata
Owenia sp.
Paradiopatra sp.
Paramphinome pulchella
Paraonis neopolitana
Phyllodoce mucosa
Prionospio sp.
Scalibregma inflatum
Sphaerodorum gracilis
Spio sp.
Spiochaetopterus sp.
Spiophanes bombyx
Sternaspis scutata
Sthenelais limicola
Streblosoma spiralis
Tharyx sp.

Sipunculida
Golfingia catherinae
Golfingia elongata
Golfingia margaritacea
Golfingia minuta
Golfingia (*Phascoloides*) sp.
Onchnesoma steenstrupi
Phascolion strombi

Arthropoda
Amphipoda
Aeginina longicornis
Ampelisca compressa
Ampelisca macrocephala
Anonyx sp.
Byblis serrata
Caprella sp.

Amphipoda (Cont.)
Casco bigelowi
Corophium sp.
Dulichia sp.
Eriopisa elongata
Harpinia propinqua
Haustoriidae
Hippomedon serratus
Lembos sp.
Leptocheirus pinguis
Orchomenella groenlandica
Paraphoxus sp.
Photis macrocoxa
Phoxocephalus holbolli
Ptotomedia fasciata
Siphonoecetes smithianus
Stenopleustes gracilis
Unciola irrorata
Unciola leucopis
Decapoda
Axius serratus
Cancer borealis
Cancer irroratus
Catapagurus sharreri
Crangon septemspinosa
Bythocaris nana
Dichelopandalus leptocerus
Europrognatha rastellifera
Hyas coarctatus
Munida iris
Pagurus acadianus
Pagurus arcuatus
Pagurus politus
Pontophilus brevirostris
Isopoda
Calathura sp.
Chiridotea tuftsi
Cirolana polita
Edotea triloba
Ptilanthura tenuis
Cumacea
Diastylis polita
Diastylis quadrispinosa
Eudorella emarginata
Eudorellopsis sp.
Leptocuma minor
Leptostylis sp.
Petalosarsia declivis
Mysidacea
Bathymysis renoculata
Erythrops erythropthalma
Hypererythrops caribbaea
Mysis mixta
Neomysis americana
Cirripedia
Balanus sp.
Pycnogonida
Achelia spinosa
Paranymphon spinosum

Mollusca
Amphineura
Chaetoderma nitidulum
Pelecypoda
Anomia sp.
Arctica islandica
Astarte undata
Bathyarca pectunculoides
Cerastoderma pinnulatum
Crenella glandula
Cuspidaria perrostrata
Cuspidaria striata
Ensis directus
Hiatella sp.
Lyonsia arenosa
Lyonsia hyalina
Macoa calcarea
Mesodesma arctatum
Mytilidae
Nucula proxima
Nucula tenuis
Nuculana acuta
Pandora gouldiana
Pandora inflata
Periploma papyratium
Phacoides blakeanus

Pelecypoda (Cont.)
Phacoides filosus
Placopecten magellanicus
Siliqua costata
Spisula solidissima
Tellina agilis
Thracia sp.
Thyasira ferruginosa
Thyasira gouldi
Thyasira ovata
Thyasira trisinuata
Venericardia borealis
Yoldia sapotilla
Scaphapoda
Cadulus pandionis
Cadulus verrilli
Dentalium occidentale
Gastropoda
Alvania carinata
Buccinum undatum
Colus stimpsoni
Crepidula plana
Crucibulum striatum
Cylichna alba
Epitonium dallianum
Lunatia heros
Lunatia triseriata
Nassarius trivittatus
Neptunea sp.
Polinices sp.
Retusa gouldi
Scaphander sp.

Echinodermata
Asteroidea
Asterias vulgaris
Astropecten americanus
Astropecten sp.
Henricia sanguinolenta
Leptasterias tenera
Porania sp.
Echinoidea
Schizaster fragilis
Echinarachnius parma
Ophiuroidea
Amphilimna olivacea
Amphioplus abditus
Amphioplus macilentus
Amphiura fragilis
Amphiura otteri
Axiognathus squamatus
Ophiura robusta
Ophiura sarsi
Holothuroidea
Caudina arenata
Chiridota sp.
Cucumaria frondosa
Havelockia scabra
Molpadia oolitica
Psolus fabricii
Stereoderma unisemita

Bryozoa
Dendrobeania murrayana
Electra hastingsae
Electra pilosa
Haplota clavata
Hippothoa hyalina
Scruparia chelata

Ascidiacea
Bostrichobranchus pilularis
Ciona intestinalis
Cnemidocarpa mollis
Heterostigma singulare
Molgula citrina
Molgula complanata
Molgula siphonalis

Pogonophora
Siboglinum atlanticum
Siboglinum ekmani

Hemichordata
Enteropneusta
Balanoglossus sp.

Appendix Table 3. Wet Weight Biomass (g/m^2) of Major Taxa of Macrobenthic Invertebrates per Station off Martha's Vineyard, Massachusetts.

Station Number	PORIFERA	COELENTERATA	NEMERTEA	ANNELIDA	POGONOPHORA	SIPUNCULA	MOLLUSCA	Gastropoda	Pelecypoda	Scaphapoda
1	12.0	1.1	8.2	22.6	-	-	45.2	0.5	44.7	-
2	2.9	-	-	3.1	-	-	-	-	-	-
3	-	-	0.2	0.5	-	-	928.4	-	928.4	-
4	-	18.7	3.1	68.5	-	11.9	934.8	392.7	542.1	-
5	-	0.9	1.7	45.4	-	1.2	272.5	0.1	272.4	-
6	-	1.9	0.2	32.5	-	-	47.5	-	47.5	-
8	-	6.2	-	11.7	-	<0.1	-	-	-	-
9	0.9	10.9	0.1	14.8	-	0.1	6.8	-	5.7	1.1
10	-	10.5	0.3	4.7	-	0.1	3.0	-	3.0	-
11	-	11.6	8.9	10.6	-	2.1	6.0	0.1	5.9	-
12	-	5.0	1.5	26.7	-	0.1	1413.0	0.1	1412.9	-
13	-	0.3	3.8	118.8	-	0.2	65.6	1.0	64.6	-
14	-	0.1	0.2	13.3	-	5.4	0.2	0.1	0.1	-
15	-	-	0.1	6.8	-	-	0.1	-	0.1	-
16	-	-	-	2.6	-	-	1.4	-	1.4	-
17	-	0.6	0.4	44.9	-	3.6	545.2	9.1	536.1	-
18	-	0.1	0.6	29.4	-	0.1	496.3	0.2	469.1	-
19	-	-	1.4	8.8	-	0.1	1.2	-	1.2	-
20	-	342.3	-	1.3	-	0.1	0.8	-	0.8	-
21	-	-	-	4.9	-	0.1	6.4	-	6.4	-
22	-	-	-	5.7	-	4.1	0.2	-	0.2	-
23	-	1.9	2.0	15.6	-	0.2	2.2	-	2.2	-
24	-	3.8	20.0	15.3	-	-	0.3	-	0.3	-
25	-	-	1.3	20.8	-	-	9.4	0.1	9.3	-
26	-	0.1	2.5	73.4	-	0.1	7.2	0.1	7.1	-
27	-	0.1	3.1	72.7	-	-	77.8	-	77.8	-
28	-	0.1	1.8	83.9	-	11.0	933.1	1.0	932.1	-
29	-	5.2	8.5	60.2	-	-	44.4	0.1	44.3	-
30	-	-	4.1	3.4	-	11.9	808.0	-	808.0	-
31	-	2.1	0.3	35.7	-	10.1	23.2	10.6	12.6	-
32	-	-	0.4	15.9	-	-	3.4	0.1	3.3	-
33	-	-	0.3	31.3	-	-	7.0	0.1	6.9	-
34	-	2.0	0.1	15.9	-	1.4	5.3	0.2	5.1	-
35	-	7.4	2.0	21.9	-	3.7	4.2	0.3	3.9	-
36	-	18.7	0.7	15.3	-	-	0.9	-	0.9	-
37	-	-	2.7	2.6	-	-	1.6	0.1	1.5	-
38	-	1.4	-	24.1	-	0.1	0.3	0.1	0.1	0.1
39	-	-	1.1	10.0	-	-	3.6	0.1	3.5	-
40	-	5.3	0.1	2.4	-	-	12.5	0.1	12.4	-
41	-	5.6	-	10.3	-	-	0.1	-	0.1	-
42	-	0.9	0.1	32.6	-	-	0.1	0.1	-	-
43	-	-	0.1	22.4	-	-	23.0	0.1	22.9	-
44	-	-	0.2	44.0	-	-	0.8	0.7	0.1	-
45	-	-	-	37.6	-	-	-	-	-	-
46	-	-	0.1	11.8	-	-	1.6	0.3	1.3	-
47	-	-	1.0	10.3	-	-	-	-	-	-
48	-	-	0.1	49.2	-	-	1326.5	0.5	1326.0	-
49	-	0.5	0.1	38.5	-	-	11.1	0.2	10.9	-
50	-	1.5	-	48.1	-	-	3.1	0.1	3.0	-
51	-	17.8	0.1	53.8	-	0.1	9.5	0.1	9.4	-
52	-	9.9	0.1	25.3	-	-	13.9	0.1	13.8	-
53	0.2	2.9	0.1	8.4	-	0.1	6.6	-	6.6	-
54	-	0.3	-	13.2	0.1	13.4	1.2	0.2	0.9	0.1
55	-	-	-	8.3	0.2	-	2.2	0.1	2.1	-
56	-	1.3	1.1	8.7	-	-	4.3	0.1	4.2	-
57	-	1.8	-	-	-	0.1	-	-	-	-
58	-	7.9	0.6	19.2	-	-	15.3	1.0	14.3	-
59	-	8.8	0.1	23.4	-	-	5.1	-	5.1	-
60	-	-	0.2	114.7	-	6.8	24.3	0.2	24.1	-
61	-	-	0.2	40.5	-	0.1	0.9	0.2	0.7	-
62	-	0.1	-	14.8	-	7.6	7.9	7.8	0.1	-
63	-	-	-	28.2	-	0.1	-	-	-	-
64	-	-	-	21.0	-	13.1	622.5	0.1	622.4	-

Appendix Table 3 (cont.)

Station Number	CRUSTACEA	Cumacea	Isopoda	Amphipoda	Decapoda	ECHINODERMATA	Holothuroidea	Echinoidea	Ophiuroidea	Asteroidea	ECTOPROCTA	ENTEROPNEUSTA	Ascidiacea	TOTAL
1	18.9	–	–	3.6	15.3	–	–	–	–	–	51.6	–	–	159.6
2	2.2	–	0.1	2.0	0.1	–	–	–	–	–	1.1	–	–	9.3
3	1.2	0.1	0.1	1.0	–	2.7	–	2.7	–	–	–	–	0.1	933.1
4	9.2	0.2	0.1	8.8	0.1	11.8	–	11.8	–	–	4.7	–	1.9	1064.6
5	52.5	0.2	4.3	40.9	7.1	1.8	–	0.9	–	0.9	–	–	–	376.0
6	18.9	0.1	0.1	12.5	6.2	7.4	3.5	–	3.9	–	–	–	4.0	112.4
8	0.2	0.1	–	0.1	–	105.3	–	–	105.3	–	–	–	–	123.4
9	0.7	–	0.1	0.6	–	1.1	–	–	1.1	–	–	–	1.2	36.6
10	0.2	0.1	–	0.1	–	86.4	–	38.4	34.1	13.9	0.1	–	–	105.3
11	1.9	0.1	0.7	1.1	–	71.4	25.0	–	46.4	–	–	–	7.1	119.6
12	16.9	0.1	0.1	16.7	–	12.3	12.2	–	0.1	–	–	10.2	–	1485.7
13	32.3	0.7	3.2	27.9	0.5	0.5	0.5	–	–	–	–	–	1.5	223.0
14	2.4	0.1	0.2	2.1	–	20.9	–	20.7	0.1	0.1	0.1	–	0.1	42.7
15	4.0	–	–	3.9	0.1	–	–	–	–	–	–	–	–	11.0
16	4.5	0.1	0.1	4.3	–	0.6	–	0.6	–	–	0.1	–	7.7	16.9
17	14.8	0.1	0.2	14.5	–	7.8	–	7.8	–	–	–	–	3.1	620.4
18	13.5	0.1	1.1	12.3	–	–	–	–	–	–	–	–	0.2	513.2
19	8.4	–	–	8.4	–	615.9	562.4	–	21.6	31.9	–	–	0.5	636.3
20	0.2	0.1	–	0.1	–	15.3	–	–	12.7	2.6	–	–	–	360.0
21	0.2	0.1	–	0.1	–	284.0	–	251.6	32.3	0.1	–	–	–	295.6
22	0.1	–	–	0.1	–	86.6	10.2	–	76.4	–	–	–	–	96.7
23	0.3	0.1	0.1	0.1	–	38.5	12.8	–	15.6	10.1	–	–	11.0	71.7
24	2.1	–	–	2.1	–	188.9	175.5	–	13.4	–	–	–	–	230.4
25	5.6	0.2	–	1.9	3.5	–	–	–	–	–	–	–	–	37.1
26	12.2	0.2	0.1	11.9	–	–	–	–	–	–	0.1	–	–	95.6
27	20.0	0.2	1.1	18.7	–	2.4	–	2.4	–	–	–	–	–	176.1
28	7.8	0.1	2.6	4.9	0.2	4.7	–	4.7	–	–	0.1	–	–	1042.5
29	9.8	0.2	0.2	8.3	1.1	–	–	–	–	–	16.5	–	22.4	167.0
30	15.5	1.1	1.3	13.1	–	9.1	–	9.1	–	–	–	–	2.8	854.8
31	63.4	0.2	0.7	62.5	–	7.1	–	6.3	–	0.8	4.0	–	0.2	146.1
32	0.4	0.1	–	0.3	–	0.5	–	–	–	0.5	–	–	–	20.6
33	1.1	0.2	0.1	1.8	–	455.0	454.9	0.1	–	–	–	–	–	494.7
34	6.1	0.1	0.1	5.8	0.1	216.0	211.5	–	4.5	–	–	–	–	246.8
35	1.6	0.1	–	1.5	–	108.7	66.8	–	41.9	–	–	–	–	149.5
36	0.3	0.1	–	0.2	–	33.9	–	–	33.9	–	–	–	37.6	107.4
37	0.1	–	–	0.1	–	244.6	8.4	177.1	59.1	–	–	–	0.2	251.8
38	2.9	–	2.4	0.5	–	8.4	8.2	–	0.2	–	–	–	–	37.2
39	0.1	–	–	0.1	–	74.5	–	32.9	41.6	–	–	–	7.2	96.5
40	5.0	0.1	0.1	4.8	–	58.7	2.4	23.0	33.3	–	–	–	7.6	91.6
41	5.8	0.1	–	5.7	–	37.5	–	–	1.0	36.5	–	–	5.6	64.9
42	3.2	0.1	–	3.1	–	–	–	–	–	–	–	–	–	36.9
43	14.9	0.1	0.1	14.7	–	0.1	–	–	0.1	–	–	–	–	60.5
44	23.2	0.1	2.6	20.5	–	–	–	–	–	–	–	–	–	68.2
45	16.4	0.1	0.1	16.2	–	–	–	–	–	–	–	–	49.7	103.7
46	23.3	0.3	0.4	22.6	–	0.1	–	0.1	–	–	–	–	5.4	42.3
47	13.0	0.3	3.9	8.8	–	–	–	–	–	–	–	–	1.0	25.3
48	41.0	0.4	0.8	37.7	2.1	0.1	–	–	–	0.1	–	–	–	1416.9
49	3.7	–	–	3.7	–	0.1	–	–	–	0.1	–	–	–	54.0
50	0.2	0.1	–	0.1	–	183.2	138.7	–	11.9	32.6	–	–	32.8	268.9
51	3.1	0.1	0.1	2.9	–	33.5	15.8	–	17.7	–	–	5.3	10.1	133.3
52	0.1	–	–	0.1	–	10.2	3.9	–	6.3	–	–	2.0	–	61.5
53	0.1	–	–	0.1	–	61.0	23.7	–	37.3	–	–	–	–	79.4
54	0.3	–	0.1	0.2	–	3.4	2.6	–	0.8	–	–	–	–	31.9
55	0.1	–	–	0.1	–	10.3	–	–	10.3	–	–	0.1	–	21.2
56	0.2	–	0.1	0.1	–	17.0	–	–	8.7	8.3	–	–	–	32.6
57	0.2	0.1	–	0.1	–	31.7	10.2	–	21.5	–	–	–	8.8	42.6
58	0.3	–	–	0.3	–	72.8	–	–	22.2	50.6	–	–	3.3	119.4
59	0.6	–	–	0.6	–	2.8	–	–	2.8	–	–	–	9.7	50.5
60	26.6	0.1	0.1	26.4	–	–	–	–	–	–	–	–	15.1	187.7
61	69.7	0.4	0.1	69.2	–	0.1	–	–	–	0.1	–	–	–	111.5
62	17.6	0.1	3.7	13.8	–	0.1	–	0.1	–	–	–	–	1.7	49.8
63	5.6	0.1	0.3	5.2	–	56.3	–	56.2	0.1	–	–	–	–	90.2
64	12.8	0.4	0.1	12.1	0.2	0.5	–	0.5	–	–	–	–	0.4	670.3

Appendix Table 4. Number of Individuals per m^2 of Major Taxa Per Station.

Station Number	PORIFERA	COELENTERATA	NEMERTEA	ANNELIDA	POGONOPHORA	SIPUNCULIDA	MOLLUSCA	Gastropoda	Pelecypoda	Scaphopoda	CRUSTACEA	Cumacea	Isopoda	Amphipoda	Decapoda	ECHINODERMATA	Holothuroidea	Echinoidea	Ophiuroidea	Asteroidea	ECTOPROCTA	ENTEROPHEUSTA	ASCIDACEA	TOTAL
1	11	11	11	1,145	-	-	22	11	11	-	1,192	-	-	1,171	21	-	-	-	-	-	1,932	-	-	4,324
2	11	-	-	53	-	-	-	-	-	-	73	-	31	31	11	-	-	-	-	-	11	-	-	148
3	-	-	32	42	-	-	11	-	11	-	170	11	21	138	-	21	-	21	-	-	-	-	111	287
4	-	144	21	1,360	-	41	37	11	26	-	2,379	82	36	2,251	10	135	-	135	-	-	11	-	111	4,139
5	-	16	16	1,129	-	11	179	16	163	-	10,957	47	21	10,868	21	32	-	11	-	21	-	-	-	12,340
6	-	10	62	955	-	-	279	-	279	-	8,970	16	27	8,916	11	225	36	-	189	-	-	-	62	10,563
8	-	21	-	572	-	62	114	-	114	-	31	10	-	21	-	489	-	-	489	-	-	-	-	1,289
9	11	140	11	483	-	11	166	-	123	43	222	-	11	211	-	32	-	-	32	-	-	-	11	1,087
10	-	51	10	170	-	10	61	-	61	-	36	10	-	26	-	379	-	10	339	30	10	-	-	727
11	-	23	28	500	-	28	491	12	479	-	564	35	11	518	-	1,096	81	-	1,015	-	-	-	23	2,753
12	-	10	15	678	-	10	159	10	149	-	9,353	10	10	9,333	-	41	31	-	10	-	-	51	-	10,317
13	-	10	10	1,346	-	20	255	10	245	-	19,083	71	10	18.992	10	30	10	-	20	-	-	-	41	20,795
14	-	10	26	820	-	31	20	10	10	-	371	37	37	297	-	412	-	392	10	10	10	-	10	1,710
15	-	-	10	26	-	-	21	-	21	-	524	-	-	514	10	-	-	-	-	-	-	-	-	581
16	-	-	-	456	-	-	21	-	21	-	631	16	32	583	-	11	-	11	-	-	11	-	196	1,326
17	-	10	21	1,082	-	26	115	47	68	-	3,031	62	62	2,907	-	172	-	172	-	-	-	-	31	4,488
18	-	10	15	651	-	10	308	40	268	-	3,030	20	10	3,000	-	-	-	-	-	-	-	-	10	4,034
19	-	-	20	394	-	51	230	-	230	-	2,708	-	-	2,708	-	861	200	-	651	10	-	-	10	4,274
20	-	20	-	41	-	18	27	-	27	-	84	12	-	72	-	344	-	10	324	10	-	-	-	534
21	-	-	-	172	-	20	153	-	153	-	25	10	-	15	-	335	-	15	310	10	-	-	-	705
22	-	-	-	199	-	61	71	-	71	-	41	-	-	41	-	416	10	-	406	-	-	-	-	788
23	-	35	20	379	-	101	81	-	81	-	50	20	20	10	-	576	10	-	556	10	-	-	51	1,293
24	-	20	30	318	-	-	25	-	25	-	111	-	-	111	-	283	91	-	192	-	-	-	-	787
25	-	-	25	838	-	-	576	20	556	-	343	20	-	313	10	-	-	-	-	-	-	-	-	1,782
26	-	10	15	1,184	-	10	722	20	702	-	1,312	66	10	1,236	-	-	-	-	-	-	10	-	-	3,263
27	-	31	10	750	-	-	357	-	357	-	1,999	56	20	1,923	-	15	-	15	-	-	-	-	-	3,162
28	-	10	10	1,225	-	21	82	10	72	-	1,737	10	222	1,484	21	16	-	16	-	-	10	-	-	3,111
29	-	20	21	867	-	-	82	20	62	-	1,326	36	42	1,238	10	22	-	22	-	-	31	-	541	2,910
30	-	-	16	993	-	48	37	-	37	-	1,409	595	56	758	-	22	-	22	-	-	-	-	49	2,574
31	-	10	10	833	-	10	239	56	183	-	3,883	137	15	3,731	-	20	-	10	-	10	10	-	10	5,025
32	-	-	25	247	-	-	101	10	91	-	76	10	-	66	-	10	-	-	-	10	-	-	-	459
33	-	-	15	490	-	-	457	354	121	-	152	51	20	81	-	20	10	10	-	-	-	-	-	1,152
34	-	30	10	227	-	20	162	51	111	-	853	35	10	788	20	112	56	-	56	-	-	-	-	1,414
35	-	30	20	379	-	40	1,030	404	626	-	131	20	-	111	-	576	71	-	505	-	-	-	-	2,206
36	-	76	10	394	-	-	30	-	30	-	50	10	-	40	-	424	-	-	424	-	-	-	333	1,317
37	-	-	10	61	-	-	131	10	121	-	30	-	-	30	-	368	40	10	318	-	-	-	20	620

Appendix Table 4 (cont.)

Station Number	PORIFERA	COELENTERATA	NEMERTEA	ANNELIDA	POGONOPHORA	SIPUNCULIDA	MOLLUSCA	Gastropoda	Pelecypoda	Schaphopoda	CRUSTACEA	Cumacea	Isopoda	Amphipoda	Decapoda	ECHINODERMATA	Holothuroidea	Echinoidea	Ophiuroidea	Asteroidea	ECTOPROCTA	ENTEROPNEUSTA	ASCIDACEA	TOTAL
38	–	42	–	965	–	62	82	10	62	10	139	–	10	129	–	20	10	–	10	–	–	–	–	1,310
39	–	–	10	177	–	–	91	20	71	–	20	–	–	20	–	717	–	10	707	–	–	–	106	1,121
40	–	51	10	61	–	–	570	30	540	–	166	10	10	146	–	1,606	20	778	808	–	–	–	51	2,512
41	–	30	–	182	–	–	51	–	51	–	1,393	40	–	1,353	–	30	–	–	20	10	–	–	81	1,767
42	–	10	10	1,020	–	–	133	102	31	–	1,571	10	–	1,561	–	–	–	–	–	–	–	–	–	2,744
43	–	–	10	763	–	–	46	31	15	–	1,960	10	10	1,940	–	10	–	–	10	–	–	–	–	2,789
44	–	–	10	959	–	–	46	20	26	–	2,800	31	102	2,667	–	–	–	–	–	–	–	–	–	3,815
45	–	–	–	841	–	–	–	–	–	–	5,623	10	10	5,603	–	–	–	–	–	–	–	–	98	6,562
46	–	–	31	619	–	–	58	21	37	–	4,381	68	21	4,292	–	16	–	16	–	–	–	–	73	5,178
47	–	–	20	444	–	–	–	–	–	–	3,075	30	81	2,964	–	–	–	–	–	–	–	–	20	3,559
48	–	–	16	1,804	–	–	198	73	125	–	3,651	276	16	3,338	21	16	–	–	–	16	–	–	–	5,685
49	–	15	10	1,116	–	–	177	81	96	–	813	–	–	813	–	30	–	–	–	30	–	–	–	2,161
50	–	10	–	333	–	–	252	10	242	–	40	20	–	20	–	125	15	–	101	10	–	–	51	812
51	–	51	20	273	–	10	394	30	364	–	111	10	30	71	–	747	45	–	702	–	–	30	71	1,707
52	–	77	10	979	–	–	280	10	270	–	10	–	–	10	–	461	10	–	461	–	–	10	–	1,837
53	10	10	10	328	–	20	273	–	273	–	25	–	–	25	–	222	10	–	212	–	–	–	–	898
54	–	20	–	803	51	197	91	25	51	15	25	–	10	15	–	35	10	–	25	–	–	–	–	1,222
55	–	–	–	432	36	–	30	10	20	–	10	–	–	10	–	20	–	–	20	–	–	10	–	538
56	–	51	10	503	–	–	133	10	123	–	116	–	10	106	–	72	–	–	62	10	–	–	–	885
57	–	10	–	259	–	36	71	–	71	–	66	20	–	46	–	550	10	–	540	–	–	–	15	1,007
58	–	35	15	374	–	–	576	10	566	–	51	–	–	51	–	697	–	–	687	10	–	–	61	1,809
59	–	35	10	490	–	–	56	–	56	–	15	–	–	15	–	126	–	–	126	–	–	–	354	1,086
60	–	–	15	938	–	15	525	20	505	–	1,555	50	10	1,495	–	–	–	–	–	–	–	–	126	3,174
61	–	–	15	756	–	10	122	20	102	–	3,442	162	30	3,250	–	10	–	–	–	10	–	–	–	4,355
62	–	12	–	871	–	53	62	52	10	–	4,980	12	72	4,896	–	10	–	10	–	–	–	–	54	6,042
63	–	–	–	380	–	21	–	–	–	–	1,929	73	26	1,830	–	135	–	125	10	–	–	–	–	2,465
64	–	–	–	439	–	63	83	10	73	–	3,681	177	10	3,483	11	10	–	10	–	–	–	–	10	4,286