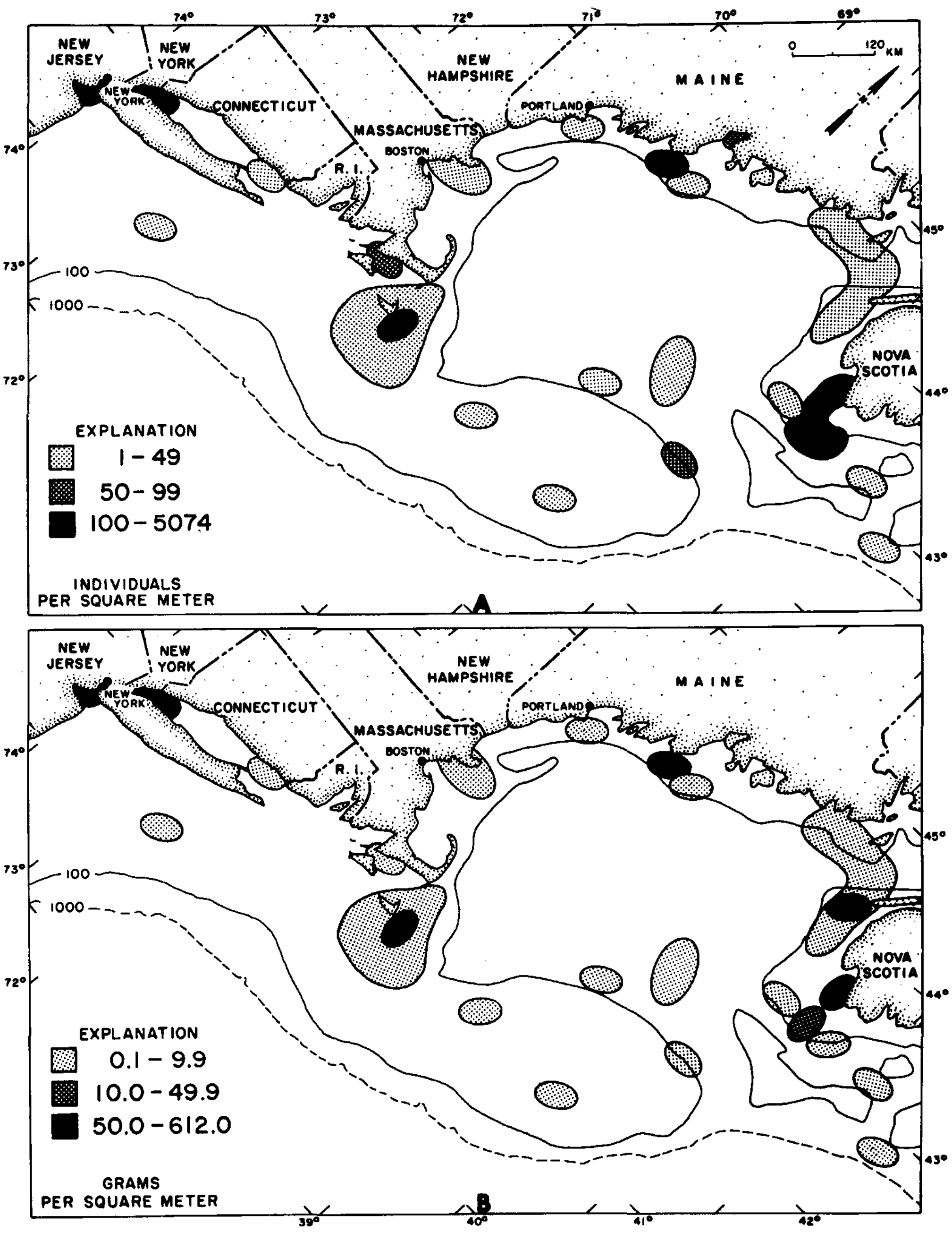


Figure 148
Geographic distribution of Cirripedia: A—number of specimens per square meter of bottom; B—biomass in grams per square meter of bottom.

Bathymetric Distribution
Barnacles were limited to the rather shallow depth range of 8 to 329 m. They were substantially more plentiful (214 individuals/m^2) in shallow water and diminished sharply in abundance with increasing water depth (Table 11; Fig. 150). Densities on the outer continental shelf and upper slope were 2.3 and 0.7 individuals/m^2, respectively.

Biomass of barnacles in relation to bathymetric distribution was similar to that of numerical density. Biomass was largest (27 g/m^2) in shallow water and de-

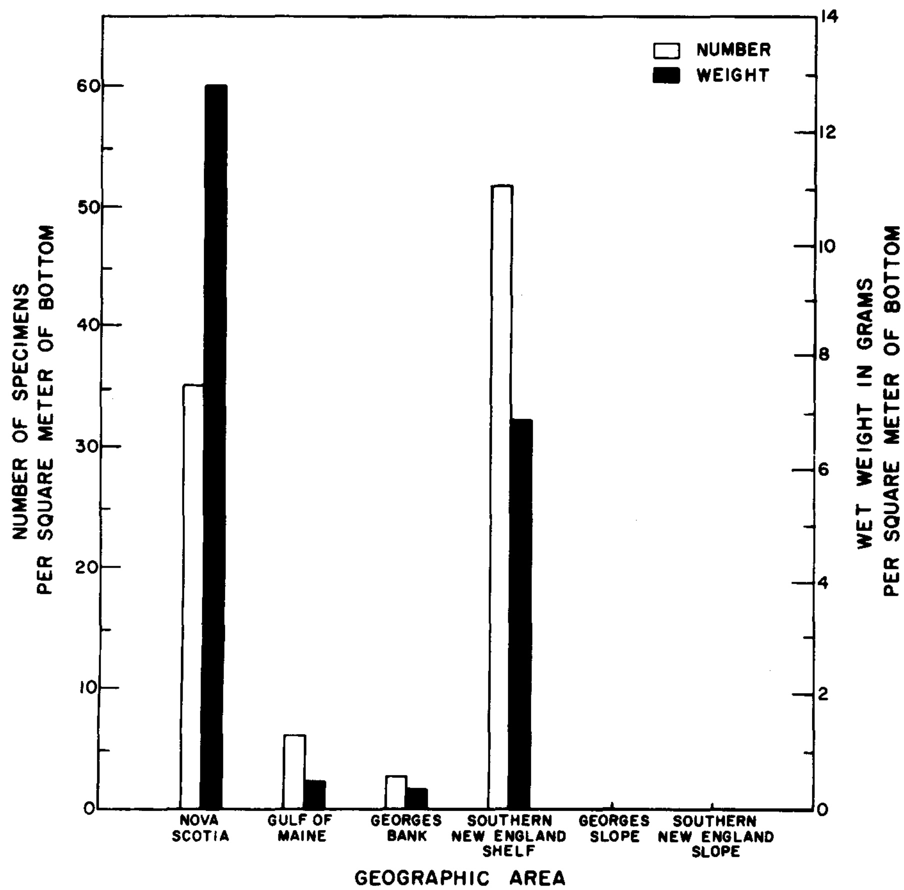


Figure 149
Density and biomass of Cirripedia in each of the six geographic areas.

creased with increasing depth (to 0.1 g/m^2 at 100–199 m) (Table 13; Fig. 150). An exception to this trend occurred in the 200–499 m depth class. In this deepwater zone the density was low but the biomass was much larger (2.5 gm^2) than the general trend would have indicated. This relatively large value may have been due to the presence of *Balanus hameri* in this depth class. This species is exceptionally large and occurs in moderately deep water.

Barnacles occurred in only a small proportion of the samples, but they were much more common (13%) in the shallow depth class (0–24 m) than in the other classes (3 to 4%). None were present in depths greater than 500 m (Table 15).

Relation to Sediments

Barnacles were found in all sediment types of the New England region that were sampled. Their average density was, surprisingly, highest (56 individuals/m^2) in sand-silt sediments (Table 16; Fig. 151). Moderate densities (29 and 16 individuals/m^2) occurred on gravel and sand bottoms. The other sediment types yielded low (<5/m^2) densities.

The biomass of barnacles was largest (11 g/m^2) on gravel bottoms and was moderate (4.4 and 2.4 g/m^2) in sand-silt and sand. Low quantities (<0.5 g/m^2) prevailed in the other sediments (Table 18; Fig. 151).

The unexpectedly high density of cirripedes in sand-silt bottoms resulted from high concentrations of small specimens (average weight <0.1 g) in a small proportion (3%) of the samples. Small barnacles densely colonize occasional mollusk shells and other firm substrates, often of biogenic origin, but rarely are they able to attain large size in these habitats. Conversely, on gravel bottoms the average size of individual barnacles was 0.3 to 0.4 g.

Frequency of occurrence of barnacles was low in all types of bottom sediments. Shell and gravel ranked

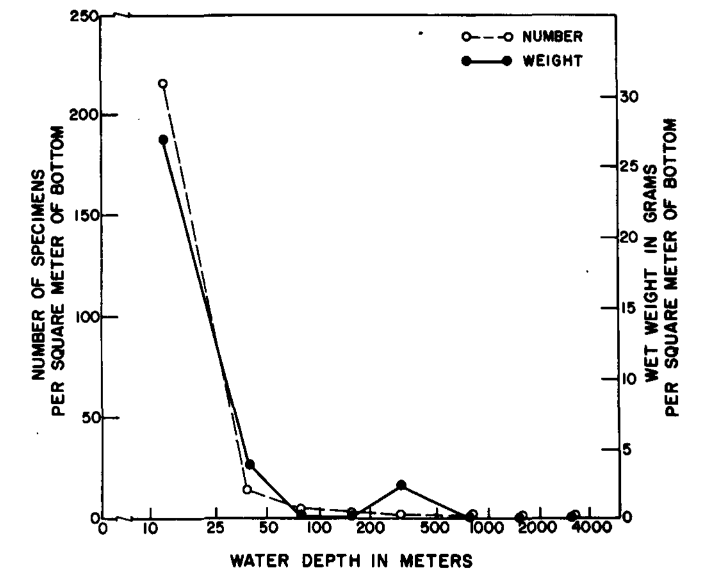


Figure 150
Density and biomass of Cirripedia in relation to water depth.

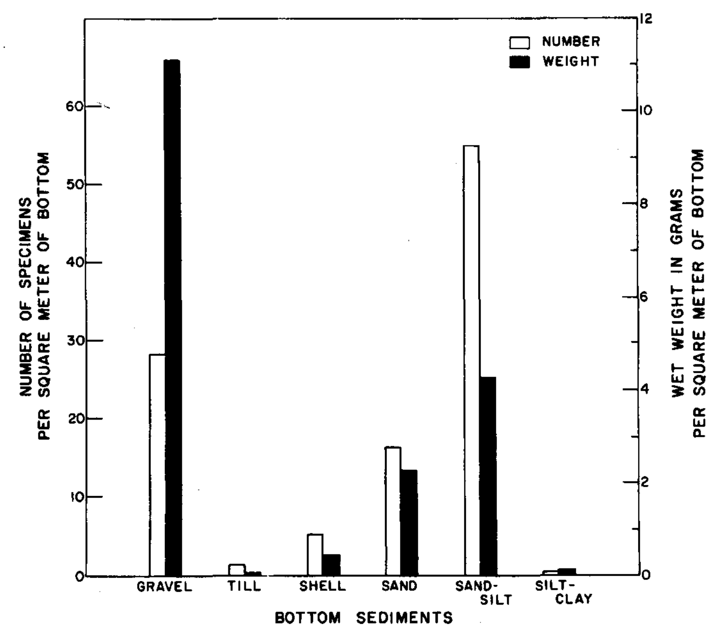


Figure 151
Density and biomass of Cirripedia in relation to bottom sediments.

highest with an incidence rate of 13 to 17%. The rate was moderately high in till, but in all other types they were present in less than 3% of the samples (Table 20).

Relation to Water Temperature

Barnacles occurred throughout the entire temperature range spectrum of the New England region (Table 21; Fig. 152). There was a pronounced increase in density as

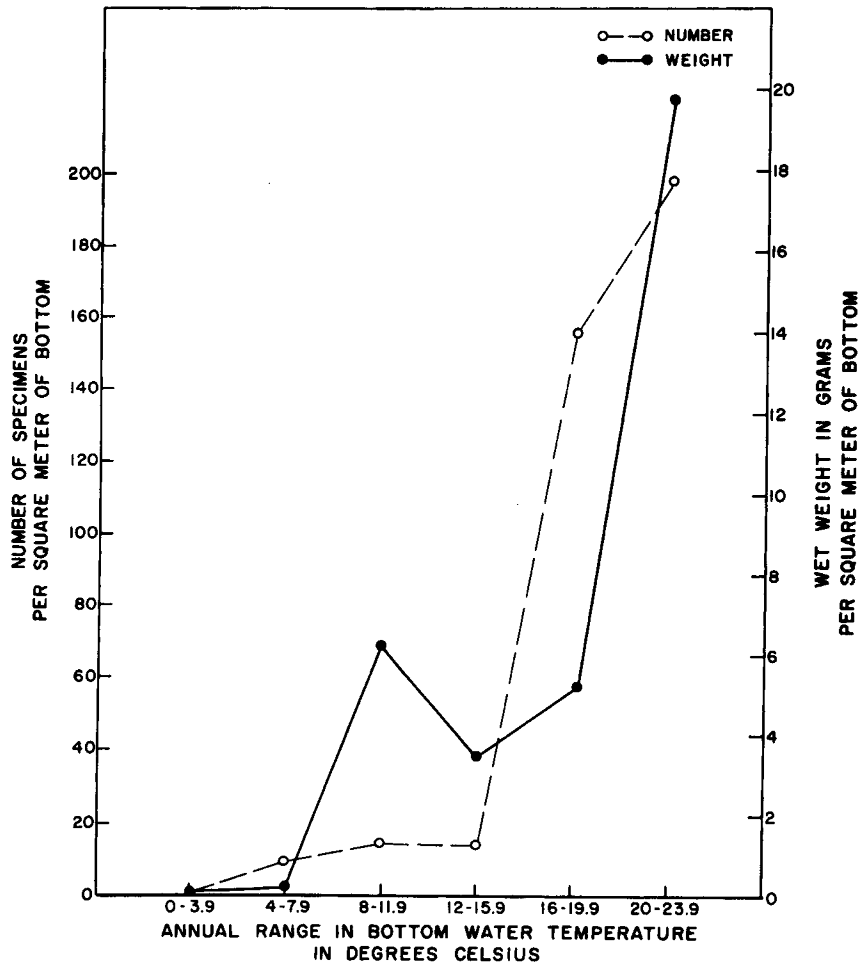


Figure 152
Density and biomass of Cirripedia in relation to the annual range of bottom water temperature.

the temperature range broadened. This trend was very pronounced. Their density was 0.3/m^2 where the temperature range was nil or small. Their density steadily increased to 196/m^2 where the temperature range was greatest.

Biomass similarly showed a marked increase in relation to increased temperature range. The range in average biomass was from 0.05 to 20.32 g/m^2, the extreme values occurring in the two extreme temperature range classes (Table 23; Fig. 152).

Frequency of occurrence of cirripedes was rather low (2 to 5% of the samples) in all temperature range classes except the highest (20°–23.9°C), where a moderate (18%) incidence rate was obtained (Table 25).

Relation to Sediment Organic Carbon
There was a distinct bimodal relationship of cirripede abundance with regard to organic carbon content of the sediment. This was especially apparent in terms of density. Moderate densities (19 and 39 individuals/m^2) occurred in the two carbon content range classes between 0.01 and 0.99%; none occurred in content classes between 1.00 and 1.99%; but density increased dramatically to 613/m^2 where carbon content was from 2.00 to 2.99%, and was moderately high (83/m^2) in carbon contents between 3 and 5% (Table 26; Fig. 153).

Biomass displayed a similar trend but not as dramatically. Moderate biomass (6.5 and 4.1 g/m^2) occurred in the two range classes between 0.01 and 0.99%, with highest biomass (14.3 g/m^2) in the 2.00 to 2.99% class (Table 28; Fig. 153). Lowest biomass was in the highest organic content class.

Frequency of occurrence of barnacles was moderate (3 and 6%) in the lower level organic carbon content classes but was moderately high (15 and 25%) in the

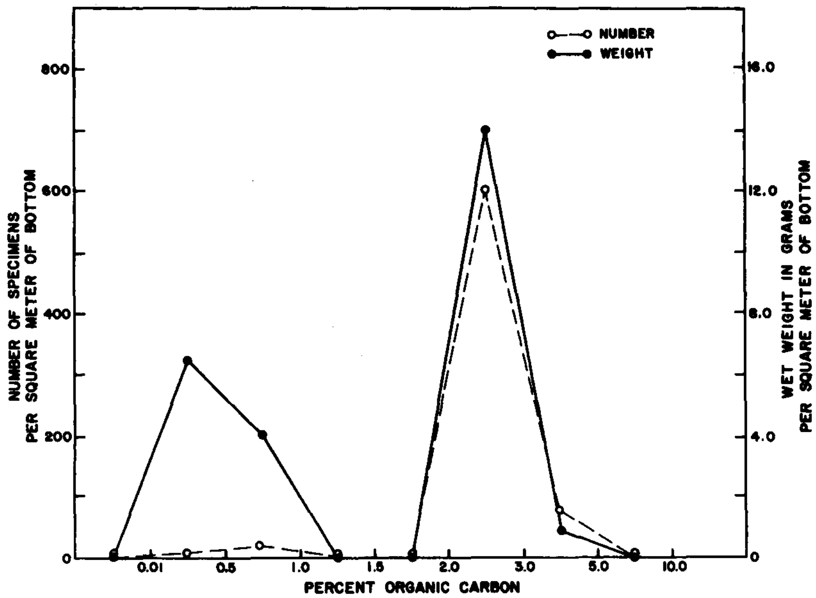


Figure 153
Density and biomass of Cirripedia in relation to sediment organic carbon.

higher level classes, reflecting the trends established by density and biomass (Table 30).

Copepoda—Only four of our samples contained specimens of Copepoda, representing only 0.4% of the total samples. The small size of members of this group in relation to the sampling methods used in this study led to incomplete sampling and the attendant extremely conservative abundance estimates.

Copepoda represented less than 0.1% of the total macrofaunal biomass and density (Table 3). A total of 26 specimens was obtained, yielding a mean density of $<0.1/m^2$ and a mean biomass of <0.01 g/m^2 (Table 5).

Samples containing copepods were located in the Southern New England Shelf and Slope subareas. Depth ranges occupied were 50–99 m, 200–499 m and 500–599 m. Copepods were present in three sediment types (sand, sand-silt, and silt-clay), in two temperature range classes (0–3.9° and 12–15.9°C), and in the three organic carbon content classes between 0.01 and 1.49%.

Values of copepod biomass and density for each environmental parameter considered in this report may be found in Tables 6–30.

Cumacea—Cumaceans are marine peracarid crustaceans that were widely distributed and well represented in New England waters (Theroux and Schmidt-Gengenbach[7]). Twenty-three species in 13 genera belonging to 5 families were identified in our samples from the New England region. Cumaceans were among the subdominant taxa in terms of density, providing 1.7% of the total number of specimens, but owing to their small size, were much less important in terms of biomass, contributing only 0.1% of the total (Table 3).

Cumaceans in our collections ranged from 7 to 15 mm in length; most were between 8 and 12 mm long.

Color of our specimens was mostly drab olive to olive brown with a few lighter in color and mottled by dark spots.

The majority of cumaceans are bottom dwellers that were found buried in sand and mud, filter feeding or browsing organic matter from sand grains. Many exhibit diel excursion to the surface or into the water column where they swarm at night.

Cumaceans occurred in 390 samples (36% of the total), yielding a total of more than 27,500 specimens (Table 5). Their mean density was 26/m^2, and mean biomass was 0.11 g/m^2.

Geographic Distribution

Although found throughout the study area, cumaceans showed some interesting patterns of absence, especially in the Gulf of Maine. These distributional patterns reflect the rather restricted sediment particle size preferences of cumaceans. They tend to favor sediments of medium to medium-fine particle sizes that are most prevalent in the sand fractions, and shun the coarser (gravels, tills, shelly fractions) and finer (sandy silts, silts and clays) fractions. The Nova Scotian shelf and Gulf of Maine each contain extensive deep basins floored with fine muds, as well as shallower banks paved with

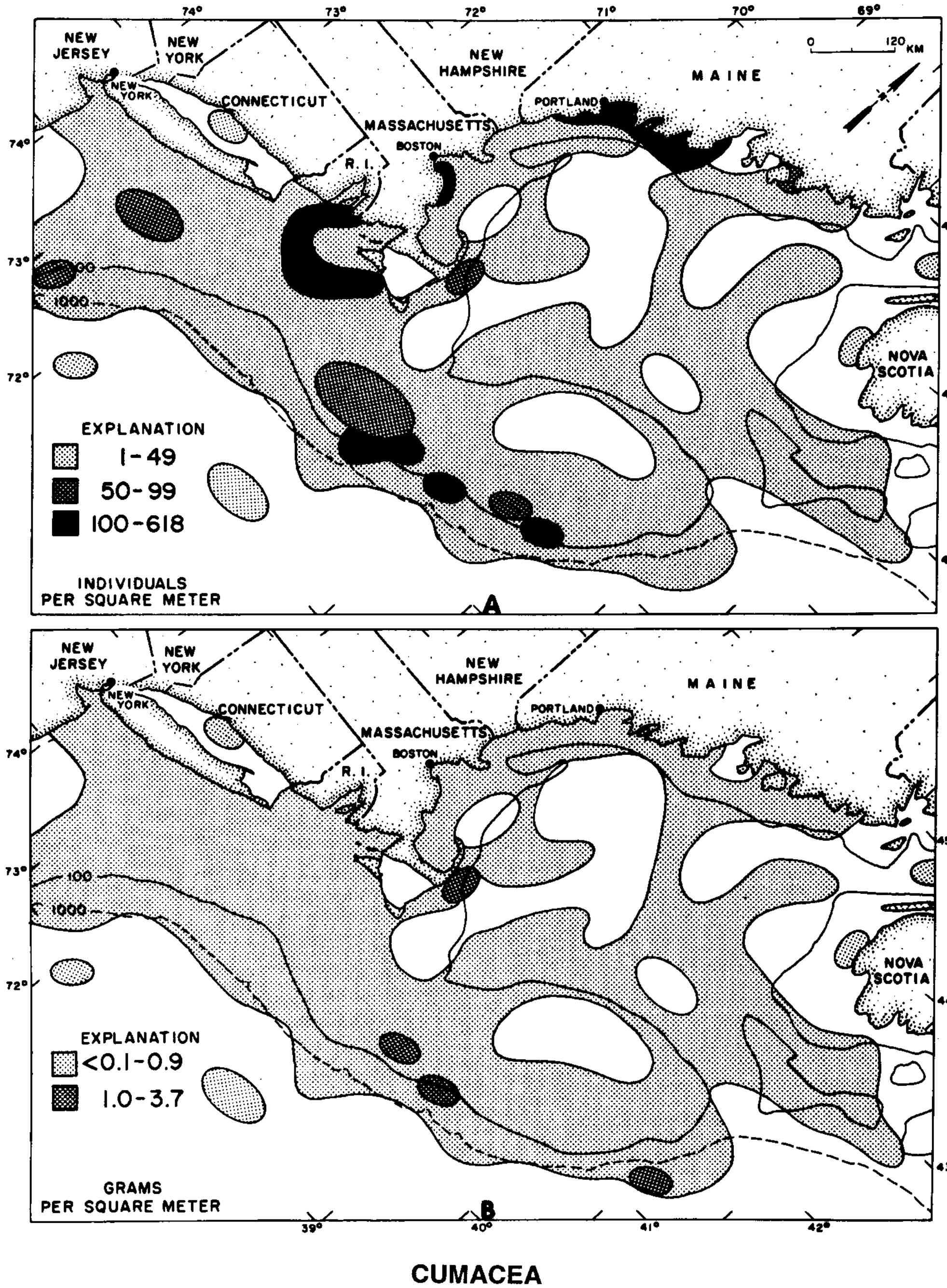


Figure 154
Geographic distribution of Cumacea: A—number of specimens per square meter of bottom; B—biomass in grams per square meter of bottom.

cobbles, gravels, and coarse sands; the central part of Georges Bank is largely made up of coarse shifting sands; and Nantucket, Vineyard, and Long Island Sounds contain large expanses of very fine muds and silts. Most of these areas were devoid of cumaceans (Fig. 154).

Average densities ranged from 1 to 618 individuals/m^2. The majority of the region contained moderate densities (1–49/m^2) with medium size patches of intermediate (50–99/m^2) density at continental shelf depths, and high (100–618/m^2) density along the southern edge of Georges Bank and along the coasts of Maine, Massachusetts, and Rhode Island.

Average biomass was low (<0.1–0.9 g/m^2) over most of their range with only small patches of moderately

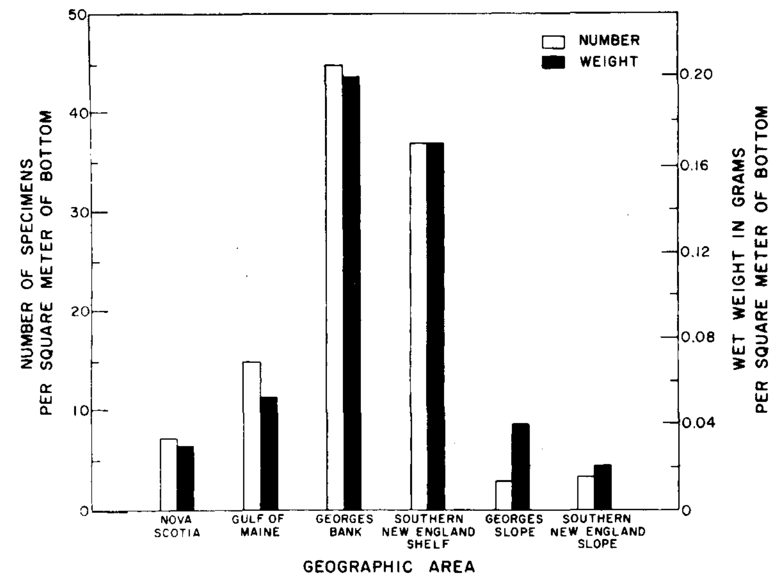


Figure 155
Density and biomass of Cumacea in each of the six geographic areas.

low biomass (1–4 g/m^2) along the shelf break on Georges Bank and the eastern shore of Cape Cod.

Among the standard geographic areas, Georges Bank and the Southern New England Shelf yielded the highest mean densities (45 and 37/m^2, respectively) and biomass (0.20 and 0.17 g/m^2, respectively).

Lower densities and biomasses occurred in the Gulf of Maine and Nova Scotia shelf, and lowest values for both measures occurred in the two slope areas (Tables 6, 8; Fig. 155).

Frequency of occurrence was moderately high in all geographic areas with from 19 to 49% of the samples containing specimens of cumaceans (Table 10).

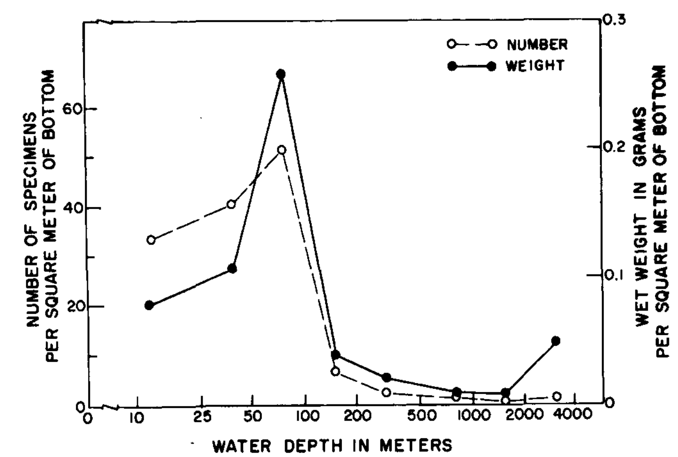


Figure 156
Density and biomass of Cumacea in relation to water depth.

Bathymetric Distribution

Cumaceans were obtained at depths from 4 to 2,840 m. They were most plentiful, however, at depths shallower than 100 m. The three depth zones between 0 and 100 m contained significantly higher mean densities than the deeper zones, ranging from 50 to 33/m^2 as depth decreased, whereas in the deeper (>100 m) ones they ranged from 7 to 0.7/m^2 as depth increased to 1,999 m. In the deepest zone (2,00–3,999 m) mean density was 2/m^2 (Table 11; Fig. 156).

The trend for biomass in relation to depth was similar to that for density but was from one to three orders of magnitude lower. Mean biomass ranged from 0.26 to 0.08 g/m^2 in waters 100 m and less in depth and was lower still at deeper (>100–1,999 m) sites, ranging from 0.04 to 0.01 g/m^2 with increasing depth. The deepest zone contained a mean biomass of 0.05 g/m^2 (Table 13; Fig. 156).

Cumaceans were well represented in the samples in each depth class. Four depth classes, the three between 25 and 200 m and the 500–999 m class, each yielded specimens in over 30% of the samples (range: 30–

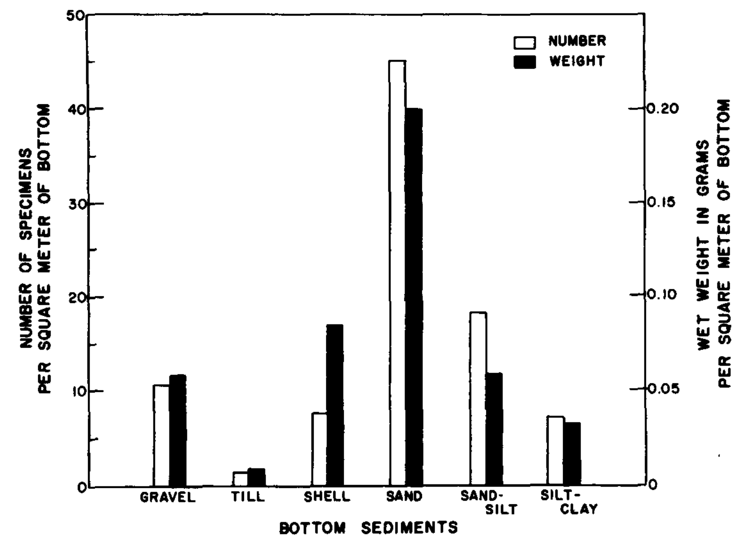


Figure 157
Density and biomass of Cumacea in relation to bottom sediments.

56%), while the other depth classes had frequencies over 15% (Table 15).

Relation to Sediments

Cumaceans occurred in all sediments found in the region but in significantly different proportions. Sand, sand-silt, and gravel contained the greatest numbers of individuals, with mean densities of 45, 18, and 11/m^2, respectively; shell and silt-clay sediments yielded moderate mean densities (8 and 7/m^2, respectively), with smallest (1/m^2) amounts in till substrates (Table 16; Fig. 157).

The trend for biomass was essentially similar to that of density but at much reduced levels (Table 18; Fig. 157). Sand, shell, and sand-silt contained mean biomasses of 0.20, 0.08, and 0.06 g/m^2, respectively, while the values for gravel, till, and silt-clay were 0.06, 0.01, and 0.03 g/m^2, respectively.

The frequency of occurrence of cumaceans ranged from 50 to 26%, in samples from sand, sand-silt, and gravel and was between 14 and 22% in the other sediment types (Table 20).

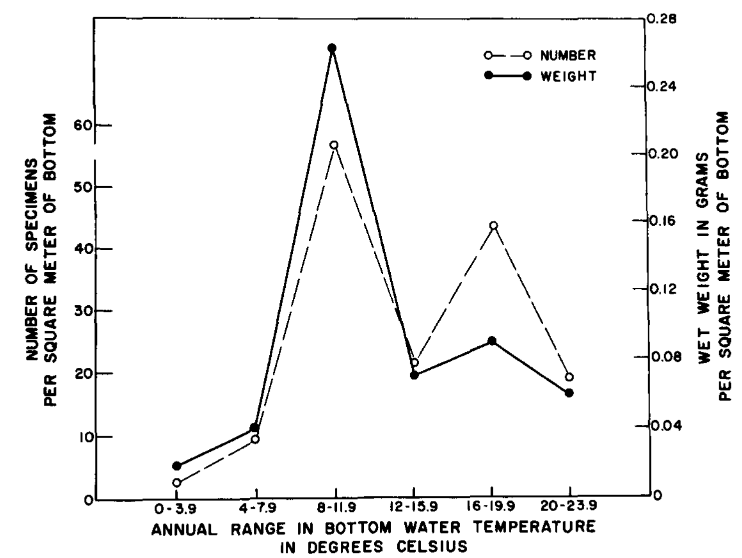


Figure 158
Density and biomass of Cumacea in relation to the annual range of bottom water temperature.

Relation to Water Temperature

Both measures of cumacean abundance showed a bimodal trend in relation to annual range in bottom water temperature. The greatest numerical abundance (56/m^2) and biomass (0.26 g/m^2) occurred where temperature range was moderate (8–11.9°C), followed by another peak in areas experiencing a somewhat higher (16–19.9°C) range where high density (44/m^2) but considerably lower (0.09 g/m^2) biomass occurred (Tables 21, 23; Fig. 158). Density was also relatively high in the two other high temperature range classes (12–15.9° and >20°C) but fell off considerably in the more stable temperature regimes with ranges between

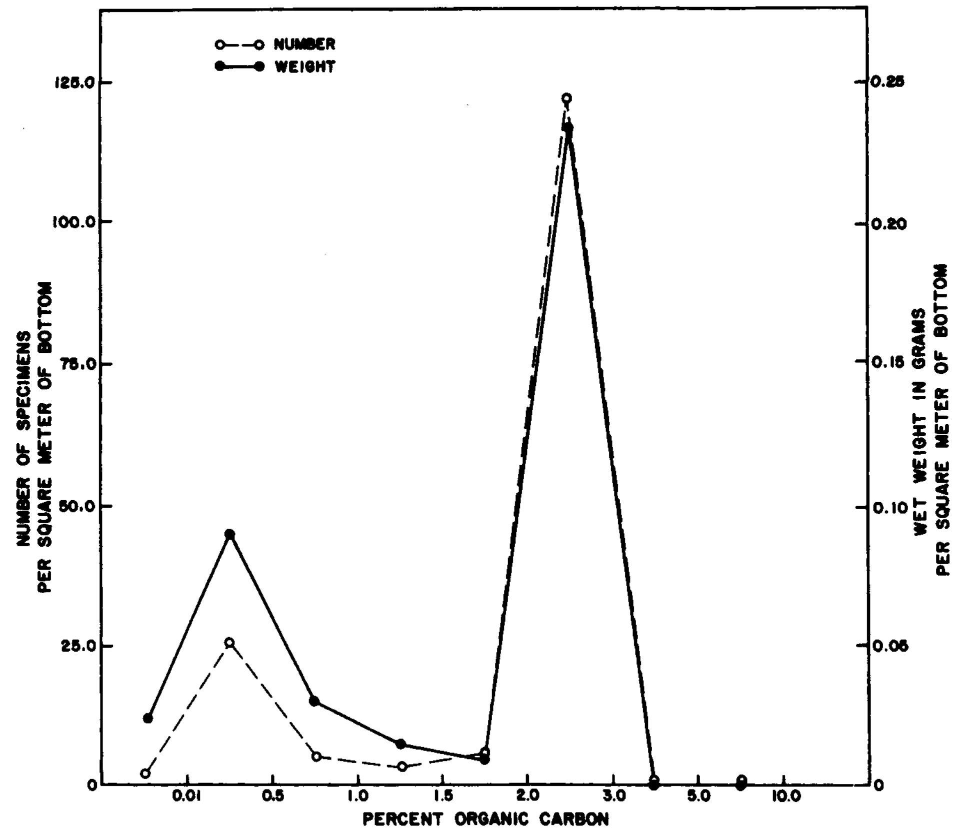


Figure 159
Density and biomass of Cumacea in relation to sediment organic carbon.

0 and 7.9°C. Biomass values, although at a much lower level, were similarly affected.

Frequency of occurrence of cumaceans in samples in the various temperature range classes was fairly equal (ranging from 31 to 38%) in all but two: the 8–11.9°C class had a 54% occurrence and the 0–3.9°C class had a 19% rate (Table 25).

Relation to Sediment Organic Carbon

Among the various taxa considered in this study, Cumacea is one of only a few which showed a marked preference in relation to organic carbon content. Sediments containing 2.00–2.99% organic carbon were clearly preferred over all other content classes (Tables 26, 28; Fig. 159). There the mean density of cumaceans was $123/m^2$ with a mean biomass of 0.24 g/m^2, reflecting, no doubt, the habit adopted by many species of browsing organic matter from sand grains. Another peak in abundance ($25/m^2$ and 0.09 g/m^2) occurred in the much lower organic carbon content class 0.01–0.49% Significantly lower densities and biomasses occurred in the other carbon content classes, and none occurred in levels above 3%.

The highest frequency of occurrence, 44%, was in the 0.01–0.49% content class followed by the 2.00–2.99% class, in which 31% of the samples yielded specimens of cumaceans. Twelve to 29% of the samples in the other content classes in which they occurred provided specimens (Table 30).

Tanaidacea—Tanaidaceans are peracaridan crustaceans generally considered to be transitory forms between the Mysidacea-Cumacea and the Isopoda. The order is made up of four families, but only two, the Paratanaidae and Neotanaidae, were represented in our collections.

Although our specimens were collected in relatively deep water, tanaidaceans can be found from between tide marks to ultra-abyssal depths exceeding 9,000 m. They inhabit burrows, tubes, or rock crevices. Some species are known to inhabit sponges; others may be found on algae or the shells of bivalve mollusks, barnacles, and other animal groups.

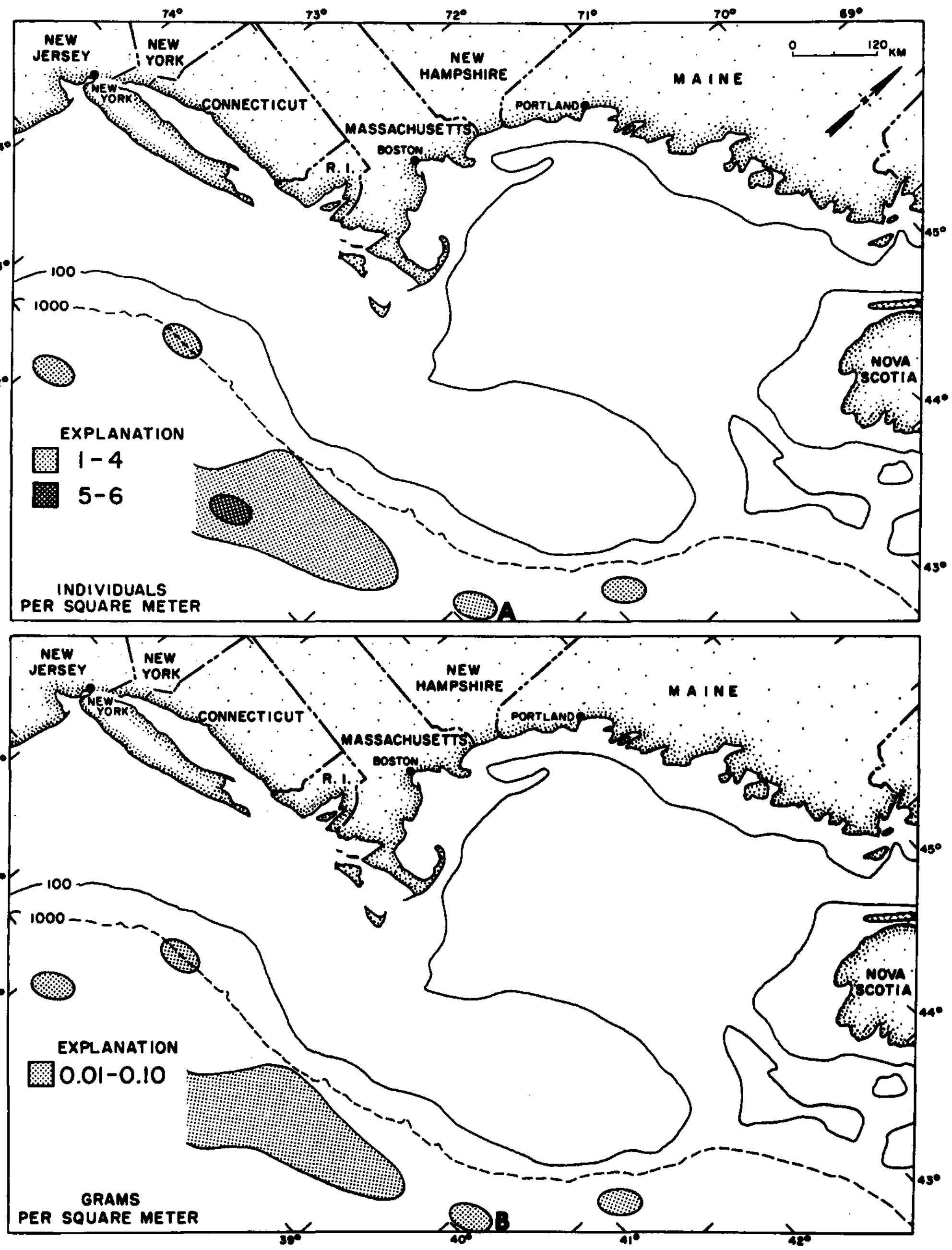
Tanaidaceans attain lengths of 2 cm or more, but most specimens in our samples were generally small in size, usually less than 0.5 cm long.

The color of our specimens was most commonly whitish and tinged with light green or light tan. Some specimens bore small brownish patches in the head region.

Tanaidaceans occurred in 15 samples (1% of total). Their density averaged $<0.1/m^2$ and their biomass averaged <0.01 g/m^2 (Table 5).

Geographic Distribution

Tanaidaceans were present only on the continental slope and continental rise south of Georges Bank and Southern New England (Fig. 160). They occurred in low density (6 individuals or less/m^2), and their biomass was very small (<0.01 to 0.10 g/m^2) in all sectors.



TANAIDACEA

Figure 160

Geographic distribution of Tanaidacea: A—number of specimens per square meter of bottom; B—biomass in grams per square meter of bottom.

None were present in quantitative samples from the continental shelf even though previous studies and our own nonquantitative samples have revealed their presence in certain habitats in the intertidal and shallow sublittoral areas along the coast. They appear to be rare or absent from most of the outer continental shelf areas in the New England region.

Tanaidaceans were present in only two of the six standard geographic areas: Georges Slope and Southern New England Slope (Tables 6, 8; Fig. 161). Average density in each area was 0.4 individual/m^2 with an average biomass of 0.01 g or less/m^2.

Members of this group were present in 15% of the samples from Georges Slope and in 9% of samples from Southern New England Slope (Table 10).

Bathymetric Distribution

In the present study tanaidaceans were found only in water depths ranging from 366 to 3,820 m (Table 11; Fig. 162). Their density was low in all depth classes within the range of their occurrence but was relatively higher (averaged 1 individual/m^2) in depths greater than 2,000 m than at shallower depths, where they averaged only 0.1 of an individual/m^2.

Biomass revealed a trend similar to that of numerical density. The biomass averaged <0.01 g/m^2 in the shallower depth classes, and 0.01 g/m^2 in deep water (Table 13; Fig. 162).

Frequency of occurrence disclosed trends similar to both density and biomass. The occurrence rate of tanaidaceans at depths greater than 2,000 m was 35%, an unusually high ratio compared to only 1 to 3% occurrence in the shallower portion of their bathymetric range (Table 15).

Relation to Sediments

Tanaidaceans were found only in soft, fine-grain sediments: sand-silt and silt-clay (Tables 16, 18, 20; Fig. 163). Density, biomass, and frequency of occurrence were very low and approximately equal in both sediment types.

Relation to Water Temperature

Tanaidaceans were encountered only in areas where the annual temperature range was less than 8°C (Tables 21, 23, 25; Fig. 164). All of the measures of abundance (density, biomass, and frequency of occurrence) were very low in each of the two temperature range classes (0°–3.9° and 4°–7.9°C) in which tanaidaceans occurred.

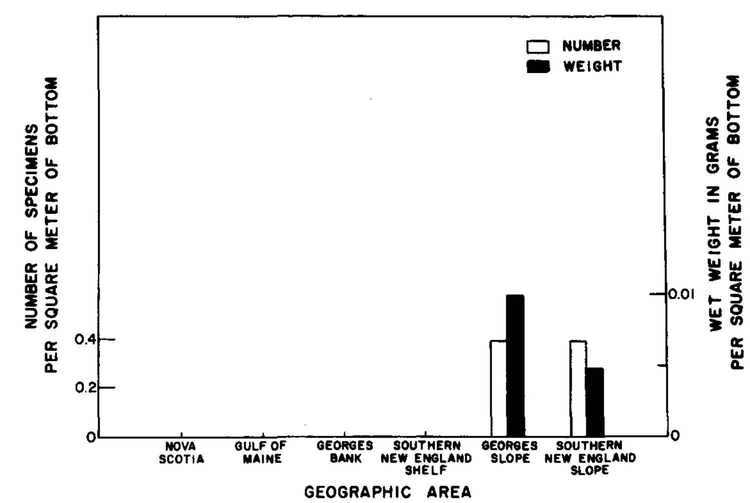


Figure 161
Density and biomass of Tanaidacea in each of the six geographic areas.

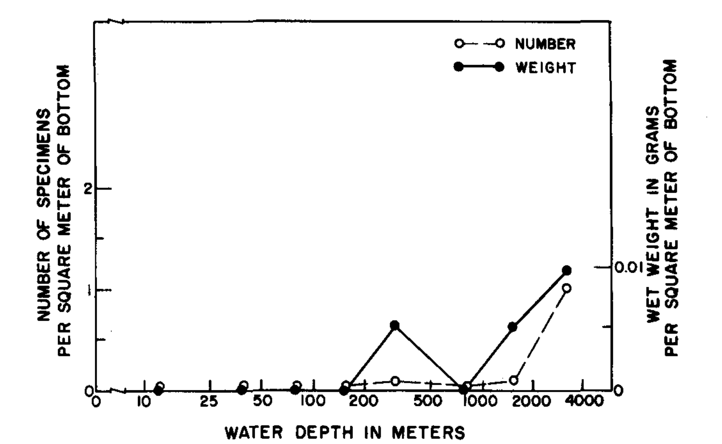


Figure 162
Density and biomass of Tanaidacea in relation to water depth.

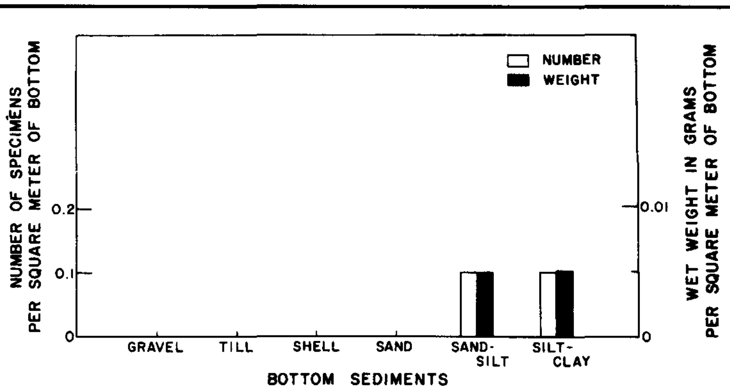


Figure 163
Density and biomass of Tanaidacea in relation to bottom sidements.

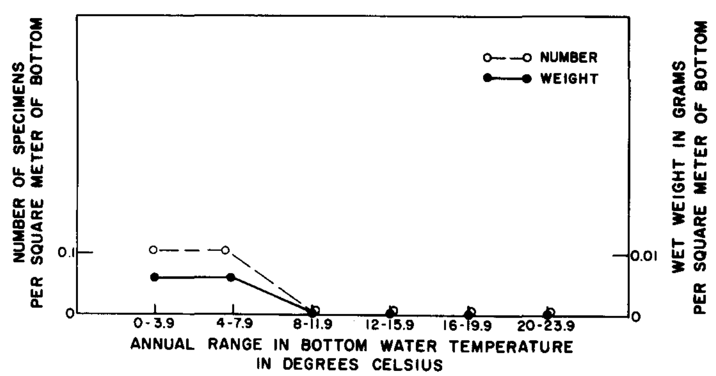


Figure 164
Density and biomass of Tanaidacea in relation to the annual range of bottom water temperature.

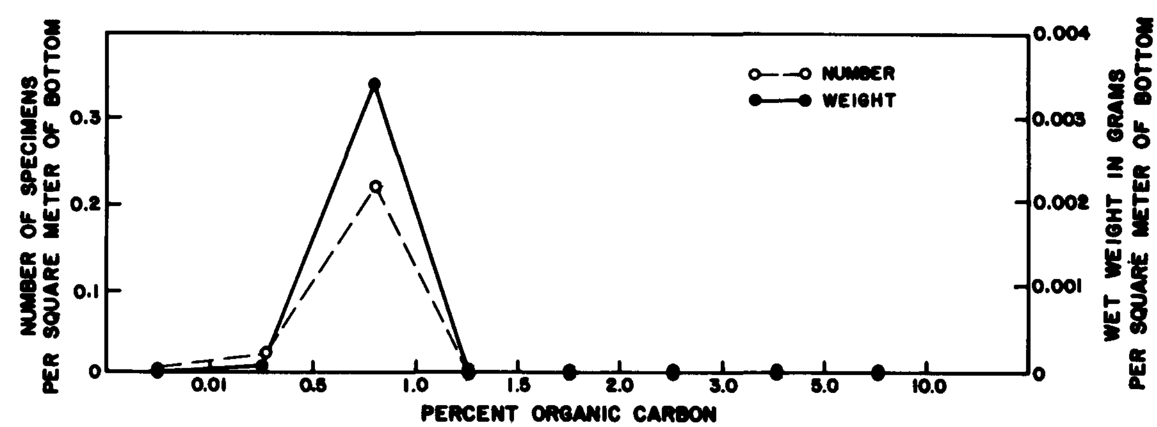


Figure 165
Density and biomass of Tanaidacea in relation to sediment organic carbon.

Relation to Sediment Organic Carbon

Tanaidaceans occurred only in areas of low organic carbon (Tables 26, 28, 30; Fig. 165). Density, biomass, and incidence of occurrence were all low in two organic carbon content classes (0.01–0.49 and 0.50–0.99%).

Isopoda—Isopods were moderately sparse but widely distributed throughout New England waters. Because of their limited abundance and small size they made up only a small portion of the total benthic fauna. They accounted for <1% of the total number of benthic animals and only 0.2% of the total biomass (Table 3).

Isopods in our samples ranged from 3 to 20 mm in length; the majority of specimens were approximately 10 to 15 mm long. Color of most specimens was translucent to light tan or medium brown.

Approximately 13 species of isopods were represented in the collections, most of which belonged to the families Cirolanidae and Idoteidae. A new species, *Chiridotea arenicola* Wigley (1960a), was described from specimens found in collections from Georges Bank.

A large proportion of the specimens were adapted for burrowing in sand or for crawling on sandy or rocky substrates.

Isopods occurred in 390 samples (36% of total). Their density averaged 12.1/m^2 and their biomass averaged 0.29 g/m^2 (Table 5).

Geographic Distribution

Isopods were widely distributed over large portions of the study area (Fig. 166). They were especially common on the banks and in coastal regions. They were least common in the deeper portion of the western Gulf of Maine, in the vicinity of Nova Scotia, and on the continental shelf and rise. Densities between 10 and 50 indi-

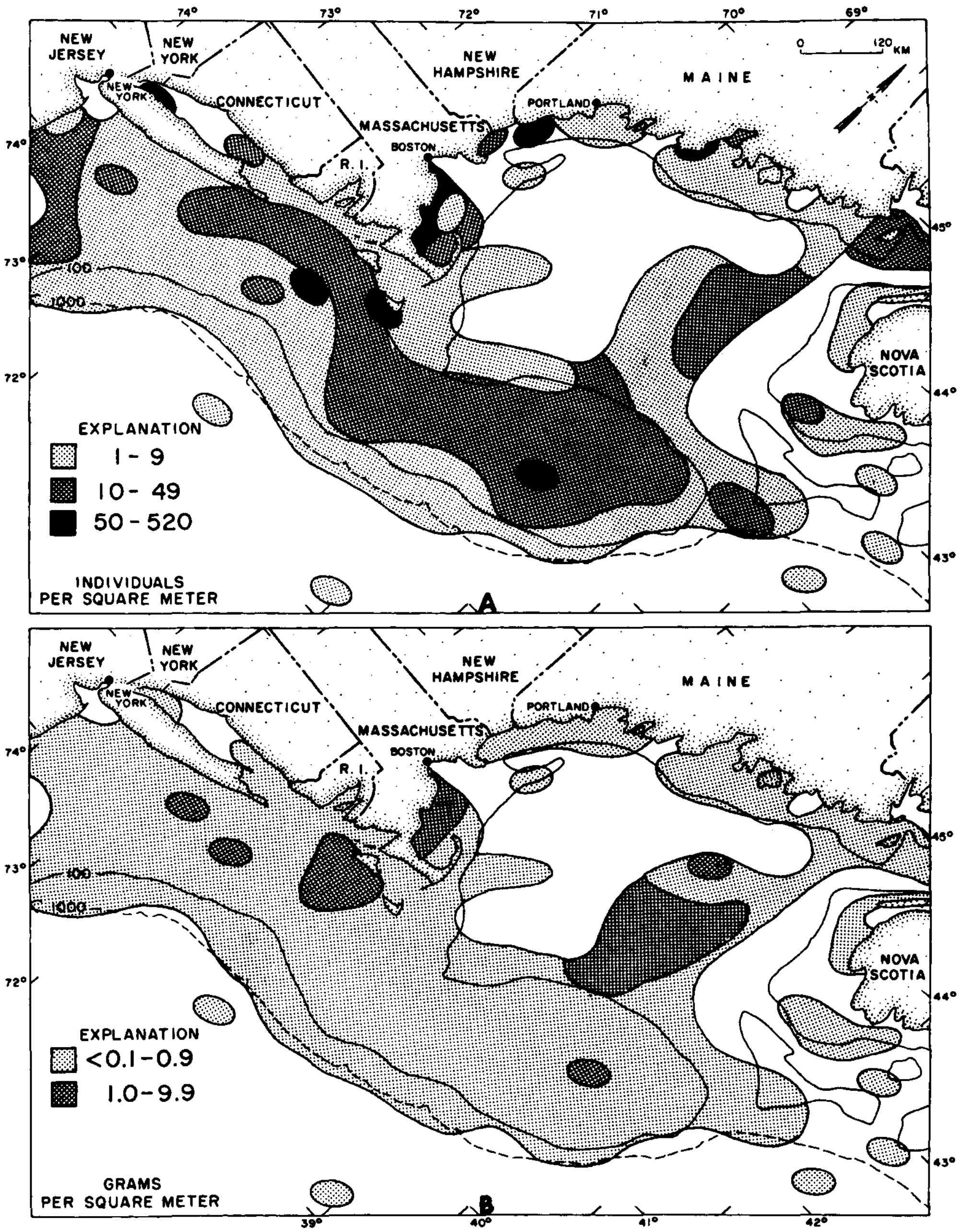


Figure 166

Geographic distribution of Isopoda: A—number of specimens per square meter of bottom; B—biomass in grams per square meter of bottom.

viduals/m^2 extended over large areas of the Gulf of Maine and Southern New England. High densities of 50 to 520 individuals/m^2 occurred in relatively few small areas. Average biomass was commonly less than 1 g/m^2, and the highest average biomasses were between 1 and 9.9 g/m^2.

Among the six standard geographic areas, isopods were most numerous (18 and 17 individuals/m^2) on Georges Bank and the Southern New England Shelf (Table 6; Fig. 167). Intermediate densities (3.9 and 9.5/m^2) were found in the Nova Scotia and Gulf of Maine areas. Low densities (1.0 and 1.3/m^2) occurred in the two slope areas.

The average biomass of isopods was small (0.4 g/m^2 or less) in all areas (Table 8; Fig. 167).

The quantitative geographic distribution of isopods was very similar to that of cumaceans (see Table 6). The major difference was that cumaceans were twice as numerous as isopods, but the relative densities of the two groups corresponded rather closely. The geographic distributions of the two groups were also similar (see Fig. 154).

Frequency of occurrence of isopods in the samples was moderate (48% of the samples) on Georges Bank and the Southern New England Slope. In the other four geographic areas isopods occurred in 20 to 35% of the samples (Table 10).

Bathymetric Distribution

Isopods occupied a very wide depth range (5–3,820 m) and specimens were present in all eight depth classes (Table 11; Fig. 168). Densities were highest (22–38 individuals/m^2) in the two shallowest depth classes and decreased as water depth increased. Lowest density (0.4/m^2) was encountered in water depths between 1,000 and 2,000 m. In samples from the deepest strata (2,000–4,000 m) the density was 1.9/m^2.

Biomass values exhibited similar patterns in relation to water depth (Table 13; Fig. 168). The average biomasses of isopods were much higher (ranging from 0.15 to 0.66 g/m^2) in water depths less than 500 m than in deeper water where the average biomass ranged from only 0.01 to 0.02 g/m^2.

Frequency of occurrence of isopods was highest (46 to 69%) in samples from water depths ranging between 25 and 100 m. Occurrence rates were intermediate (12–20%) in samples from outer continental shelf and continental slope depths (100–2,000 m) and moderately high (43%) at depths greater than 2,000 m (Table 15).

Relation to Sediments

Isopods were found in all of the sediment types occurring in the study area (Table 16; Fig. 169) but were three to seven times more numerous (22.4 individuals/m^2) in sand substrates than in any other type of bottom. The average density of isopods in the other sediment types was fairly uniform, ranging only from 3 to 7/m^2.

The average biomass of isopods was highest (1.36 g/m^2) in till substrates (Table 18; Fig. 169). Also, as was the case

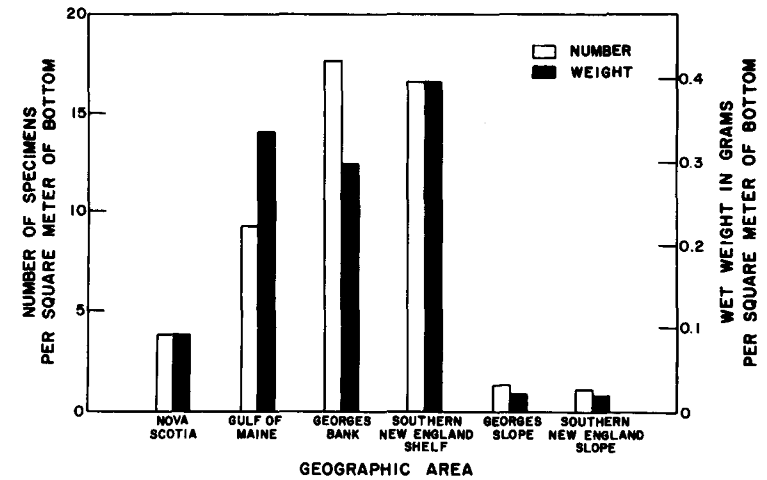


Figure 167
Density and biomass of Isopoda in each of the six geographic areas.

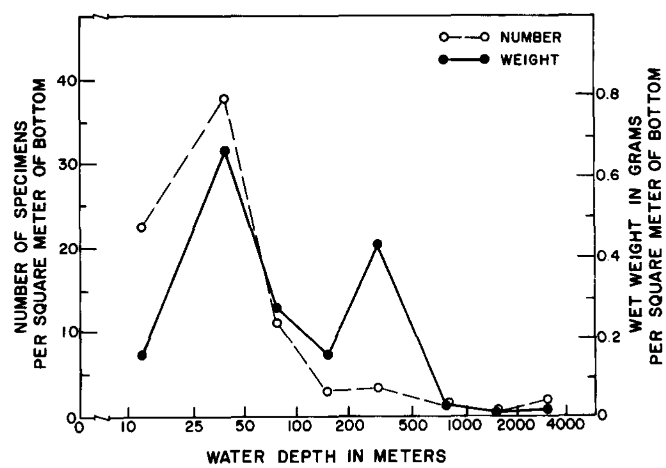


Figure 168
Density and biomass of Isopoda in relation to water depth.

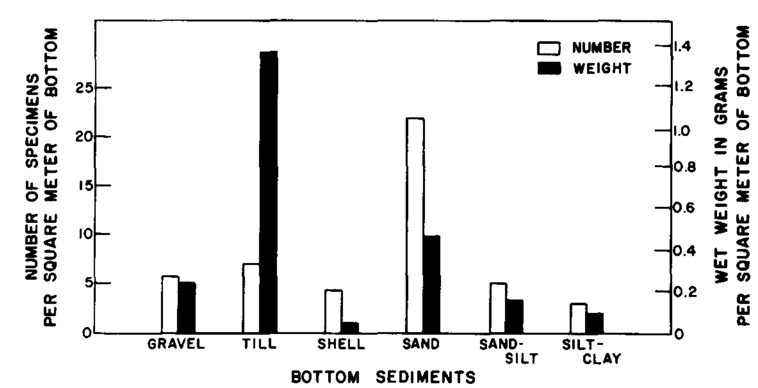


Figure 169
Density and biomass of Isopoda in relation to bottom sediments.

with density, the disparity between the highest and lowest biomass values was quite large. Average biomass (0.44 to 0.04 g/m^2) in the other five sediment types was nearly 3 to 30 times smaller than in till.

Frequency of occurrence of isopods in samples from the various sediment types reflected about the same quantitative distribution exhibited by density and biomass combined. Fifty percent or more of the samples from both till and sand contained isopods, whereas only 16 to 32% of the samples from the other sediment types yielded specimens (Table 20).

Relation to Water Temperature

Among the six temperature range classes two major concentrations of isopod density were detected (Table 21; Fig. 170). One concentration occurred in the broadest (20–23.9°C) temperature range class, which contained the highest density (67 individuals/m^2). The second concentration occurred where the temperature range was from 8 to 15.9°C. Isopod densities in this zone averaged 16 to 25/m^2. Over the remaining temperature ranges, average isopod densities were from 3 to 7/m^2.

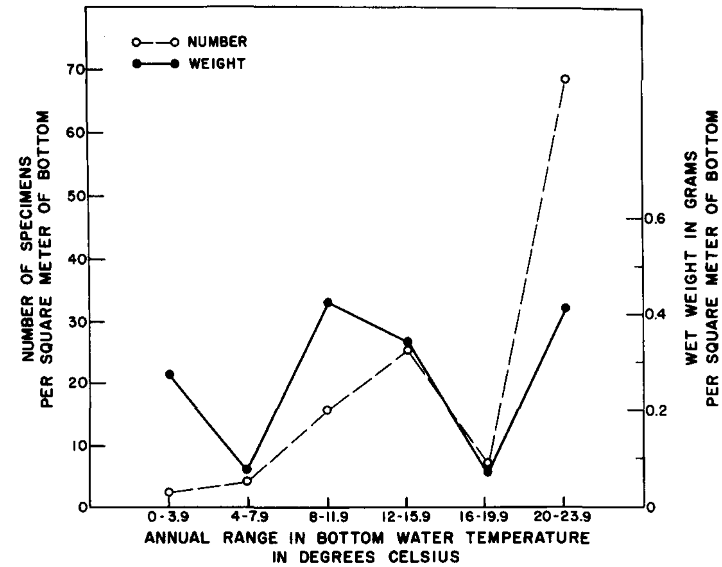


Figure 170
Density and biomass of Isopoda in relation to the annual range of bottom water temperature.

Although the biomass of isopods was small in all temperature range classes, the quantities varied in approximately direct proportion to their density (Table 23; Fig. 170). Relatively large biomasses (0.34 to 0.42 g/m^2) occurred in the same temperature range classes as those for high density. Smaller quantities were present where the density was low.

Frequency of occurrence in each of the temperature range classes was moderate to moderately low. The occurrence rates varied directly with density and biomass values. Relatively high percentages of samples (43 to 61%) contained isopods in the intermediate and broadest temperature range classes. Relatively low occurrence rates (20 to 31% percent) were found in the other classes (Table 25).

Relation to Sediment Organic Carbon

Isopod density in the various organic carbon content classes exhibited a trend similar to that in relation to water temperature in that two major concentrations were detectable (Table 26; Fig. 171). The highest concentration (18 individuals/m^2) occurred in the next to highest content class (3.00–4.99% organic carbon); whereas, the second highest concentration (13/m^2) was in the class containing the lowest amounts of organic carbon detected (0.02–0.49%). Interestingly, a moderate density (9/m^2) of isopods occurred in areas of undetectable organic carbon. Lowest density (<1/m^2) occurred in the lower middle range (1.5–1.99%) of carbon content.

Biomass of isopods was negatively correlated to organic carbon content, tending to decrease as organic content increased (Table 28; Fig. 171). On the whole, biomass was relatively low, ranging from 0.27 to 0.03 g/m^2. Notable anomalies in the general trend occurred in the absence of measurable carbon (0.19 g/m^2) and in a comparatively sizeable (0.14 g/m^2) biomass in the content class that contained the lowest density (1.5–1.99%).

Frequency of occurrence of isopods in the samples in the organic carbon content classes was moderately high (47 and 25%) at the extreme ends of the range and intermediate (5 to 15%) in the intervening content classes (Table 30).

Amphipoda—Amphipods were exceedingly numerous and widely distributed throughout New England marine waters. They were the most abundant taxonomic group encountered in this study, forming 43% of the total number of individuals in the macrobenthos. Because of their small size, however, they did not contribute a correspondingly large share (2.3%) of the total standing crop (Table 3).

The amphipods collected included a wide variety of taxonomically diverse kinds (Dickinson et al., 1980; Dickinson and Wigley, 1981). We estimate that between 100 and 150 different species are represented in the samples. Four new genera and eight new species of amphipods were described, at least in part, from specimens collected during the present study. The following

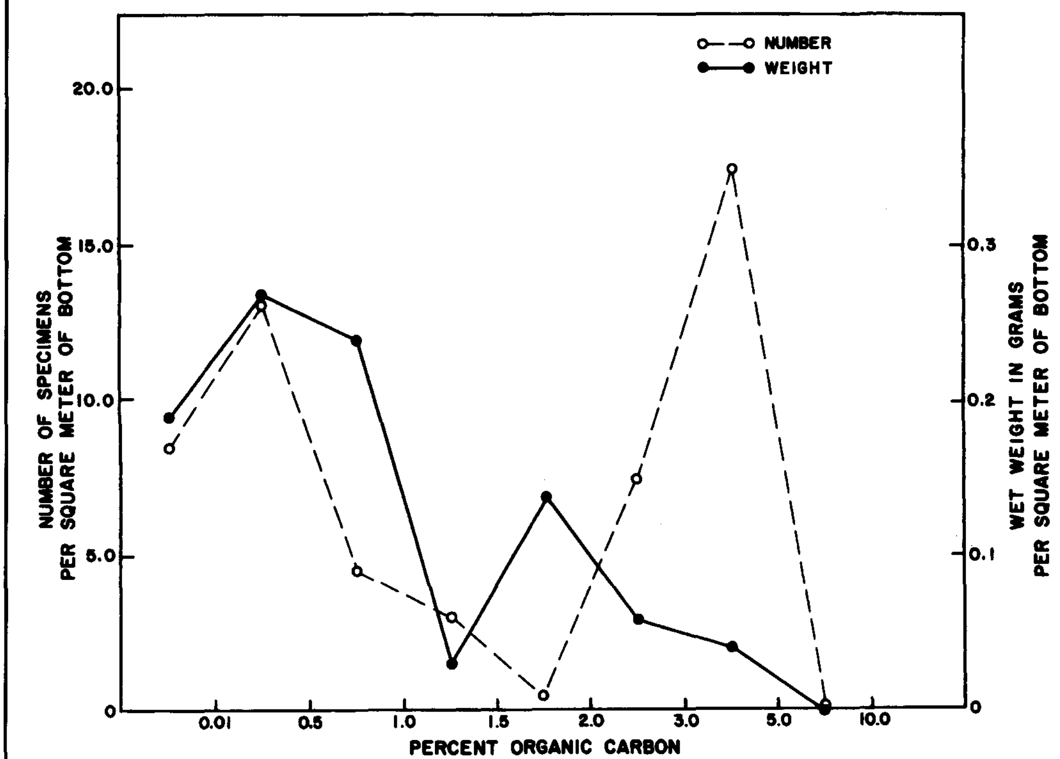


Figure 171
Density and biomass of Isopoda in relation to sediment organic carbon.

new forms were described by Edward L. Bousfield (1965), National Museum of Canada: *Protohaustorius wigleyi, Parahaustorius longimerus, P. holmesi, P. attenuatus, Pseudohaustorius borealis, Acanthohaustorius millsi, A. intermedius,* and *A. spinosus.* At least three suborders are represented in the collections: Gammaridea, Caprellidea, and Hyperiidea. Both the species and the number of individuals of the first group were considerably more numerous than in the latter two groups.

Body size of amphipods was somewhat limited. Small species, which were common in the families Metopidae and Stenothoidae, were 1 to 2 mm in length, or slightly more. The largest species in our collections, the caprellid *Aeginina longicornis,* had a body length of more than 2 cm. Gammaridea larger than 1.5 cm (*Casco, Maera,* and a few others) were uncommon.

Color of amphipods ranged from light cream or nearly white (*Lysianopsis, Ampelisca,* and many others) to moderately dark brown (*Leptocheirus, Melita,* and others). No brightly colored specimens were detected. Some of the more colorful genera were *Stenothoe, Listriella,* and *Amphiporeia,* which have red eyes that contrast with the cephalon, and some members have contrasting colors on the thoracic and abdominal plates.

Quite a few species of New England gammaridean amphipods are tube dwellers. The tubes are usually elongate, cylindrical, or laterally flattened structures constructed of sand grains or clay particles cemented together. It may be significant that at least two of the most common genera (*Ampelisca* and *Unciola*) are tube dwellers. Also *Haploops,* which is one of the few amphipods that was relatively common in the deeper waters of the Gulf of Maine, is tubicolous.

Amphipods occurred in 862 samples (80% of total), their density averaged $656/m^2$, and their biomass averaged 4.16 g/m^2 (Table 5).

Geographic Distribution

Amphipods were extensively distributed throughout the New England region (Fig. 172). They were particularly abundant on the continental shelf, except for the deeper parts of the Gulf of Maine and the southwestern part of the Nova Scotian shelf. Amphipods were an exceptionally abundant group and densities in the coastal areas and on the offshore banks commonly averaged between 100 and 1,000 individuals/m^2. High density (1,000 to 8,900 individuals/m^2) areas were not uncommon in this region. Densities of 1 to $100/m^2$ were typical in the

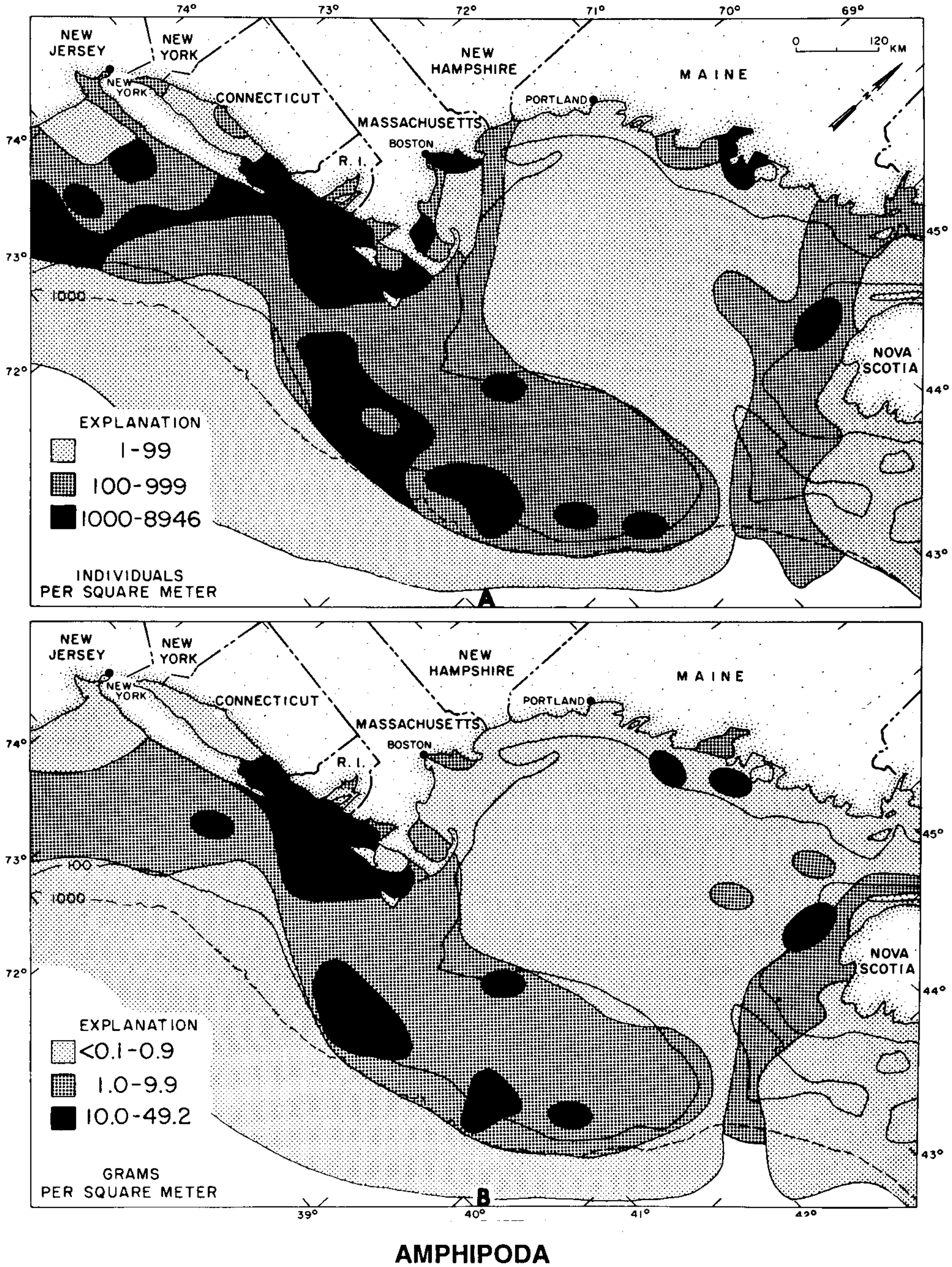


Figure 172

Geographic distribution of Amphipoda: A—number of specimens per square meter of bottom; B—biomass in grams per square meter of bottom.

deeper parts of the Gulf of Maine and on the continental slope and rise. The biomass of amphipods in the coastal areas and on the offshore banks generally averaged between 1 and 50 g/m^2. In the central Gulf of Maine and on the continental slope and rise, the biomass of amphipods averaged less than 1 g/m^2.

Two of the standard geographic areas, Georges Bank and the Southern New England Shelf, contained very high average densities (953 and 1,269 individuals/m^2, respectively) of amphipods (Table 6; Fig. 173). Three areas (Gulf of Maine, Georges Slope, and Nova Scotia) had intermediate densities (118 to 280/m^2). The South-

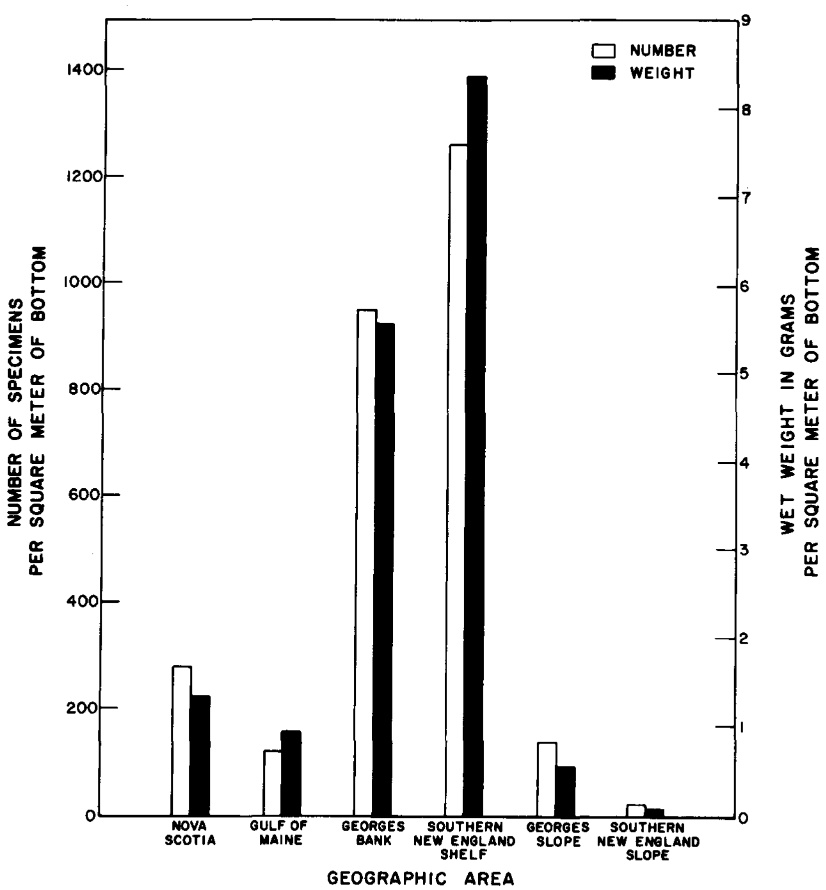


Figure 173
Density and biomass of Amphipoda in each of the six geographic areas.

ern New England Slope area yielded an average of only 17 amphipods/m^2.

Average biomass was very closely correlated with number of specimens and ranged from 8.34 g/m^2 in the Southern New England Shelf area to 0.08 g/m^2 in the Southern New England Slope area (Table 8; Fig. 173).

Frequency of occurrence of amphipods was generally high; they were found in 58 to 94% of the samples. In the three shallow shelf areas their occurrence ranged from 92 to 94% of the samples. Occurrence was lowest (58 to 73%) in the Gulf of Maine and the two slope areas (Table 10).

Bathymetric Distribution

Amphipods occurred at depths of 5 to 3,975 m. Their densities were highest on the continental shelf and decreased with increasing water depth (Table 11; Fig. 174). Usually high average densities (1,149 and 1,274 individuals/m^2) were encountered at depths between 25 and 100 m. In water depths greater than 100 m, amphipod densities dropped sharply. The average value for the lower continental slope area was 12/m^2, and on the continental rise their density declined to an average of only three specimens/m^2.

Biomass values revealed distribution patterns in relation to depth similar to those described above for density (Table 13; Fig. 174). At depths less than 100 m, the average biomass values were between 6 and 10 g/m^2. In water deeper than 100 m, a pronounced decline in biomass occurred; values ranged from 0.97.g/m^2 on the outer continental shelf to 0.02 g/m^2 on the continental rise.

Frequency of occurrence was moderate to high. In the shallow and moderately shallow water (0–100 m) amphipods occurred in 80 to 98% of the samples, but in deeper water they were present in 44 to 77% of the samples (Table 15).

Relation to Sediments

Amphipods were encountered in all of the different bottom types and revealed marked changes in density

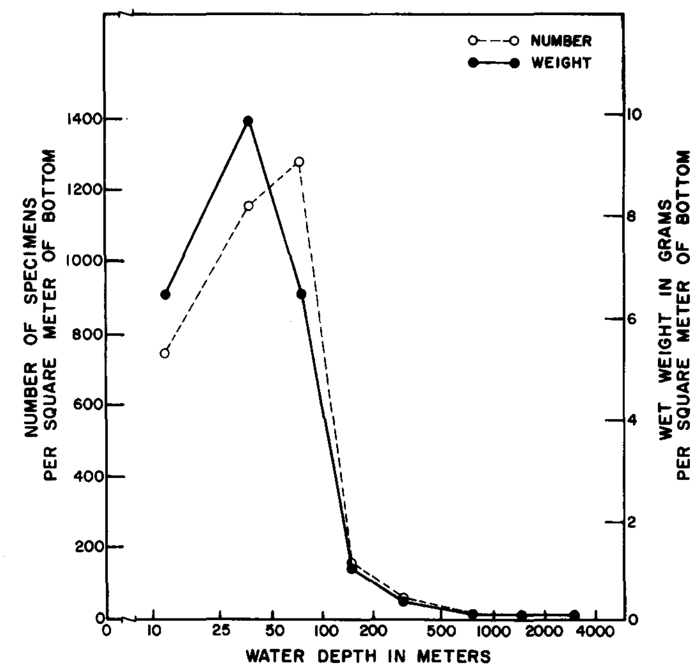


Figure 174
Density and biomass of Amphipoda in relation to water depth.

from one type to another (Tables 16, 17; Fig. 175). Density was exceptionally high (1,238 individuals/m^2) in sand and contributed over 56% of the total number of animals in this type of sediment. Density was moderately high in gravel; intermediate in sand-silt, till, and shell; and relatively low (23/m^2) in silt-clay.

Biomass trends were the same as those for density (Table 18; Fig. 175). Sand sediments contained the largest biomass, an average of 7.7 g/m^2. Intermediate quantities (0.5 to 3.4 g/m^2) were present in gravel, till, shell, and sand-silt. The lowest biomass (0.18 g/m^2) was found in silt-clay.

The occurrence of amphipods in different types of sediments ranged from very high to moderate. It was high to very high (93 to 100%) in sand, shell, and gravel types; intermediate in till and sand-silt; and moderate (51%) in silt-clay (Table 20).

Relation to Water Temperature
Amphipods occupied the entire spectrum of temperature range variations occurring in the study area (Table 21; Fig. 176). Highest average density (1,372 individuals/m^2) was encountered where the temperature was intermediate (8°–11.9°C). Densities were moderately high (598–809/m^2) in areas where the range in temperature was broad, but were substantially lower (58–311/m^2) where the temperature range was nil or small.

Amphipod biomass in relation to temperature range paralleled the same trends as those revealed by numerical density (Table 23; Fig. 176). Greatest biomass (8.1 g/m^2) occurred in an intermediate temperature range class (8°–11.9°C). Moderate values occurred in adjacent broader and narrower range classes. The smallest (0.41 g/m^2) biomass was found where the temperature range was less than 4°C.

The frequency of amphipods in our samples was moderate to high in all temperature range classes (Table 25). The highest rates of occurrence (92 to 97%) were encountered where the temperature range was moderate. Somewhat lower incidence rates occurred where the ranges in temperature were slightly narrower and slightly broader. Lowest occurrence rates prevailed in those areas where the temperature range was lowest (less than 4°C) and highest (more than 20°C).

Relation to Sediment Organic Carbon
Amphipods occurred in all sediments containing organic carbon (Table 26; Fig. 177). Two abundance peaks were clearly evident. Densities were very high (between 1,000 and 1,256 individuals/m^2) in both low (0.01–0.49%) and high (3.00–4.99%) concentrations of organic carbon and were much lower (24 to 164/m^2) where organic carbon content was between these ex-

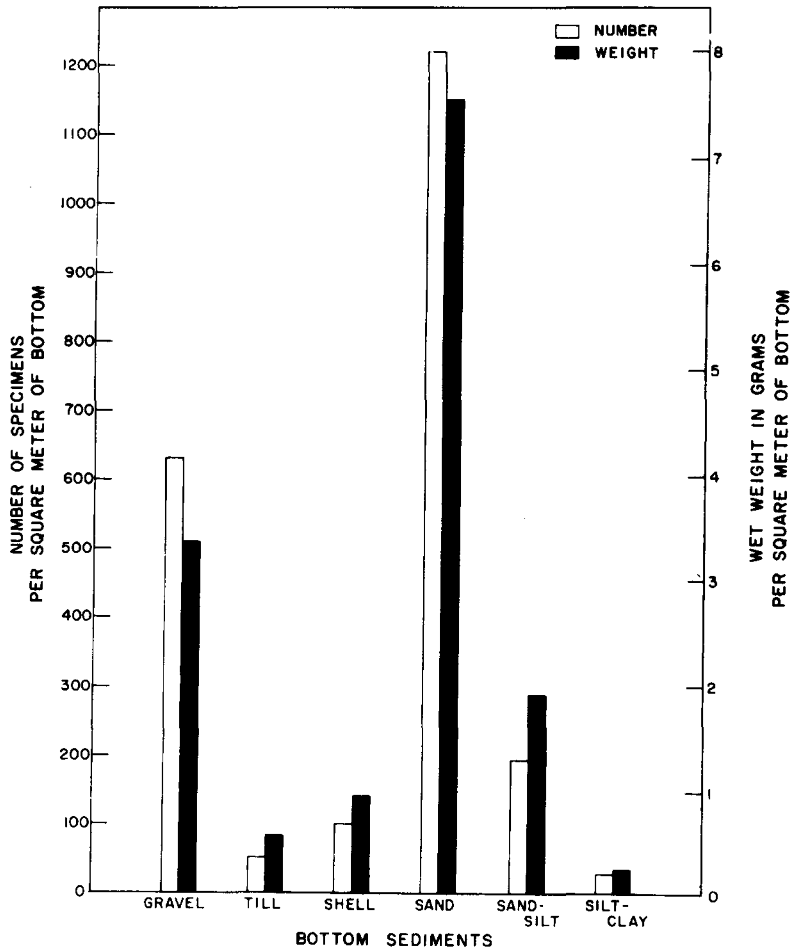


Figure 175
Density and biomass of Amphipoda in relation to bottom sediments.

tremes. Lowest density occurred in the absence of measurable organic carbon.

Biomass followed the pattern established by density (Table 28; Fig. 177). Biomass was high (8.3 to 5.3 g/m^2) at high and low carbon concentrations, fell to much lower levels (0.2 to 1.8 g/m^2) in intermediate levels, and was lower still where carbon was absent or at the highest levels measured.

Frequency of occurrence was high (93 to 100% of the samples) in the organic carbon content classes containing the lowest and highest concentrations measured but dropped to moderate levels (49 to 72%) in all other classes (Table 30).

Mysidacea—Mysids constituted a minor portion of the total benthos, 0.2% of the number of individuals and less than 0.1% of the biomass (Table 3). They were small in size, their geographic distribution was limited, and their numerical density was generally low. The average number of specimens usually was less than 5/m^2 and average biomass less than 0.01 g/m^2. Some species of mysids characteristically make diurnal excursions from the sea bottom to the upper water layers, at which time they become members of the plankton community; however, when they retreat to the ocean floor to feed or to excavate in the bottom sediments, they are considered an integral part of the benthos. Since bottom grabs do not sample mysids well, our data should not be taken as indicative of actual distribution or abundance.

Individual specimens in our collections ranged in body length from 3 to 12 mm. The large inshore species *Mysis stenolepis* and *Praunus flexuosus* were not present in our quantitative samples.

The color of the majority of specimens was white or translucent with small areas of brownish to nearly black

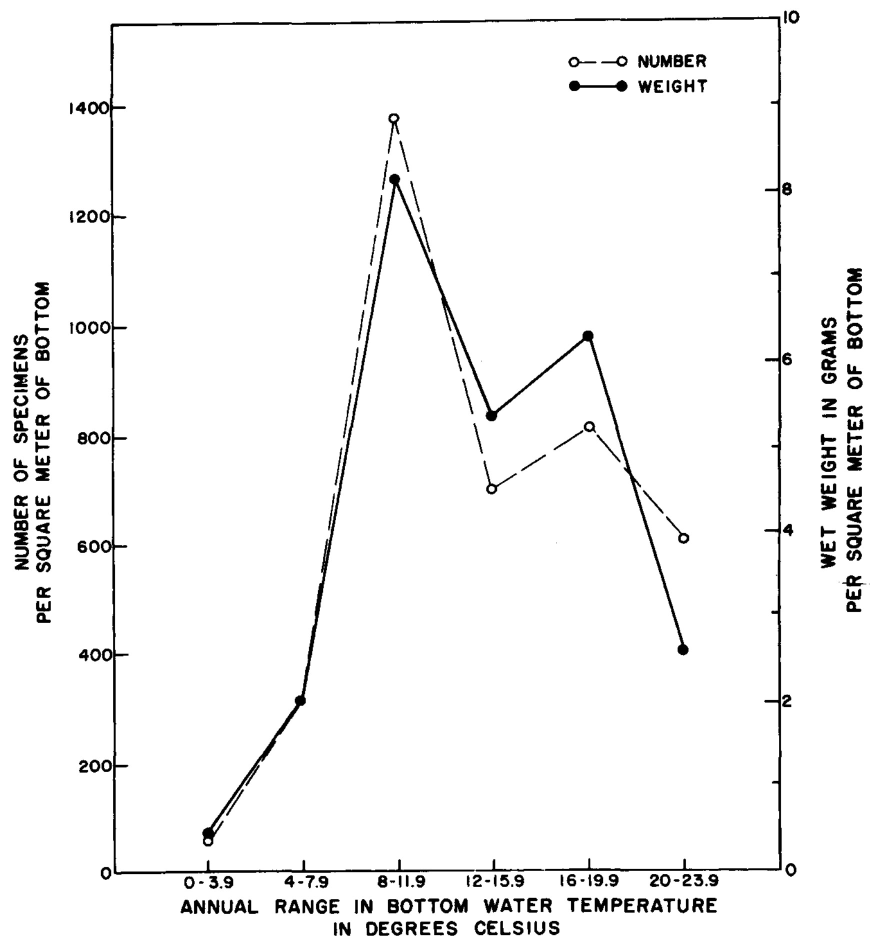


Figure 176

Density and biomass of Amphipoda in relation to the annual range of bottom water temperature.

pigmentation on the body and appendages. The eyes of most species were brownish-black. The most colorful members of the group were specimens of *Erythrops erythrophthalma*, which had red eyes and yellow and orange color patches on the body.

Mysids occurred in 41 samples (nearly 4% of the total). Their density averaged 2.5/m^2, and biomass averaged 0.01 g/m^2 (Table 5).

Geographic Distribution

Mysids were sparsely distributed in the study area occurring in widely separated patches mainly along the Southern New England, Long Island, and New Jersey shores (Fig. 178), and on Georges Bank. Two small enclaves also occurred inshore on the central Maine coast and in the mouth of Saint Mary Bay in western Nova Scotia.

Average density was low (1–49 individuals/m^2) in all localities except for two small patches of moderate density (50–99/m^2) south of the northern edge on Georges Bank and a patch of moderately high density, between 100 and 187 individuals/m^2, on south-central Georges Bank.

Mysid biomass was typically low (<0.1–0.9 g/m^2) in all areas of occurrence except for one small patch in the region of highest density where biomass barely exceeded 1 g/m^2.

Georges Bank was dominant among the standard geographic areas in both measures of mysid abundance (Tables 6, 8; Fig. 179), containing an average density and biomass of 10.6 individuals/m^2 and 0.06 g/m^2, respectively. The other geographic areas contained significantly lower amounts, ranging from 10 to 100 times less in terms of density and 6 times less in terms of biomass.

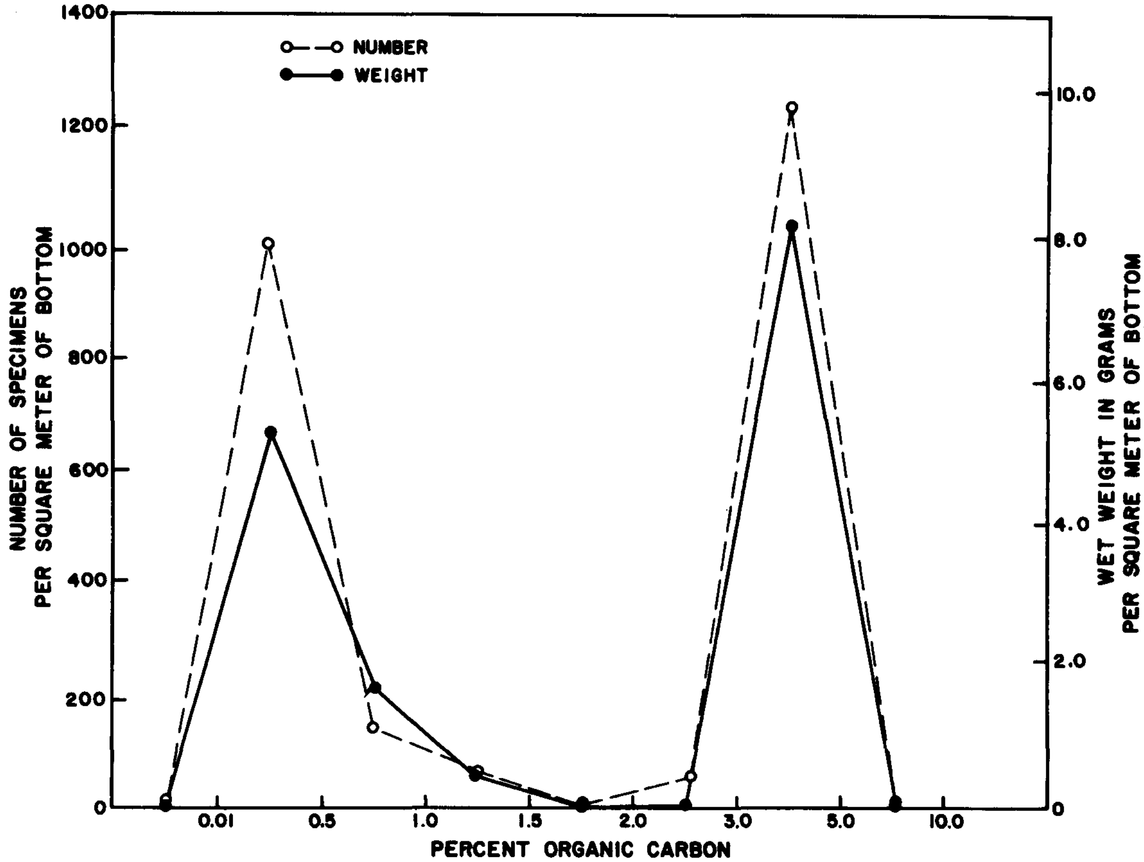


Figure 177
Density and biomass of Amphipoda in relation to sediment organic carbon.

Frequency of occurrence of mysids in samples was low in all areas ranging only from 1 to 10% (Table 10). Georges Bank had the highest occurrence frequency.

Bathymetric Distribution

Mysids occurred in the somewhat limited depth range of 9 to 292 m. They were most abundant (densities of 3.8 to 6.5 individuals/m^2) at depths less than 100 m (Table 11; Fig. 180). At depths greater than 100 m, their density was only 0.1 or less/m^2.

Biomass, although very small, revealed a rather constant diminution in quantity from shallow to deep water (Table 13; Fig. 180).

Mysids occurred in 13% of the samples from the shallowest depth class, and their rate of occurrence dropped with increasing water depth to 1% or less in the deepwater classes (Table 15).

Relation to Sediments

Mysids were found in four of the six bottom sediment types (Table 16; Fig. 181). Their density (5 individuals/m^2) in sediments composed of sand was substantially higher than in the other sediment types. In gravel, sand-silt, and silt-clay the densities were less than 1/m^2.

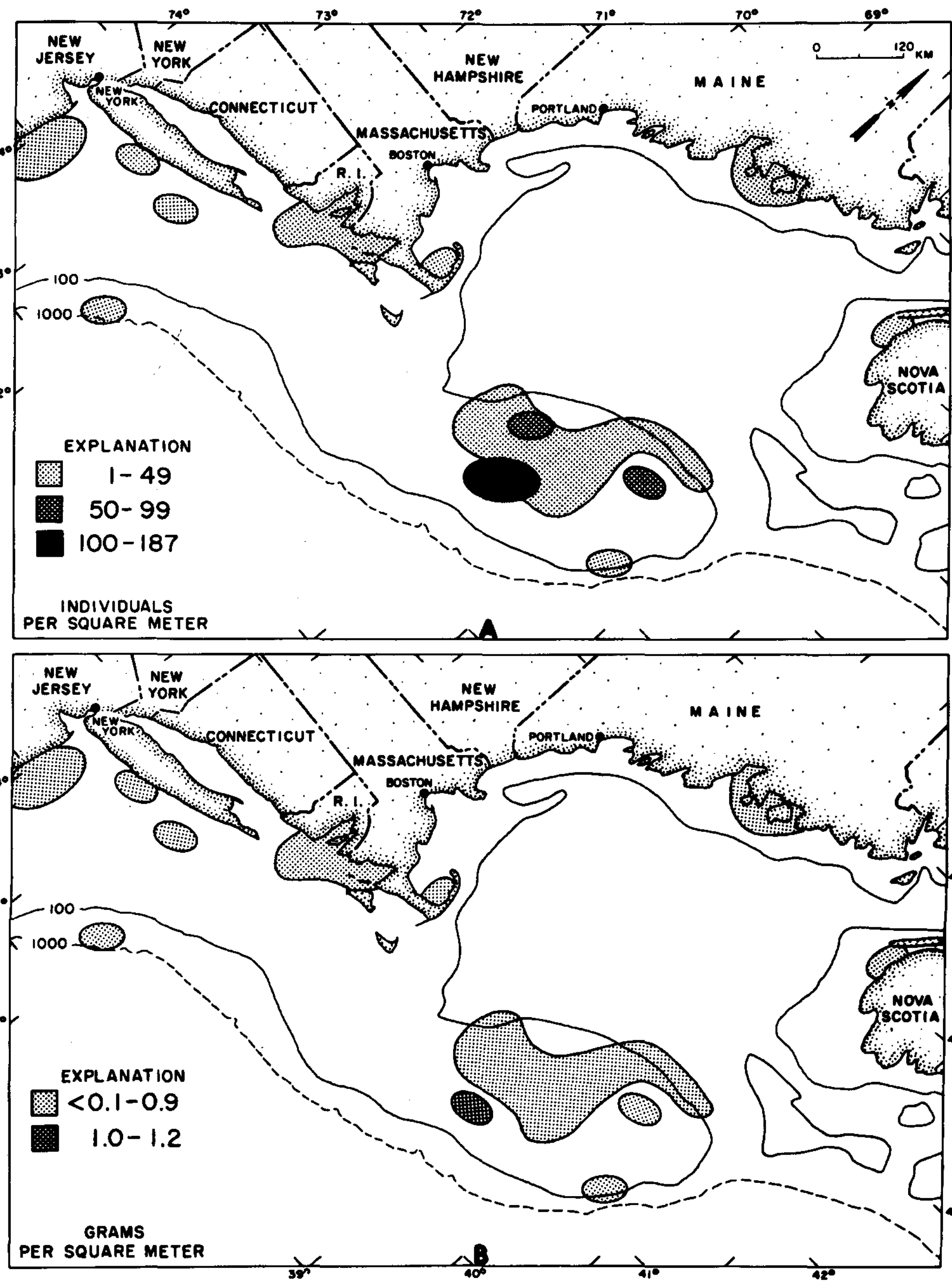
Biomass was very low (0.02 g/m^2) even in sand sediments where mysids were most abundant (Table 18; Fig. 181). Values for the other bottom types were 0.01 g or less/m^2.

Mysids were present in a higher proportion of the samples (6%) from sand sediments than from the other bottom types (Table 20).

Relation to Water Temperature

Mysids exhibited a general trend of increasing in both density and biomass as the annual range in temperature broadened (Tables 21, 23; Fig. 182). Average numerical density increased from <0.1/m^2 where the temperature range was <4°C, to 6.1/m^2 in localities where the temperature range was over 20ºC. Biomass ranged from <0.01 to only 0.02 g/m^2.

Frequency of occurrence values varied in a similar, but more consistent, manner to those of density and biomass. The percentage of samples yielding specimens



MYSIDACEA

Figure 178
Geographic distribution of Mysidacea: A—number of specimens per square meter of bottom; B—biomass in grams per square meter of bottom.

ranged from less than 1% in the lowest range class to 18% in the highest range class (Table 25).

Relation to Sediment Organic Carbon

Mysids occurred in four of the eight organic carbon content classes (Table 26; Fig. 183). Average densities (ranging from 0.8 to 1.8 individuals/m^2) were quite similarly distributed among the four classes, exhibiting a bimodal trend, one in the lower carbon content classes (between 0.01 and 0.99%) and the other in the intermediate (1.5 to 2.99%) classes.

Biomass values were uniformly low (0.01 g/m^2) in all organic carbon classes in which they occurred (Table 28; Fig. 183).

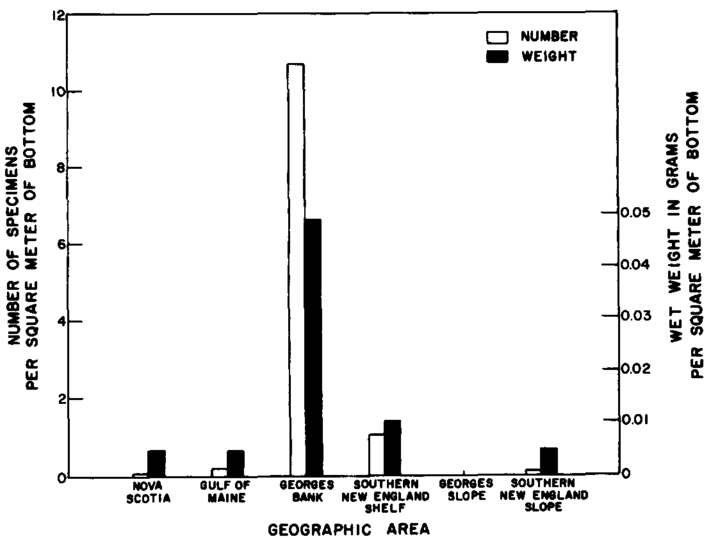


Figure 179
Density and biomass of Mysidacea in each of the six geographic areas.

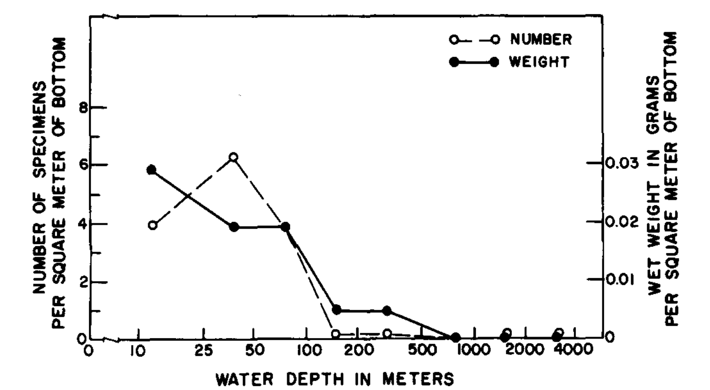


Figure 180
Density and biomass of Mysidacea in relation to water depth.

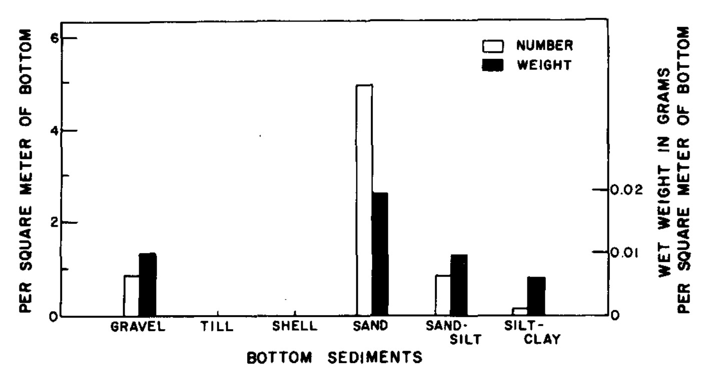


Figure 181
Density and biomass of Mysidacea in relation to bottom sediments.

Frequency of occurrence of mysids was higher (7 and 8%) in the intermediate carbon content classes than in the lower ones (3 and 5%) in which they occurred (Table 30).

Decapoda—Decapods, although well represented in terms of the number of taxa that were found in our quantitative samples (two suborders and three sections contained 24 genera and 34 species, Table 4), did not rank as highly in their contributions to the total number of specimens (0.5%), or to total biomass (0.8%) (Table 3). The apparent poor showing of the class, the largest among all classes of crustaceans, is misleading, precisely because of the large size and mobility of many of the representative species. These large, highly mobile forms are more effectively sampled by qualitative gear types, such as dredges and trawls, than by quantitative grab samplers. Thus the estimates of density and biomass presented in this report, for this class of crustaceans, should be considered to be very conservative at best. Indeed, the taxonomic list of decapods obtained by means of qualitative sampling gears in our databases is considerably more expansive than the one included here in Table 4. Nevertheless, the quantitative data reported in our report contain a fair representation of the major forms present in the region and constitute the most extensive and complete set (known to us) upon which to base our estimates.

Decapods were not found in most of the Gulf of Maine. For the most part, they are restricted to the Southern New England continental shelf and upper slope and to Georges Bank; some occurred on the western portion of the Nova Scotia shelf and the western basin of the Gulf of Maine. Average densities were low, ranging from 1 to 49 individuals/m^2, over most of their range in the study area. Size of captured specimens tended to be smaller than the overall average for this class, reflecting the bias imparted by the relatively small area sampled by the quantitative grabs used in our study. The smaller members of this group were less adroit at avoiding capture. The average size of caridian shrimps ranged from 20 to 40 mm; occasional larger specimens (40–60 mm) were captured. The latter were usually representatives of more sedentary, less active taxa, such as the burrowing sand shrimp *Crangon septemspinosus.* Average anomuran size ranged between 4 and 20 mm carapace length. Most frequently captured were representatives of the relatively slow-moving pagurid hermit crabs. Size of brachyuran crabs averaged between 15 and 20 mm carapace width; the two species of *Cancer* did provide some larger specimens in the 50 to 60 mm range, and *Pinnixa* spp. provided some of the smaller specimens in the 5 to 6 mm range.

Colors of decapods in our samples ranged from the nearly transparent or translucent white of *Crangon* to the dark reddish browns and blacks of *Hyas*. A veritable spectrum of colors was represented between these extremes, ranging from the delicate flesh and pink hues of the pandalid shrimps, to the tans, greens, blues, and grays and muted reds of the pagurid and brachyuran crabs. Most colorful were the bright red-orange *Geryon quinquedens*.

The decapods as a group are similar to bivalves in providing a broad spectrum of prey to a variety of predators. In addition to man, whose harvests of lobsters, shrimps, and crabs are well known, many other marine animals (including other invertebrates, mammals, birds, and fishes) depend on decapod prey for a substantial portion of their sustenance.

Decapods occurred in 246 samples (23% of the total). Their density averaged 8 individuals/m^2, and their biomass 1.32 g/m^2 (Table 5).

Geographic Distribution

The most striking feature of decapod distribution revealed by our samples was their apparent absence from large portions of the Gulf of Maine (Fig. 184). This artifact is due primarily to sampling gear bias since, traditionally, this region has been well known for the high annual yields of lobsters and shrimps. However, low densities were recorded from the northeast corner of the Gulf at the entrance to the Bay of Fundy, the Western Basin section north of Great South Channel, and some inshore localities. Low densities (1–49 individuals/m^2) also prevailed over most of their range elsewhere on the continental shelf in the study area. Moderate (50–99/m^2) and high (100–266/m^2) average densities were restricted to small patches on Georges Bank and in Nantucket and Vineyard Sounds and at the head of Long Island Sound.

Average biomass of decapods was low (<0.1 to 9.9 g/m^2) over the major portion of their range; there were only a few small patches of moderate (10–50 g/m^2)

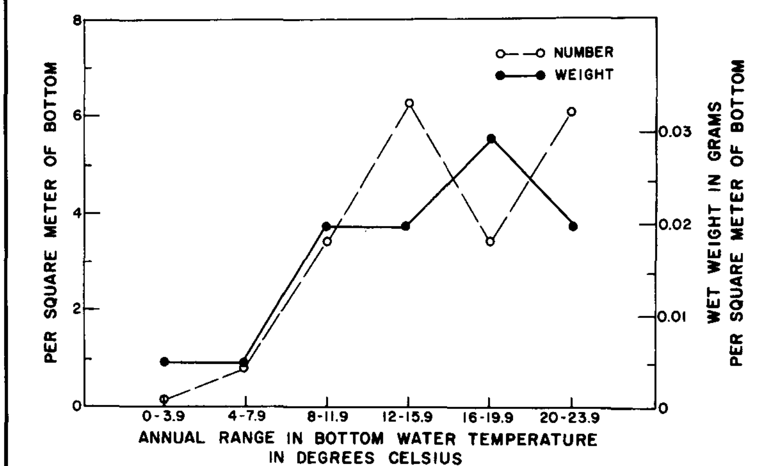


Figure 182
Density and biomass of Mysidacea in relation to the annual range of bottom water temperature.

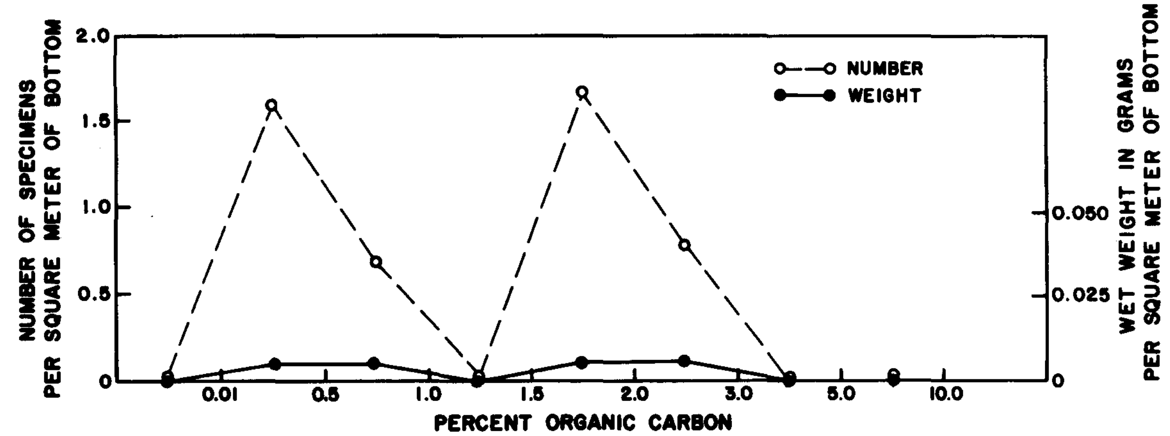


Figure 183
Density and biomass of Mysidacea in relation to sediment organic carbon.

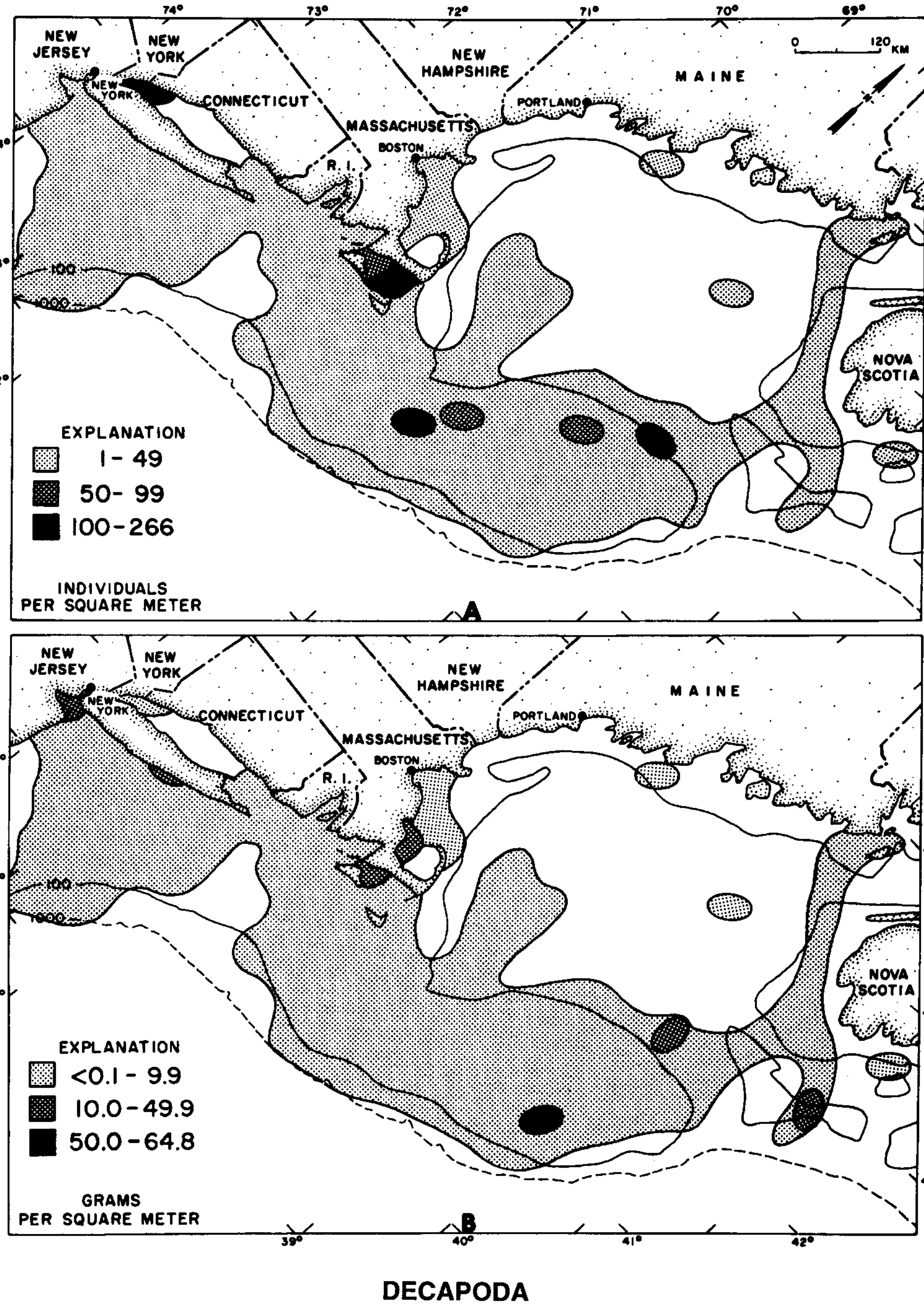


Figure 184
Geographic distribution of Decapoda: A—number of specimens per square meter of bottom; B—biomass in grams per square meter of bottom.

biomass, mostly in inshore regions near Cape Cod and Long Island. One small area of moderately high biomass (50–65 g/m^2) occurred on the southeast part of Georges Bank.

Decapods occurred in five of the six standard geographic areas; they were absent only in the Georges Slope area. Highest average density (22/m^2) occurred on Georges Bank followed by significantly lower densities on the Southern New England Shelf and off Nova Scotia (9 and 2/m^2, respectively). Density was below 1/m^2 in the Gulf of Maine and on the Southern New England Slope (Table 6; Fig. 185).

Average biomass ranged from slightly over 3 g/m² on Georges Bank to 0.02 g/m² on the Southern New England Slope (Table 8; Fig. 185). In the other areas, biomass ranged from 0.6 to slightly over 2 g/m².

Frequency of occurrence of decapods in the samples was moderately high on Georges Bank, Southern New England Shelf, and off Nova Scotia, ranging from 46 to 18% (Table 10). Their occurrence in samples from the Gulf of Maine and Southern New England Slope was considerably lower, 6 and 3%, respectively.

Bathymetric Distribution

Decapods were almost wholly restricted to water depths of less than 500 m and showed a general trend of diminishing in abundance as water depth increased (Table 11; Fig. 186). Average density was highest (18/m²) in the shallowest depth-range class (0–24 m) and dropped to 50% and less of this value in the continental shelf depth classes between 25 and 200 m. Density in the upper slope depth class (200–499 m) was low (0.3/m²) and very low (0.1/m²) in the only deepwater depth class (1,000–1,999 m) in which they occurred.

Average biomass generally followed the trend established for density (Table 13; Fig. 186). In the shallow-water depth class, average biomass was nearly one and one half to three times (3.3 g/m²) higher than that in the continental shelf depth classes where it ranged from 1.1 to 2.1 g/m². Biomass was 0.61 g/m² in the upper slope depth class (200–499 m) but only 0.03 g/m² in the deepest class in which decapods occurred (1000–1999 m).

Decapod frequency of occurrence in the samples was fairly uniform at moderate levels (35 to 39%) in the three depth classes <99 m, moderately low (13%) in the shelf edge class, and low (3 and 4%) in the other two classes they occupied (Table 15).

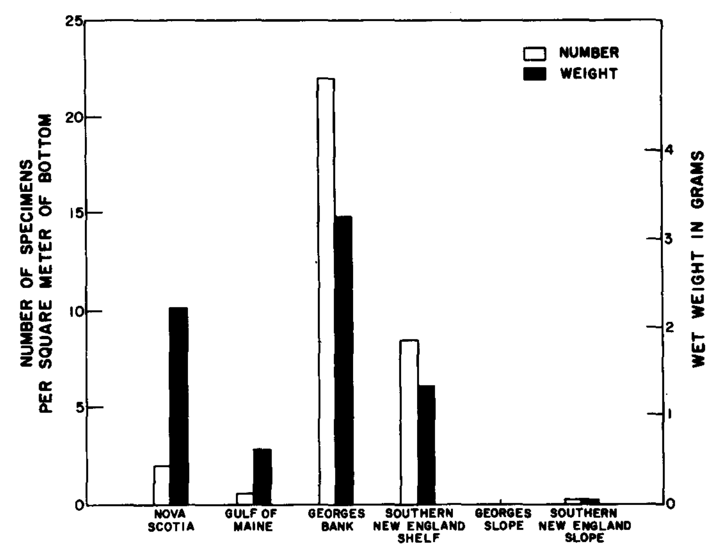


Figure 185
Density and biomass of Decapoda in each of the six geographic areas.

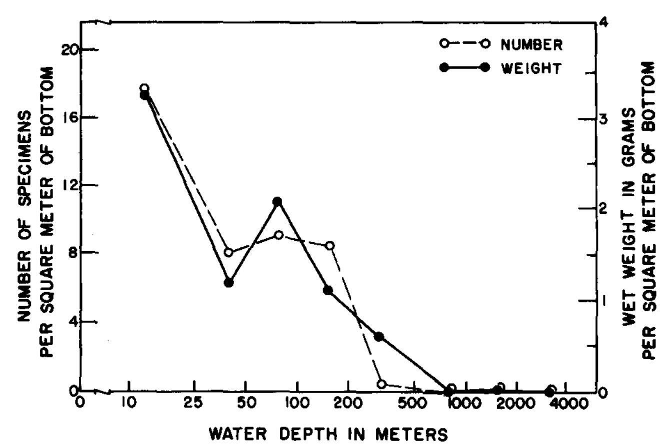


Figure 186
Density and biomass of Decapoda in relation to water depth.

Relation to Sediments

Decapods were present in all sediment types except till. Both density and biomass diminished with decreasing sediment particle size (Tables 16, 18; Fig. 187). Gravel bottoms contained the greatest average number (24/m²) of decapods as well as greatest biomass (5.56 g/m²). A drop in density occurred in shell and sand, each of which yielded an average of 9/m², nearly three times fewer decapods, but biomass diminution was not as dramatic in shell which contained an average of 4.78 g/m²; however, sand contained nearly five times less biomass (1.16 g/m²) than gravel. Sand-silt and silt-clay, the finest sediments, yielded lower density and biomass.

Frequency of occurrence of decapods was moderate and uniform in samples in gravel, shell, and sand, ranging from 33 to 37%, but was relatively low in sand-silt and silt-clay, 7 and 4%, respectively (Table 20).

Relation to Water Temperature

Average density and biomass of decapods showed a tendency to increase with broadening temperature range to

19.9°C; beyond this, in the 20.0–23.9°C range class, both measures declined (Tables 21, 23; Fig. 188). Average density and biomass (0.9/m^2 and 0.47 g/m^2, respectively) were lowest in the narrowest temperature range class (0–°3.9°C) and generally increased with broadening temperature range, peaking at 23.2/m^2 and 4.26 g/m^2 in the 16.0–19.9°C range class. Intermediate values of both measures occurred where the temperature range was broadest.

The frequency of occurrence of decapods in the samples in the various temperature range classes parallels the trend established for density and biomass, ranging from 6% in the narrowest range class to 53% in the 16–9.9°C class, and dropping to intermediate (18%) levels in the broadest range class (Table 25).

Relation to sediment organic carbon

Decapods were absent in areas where no measurable organic carbon occurred in the sediments, as well as in areas with the highest recorded amounts. They were present in the five organic carbon content classes between 0.01 and 2.99% where average density and biomass described U-shaped distributions (Tables 26, 28; Fig. 189). Average density ranged from nearly 8 to 0.5 individuals/m^2 and average biomass from 4.15 to 0.30 g/m^2. Values were highest at the extremes of the carbon content classes in which they occurred and fell to the lowest levels in the middle carbon content classes, slightly biased toward the higher end.

Frequency of occurrence of decapods in the samples described a distribution similar to density and biomass. Occurrence was moderate, ranging from 4 to 32%, but in this instance was biased slightly toward the lower end of the content range (Table 30).

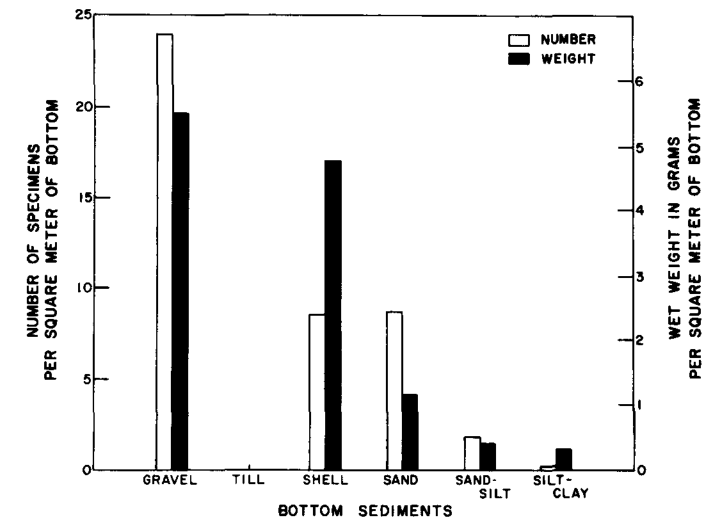


Figure 187
Density and biomass of Decapoda in relation to bottom sediments.

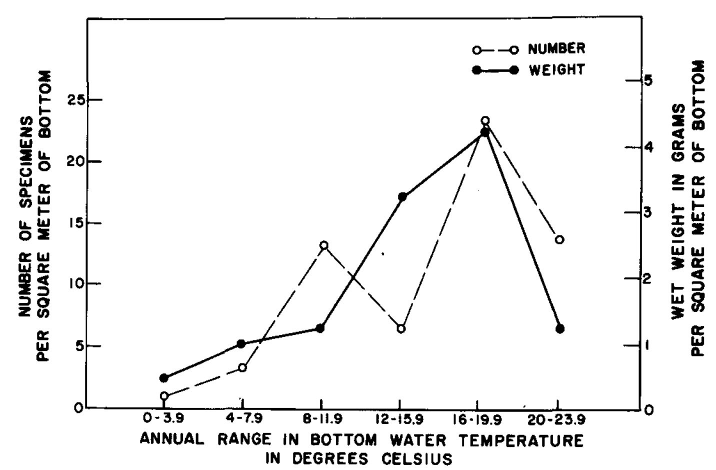


Figure 188
Density and biomass of Decapoda in relation to the annual range of bottom water temperature.

Bryozoa

Bryozoans are sessile colonial animals most frequently found attached to rocks, shells, ship bottoms, pilings, firm outer surfaces of other animals, and other similar hard substrates. Their distribution in the study area was somewhat patchy owing to their requirement for a firm substrate and moderate to strong water currents. The currents transport to them their main food supply, minute plankton, principally diatoms.

These organisms contribute a significant number (more than one hundred) of species to the New England benthic fauna. The majority of these species belong to the class Gymnolaemata, order Cheilostomata. The calcareous encrusting forms were especially numerous, but the chitinous foliaceous types were usually the largest specimens encountered.

Although the Bryozoa constitute a major phylum in species diversity and are a major contributor to the biomass in certain localized habitats, their small size and patchy distribution rather severely limited their contribution to the total benthic fauna. In terms of numerical density, ectoprocts made up 1% of the total fauna and contributed only 0.7% of the total biomass (Table 3).

Bryozoans occurred in 119 samples (11% of total). Their density averaged 15.7/m^2. Their biomass averaged 1.29 g/m^2 (Table 5).

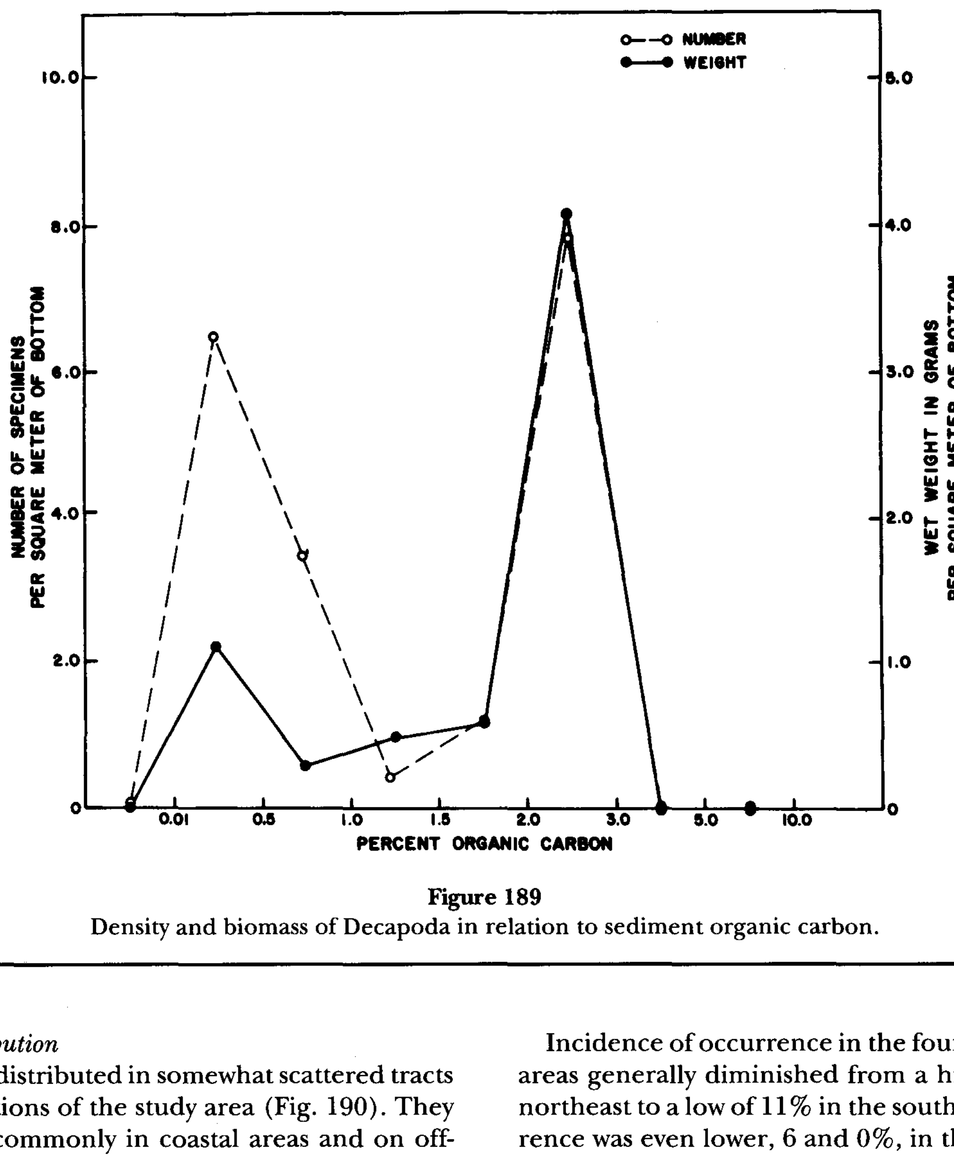


Figure 189
Density and biomass of Decapoda in relation to sediment organic carbon.

Geographic distribution
Bryozoans were distributed in somewhat scattered tracts in nearly all sections of the study area (Fig. 190). They occurred most commonly in coastal areas and on offshore banks. Specimens were noticeably scarce in the central part of the Gulf of Maine, over large portions of the eastern Nova Scotian Shelf, from offshore parts of the Southern New England Shelf, and on the continental slope and rise. Dense assemblages of over one hundred colonies per square meter were present in small areas dispersed throughout the banks and coastal areas.

In the six standard geographic areas, bryozoans were most prevalent, on the average, on Georges Bank (28 colonies/m^2) and on the Southern New England Shelf (22 colonies/m^2) (Table 6; Fig. 191). They were moderately common in the Nova Scotia and Gulf of Maine areas and scarce or absent in the two slope areas.

The largest average biomass, 6.3 g/m^2, occurred in the Nova Scotia area (Table 8; Fig. 191). Georges Bank ranked second with 2.6 g/m^2, and all other areas contained less than 1 g/m^2.

Incidence of occurrence in the four continental shelf areas generally diminished from a high of 19% in the northeast to a low of 11% in the southwest. Their occurrence was even lower, 6 and 0%, in the two slope areas (Table 10).

Bathymetric Distribution
Bryozoans were taken at water depths ranging from 8 to 3,820 m. There was a very pronounced decrease in the density as water depth increased (Table 11; Fig. 192). The average number of colonies in the shallowest (0–24 m) depth zone was 39/m^2 and decreased steadily to an average of 4.3/m^2 on the upper continental slope at a depth of 500 m. Below 500 m they were absent or present in very low (0.5 colony/m^2) quantities.

The average biomass of bryozoans was higher in shallow water than in deep water. This relationship was similar to that described above for density, except for an unusually large average biomass of 2.9 g/m^2 at depths between 50 and 99 m. This was the largest average biomass from any one depth class (Table 13; Fig. 192).

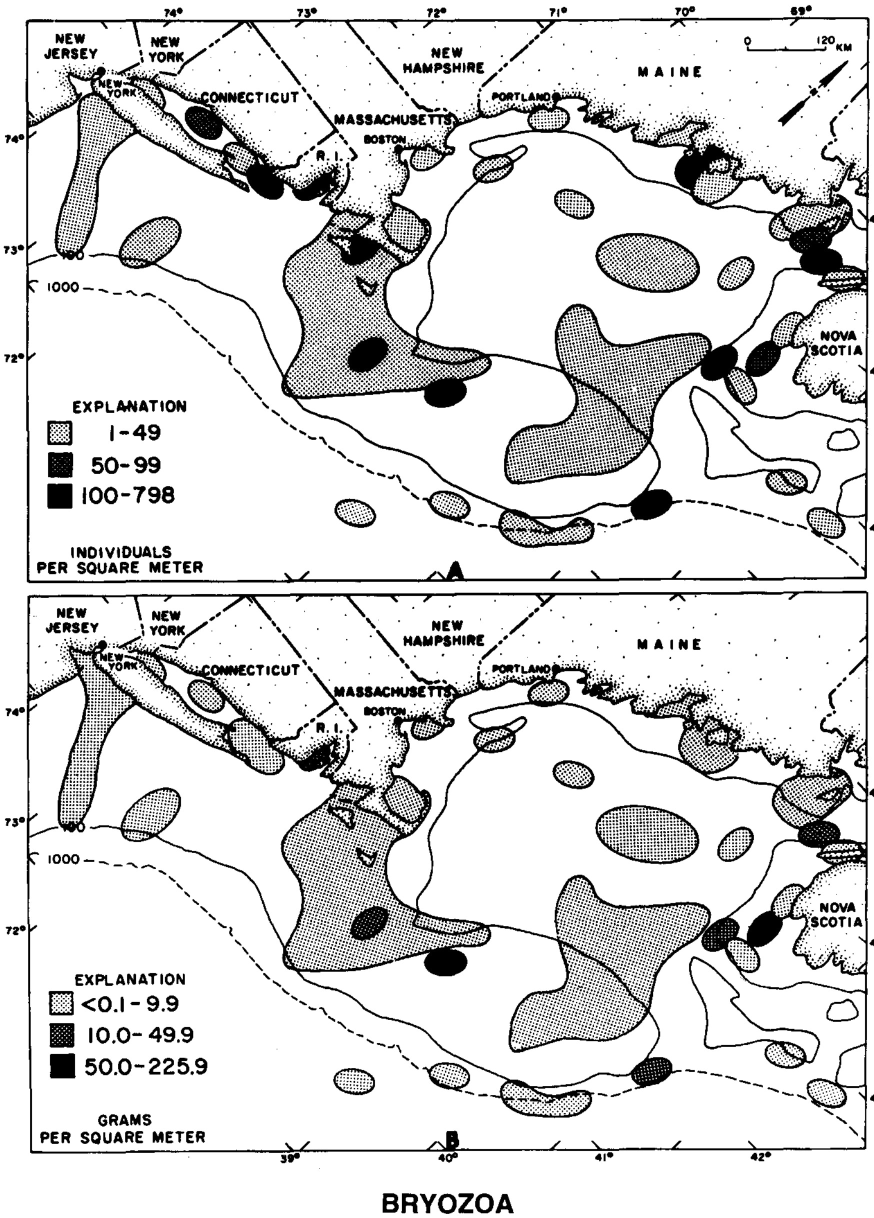


Figure 190

Geographic distribution of Bryozoa: A—number of specimens per square meter of bottom; B—biomass in grams per square meter of bottom.

The percentage of samples containing bryozoans generally decreased with increasing water depth. The highest incidence of occurrence (19%) was in the shallowest depth class. At depths greater than 500 m, they occurred in from 0 to 5% of the samples (Table 15).

Relation to Sediments

Bryozoans were especially common in the hard, coarse substrates that afforded suitable surfaces for attachment. In addition, they were also found in smaller quantities in the soft fine-grain sediments but attached to hard biogenic materials, occasional pieces of gravel, or man-made debris (Tables 16, 18; Fig. 193). Shell substrate seemed particularly suitable in as much as it yielded an average of over 300 colonies/m^2 and an average biomass of nearly 17 g/m^2. Moreover, bryozoans made up over 25% of the total number of specimens and 7.5% of the biomass of the total benthic fauna in shell substrates (Tables 17, 19). Gravel substrates ranked second in quantity, with an average density of 75 colonies/m^2 and a biomass of 7.4 g/m^2. Quantities were low (less than 6 colonies and 0.4 g/m^2) in the remaining four sediment types.

Incidence of occurrence was highest (50%) in shell, moderately high in till and gravel, and low (10% or less) in the fine-grain sediments (Table 20).

Relation to Water Temperature
Although bryozoans were rather severely limited in distribution by specific substrate requirements, water temperature range appeared to play a lesser role in inhibiting abundance. Members of this phylum occurred in all temperature range classes but revealed a pronounced trend of increasing density with a broadening of the temperature range (Table 21; Fig. 194). The density of bryozoans averaged only 3 colonies/m^2 where the temperature range was less than 4°C. Their density increased to an average of 66 colonies/m^2 where the temperature range was greater than 20°C.

Biomass values also exhibited a general upward trend (0.28–2.45 g/m^2) as the temperature range broadened. This increase, however, was less consistent than that exhibited by numerical density (Table 23; Fig. 194).

The occurrence of bryozoans in the samples ranged from 8 to 21%. Generally, incidence of occurrence was low where the temperature range was narrow, and high where the temperature range was broad (Table 25).

Relation to Sediment Organic Carbon
The relationship of bryozoans to sediment organic carbon was not nearly as well defined as that in other parameters because no orderly trend or pattern was discernible. Relatively high average densities, between 21 and 35 individual colonies/m^2, occurred in widely separated organic carbon content classes in the low, middle, and higher regions of the content spectrum (Table 26; Fig. 195). Significantly lower average densities, ranging between 0 and 8/m^2, occurred in adjacent carbon content classes, effectively separating and isolating the higher values.

Average biomass was distributed in a manner similar to that for density but was not as pronounced. Highest bryozoan biomasses (1.95 and 1.21 g/m^2) occurred in the low and upper middle carbon content range, interspersed with significantly lower values (Table 28; Fig. 195).

The percentage of samples containing bryozoans ranged from 0 to 25% (Table 30). Incidence of occurrence showed a general trend of decreasing (20 to 0%) as organic carbon content increased from 0 to 2.99%, but it shot up to 25% in the 3.00–4.99% class.

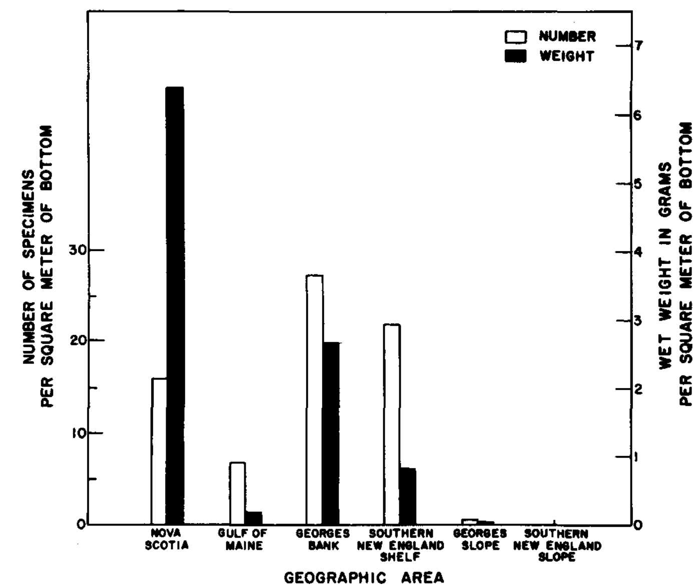


Figure 191
Density and biomass of Bryozoa in each of the six geographic areas.

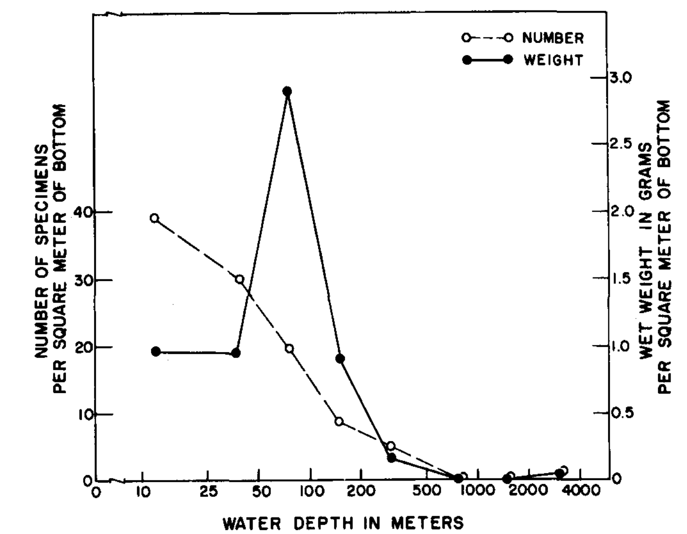


Figure 192
Density and biomass of Bryozoa in relation to water depth.

Brachiopoda

Brachiopods, commonly known as lamp shells, are sessile organisms normally found attached to rocks and other firm substrata at continental shelf depths, usually in cold water. These requirements limited the scope of their distribution to the northeastern sectors where suitable habitats were more prevalent than elsewhere in

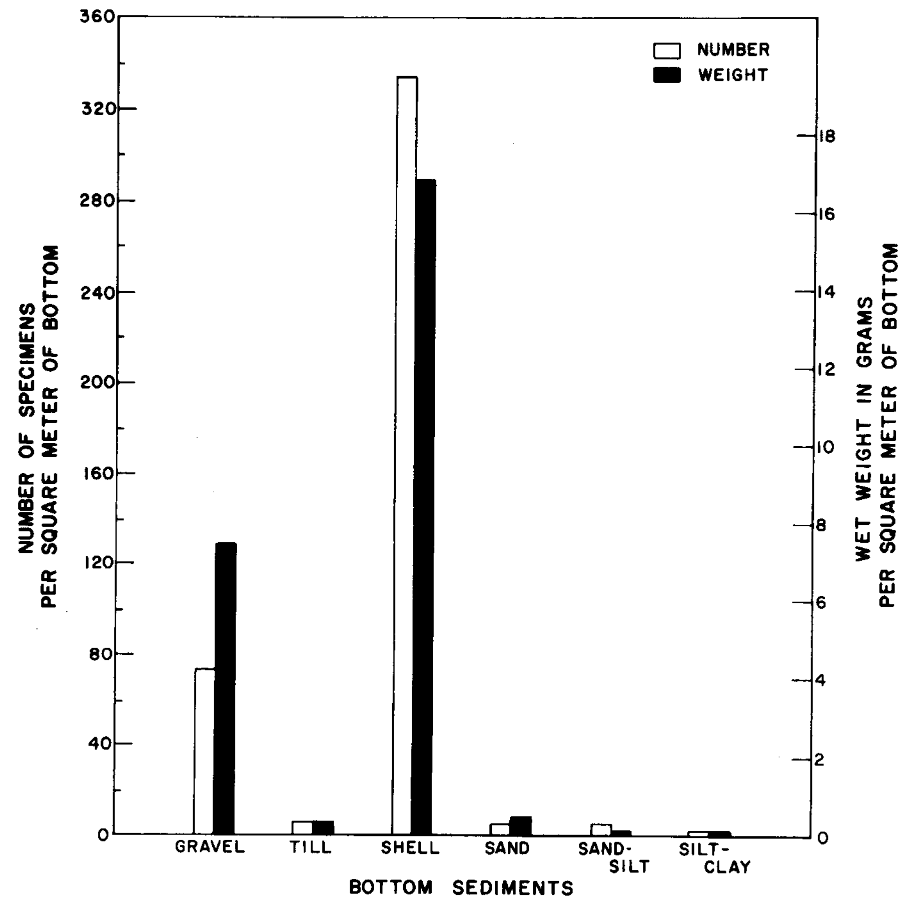


Figure 193
Density and biomass of Bryozoa in relation to bottom sediments.

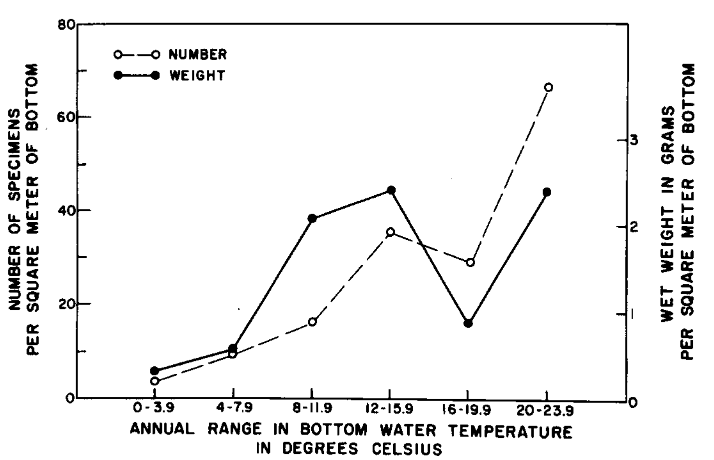


Figure 194
Density and biomass of Bryozoa in relation to the annual range of bottom water temperature.

the New England region. Although often locally significant in terms of density and biomass, their contribution to the total fauna was limited by the patchiness of suitable habitats. Brachiopods accounted for only 0.3% of the total number of specimens and 0.7% of the total biomass (Table 3).

Brachiopod diversity was also noteworthy. Although the phylum is not noted for large numbers of species, there being only about 280 known living species, our samples contained only members of one genus, *Terabratulina*.

Size of specimens ranged from about 5 mm to some large specimens of about 30 mm length. Color was typical for the genus with dull white and silvery gray hues predominating; many specimens were fouled by other sessile forms such as bryozoans, hydroids, and encrusting sponges of various hues, but tans, browns, yellows, and grays predominated.

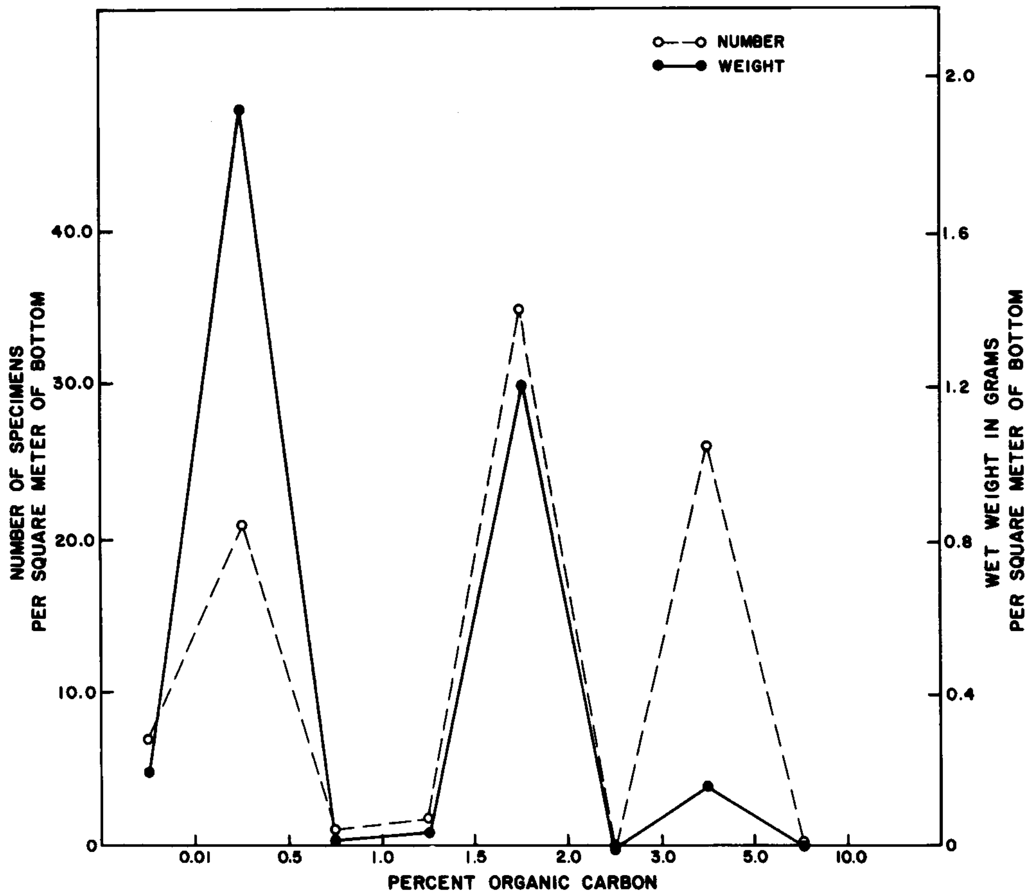


Figure 195
Density and biomass of Bryozoa in relation to sediment organic carbon.

Brachiopods occurred in 54 samples (5% of total). Their numerical density averaged 4.5 individuals/m^2, and their biomass averaged 0.89 g/m^2 (Table 5).

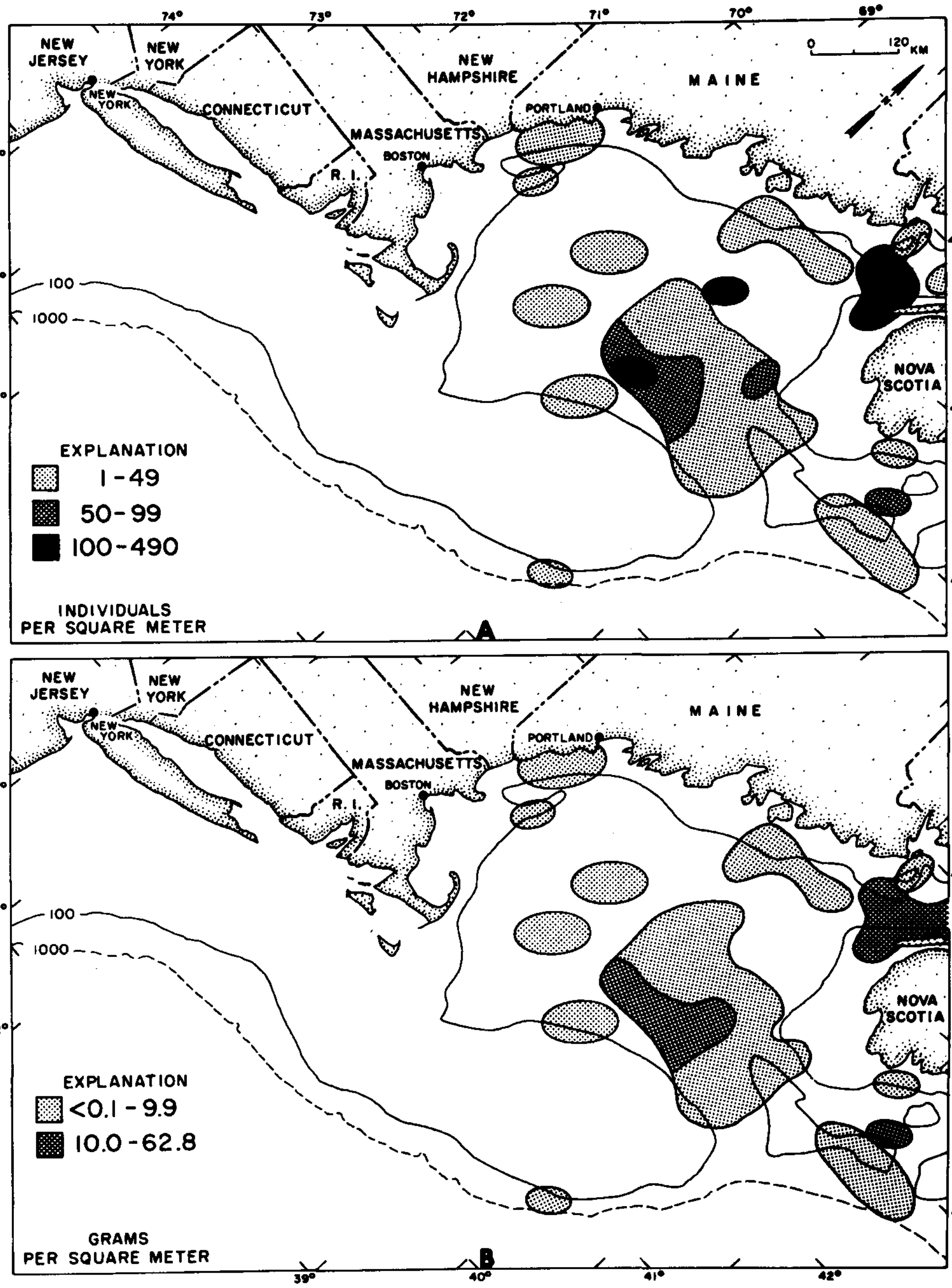
Geographic Distribution
Brachiopods were restricted to the northeastern sector of the study area, the only region in which suitable habitats were found (Fig. 196). Numerical density was usually low (<49 individuals/m^2) over most of their range as was biomass (<10 g/m^2); small areas of moderate (between 50 and 100/m^2) density and biomass (10 to 63 g/m^2) occurred in south-central Gulf of Maine adjacent to the northern edge of Georges Bank and on the Nova Scotian shelf. Significant densities (between 100 and 490/m^2) did occur in a few places, notably at the mouth of the Bay of Fundy.

Among the six standard geographic areas brachiopods were restricted to Nova Scotia, the Gulf of Maine, and Georges Slope. Largest average density (22/m^2) and biomass (3.68 g/m^2) occurred off Nova Scotia followed by Gulf of Maine (9.5/m^2 and 2.12 g/m^2); Georges Slope contained insignificant quantities (Tables 6, 8; Fig. 197).

Twenty-one percent of the samples off Nova Scotia contained brachiopods versus 12% in the Gulf of Maine; only 2% of the Georges Slope samples yielded specimens (Table 10).

Bathymetric Distribution
Brachiopods were taken at depths between 51 and 690 m. Very few occurred in water deeper than 499 m (Tables 11, 13; Fig. 198). Largest average density and biomass were found at depths between 200 and 499 m in so-called upper slope depths; there density averaged 17 individual/m^2 and biomass nearly 4 g/m^2. Both average density and biomass decreased significantly with decreasing depth above 200 m.

Frequency of occurrence of brachiopods in the samples was moderate to low. The highest frequency was in the 200–499 m depth class at 14%; the rate



BRACHIOPODA

Figure 196

Geographic distribution of Brachiopoda: A—number of specimens per square meter of bottom; B—biomass in grams per square meter of bottom.

decreased to 5% in deeper water classes and to 10 to 2% in the shallower water depth classes (Table 15).

Relation to Sediments

Brachiopods occurred in all sediment types found in the region but showed a pronounced preference for the coarser types over the finer ones (Tables 16, 18; Fig. 199). Till sediments ranked first in preference, containing an average of 48 individuals/m^2 and an average biomass of nearly 16 g/m^2.

Interestingly, although shell sediments ranked second in terms of density (37/m^2), they ranked last (0.22 g/m^2) in terms of biomass. Gravel, with a mean density and biomass of 14/m^2 and 2.44 g/m^2, respectively, ranked third. Both mean density (range 0 to 2/m^2) and mean biomass (range 0.24 to 0.33 g/m^2) were significantly lower in sand, sand-silt, and silt-clay, each of which offered very limited attachment potential.

Samples in till substrates yielded the highest occurrence frequency of specimens (41%), shell and gravel were about even, but considerably lower in overall frequency than till (17 and 14%, respectively; Table 20). Only 2 to 3% of samples in the other sediment types provided brachiopod specimens.

Relation to Water Temperature

Brachiopods were quite restricted in their relation to the annual range in water temperature and showed a very strong tendency of decreasing abundance with increasing temperature range (Tables 21, 23; Fig. 200). None were found where the annual temperature range exceeded 11.9°C. They were most plentiful (average density of 9/m^2 and biomass of 1.93 g/m^2) in the narrowest (0–3.9°C) temperature range and declined rapidly and steadily as the temperature range broadened.

The frequency of occurrence of brachiopods in samples in the temperature range groupings was low (10 to 2%) and followed the trend established in the abundance measures (Table 25).

Relation to Sediment Organic Carbon

Brachiopods preferred low levels of sediment organic carbon (Tables 26, 28; Fig. 201), being absent at levels above 1.49% carbon content. Numerical density was 3 to 5 times (range 16 to 3/m^2) higher where no measurable carbon was found than where small amounts occurred. Biomass was greatest (1.74 g/m^2) in the 0.5 to 0.99% carbon content class versus a slightly lower biomass (1.31 g/m^2) in the 0% grouping. Significantly lower levels occurred in the other carbon content groupings.

Frequency of occurrence of brachiopods in samples declined rapidly from a high of 40% in the 0% organic carbon level grouping to only 6% in the next (0.01–0.49%) grouping, then more slowly to 2% in the 1.00 to 1.49% grouping (Table 30).

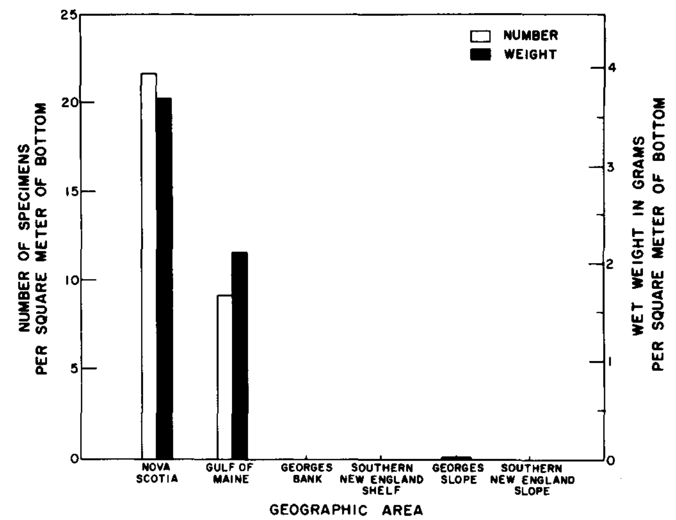


Figure 197
Density and biomass of Brachiopoda in each of the six geographic areas.

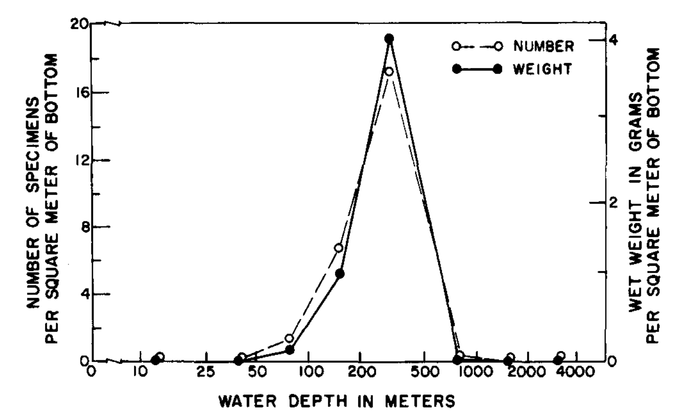


Figure 198
Density and biomass of Brachiopoda in relation to water depth.

Echinodermata

The phylum Echinodermata is represented, in the New England region, by members of five classes: Crinoidea, Holothuroidea, Echinoidea, Ophiuroidea, and Asteroidea. All but Crinoidea provide significant contributions to the total benthic fauna. In terms of contribution to overall density, members of Echinoidea are second in dominance, providing 20% of the total number of organisms in the region, and Holothuroidea rank fourth with a 7% contribution (see Table 3). Ophiuroidea and Asteroidea are subdominants, providing 1.8 and 1.2%, respectively, of the total number of organisms. In terms of biomass, however, none of the four rank among the top dominants, but Ophiuroidea and Echinoidea are subdominants providing 2.9 and 1.9%, respectively, of the total. Holothuroidea and Asteroidea contributions to biomass, 0.3 and 0.1% respectively, are significantly below their showing in terms of density (see Table 3).

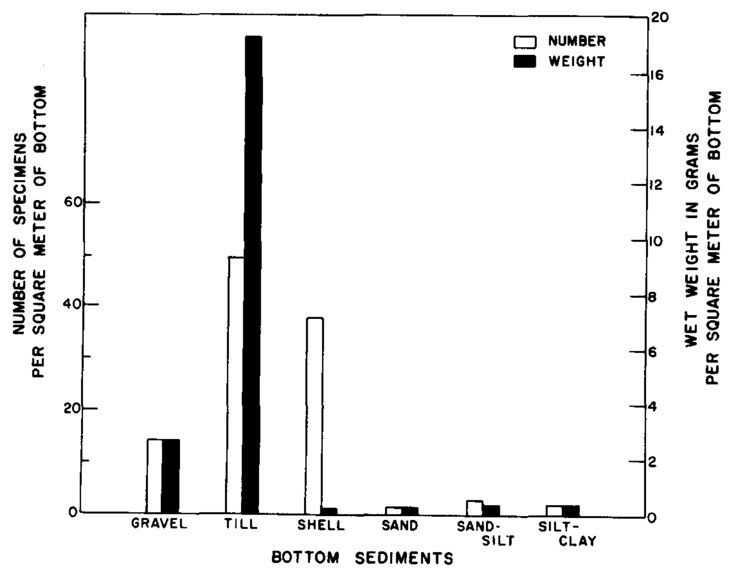


Figure 199
Density and biomass of Brachiopoda in relation to bottom sediments.

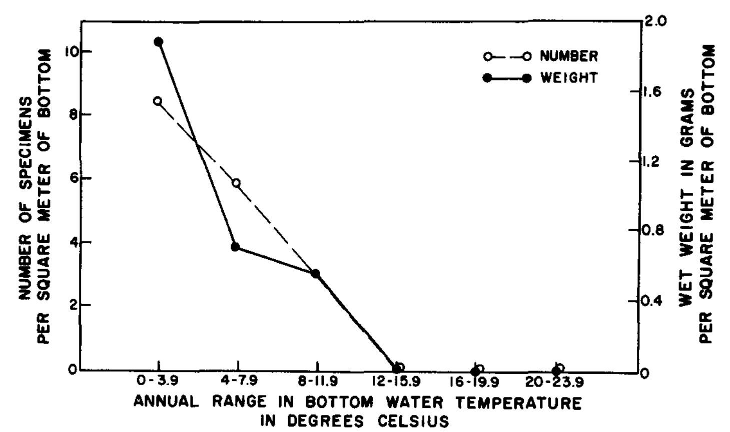


Figure 200
Density and biomass of Brachiopoda in relation to the annual range of bottom water tempereature.

Following the procedure established above for the other major taxa, the figures relating to Echinodermata (Figs. 202–207) will be presented here, and a detailed discussion of the phylum will be presented in the section "Dominant Components of the Macrobenthos" below. Discussion of the five classes of echinoderms follows.

Crinoidea—Crinoids formed a minute portion of the New England benthic fauna. Members of this group were obtained at only two stations. Six specimens that totaled 0.16 g in weight were taken at station 1038 in the Gulf of Maine. Water depth at this locality was 203 m; bottom sediments were of sand-silt. Two specimens that weighed 0.02 g were taken at station 2185 in the Georges Slope area. Water depth at this locality was 1,420 m; bottom sediments were composed of silt-clay. The annual range in bottom water temperature at each of these sites was less than 4°C. Organic carbon content at station 1038 was 0.40% and at station 2185, 0.55%.

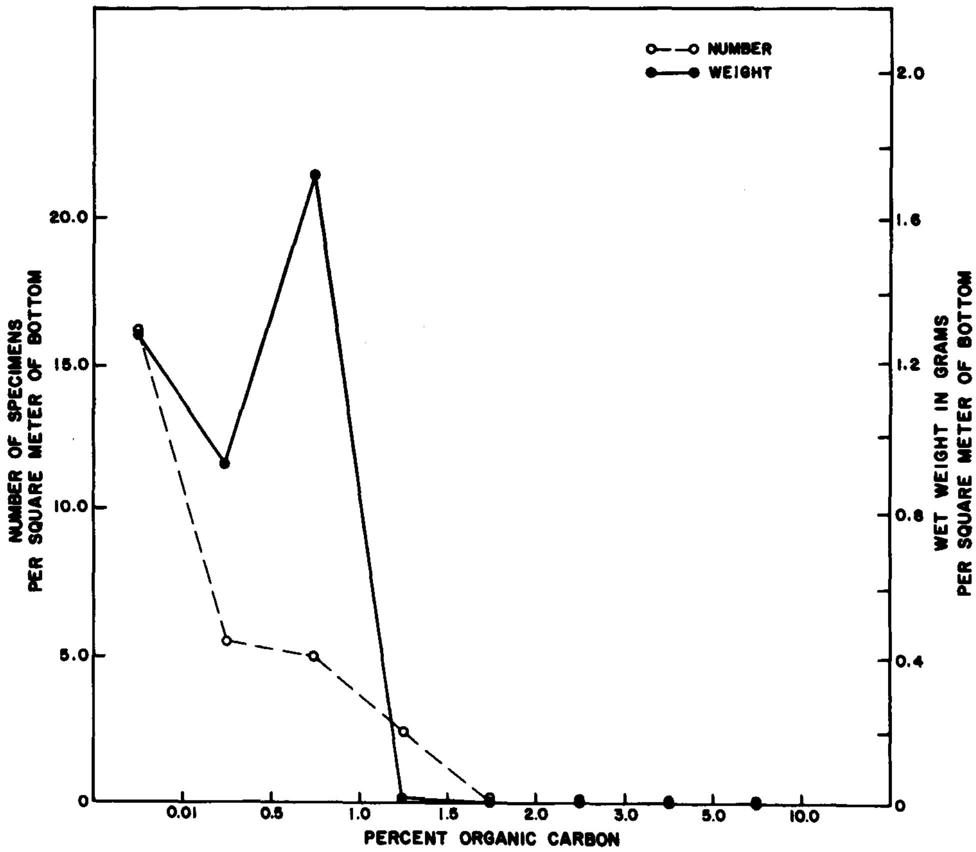


Figure 201
Density and biomass of Brachiopoda in relation to sediment organic carbon.

Holothuroidea—Holothurians formed a moderate component of the New England benthos in terms of biomass, but made up only a minor portion of the total number of specimens (Table 3). This was due mainly to the relatively large size of individual specimens. Members of this group averaged 3 g each, which is a size unsurpassed by any other major faunal group collected in this study. The larger specimens, *Cucumaria* and *Molpadia*, were 10 to 14 cm long, and 2 to 4 cm in diameter. The smallest specimens were juvenile *Psolus* about 4 mm in length.

Five orders of holothurians were represented in the samples (Table 4). The dominant group, from the standpoint of abundance and taxonomic diversity, was the Dendrochirotida. Few species and specimens were taken belonging to the orders Molpadiida, Apodida, Aspidochirotida, and Dactylochirotida.

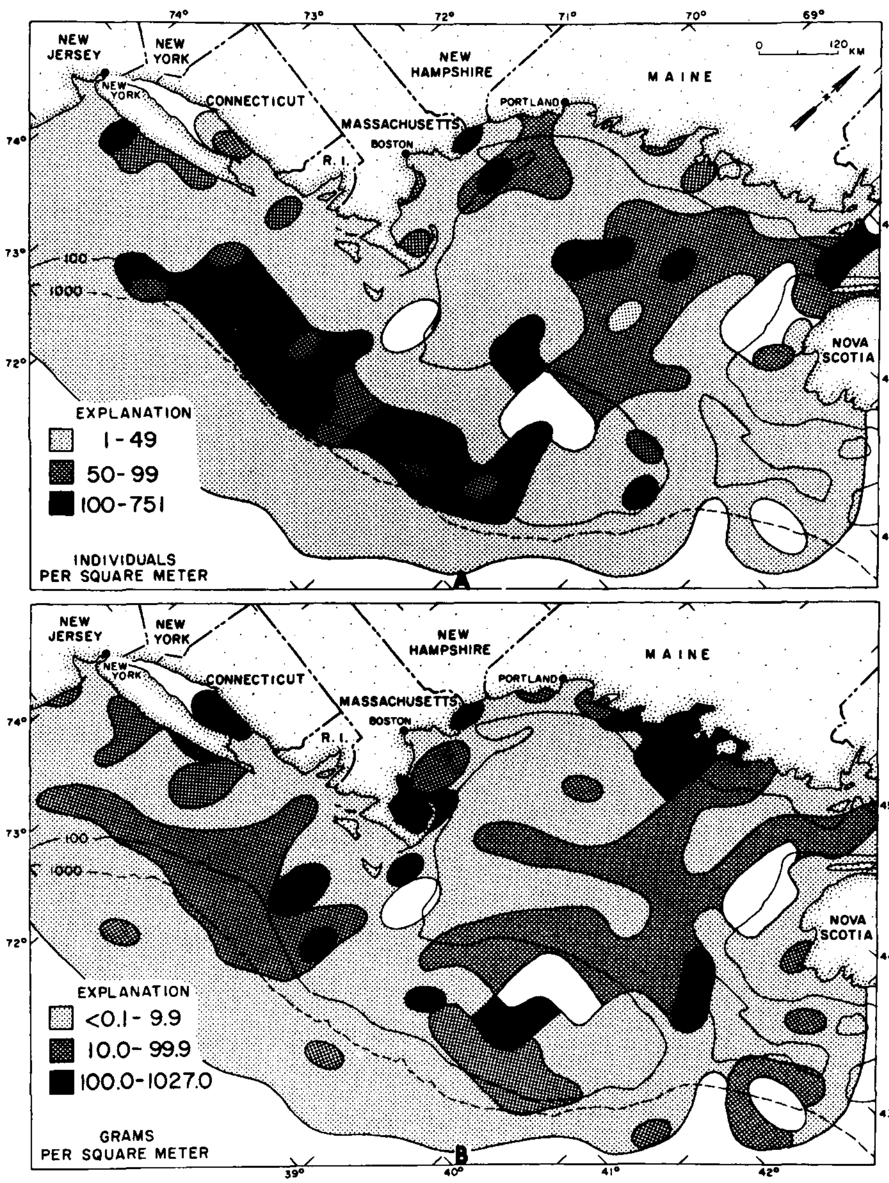
Color of specimens in this region was generally uniform over the body surface (except for the contrasting light colored tube feet in some species), which usually was reddish-brown, tan, or occasionally light cream. One small species was very dark violet and black.

Holothurians occurred in 202 samples (19% of total). Their density averaged 4.3/m^2 and their biomass averaged 12.9 g/m^2 (Table 5).

Geographic Distribution

Holothurians were prevalent over large sections of the Gulf of Maine and in the offshore Southern New England Shelf area (Fig. 208). They occurred on Georges Bank in low densities and in very few samples. Relatively high densities (25 to 88 individuals/m^2) occurred over rather large portions of the central Gulf of Maine and along the southern end of Great South Channel. In most localities, however, the average densities were less than 9 dividuals/m^2. In terms of biomass, holothurians were present in substantial quantities, usually greater than 1 g/m^2, and not uncommonly in quantities of 10 to over 50 g/m^2.

Among the six standard geographic areas, holothurians were present in largest quantities in the Gulf of



ECHINODERMATA

Figure 202
Geographic distribution of Echinodermata: A—number of specimens per square meter of bottom; B—biomass in grams per square meter of bottom.

Maine area (Tables 6, 8; Fig. 209), where the average density was nearly 8 individuals per/m^2 and the biomass averaged more than 27 g/m^2. The Georges Bank area had the lowest average density, 0.2/m^2, and an average biomass of only 0.5 g/m^2. The other four areas had intermediate quantities.

Holothurians accounted for a small proportion of the total number of specimens in all areas, but made up a substantial part of the total weight in two areas (Table 9). In the Gulf of Maine area they accounted for 22% of the total faunal weight and on the Southern New England Slope they made up 14% of the total faunal weight.

The occurrence of holothurians in the samples was moderately low (17 to 40%) in all areas except Georges Bank, where they were present in only 2% of the samples. They were present in a slightly higher proportion of the samples from the two slope areas than from the shelf areas (Table 10).

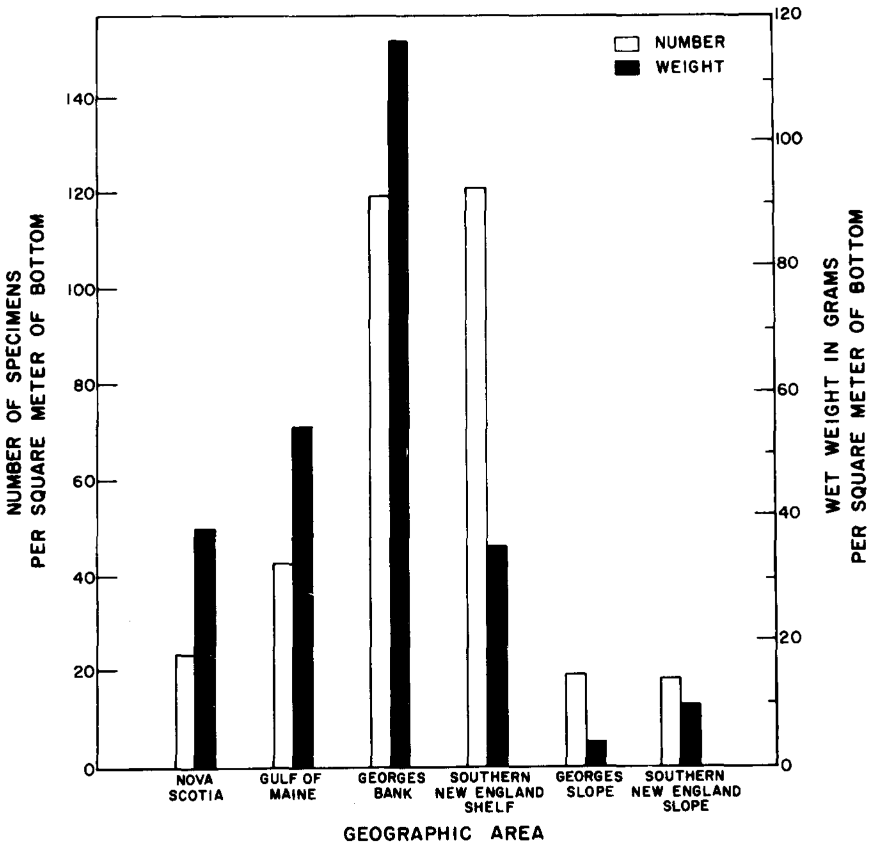


Figure 203
Density and biomass of Echinodermata in each of the six geographic areas.

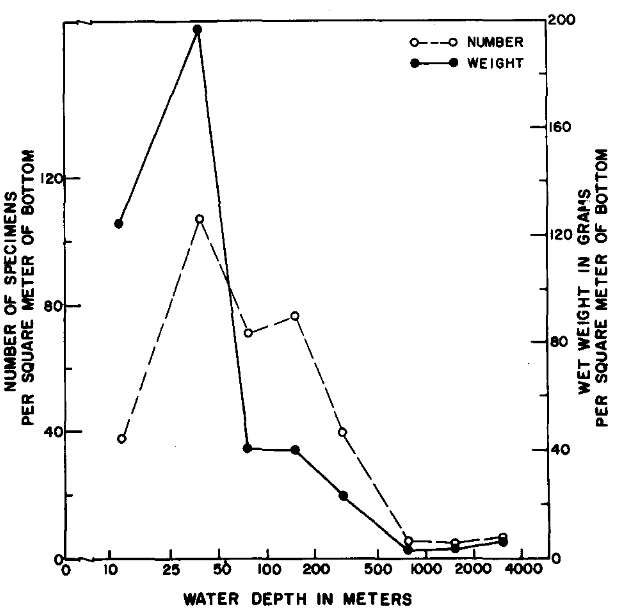


Figure 204
Density and bomass of Echinodermata in relation to water depth.

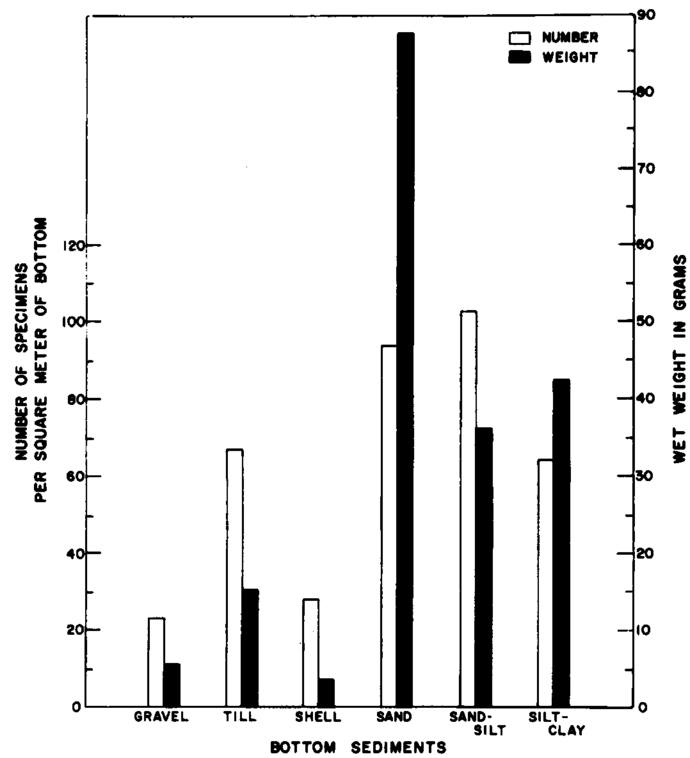


Figure 205
Density and biomass of Echinodermata in relation to bottom sediments.

Bathymetric Distribution

Holothurians were collected at depths ranging from 6 to 3,820 m, and were present in all depth classes over this broad depth range (Table 11; Fig. 210). Densities were highest (average 4 to 10 individuals/m^2) at intermediate depths (50 to 500 m) and somewhat lower (0.7 to 1.9/m^2) in both shallower and deeper bathymetric classes.

Biomass distribution of holothurians differed substantially from the depth-density relationship (Table 13; Fig. 210). Highest biomass averages (13 to 37 g/m^2) were found in depths less than 100 m. Lowest biomass (0.2 g/m^2) occurred at 500 to 999 m; intermediate quantities (1 to 6 g/m^2) were found in other depth classes.

Individual holothurians from shallow water (0 to 24 m) were larger, averaging nearly 25 g each, and size decreased with increasing depth to less than 1 g each at depths greater than 500 m.

The frequency of holothurian occurrence was higher in samples from deep water than in those from shallow water (Table 15). At depths less than 50 m they were present in 8 to 9% of the samples, whereas, in water depths greater than 50 m they occurred in 14 to 33% of the samples.

Relation to Sediments

Holothurians were relatively numerous in till substrates and much less common in all other bottom types (Table 16; Fig. 211). Their average density in till was 25 individuals/m^2, whereas, in the other types of sediments their density was only 2.0 to 7.4/m^2.

The relationships of holothurian biomass to sediments were entirely different from those pertaining to density. The biomass was high (25 to 29 g/m^2) in sand-silt and silt-clay (Table 18; Fig. 211). In fact, holothurians accounted for from 15 to over 33%, respectively, of the total benthic biomass in those two sediment types (Table 19). In other types of sediments their biomass was moderate to small (4.7 to 0.4 g/m^2).

The presence of relatively fewer but larger specimens in soft sediments and numerous small specimens in till sediments accounts for the disparity between the biomass and density values in these substrates. In the other sediment types they were generally more equally distributed in density and biomass.

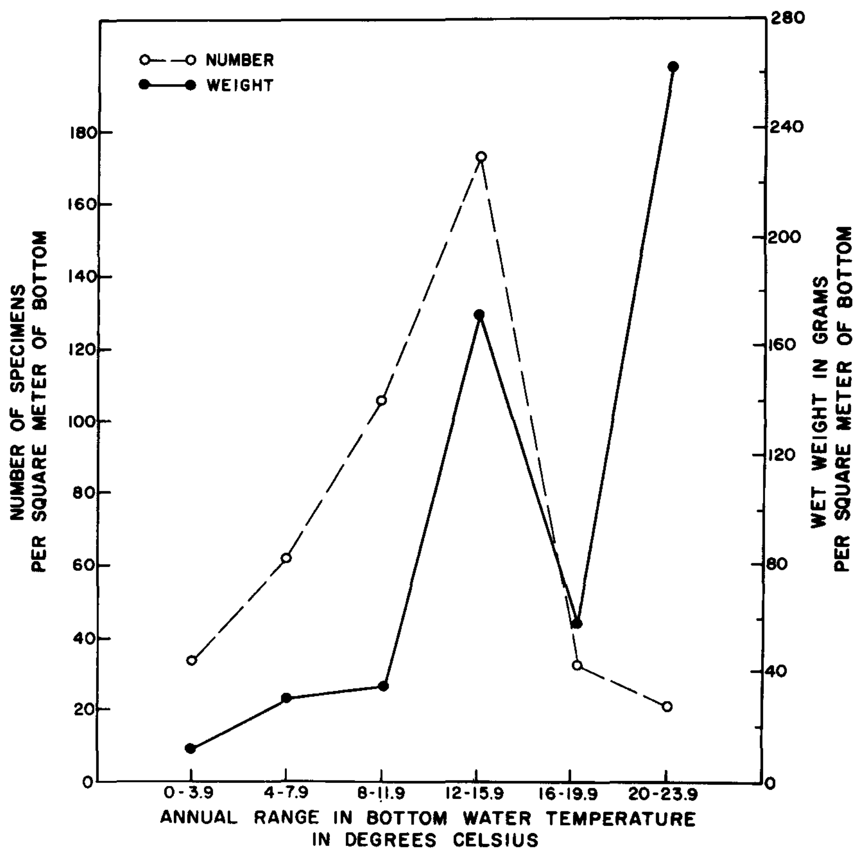


Figure 206
Density and biomass of Echinodermata in relation to the annual range of bottom water temperature.

Frequency of occurrence was moderate to low in all sediment types, and the relationship of holothurians with various sediments was similar to that described for numerical density (Table 20). Occurrence was highest (50%) in till, lowest (8%) in sand, and intermediate (16 to 36%) in the other sediment types.

Relation to Water Temperature
The relation of holothurian numerical density to the range in water temperature was the opposite of that exhibited by their biomass. Density generally decreased as the temperature range increased (Table 21; Fig. 212). The average density of holothurians was about 6 individuals/m^2 where the temperature range was less than 4°C and decreased to about 2 individuals/m^2 where the temperature variation was 16° to 19°C.

Conversely, the biomass of holothurians increased as water temperature ranges increased (Table 23; Fig. 212). Their biomass was relatively small (3 g/m^2) where the temperature range was small (<4°C). With increased annual temperature range, the biomass of holothurians increased substantially to an average of 128 g/m^2 where the range was greatest (20°–23.9°C).

Size disparity of specimens in the various temperature range classes was the principal cause of the reversed trends. The size of specimens increased markedly in waters having a broad temperature range, whereas the numerical density diminished slightly.

Holothurians contributed a moderately large proportion (4–9%) of the total biomass in five of the six temperature range classes. In the other class, where the temperature variation was high (>20°C), they contributed an extraordinarily large share (>30%) of the biomass (Table 24).

Frequency of occurrence was quite uniform at a moderate level (14–25%) in all temperature range classes except one (16°–19.9°C), in which holothurians contributed only 8% of the samples (Table 25).

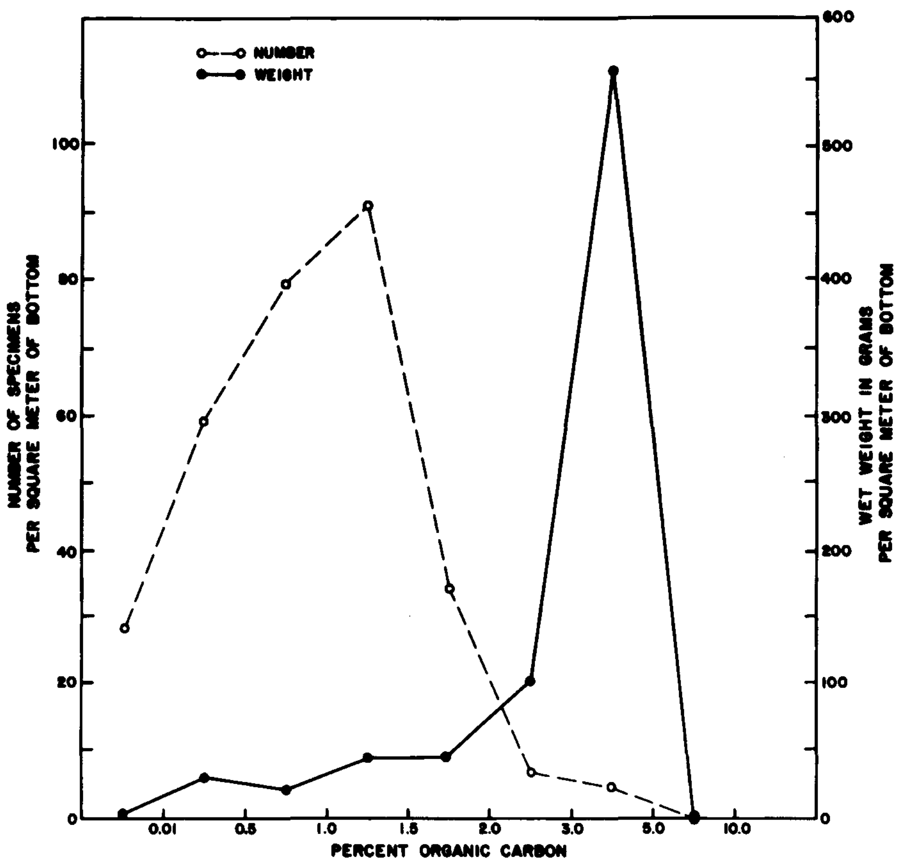


Figure 207
Density and biomass of Echinodermata in relation to sediment organic carbon.

Relation to Sediment Organic Carbon
Holothuroidea was one of only a very few taxonomic groups for which definite, consistent trends were clearly demonstrated in relation to the amount of organic carbon in the sediments.

The trend was the reverse of that pertaining to water temperature. The organic carbon-density relationship was in general negatively correlated, whereas the organic carbon-biomass relationship was essentially positively correlated. Seven of the eight carbon content classes were occupied; the one exception was the highest class (5.0+%).

Holothurian average density was highest (18 individuals/m^2) where no measurable organic carbon was found (Table 26; Fig. 213). Much lower average densities (ranging from 8 to 2/m^2) prevailed in the other carbon content classes with a general tendency of decreasing with increasing organic carbon content.

Average biomass, on the other hand, showed a trend that was the reverse of the one for density (Table 28; Fig. 213). Average biomass was lowest (6 g/m^2) in the 0% carbon content class and steadily increased with increasing organic carbon content, culminating in exceptionally large biomasses in the two highest classes occupied. There was nearly a threefold increase between the 1.50 and 1.99% class and the 2.00 and 2.99% class (41 vs. 104 g/m^2) and a fivefold increase from the latter class to the 3.00–4.99% class (562 g/m^2).

Frequency of occurrence was quite uniform at a moderate level (15 to 40%) in all organic carbon content classes (Table 30).

Echinoidea—Sea urchins are the second largest (after bivalves) contributors to the New England benthic biomass, providing 20% of the total (Table 3). This large contribution was made by a group with low taxonomic diversity. Fewer than six species contributed over 95% of the specimens. The major contributors were sea urchins, heart urchins, and sand dollars.

The feeding habits of echinoids are varied. Most are bottom feeders (carnivores, herbivores, or omnivores), but some common species are plankton feeders, and

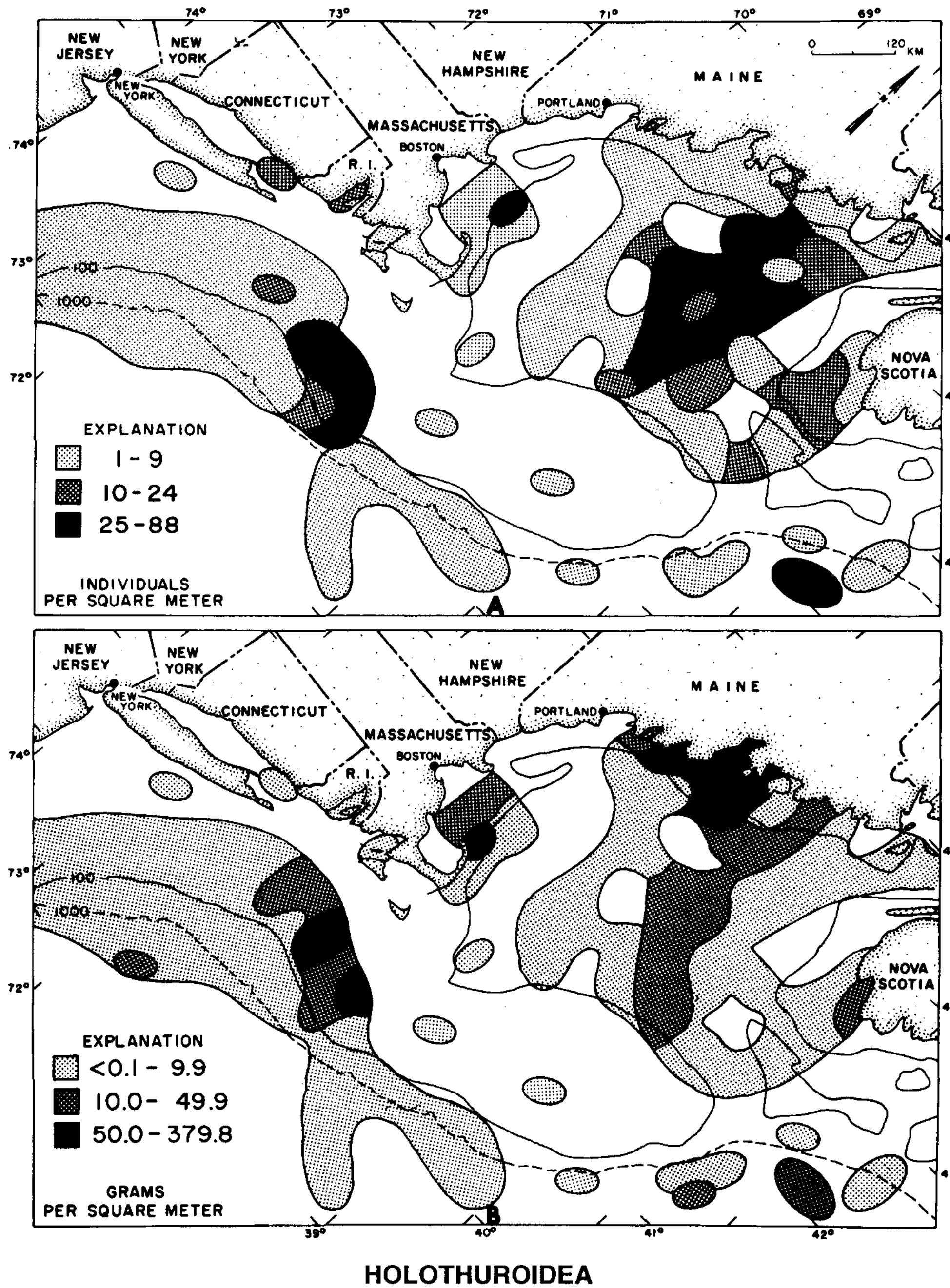


Figure 208

Geographic distribution of Holothuroidea: A—number of specimens per square meter of bottom; B—biomass in grams per square meter of bottom.

the distinction is not always maintained. When the preferred food types are unavailable, echinoids may may revert to other food sources, or in some species, to a different mode of feeding.

Echinoids in turn are preyed upon by a variety of benthic and nektonic animals. They have been observed in the diet of crabs, starfish, finfish, lobsters, birds, and mammals, including man. The quantity utilized for human consumption in recent years has increased with an annual harvest worth several million dollars.

Coloration of most of our echinoids was rather drab consisting largely of grays, brown, reddish-browns, and brownish-violet. In many species the color was gray or brown with suffusions of white, green, pink, or violet.

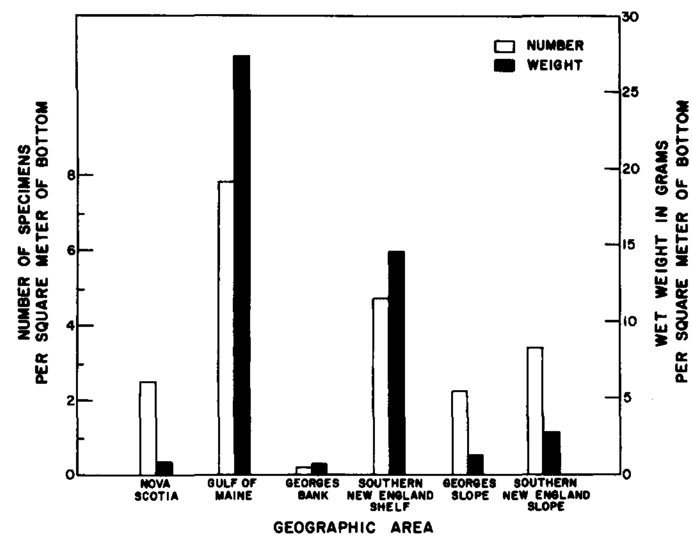


Figure 209
Density and biomass of Holothuroidea in each of the six geographic areas.

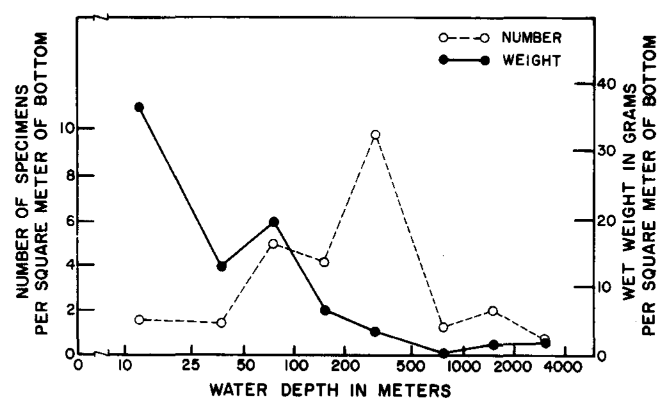


Figure 210
Density and biomass of Holothuroidea in relation to water depth.

Sizes ranged from 2 mm in diameter, in juvenile specimens, to large adults having a test diameter of 5 cm. The majority of specimens ranged between 0.5 and 3 cm.

Echinoids occurred in 293 samples (27% of the total). Their density averaged 29.3/m^2 and their biomass averaged 36.8 g/m^2 (Table 5).

Geographic Distribution
Echinoids occurred extensively throughout most of the study area (Fig. 214), but their distribution pattern was somewhat patchy and irregular in density. Intermediate and high densities (10 to 1,051 individuals/m^2) were common from Georges Bank to the Southern New England Shelf areas. The biomass of echinoids was especially high (100 to 1,027 g/m^2) on Georges Bank where they made up 50% of the total benthic biomass in Northeast Channel, and in coastal areas of central and Southern New England (24%).

Among the six standard geographic areas, the average density of echinoids was moderately high (over 100 individuals/m^2) on Georges Bank, intermediate (4 to 22/m^2) in the Nova Scotia, Gulf of Maine, and Southern New England Shelf areas; and low (0.2 and 0.3/m^2) in the two slope areas (Table 6; Fig. 215).

Biomass was moderate to very high in all areas. It was especially high (averaging 117 g/m^2) in the Georges

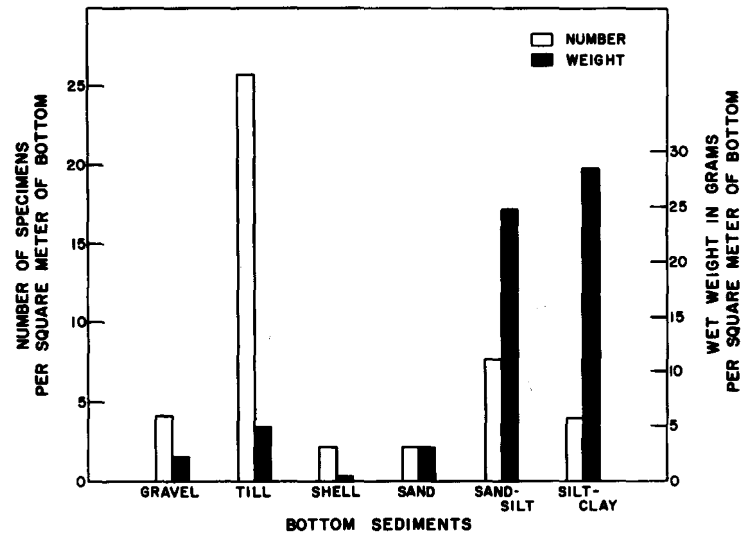


Figure 211
Density and biomass of Holothuroidea in relation to bottom sediments.

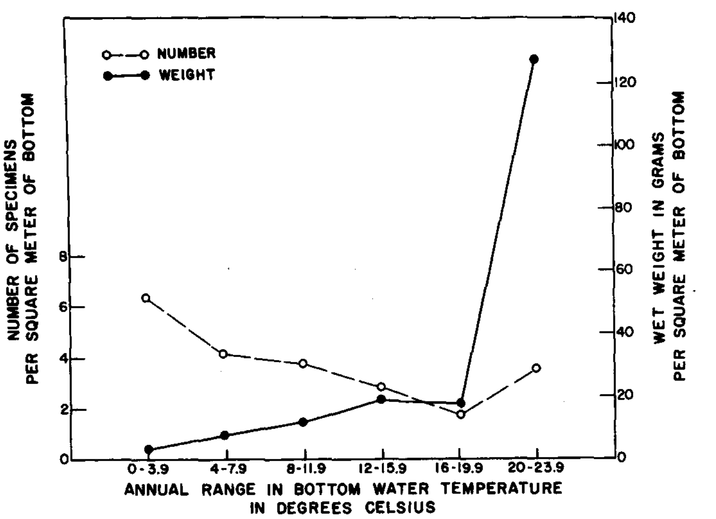


Figure 212
Density and biomass of Holothuroidea in relation to annual range of bottom water temperature.

Bank area. Moderately high (13 to 33 g/m^2) biomasses of echinoids were found off Nova Scotia, in the Gulf of Maine, and on the Southern New England Shelf. Lowest biomass averages occurred in the slope areas (Table 8; Fig. 215).

Echinoids were present in only moderate to small percentages of the total number of samples. Frequency of occurrence was moderate (19 to 51%) in the four continental shelf areas, and low (8 to 9%) in the two slope areas (Table 10).

Bathymetric Distribution
Echinoids occurred in water depths ranging from 7 to 2,950 m. Average densities were highest (127 individuals/m^2) near mid-shelf depths (25 to 49 m) and diminished in both shallower and deeper regions (Table 11;

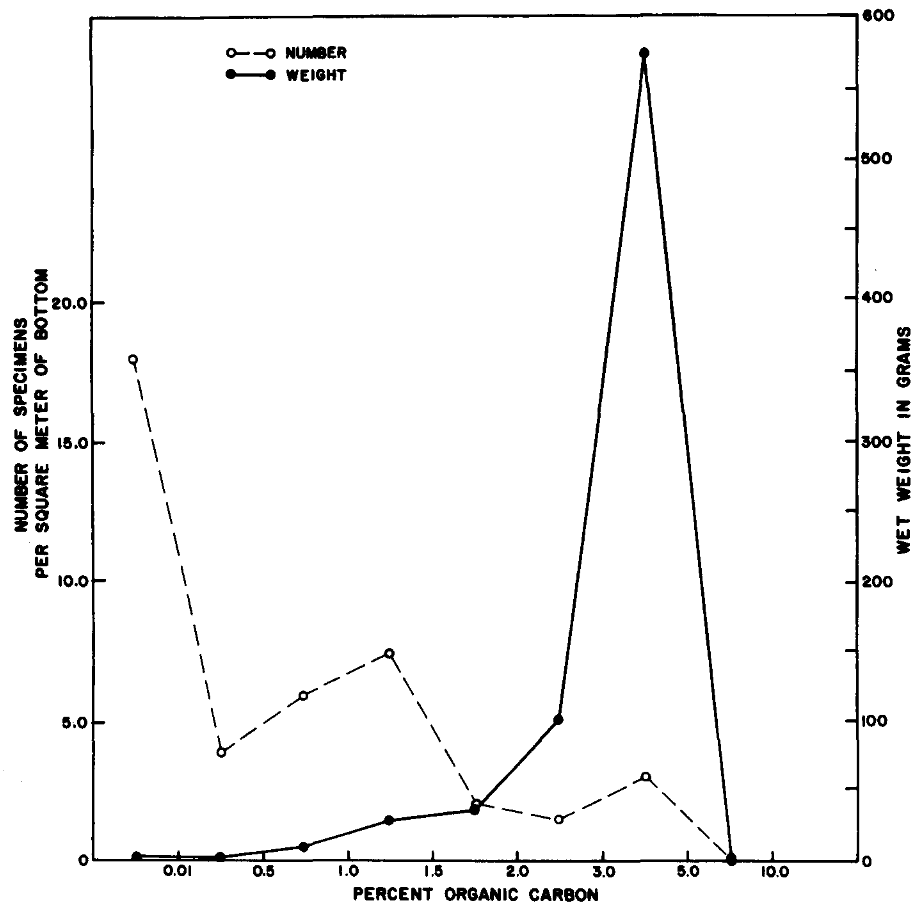


Figure 213
Density and biomass of Holothuroidea in relation to sediment organic carbon.

Fig. 216). At depths greater than 100 m, their density was drastically reduced (2.0 or fewer individuals/m^2).

The pattern of biomass distribution was quite similar to that for density. Average biomass was exceptionally high (154 g/m^2) near mid-shelf depths (25 to 49 m) and decreased in both shallower and deeper regions (Table 13; Fig. 216). The decrease was only moderate in the shallower depth class but was severe (0 to 1.8 g/m^2) in depths greater than 500 m.

Occurrence of echinoids in the samples was moderate to low in all depth classes and followed the same trend as density and biomass. They were present in 57% of the samples near the mid-shelf depths and decreased in samples from both shallower and deeper bathymetric classes (Table 15).

Relation to Sediments

The correlation of echinoids with sand substrates was exceedingly high (Table 16; Fig. 217). Although they were present in all other types of sediments, their density averaged 67 individuals/m^2 in sand but only 3.4 or less per square meter in other sediments.

Precisely the same pattern was revealed for biomass. The average biomass in sand sediments was 81 g/m^2; in all other sediments the biomass of echinoids averaged 7.3 g or less/m^2 (Table 18; Fig. 217). The proportion of the total benthic biomass that was formed by echinoids in the sand sediments was 33%, which is an exceptionally large contribution for one taxon (Table 19).

The occurrence of echinoids in the samples was moderate to low in all sediment types (Table 20). As expected, it was highest (47%) in sand substrates. Somewhat unexpectedly, the incidence rate was lowest (8%) in sand-silt sediments and relatively high (32%) in till.

Relation to Water Temperature

Echinoids were most abundant in terms of both density and biomass in areas where the annual range in bottom water temperature was moderate, 12° to 15.9°C.

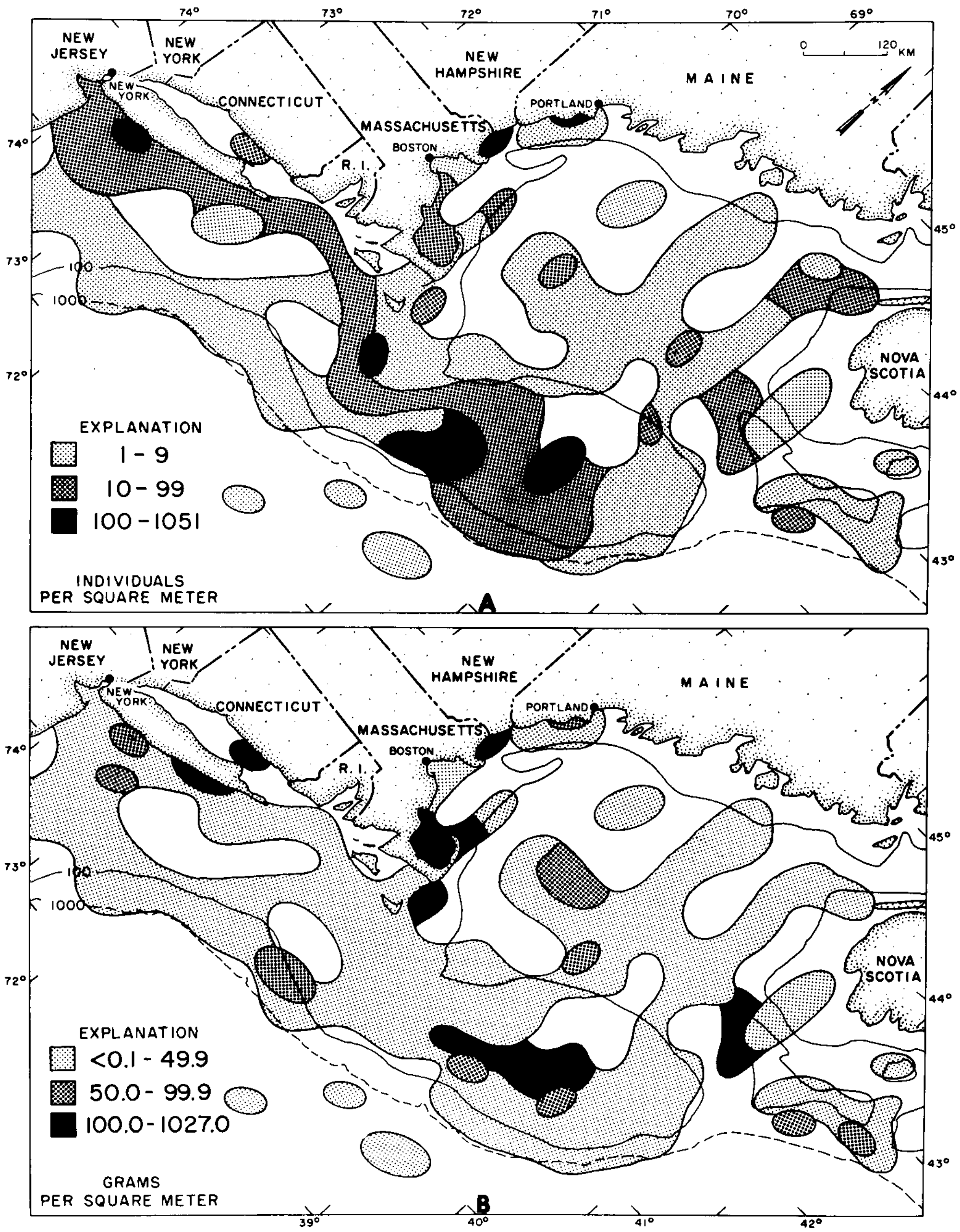


Figure 214

Geographic distribution of Echinoidea: A—number of specimens per square meter of bottom; B—biomass in grams per square meter of bottom.

Echinoid density averaged 93 individuals/m^2 at mid-range (Table 21; Fig. 218). From this peak the average density diminished to 1.4/m^2, where the temperature range was less than 4°C, and to about 15/m^2 where the temperature change was 20°C or more.

The biomass of urchins was distributed in essentially the same manner as their numerical density among the various temperature range groupings, with one exception (Table 23; Fig. 218). Large biomass (148 g/m^2) occurred in the mid-range; moderate biomass (about 14 to 38 g/m^2) in intermediate ranges; and small biomass (6 g/m^2) in the stable areas. The one exception was a relatively large biomass (135 g/m^2) in the broadest (20°–23.9°C) temperature range class.

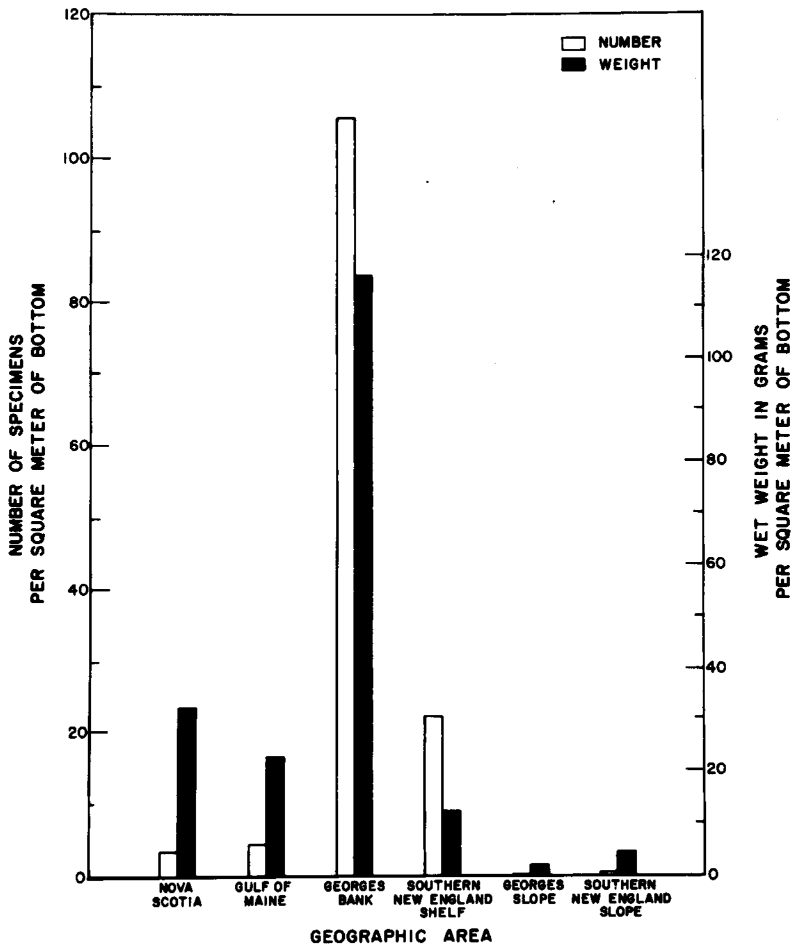


Figure 215
Density and biomass of Echinoidea in each of the six geographic areas.

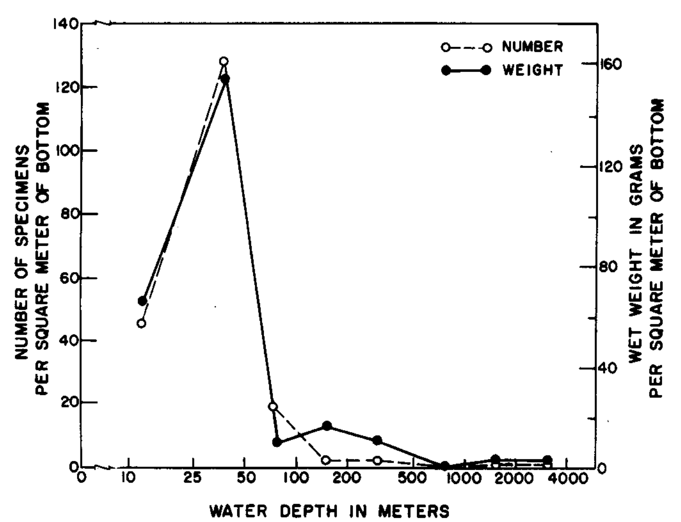


Figure 216
Density and biomass of Echinoidea in relation to water depth.

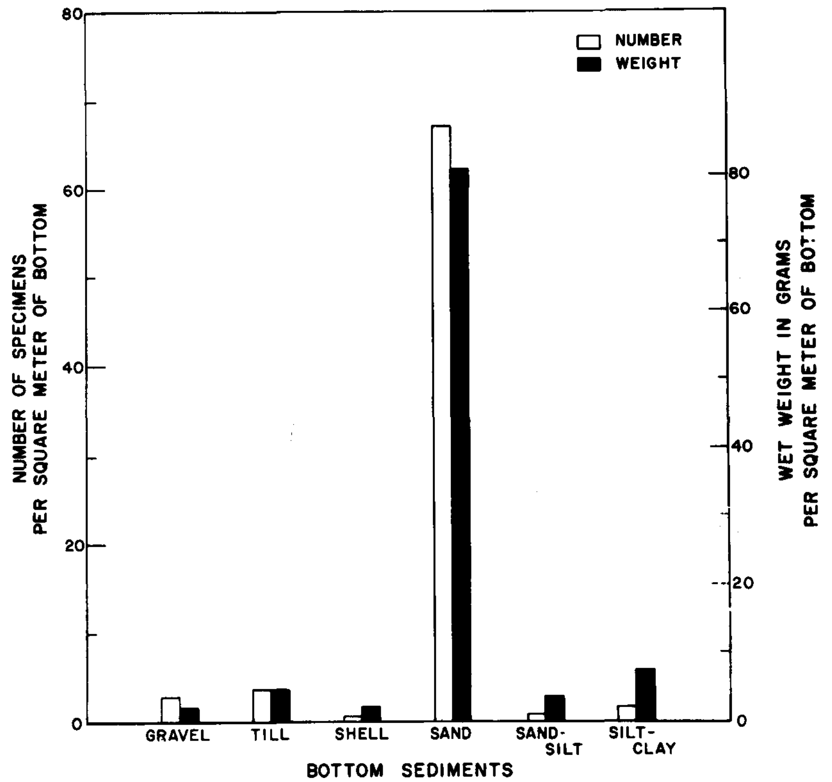


Figure 217
Density and biomass of Echinoida in relation to bottom sediments.

The proportion of the number of individuals in the total macrobenthos made up by urchins was low to moderate (0.3–5%, Table 22), but in terms of biomass they contributed extraordinarily large amounts (8–47%, Table 24) of the total.

Echinoids were present in 14 to 44% of the samples in the various temperature range classes. Frequency of occurrence, as for density and biomass, was highest in the mid-range classes and decreased in both the broader and narrower range classes (Table 25).

Relation to Sediment Organic Carbon
Echinoids showed a marked preference for low levels of sediment organic carbon and were entirely absent where levels of 2% or more prevailed. Their density was highest, but only at moderate levels (24 individuals/m^2), in the lowest carbon content class (0.01–0.49%) and fell off drastically where organic carbon was absent (2.6/m^2), as well as in the classes between 0.50 and 1.99% where density ranged from only 0.6 to 1/m^2 (Table 26; Fig. 219).

Biomass was similarly distributed among the carbon content classes. The lowest content class contained nearly 28 g/m^2 and biomass values fell off markedly in adjacent classes (Table 28; Fig. 219).

Frequency of occurrence of echinoids in the samples was generally low, ranging between 6 and 34%, and paralleled the trend exhibited by density and biomass measures (Table 30).

Ophiuroidea—Ophiuroids formed a moderately small but significant component of the New England benthos. On the average they made up about 3% of the number of animals and 2% of the biomass in the total macrobenthos.

Two orders of ophiuroids (Euryalae—basketstars, and Ophiurae—brittlestars) inhabit the study area. The basketstars have a limited distribution within the region and are relatively rare. Brittlestars, however, are widely distributed and form the bulk of all ophiuroids in our collections. They have the greatest diversity of species of all echinoderm groups; more than a score of species have been identified within the region.

The size of brittlestars in our samples ranged from large specimens of *Ophiomusium*, with disc diameters of

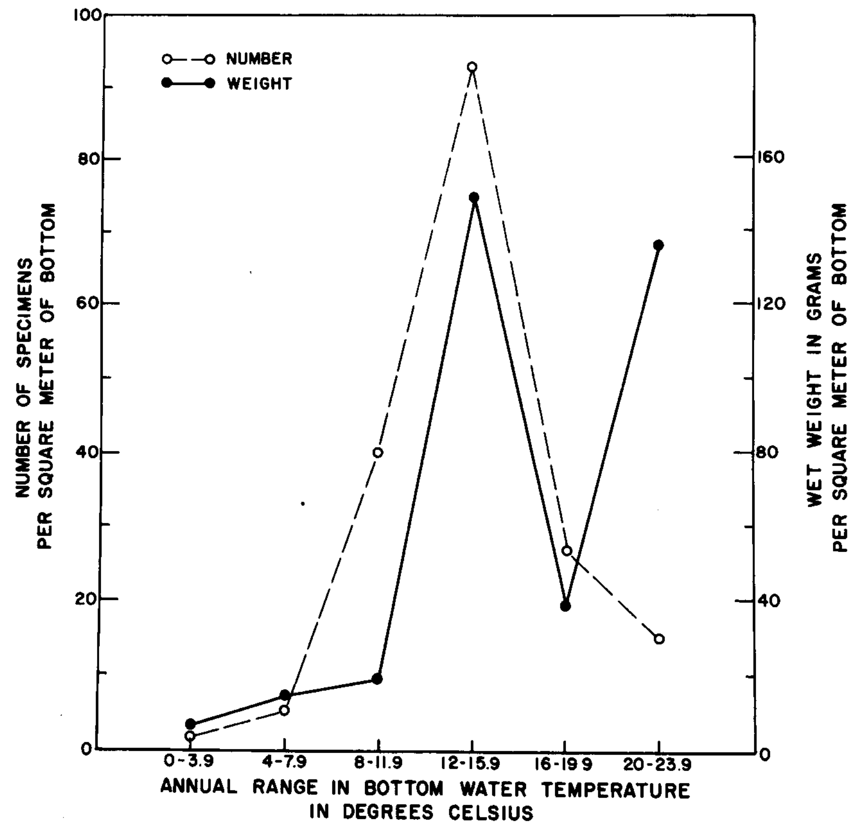


Figure 218
Density and biomass of Echinoidea in relation to the annual range of bottom water temperature.

about 25 mm and arm lengths over 12 cm, to small specimens of *Amphipholis* and *Ophiura*, with disc diameters of less than 2 mm and arms 10 mm long.

The coloration exhibited by ophiuroids in our samples was varied. Some genera, such as *Ophiura* and *Ophiomusium*, were uniformly whitish or light gray. Others were more colorful because of their mottled patterns of contrasting hues, including dark red, pink, brown, and orange. Among the more brightly colored genera were *Ophiopholis*, *Amphiura*, and *Ophioscolex*.

Ophiuroids obtain their food by a variety of different feeding methods; feeding types represented in our samples were carnivores, detritus feeders, filter feeders, and omnivores. A large share of the New England species generally combines the ingestion of bottom material with selective carnivorous feeding. The diet thereby consists of detritus, diatoms, and other small-size foods, as well as polychaete worms, crustaceans, bivalve mollusks, and other similar types of organisms. Brittlestars, in turn, are preyed upon by other echinoderms, but most significantly by demersal fishes.

Ophiuroidea occurred in 487 samples (45% of the total). Their density averaged 44.2/m^2 and their biomass averaged 3.26 g/m^2 (Table 5).

Geographic Distribution

Brittlestars occurred over approximately three-fourths of the study area (Fig. 220). Their average density over most of their range was between 1 and 49 individuals/m^2. High densities (100 to 680/m^2) were widespread along the outer continental shelf south of Nantucket Shoals. Brittlestars were absent from large portions of central Georges Bank, Nantucket Shoals, and much of the New York and New Jersey region.

Biomass distribution of ophiuroids tended to parallel their density distribution. Moderate (1–10 g/m^2) and large (10–80 g/m^2) biomasses were widespread off Southern New England on the outer continental shelf, and in the eastern Gulf of Maine.

The average density of ophiuroids was moderate to moderately high in all six standard geographic areas (Table 6; Fig. 221). Highest average density (94/m^2)