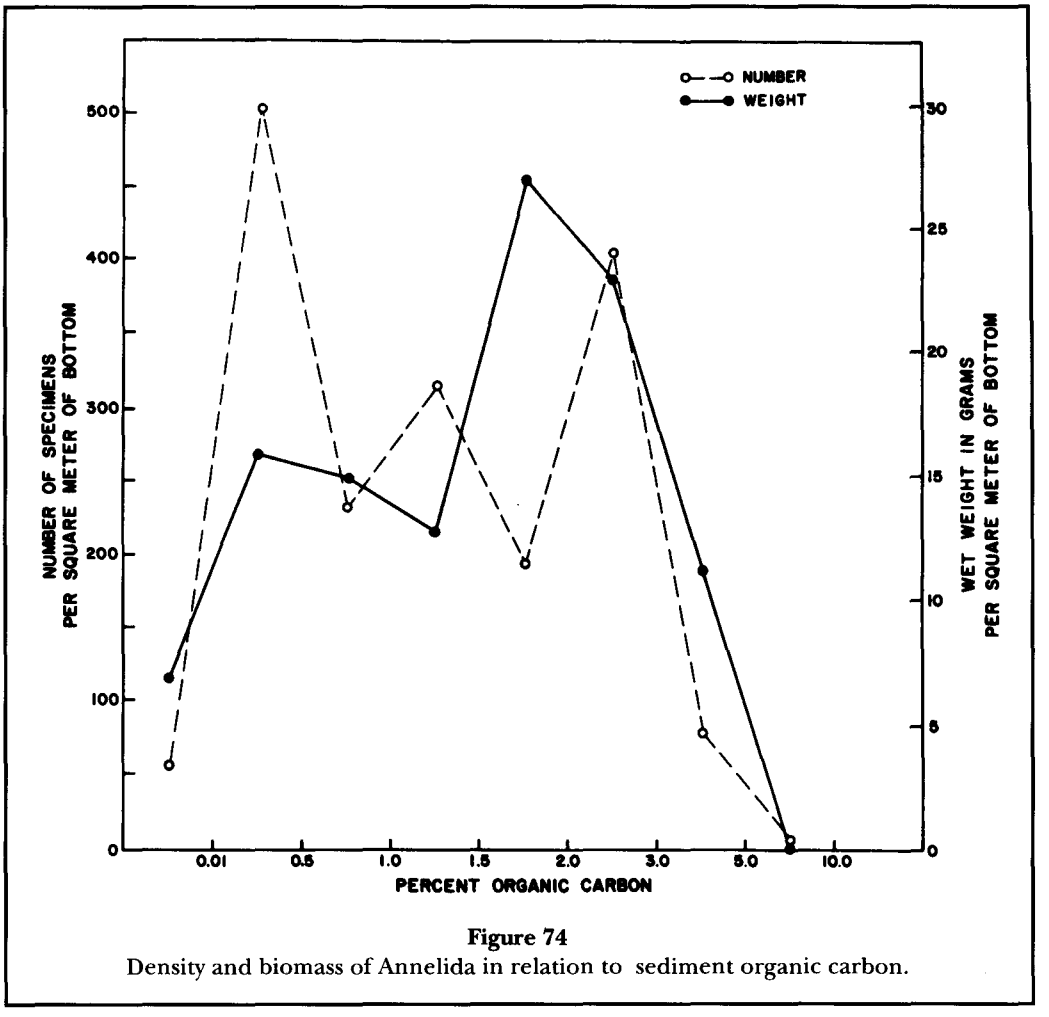


Figure 74
Density and biomass of Annelida in relation to sediment organic carbon.

Average density was highest (6.8 individuals/m^2) between 500 and 1,000 m. Density was slightly lower (3.2 to 3.5/m^2) in deeper water (1,000 to 2,870 m) but substantially lower in depths less than 500 m (Table 11).

Biomass ranged from 0 to 0.03 g/m^2, and the trend in relation to water depth was comparable to that described for density (Table 13).

Pogonophores were present in approximately half the samples from depths greater than 500 m. In the two shallower but adjacent depth classes (100–199 m and 200–499 m), there was a sharp drop in their occurrence to 5 and 1%, respectively, They were absent in the three shallow depth classes (Table 15).

Relation to Sediments

Pogonophores were absent in coarse textured sediments but were increasingly common as the sediment particle size decreased from sand to silt-clay (Fig. 78). The density of pogonophores was exceedingly sparse (<0.1/m^2) in sand sediments, intermediate in sand-silt, and highest (1.9/m^2) in silt-clay (Table 16).

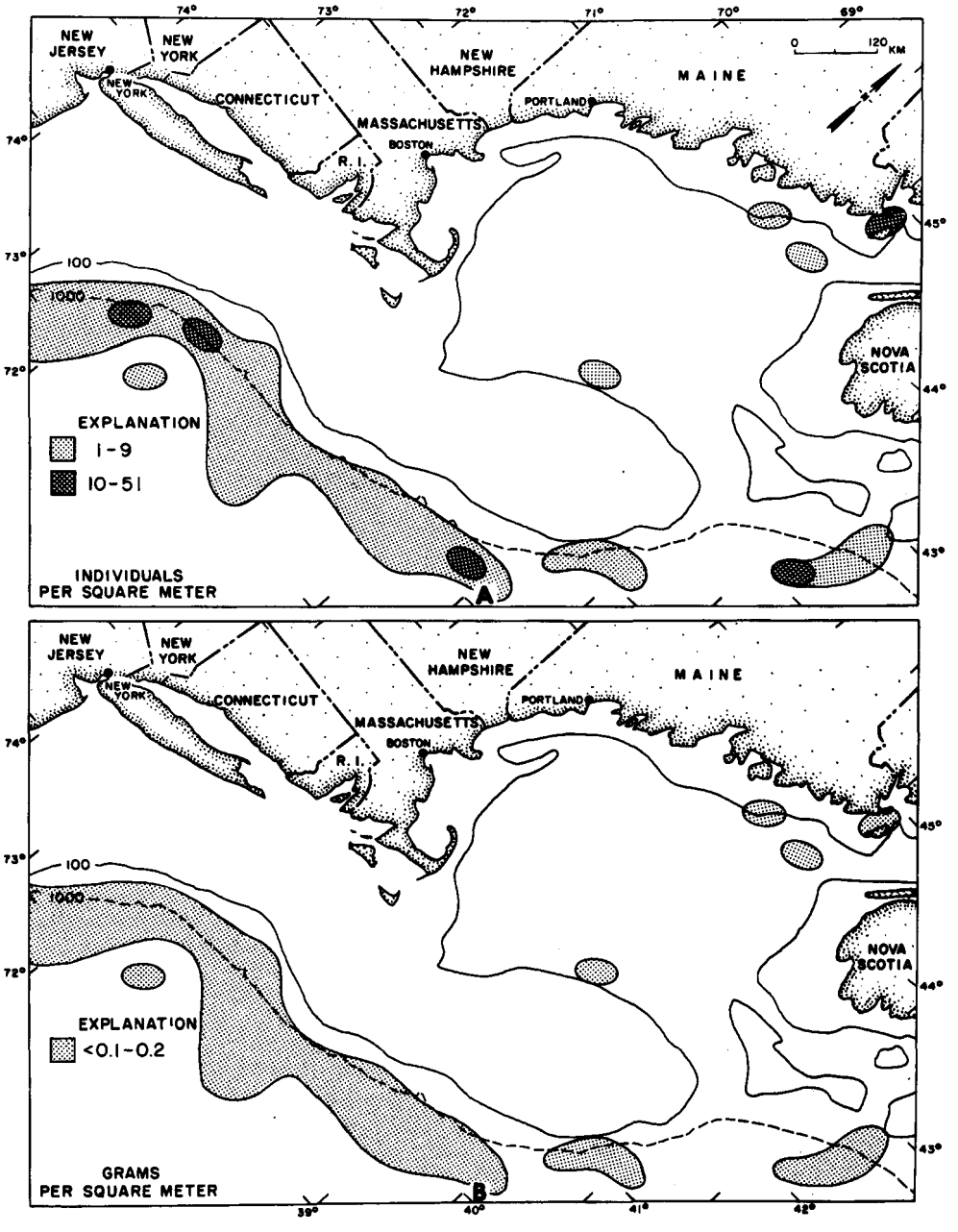
Their biomass was very low (<0.01 g/m^2) in sand, and only slightly higher in the other fine-grade sediments (Table 18).

The occurrence of pogonophores in the samples correlated very closely with average density. They were exceedingly sparse (occurring in <1%) in samples from sand sediments, moderately sparse in sand-silt, and most common (16%) in silt-clay substrates (Table 20).

Relation to Water Temperature

Pogonophores were restricted in their distribution to areas that exhibited an annual bottom temperature range of less than 12°C (Fig. 79). The vast majority were obtained where the temperature range varied less than 4°C. In these waters their density averaged 1.5/m^2 and the biomass averaged 0.01 g/m^2 (Tables 21, 23). Even in areas where the temperature range was between 4° and 11.9°C they were exceedingly sparse in both density (0.1 and 0.7/m^2) and biomass (<0.01 g/m^2).

The areas of small temperature variation (see Fig. 11) correspond to the deepwater regions on the conti-



POGONOPHORA

Figure 75
Geographic distribution of Pogonophora: A—number of specimens per square meter of bottom; B—biomass in grams per square meter of bottom.

nental slope and continental rise (see preceding sections on geographic and bathymetric distribution).

Among the three temperature range classes in which pogonophores were found, their frequency of occurrence was highest (15% of the samples) where the temperature range was smallest. Frequency of occurrence was very low in the other two temperature range classes in which they occurred.

Relation to Sediment Organic Carbon

Pogonophores were found where sediment organic carbon content was low to moderate, ranging from 0.01 to slightly under 2% (Fig. 80).

Highest density ($2.2/m^2$) occurred in carbon contents in the 0.50 to 0.99% range, and lowest ($0.1/m^2$) in the 1.50 to 1.99% range (Table 26).

Biomass was low (0.01 to <0.01 g/m^2) in the four organic carbon range classes in which they occurred (Table 28).

The greatest frequency of occurrence (21%) in samples was in the 0.50 to 0.99% range class, but frequency diminished rapidly in the higher and lower adjacent classes (Table 30).

Sipunculida

Sipunculids, or peanut worms as they are sometimes called, are a taxonomically small group but are found in great abundance in some habitats and have a wide distribution in many parts of the world ocean. Although locally abundant in New England waters, they account for less than 0.5% of the total benthic fauna in terms of both numerical density and biomass (Table 3).

Peanut worms are elongate and cylindrical in shape and characteristically burrow into the bottom sediments where they feed predominantly on detritus. A few species utilize abandoned gastropod shells for permanent shelter, and one small species was found to inhabit empty foraminifera tests.

Specimens in our samples ranged in length from about 0.5 to 12 cm.

Brown, in various shades, was the predominant color exhibited by our specimens; most often they were tan, flesh, or reddish-brown.

Sipunculids occurred in 249 samples (23% of total). Their density averaged 5.9/m^2, and biomass averaged 0.75 g/m^2 (Table 5).

Geographic Distribution

Sipunculids were widely distributed over the study area (Fig. 81), occurring in low densities over large areas of banks and basins. Densities generally averaged between 1 and 49 individuals/m^2 and exceeded these values in only three localities. The maximum density detected was 152 individuals/m^2.

Average biomass of sipunculids was moderately low, usually 1 g or less per square meter, and with few exceptions was less than 10 g/m^2.

Among the six standard geographic areas there was rather little difference in average density (Table 6; Fig. 82); the range was about 1 to 9 individuals/m^2. Slightly

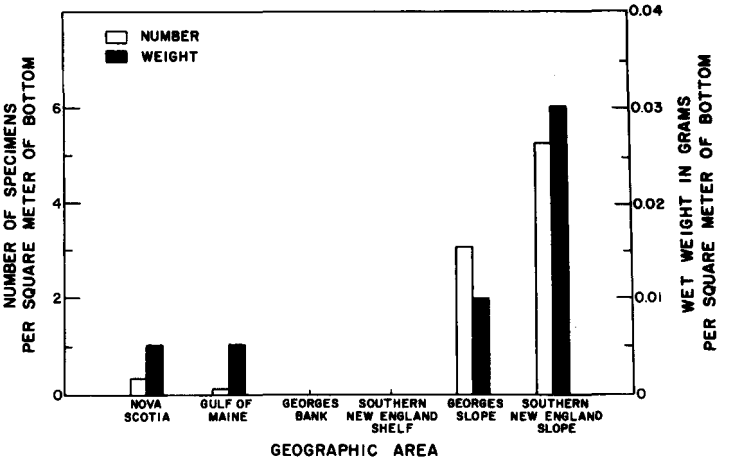


Figure 76
Density and biomass of Pogonophora in each of the six geographic areas.

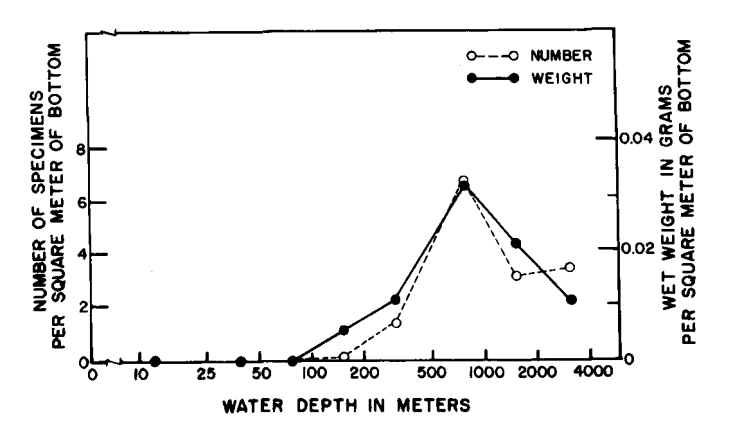


Figure 77
Density and biomass of Pogonophora in relation to water depth.

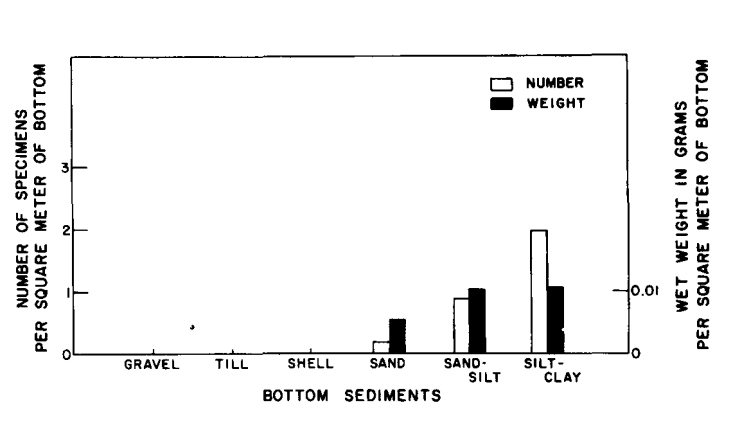


Figure 78
Density and biomass of Pogonophora in relation to bottom sediments.

higher average densities were found in Nova Scotia, Southern New England, and the Southern New England Slope. The lowest density (1.2/m^2) was in the Georges Slope area.

Differences in average biomass were also comparatively small among the six geographic areas (Table 8; Fig. 82). Largest average biomass (1.83 g/m^2) occurred in the Southern New England Slope area; the smallest (0.37 g/m^2) was in the Gulf of Maine.

Individual sipunculids averaged approximately 0.1 g in weight in all areas except Georges Slope, where their average weight was nearly forty times greater, 4 g per individual.

Frequency of occurrence of sipunculids was moderate to moderately low. They were present in 13 to 42% of the samples (Table 10). Highest frequency of occurrence was in the Nova Scotia area and lowest was on Georges Bank.

Bathymetric Distribution

Sipunculids were taken at depths ranging from 16 to 3,975 m. They were most common at moderate depths, 25 to 500 m, where they averaged about 6 to 8 individuals/m^2 (Table 11; Fig. 83). In both shallower and deeper zones they averaged nearly 1 or 2/m^2.

The relation between biomass of sipunculids and water depth was substantially different from that of numerical density. Biomass was much greater (averaging about 1 to 4 g/m^2) on the middle and lower portions of the continental slope (500 to 2,000 m) than it was on the continental shelf and continental rise (Table 13, Fig. 83). Also, sipunculids formed 10 to 26% of the total benthic biomass at these depths, compared with less than 1% for the shallower zones and 5% for the continental rise (Table 14).

The percentage of samples containing sipunculids was lowest (3 to 13%) at depths less than 50 m (Table 15). At depths greater

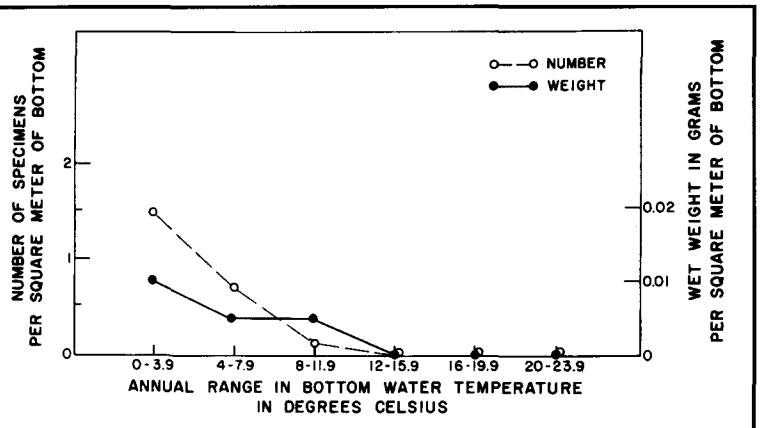


Figure 79
Density and biomass of Pogonophora in relation to the annual range of bottom water temperature.

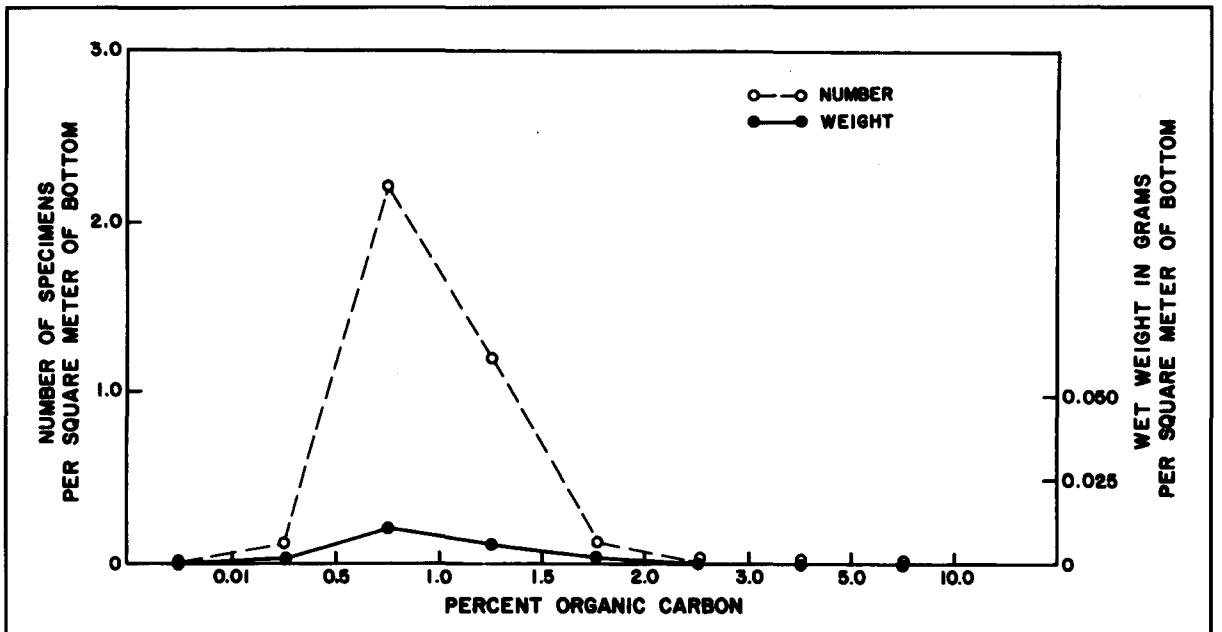
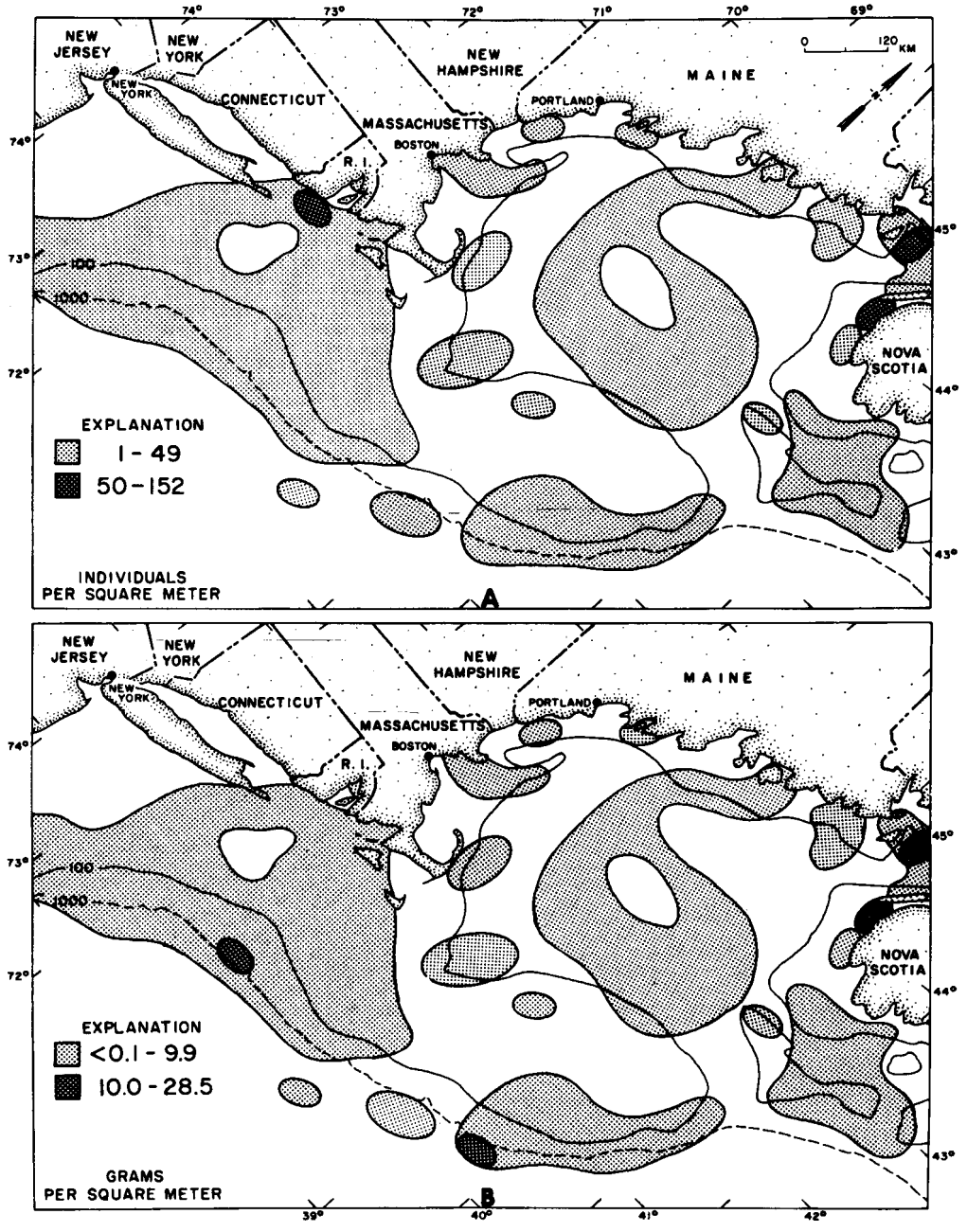


Figure 80
Density and biomass of Pogonophora in relation to sediment organic carbon.



SIPUNCULIDA

Figure 81

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

than 50 m the percentage of occurrence ranged from 21 to 32%, with the highest rates occurring at depths <1,000 m and the lower rates at depths >1,000 m.

Relation to Sediments

Sipunculids inhabited all sediment types and occurred in about the same density in each type (Table 16; Fig. 84). The range in average density in the various types of bottom sediments was from 4.0 to 7.1/m^2. Sand contained the highest density.

Biomass of sipunculids in relation to various sediment types was considerably more varied than density of sipunculids (Table 18; Fig. 84). Biomass ranged from low values (0.16 to 0.29 g/m^2) in shell and till sub-

strates to high quantities (0.81 and 0.89 g/m^2) in sand and sand-silt.

Specimens from the shell substrates were the smallest in individual size.

Frequency of occurrence of sipunculids in the samples was moderately low and approximately equal among the different types of bottom sediments (Table 20). Range in percentage occurrence was 17 to 28, with highest values in sand and sand-silt; lowest values occurred in shell and silt-clay sediments.

Relation to Water Temperature

Sipunculid density, biomass, and frequency of occurrence generally tended to decrease as the range in temperature broadened (Fig. 85). None were found where the temperature range exceeded 20°C.

Density averaged about 5 to 9 individuals/m^2 where the temperature range was restricted and diminished to zero where the temperature range was most extensive (Table 21). The percentage of the total benthic fauna made up of sipunculids decreased at a rather uniform rate as the temperature range increased (Table 22).

Biomass of sipunculids was low or moderately low, and the changes in quantity in relation to temperature range followed precisely the same pattern as those in relation to density (Tables 23, 24). Biomass averaged about 0.7 to 1 g/m^2 in the narrow temperature range classes and decreased to zero where the temperature range was greater than 20°C. The percentage biomass composed of sipunculids also decreased as the temperature range expanded.

Frequency of sipunculids in the samples ranged from 0 to 29% (Table 25). They occurred most frequently, 25 to 29%, in samples where the temperature range was less than 12°C. Where the temperature range was broader than 12°C, the occurrence of sipunculids dropped substantially and they were absent in samples from areas where the temperature range was more than 20°C.

Relation to Sediment Organic Carbon

Sipunculids showed a decided preference for sediments with moderately low to low amounts of sediment organic carbon (Fig. 86). Both measures of abundance were greatest in the two classes between 0.01

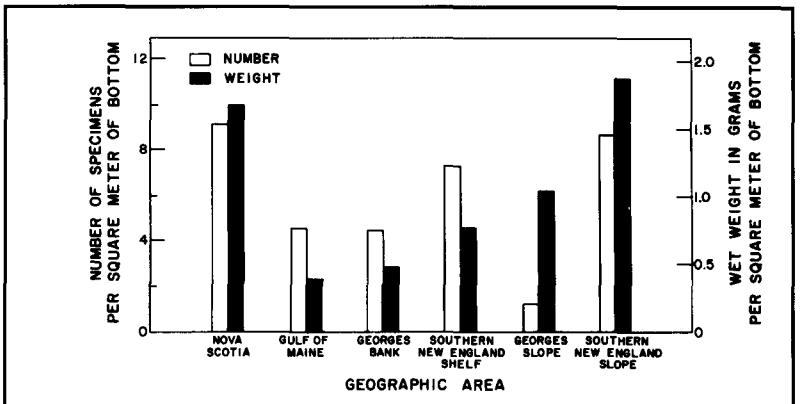


Figure 82

Density and biomass of Sipunculida in each of the six geographic areas.

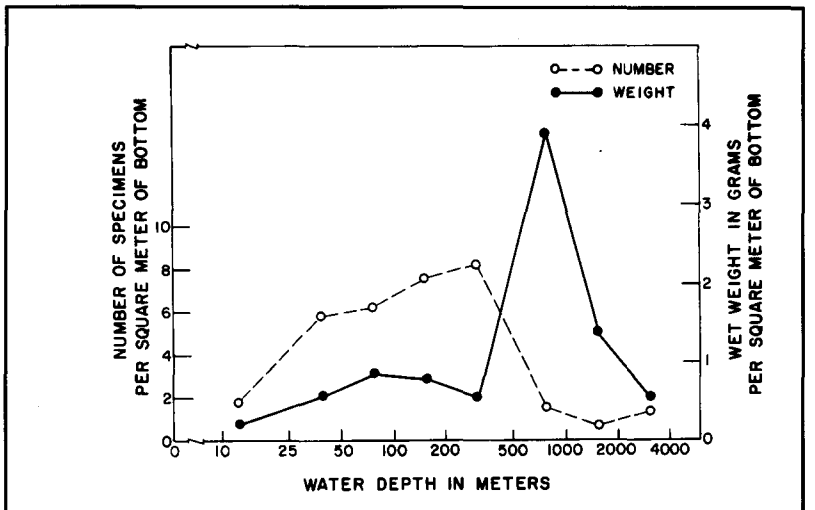


Figure 83

Density and biomass of Sipunculida in relation to water depth.

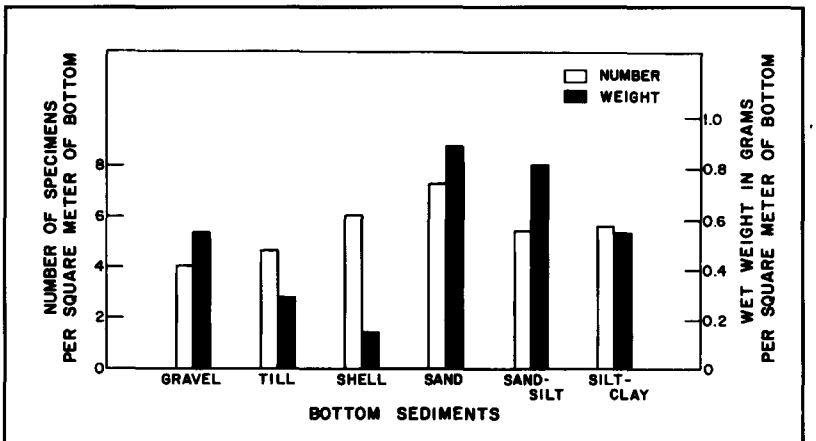


Figure 84

Density and biomass of Sipunculida in relation to bottom sediments.

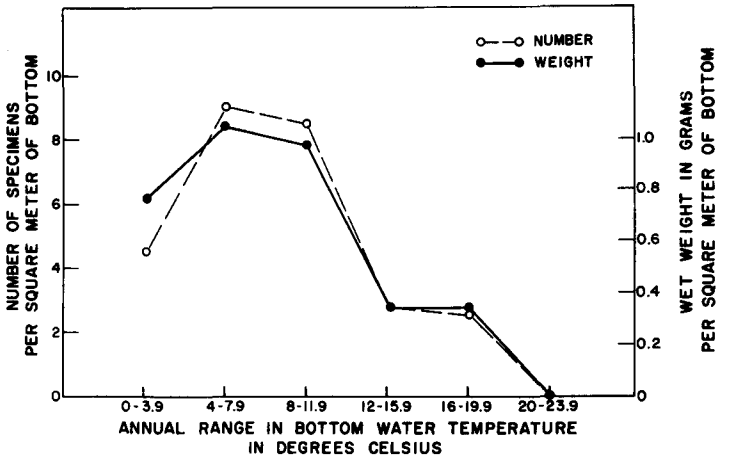


Figure 85
Density and biomass of Sipunculida in relation to the annual range of bottom water temperature.

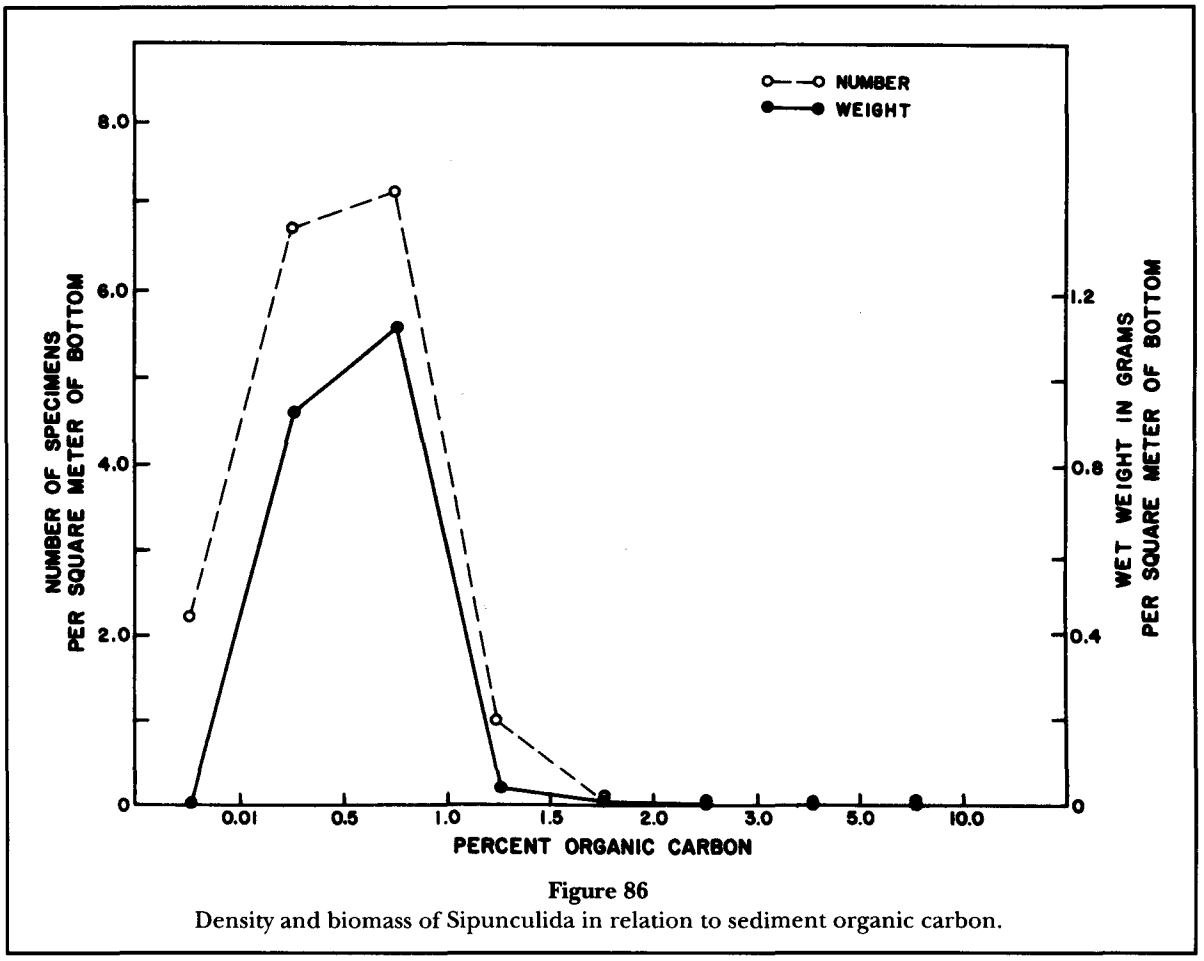


Figure 86
Density and biomass of Sipunculida in relation to sediment organic carbon.

and 0.99% organic carbon. Abundances were low where carbon was absent, but sipunculids were entirely absent in sediments whose carbon levels were 2% or greater.

Density of sipunculids ranged from 0.1 to slightly more than 7 individuals/m^2 (Table 26), and biomass ranged from <0.01 to a little more than 1.1 g/m^2 (Table 28).

Frequency of occurrence of sipunculids in the samples paralleled the trends established by density and biomass. Range of occurrence was from 2 to 31% (Table 30).

Echiura

Echiurid worms, like sipunculids and priapulids to which they are taxonomically allied and which they resemble somewhat in terms of size and habits, form a rather obscure and small group and are not very well known in this region. They are not especially abundant in the New England region, accounting for only 0.2% of total biomass and >0.1% of total density (Table 3).

Echiurids are round, unsegmented worms that typically burrow into sand and mud. Others are found among rocks and on coral reefs; one southern species uses the tests of sand dollars as a habitat.

Their size varies greatly, ranging from tiny 3-mm males to large females over 300 mm in length. Specimens in our samples were in the 2 to 8 cm size range.

They are reported to prefer shallow waters; however, the majority of our specimens were collected from deep water. Depth range of our samples was from 20 to 3,975 m, but only 5 of the samples were in water depths of less than 1,000 m.

Color of specimens ranges from drab grays and brown to green, red, and rose colored, and some were transparent.

Echiurids occurred in 17 samples (1.6% of total). Density averaged 0.1/m^2 and biomass 0.30 g/m^2 (Table 5).

Geographic Distribution

Echiurids were almost exclusively restricted in their geographic distribution to the lower continental shelf and upper continental slope and were found in rather small, discrete patches (Fig. 87). The only exceptions were two small areas inshore, one at the mouth of Long Island Sound and the other near Mt. Desert Island in the Gulf of Maine. Densities averaged between 1 and 9 individuals/m^2, whereas average biomass ranged from <0.1 to a high of 12.5 g/m^2.

Echiurids were absent from Nova Scotia and Georges Bank and were present in generally equitable densities in the other standard geographic areas. Highest average densities occurred in the two slope areas (Table 6; Fig. 88). Biomass was also highest in the slope area; significantly lower values were observed in the other areas in which they were found (Table 8; Fig. 88). Frequency of occurrence of echiurids in samples ranged from <1% to 15%. Lowest occurrence was in Gulf of Maine and highest on Georges Slope (Table 10).

Bathymetric Distribution

Echiurids were found at depths ranging from 20 to 3,975 m. Their numerical abundance was greatest, albeit low (0.5 to 0.6/m^2), in water depths greater than 1,000 m and even lower (0.02-0.3/m^2) at shelf and inshore depths (Table 11, Fig. 89).

The relation of biomass to water depth was similar to that of numerical density. Continental slope depths (1,000 to nearly 4,000 m) provided highest mean biomass of this small group ranging from 3.5 to 5 g/m^2. Significantly lower (0.22 to 0.01 g/m^2) biomasses occurred in inshore and midshelf depths, respectively (Table 13; Fig. 89).

Echiurids were found in 19 to 21% of the samples in the two depth range classes below 1,000 m, but in only <1% of the samples in the 100–199 m range and 2% in the 0–24 m range class (Table 15).

Relation to Sediments

Echiurids in our samples were rather restrictive in their choice of sediment, preferring to inhabit only the two finest-grained types. Both mean density (0.2 and 0.3/m^2) and biomass (0.79 and 0.69 g/m^2) were quite evenly apportioned between sand-silt and silt-clay, respectively (Tables 16, 18; Fig. 90). Three percent of the samples in sand-silt and 5% in silt-clay contained specimens (Table 20).

Relation to Water Temperature

Considering the deep water and fine sediment preferences of echiurids, it is not surprising to find that they also had restricted temperature preferences. They occupied only three temperature ranges; areas with the most stable annual range (0–3.9°C) contained the lowest density (0.1/m^2) but the highest biomass (0.9 g/m^2); areas with an annual range of 16–19.9°C had the highest density (0.4/m^2) and also contained the second highest biomass; and areas where the temperature range was between 4° and 7.9°C had moderate density and low biomass (Tables 21, 23; Fig. 91).

Frequency of occurrence ranged from 1 to 4% (Table 25), being highest in the narrowest temperature range.

Relation to Sediment Organic Carbon

Echiurids were also restrictive in relation to organic carbon content of sediments, occurring only where amounts ranged from 0.01 to 1.49% (Fig. 92). Density was greatest in carbon contents 0.50 to 0.99%, falling to lower levels in areas of both lesser and greater content (Table 26); conversely, biomass showed an increasing trend with organic carbon content (Table 28). Frequency of occurrence in samples reflected the trend for density (Table 30).

Priapulida

Among the invertebrate fauna of the New England region priapulid worms make up perhaps the rarest

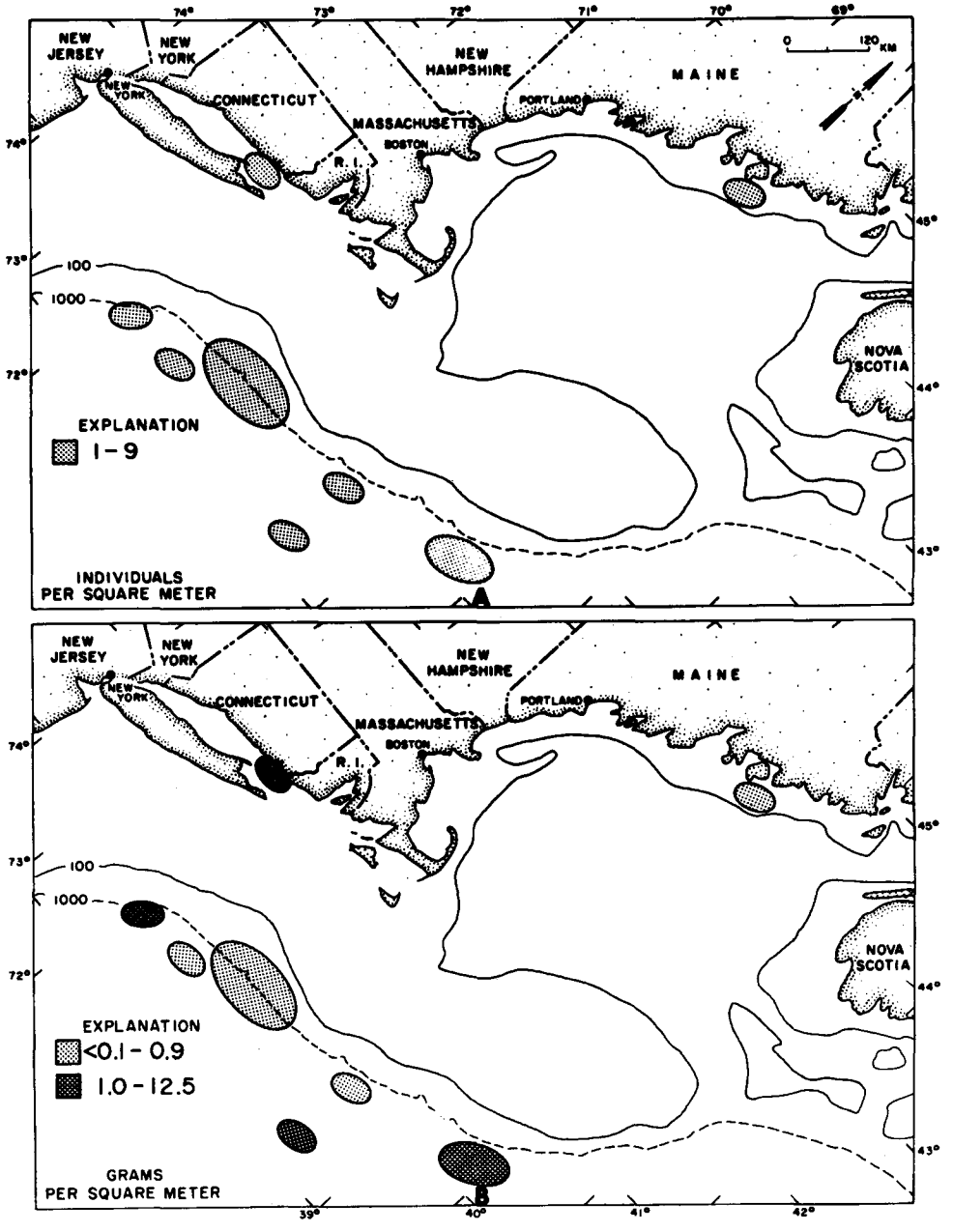


Figure 87

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

and least known group; they are also uncommon in other areas of the world ocean as well—only eight species belonging to six genera have been reported (Barnes, 1974). Priapulids contributed <0.1% of the total number of specimens and biomass in the region (Table 3).

Priapulids are cucumber-shaped predacious worms that burrow into sand and mud and feed upon other soft-bodied, slow-moving invertebrates, especially polychaete worms. They are typically between 4 to 8 cm. in length. Our specimens were considerably smaller, in the 1 to 2 cm size range. Color of specimens ranges from whitish to flesh colored with some yellow on appendages; some of our specimens were somewhat reddish brown.

Only 4 (0.4% of total) of our samples yielded specimens (10 individuals weighing a total of 4.60 g) whose mean density was <0.1/m^2 and whose biomass was <0.01 g/m^2 (Table 5).

Priapulids in the New England region were found in the deep (1,420–2,035 m), cold (0–3.9°C), sand-silt and silt-clay bottoms of Georges and Southern New England Slope waters, where organic carbon levels range from 0.01 to 1.49%, in very low abundance (Figs. 93–98).

Mollusca

The phylum Mollusca contributes significantly to both measures of abundance (numerical density and biomass) in the New England region as it does in the Middle Atlantic Bight region (Wigley and Theroux, 1981). The molluscan fauna comprises five classes: Polyplacophora, Gastropoda, Bivalvia, Scaphopoda, and Cephalopoda. Each of these classes will be discussed separately below. For the sake of continuity in the phylogenetic ordering of figures, those figures dealing with phylum Mollusca (Figs. 99–104, inclusive) are included here, but a detailed discussion of the phylum as a whole will be presented in the section "Dominant Components of the Macrobenthos" below.

Polyplacophora—This class of mollusks is also called chitons, which are bilaterally symmetrical, have eight overlapping dorsal plates, and a broad, flat, ventral foot. They accounted for less than 1% of the biomass and number of animals of the total benthic invertebrate fauna (Table 3).

Specimens ranged in size from 4 mm to 2 cm and exhibited considerable variation in color. They were commonly chalky white or various shades of light gray; a small proportion were light brown. A few had a dark, nearly black coating over their plates that contrasted sharply with the underlying white or light gray.

Chitons were relatively common in the coastal areas, on relatively shallow offshore banks, on coarse bottom sediments, and where the water temperature range was moderately broad.

Polyplacophorans occurred in 84 samples (8% of total). Their density averaged 1.5/m^2, and biomass averaged 0.14 g/m^2 (Table 5).

Geographic Distribution

Polyplacophorans, although rather sparse, occurred in small to moderately large geographi-

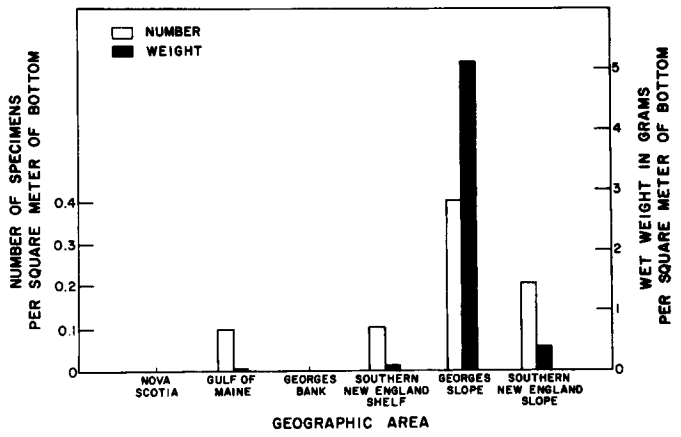


Figure 88
Density and biomass of Echiura in each of the six geographic areas.

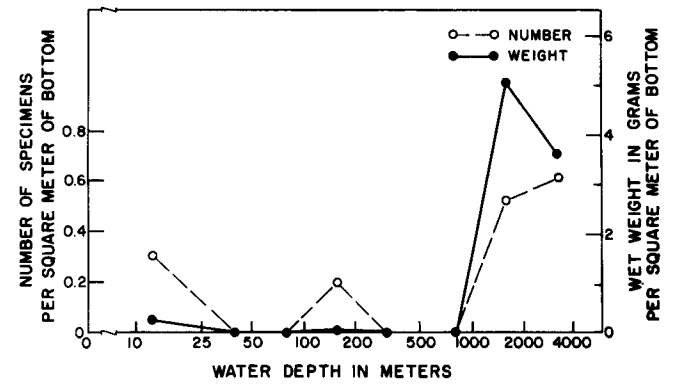


Figure 89
Density and biomass of Echiura in relation to water depth.

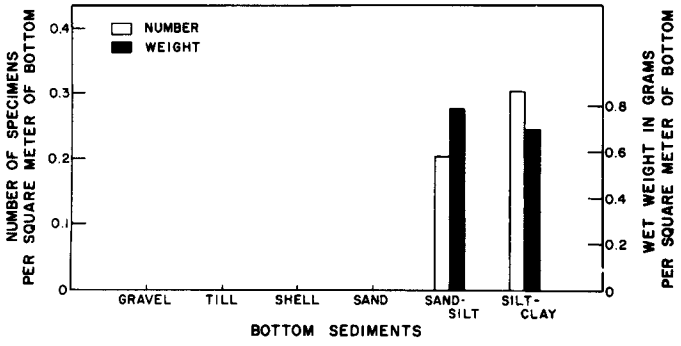


Figure 90
Density and biomass of Echiura in relation to bottom sediments.

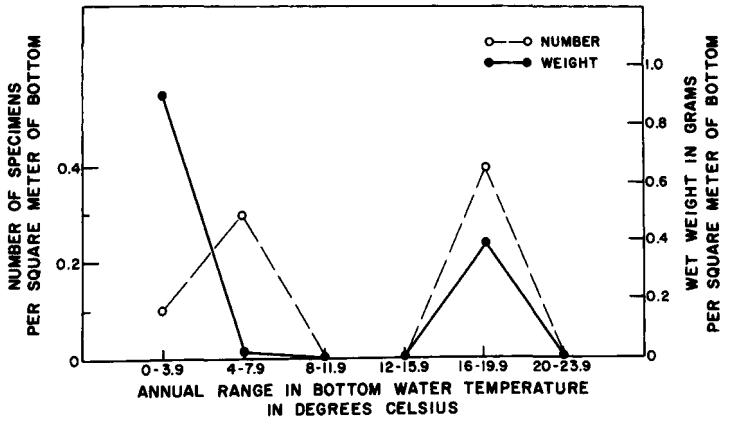


Figure 91
Density and biomass of Echiura in relation to the annual range of bottom water temperature.

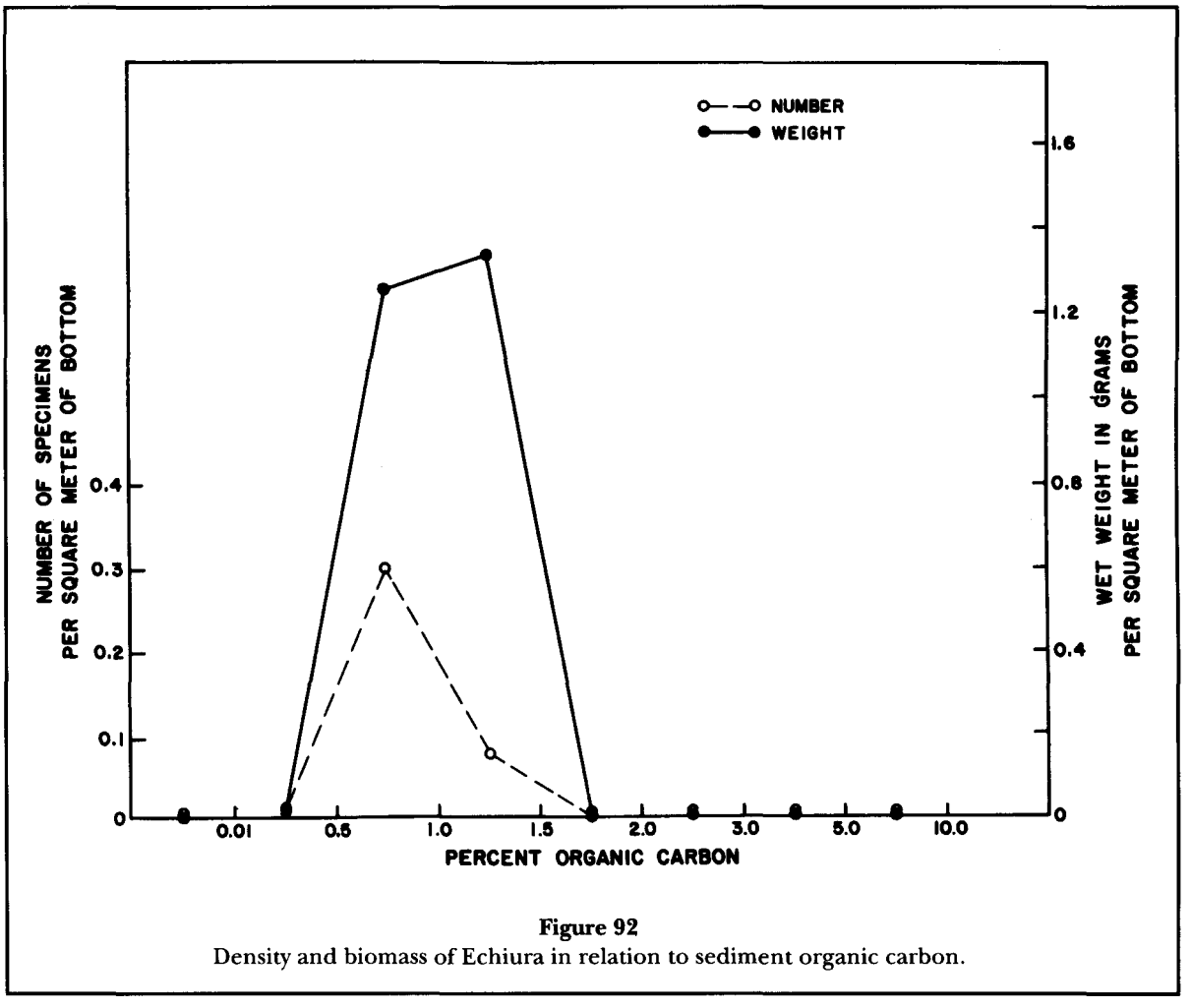
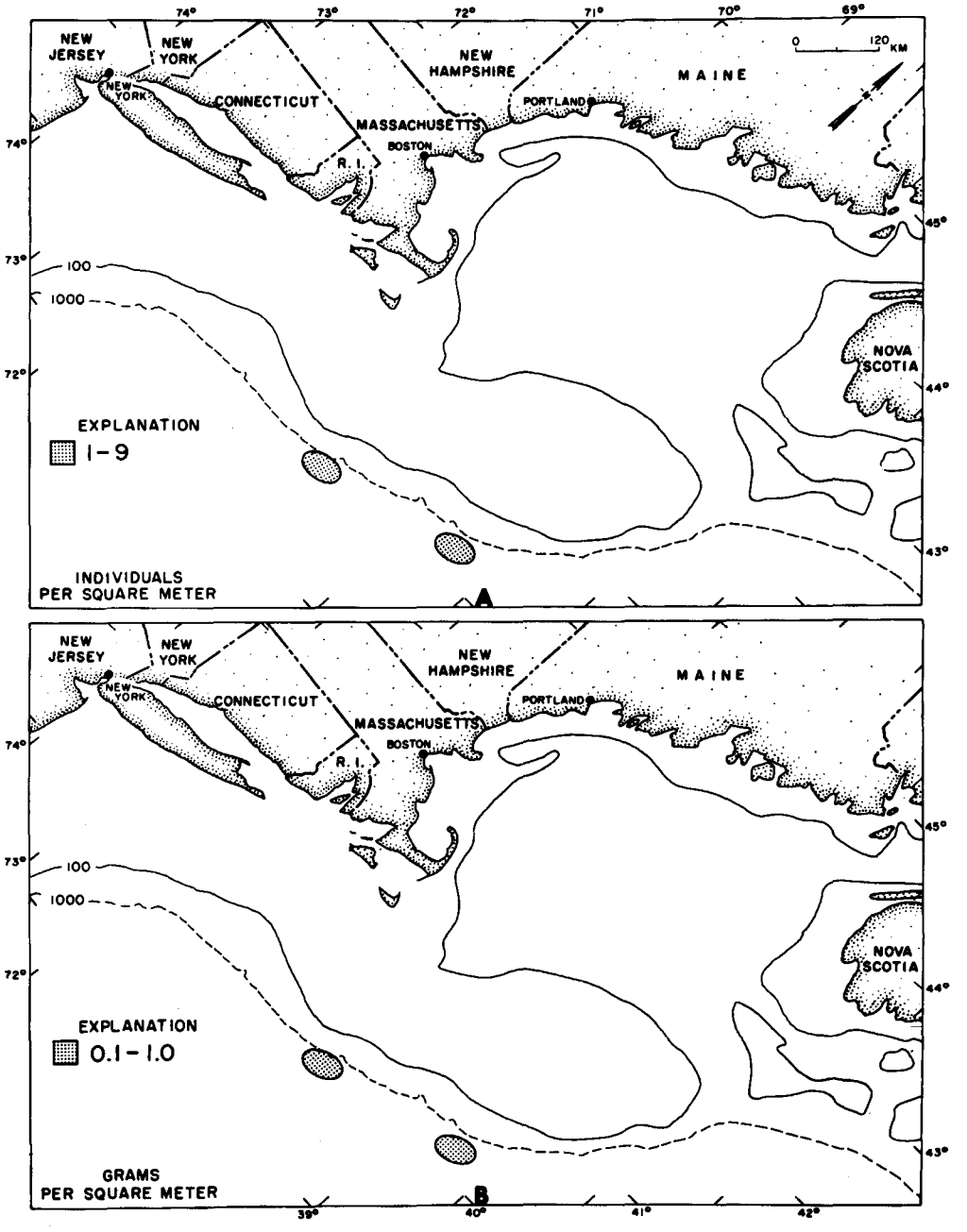


Figure 92
Density and biomass of Echiura in relation to sediment organic carbon.



PRIAPULIDA

Figure 93

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

cal areas throughout much of the study area (Fig. 105). They were most common in the Nova Scotia region, the periphery of the Gulf of Maine, in deep water south of Georges Bank, and on the outer shelf south of Cape Cod, Massachusetts. They were notably absent in the Georges Bank-Nantucket Shoals area and in deep water in the western Gulf of Maine. In all but a few locations their numerical density was less than $9/m^2$ and their weight averaged less than 1 g/m^2.

Three of the six standard geographic areas contained significant quantities of chitons: Nova Scotia, Gulf of Maine, and the Southern New England Shelf (Tables 6, 8; Fig. 106). The average number of specimens ranged from 0.9 to $3.6/m^2$. Average biomass was small, 0.24 g/m^2

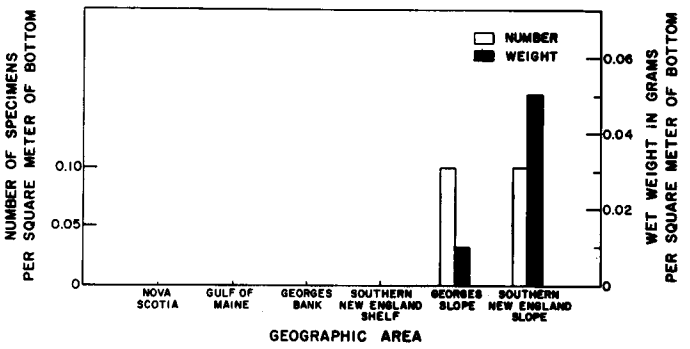


Figure 94
Density and biomass of Priapulida in each of the six geographic areas.

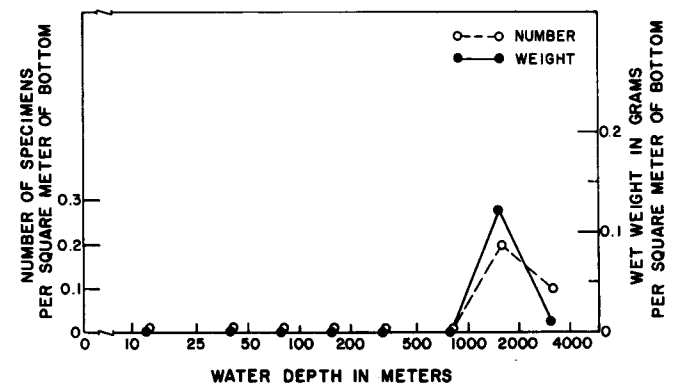


Figure 95
Density and biomass of Priapulida in relation to water depth.

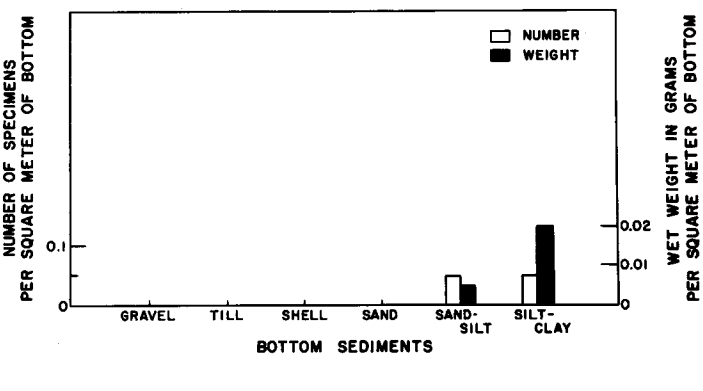


Figure 96
Density and biomass of Priapulida in relation to bottom sediments.

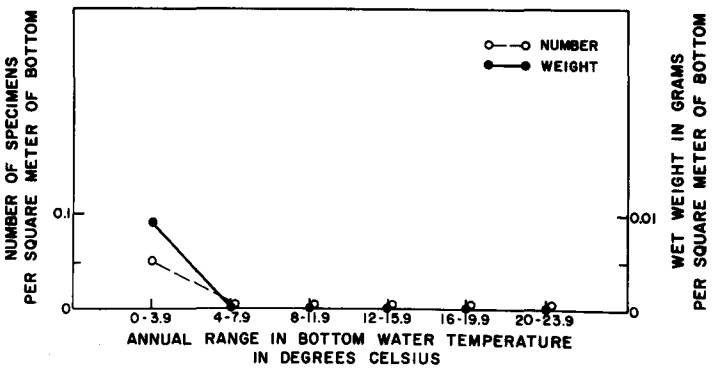


Figure 97
Density and biomass of Priapulida in relation to the annual range of bottom water temperature.

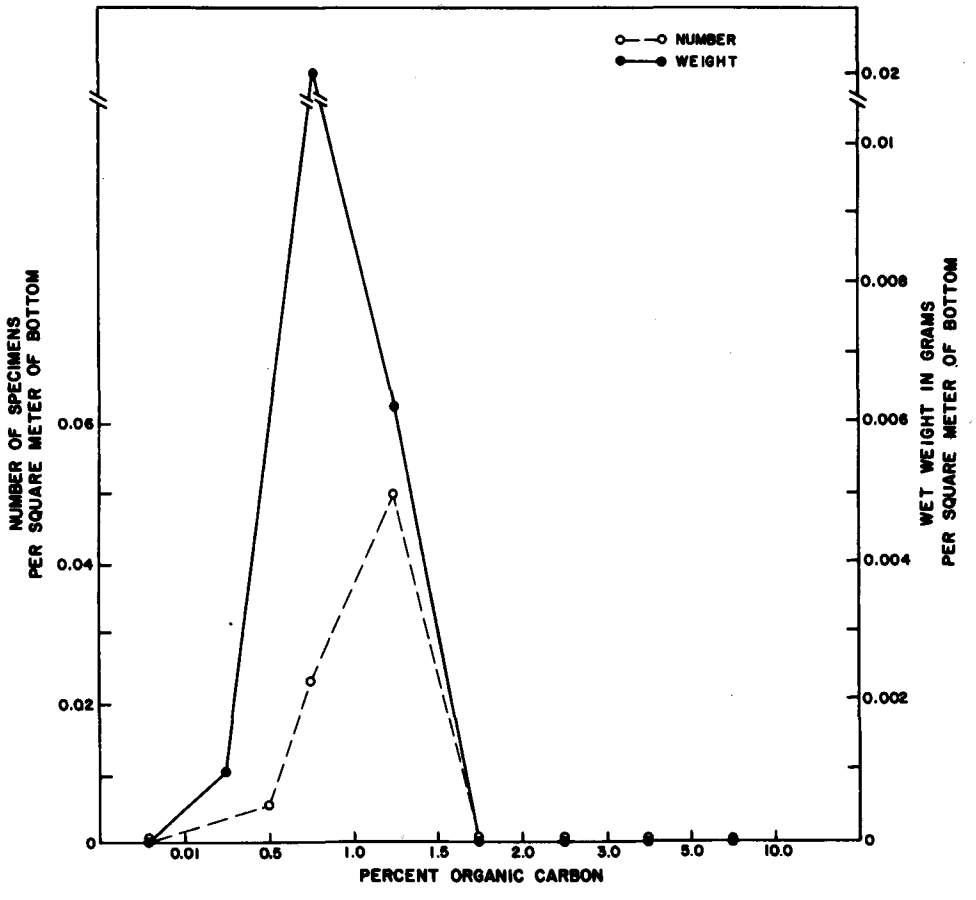


Figure 98
Density and biomass of Priapulida in relation to sediment organic carbon.

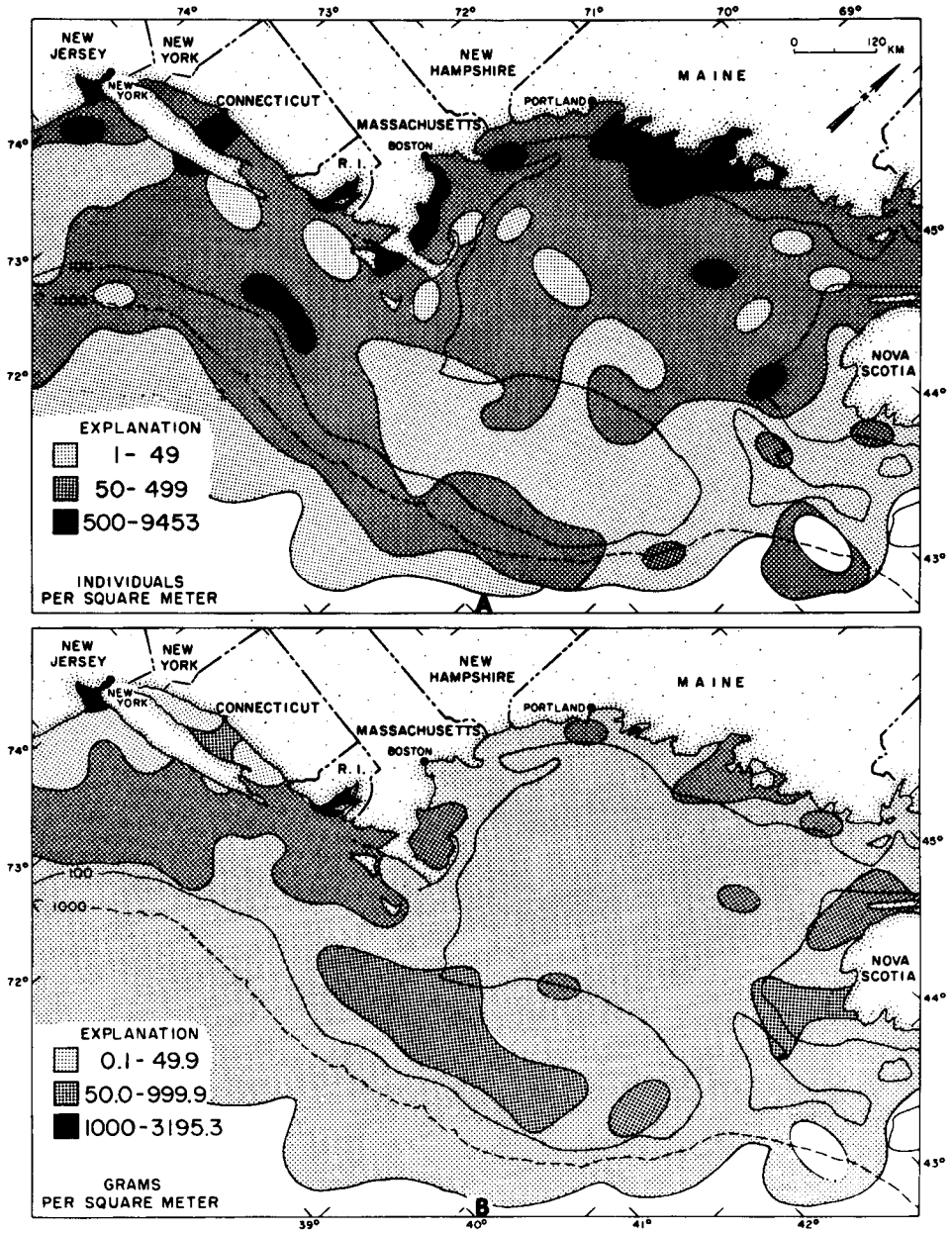


Figure 99

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

or less. On Georges Bank, Georges Slope, and the Southern New England Slope their density averaged 0.1 to 0.6/m^2, and their weight averaged 0.01 g/m^2 or less.

Frequency of occurrence was relatively high (1 to 24%) considering the small quantities that were present (Table 10). This high frequency of occurrence is simply a reflection of their small size and wide dispersion. Individuals were especially small in the Georges Slope area and relatively larger in the Southern New England Shelf area.

Bathymetric Distribution

Polyplacophorans were present at depths from 16 to 2,840 m. They were more abundant in shallow and moderate depths than in very deep water (Table 11; Fig. 107). Average density in depth classes less than 500

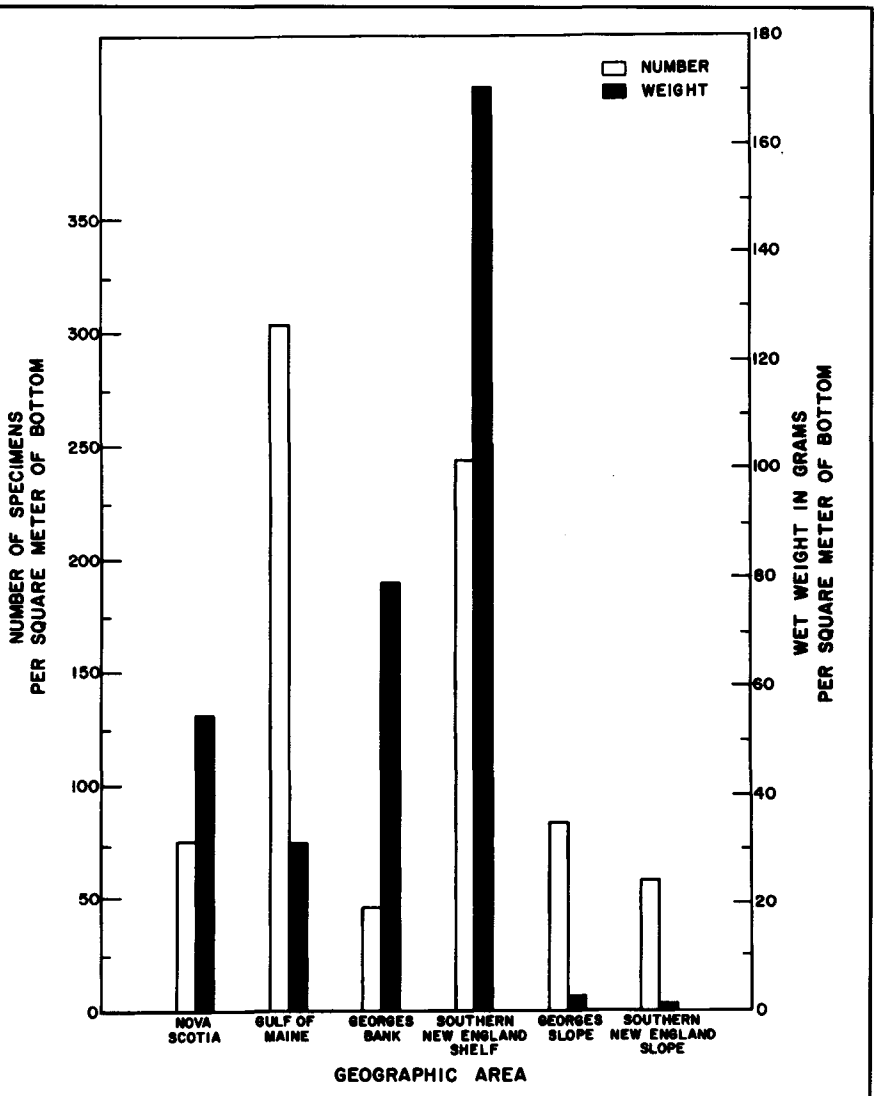


Figure 100
Density and biomass of Mollusca in each of the six geographic areas.

m ranged from 0.4 to 4.0/m^2. Below 500 m the average density in the various depth classes was 0.2 to 0.5/m^2.

Average biomass of chitons was greater (0.3 to 0.8 g/m^2) at depths less than 500 m than in the deeper water where their biomass averaged 0.01 g/m^2 or less (Table 13; Fig. 107).

Frequency of occurrence was low (1 to 18%) and no clear relations with depth were evident. The trend indicated a slightly higher rate of occurrence in moderate (50 to 200 m) and deep (>200 m) water (Table 15).

These results indicate that polyplacophorans are less abundant but more uniformly distributed in deep water (>500 m) than on the continental shelf and upper portion of the continental slope.

Relation to Sediments

Polyplacophorans occurred in all sediments except shell (Table 16; Fig. 108). Highest density (3.8/m^2) was encountered in sand-silt sediment. Till, gravel, and silt-clay ranked second to fourth, respectively, and only very small quantities (0.3/m^2) were found in sand sediments.

The relationship of average biomass to various types of bottom sediments was quite different from that of density (Table 18; Fig. 108). Gravel and till yielded the largest biomasses (0.7 and 0.3 g/m^2, respectively), whereas in all other sediments it averaged <0.07 g/m^2.

Frequency of occurrence was highest (11 to 27% of the samples) in those sediments where chitons were

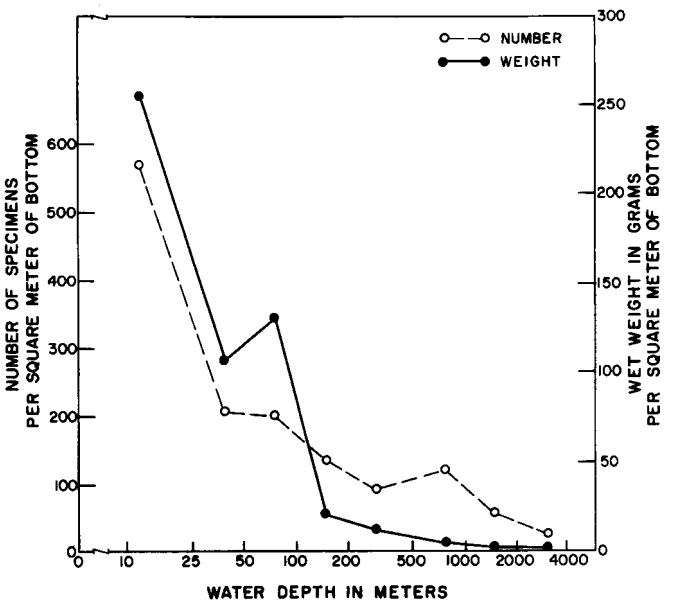


Figure 101
Density and biomass of Mollusca in relation to water depth.

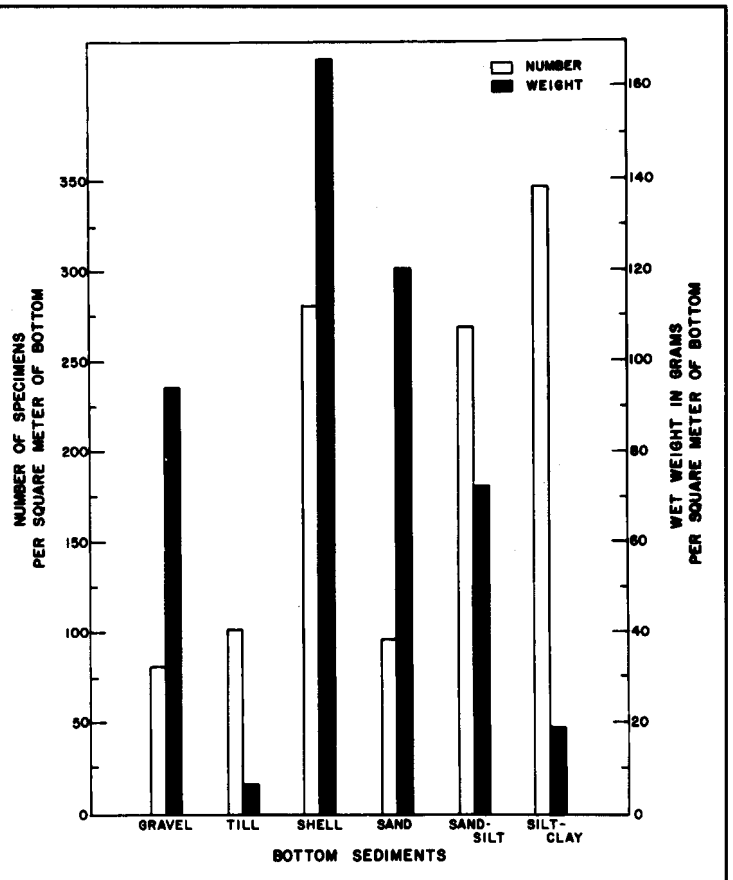


Figure 102
Density and biomass of Mollusca in relation to bottom sediments.

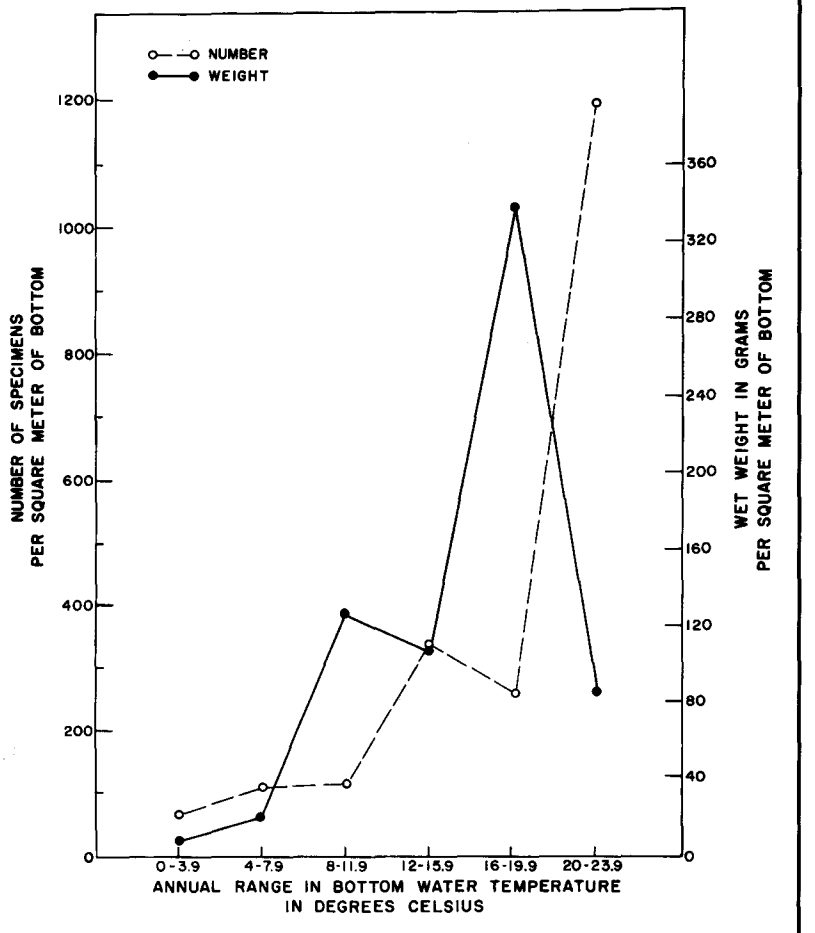


Figure 103
Density and biomass of Mollusca in relation to the annual range of bottom water temperature.

most numerous, namely till, gravel, and sand-silt (Table 20). Their occurrence rate was low (3 to 9% of the samples) in sand and silt-clay.

Relation to Water Temperature

Polyplacophorans were found to inhabit a rather broad span of annual ranges in water temperature, from 0–3.9° to 16–19.9°C, inclusive (Table 21, Fig. 109). They were numerous; average density was 7.3/m^2, where the water temperature range was greatest. Lower densities (0.8 to 1.4/m^2) were found in the middle and low temperature range groupings.

Biomass values in relation to water temperature range rather closely paralleled the trends described above for density (Table 23; Fig. 109). At the greater temperature range, 16° to 19.9°C, the biomass averaged 1.3 g/m^2, whereas in the middle and lower range groupings, the biomass averaged 0.12 g/m^2 or less.

Frequency of occurrence was low in all temperature ranges but was relatively higher (10%) where the fluctuation in temperature was less than 8°C (Table 25). Occurrence rate was relatively moderate (5 to 7%) where the temperature range was moderate. No chitons were taken where the temperature range was greater than 20°C.

Relation to Sediment Organic Carbon

Polyplacophorans were rather restricted in their distribution in relation to the quantity of organic carbon in the sediments, occurring only where the carbon content ranged from 0.01 to 1.99% (Table 26; Fig. 110). Average density was highest (2.5 /m^2) in the lowest carbon content class (0.01–0.49%), lower still (1/m^2) in the 1 to 1.5% content class; and significantly lower in the other two classes they occupied.

Average biomass decreased markedly from its highest point (0.25 g/m^2) in the lowest content class (0.01–

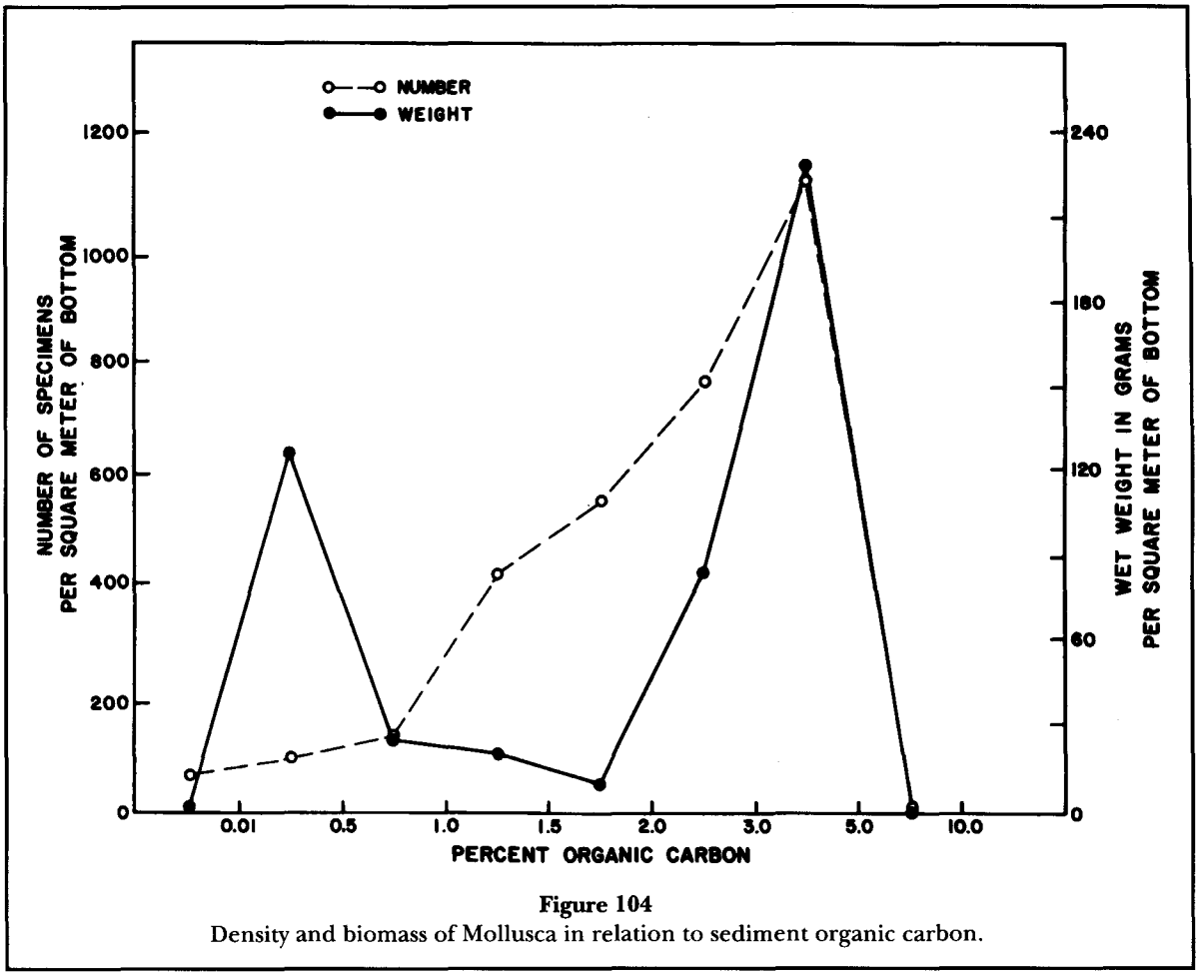


Figure 104
Density and biomass of Mollusca in relation to sediment organic carbon.

0.49%) to very small (<0.01 g/m^2) as carbon content increased to just under 2% (Table 28; Fig. 110).

Frequency of occurrence in samples exhibited a trend similar to that of biomass. Incidence was relatively low (ranging from 2 to 12%) and diminished with increasing carbon content (Table 30).

Gastropoda—Gastropods formed a moderately common component of the New England benthos. They were distributed throughout most of the study area, but because of their generally small size they accounted for only a small proportion (1.2%) of the total benthic biomass (Table 3).

These mollusks varied enormously in size, from the tiny *Retusa* and *Alvania* (approximately 2 mm in length) to large specimens of *Neptunea, Colus, Busycon,* and *Buccinum* (ranging up to 13 cm or more). The majority of specimens were between 2 and 30 mm.

Shelled gastropods were predominant in our collections, although some shell-less groups (Nudibranchia and Aplysiacea) were represented. Nudibranchs were abundant in a few localized shallow water habitats but were generally uncommon to rare in the offshore regions.

Specimens in our samples were usually drab colored, with various shades or combinations of white, gray, and brown predominating. The shell-less groups contained some of the more brightly colored forms. In these groups light yellow, pink, orange, and rusty-red hues were common on the dorsal body surface and in the cerata and tentacles.

Gastropods of different taxonomic groups obtain their nourishment by a variety of methods. Feeding types known to be represented in our collections were herbivores, predacious and nonpredaceous carnivores, and parasites. Carnivores and scavengers that feed heavily on bivalve mollusks were the largest and most common forms encountered. Parasitic species were rare.

Gastropods occurred in 470 samples (44%). Their density averaged 8/m^2; biomass averaged 2.2 g/m^2 (Table 5).

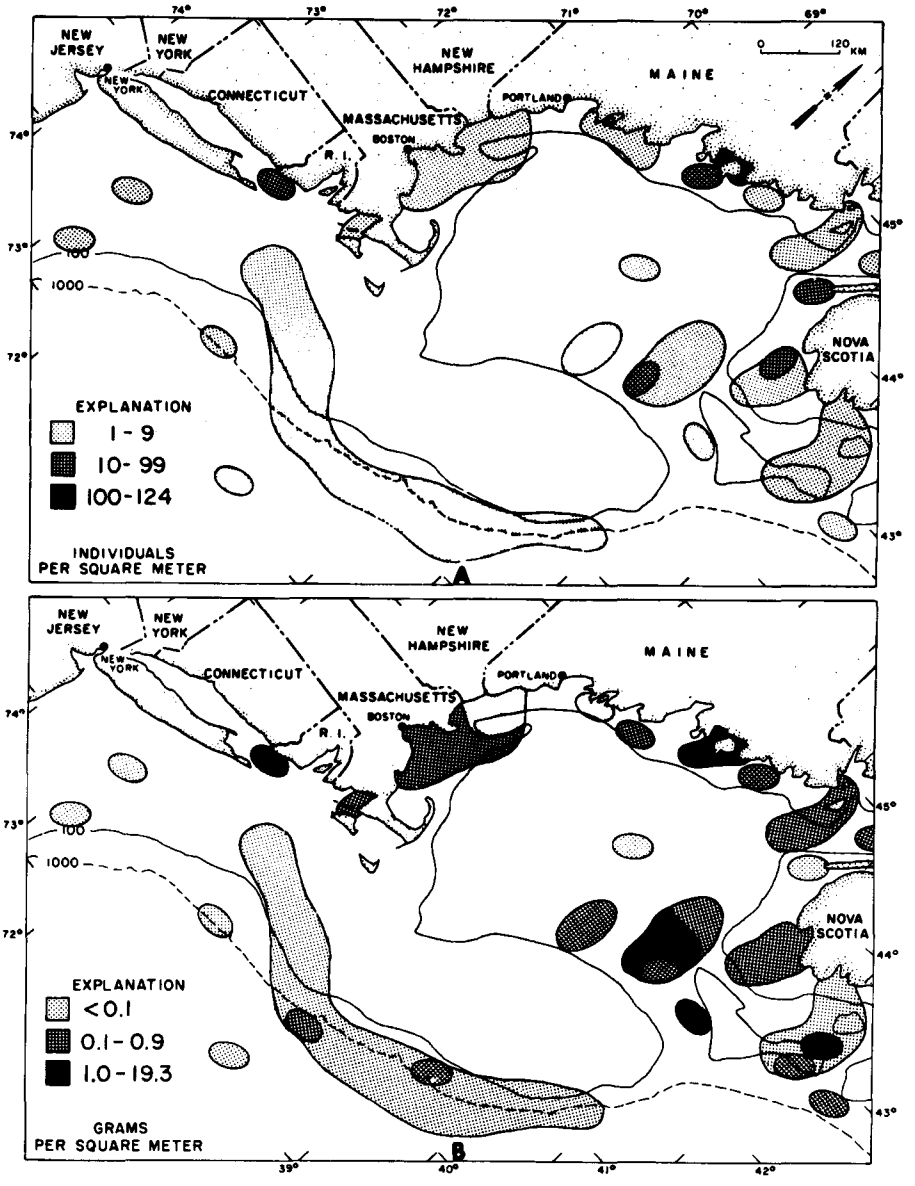


Figure 105

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

Geographic Distribution

Gastropods were distributed over nearly the entire region (Fig. 111). Moderately low densities (1 to 49 individuals/m^2) were widespread over a large part of the study area. Medium and high densities generally occurred in limited areas inshore and nearshore.

In most areas where gastropods were found, their average biomass was less than 1 g/m^2. Moderately high biomasses (1 to 25 g/m^2) occurred over rather large areas both inshore and offshore, whereas large biomasses (25 to 133 g/m^2) occurred in only four localities.

Gastropods were present in all six of the standard geographic areas (Tables 6, 8; Fig. 112). Quantities, in terms of both number of individuals and biomass, were highest in the four continental shelf areas and lowest in the Georges Slope and Southern New England Slope areas. Average density in the shelf areas ranged from 11 to 29 individuals/m^2 and average biomass from 0.9 to 4.3 g/m^2. In the slope areas the average density was 7 to 8 individuals/m^2 and average biomass was less than 0.3 g/m^2. Gastropods made up a slightly higher proportion of the total faunal density in the slope areas than they did in the continental shelf areas.

Frequency of occurrence of gastropods was moderately high in all geographic areas. They were present in 35 to 58% of the samples (Table 10). The high frequency of occurrence in the Georges Slope and Southern New England Slope areas, in comparison to the low density and small average biomass in these areas, is indicative of small-size specimens and of rather widespread and uniform distribution.

Bathymetric Distribution

Gastropods occurred at water depths ranging from 3 to 3,310 m. They were far more abundant (64/m^2) in shallow water (0 to 24 m) than at other depths. Their average density (Table 11; Fig. 113) generally diminished with increasing water depth, except for a slight reversal of this trend on the upper and middle sections of the continental slope. Density was roughly uniform (11 to 24 individuals/m^2) between 25 and 1,000 m. In the two deepwater classes the densities were considerably lower (4 and 1/m^2).

Average biomass also was largest in shallow water and smallest in deep water (Table 13; Fig. 113). The average biomass in all depth classes on the continental shelf was moderate (1.1 to 4.8 g/m^2), whereas at all depths greater than 200 m the average biomass was small (0.15 to 0.29 g/m^2).

Frequency of occurrence of gastropods was moderately high (37 to 52%) on the continental shelf and upper slope (Table 15). At mid- and lower-slope depths occurrence was high (74 to 77%). On the continental rise their rate of occurrence diminished to only 30%.

Relation to Sediments

Although there was no consistent trend in density of gastropods in relation to sediment particle size, there were several correlative points of interest (Table 16; Fig. 114). Gastropods occurred in particularly high densities in shelly sediments, where their average concentration was 83 individuals/m^2. Presumably these gastropods were predators on the bivalves whose shells formed the substrate. Densities were also high (40/m^2) on gravel bottoms. In all other sediment types they occurred in only moderate densities (9 to 22 individuals/m^2). The unexpectedly low density of 9/m^2 in till substrates indicates that till is more closely allied to silt-clay as a gastropod habitat than it is to gravel. Just the reverse is true for other molluscan groups.

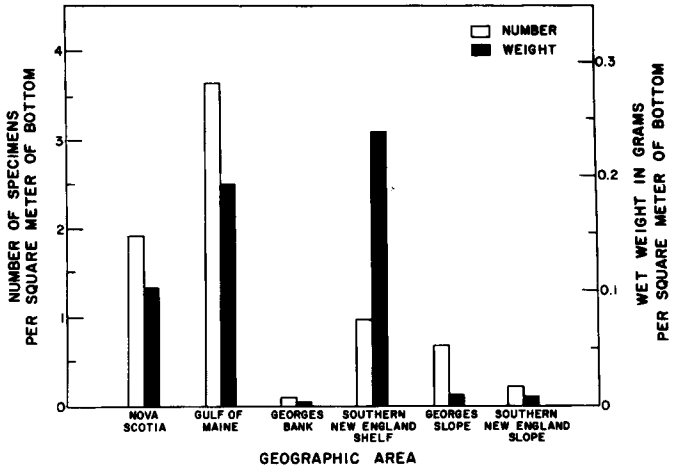


Figure 106
Density and biomass of Polyplacophora in each of the six geographic areas.

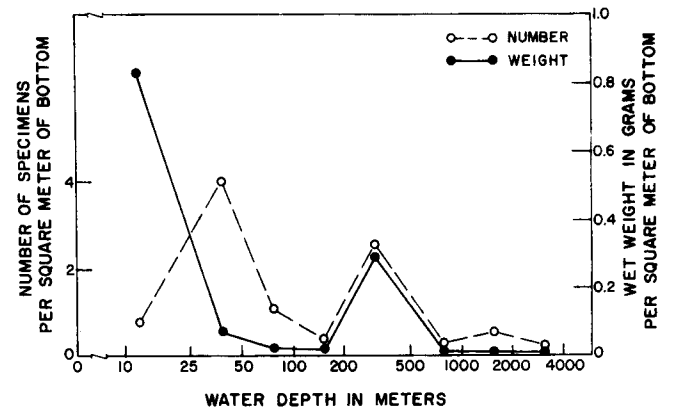


Figure 107
Density and biomass of Polyplacophora in relation to water depth.

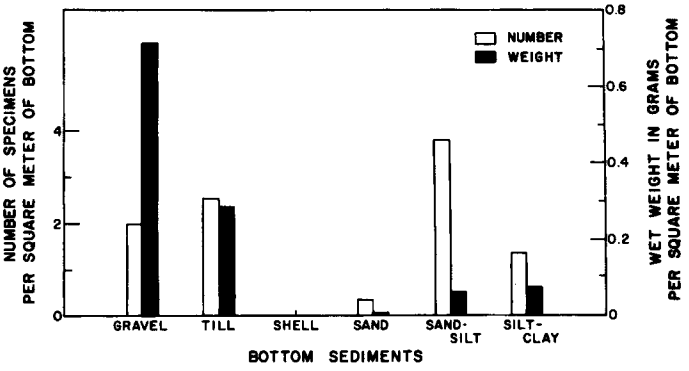


Figure 108
Density and biomass of Polyplacophora in relation to bottom sediments.

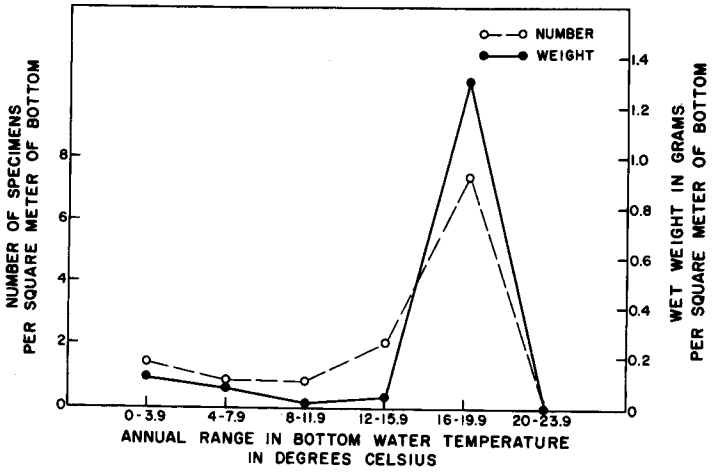


Figure 109
Density and biomass of Polyplacophora in relation to the annual range of bottom water temperature.

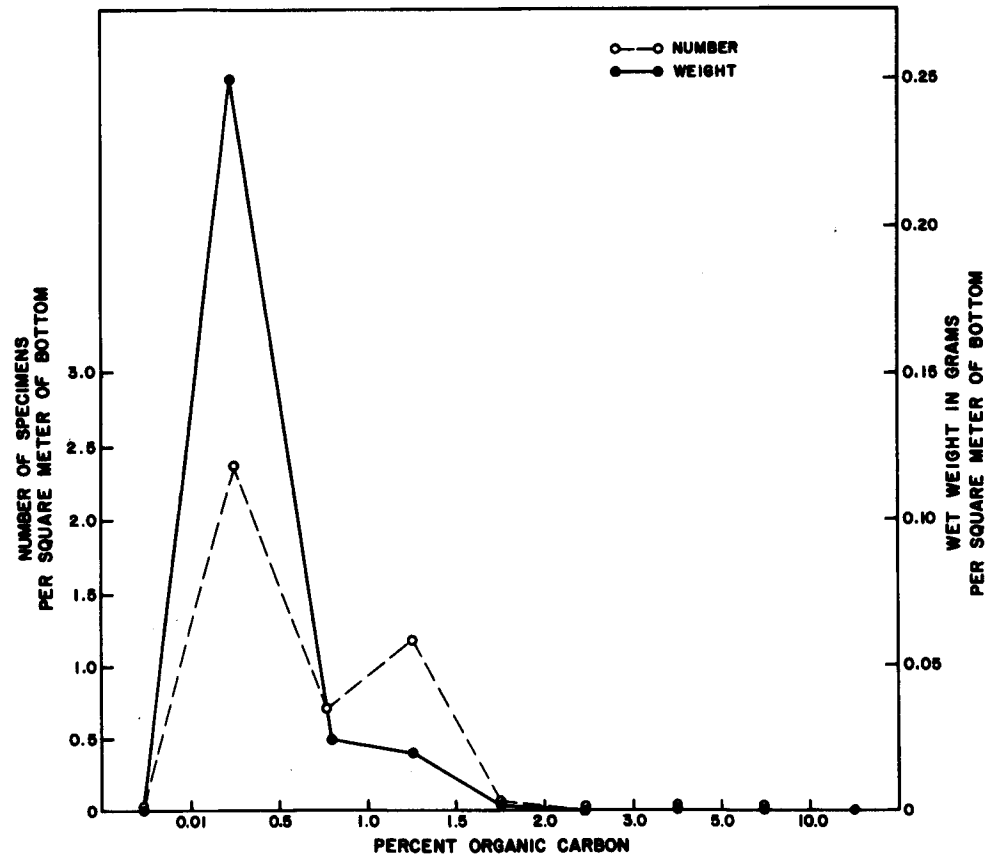


Figure 110
Density and biomass of Polyplacophora in relation to sediment organic carbon.

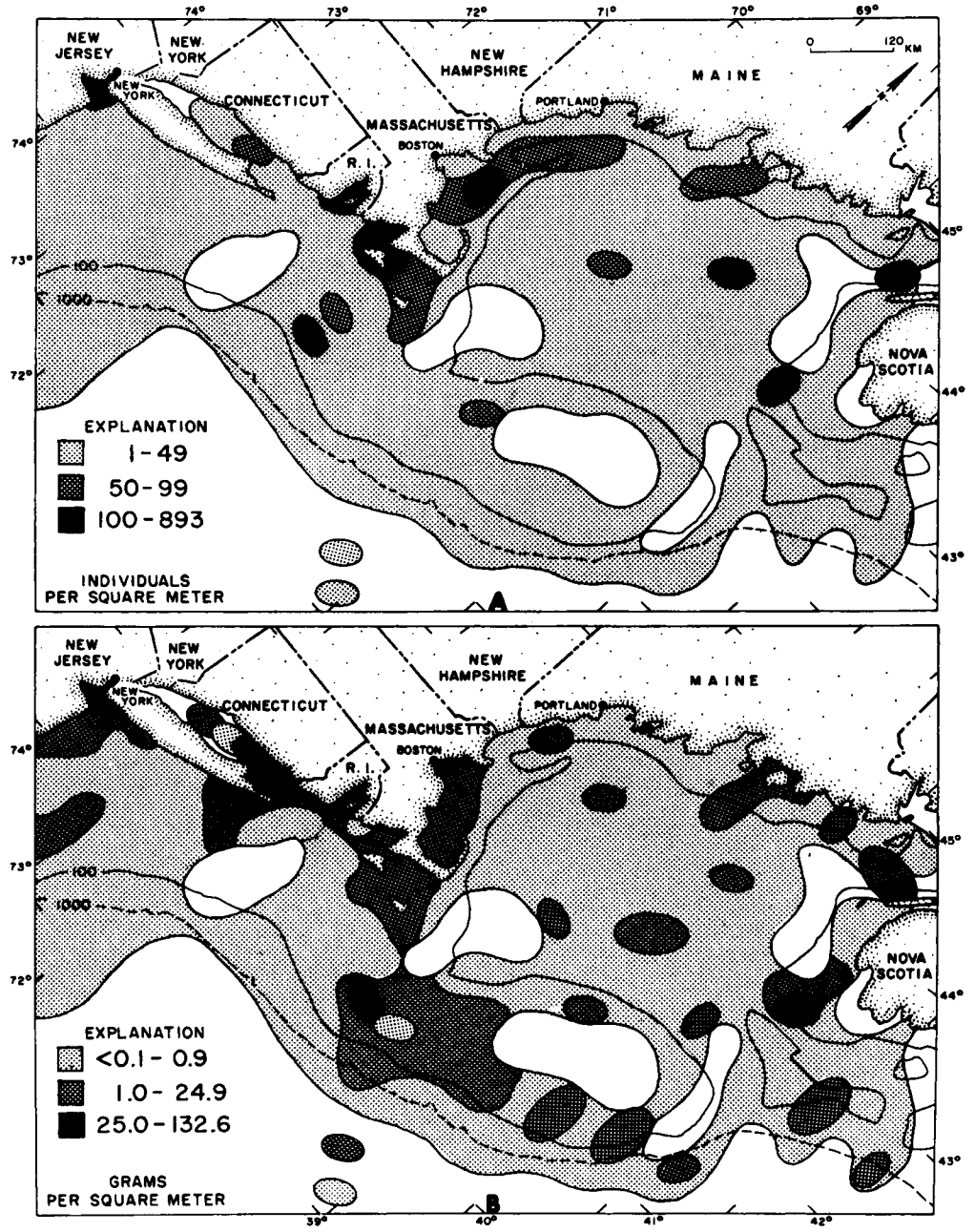


Figure 111

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

In terms of biomass, the gastropods were most prevalent (3.3 g/m^2) in sand and gravel substates (Table 18; Fig. 114). They occurred in intermediate quantities (2.1 and 1.6 g/m^2) in shell and sand-silt. Low quantities (0.2 g/m^2) were found in till and silt-clay sediments.

Frequency of occurrence was high (83%) only in samples from shelly sediments (Table 20). In all other bottom types the occurrence of gastropods was quite uniform at a moderate (42 to 50%) level.

Relation to Water Temperature

The greatest quantities of gastropods, in terms of both density and biomass, occurred where the annual range in temperature exceeded 16°C (Tables 21, 23; Fig. 115).

Both measures indicated a trend of increasing abundance with increased range in temperature. Quantitative values for density were proportionally higher than those for biomass, but the percentage composition of the total fauna for both measures was moderately low (Tables 22, 24). With the exception of the two broadest temperature range classes (16°–19.9° and 20°–23.9°C), where relatively high densities (85 and 47 individuals/m^2, respectively) occurred, gastropod density was fairly uniform at a moderate level of about 10 to 15 individuals/m^2.

Gastropod biomass values generally paralleled those of density, but the trend of increased biomass with increased temperature range was more pronounced. The two largest biomasses (4.96 and 4.09 g/m^2) occurred in the two broadest temperature range classes. In all other temperature range classes the biomass was moderate (0.26 to 3.75 g/m^2) and fairly stable.

Frequency of occurrence of these organisms was moderately high and stable in all temperature range classes (Table 25). They varied only from 38 to 57%, with no obvious trends.

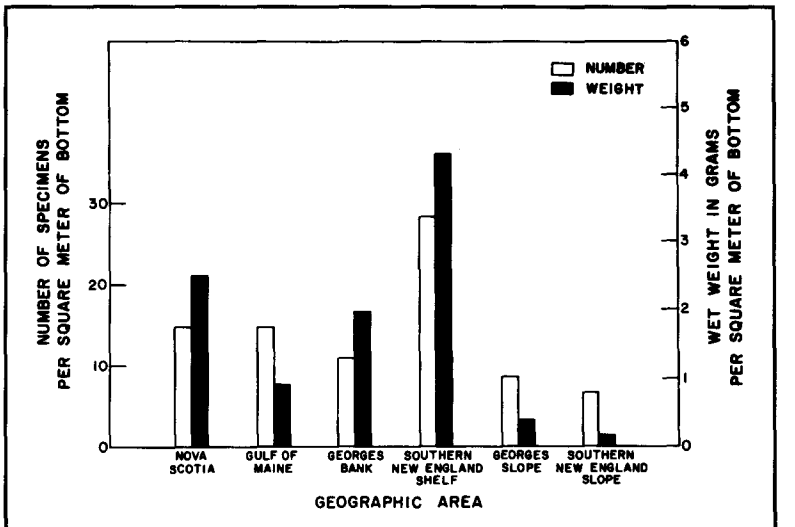


Figure 112
Density and biomass of Gastropoda in each of the six geographic areas.

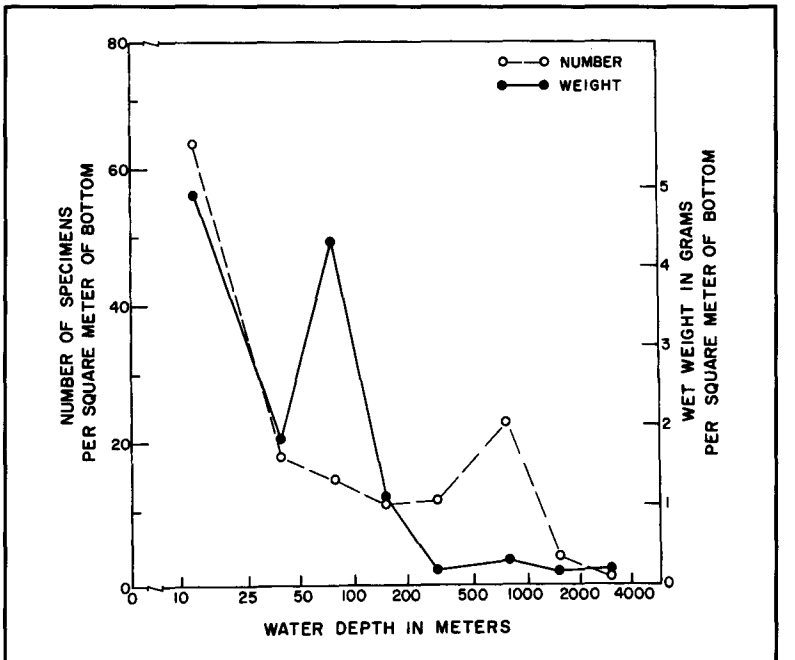


Figure 113
Density and biomass of Gastropoda in relation to water depth.

Relation to Sediment Organic Carbon

Gastropods displayed a generally bimodal trend of increasing numerical abundance and biomass with increasing (to moderate levels) organic carbon content in the sediments (Tables 26, 28; Fig. 116). Average density ranged from a low of 2 individuals/m^2 in areas with no measurable organic carbon to a high of 45/m^2 in 1.5 to 1.9% organic carbon. The first peak (20/m^2) occurred in levels of 0.01 to 0.49% and the second in the 1.5 to 1.9% class. No gastropods were found where carbon content was greater than 3%.

Biomass values ranged from a low of 0.02/m^2 in the absence of organic carbon to a high of 10.42 g/m^2 in the 2.00–2.99% content class. The first peak in moderate biomass (3.8 g/m^2) occurred at levels of 0.01–0.49%. Biomass decreased significantly between 0.50 to 1.99% levels and rose dramatically to highest recorded biomass in the highest levels in which they were found.

Frequency of occurrence ranged from 20 to 61% of the samples (Table 30). Lowest occurrence occurred at both extremes of carbon content, whereas fairly uniform occurrence occurred in the other content classes.

Bivalvia—Bivalvia were inordinately dominant in terms of wet weight, contributing 44.1% of the total biomass of the New England marine benthic fauna. In terms of number of individuals they provided 10.8% of the total (Table 3). Weight determinations included shells (see "Material and Methods"), but even if shells were excluded from weight measurements, the Bivalvia would still rank first in biomass. In number of individuals they rank third, after Amphipoda and Annelida.

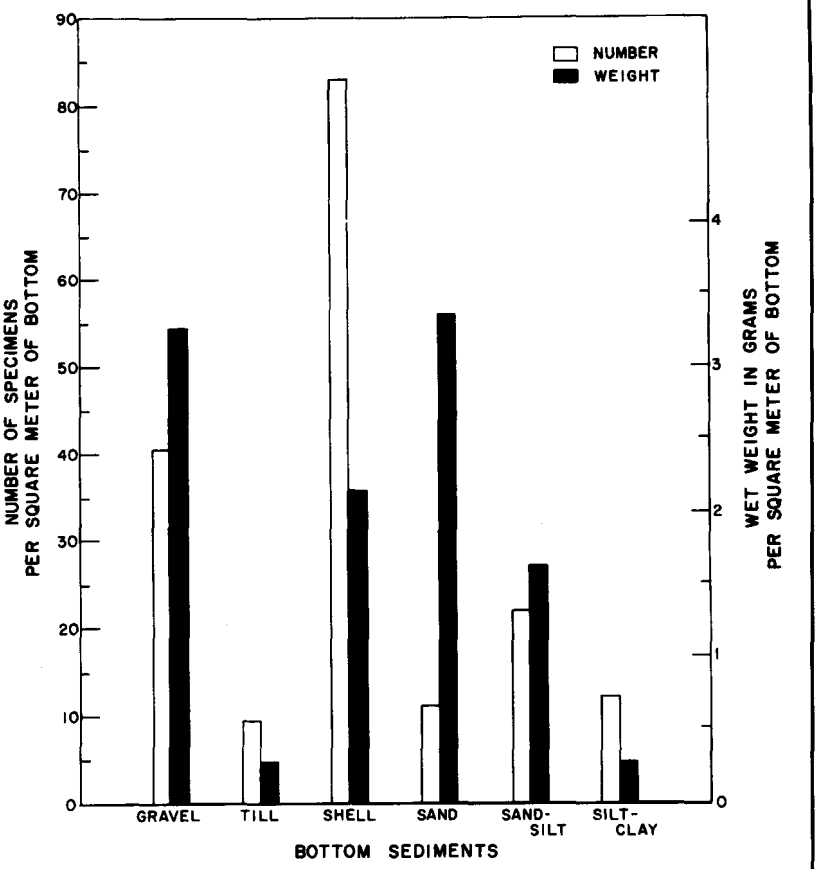


Figure 114
Density and biomass of Gastropoda in relation to bottom sediments.

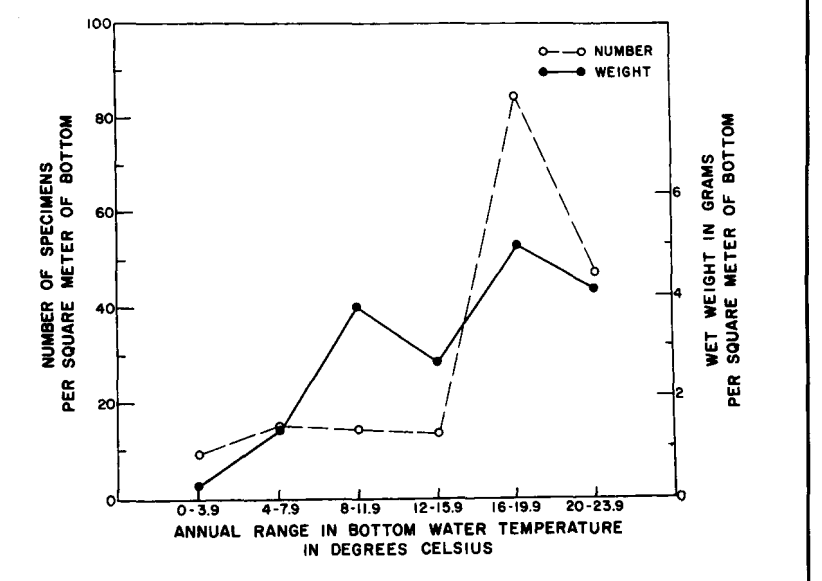


Figure 115
Density and biomass of Gastropoda in relation to the annual range of bottom water temperature.

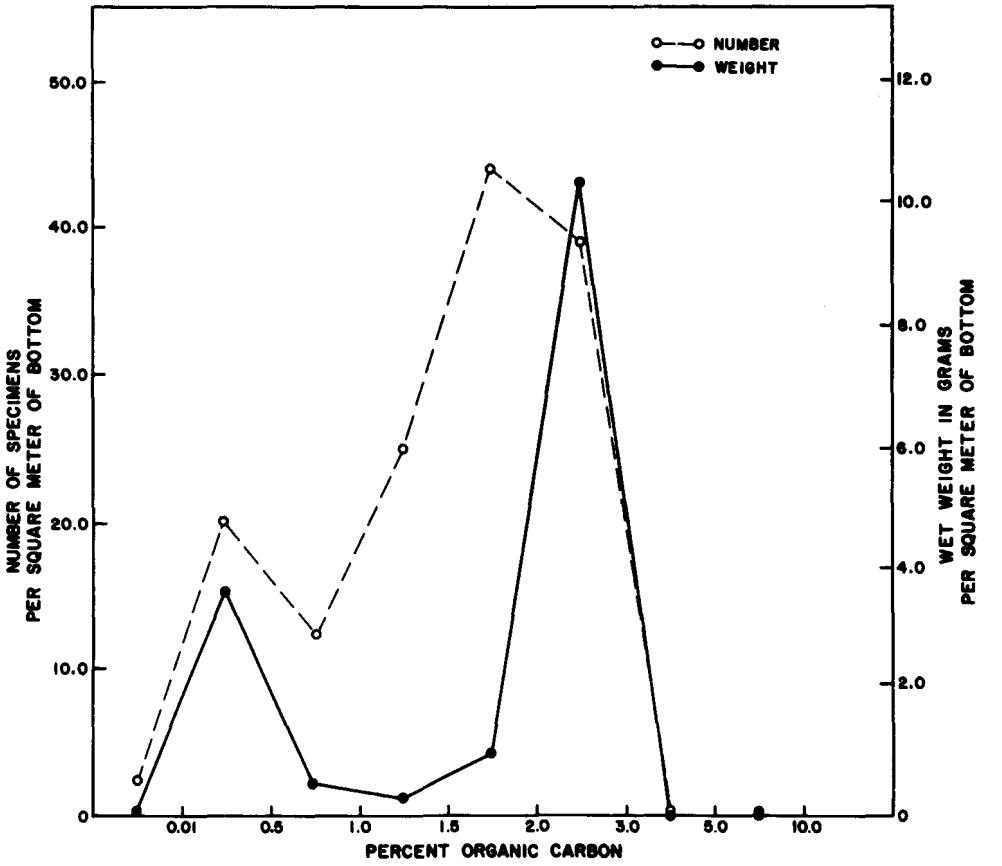


Figure 116
Density and biomass of Gastropoda in relation to sediment organic carbon.

Bivalvia were distributed throughout the entire area sampled in all water depths, sediment types, and temperature range classes. They were especially plentiful on the continental shelf where their average density commonly ranged from about 50 to 500/m^2. Biomass of bivalves averaged 100g/m^2 or more over a large portion of the continental shelf.

A rather wide variety of bivalve species occurs in this region, and it is estimated that more than 125 species were present in the samples (Theroux and Wigley, 1983). Some of the more common families represented were Astartidae, Veneridae, Mytilidae, and Nuculanidae.

Size of specimens ranged from roughly 15 cm for *Modiolus modiolus* and *Placopecten magellanicus* to about 3 mm for *Gemma gemma, Thyasira gouldi,* and other small forms. Large specimens occurred only in shallow and moderately shallow water, and in medium to coarse sediments, whereas small specimens were taken at all depths but mostly in fine-grained sediments.

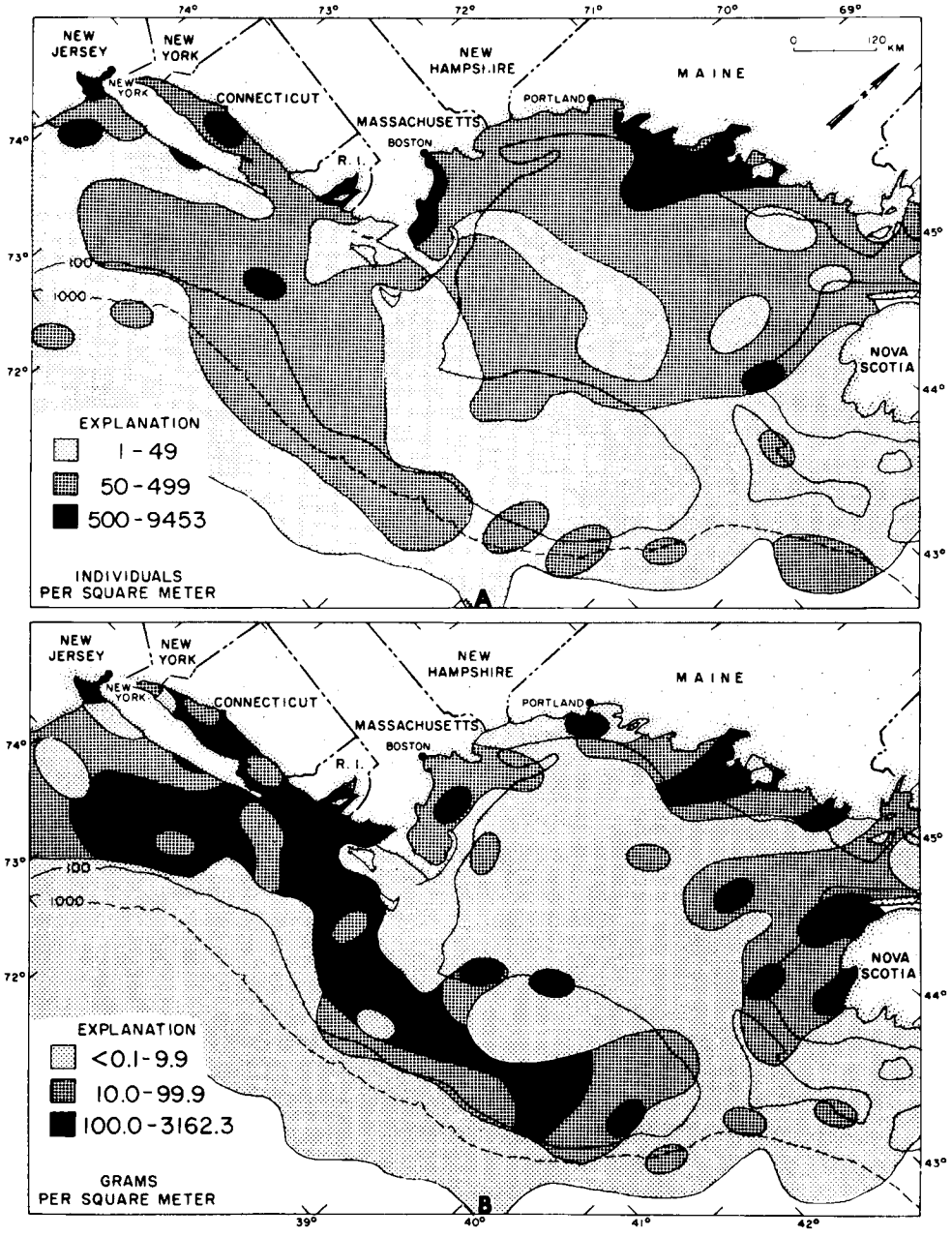
The color of bivalves in these collections ranged from white to blackish-brown. The most common colors were white, light gray, and various shades of brown or olive. No bright or vividly colored species were represented. Some of the more colorful forms were *Tellina, Thyasira ovata,* and some specimens of *Placopecten magellanicus.*

In addition to the importance of oysters, soft-shell clams, quahogs, surf clams, and scallops as food for man, the bivalves as a group are a major source of nourishment for many marine animals. Mammals, birds, fishes, and invertebrates all have members that prey heavily upon bivalves.

Bivalves occurred in 893 samples (83% of total). Their density averaged 163/m^2 and biomass averaged 81 g/m^2 (Table 5).

Geographic Distribution

Bivalves were distributed over the entire New England region (Fig. 117). Average densities per 20-minute unit area ranged from 1 to nearly 10,000 individuals/m^2. High densities (>500/m^2) were most common in nearshore areas. Moderate densities (50 to 500 individuals/m^2) occurred over extensive areas in the Gulf



BIVALVIA

Figure 117

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

of Maine, on the Southern New England Shelf, and along the continental slope south of Georges Bank and Nova Scotia.

Bivalves ranked above all other benthic animals in terms of weight. Average biomass ranged as high as 3,162 g/m^2 in some 20-minute unit areas. High biomass values of bivalves occurred over broad expanses of both the inshore and offshore sections of the Southern New England continental shelf, in Great South Channel, on the southern half of Georges Bank, and in coastal areas of the Gulf of Maine.

Within the six standard geographic areas bivalves were most numerous (212 to 276 specimens/m^2, respectively) on the Southern New England shelf and in the Gulf of Maine (Table 6; Fig. 118). Densities were moderate in all other areas including Georges Slope and Southern New

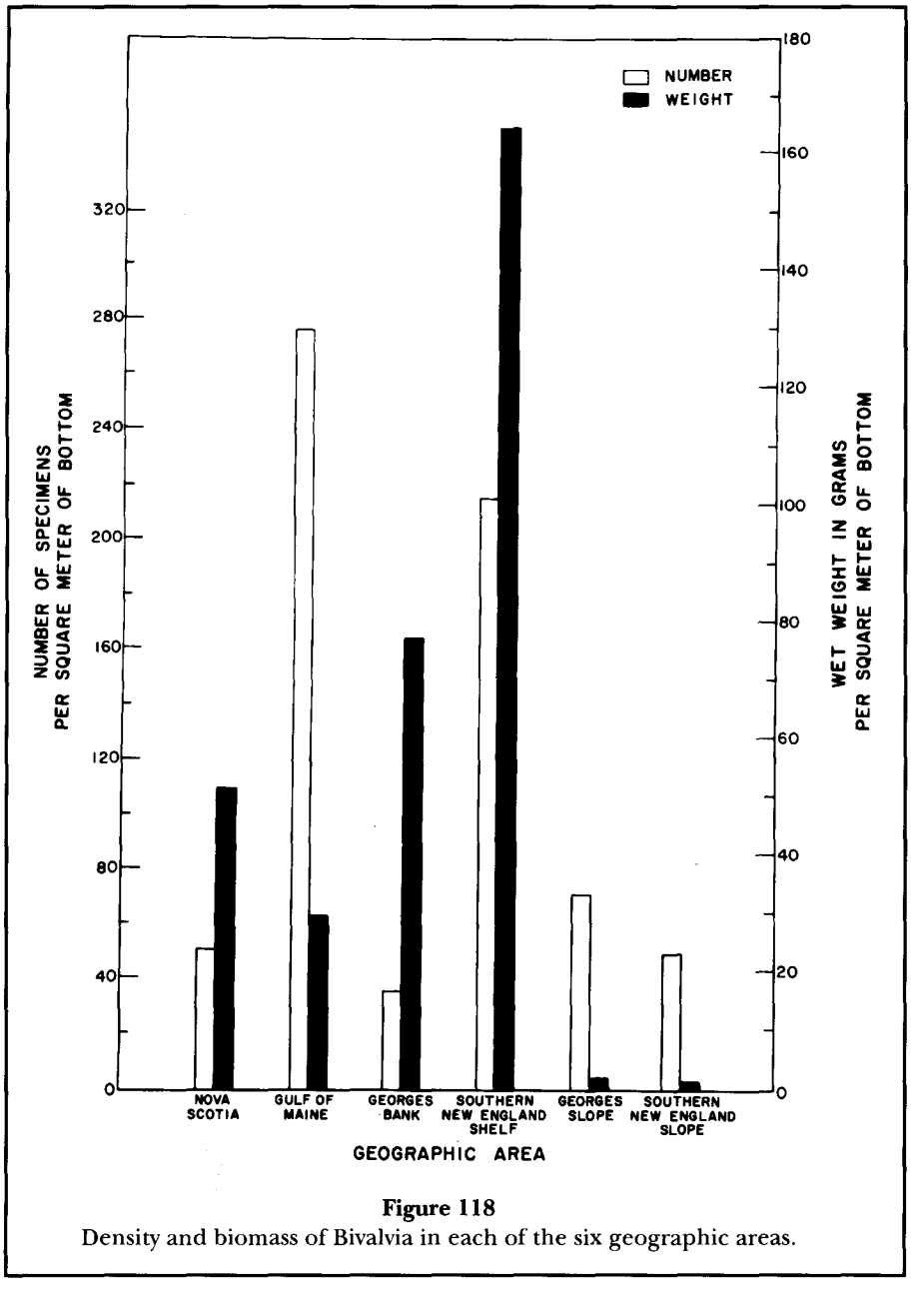


Figure 118
Density and biomass of Bivalvia in each of the six geographic areas.

England Slope. Lowest abundance (34/m^2) was on Georges Bank, but there the average size was greatest.

The biomass of bivalves was exceptionally high (averaged 166 g/m^2) on the Southern New England Shelf (Table 8; Fig. 118). Biomasses were moderate (30 to 77 g/m^2) in Nova Scotia, Gulf of Maine, and on Georges Bank. Average biomass of bivalves was smallest (1 to 2 g/m^2) in the Georges Slope and Southern New England Slope areas.

Frequency of occurrence was high in all areas, especially in the two slope areas where bivalves occurred in 89 and 94% of the samples (Table 10). Georges Bank had the lowest (64%) rate of occurrence. In all other areas the rate of occurrence was 80 to 89%.

Bathymetric Distribution

Bivalves were taken at depths from 3 to 3,820 m. They were common in all depth zones but occurred in greatest density (505 individuals/m^2) in shallow water (0 to 24 m) and diminished markedly with increasing water depth (Table 11; Fig. 119). In the deepest zone samples (2,000 to 3,999 m) their density was only 26/m^2. The decrease in density was quite uniform; the major decrements in the trend were at about 25 m and 200 m.

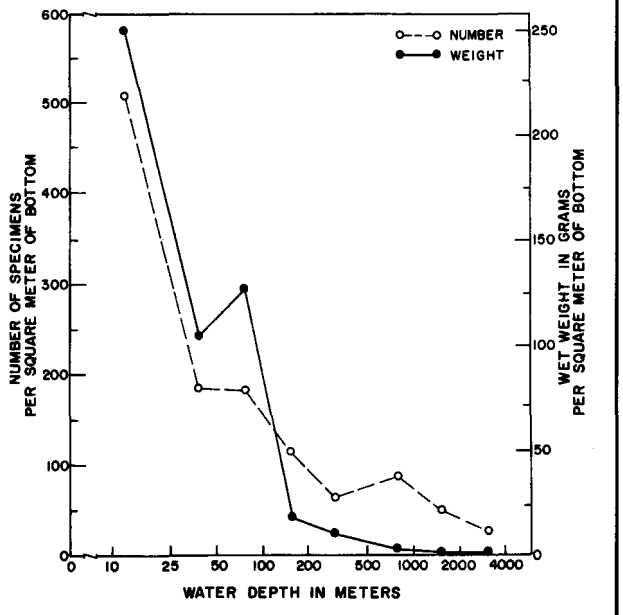


Figure 119
Density and biomass of Bivalvia in relation to water depth.

Biomass of bivalves, as with density, was greatest (252 g/m^2) in shallow water and decreased sharply with increasing water depth (Table 13; Fig. 119). On the continental rise their biomass was only 0.4 g/m^2.

Bivalves were present in a high percentage of the samples from all depth classes. There was, however, a slightly higher rate (81 to 100%) of occurrence in deep water (greater than 500 m) than in shallow water, where the occurrence rate was 75 to 88% (Table 15). Other characteristics of the bivalve fauna in deep water are lower average density, lower maximum density, smaller average biomass, and smaller maximum biomass.

Relation to Sediments

Several clear trends were detected in the correlation between the quantity of bivalves and the type of bottom sediments they inhabited (Table 16; Fig. 120). Density was highest (330/m^2) in sediments composed of silt-clay and decreased as particle size increased, except in shell bottoms where the density of bivalves was moderately high (180/m^2). Gravels contained the lowest density (39/m^2).

An entirely different trend was observed for bivalve biomass (Table 18; Fig. 120). The largest quantities (117 to 165 g/m^2) were found in sediments of medium grain size. Smallest quantities (5 to 18 g/m^2) occurred in till and silt-clay. It should be noted that in four of the six sediment types, the biomass of bivalves accounted for over 42% of the total benthic biomass (Table 19). In shelly sediments they formed the exceptionally large proportion of 74% of the total fauna.

Bivalves were present in a high proportion of the samples in all sediment types. They occurred in all samples from shelly bottoms and in a particularly high percentage (91 to 92%) of the samples from fine-grained sediments (Table 20). Only a moderately high proportion of the samples from sand and gravel contained live specimens of bivalves.

Relation to Water Temperature

Bivalves occurred in significant quantities in all of the temperature range classes (Tables 21, 23; Fig. 121). Although the density and biomass exhibited a general tendency of increasing as the temperature range broadened, two major anomalies in this trend were observed in the two highest range intervals. The 16°–19.9°C class had a large biomass (334 g/m^2) and a moderate (252 individuals/m^2) density, indicating the presence of larger individuals than in other areas. Conversely, the 20°–23.9°C class had a high density (1,195 individuals/m^2) but a small biomass (84 g/m^2).

Bivalve biomass was unusually large (106 to 334 g/m^2) where the temperature range was moderate (8°–19.9°C) and was comparatively smaller in the low and high ranges (6.8 and 84 g/m^2, respectively).

Frequency of occurrence of bivalves was high and rather uniform (75 to 93%) among all temperature range classes (Table 25).

Relation to Sediment Organic Carbon

Bivalves were found in significant quantities in all organic carbon content classes except the highest (5.00+%). There was a well-defined positive correlation of increasing density with increasing organic carbon content (Table 26; Fig. 123). Density of bivalves rose from moderate levels (64/m^2) in the absence of organic carbon to high levels (1,120/m^2) where organic carbon content was between 3 and 5%. Bivalvia is the only taxonomic group showing such a well-defined trend in relation to sediment organic carbon. This trend corresponds to that shown for depth distribution, wherein higher bivalve densities occurred in the shallower estuarine and embayment waters that contained the highest levels of organic carbon.

Although the highest biomasses of bivalves (227 to 801/m^2) were found in the higher carbon content classes (3.00–4.99% and 2.00–2.99%, respectively) the relationship was not as well-defined as that for density (Table 28; Fig. 122). Moderately high biomass (128/m^2) also occurred in low carbon levels (0.01–0.49%). The other carbon content classes contained significantly lower biomasses.

Frequency of occurrence of bivalves in samples in the various organic carbon content classes was quite high

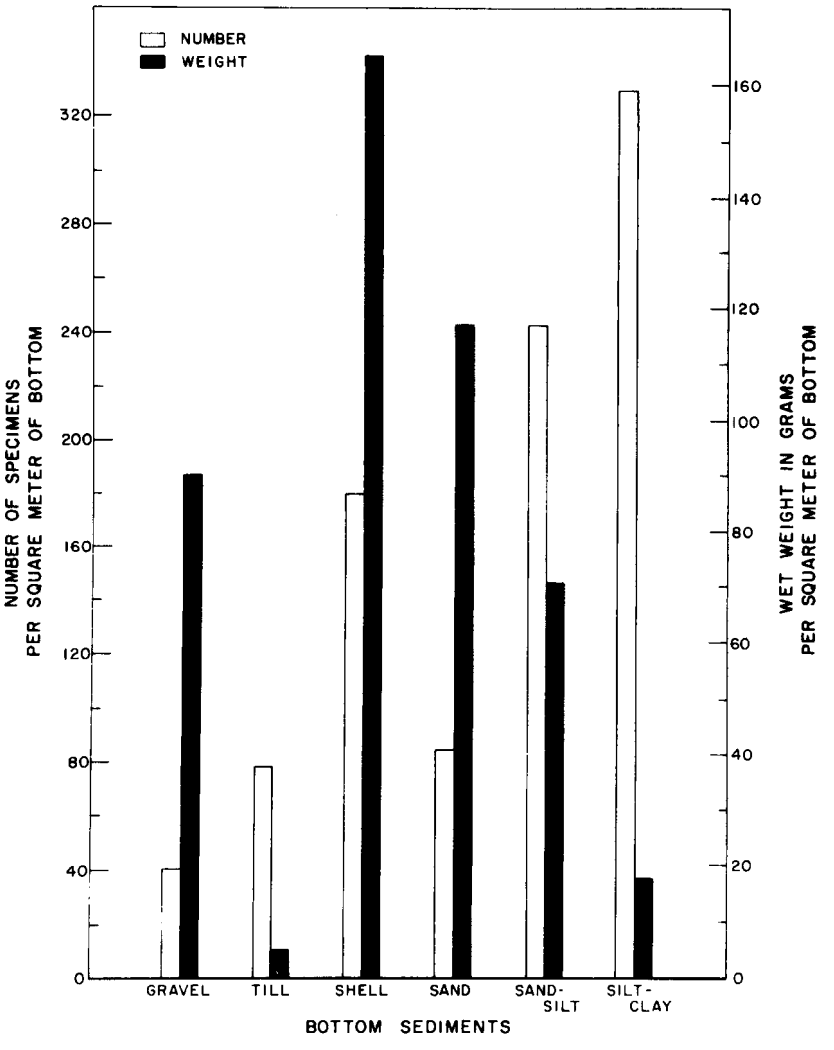


Figure 120
Density and biomass of Bivalvia in relation to bottom sediments.

and relatively uniform, ranging from 80 to 100% between the 0.00 and the 2.00–2.99% classes; the lowest occurrence (75%) was in the 3.00–4.99% class (Table 30).

Scaphopoda—Scaphopods constituted a minor component of the New England benthic fauna. They accounted for 0.2% of the number of animals and 0.3% of biomass in the total benthic fauna (Table 3). These samples included the first representative of the genus *Cadulus* known to occur in the Gulf of Maine (Wigley, 1966b). This same report postulated that the relatively warm high-salinity bottom water in the larger Gulf of Maine basins permitted scaphopods from the continental slope to inhabit deeper sections of the Gulf.

They are burrowing forms that most commonly inhabit medium to fine-grained sediments. The head and relatively large foot project from the anterior (larger) aperture of the shell. When buried in the sediment the anterior end of the shell faces downward and the posterior end is pointed upward. Scaphopods have planktonic eggs and free-swimming trochophoric larvae.

This group of mollusks is taxonomically small. Less than a score of species and one-half dozen genera are known from the New England region. Sizes of specimens in our samples ranged from about 1 to 6 cm in length.

Color of the shells was generally various shades of white, either uniformly white, or white with partial discolorations of yellow or brown, or occasionally black.

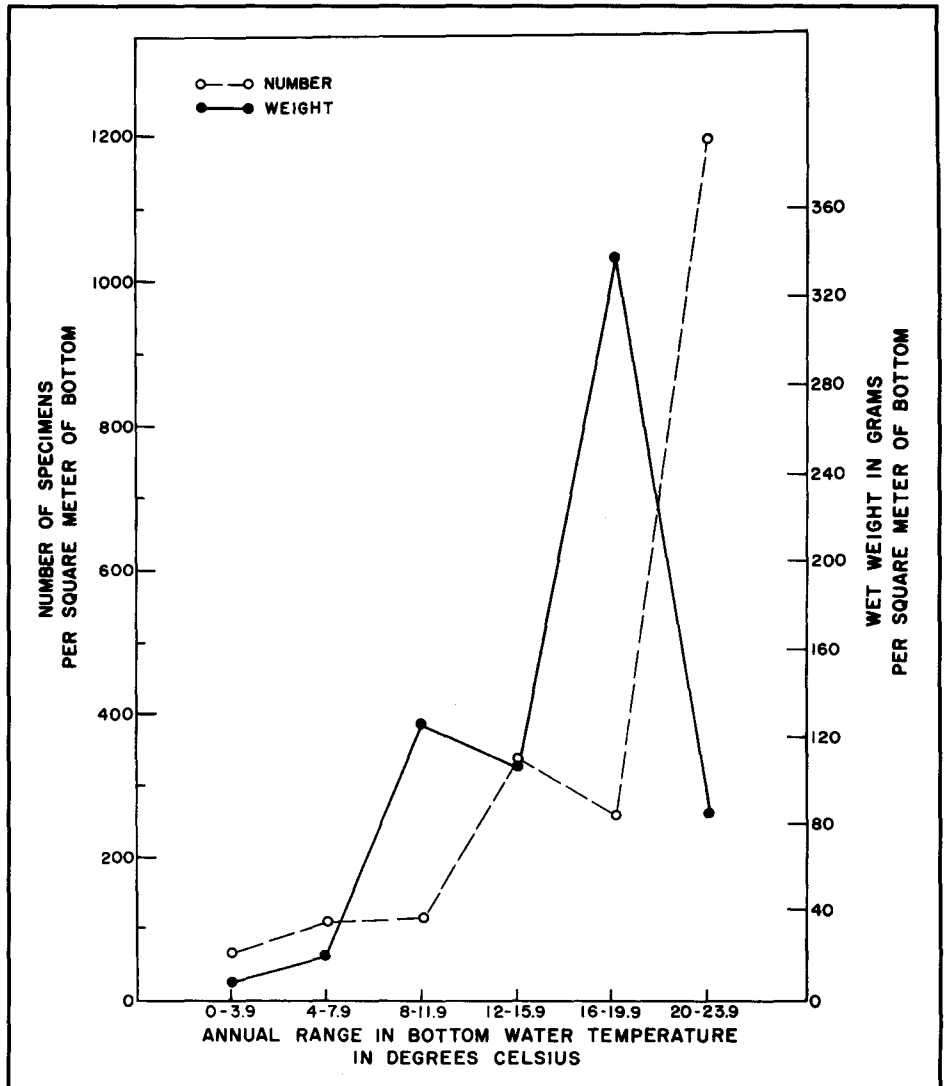


Figure 121
Density and biomass of Bivalvia in relation to the annual range of bottom water temperature.

Scaphopoda occurred in 218 samples (20% of total). Their density averaged 5.1/m^2 and biomass averaged 0.32 g/m^2 (Table 5).

Geographic Distribution

Scaphopods were present in moderately low densities (1 to 49 individuals/m^2) in large portions of the Nova Scotia and Gulf of Maine regions (Fig. 123). Farther south, with few exceptions, they were present only along the continental slope and the outer portion of the continental shelf. One area of relatively high density (50 to 106 individuals/m^2) was encountered in the north central part of the Gulf of Maine. The average biomass of scaphopods was moderately small in all areas, averaging less than 1 g/m^2 in more than 50% of their area of occurrence. Relatively large average biomasses (1 to 6 g/m^2) were common only in the northern part of the study area.

Within the six standard geographic areas scaphopods were most abundant (10 to 11 individuals/m^2) in the Nova Scotia and Gulf of Maine area (Table 6; Fig. 124). On Georges Slope and the Southern New England Slope their density was about 5/m^2. Lowest densities, approximately 1/m^2, were found on Georges Bank and the Southern New England Shelf.

The biomass of scaphopods was largest (0.7 to 1.0 g/m^2) in the northern areas, smallest (0.02 to 0.08 g/m^2) in the southern areas, and intermediate in intervening areas (Table 8; Fig. 124).

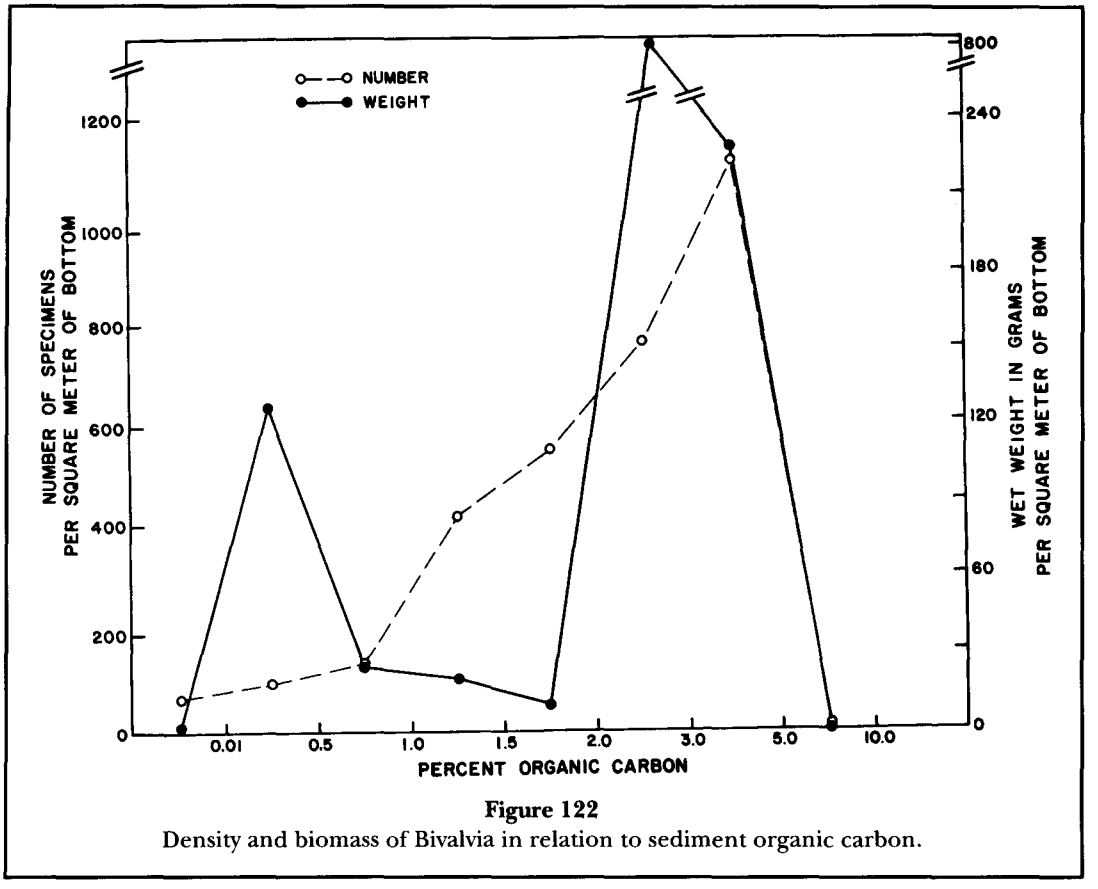


Figure 122
Density and biomass of Bivalvia in relation to sediment organic carbon.

A comparison of average density and average biomass in the various areas indicates that scaphopods are relatively large in Nova Scotia and on Georges Bank, and relatively small in the Southern New England Slope area.

Frequency of occurrence was low (4 to 7% of the samples) on Georges Bank and the Southern New England Shelf, and moderate (33 to 46% of the samples) in all other areas (Table 10).

Bathymetric Distribution

Scaphopods were taken at depths ranging from 19 to 2,329 m. They occurred in low density (0.1 and 0.2 individual/m^2) in both shallow water and deep water but were present in relatively high densities (10 to 14 individuals/m^2) in moderately deep water, 100 to 1,000 m (Table 11; Fig. 125). Increases and decreases in density about their center of abundance were surprisingly consistent and well correlated with changes in depth.

The biomass of scaphopods (Table 13; Fig. 125) was small (<1 g/m^2) in all depth classes, but changes in abundance relative to changes in water depth were similar to that described above for numerical density. Average biomasses in the shallowest and deepest bathymetric classes were <0.01 g/m^2. The average biomass was largest (0.17 to 0.98 g/m^2) in moderately deep water (100 to 2,000 m). Because of the small size and low density of this taxonomic group, it contributed a rather small share (1.6% or less) of the total benthic biomass in any depth class (Table 14).

Scaphopods occurred in a moderate share (35 to 59%) of the samples collected from depths between 100 and 2,000 m (Table 15). At depths both shallower and deeper, they occurred in less than 10% of the samples and in the two shallowest depth classes, they were present in only 1% of the samples.

Relation to Sediments

Scaphopods were present in all types of bottom sediments sampled, but were clearly more abundant (11 to 26 individuals/m^2) in the shelly and fine-grained sediments than in the coarse types (Table 16; Fig. 126). Sand and gravel bottoms yielded the lowest (1.8 and 2.0/m^2) densities. The percentage of the total faunal density composed of scaphopods was small (2.2% or less) in all types (Table 17).

Differences in biomass from one type of bottom to another were less pronounced than they were for density; however, the trend was the same (Table 18; Fig.

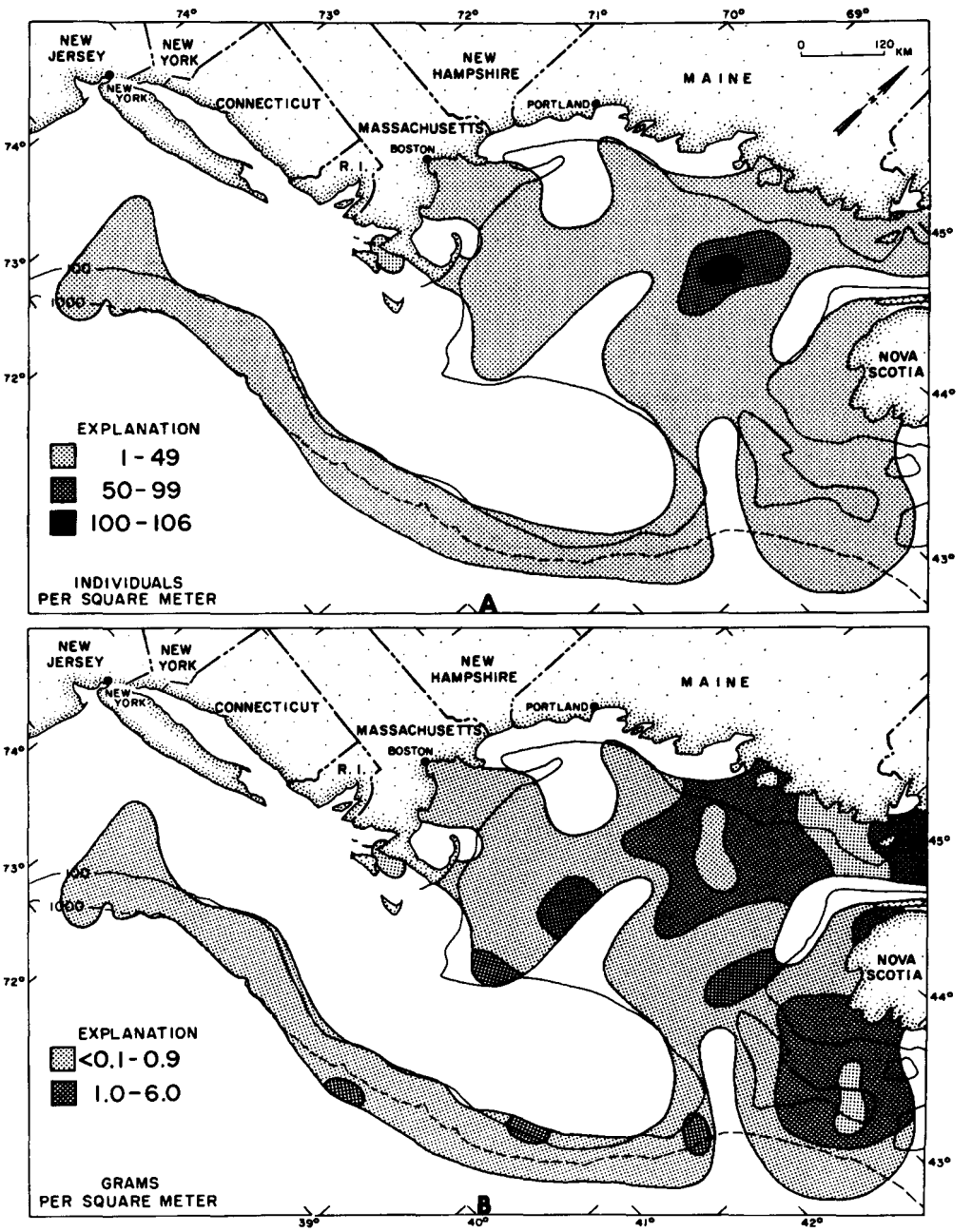


Figure 123
Geographic distribution of Scaphopoda: A—number of specimens per square meter of bottom; B—biomass in grams per square meter of bottom.

126). Relatively large biomasses were found in shell, till, and silt-clay sediments and small biomasses occurred in sand, sand-silt, and gravel. Scaphopods made up only a small portion (1.2% or less) of the total biomass in all bottom types (Table 19).

Frequency of occurrence of scaphopods was especially low (10 to 17%) in sand and gravel (Table 20). In shell, till, and other finer sediments they occurred in a moderate (30 to 46%) proportion of the samples.

Relation to Water Temperature

Scaphopods were most often found in the more stable environments where the temperature variations were small. Density and biomass of these organisms were

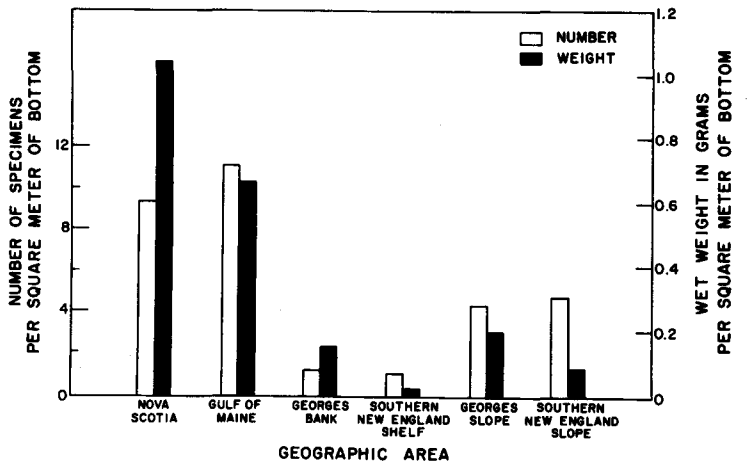


Figure 124
Density and biomass of Scaphopoda in each of the six geographic areas.

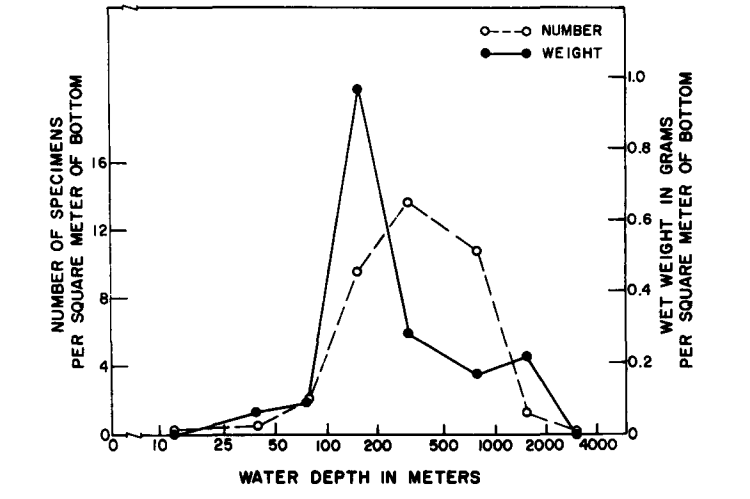


Figure 125
Density and biomass of Scaphopoda in relation to water depth.

greatest in the 4°–7.9°C range class and diminished steadily as temperature range broadened (Tables 21, 23; Fig. 127). None were found in the 20°–23.9°C class. Quantitative values for density ranged from 0.2 to 10.3 individuals/m^2 and for biomass from <0.01 to 0.92 g/m^2. In terms of both density and biomass they provided generally less than 2% of the total fauna (Tables 22, 24).

Scaphopods occurred in 2 to 37% of the samples in the temperature range classes in which they were found (Table 25). Frequency of occurrence was highest where the temperature range was small, and the frequency rate decreased as the temperature range expanded.

Relation to Sediment Organic Carbon

Scaphopods occurred where organic carbon content ranged from 0 to 2.99%. They were most abundant (12 to 13 individuals/m^2) in the two moderate carbon content classes 1.50–1.99 and 1.00–1.49%, respectively, and

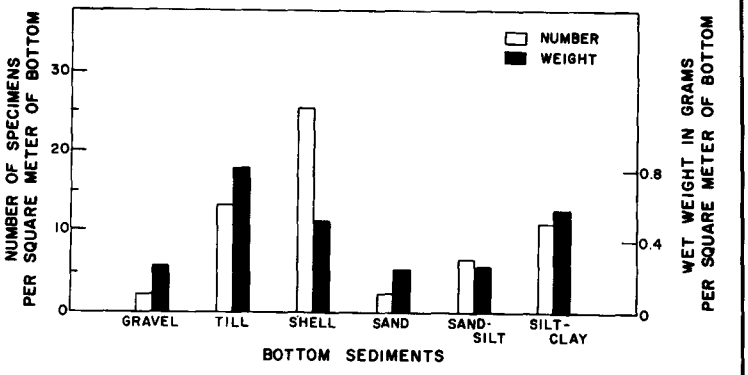


Figure 126
Density and biomass of Scaphopoda in relation to bottom sediments.

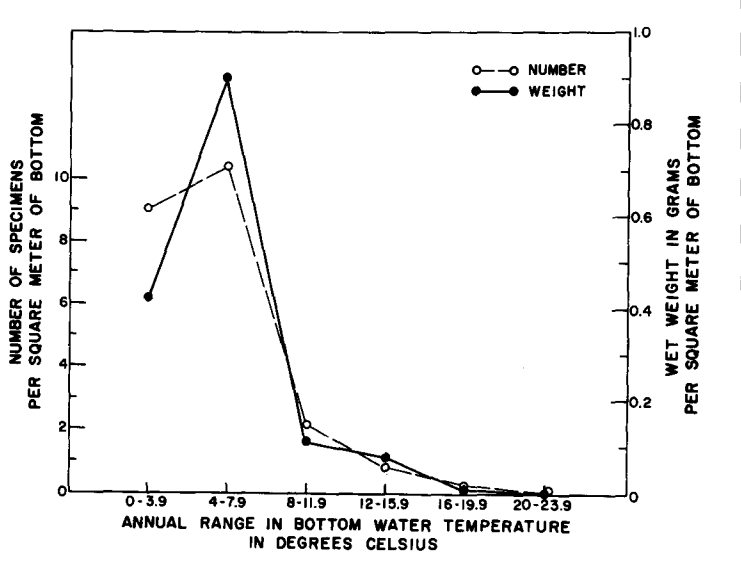


Figure 127
Density and biomass of Scaphopoda in relation to the annual range of bottom water temperature.

diminished in abundance where carbon content was both higher than and below those values (Table 26; Fig. 128).

Biomass peaked (0.48 g/m^2) in the 1.00–1.49% carbon content class with somewhat smaller amounts (0.31 g/m^2) in the 0.01–0.49% class (Table 28; Fig. 128); biomass in the other classes was fairly uniform ranging from 0.10 to 0.24 g/m^2.

Frequency of occurrence was moderately low in the 2.00–2.99% and 0.01–0.49% content classes (15 and 17%, respectively) but rose to moderate levels (20 to 32%) in samples in the other content classes (Table 30).

Cephalopoda—Representatives of the class Cephalopoda were not commonly encountered; they accounted for less than 0.1% of total biomass and density (Table 3). This apparent rarity is due primarily to sampling bias exemplified by the taxa represented in the samples. The class Cephalopoda contains some of the largest, most mobile, and most highly developed marine invertebrates known to science; further, many are semipelagic or pelagic in habit and are therefore severely undersampled by bottom grabs. The abundance and distribution of the commercially important squids inhabiting the study area in the order Decapoda, *Illex*

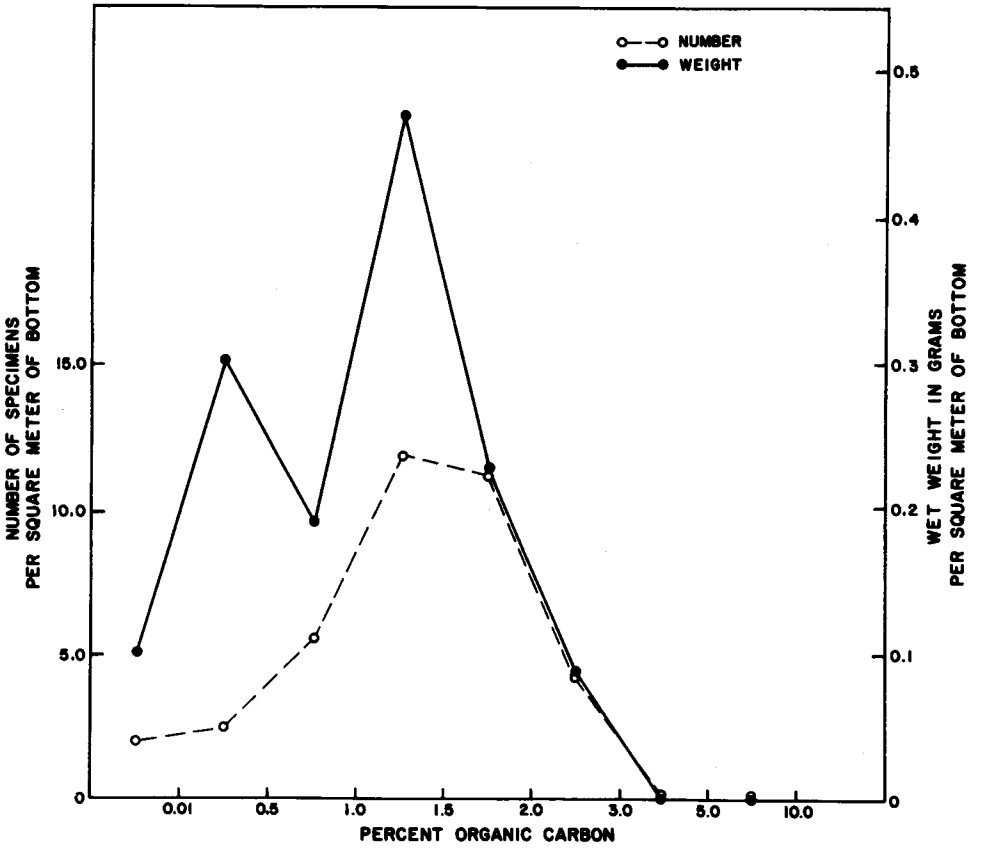


Figure 128
Density and biomass of Scaphopoda in relation to sediment organic carbon.

illecebrosus, and *Loligo pealei*, are well documented (Vovk, 1969; Tibbets, 1977; Lange, 1979, 1982; Wigley, 1982; Murray and Wigley[14] and others) in the fisheries literature but are not represented in our grab samples. Nautili and cuttlefish, two other orders of cephalopods that are wholly pelagic, are extremely rare in this region, which leaves only members of the order Octopoda, the octopi, which are almost wholly benthic in habit, and the smaller and more sedentary squids available to quantitative grab samplers. Thus the representation of cephalopods in our collections does not accurately characterize this portion of the molluscan fauna.

Our samples, 5 representing 0.5% of the total, contained a total of 376 individual cephalopods from 2 genera, *Octopus* sp. and *Rossia* sp. (Table 5). Their mean density was 0.4/m^2, and biomass averaged 0.01 g/m^2.

[14] Murray, H. E., and R. L. Wigley. 1968. Squid catches on three cruises of *Albatross IV*: cruise 63-5, July–August 1963; cruise 63-7, November–December 1963; cruise 64-1, January–February 1964. Bur. Comm. Fish, Biol. Lab., Woods Hole, Massachusetts Lab. Ref 68-12, 16 p. Unpubl. manuscript.

Geographic Distribution

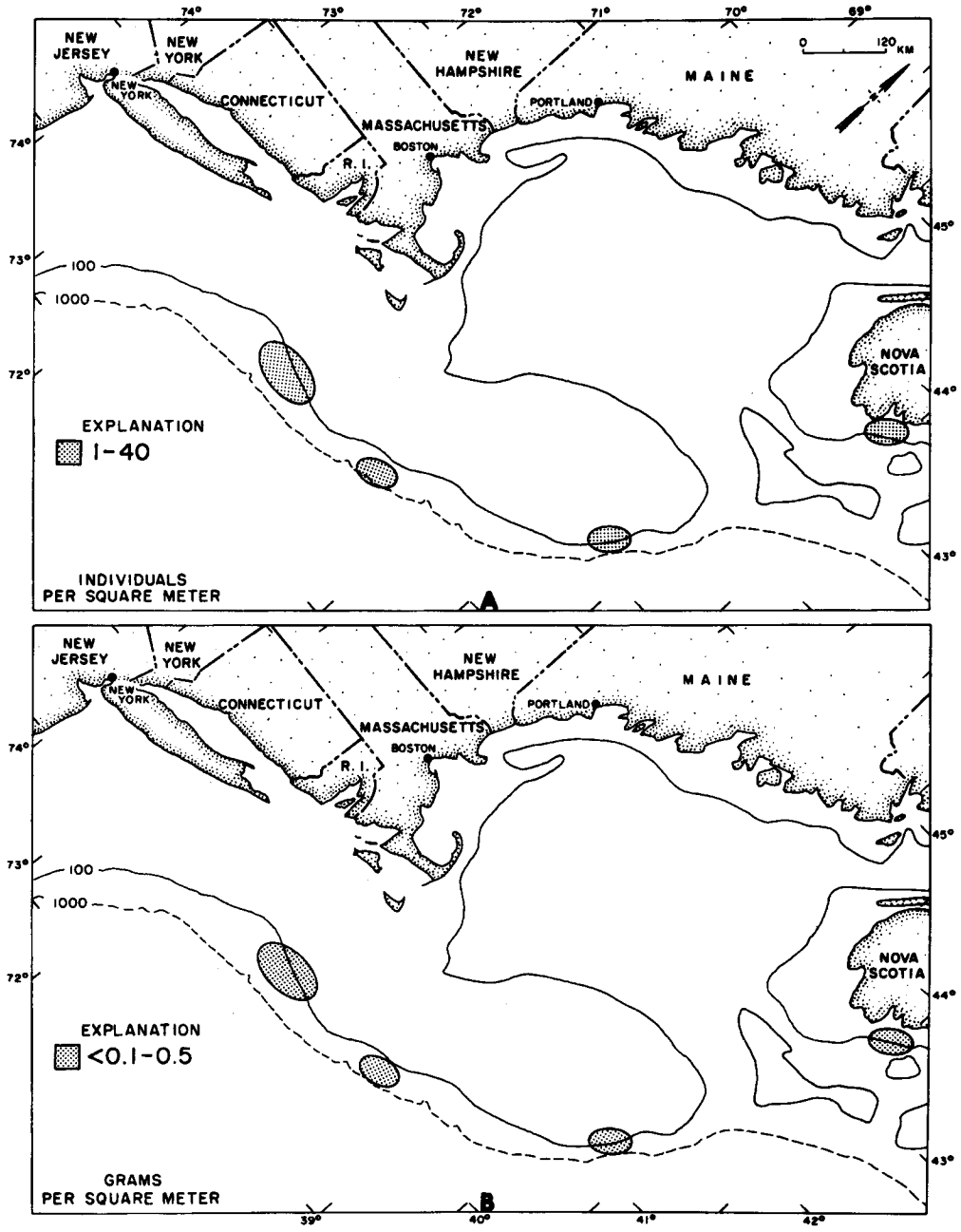
Cephalopods that were sampled occurred in low to moderate quantities (1 to 40 individuals/m^2, and <0.1 to 0.5 g/m^2) primarily along the offshore fringes of the study area at the shelf break and deeper from the northeast peak of Georges Bank westerly to south of Nantucket Shoals (Fig. 129). One inshore area, on the eastern Nova Scotian shelf, also yielded specimens of cephalopods.

Cephalopods occurred in all standard geographic areas but the Gulf of Maine in small quantities; mean densities ranged from <0.1 to only 1 individual/m^2, and mean biomass ranged from <0.01 to 0.01 g/m^2 (Tables 6, 8; Fig. 130).

Frequency of occurrence in the subareas was also low with <1 to only 2% of the samples containing specimens (Table 10).

Bathymetric Distribution

Cephalopods were taken at depths ranging from 114 to 320 m, placing them in two of our standard depth



CEPHALOPODA

Figure 129

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

range groupings (Tables 11, 13; Fig. 131). Highest mean density and biomass ($1.5/m^2$ and $0.03/m^2$, respectively) occurred in continental shelf depths between 100 and 199 m, whereas at deeper depths, 200–499 m, mean density and biomass were significantly lower ($0.1/m^2$, and <0.01 g/m^2). Only 1% of the samples in each depth range grouping contained cephalopods (Table 15).

Relation to Sediments

Cephalopods were found only in gravel, sand, and sand-silt sediments. Average density was only $<0.1/m^2$ in both gravel and sand but was $1.7/m^2$ in sand-silt substrates; average biomass, although low, increased with decreasing particle size ranging from <0.01 to 0.02 g/m^2 (Tables 16, 18; Fig. 132).

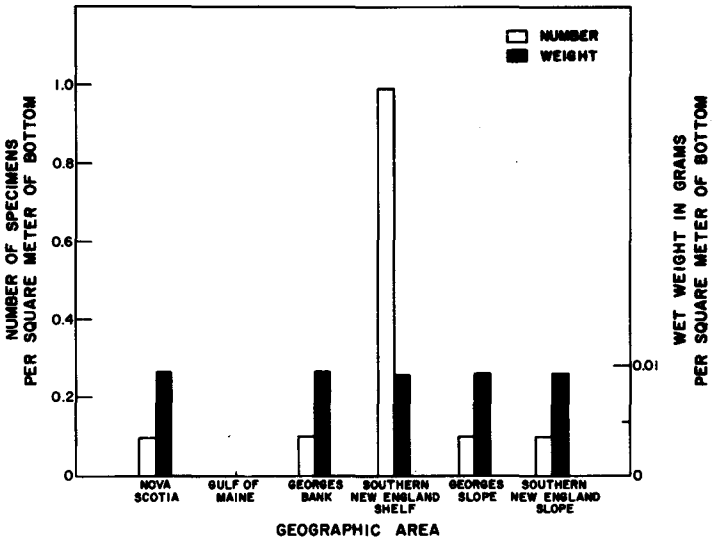


Figure 130
Density and biomass of Cephalopoda in each of the six geographic areas.

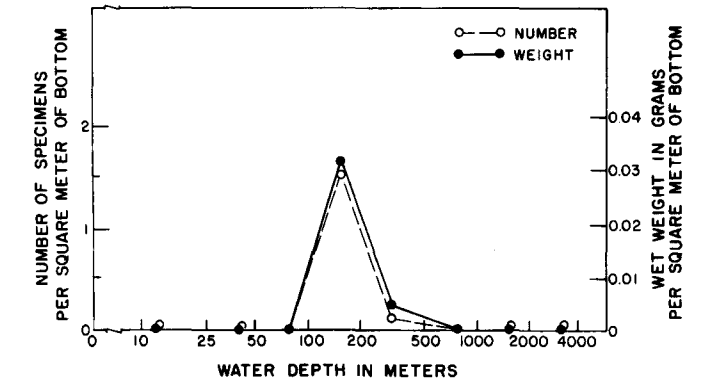


Figure 131
Density and biomass of Cephalopoda in relation to water depth.

Frequency of occurrence was low with only 1% of the samples in each of the three sediment types containing specimens (Table 20).

Relation to Water Temperature

Cephalopods were found only where the annual range in temperature was less than 12°C. Density showed a positive correlation with increasing temperature range from <0.1 individuals/m^2 in the narrowest (0–3.9°C) range to 1.1 individuals/m^2 in the broadest (8–11.9°C) range in which they occurred (Table 21; Fig. 133).

Biomass was stable (0.02 g/m^2) in the ranges between 4° and 11.9°C, and low (<0.01 g/m^2) in the narrowest range (Table 23; Fig. 133).

Less than 1% of the samples in the 0–3.9° and 8–11.9°C range groupings contained cephalopods, whereas 2% of the samples in the 4–7.9°C grouping yielded specimens (Table 25).

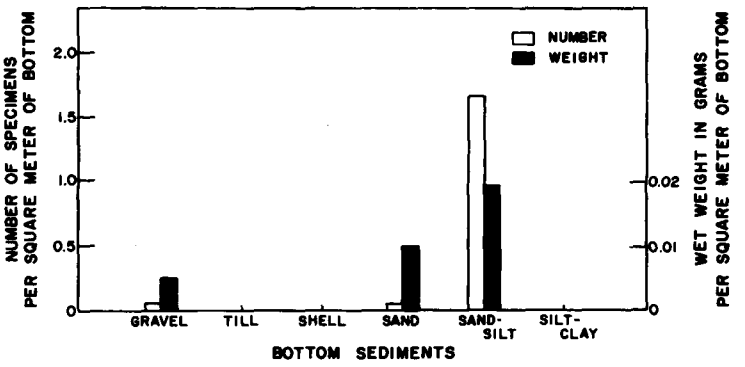


Figure 132
Density and biomass of Cephalopoda in relation to bottom sediments.

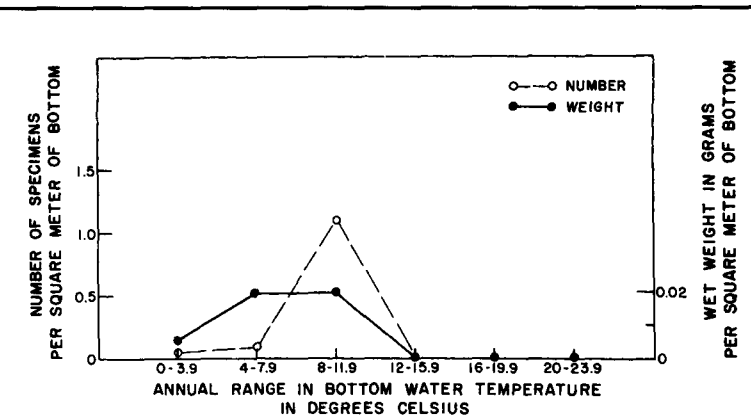


Figure 133
Density and biomass of Cephalopoda in relation to the annual range of bottom water temperature.

Relation to Sediment Organic Carbon

Cephalopods occurred only where organic carbon content ranged between 0.01 and 0.99%. Highest density (2.1 individuals/m^2) and biomass (0.03 g/m^2) occurred in sediments with between 0.5 and 0.99% organic carbon; significantly lower quantities of both measures occurred at levels between 0.01 and 0.49% (Tables 26, 28; Fig. 134).

Frequency of occurrence of cephalopods in the samples was only 1% in each of the content classes into which they were grouped (Table 30).

Arthropoda

Representatives of the phylum Arthropoda in the New England region, members of the classes Arachnida, Pycnogonida, and Crustacea, contribute significantly to both measures of abundance. Among the nine orders of Crustacea inhabiting the region (see Table 4), Amphipoda is the overall dominant taxon in terms of density, contributing slightly over 43% of the total number of specimens; this is the same as their ranking in the Middle Atlantic Bight (Wigley and Theroux, 1981). The classes Arachnida and Pycnogonida and the nine orders of class Crustacea will be discussed separately below. In keeping with the phylogenetic order of treatment, the figures relating to Arthropoda (Figs. 135–139) are presented here, but the detailed discussion of the phylum, represented almost wholly by the class Crustacea, will be presented in the section "Dominant Components of the Macrobenthos" below.

Pycnogonida—The class Pycnogonida, a relatively small group of marine arthropods containing about 600

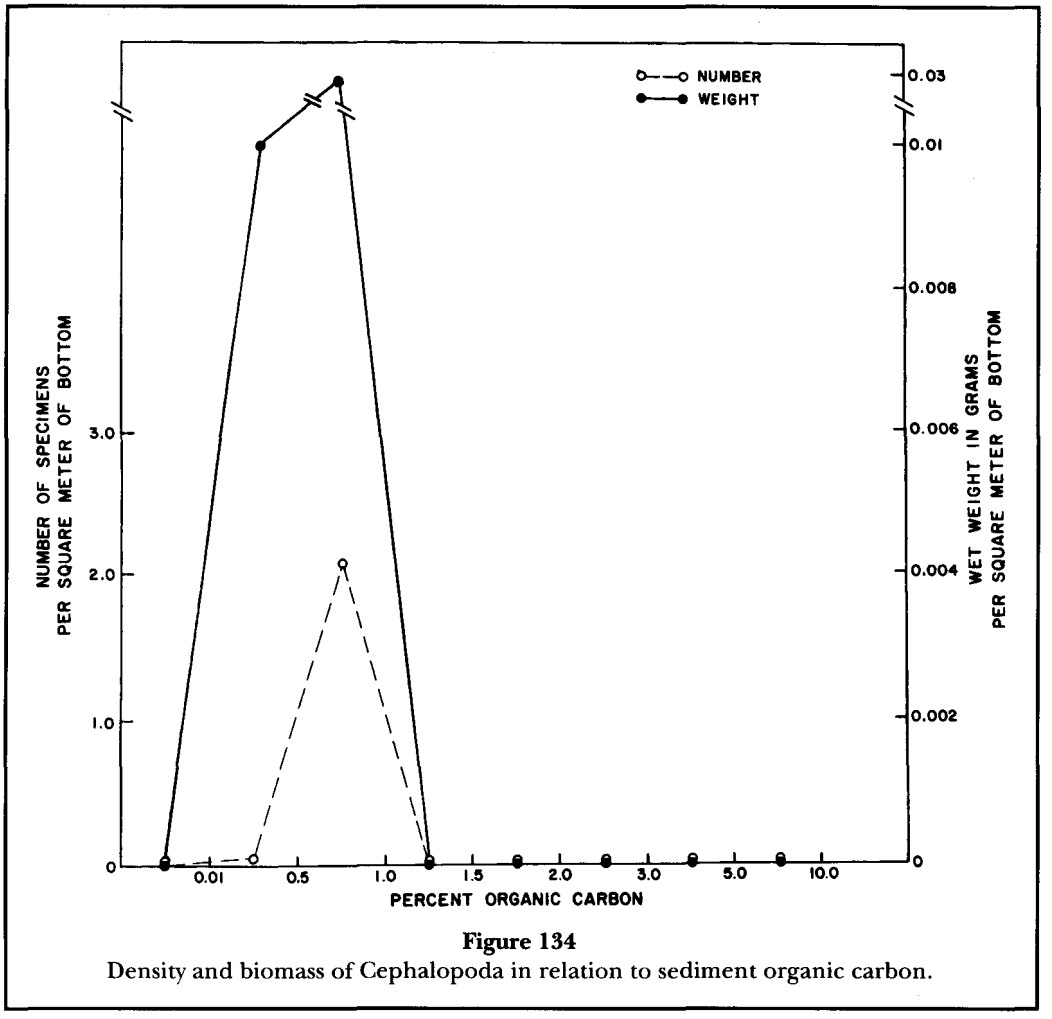


Figure 134
Density and biomass of Cephalopoda in relation to sediment organic carbon.

known species (Barnes, 1974), is commonly referred to as sea spiders. These organisms are found throughout the world ocean from the Arctic to the Antarctic and are considered to be common in occurrence. Most species prefer cold waters, and although some do swim, most are bottom dwellers and feed on hydroids, bryozoans, soft corals, anemones, and sponges. The sexes are separate and the males brood the developing eggs on specialized oviferous legs. They are for the most part small, ranging in length from 1 to 10 mm; however, a few species are much larger with body lengths of more than 6 cm and leg spans to 75 cm. They are found at nearly all depths but many species are littoral in habits. Color tends to be drab, but some pycnogonids are green and a few deepwater species are red.

Sea spiders were not very abundant in the study area, contributing less than 0.1% to total biomass and density (Table 3). In spite of this low abundance, a total of 10 species were identified from our samples (see Table 4). They ranged in depth from 18 to 1,420 m and were mostly 5 to 15 mm in size, with a few to 25 mm in length. Specimens ranged in color from flesh colored to dark tan and light brown.

Pycnogonids occurred in 25 samples (2.3% of total) which yielded a total of 369 individuals; mean number was 0.3/m^2 and biomass 0.01 g/m^2 (Table 5).

Geographic Distribution

The distribution of pycnogonids was quite patchy in the New England region, exhibiting inshore and offshore components (Fig. 140). The inshore component was composed of isolated patches of low density (1–9/m^2) and low biomass (<0.1–0.9 g/m^2) on the Nova Scotian shelf and inshore Gulf of Maine and in Long Island Sound. Patches of moderate density (10–49/m^2), but low biomass, were located at the entrances to the Bay of Fundy and Long Island Sound.

The offshore component contained patches of low density and biomass on Browns Bank, the Western Basin of the Gulf of Maine, and the periphery of Georges

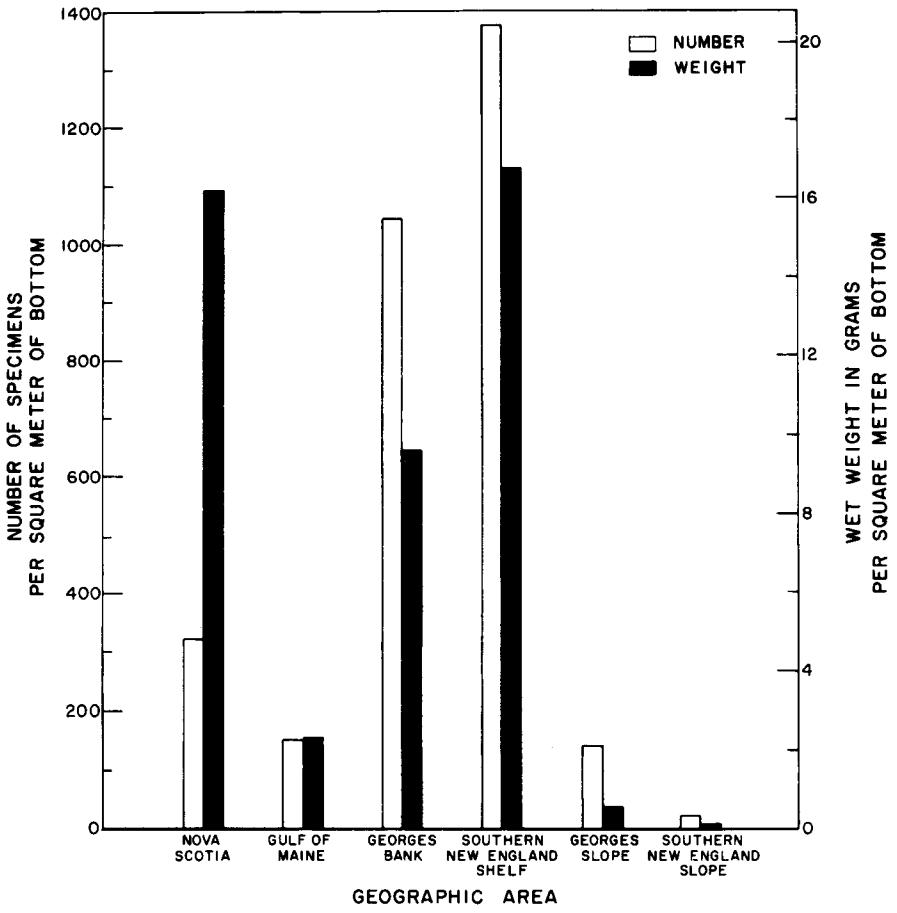


Figure 135
Density and biomass of Arthropoda in each of the six geographic areas.

Bank out onto Georges Slope. One patch of moderate density was located in Great South Channel.

Among the standard geographic areas, sea spiders were found in all but the Southern New England Slope. The shallow-water shelf areas, Nova Scotia, Southern New England Shelf, and Georges Bank, yielded higher mean densities (0.8–0.3/m^2) than the deeper Gulf of Maine and Georges Slope localities (Table 6; Fig. 141).

Mean biomass showed a diminishing trend from northeast to southwest, ranging from 0.02 to <0.01 g/m^2 (Table 8; Fig. 141).

Frequency and of occurrence was highest in Nova Scotia and on Georges Slope and lower in the other subareas (Table 10).

Bathymetric Distribution

Pycnogonids were absent in the 200–499 m and 2,000–3,999 m depth zones but present in small quantities in the other zones. Mean densities were highest (0.6/m^2) in the two zones between 0 and 49 m depth and diminished as depth increased (Table 11; Fig. 142). Lowest density (0.1/m^2) occurred in the deepest depth zone that they occupied (1,000–1,999 m).

Biomass of pycnogonids was low in all depth zones in which they occurred, ranging from <0.01 to only 0.03 g/m^2 (Table 13; Fig. 142). The highest biomass was in the 100–199 m depth zone.

Frequency of occurrence of sea spiders in samples was fairly uniform in most depth zones, ranging from 2 to 4%; however, 9% of samples in the 500–999 m zone contained specimens (Table 15).

Relation to Sediments

Shell is the only sediment type in which pycnogonids were not found. They were most prevalent (by a wide margin) in both measures of abundance in gravel, where

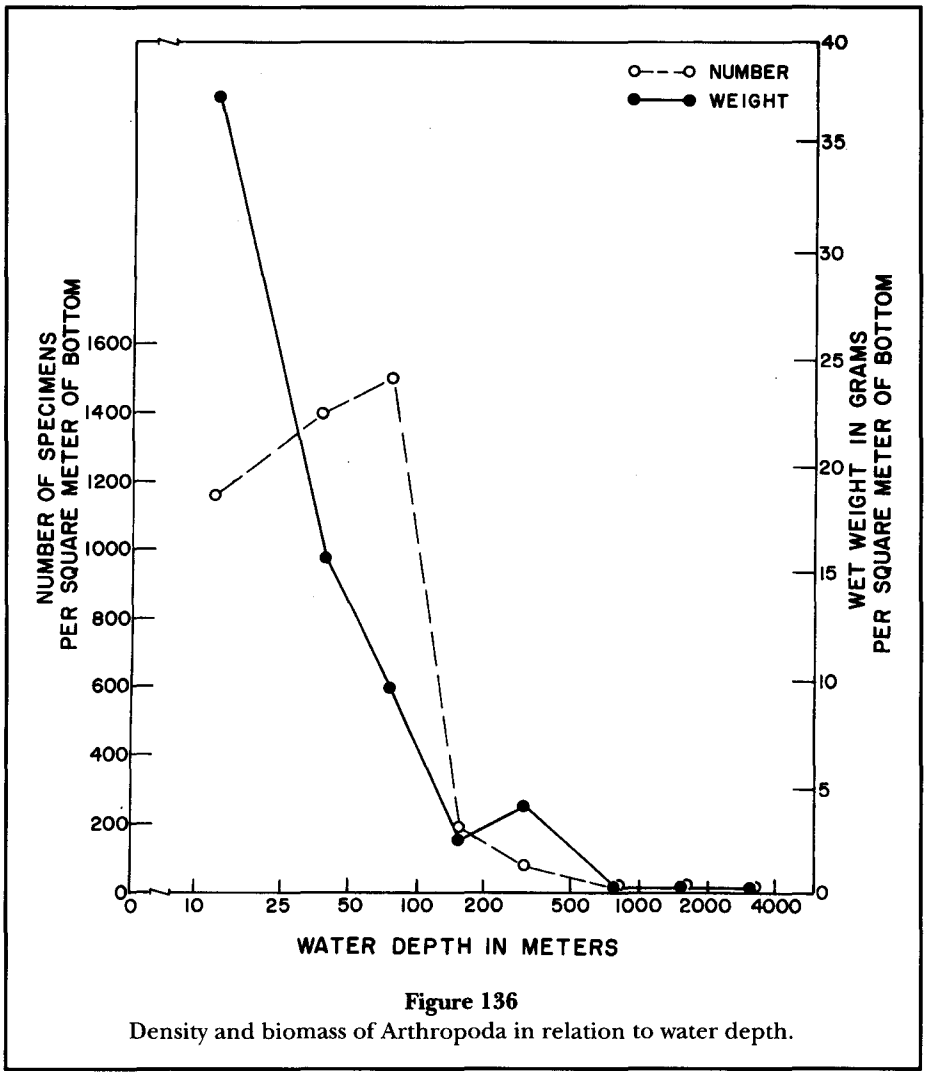


Figure 136
Density and biomass of Arthropoda in relation to water depth.

mean density and biomass were 2.1/m^2 and 0.05 g/m^2, respectively. Density and biomass in all other sediment types were significantly lower, 0.1/m^2 and <0.01 g/m^2, respectively (Tables 16, 18; Fig. 143).

Frequency of occurrence, as might be expected, was greatest in gravel (11% of samples), intermediate (5%) in till, and low (1%) in the other sediment types (Table 20).

Relation to Water Temperature

Sea spiders occurred in all temperature range classes. In terms of mean density there was a wide disparity in the quantities contained; the broadest temperature range (20–23.9°C) contained from 2 to 15 times more individuals (1.5/m^2) than any other range class, which had ranges from 0.1 to 0.7/m^2 (Table 21; Fig. 144).

Biomass was more evenly distributed among the different temperature range classes. However, the broadest temperature range did not contain the highest mean biomass (only 0.01 g/m^2), as it did density. The highest mean biomass occurred in the 4–7.9°C range class which contained 0.03 g/m^2. Mean biomass in the other temperature range classes was 0.01 g/m^2 or less (Table 23; Fig. 144).

Frequency of occurrence of pycnogonids in the samples in the various temperature range classes was rather uniformly low, ranging from 1 to 4%, with the highest incidence occurring in the two range classes that yielded the highest density and biomass (Table 25).

Relation to Sediment Organic Carbon

Pycnogonids were restricted to areas of low and moderate levels of organic carbon content, being found where values were between 0.01 and 1.49%. Mean density decreased from 0.4 to 0.1/m^2 as organic carbon con-

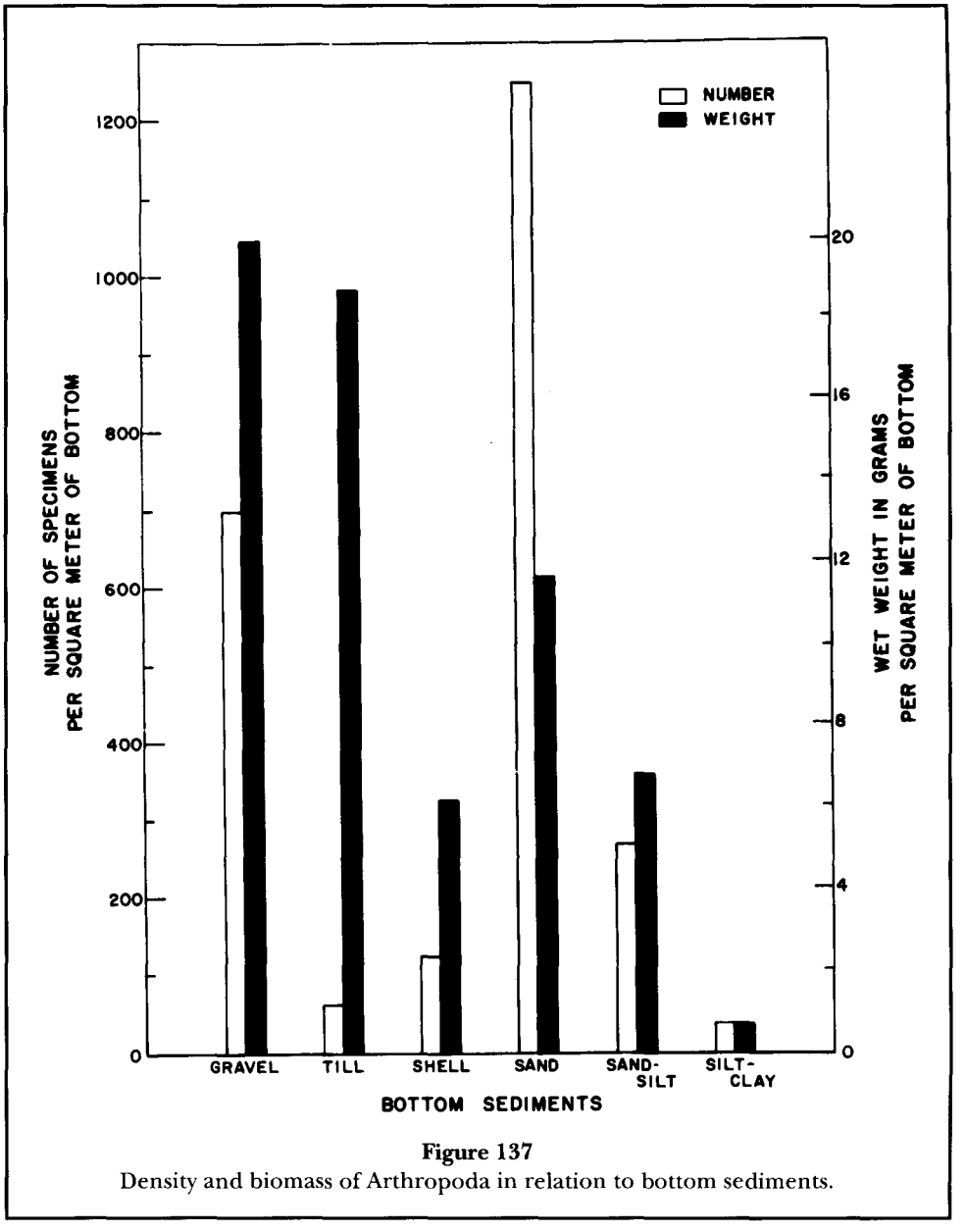


Figure 137
Density and biomass of Arthropoda in relation to bottom sediments.

tent increased, but mean biomass was fairly uniform, between 0.01 and <0.01 g/m^2 (Tables 26, 28; Fig. 145).

Frequency of occurrence of pycnogonids in samples also diminished as organic carbon content increased, ranging from 3 to 1% (Table 30).

Arachnida—One specimen of the class Archnida, order Acarina, family Halicaridae (water mite) was collected during the course of this study. This specimen was taken at station 1130, located at a depth of 86 m on the northeastern edge of Georges Bank. Sediment at this location was sand, and the temperature range was between 4° and 7.9°C.

Because of the small size of members of the family Halicaridae, only a very small proportion of them (the largest specimens) are components of the macrobenthos.

Adjusted statistics for this group are contained in Tables 3 and 5 for overall faunal relationship and in Tables 6 through 30 for relationships to the considered parameters.

Crustacea—The class Crustacea in the New England region contains representatives from nine orders, each of which will be discussed separately below. At least three of these orders, Amphipoda, Cumacea, and Cirripedia, rank as dominant components of the macro-

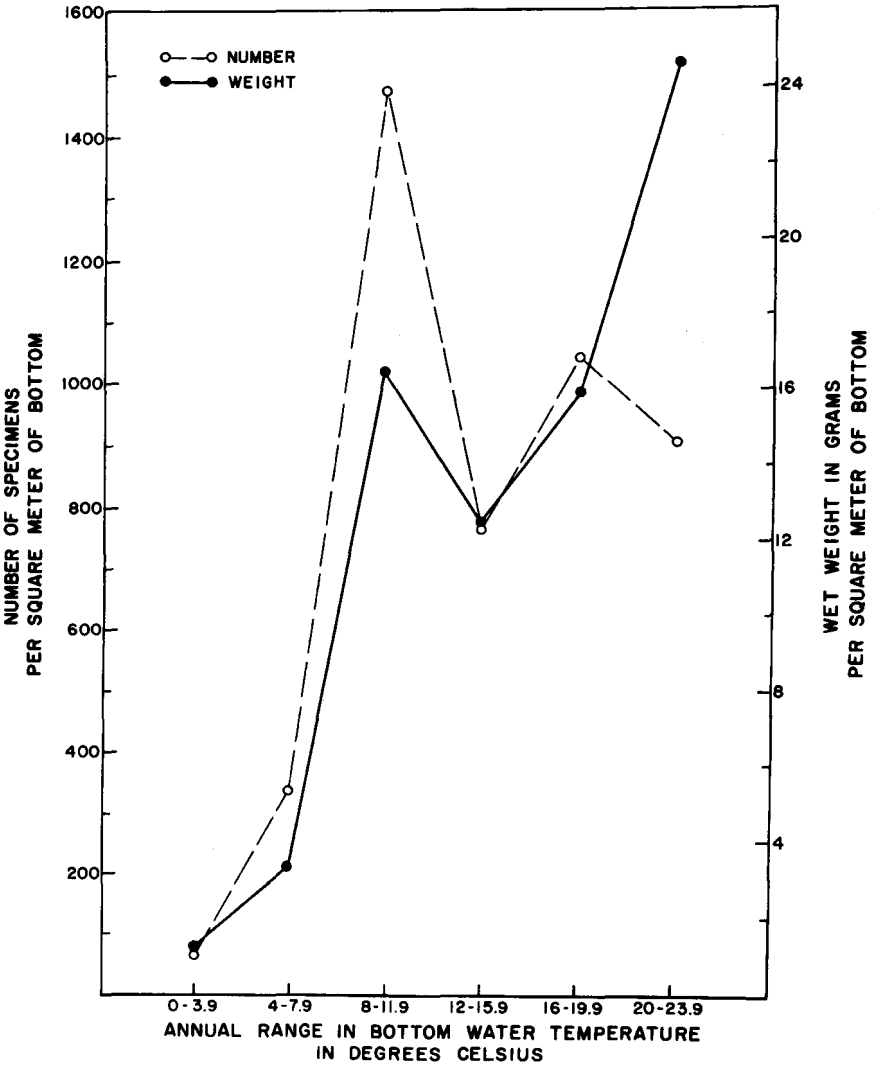


Figure 138
Density and biomass of Arthropoda in relation to the annual range of bottom water temperature.

benthic invertebrate fauna in terms of numerical density. Amphipoda, in particular, contributes an overwhelming majority of individuals (43%) to total faunal density, 1.5 times as many as the second dominant taxon, Annelida (28%) (Table 3). Cumacea and Cirripedia each contributed over 1.5% of total numerical density.

Detailed analysis of this class as a whole will appear below, along with the other dominant taxa, in the section "Dominant Components of the Macrobenthos." Figure 146, which shows the distribution of density and biomass of Crustacea, however is included here so as not to create disorder in the phylogenetic arrangement of the figures.

Ostracoda—Because of the small size of most members of this group, only a small proportion were retained by the processing techniques used in this study. Specimens in our samples were approximately 1 to 2 mm in length. The vast majority of ostracods inhabiting the sediments of this region, however, were smaller than this and as such belong to the meiofaunal realm not sampled in this study. Except for references to the literature, our comments here pertain only to the very largest species that occur in the New England region.

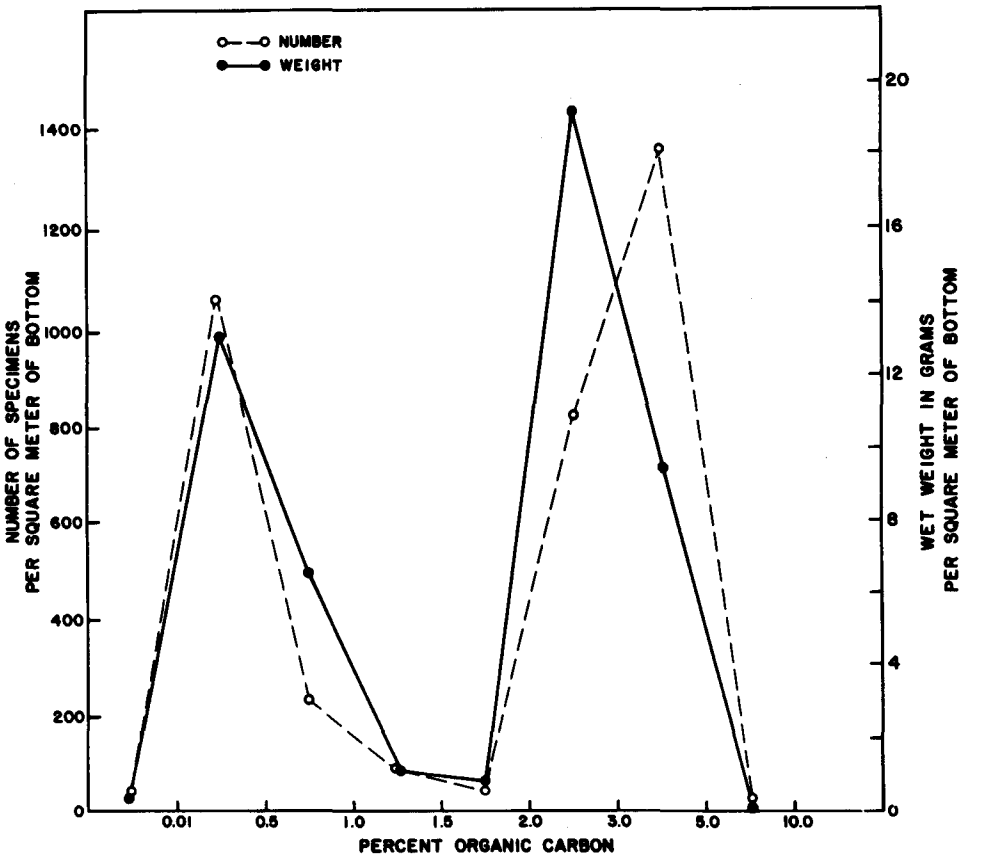


Figure 139
Density and biomass of Arthropoda in relation to sediment organic carbon.

Other studies (Wigley and McIntyre, 1964) revealed that ostracods, including specimens as small as 75 microns or less, are not abundant in the offshore Southern New England region. Their average density there was only slightly more than 1 individual/m^2.

Ostracods were taken at only five stations (0.5% of total) situated in diverse localities, all in offshore waters (Fig. 147). Two of the stations were situated on the Nova Scotia shelf, and one station was situated at each of the following locations: the Gulf of Maine, the continental slope south of Georges Bank, and the continental rise east of New Jersey. Density of these ostracods averaged <0.1/m^2 and their biomass <0.01 g/m^2 (Table 5).

Water depths at which ostracods were found ranged from 61 to 2,682 m. Their average density was slightly higher at depths below 200 m than on the continental shelf (Tables 11, 13).

Ostracods occurred in three types of bottom sediments: gravel, sand-silt, and silt-clay. Their density was about equal in each type (Tables 16, 18).

Members of this group were found only in areas where the temperature range was below 8°C. Although their density in all areas was low, it was slightly higher where the temperature range was less than 4°C than in areas where slightly higher (4–7.9°C) ranges prevailed (Tables 21, 23).

Ostracods occurred where sediment organic carbon content levels ranged between 0.01 and 0.99%. Densities were somewhat greater at the higher levels than at the lower ones (Tables 26, 28).

Cirripedia—Barnacles were generally sparse and, except in a few local areas, made up a small proportion of the total benthic fauna. In some favorable habitats, such as rocky areas in shallow coastal waters and on offshore banks subjected to relatively strong water currents, barnacles were common to very abundant (Table 3). Densities of nearly 8,000 individuals/m^2 and biomasses of over 1,000 g/m^2 were encountered.

Members from two suborders, Balanomorpha (rock barnacles) and Lepadomorpha (stalked barnacles), were

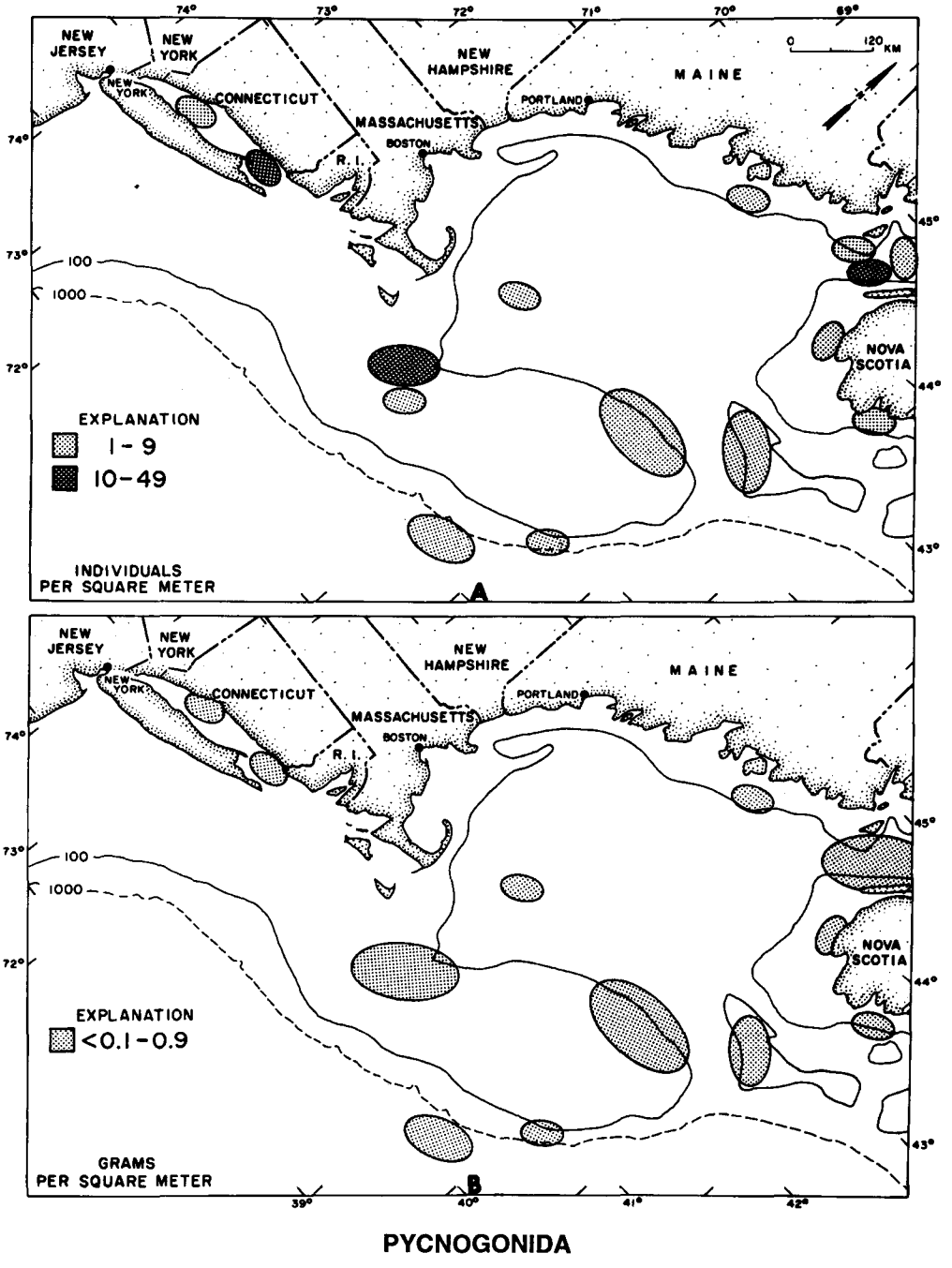


Figure 140
Geographic distribution of Pycnogonida: A—number of specimens per square meter of bottom; B—biomass in grams per square meter of bottom.

present in the collections, but those from the latter group were uncommon. The genus *Balanus* was overwhelmingly the dominant form, of which three species were common.

Rock barnacles were usually 0.5 to 1.5 cm in height and diameter; however, some newly settled specimens as small as 1 mm and a few specimens greater than 5 cm in length and diameter were collected. Stalked barnacles had a more restricted size range; they averaged 0.5 cm in length, with extremes of about 0.25 to 1 cm.

Rock barnacles were most commonly found attached to rocks, mollusk shells, and shells of other barnacles. A

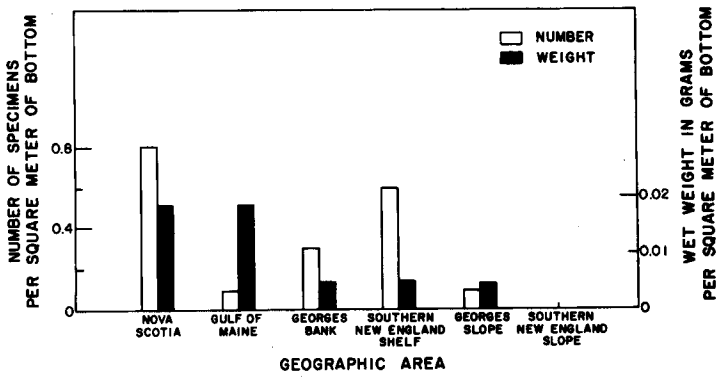


Figure 141
Density and biomass of Pycnogonida in each of the six geographic areas.

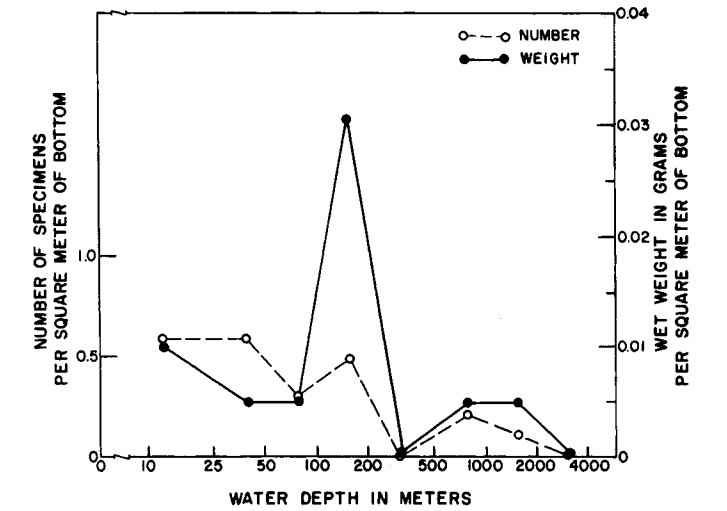


Figure 142
Density and biomass of Pycnogonida in relation to water depth.

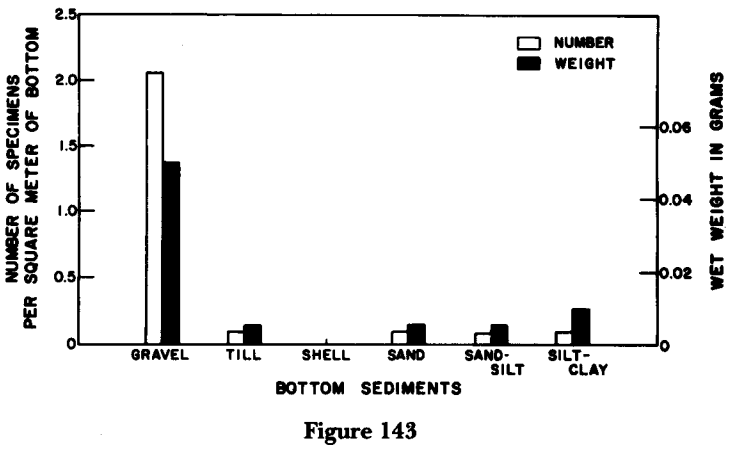


Figure 143
Density and biomass of Pycnogonida in relation to bottom sediments.

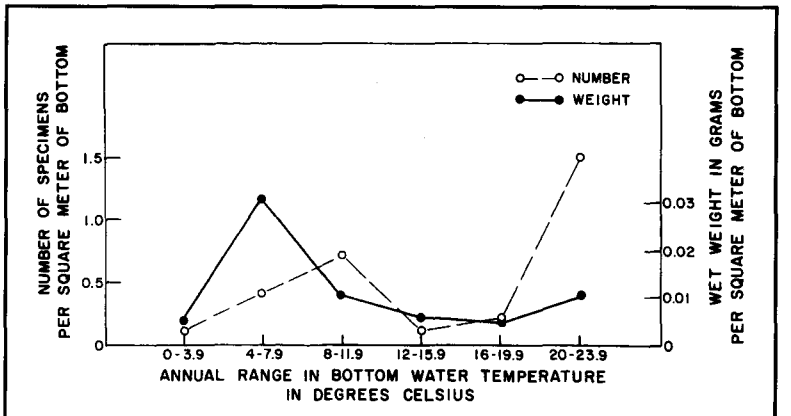


Figure 144
Density and biomass of Pycnogonida in relation to the annual range of bottom water temperature.

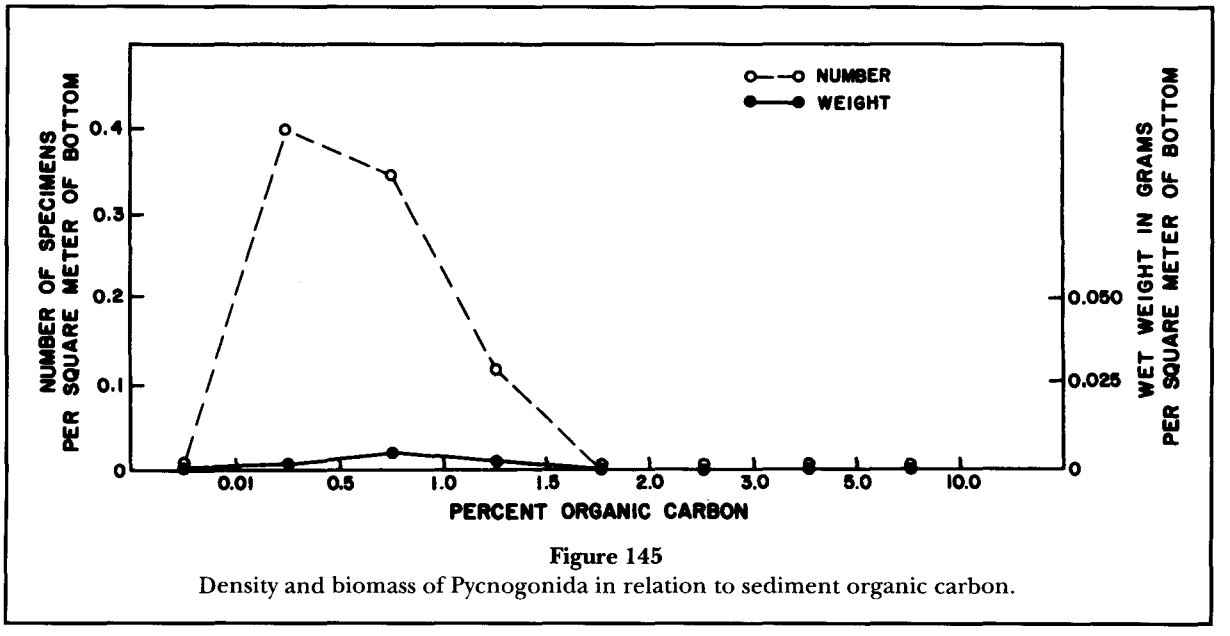


Figure 145
Density and biomass of Pycnogonida in relation to sediment organic carbon.

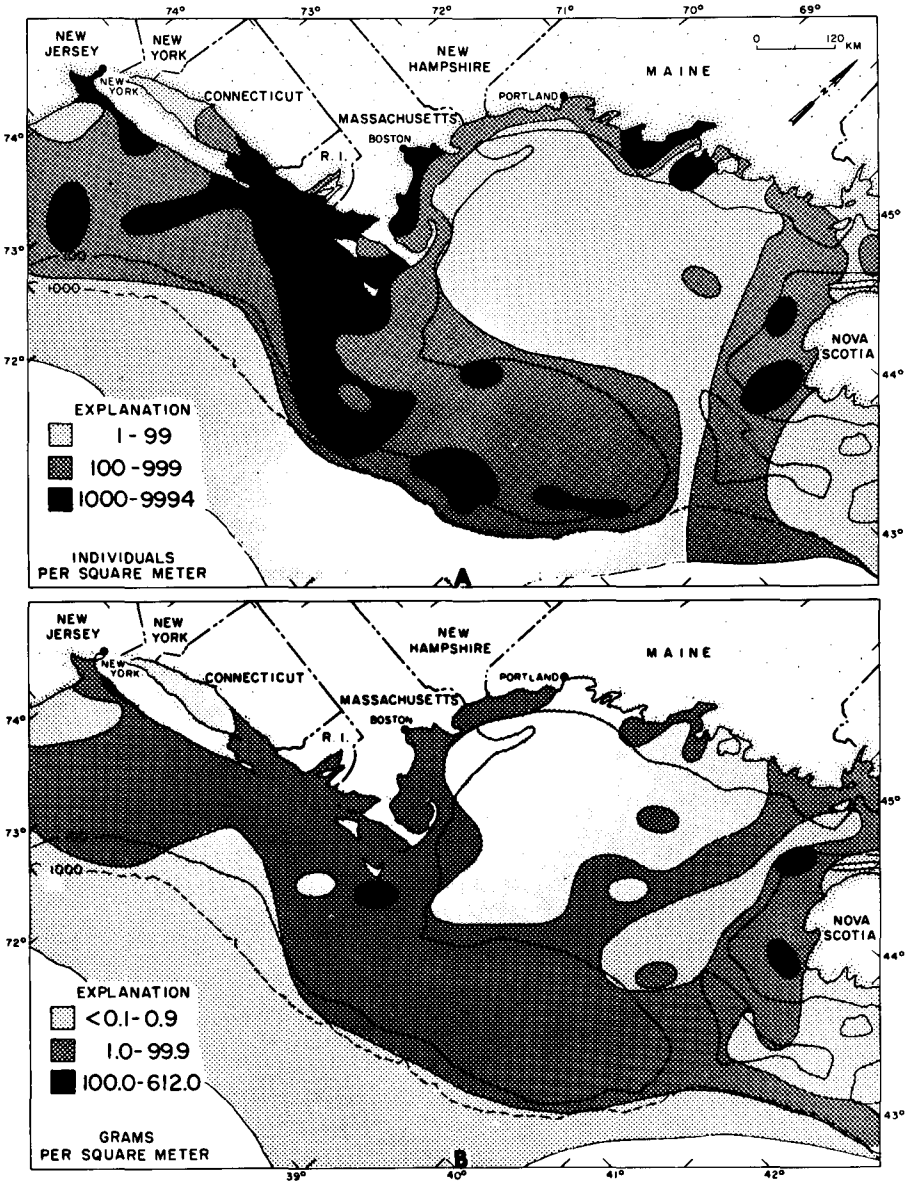
small proportion occurred on stalks of ascidians, on carapaces of decapod crustaceans, and on a variety of other hard to moderately hard objects. Stalked barnacles were attached to similar substrates but were relatively more common on crustaceans, hydroids, and corals.

The majority of specimens were chalky white. Rock barnacles from inshore localities sometimes had a film of yellowish or greenish algae covering their plates, and in some ridged species a brownish layer occurred in the grooves of the shell. Very large specimens were commonly light yellow and white, whereas some of the very small ones were pale gray. Stalked barnacles generally had white shells on both the capitulum and peduncle, but a few specimens had delicate shades of rose on the larger plates. The color of the peduncle ranged from yellow to grayish brown.

Cirripedia occurred in 41 samples (4% of total). Their density averaged 21.8/m^2. Their biomass averaged 3.39 g/m^2 (Table 5).

Geographic Distribution

Barnacles were found at scattered locations along the entire length of the region's continental shelf (Fig. 148). Coastal regions, shoals, and banks were the most



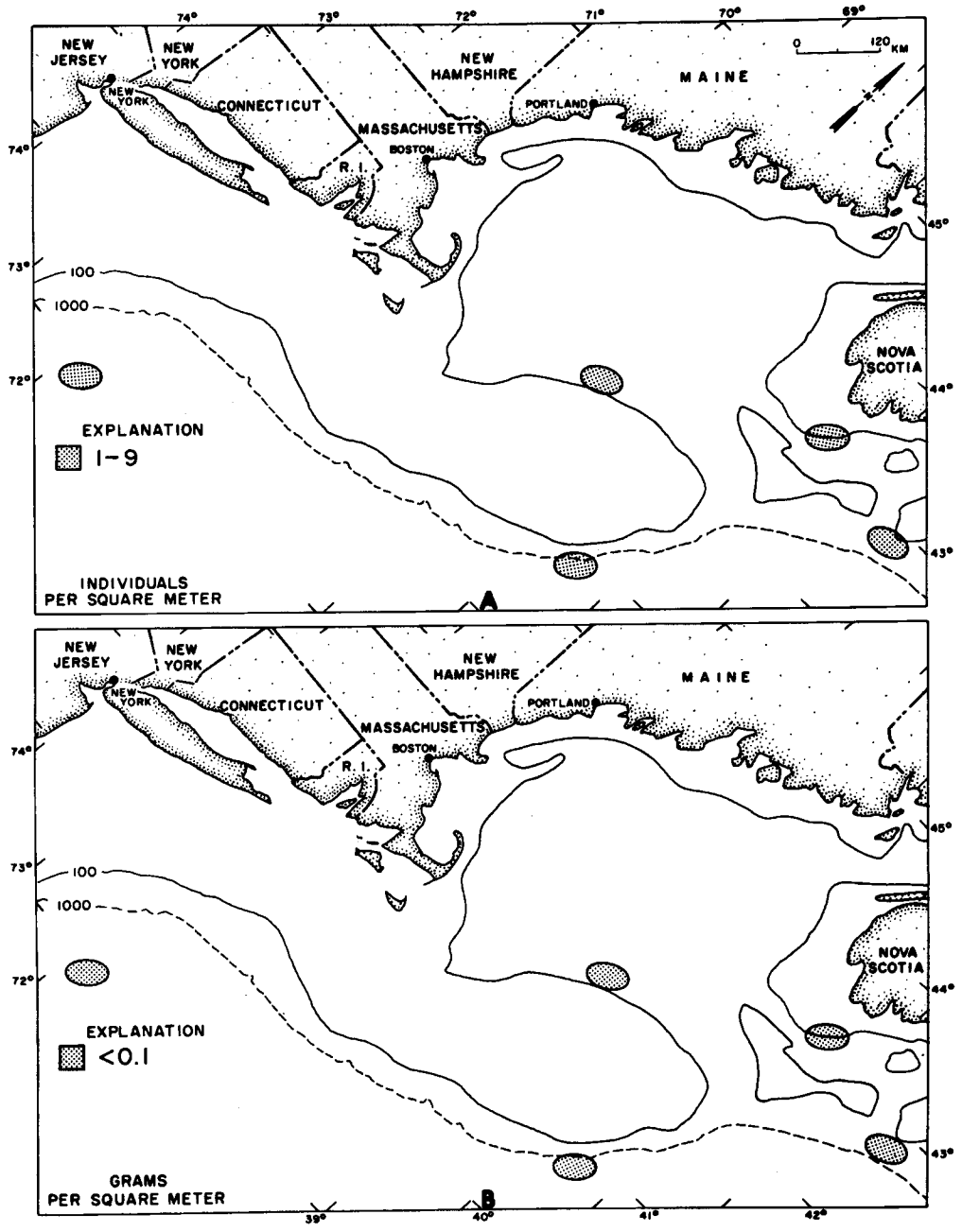
CRUSTACEA

Figure 146
Geographic distribution of Crustacea: A—number of specimens per square meter of bottom; B—biomass in grams per square meter of bottom.

commonly inhabited areas. They were absent from almost all of the continental slope and from much of the central Gulf of Maine. Densities of from 1 to 49 individuals/m^2 and biomasses of less than 10 g/m^2 were most prevalent, but large quantities (100–5,000 individuals and 50–612 g/m^2) were not unusual in the coastal and nearshore localities.

Barnacles were present in four of the six standard geographic areas; they were absent from Georges Slope and the Southern New England Slope (Table 6; Fig. 149). The two areas where they were especially abundant were the Southern New England Shelf (52/m^2) and Nova Scotia (36/m^2). Densities in the Gulf of Maine and on Georges Bank were only 3 and 6/m^2, respectively.

Biomass in Nova Scotia was larger (13 g/m^2) than on the Southern New England Shelf (7 g/m^2) even though densities were higher in the latter area (Table 8; Fig.



OSTRACODA

Figure 147

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

149). Thus the average size of individual barnacles was larger (0.36 g) in Nova Scotia than on the Southern New England Shelf (0.13 g). The biomass of barnacles in the Gulf of Maine and on Georges Bank was less than 0.5 g/m^2.

Frequency of occurrence was highest (15% of the samples) in the Nova Scotia area and substantially lower (2 to 4%) in the remaining shelf areas. They were absent in the two slope areas (Table 10).