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Distribution of zooplankton on the fishing grounds of Georges Bank, Browns Bank, and the Gulf of Maine Autumn, 1974[1]

by

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Abstract

A description is given of the abundance, composition, and distribution of zooplankton in the waters of Georges Bank, Browns Bank and the Gulf of Maine. The ten most dominant zooplankton groups (major taxa) out of the thirty-four represented, were examined. Comparisons were made among the ten in regard to total biomass contribution. The results were considered in relation to plankton feeding fishes. Copepoda were the most abundant zooplankters, followed by Euphausiacea and Gastropoda. Large numbers of predacious Salpidae occurred in areas of low concentration of Copepoda suggesting competition with the plankton eating fishes for Copepoda. Both the total zooplankton biomass and volumes of individual groups revealed a differential pattern of abundance with zooplankton concentration more dense on Georges Bank, Browns Bank, and the outer edges of the Gulf of Maine than in the central Gulf of Maine. The greatest variety of groups occurred in the southern section of Georges Bank; species diversity decreased from Georges Bank, Browns Bank and the eastern Gulf of Maine to the central and western parts of the Gulf of Maine.

[1] Presented to ICNAF Environmental Working Group meeting, Szczecin, Poland, April 1976 as Working Paper 76/IV/109.

Introduction

In 1974 the R/V "Wieczno" collected ichthyoplankton and zooplankton as part of the joint ICNAF international larval herring survey on Georges Bank. Larval herring were sampled with paired 60 cm bongos fitted with 0.505 and 0.333 mm mesh nets. Analysis of larval herring distribution and abundance was based on the 0.505 collections. The present paper provides an initial description of the zooplankton on the important feeding grounds of Georges Bank, Browns Bank, and the Gulf of Maine, and is based on the collections made with 0.333 mm nets.

Samples were collected from September 27 through October 18, 1974. Station locations are given in Figure 1. The volume of water sampled ranged from 166 m^3 to 526 m^3 per tow. All zooplankton was preserved in a 3-4% formalin solution.

Methods

In the laboratory before sorting and identification, the following operations were completed:

1. All non-planktonic organisms, i.e. other animals, phytobenthos as well as other elements present in the samples were removed.
2. Zooplankton volumes were determined by displacement.
3. Samples were split (by a splitter of our own construction) in such a way as to obtain:

    a) 15-30 ml of plankton to analyze for dry material, organic elements, and ash.
    b) 5-10 ml of plankton to sort for bigger organisms (Mysidacea, Euphausiacea, Decapoda, Chaetognatha, Salpidae, fish larvae, and rarely found organisms).
    c) 1 ml of plankton to sort for small organisms belonging to definite systematic groups (Copepoda, Cladocera, Ostracoda, etc.).

4. Identified organisms were counted and recorded on the MARMAP Zooplankton Volume and Identification Log.

Using the laboratory processed material, the following analyses were performed:

1. Determination of total zooplankton biomass in millilitres per 1 cubic meter of water strained (Fig. 2).
2. Determination of frequency of occurrence and quantity of the dominant groups (Table 1).
3. Determination of biomass of the dominant groups (Table 1).
4. Determination of the quantity of the dominant groups-numbers per 1000m^3 of water strained at each station (Fig. 3-12).
5. Determination of the number of different groups appearing at the same station (Fig. 13).

Mean biomass determination for one specimen in each of the 10 dominant groups was done using Tschislenko (1968) nomograms. The mean biomass of each individual group in the area of occurrence and in the investigated area has been calculated multiplying the obtained mean biomass of one specimen by mean quantity of organisms.

Results

Zooplankton sampled from 145 stations on the fishing grounds of Georges Bank, Browns Bank and the Gulf of Maine in autumn 1974 was composed of nearly all animal groups from protozoans to vertebrates in various stages of development. The following animal groups were found: Foraminifera, Hydromedusae, Siphonophora, Ctenophora, Turbelaria, Nematoda, Polychaeta, Cladocera, Ostracoda, Copepoda, Isopoda, Amphipoda, Anisopoda, Cumacea, Mysidacea, Euphausiacea, Stomatopoda, Phyllopoda, Decapoda, Gastropoda, Heteropoda, Bivalvia, Cephalopoda, Bryozoa, Echinodermata, Chaetognatha, Appendicularia, Salpidae and fish. The distribution pattern of these animal groups showed certain characteristics. In the Gulf of Maine, there were $\leq$10 groups occurring together but in the north-eastern section of the Gulf as well as on the fishing grounds of Browns Bank and Georges Bank, the number of animal groups ranged between 11-20. In three stations in the southern part of the Georges Bank area, the number of groups was above 20 (Fig. 13).

Out of 34 animal groups, 10 were chosen for closer examination on the basis of quantity and frequency of occurrence. Quantity relationships between these groups of organisms are shown in Table 1. Copepoda were present in all sta-

tions; Chaetognatha, Gastropoda, Appendicularia, Amphipoda, Euphausiacia, Crustacea larvae and Salpidae were present in 93.79% to 51.72%. Decapoda and Mysidacea were found in 20% and 18.62% of the stations and were included because of their importance as fish food.

Distribution of Major Taxa

The frequency occurrence at individual stations does not correlate with the quantity mean in 1000m^3 of water strained except for Copepoda. In quantity, Copepoda were the most numerous taxa per 1000m^3 of water strained followed by Salpidae, Chaetognatha, Appendicularia, Mysidacea, Amphipoda, Gastropoda, Crustacea larvae, Euphausiacea and Decapoda.

The greatest concentrations of Copepoda were in sections on the western and northern borders of the Gulf of Maine, north of Browns Bank and in central Georges Bank where the numbers were more than 1,000,000 per 1000m^3. The lowest quantity 0 to 100,000 per 1000m^3 was observed in the southern and eastern borders of Georges Bank and west of Browns Bank. All other areas had an abundance of Copepoda numbering 100,000 - 1,000,000 per 1000m^3 (Fig. 3).

The numbers of Chaetognatha were much lower with the highest densities above 20,000 per 1000m^3 occurring in the western and central portions of Georges Bank and to the west of this area. Numbers decreased to 2000 to 20,000 Chaetognatha per 1000m^3 in areas surrounding the highest densities in the Georges Bank area and in Browns Bank. Quantities below 2000 per 1000m^3 were found in most areas of the Gulf of Maine and a few stations in the eastern and southern parts of Georges Bank. There were no Chaetognatha found in three stations in the central part of the Gulf of Maine (Fig. 4).

Pteropoda and Gastropoda in quantities above 10,000 per 1000m^3 were common throughout the rest of Georges Bank except for the eastern sector. These densities also occurred in Browns Bank and the eastern Gulf of Maine. The densities decreased to <1000 per 1000m^3 in many sections of the Gulf of Maine and the eastern section of Georges Bank. Several stations in the north central, central and west Gulf of Maine as well as the east and south-west Georges Bank were noted for the absence of Pteropoda and Gastropoda (Fig. 5).

Appendicularia in quantities above 10,000 per 1000m^3 were found at two stations in the north-east sector of the Gulf of Maine and in several stations in the Georges Bank area. The range of density in other stations in this area was 1000 - 10,000 per 1000m^3. These densities were also found in the central Browns Bank and north and south of this area. Decreasing densities of <1000 per 1000m^3 were found in the Gulf of Maine and the western sector of Browns Bank, and none were found at several stations in the central and western Gulf of Maine (Fig. 6).

Amphipoda in concentrations of >10,000 were found in central Georges Bank and to the west. Decreasing concentrations ranging from 1,000 to 10,000 per 1000m^3 were found in the central Georges Bank, to the west and south of Georges Bank and to the north of Browns Bank. Densities decreased to <1000 per 1000m^3 in the remaining parts of Georges Bank, Browns Bank and the eastern part of the Gulf of Maine. Lack of Amphipoda was observed throughout most of the other stations in the Gulf of Maine (Fig. 7).

Concentrations of Euphausiacea of >5000 per 1000m^3 were found in a small patch in the south-central portion of Georges Bank. Densities decreased to between 1000 - 5000 specimens per 1000m^3 water strained in southern and western sections of Georges Bank and to the south west of the area and central Browns Bank northward as well as stations to the west, north-west and south-east of the Gulf of Maine. Densities decreased to <1000 per 1000m^3 throughout the remaining areas with absence of specimens noted in the western and eastern sectors of Georges Bank (Fig. 8).

The largest concentrations of Crustacea larvae above 10,000 per 1000m^3 is noted for the west-central areas of Georges Bank and to the west of this area. Densities decrease to 1000 - 10,000 per 1000m^3 in many stations in Georges Bank and westward and to the north of Browns Bank as well as in the north-east part of the Gulf of Maine. Numbers of organisms <1000 per 1000m^3 were found in the north-east and south-east Georges Bank, Browns Bank and the outer edges of the Gulf of Maine. Absence of specimens is noted in most of the stations in the Gulf of Maine and in one station in the north-west portion of Georges Bank (Fig. 9).

Salpidae abundance above 10,000 per 1000m³ occurs mainly in patches in the north and south Georges Bank and to the west and east of this area northward to Browns Bank. Concentrations of 1000 to 10,000 per 1000m³ were characteristic of a few stations south and west of Georges Bank and south of Browns Bank. The numbers decreased to <1000 per 1000m³ at many stations in eastern sections of Georges Bank and the Gulf of Maine. None of these organisms were found at many stations in the Gulf of Maine and in Georges Bank (Fig. 10).

Decapoda are found in quantities above 1000 per 1000m³ in small areas of the western and central parts of Georges Bank. Numbers <1000 per 1000m³ occurred at stations in Georges Bank and to the west of this area, Browns Bank northward and in a few stations in the Gulf of Maine. In the remaining areas no Decapoda were found (Fig. 11).

Mysidacea concentrations are found in the central and western parts of Georges Bank fishing grounds. Around this area the numbers of organisms decreases from 10,000 to 1000 per 1000m³. To the south of Georges Bank the number of Mysidacea is below 1000 per 1000m³. None were found in the Gulf of Maine or Browns Bank (Fig. 12).

Biomass

The total zooplankton biomass for the investigated areas has been calculated. Thus, the biomass in the range of 0.67 to 1.00 milliliters per cubic meter of water strained is characteristic only to the west of Georges Bank; 0.34 - 0.66 ml per m³ mainly occurs in Georges Bank westward and in the western and northern boundaries of the Gulf of Maine. Biomass values below 0.33m³ were characteristic for the central areas of the Gulf of Maine, Browns Bank and around the periphery of Georges Bank (Fig. 2).

Table 1 shows the mean biomass of 8 of the 10 dominant groups of zooplankton. The mean biomass was derived by using the mean weight of one organism according to Tschislenko (1968) nomograms. For Salpidae, body weight is 20% out of results counted from nomograms.

Copepoda weighed the least - 0.60 mg. and Euphausiacea the most, 12.60 mg. Mean biomass stated in grams per 1000 cubic meters of water strained in the areas of occurrence has been noted as follows: Copepoda with 265.65 g per $1000m^3$ made up 43.74% of the biomass and Salpidae made up the next highest percentage at 23.25%. Percentage contribution decreased among Euphausiacea 85.52 g=14.08%, Mysidacea 79.76 g=13.13% and Chaetognatha 23.06 g=3.80%. Mean biomass of the remaining groups - Amphipoda, Crustacea larvae and Decapoda has been noted in few numbers from 5.96 to 0.97 g making up 1%.

Total mean biomass has been estimated as 607.23 g per $1000m^3$ water strained in the area of occurrence.

Copepoda mean biomass did not change over areas investigated, but its proportional contribution increased to as much as 59.48%. Mean biomass of Salpidae decreased to 75.00 g=16.80%. Mean biomass of Euphausiacea decreased to 62.53 g and Chaetognatha to 21.11 g but the contribution of Chaetognatha to the whole biomass increased to 4.73%. An appreciable drop in mean biomass to 14.30 g=3.22% was observed in Mysidacea. Total mean biomass in the investigated areas has been noted as 446.58 g.

Observations of the frequency of occurrence, biomass and percentage participation (Table 1) of the 10 dominant zooplankton groups are relevant to discussions of distributions of plankton-feeding fishes. Copepoda is the dominant taxon in all respects. Next are Euphausiacea, Gastropoda and Mysidacea---the latter being of less importance because of their low frequency of occurrence. Large numbers of Salpidae were concentrated in areas of low concentrations of Copepoda suggesting competition with plankton eating fish for the Copepoda.

The total zooplankton biomass (Fig. 2) as well as the quantity of each individual animal group (Fig. 3-12) indicate that the biomass and the quantity of all animal groups in the central part of the Gulf of Maine is much lower than that of the Georges Bank, Browns Bank and the edges of the Gulf of Maine.

The variety of animal groups also appears to be smallest in the central and western parts of the Gulf of Maine and increases towards Browns Bank and Georges Bank reaching greatest diversity south of Georges Bank (Fig. 13).

Dry Material, Organic Elements and Ash

A great number of the samples (84 out of 145) have been examined in respect of dry material, organic elements and ash contents (Fig. 14 and 15). Water content ranged from 84-96%, and in most samples water percentage ranged from 91-95. Organic mass content ranged from 48-98% and in accordance with it was the ash content. In most of the samples organic mass content was approximately 90%.

The findings show that both Georges Banks zooplankton and Browns Bank's zooplankton have lower dry mass content in comparison with plankton of Gulf of Maine.

Similar situation is with the organic mass content, i.e. Georges Bank region and Browns Bank region are both of lower organic mass content than Gulf of Maine.

If we compare the data obtained of the dry mass, organic mass and ash contents (shown in Figs. 14, 15) with the material relative to total plankton biomass, to the main taxa biomass, and to taxa variety, we can see some relationships.

Thus, low dry mass and organic mass contents occur together with large plankton volume in water m^3 (Fig. 2) and also together with great taxa variety (Fig. 13). Probably this situation is affected by such taxa as Salpidae (Fig. 10) or Chaetognatha (Fig. 4) which occur in large amounts in this regions. High water content in plankton and low organic mass content were found there. The similar relationships occur between low dry mass and organic mass contents, and large volumes of crustacean larvae (Fig. 9) and of Appendicularia (Fig. 6). The influence of the taxon of the largest volume in water m^3 - Copepoda (Fig. 3) - on the above-mentioned relationships is not significant.

In this matter we can come to a strange conclusion: though the plankton of Gulf of Maine is of small volume in water cm, however, owing to low water content and large organic mass it has much higher feeding value than plankton volume in water m^3 would suggest.

Thus differences in plankton resources between Gulf of Maine, Georges Bank and Browns Bank are much smaller than the differences of plankton volume in water m^3 would suggest.

Reference

Tschislenko, L.L. 1968. Nomograms for weight determination of water organisms based on body size and shape of sea mezobenthos and plankton. Science Press, Leningrad.

Table 1. Occurrence frequency, quantity and biomass of main animals groups

No	Name of Group	Frequency of occurrence in per cent	Quantity in 1000m³ of water		Average weight of organisms / mg /	Average biomass of organisms /g/ 1000m³		Percentage participation	
			The occurrence area	The examined area		The occurr-ence area	The examined area	The occurr-ence area	The examined area
1.	Copepoda	100.00	442 766	442 766	0.60	265.65	265.65	43.74	59.48
2.	Chaetognatha	93.79	10 982	10 053	2.10	23.06	21.11	3.80	4.73
3.	Gastropoda	90.34	35 576	3 231	-	-	-	-	-
4.	Appendicularia	83.44	9 201	7 932	-	-	-	-	-
5.	Amphipoda	73.10	6 788	4 962	5.25	5.96	4.32	0.99	0.97
6.	Euphausiacea	72.41	1 137	823	12.60	85.52	62.53	14.08	14.00
7..	Crustacea larvae	60.68	4 106	2 633	1.26	5.17	3.31	0.85	0.72
8.	Salpidae	51.72	35 330	18 751	4.00	141.20	75.00	23.25	16.80
9.	Decapoda	20.00	312	116	3.31	0.97	0.36	0.16	0.08
10.	Mysidacea	18.62	34 235	6 138	2.33	79.76	14.30	13.13	3.22
						607.23	446.58	100.00	100.00

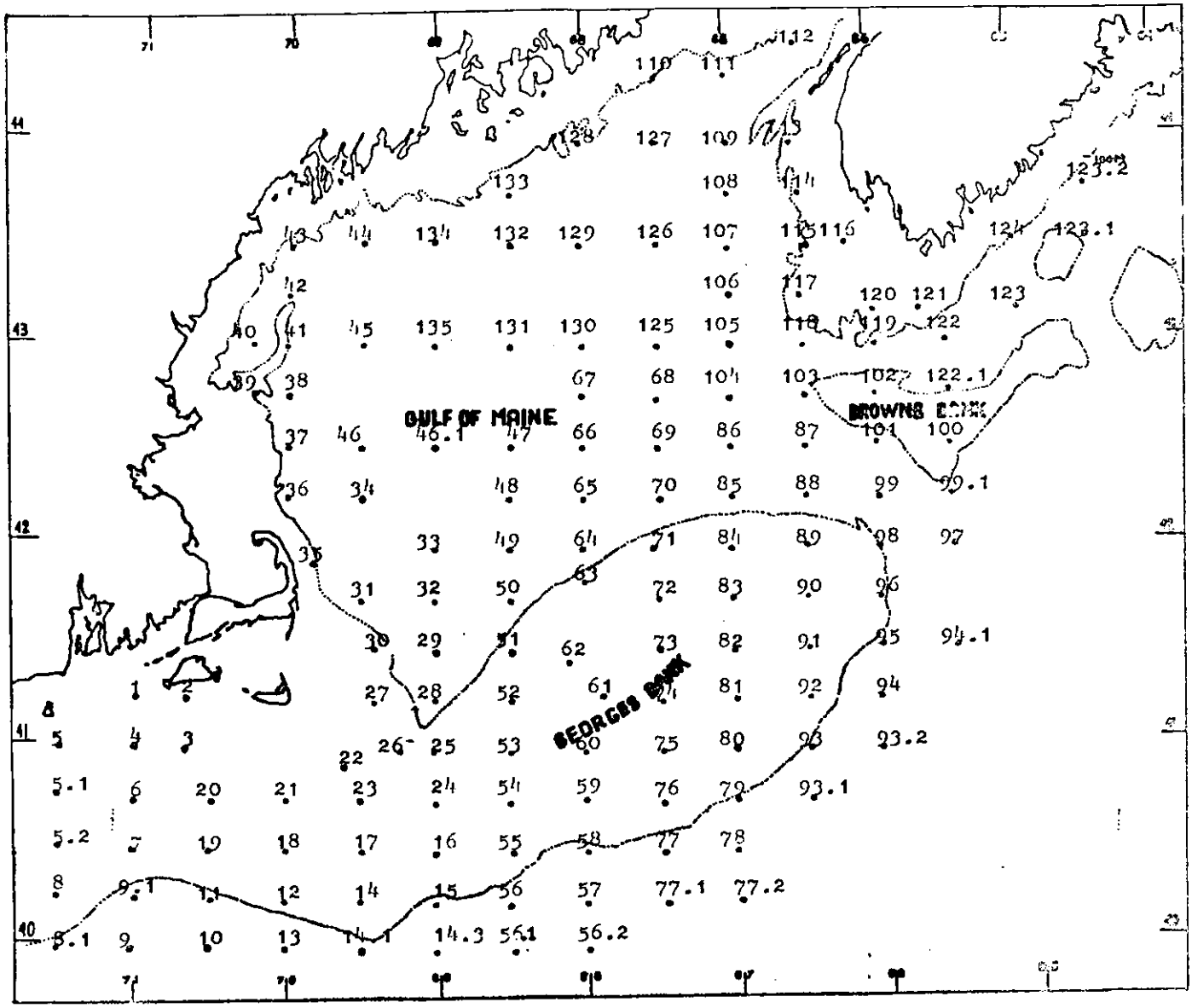

Fig. 1. Distribution of stations in the investigated areas

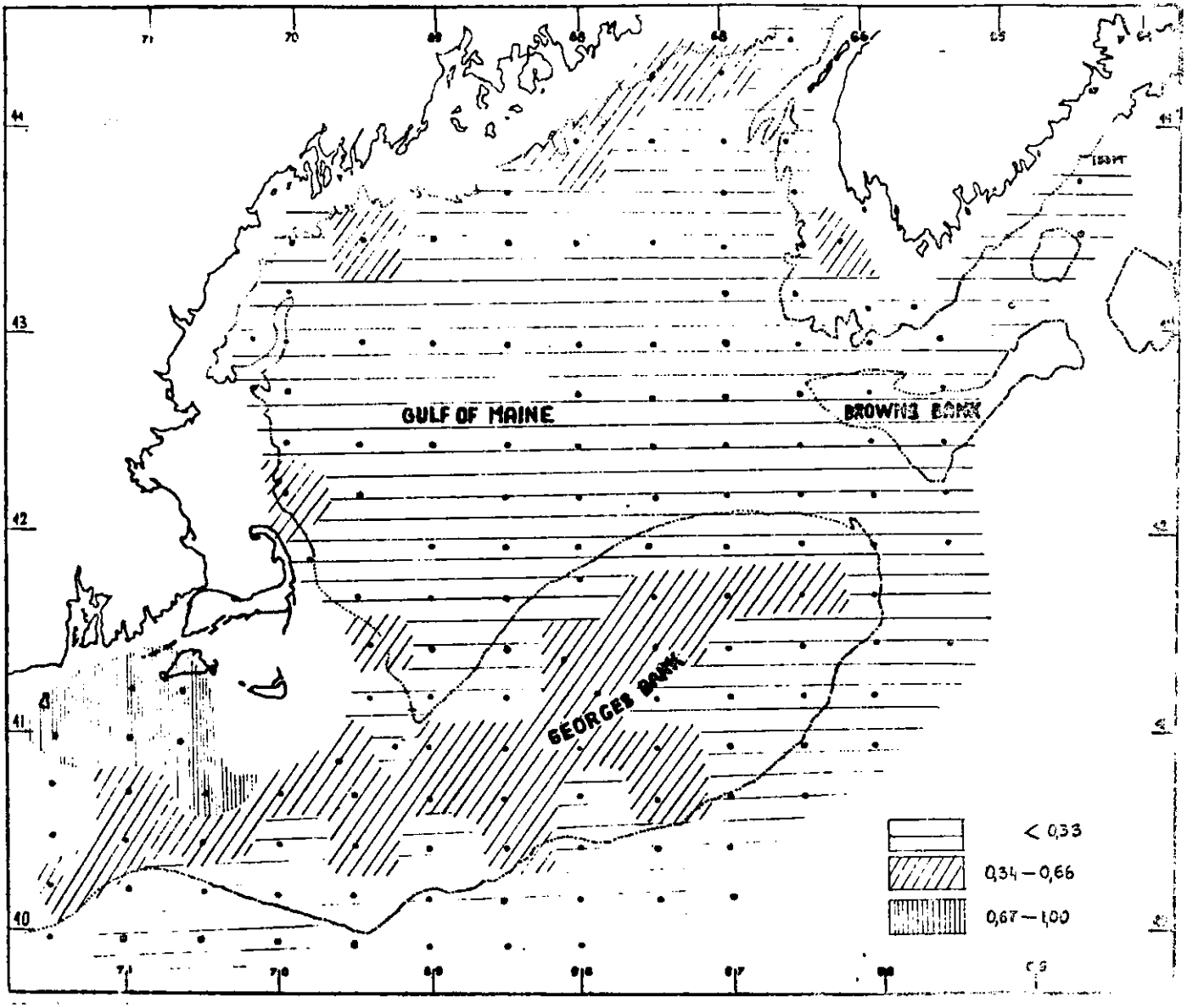

Fig. 2. ml of total zooplankton biomass per $1m^3$ water strained

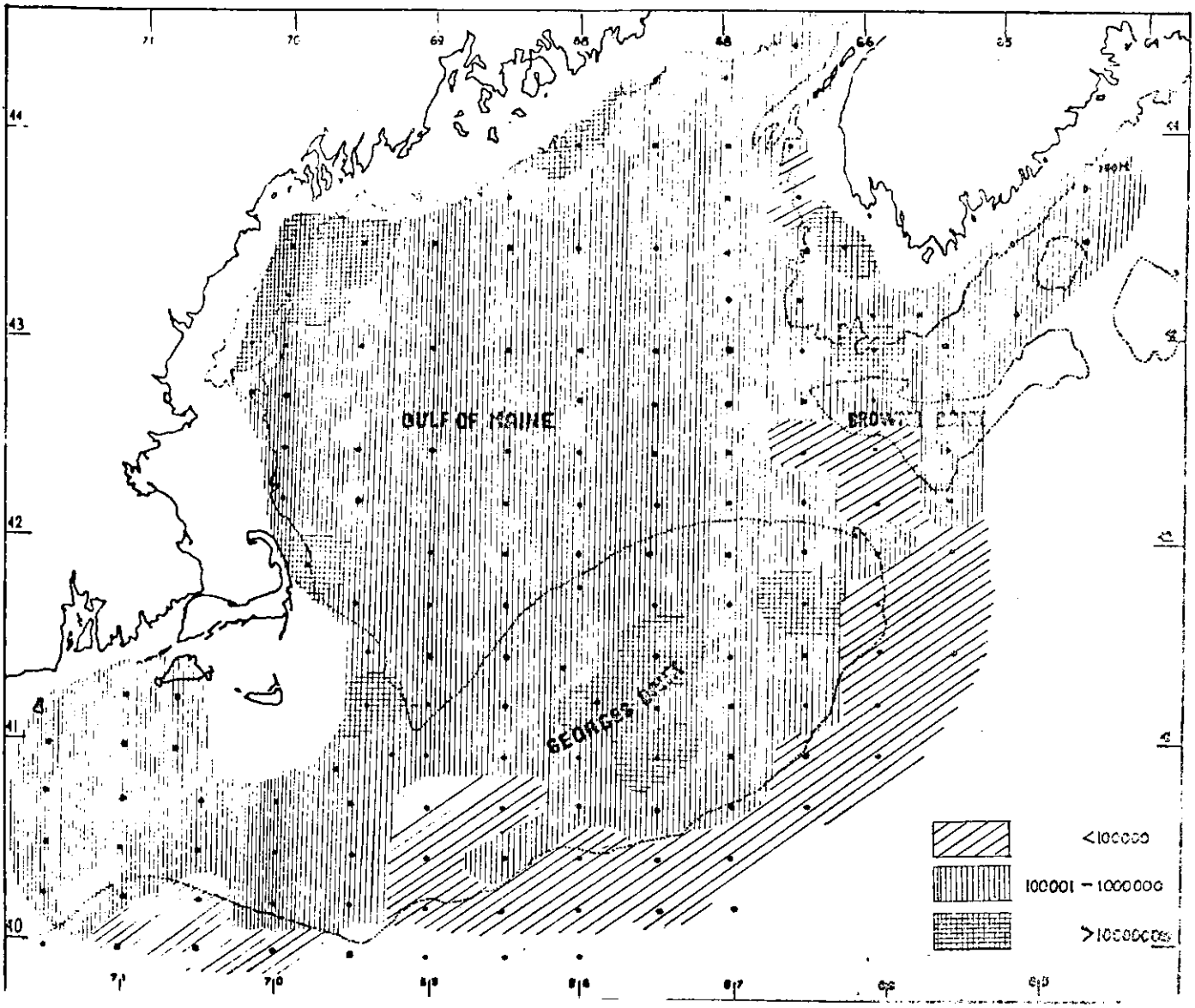

Fig. 3. Number of Copepoda per 1000 m^3 water strained.

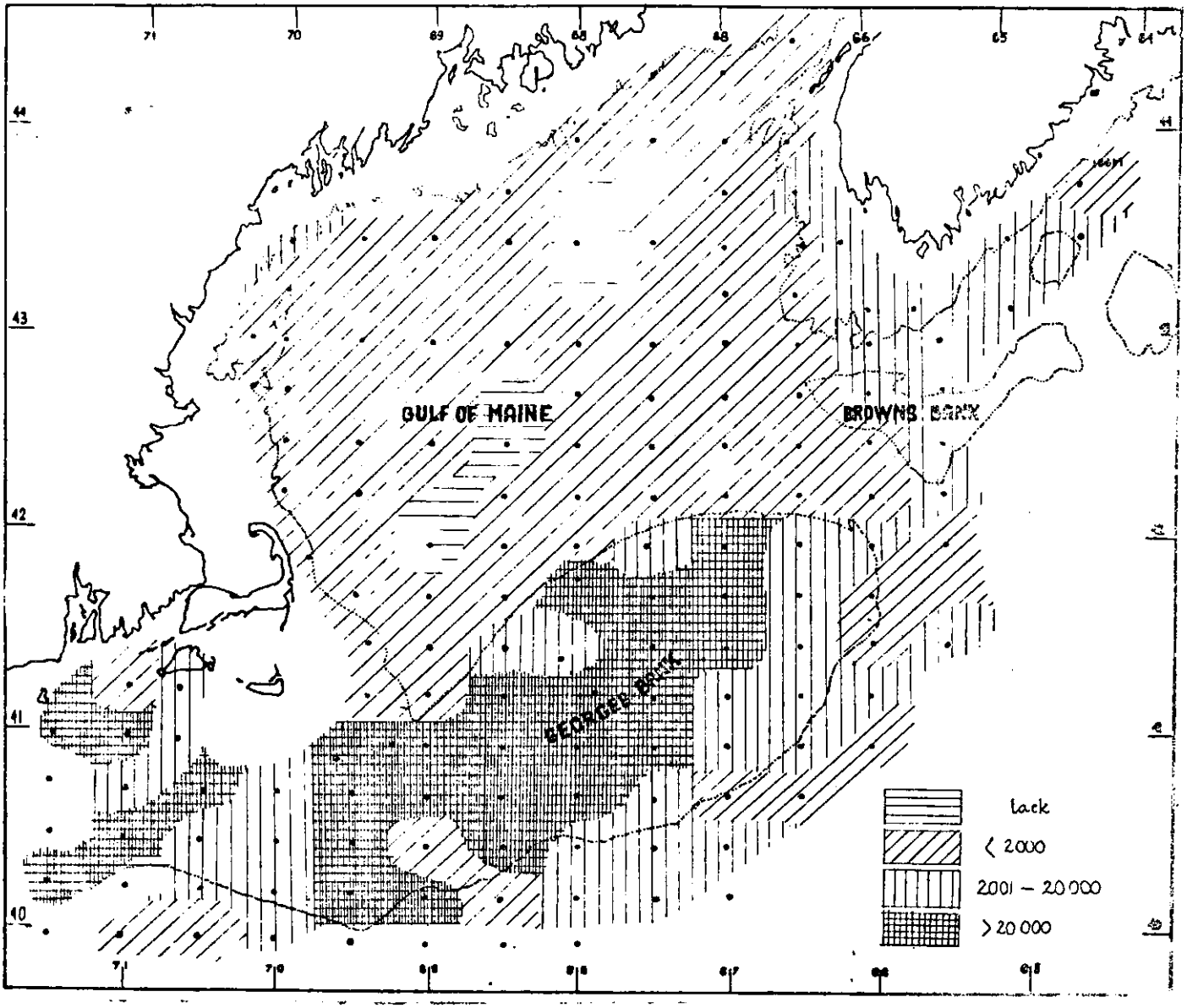

Fig. 4. Number of Chaetognatha per 1000 m^3 water strained.

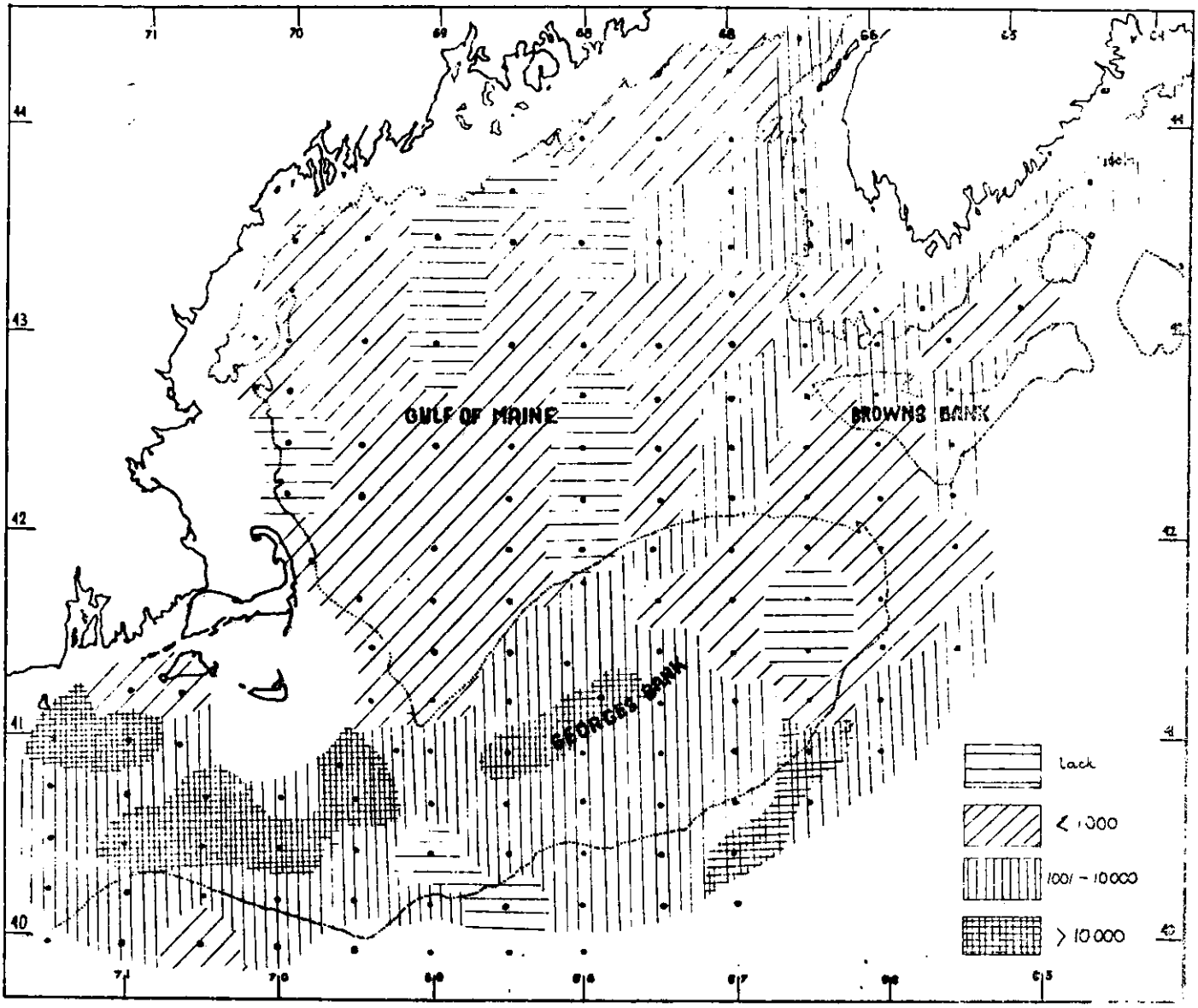

Fig. 5. Number of Pteropoda and Castropoda per 1000 m^3 water strained.

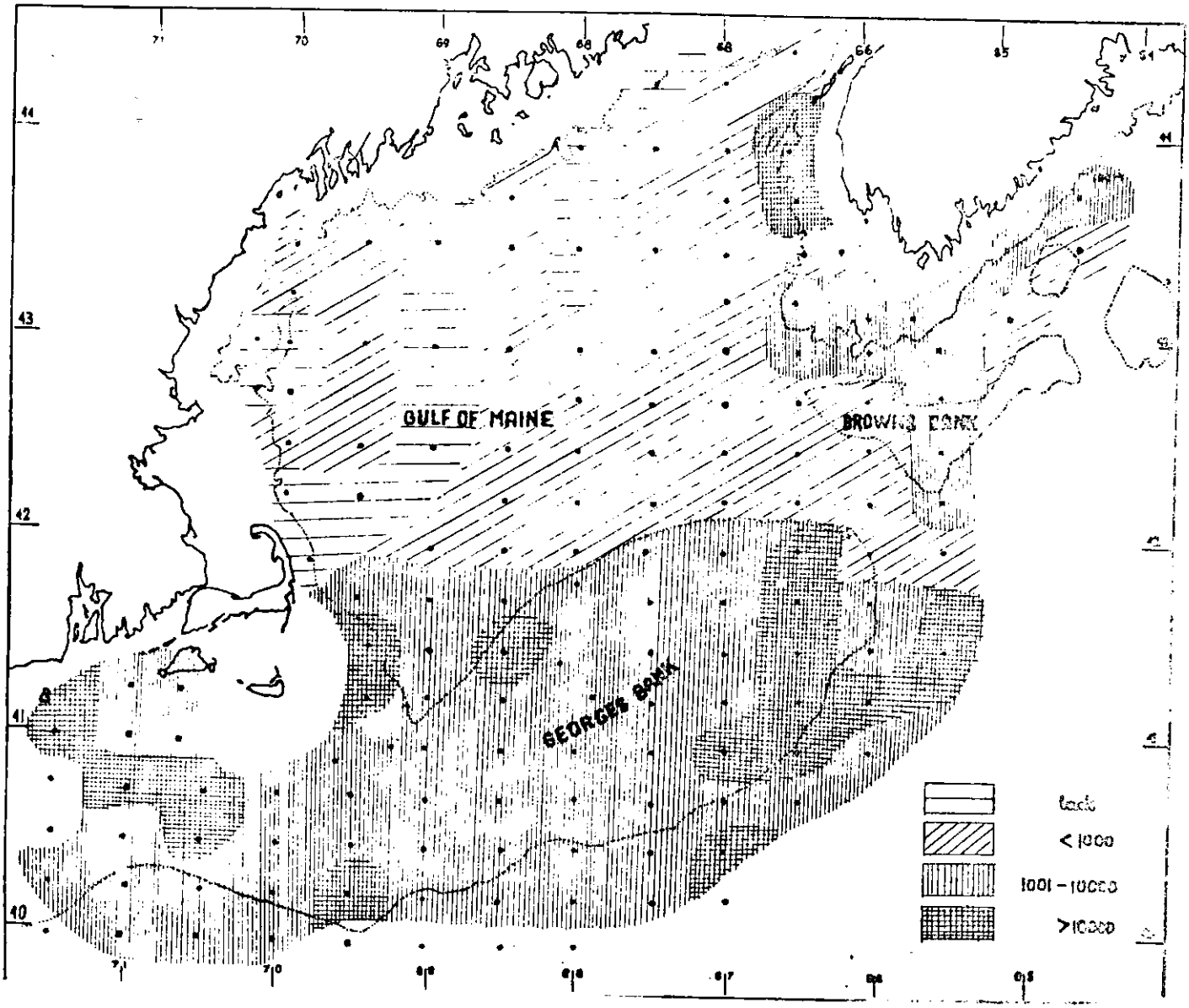

Fig. 6. Number of Appendicularia per 1000 m^3 water strained.

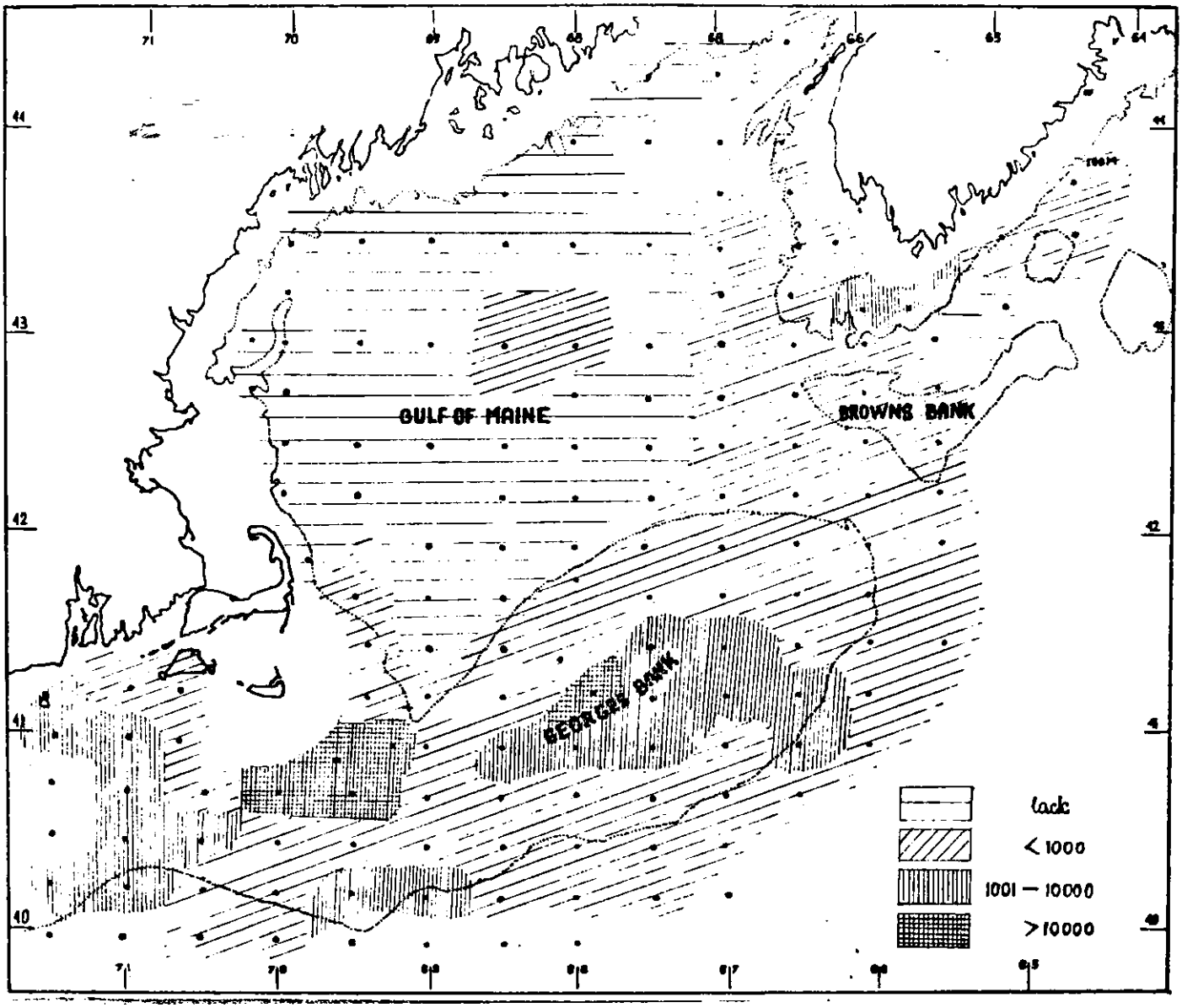

Fig. 7. Number of Amphipoda per 1000 m^3 water strained.

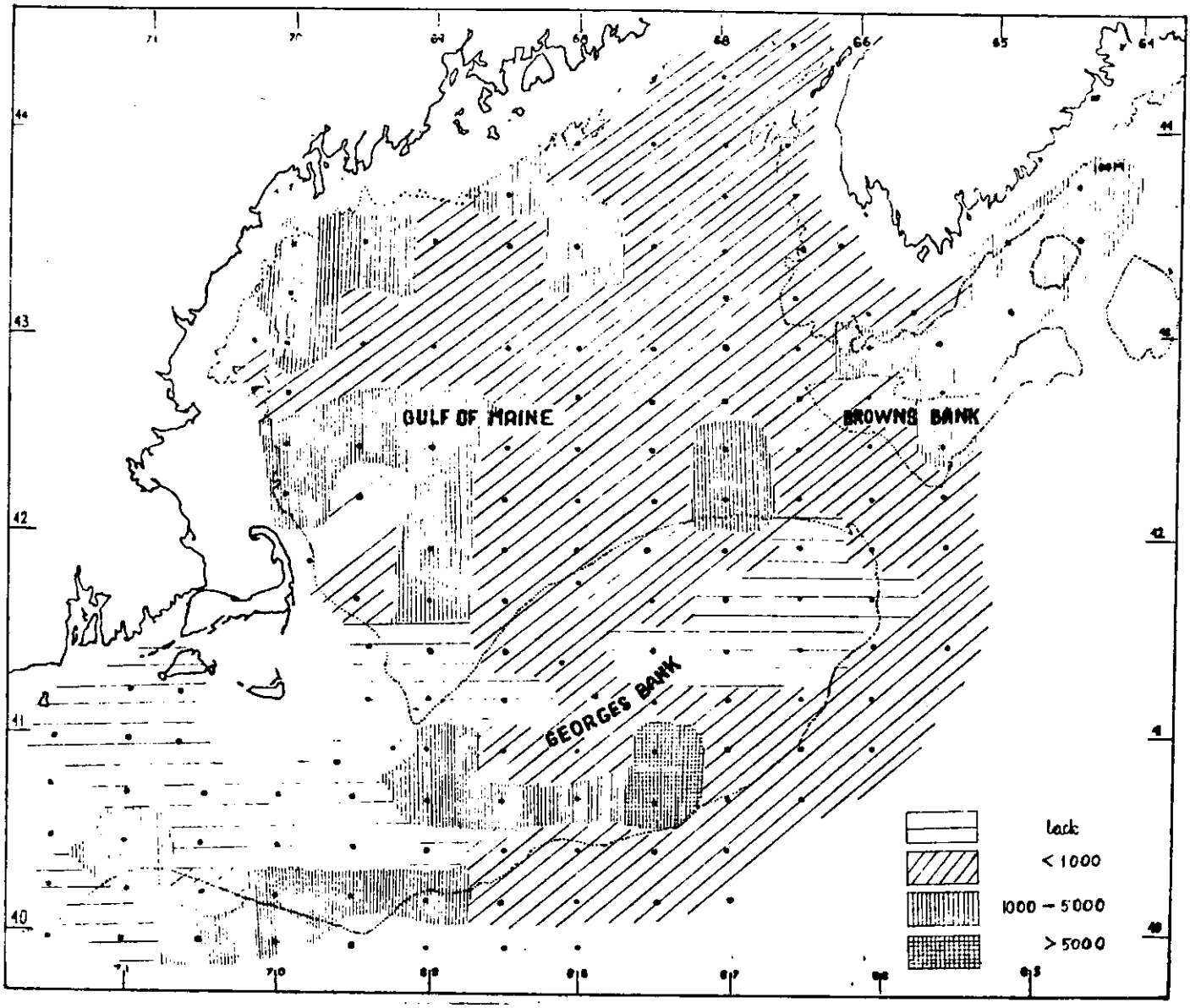

Fig. 8. Number of Euphausiacea per 1000 m^3 water strained.

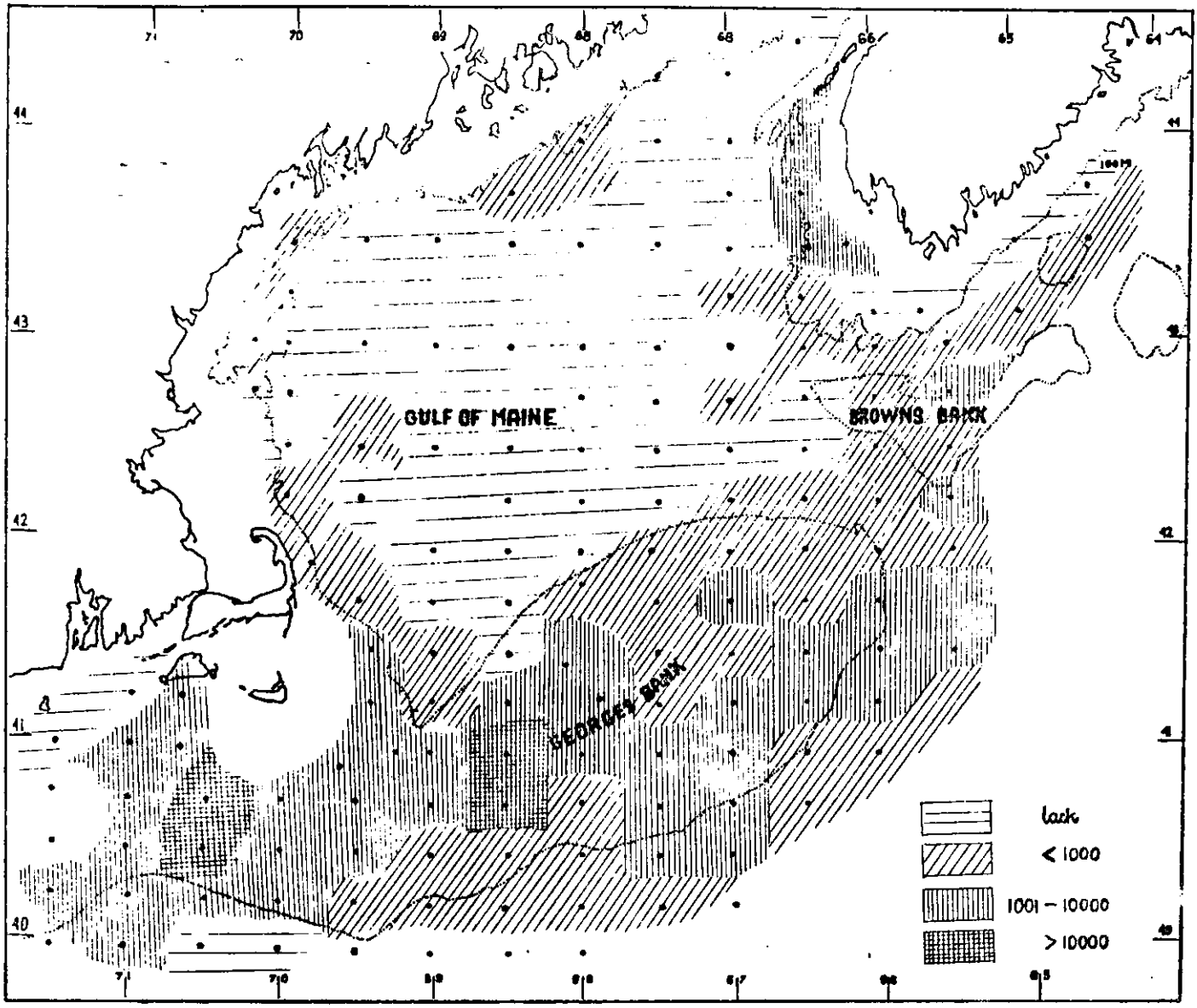

Fig. 9. Number of Crustacea larvae per 1000 m^3 water strained.

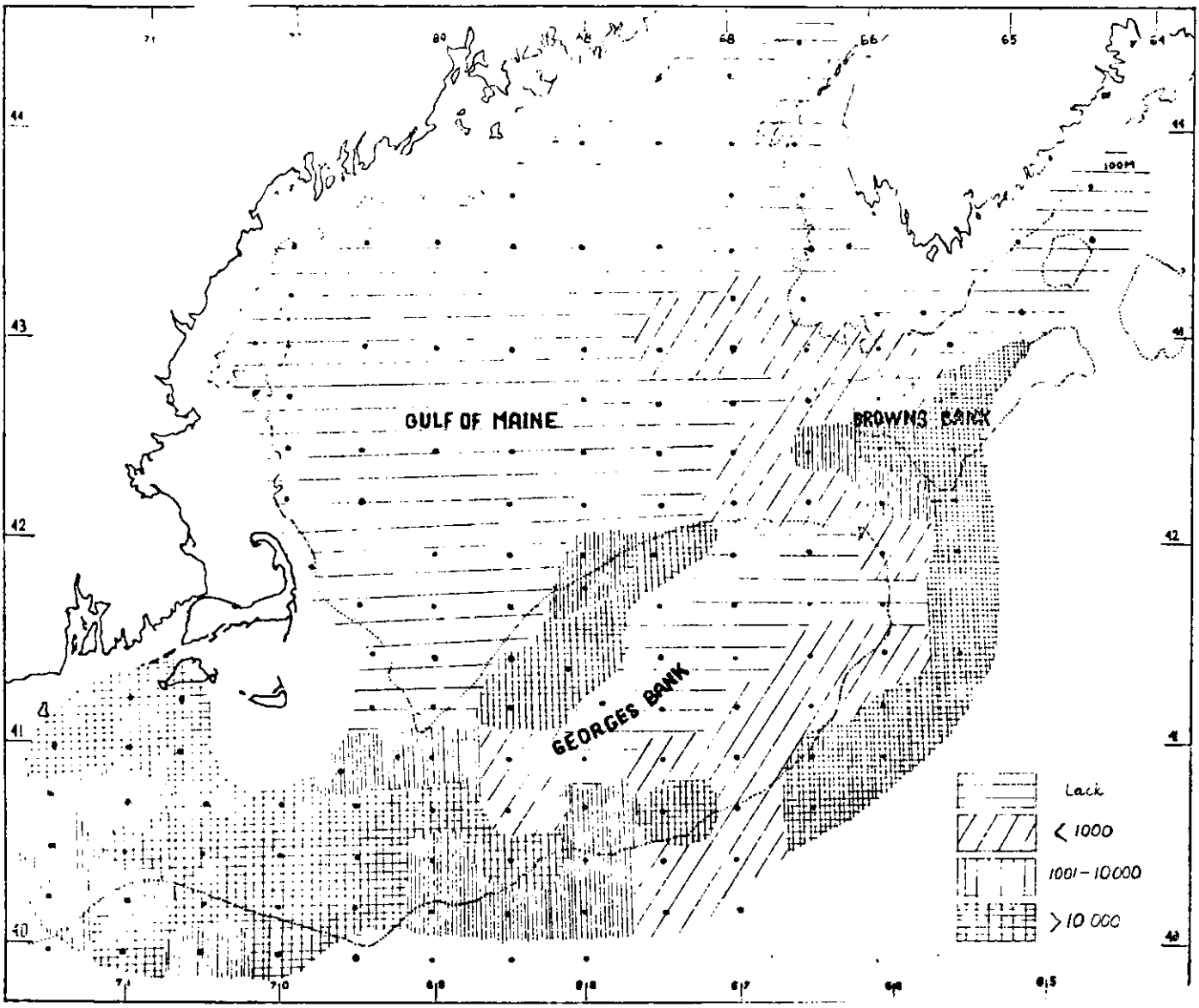

Fig. 10. Number of Salpidae per 1000 m^3 water strained.

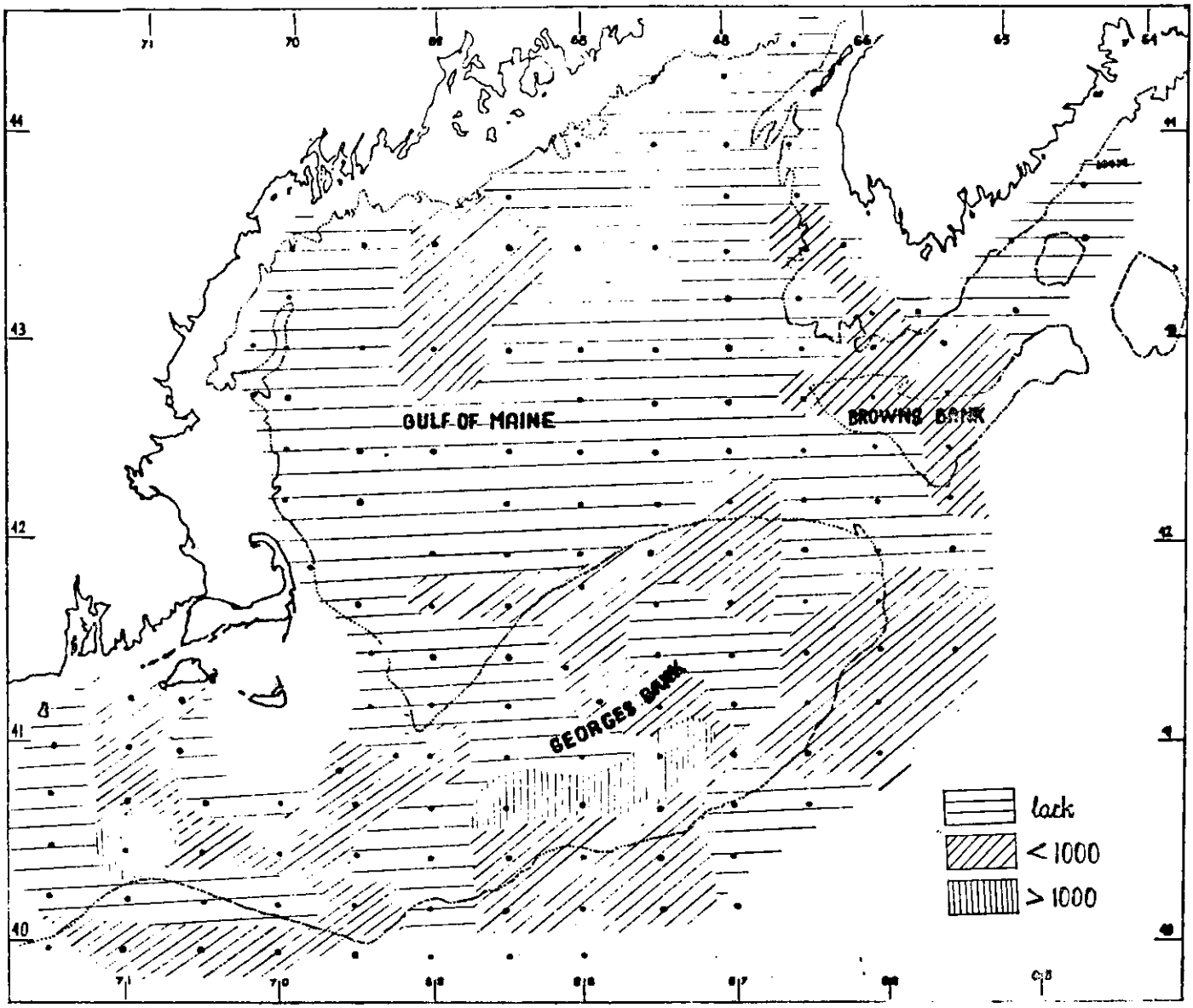

Fig. 11. Number of Decapoda per 1000 m^3 water strained.

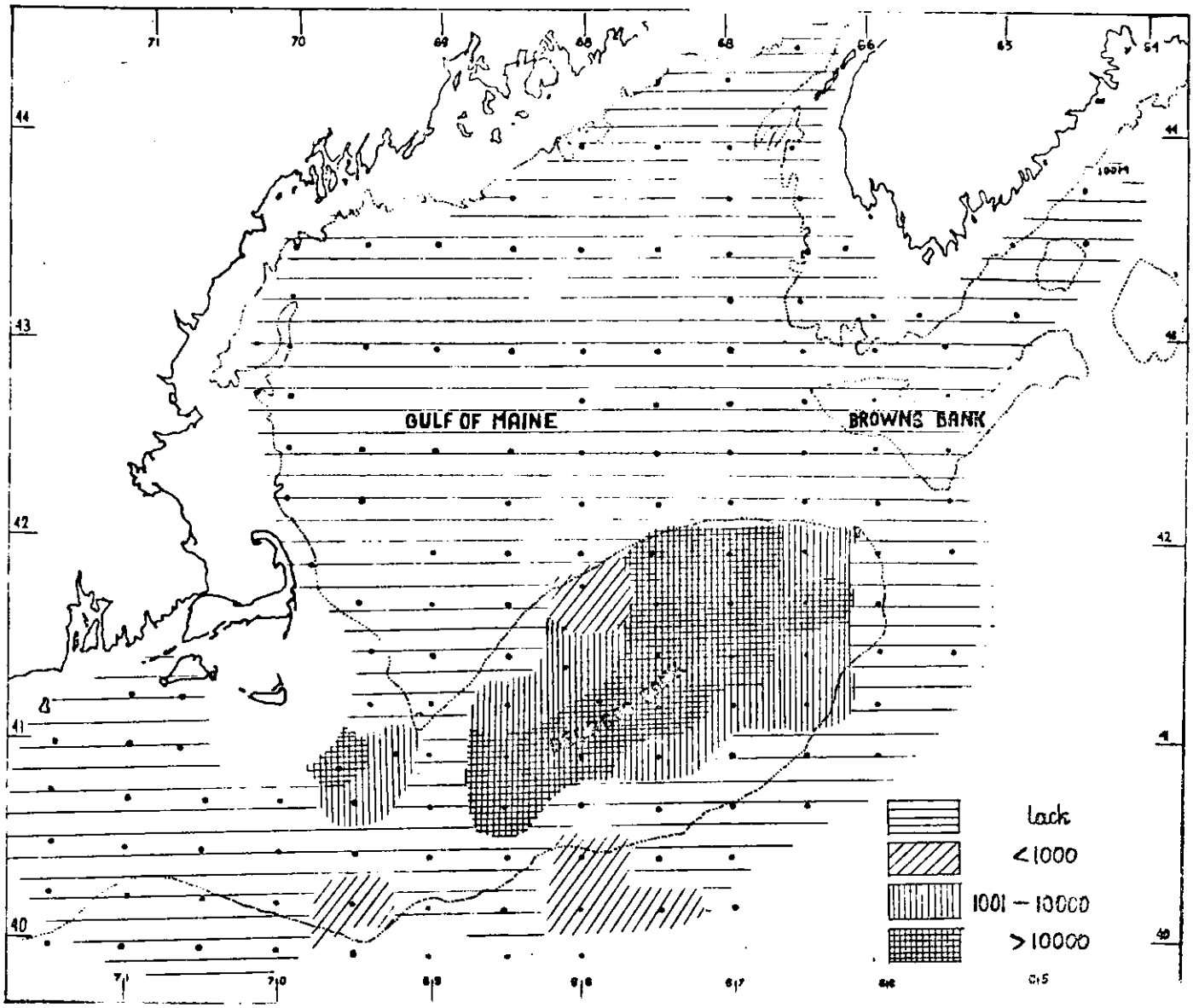

Fig. 12. Number of Mysidacea per 1000 m^3 water strained.

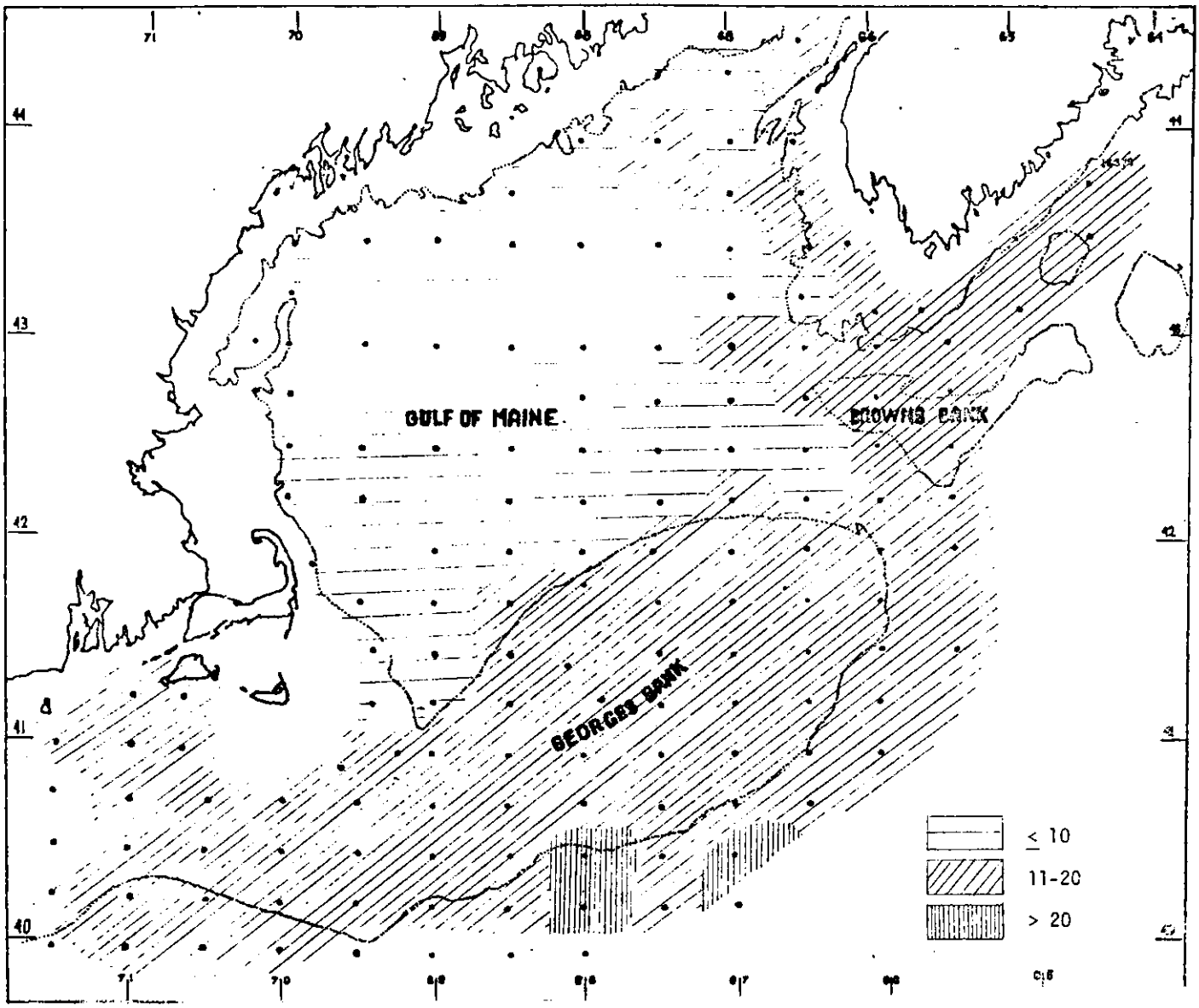

Fig. 13. Variety of planktonic fauna/animals groups in the investigated areas.

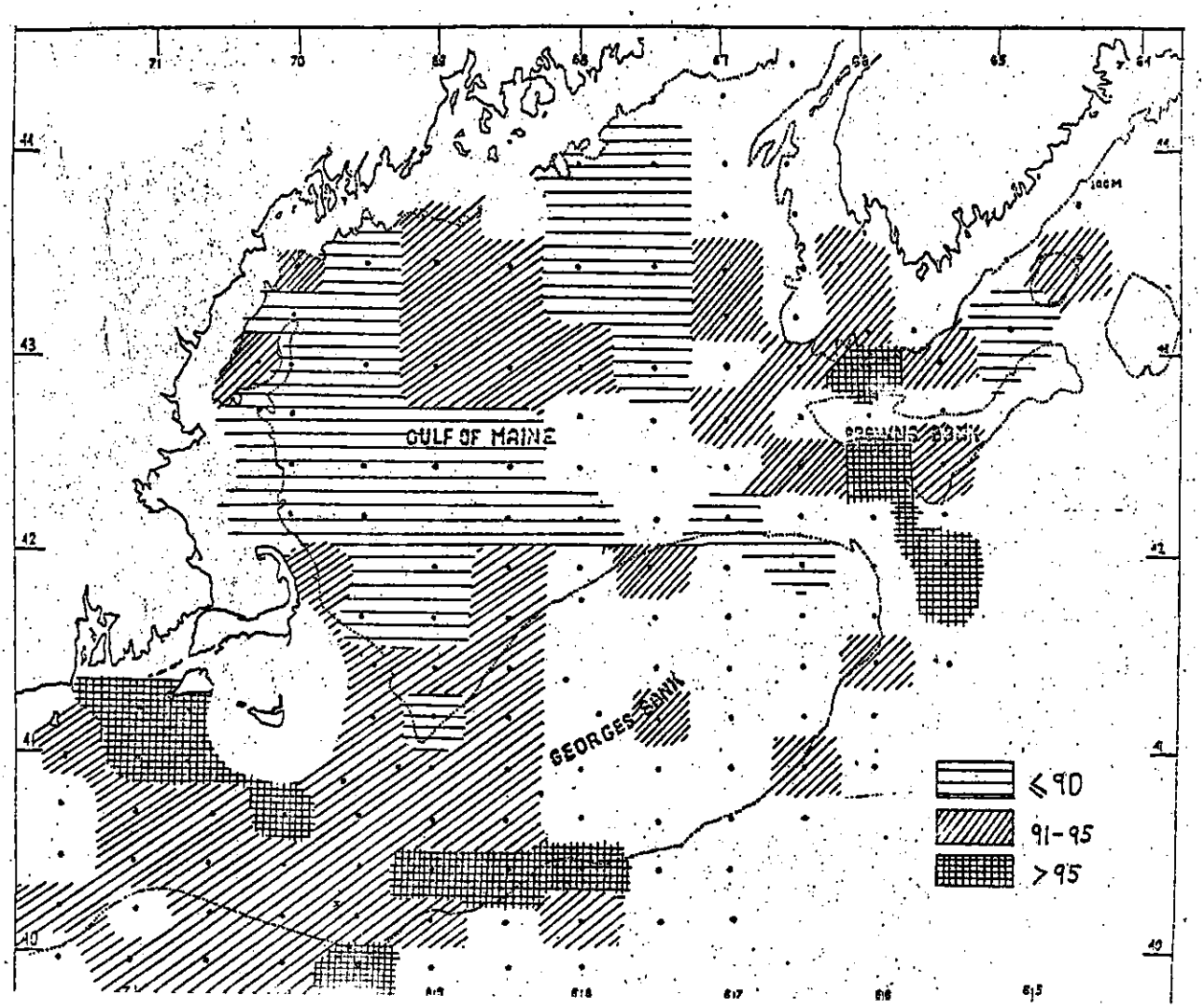

Fig. 14. Water content (%) in plankton.

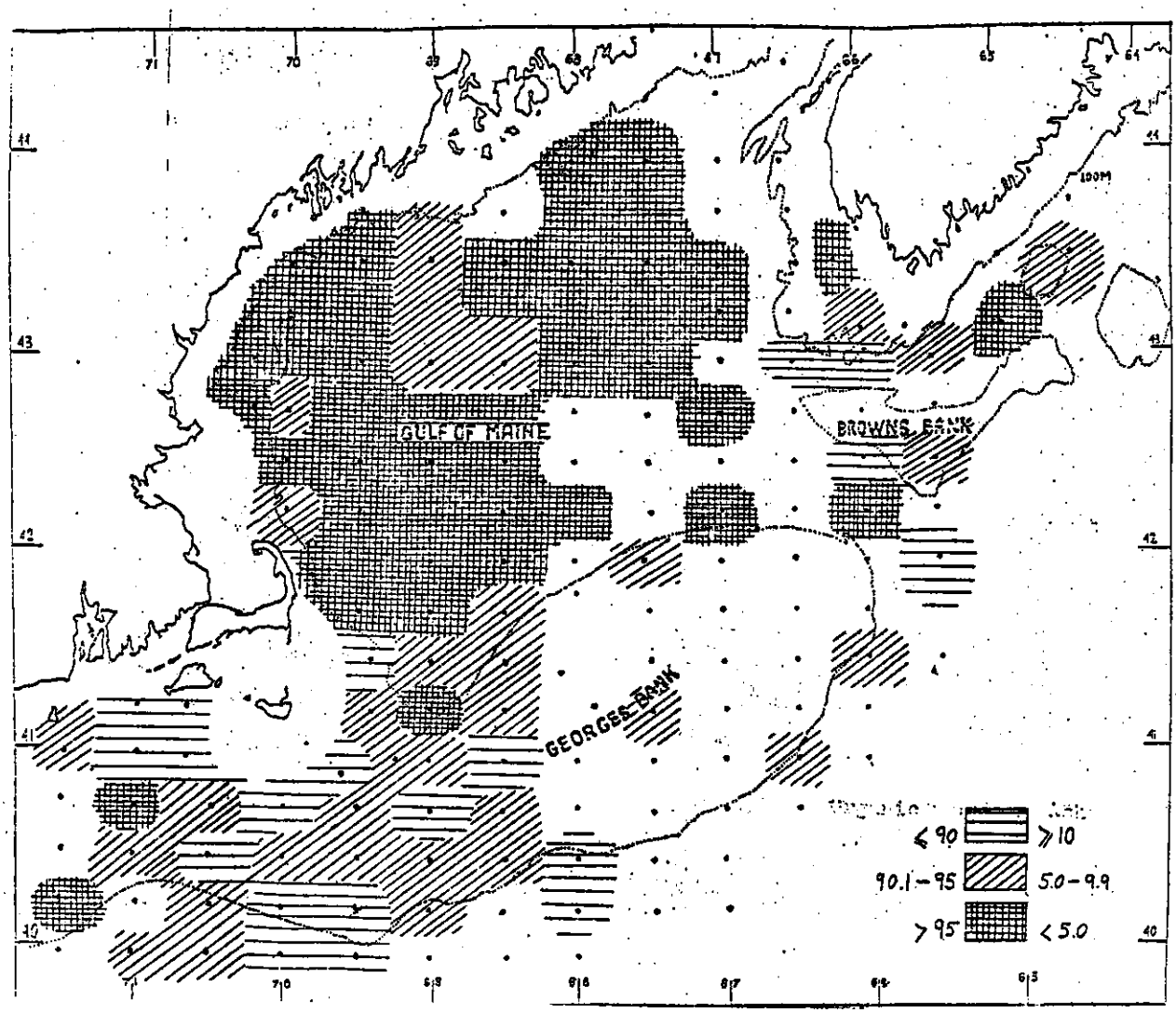

Fig. 15. Organic mass and ash contents (%) in plankton.