THE ARCTIC SEAS

Climatology, Oceanography, Geology, and Biology

Edited by

Yvonne Herman

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Contents

15: Arctic Ocean Mysids *(Crustacea, Mysidacea)*: Evolution, Composition, and Distribution

V. V. Petryashov

INTRODUCTION

Forty species of mysids belonging to 20 genera, 2 families, and 1 suborder have been described from the Arctic Ocean. These species belong to 5 biogeographic groups. There is a decline in the number of species northward and eastward of the adjacent Atlantic boreal waters (from 27 to 4 or 3 species) and a slight increase in the area of mixing of Arctic and Pacific waters (up to 5 species). Atlantic boreal and amphiboreal species are predominant in the Norwegian Sea, the southwestern part of the Barents Sea, and the Greenland Sea; Pacific boreal species dominate in the Chukchi Sea off the Alaskan coast, and boreal–Arctic and Arctic species dominate in other areas of the Arctic Ocean. Species that belong to different biogeographic groups occur in specific water masses. The distributional patterns of the recent mysid fauna were established at the onset of the Postglacial transgression with the development of present-day water circulation in the Northern Hemisphere.

Note: This chapter has been reviewed, edited, and rewritten by the Editor, Yvonne Herman.

PREVIOUS STUDIES

Studies of the Arctic Ocean Mysidacea (restricted to the area north of the Wyville-Thomson Ridge, the southern coast of the Baffin Bay, the eastern part of the Hudson Strait, and the Bering Strait) commenced in the first half of the nineteenth century. Ross (1835) mentioned *Praunus (= Mysis) flexuosus* in his work on marine invertebrates collected during his second voyage to the Arctic regions. Further studies of mysids from this area were carried out in the second half of the nineteenth century by Walker (1862), Jarzynsky (1870), Sars (1870), and Miers (1877). These investigations dealing with mysids collected mainly in the Norwegian, Barents, and White seas were followed by a study of Mysidacea off the northwestern and northern coast of Alaska (Murdoch, 1885*a*,*b*). Simultaneously intensive studies of mysids from the Norwegian, Greenland, and Barents

seas as well as from the Baffin Bay commenced (Sars, 1885, 1886; Hansen, 1888, 1908; Aurivillius, 1896; Vanhöffen, 1897; Birula, 1897; Stebbing, 1900; Ohlin, 1901; Gerstaecker and Ortmann, 1901; Ortmann, 1901).

The results allowed Zimmer (1904, 1909) to draw the first conclusions concerning the Arctic Mysidacea based on his study of 32 species from the Arctic Ocean within the geographical limits mentioned above. Studies by Linko (1907, 1908) off the northern Russian coast and by Stephensen (1912, 1913, 1918, 1933, 1938) in the seas surrounding Greenland were subsequently published. Investigations by Paulson (1909), Kramp (1913), Björck (1916), Schmitt (1919), Madsen (1936), Bertelsen (1937), Saemundsen (1937), and Dunbar (1940) dealing with mysids or coastal plankton containing Mysidacea from Iceland, Greenland, and the North American coast should also be mentioned. During the last decades the Arctic Ocean mysids were studied by Holmquist (1949, 1958, 1959, 1963, 1982), Rusanova (1962, 1963, 1971), and Kulikov (1980). In addition to the study of Arctic species, the investigation of this group in other regions was underway (Czerniavsky, 1887; Holt and Tattersall, 1905; Illig, 1930; Tattersall, 1951; Mauchline, 1980; Mauchline and Murano, 1977). However, to date the study of the Central Arctic Basin mysids has been inadequate.

MATERIAL AND METHODS

The results presented in this chapter are based on our studies of Mysidacea from the collection of the Zoological Institute of the USSR Academy of Sciences (710 samples containing 5,500 specimens were analyzed). Most of these samples were collected with a Sigsbee dredge and a few were collected with a Djedy net.

DISTRIBUTIONAL PATTERNS

Our results and literature data indicate that 40 species of mysids inhabit the Arctic Ocean; they belong to 1 suborder, 2 families, and 20 genera. The number of species inhabiting the Arctic Ocean constitute 5 percent of the world fauna.

Changes in species composition in different sectors of the Arctic Ocean were analyzed. The degree of similarity of faunas in these areas was determined using the Chekanovsky–Sørensen index (Sørensen, 1948):

$$I_{CS} = \frac{2 \cdot C \cdot 100\%}{D_1 + D_2}$$

and the degree of similarity of faunas was determined using the Jaccard index (Jaccard, 1901):

$$I_J = \frac{C \cdot 100\%}{D_1 + D_2 - C}$$

For the degree of inclusion of fauna of one area into the fauna of another region the index of Shimkevich (Simpson, 1943) was used:

$$I_{SZS} = \frac{C \cdot 100\%}{D_{min}}$$

For these three equations, C is the number of species in common, D_1 and D_2 are the numbers of species in the areas compared, and D_{min} is the minimum number of species in the areas compared ($D_{min} \leq D_{max}$).

The results of our calculations are given in Table 15-1. The data obtained indicate a rapid decline in the number of species northward and eastward from the adjacent Atlantic boreal waters (from 27 to 4 to 3 species) and a slight increase in the area of mixing of Arctic and Pacific waters (up to 5 species). The mysids of the Norwegian and southern regions of the Barents Sea

are of boreal character and differ from their counterparts in other regions. The fauna of this area has close affinities with faunas of the coast of eastern Greenland and the southern Baffin Bay (as far as 75°NL); there is a great similarity between the faunas of these areas and the mysids from the continental slope off the Central Arctic Basin from Spitzbergen and up to the northern Laptev Sea. The fauna of most of the remaining area of the coastal Arctic region is rather monotonous. The only exception is the Chukchi Sea: Its northwestern regions support a fauna similar to that of the adjacent East Siberian Sea. Off of the Alaskan coast the mysids closely resemble the faunal composition of taxa from analogous coastal regions of the Siberian Sea and the Canadian Arctic Archipelago.

BIOGEOGRAPHIC DISTRIBUTION

The following biogeographical groups are recognized:

I. Boreal-subtropical species

1. Atlantic upper sublittoral boreal-subtropical species: *Hemimysis lamornae:* in the Atlantic boreal and subtropical as well as in the Mediterranean–Lusitanian areas (Zimmer, 1904).
2. Atlantic bathypelagic boreal-subtropical species found in the adjacent Arctic sector as well: *Boreomysis tridens* (Plate 15-I, *a*), found in the Atlantic boreal and subtropical Mediterranean–Lusitanian areas and off the Greenland coast (Stephensen, 1933; Tattersall, 1951).
3. Amphiboreal-subtropical species, found in the Atlantic sector of the Arctic: *Boreomysis arctica* and *B. microps;* in boreal and subtropical waters of the Northern Hemisphere, in the Atlantic sector of the Arctic, reported off Greenland and off Franz Josef Land (Zimmer, 1904, 1909; Stephensen, 1913; Tattersall, 1951).

II. Atlantic boreal species

1. Upper sublittoral ubiquitous boreal species: *Neomysis integer, Praunus flexuosus, P. inermis* (Plate 15-I, *b*), and *Schistomysis ornata,* present in the temperate waters of the North Atlantic from the English Channel in the south to Murman and the southern Novaya Zemlya Island to the north (Zimmer, 1904, 1909; Linko, 1908).
2. Elittoral*-upper bathyal ubiquitous boreal species: *Erythrops microps, E. serrata, Pseudomma affine, Mysideis insignis, Mysidopsis didelphys,* and *Hemimysis abyssicola:* in the boreal waters of the North Atlantic and Arctic Ocean from the English Channel and Cape Cod to the south, up to the southern regions of Baffin Bay (up to 71–75°NL), along the eastern coast of Greenland (up to 76–78°NL), Nordkapp Cape, and West Murman to the north (Zimmer, 1904, 1909; Linko, 1908; Tattersall, 1951).
3. Bathyal ubiquitous boreal species: *Erythrops glacialis, Parerythrops spectabilis,* and *Michthyops parva.* Their distribution is analogous to species of the previous biogeographic group (Vanhöffen, 1897; Zimmer, 1904; Stephensen, 1913; Tattersall, 1951).
4. Sublittoral high boreal.† Species: *Dactylamblyops sarsi,* and *Mysis mixta* with distributions similar to species of the above-mentioned biogeographic groups; however, they penetrate southward only as far as the coast of southern Norway, Faroes Islands, Massachusetts Bay, off the eastern coast of Greenland in the

*Elittoral zone of Kjelman (1877) ranging from 55–70 m to 120–180 m, bathyal zone of Appellof (1912) ranging from 200 m to 2000 m (in Golikov, 1985*a*).

†High boreal species are boreal species occurring in the northern parts of the boreal region; in the Atlantic and Arctic they do not penetrate south of Massachusetts Bay, Faroes Islands, Norway (off Bergen). Their northern limits of distribution are the same as those of the above-mentioned biogeographic group.

Table 15-1. Results of the Calculations of Biogeographic Indexes.

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
1	14	37.5 64.29	24.24 57.14	22.58 50	30 42.86	50 61.54	37.5 75	44.44 66.66	28.57 100	50 80	31.85 71.43	20 75	11.76 40	5.0 14.29	13.33 100
2	54.55 9	19	43.75 73.68	34.38 57.89	22.22 42.85	45.45 76.92	17.39 50	34.78 66.66	9.52 50	31.82 70	18.18 57.14	9.52 50	9.09 40	4.0 14.29	10 66.66
3	39.02 8	60.87 14	27	88.88 100	37.67 78.57	25 61.54	12.9 50	21.88 58.33	0 0	15.63 50	9.68 42.86	0 0	0 0	0 0	0 0
4	36.84 7	57.89 11	94.12 24	24	40.75 78.57	27.59 61.54	14.29 50	24.14 58.33	0 0	17.24 50	10.71 42.86	0 0	0 0	0 0	0 0
5	42.86 6	36.36 6	53.66 11	57.89 11	14	42.11 61.54	46.67 87.5	44.44 66.66	12.5 50	33.33 60	10.53 28.57	12.5 50	11.76 40	5.0 14.29	13.33 66.66
6	59.26 8	62.5 10	40 8	43.24 8	59.26 8	13	40 75	66.66 83.33	13.33 50	64.29 90	33.33 71.43	13.33 50	12.5 40	5.26 14.29	14.29 66.66
7	54.55 6	29.63 4	22.88 4	25 4	63.64 7	57.14 6	8	33.33 62.5	33.33 75	38.46 50	25 42.86	33.33 75	18.18 40	7.14 14.29	22.22 66.66
8	61.54 8	51.61 8	35.9 7	38.89 7	61.54 8	80 10	50 5	12	23.07 75	83.33 100	35.31 71.43	14.29 50	13.33 40	5.56 14.29	15.38 66.66

9	44.44 4	17.39 2	0 0	0 0	22.22 2	23.53 2	50 3	37.5 3	4	27.27 75	57.14 100	60 75	28.57 50	10 25	75 100
10	66.66 8	48.28 7	27.03 5	29.41 5	50 6	78.26 9	55.55 5	90.91 10	42.86 3	10	41.66 71.43	16.67 50	15.38 40	6.25 14.29	30 100
11	47.52 5	30.77 4	17.65 3	19.35 3	19.05 2	50 5	40 3	52.63 5	72.72 4	58.82 5	7	37.5 75	20 40	7.69 14.29	42.86 100
12	33.33 3	17.39 2	0 0	0 0	22.22 2	23.53 2	50 3	25 2	75 3	28.57 2	54.55 3	4	50 75	22.22 50	40 66.66
13	21.05 2	16.67 2	0 0	0 0	21.05 2	22.22 2	30.75 2	23.53 2	44.44 2	26.66 2	28.57 2	66.66 3	5	33.33 60	33.33 66.66
14	9.52 1	7.69 1	0 0	0 0	9.52 1	10 1	13.33 1	10.53 1	18.18 1	11.76 1	14.29 1	36.36 2	50 3	7	11.11 33.33
15	35.29 3	18.18 2	0 0	0 0	23.53 2	25 2	36.36 2	26.67 2	85.71 3	46.15 3	60 3	57.14 2	50 2	20 1	3

Arranged Diagonally: Number of Mysid Species. Lower Left Corner Above Chekanovsky-Sørensen Coefficient: Number of Species the Regions Have in Common (bottom). Upper Right Corner: Jaccard Coefficient (top). Shimkevich-Simpson Coefficient (bottom).

Regions: 1, Baffin Bay; 2, eastern Greenland; 3, Norwegian Sea, region of Tronheim; 4, Norwegian Sea, region of Lofoten Islands; 5, southwestern Barents Sea; 6, northern Barents Sea; 7, Barents Sea southwest of the Novaya Zemlya; 8, northern Kara Sea and Novaya Zemlya Kara Sea trough; 9, southeastern Kara Sea and Laptev Sea; 10, northern Laptev Sea; 11, East Siberian Sea; 12, Chukchi Sea, east of Wrangel Island; 13, Chukchi Sea area off Point Barrow; 14, Bering Sea, Anadyr Bay; 15, Straits of the Canadian Arctic Archipelago.

southern parts of the boreal region; in the Atlantic and Arctic from the English Channel, the southern coast of Ireland, and Cape Cod (eastern coast of the United States) to the south; up to Novaya Zemlya, the western coast of Spitzbergen, Iceland, southern parts of the Baffin Bay, and in the Intermediate Water Mass of the Greenland Sea to the north; (up to 72°N) (Zimmer, 1904; Linko, 1908; Tattersall, 1951).

5. Bathypelagic high boreal species distributed in the sector adjacent to the Arctic: *Boreomysis nobilis* is present from the Faroes Islands, Iceland, eastern coast of Canada up to Greenland (up to 77°NL off the eastern coast and up to 75°NL in Baffin Bay) off Spitzbergen (Hansen, 1888; Vanhöffen, 1897; Ohlin, 1901; Zimmer, 1904, 1909) and Franz Josef Land.
6. Meso-bathypelagic amphiboreal species: *Amblyops abbreviata* (Plate 15-I, *c*), present in the temperate waters of the Atlantic, Pacific, and Arctic Ocean but absent from the Arctic water masses (Zimmer, 1904, 1909; Linko, 1908; Tattersall, 1951).

III. Sublittoral Pacific boreal species penetrating into the Chukchi and Beaufort Seas: *Neomysis rayii, Exacanthomysis arctopacifica,* and *Xenacanthomysis pseudomacropsis* (Murdoch, 1885*a,b;* Holmquist, 1982).

IV. Bathyal-pseudoabyssal* bipolar species: *Birsteiniamysis inermis* (Plate 15-I, *d*), observed in the Antarctic region and Subantarctic, in the North Pacific, North Atlantic, and Arctic (Zimmer, 1904; Stephensen, 1913; Tattersall, 1951).

*Pseudoabyssal of Derjugin (1915) basins in the bathyal zone 2,000–5,000 m depth not connected with the seafloor (in Golikov, 1985*a*).

V. Boreal–Arctic species

1. Sublittoral upper bathyal boreal–Arctic species: *Meterythrops robusta, Pseudomma truncatum* (Plate 15-I, *e*) and *Stilomysis grandis* (Plate 15-I, *f*), present in the temperate waters of the Atlantic, Pacific, and Arctic oceans (Zimmer, 1904, 1909; Linko, 1908; Stephensen, 1913; Tattersall, 1951); in the Arctic mainly in the Intermediate Water Mass from Spitzbergen up to the northern sector of the Laptev Sea, seldom penetrating the Arctic surface water.
2. Sublittoral upper bathyal Atlantic boreal–Arctic species: *Erythrops abyssorum, E. erythrophthalma* (Plate 15-I, *g*), *Parerythrops obesa, Pseudomma roseum,* and *Ps. frigidum* have the same distribution as the previous biogeographic groups, but not recorded from the Pacific Ocean (Zimmer, 1904, 1909; Linko, 1908; Stephensen, 1913; Tattersall, 1951).
3. Bathypelagic Atlantic boreal–Arctic species: *Amblyopsoides ohlinii,* found in the northwestern sector of the Atlantic Ocean and in the Norwegian Sea (Zimmer, 1904; Stephensen, 1913; Tattersall, 1951).
4. Sublittoral circumpolar Arctic–boreal species: *Mysis oculata* (Plate 15-I, *h*) and *M. litoralis,* found in the Arctic Ocean and adjacent temperate waters of the Atlantic and Pacific oceans (Zimmer, 1904, 1909; Linko, 1908; Tattersall, 1951; Holmquist, 1982).
5. Estuarine-freshwater circumpolar Arctic–boreal species: *Mysis relicta,* found in estuaries of rivers flowing into the Arctic Ocean and also in a number of rivers and lakes of northern Europe, northern Asia, and North America (Linko, 1908).

VI. Arctic species

1. Cryopelagic circumpolar species: *Mysis polaris* (Holmquist, 1959; Kulikov, 1980).

2. Sublittoral upper bathyal species: *Michthyops theeli*, distributed in the adjacent Atlantic sector of the Arctic Ocean from the eastern coast of Greenland (Ohlin, 1901) up to the northern Laptev Sea.
3. Bathypelagic species: *Pseudomysis abyssi*, observed in the Greenland and Norwegian seas (Zimmer, 1904).

DISCUSSION AND CONCLUSIONS

Distributional patterns of species belonging to different biogeographic groups in the Arctic seas (Figs. 15-1 and 15-2) show that Atlantic boreal and boreal-subtropical species dominate the mysid fauna of the Norwegian Sea, the southwestern areas of the Barents and part of the Greenland seas (up to 76–78°NL); Pacific boreal species dominate the fauna of the Chukchi Sea, northwestern Alaskan coast; boreal–Arctic species dominate the fauna of other parts of the Arctic Ocean. Arctic species do not dominate the mysids of other biogeographic groups in any sector of the Arctic Ocean, if the mysid fauna is regarded as a whole and is not divided by separate water masses.

Areas from the Labrador Peninsula up to 75°NL off the west coast and 78°NL off the east coast of Greenland and from Nordkapp Cape up to the southwest coast of Novaya Zemlya and Franz Josef Land should be considered as an ecotone, a transitional zone where mixing of boreal and Arctic hydrobiocomplexes occur.* The fauna of the latter, in the coastal regions, is dominated by Arctic and sublittoral Arctic-boreal taxa belonging to the genus *Mysis*. Sublittoral upper bathyal and elittoral upper bathyal species dominate the fauna of the upper parts of the continental slope from Spitzbergen up to the northern sectors of the Laptev Sea and the Novaya Zemlya troughs of the Kara Sea. The region from Wrangel Island and Beechey Point (North Alaska) to the north and to Prince of Wales Cape and Olyutorsky Cape (North Kamchatka) to the south can be designated as an ecotone at the boundary with the Pacific boreal fauna.

The vertical distribution of mysids in the Arctic Ocean is presented in Figure 15-3. Maximum number of species is observed in the Norwegian Sea, where species attain greatest diversity between 200 m and 400 m depth. Northward and eastward the number of upper sublittoral, bathyal, and bathypelagic species declines. Thus, boreal and boreal-subtropical bathyal and bathypelagic species can penetrate easily along the coast of east Greenland with the Intermediate Water Mass, whereas boreal upper sublittoral species are not found here and the fauna of the coastal regions is represented by two sublittoral Arctic–boreal species. Bathyal and bathypelagic species are absent from the southwestern parts of the Barents Sea and therefore the maximum number of mysids occurs at 90–200 m depth. Likewise, maximum species diversity is observed off the northwestern Alaskan coast (Chukchi Sea) at 5–30 m depth. In the northern Laptev Sea, due to the predominance of elittoral-bathyal species, the number of taxa is the highest at 200–400 m depth.

The distribution of mysids at various depths is related to the distribution of water masses in the Arctic Ocean. Thus the brackish-freshwater species *Mysis relicta* occurs in water with temperatures not higher than 8°C or 9°C and salinities of 0–7‰. This species occurs in the Arctic Ocean in estuaries at depths of 0–20 m; in fresh water it was observed even at a depth of 117 m (Lake Onega). The cryopelagic species *Mysis polaris* is stenothermal (−1.7°C to +1.1°C) and stenohaline (29.47–34.42‰), living in the surface Arctic Water Mass and on the underside of ice.

*hydrobiocomplex = hydroecosystem

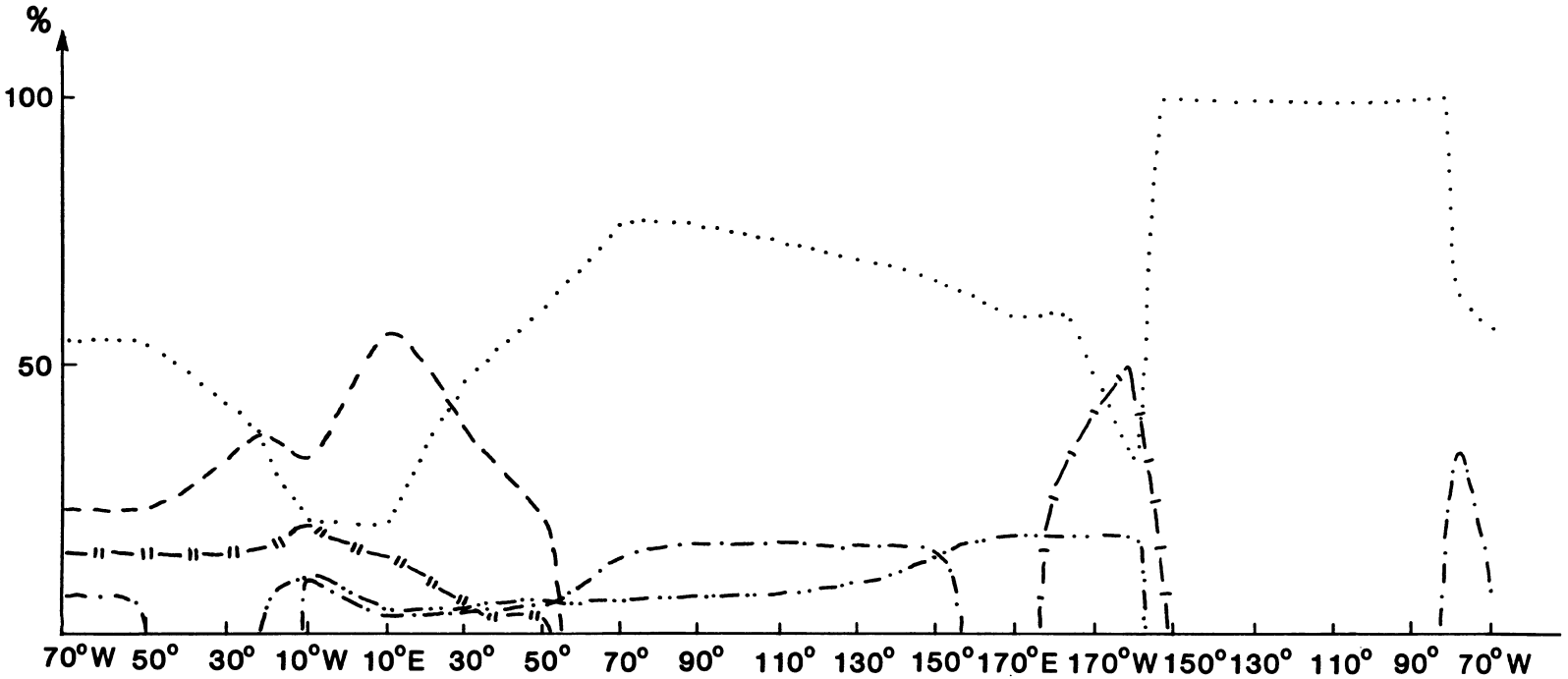


Figure 15-1. Number of mysid species belonging to different biogeographic groups in the Arctic Ocean. Abscissa: longitude; ordinate: percentage of species belonging to a certain biogeographic group out of the total number of species at a given site (%):

boreal Atlantic species and amphiboreal species

boreal–Arctic species

Arctic species

bipolar species

boreal subtropical species

boreal Pacific species

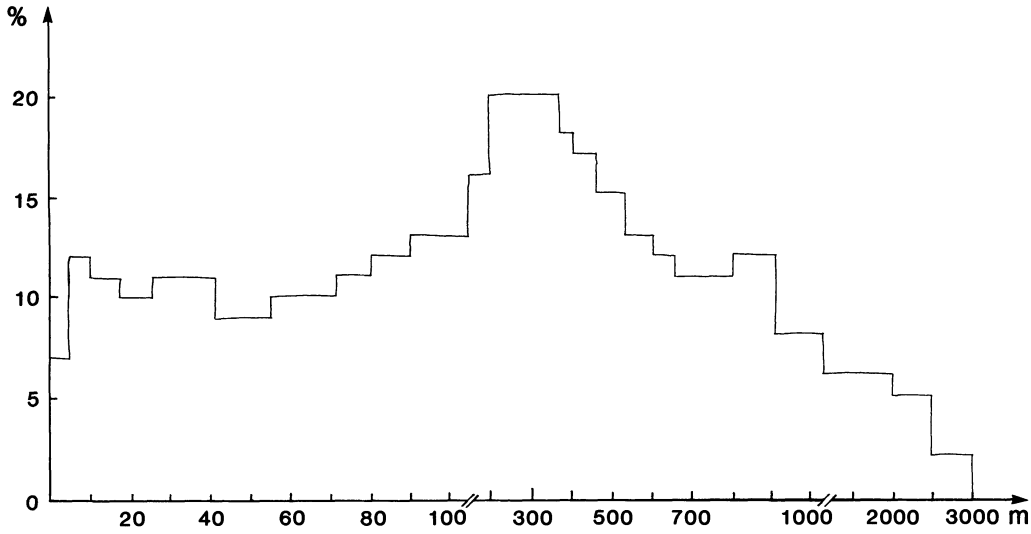


Figure 15-2. Distribution of Arctic Ocean mysids at various depth zones. Abscissa: depth in meters (m); ordinate: number of species (%).

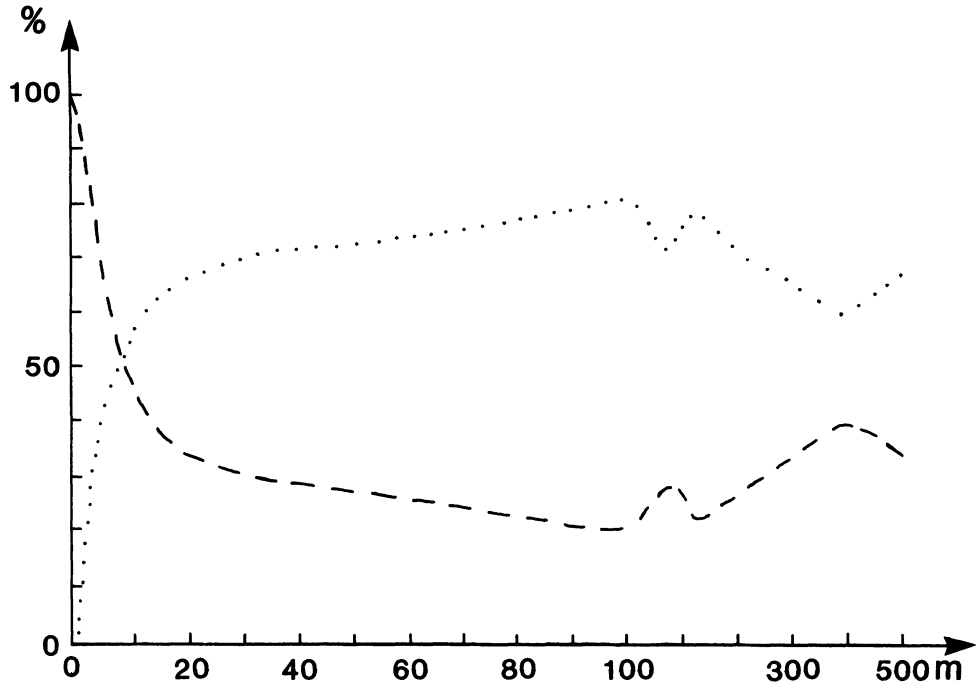


Figure 15-3. Vertical distribution of mysids off Nordkapp Cape. Abscissa: depth in meters (m); ordinate: percentage of species belonging to a biogeographic group out of the total number of species at the given site (%). Legend as in Figure 15-1.

The upper sublittoral species *Exacanthomysis arctopacifica, Hemimysis lamornae, Neomysis integer, N. rayii, Praunus flexuosus, P. inermis, Schistomysis ornata,* and *Xenacanthomysis pseudomacropsis* are eurythermal (−0.4° to +10.08°C) and euryhaline (23–32.66‰); some species occur even at river mouths where salinities are much lower than 23‰ and in the Arctic region where they have been observed in the surface North Atlantic and surface Pacific water masses at depths of 0–51 m. The sublittoral *Mysis litoralis, M. oculata,* and *M. mixta* are eurythermal (*M. mixta* 0.02°–13.68°C and *M. oculata* and *M. litoralis* −1.77°–5.4°C) and euryhaline (6.2–34.93‰); they have been observed when the water was saturated with oxygen (up to 45–96.3 percent). *M. mixta* occurs in the surface Atlantic Water Mass at 1–200 m depth while *M. oculata* and *M. litoralis* have been observed in surface Arctic water, estuarine-Arctic water and even in cool surface Atlantic and Pacific water masses at 1–249 m depth.

The sublittoral upper bathyal Stilomysis grandis, *Erythrops erythrophthalma, Pseudomma truncatum, Misidopis didelphys,* and probably *Dactylamblyops sarsi* can be both stenothermal (e.g., *E. erythrophthalma* and *Ps. truncatum,* −0.2° to −1.82°C, but probably occur at higher temperatures) and eurythermal (e.g., *St. grandis* −1.59° to +6.4°C); however, all are stenohaline (31.15–35‰) and have been observed in water saturated with oxygen (e.g., *E. erythrophthalma* at 53.3–83%, *Ps. truncatum* at 32.3–93.6‰ saturation). These taxa are found in the Arctic Ocean within the Atlantic boreal and intermediate Atlantic-Arctic water masses at 18–580 m depth. Very closely related to this group are the elittoral upper bathyal species *Erythrops abyssorum, E. glacialis, E. microps, E. serrata, Meterythrops robusta, Parerythrops obesa, P. spectabilis, Michthyops theeli, Pseudomma affine, Ps. roseum, Ps. frigidum, Mysideis insignis,* and *Hemimysis abyssicola.* In spite of the differences among these species in their thermopathy *Michthyops theeli* (1.19°C to −1.80°C), *Erythrops abyssorum* (−1.77°–7.22°C), *E. glacialis* (0.9°–1.1°C), *E. microps* (10.7°C), *Meterythrops robusta* (−1.77°–2°C), *Pseudomma roseum* (−1.77°–4.4°C), *Ps. frigidum* (0.6°–1.3°C), *Parerythrops spectabilis* (0.3°–1.0°C) all are stenohaline (31.47–35‰) and were observed in water saturated with oxygen (72.8–109.8%). These taxa occur at 54–900 m depth in the Atlantic boreal and a considerable number have been found in the Intermediate Atlantic-Arctic water masses.

The meso-bathypelagic species *Boreomysis arctica, B. nobilis, Amblyops abbreviata,* and *Michthyops parva* are also eurythermal (−0.82–5.5°C) and stenohaline (34.9–35.55‰), but inhabit depths of 140–1,250 m in the Atlantic boreal and Intermediate Atlantic-Arctic water masses. The distribution of bathypelagic species *Boreomysis microps, B. tridens, Birsteiniamysis inermis, Amblyopsoides ohlinii,* and *Pseudomysis abyssi* at various depths is more complex, although all are stenothermal (+1.0° to −1.0°C) and stenohaline (34.9–34.99‰). *B. microps* and *B. tridens* occur in the Atlantic boreal and the Intermediate Atlantic-Arctic water masses, while *A. ohlinii* is present in the Arctic deep-water mass at depths of 400–2,000 m. *B. inermis* inhabits depths of 900–2,970 m within the Arctic Ocean, and *P. abyssi* lives in the deep-water mass exclusively at 1,406–2,700 m depth.

It should be emphasized that in the Intermediate Atlantic-Arctic waters, which upwell in the Novaya Zemlya trough in the Kara Sea, a number of species occur at uncharacteristic depths. Thus *Erythrops abyssorum* (with a depth habitat of 180–540 m) rises here to 64 m and *Michthyops theeli* (119–575 m) rises here to 27 m. Analogous phenomenon has been observed in this region for other bathyal invertebrates (Zenkevich, 1963).

Information about the distribution of different water masses is provided by the composition of different biogeographic groups at different depths. Atlantic boreal

species (Fig. 15-3) dominate at depths shallower than 10 m in the southwestern Barents Sea while boreal–Arctic species dominate at greater depths and the number of Atlantic boreal species slightly increases at depths of 400–600 m. In the southern areas of this sea, east of Kola Bay, boreal–Arctic species dominated within the entire water mass. This region is characterized by a sharp decline in the numbers of boreal taxa in the area between the Varanger fjord and Kola Bay.

Atlantic boreal species penetrate into the southern Barents Sea since the Atlantic Boreal Water Mass extends in this area from the surface to 600 m depth. Sublittoral Arctic–boreal species occur in the cooler regions of this water mass (Nordkapp branch of the North Atlantic Drift) in the southwestern areas of the Barents Sea and further east. This mysid group has been observed here mainly within a limited depth range (10–30 m though sometimes to depths of 200–240 m); the mysids do not dominate species of other biogeographic groups. Atlantic boreal waters do not penetrate the Kara Sea beyond its southern sector; therefore, Atlantic boreal species have not been observed in this sea.

In the Kara Sea and further east along the coastal regions of the Siberian Arctic seas, the surface Arctic and estuarine–Arctic water masses (except for the Chukchi Sea) at depths of 100–200 m are entirely dominated by sublittoral Arctic–boreal species and estuarine–freshwater Arctic–boreal taxa. These groups are replaced by cryopelagic circumpolar Arctic species only in cryobiocenoses. The distributional patterns of mysids off east Greenland are somewhat different (Fig. 15-4). Boreal–Arctic species occur in this area only to a

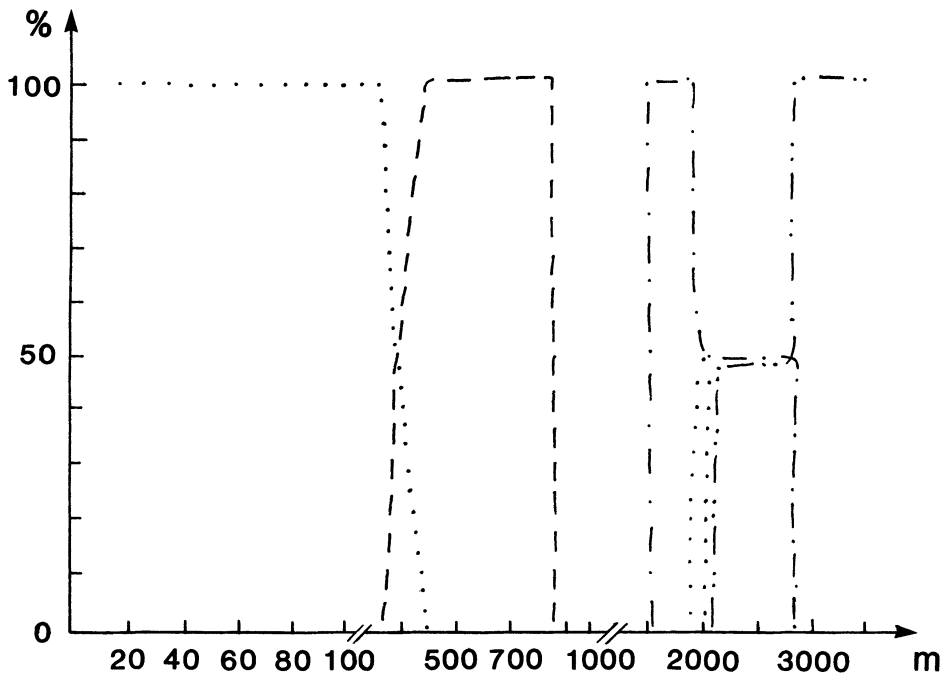


Figure 15-4. Vertical distribution of mysids off the eastern Greenland coast (75°). Abscissa: depth in meters (m); ordinate: percentage of species of a biogeographic group of the total number of species at the given site (%). Legend as in Figure 15-1.

depth of 200 m, in the surface water of the Greenland Sea. In the Intermediate Water Mass these taxa occur only in the uppermost layers, to a depth of 400 m. Atlantic boreal and amphiboreal-subtropical species found in the Arctic Ocean predominate in this water mass. Only two Atlantic boreal species penetrate to depths greater than 600 m, into the cold Arctic Water Mass and even then only in its upper layers (to a depth of 800 m). In the Greenland and Norwegian seas' basins at depths in excess of 1,400 m only the Arctic *Pseudomysis abyssi,* the boreal-Arctic *Amblyopsoides ohlinii,* and the bipolar *Birsteiniamysis inermis* have been observed to date.

The distributional patterns of mysids in different depth zones in the northern areas of Kara and Laptev seas is quite unusual. For example, the Arctic cryopelagic species *Mysis polaris* occurs in the northwestern Laptev Sea (Fig. 15-5) in the uppermost layers (0–5 m), and at depths of 5–40 m in the summer period the fauna is dominated by sublittoral Arctic-boreal species. The mysids of these two groups are typical representatives of the surface Arctic Water Mass. Lower layers of this water mass and the Intermediate Atlantic-Arctic Water Mass are dominated by sublittoral upper bathyal boreal-Arctic species. In the deep-water mass of the Central Arctic Basin, at depths in excess of 900 m, the bipolar *Birsteiniamysis inermis* has been found exclusively. The mysid fauna within the Arctic Ocean is most peculiar in the southeastern parts of the Chukchi Sea where some Pacific boreal species penetrate (Fig. 15-6). The latter dominate mysids off the northwestern Alaskan coast from the Bering Strait up to Cape Barrow at depths of 1–45 m. The great depths and regions not influ-

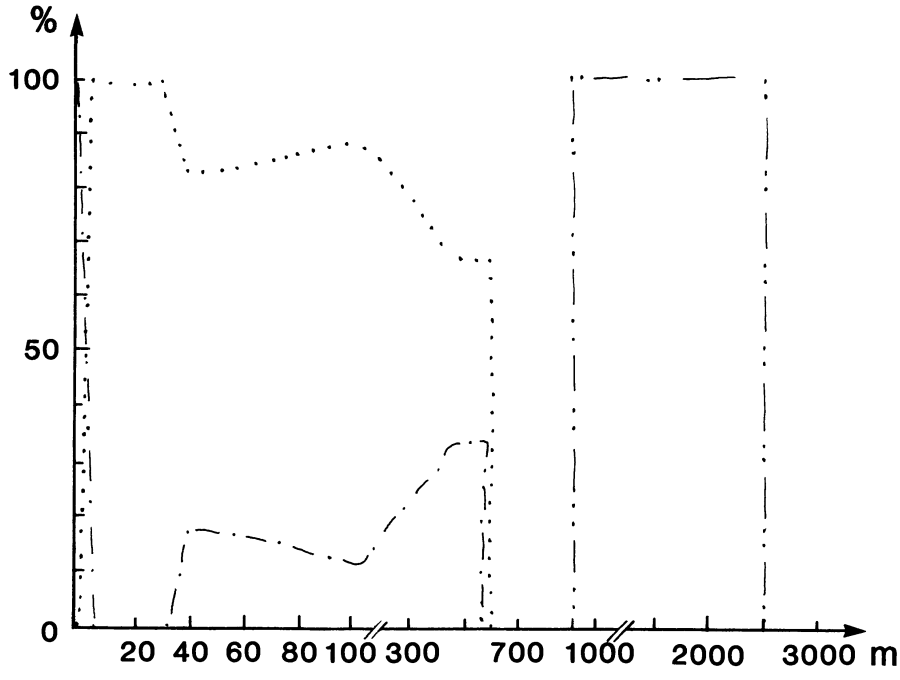


Figure 15-5. Vertical distribution of mysids in the northwestern Laptev Sea. Abscissa: depth in meters (m); ordinate: percentage of species of a biogeographic group out of the total number of species at the given site (%). Legend as in Figure 15-1.

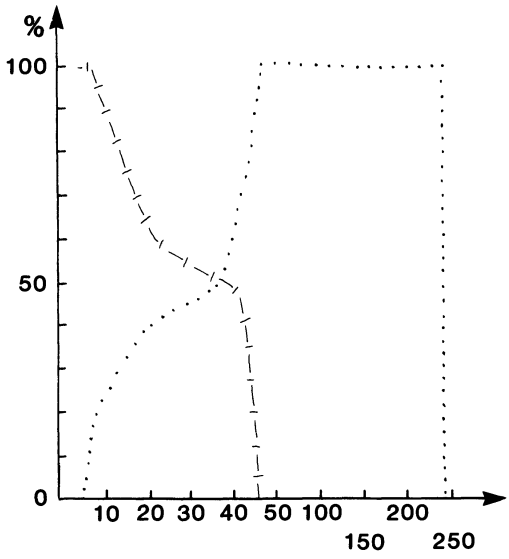


Figure 15-6. Vertical distribution of mysids off the Northwestern Alaskan Coast. Abscissa: depth in meters (m); ordinate: percentage of species of the biogeographic group out of the total number of species at a given site (%). Legend as in Figure 15-1.

enced by the Pacific surface waters are dominated by sublittoral Arctic-boreal species.

EVOLUTION OF THE MYSID FAUNA

In the view of this author, the formation of the recent mysid fauna of the Arctic Ocean is related to the termination of the Last Glaciation (Würm-Valdai-Wisconsin Glaciation, 10–12 thousand years ago), the onset of the Postglacial transgression, the establishment of recent water circulation in the Northern Hemisphere, and the development of Arctic Ocean water masses with their specific temperature-salinity structure.

Each biogeographic group has its own history of distribution within the study area. The genus *Mysis* holds a particular place in the mysid fauna of the Arctic Ocean. In the Arctic and adjacent waters the species belonging to this genus may well have evolved in three directions: (1) by adaptation to conditions of the coastal Atlantic boreal waters (*M. gaspensis, M. mixta,* and *M. stenolepis*), (2) by adaptation to coastal Arctic regions (*M. oculata, M. litoralis,* and *M. relicta*), and (3) by adaptation to the epipelagic zone and later to the cryopelagic zone (*M. polaris*). The evolution of the cryopelagic species *M. polaris* is related to the onset of ice cover over the Arctic Ocean. Therefore, this species must have existed in the Arctic during the entire late Neogene ice age or at least during the Last Glaciation. Following the melting of ice sheets of the Last Glaciation along the shallow Arctic seas and the subsequent intensive freshening of coastal waters, the estuarine freshwater species *M. relicta* penetrated the coastal zones. At the same time, *M. oculata* and *M. litoralis* penetrated to great depths where salinities were exceeding 6–8‰. With decreased freshwater discharge from the continent, these species became distributed in coastal waters also, and *M. relicta* must have formed isolated populations in the river estuaries of the Arctic seas.

Mysids belonging to the genus Mysis (e.g., *M. relicta*), which originated in the period of intensive melting of glaciers and therefore strong freshening, were euryhaline and were able to penetrate from the White Sea through the area of the recent Onega and Ladoga lakes into the arm of the sea that existed at the locus of the present Baltic Sea (Lavrova, 1960). When this connection ceased, isolated populations of *M. relicta* developed in the deepest lakes, the areas occupied by a former marine basin. It is believed that at that time or during a previous boreal transgression mysids belonging to this genus penetrated from the region south of the recent Ladoga and Onega lakes through river systems or through Rybnoye Lake into the Volga Basin and further into the Caspian Sea (Högbom, 1917; Berg, 1928) where the Mysis fauna (*M. amblyops, M. caspia, M. micro-*

lepis, and *M. microphthalma*) endemic to the Caspian Sea originated.

The Atlantic boreal and the genetically related boreal–Arctic taxa (except for Arctic–boreal) is the largest group, including 36 species. Subsequent to the Last Glaciation, species belonging to these groups migrated from the southwestern European coast and the eastern coast of North America northward. This distribution was enhanced by the North Atlantic Drift and its branches that reach far north. Thus, for example, with the Nordkapp branch of the North Atlantic Drift, 12 boreal and boreal–Arctic species reach into the middle Murman region (Kola and Motoka fjord) and some taxa (*Pseudomma truncatum, Stilomysis grandis, Praunus inermis,* and *Mysis mixta*) extend their range to Novaya Zemlya.

The West Spitzbergen branch of the North Atlantic Drift has had a significant influence on the regional faunal composition. East of Spitzbergen this branch descends gradually under the surface Arctic water and in the Arctic Ocean descends under the Intermediate Atlantic–Arctic Water Mass. Near Spitzbergen it flows at a depth of 0–900 m, north of Franz Josef Land at a depth of 150–900 m, and north of Severnaya Zemlya at a depth of 200–900 m (Zenkevich, 1963). With this narrow water mass band, 9 elittoral upper bathyal and meso-bathypelagic species penetrate into the northern areas of the Barents, Kara, and Laptev seas including the Novaya Zemlya trough of the Kara Sea. The boundary of distribution of these species coincides almost entirely with the 0.5°C isotherm at 300 m depth (Zenkevich, 1963). Some boreal and boreal–Arctic species belonging to the main elittoral upper bathyal and meso-bathypelagic zones occur off the eastern Greenland coast bathed by the cool East Greenland Current. This occurrence is related to the formation of Greenland Sea's Intermediate Water Mass at 200–500 m depth. The penetration of Atlantic boreal and boreal–Arctic (except Arctic–boreal) species into Baffin Bay is via the Irminger Current and the relatively warm West Greenland Current.

The distribution of three Pacific boreal species in the Chukchi Sea is related to the development of the Postglacial transgression and the opening of the Bering Strait (Monin, 1980; *Morskaya Geomorphologiya*, 1980). These events led to the penetration of a warm current through the Bering Strait that bifurcates in the Chukchi Sea. The northeastern branch flows toward Point Barrow while the northwestern arm flows toward the region northeast of Wrangel Island. This current influences a restricted area, as compared to the influence of the North Atlantic Drift on the Arctic Ocean. This is due to the shallow depths of the Bering Strait, which limits the volume of warm water carried through the strait to 20,000 km^3 as compared to the 150,000 km^3 of Atlantic water carried into the Norwegian Sea from the south (Zenkevich, 1963).

Of the two species *Michthyops theeli* and *Pseudomysis abyssi* endemic to the Arctic Ocean, the former most probably is of boreal origin as suggested by its distribution, which is similar to that of a number of Atlantic boreal–Arctic species (Golikov, 1985*b*). The second species *Pseudomysis abyssi* may be an Ice Age relict in the Greenland and Norwegian seas. The genus Pseudomysis is amphiboreal. The ancestors of this taxon must have penetrated into the North Atlantic Ocean about 3 mya from the Pacific Ocean along the Canadian coast during a period when the Arctic was ice-free. The dispersal of other amphiboreal species and genera of mysids from the North Pacific into the North Atlantic may have been the same.

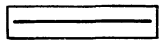
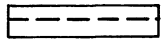
APPENDIX

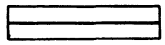
Plate 15-1

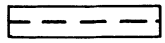
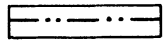
Several characteristic mysids of the Arctic Ocean (after Zimmer, 1904): *a, Boreomysis tridens; b, Praunus inermis; c, Amblyops abbreviata; d, Birsteiniamysis inermis; e, Pseudomma truncatum; f, Stilomysis grandis; g, Erythrops erythrophthalma; h, Mysis oculata.*

Map 15-1

Northern limit of distribution of mysids in the Arctic Ocean.

1.  Atlantic upper sublittoral boreal-subtropical species.
2.  Bathypelagic boreal and boreal-subtropical species:

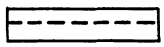
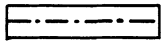
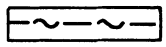
    Boreomysis arctica.
3.  Atlantic boreal and amphiboreal species:

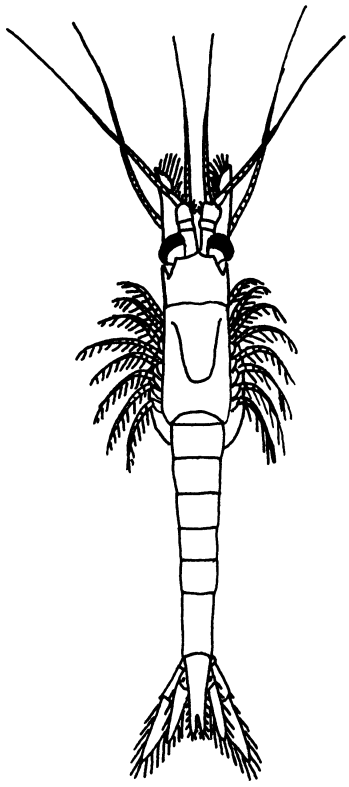
    Boreomysis nobilis.
4.  Sublittoral Pacific boreal species.
5.  Bathyal, pseudoabyssal bipolar species.

Map 15-2

Northern limits of distribution of mysids in the Arctic Ocean.

1.  Northern limit of sublittoral, upper bathyal boreal-Arctic species.

    Northeast limit of *Erythrops abyssorum.*
2. Bathypelagic Atlantic boreal-Arctic species.
3.  Southern limits of sublittoral circumpolar Arctic-boreal species.
4. Cryopelagic circumpolar Arctic species.
5.  Sublittoral, upper bathyal Arctic species.
6. Bathypelagic Arctic species.



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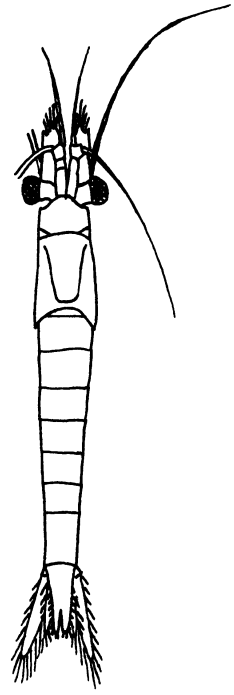

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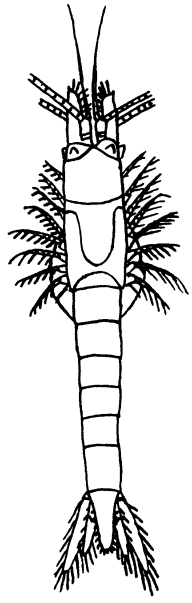

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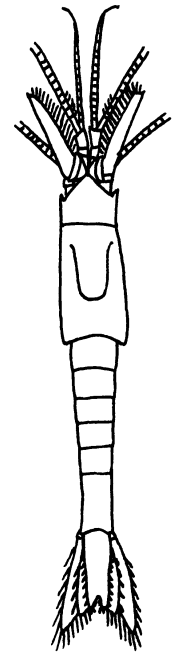
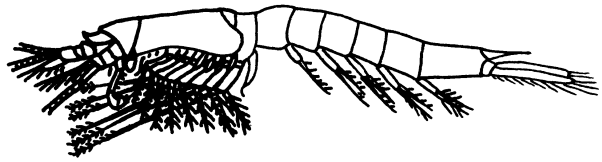


d

PLATE 15-I



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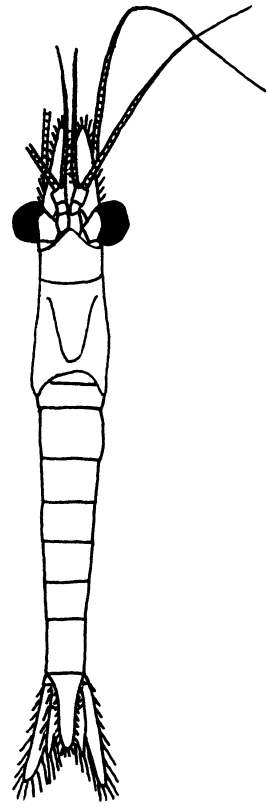

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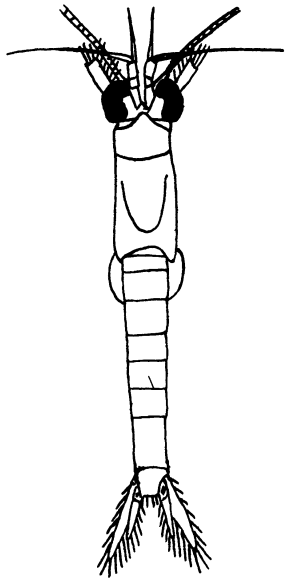

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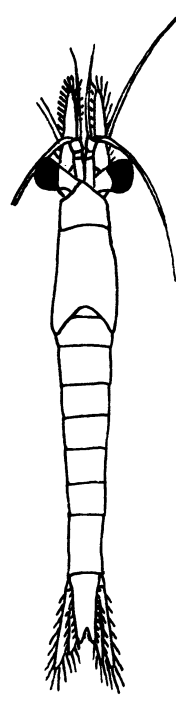

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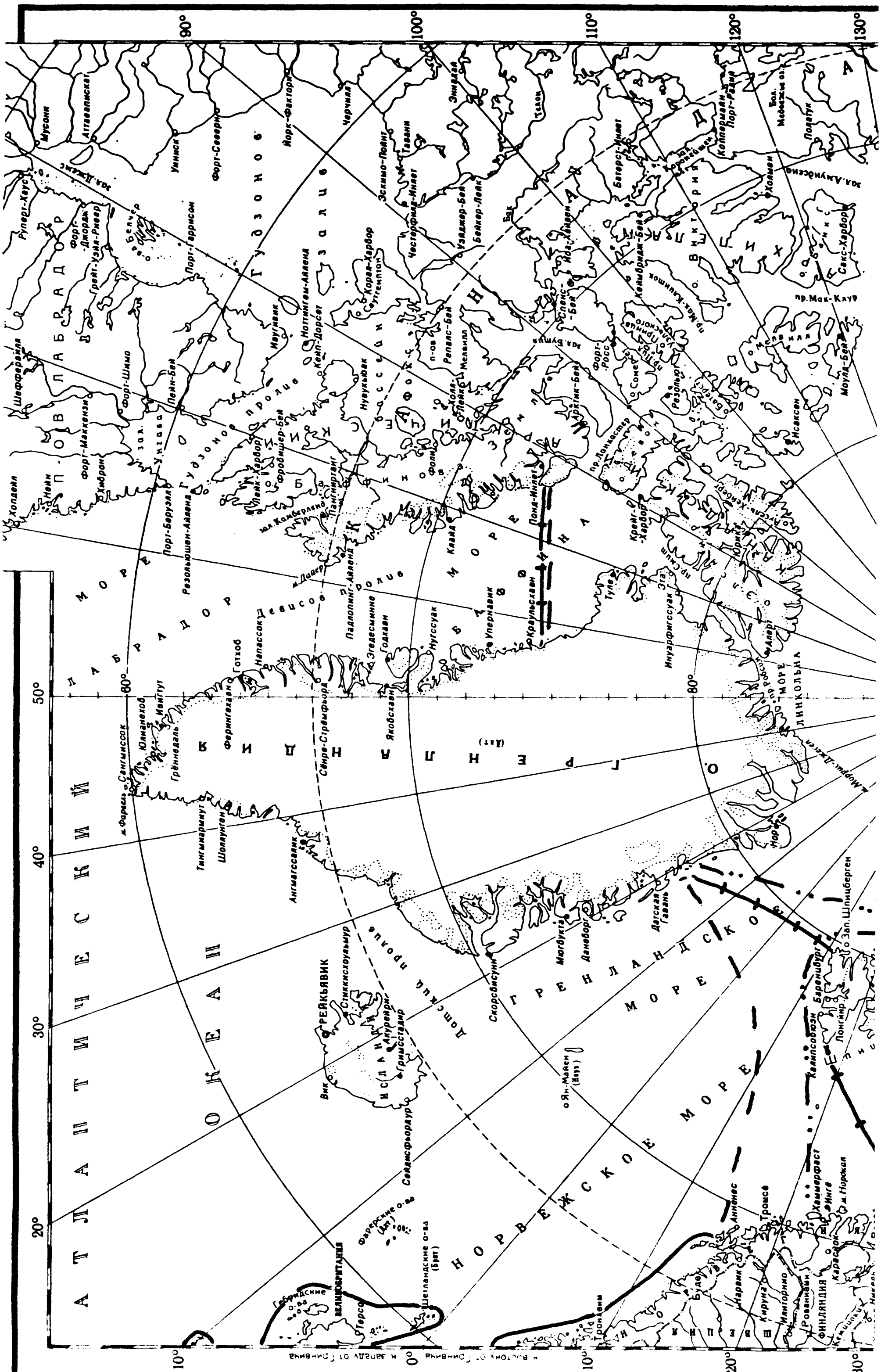
PLATE 15-I



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Гудзонов залив
Гудзонов пролив
Баффинова Земля
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ВЕЛИКОБРИТАНИЯ
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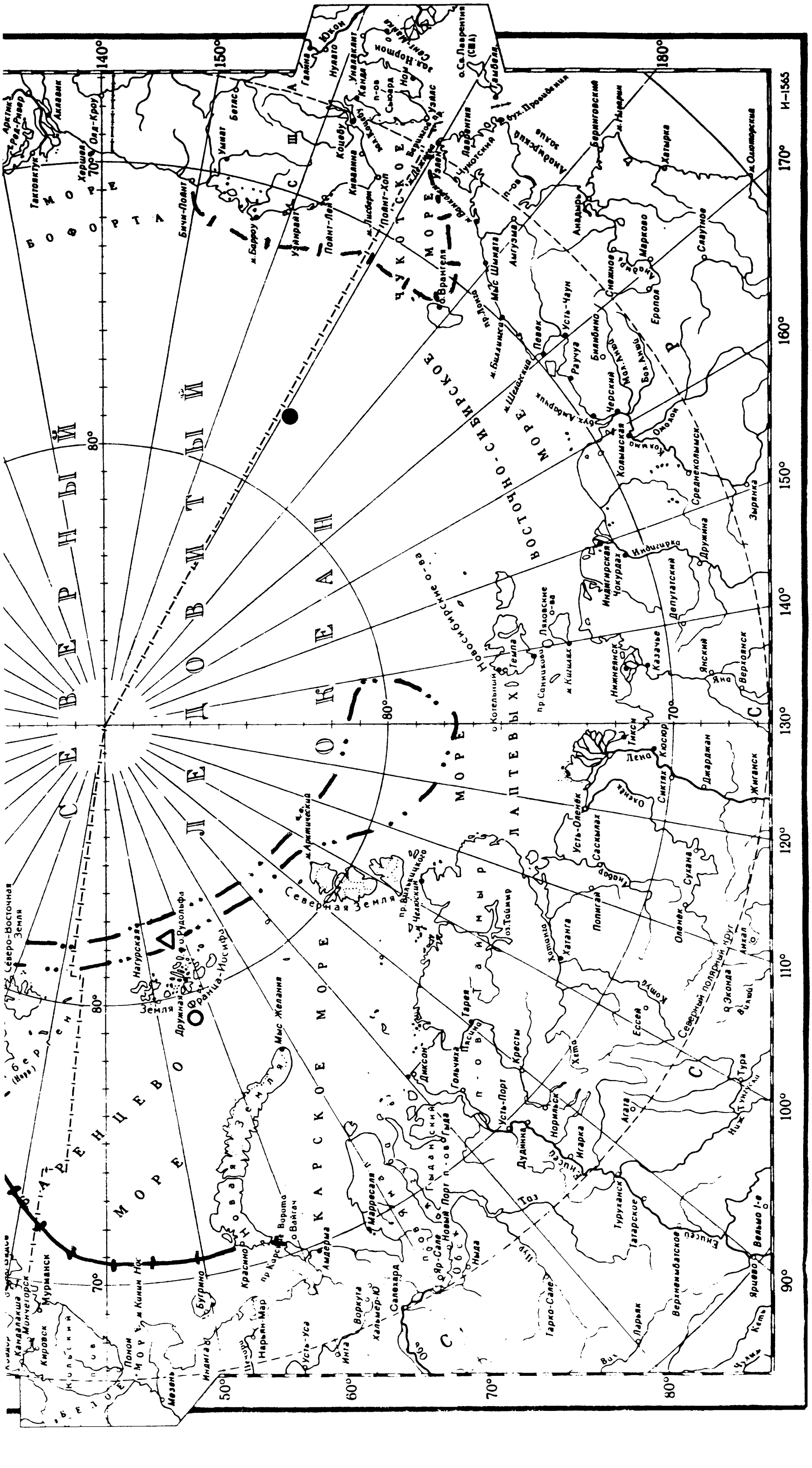
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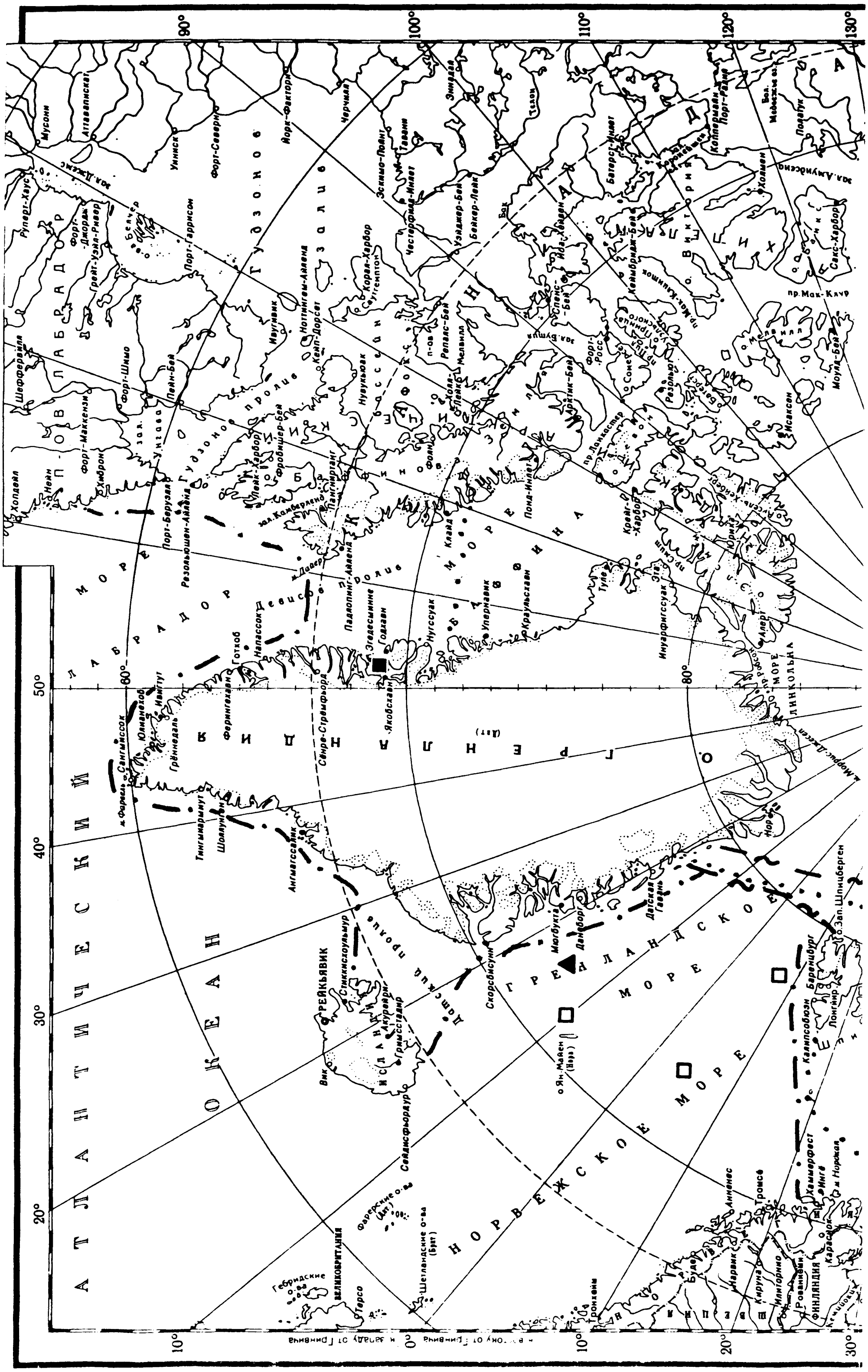
MAP 15-1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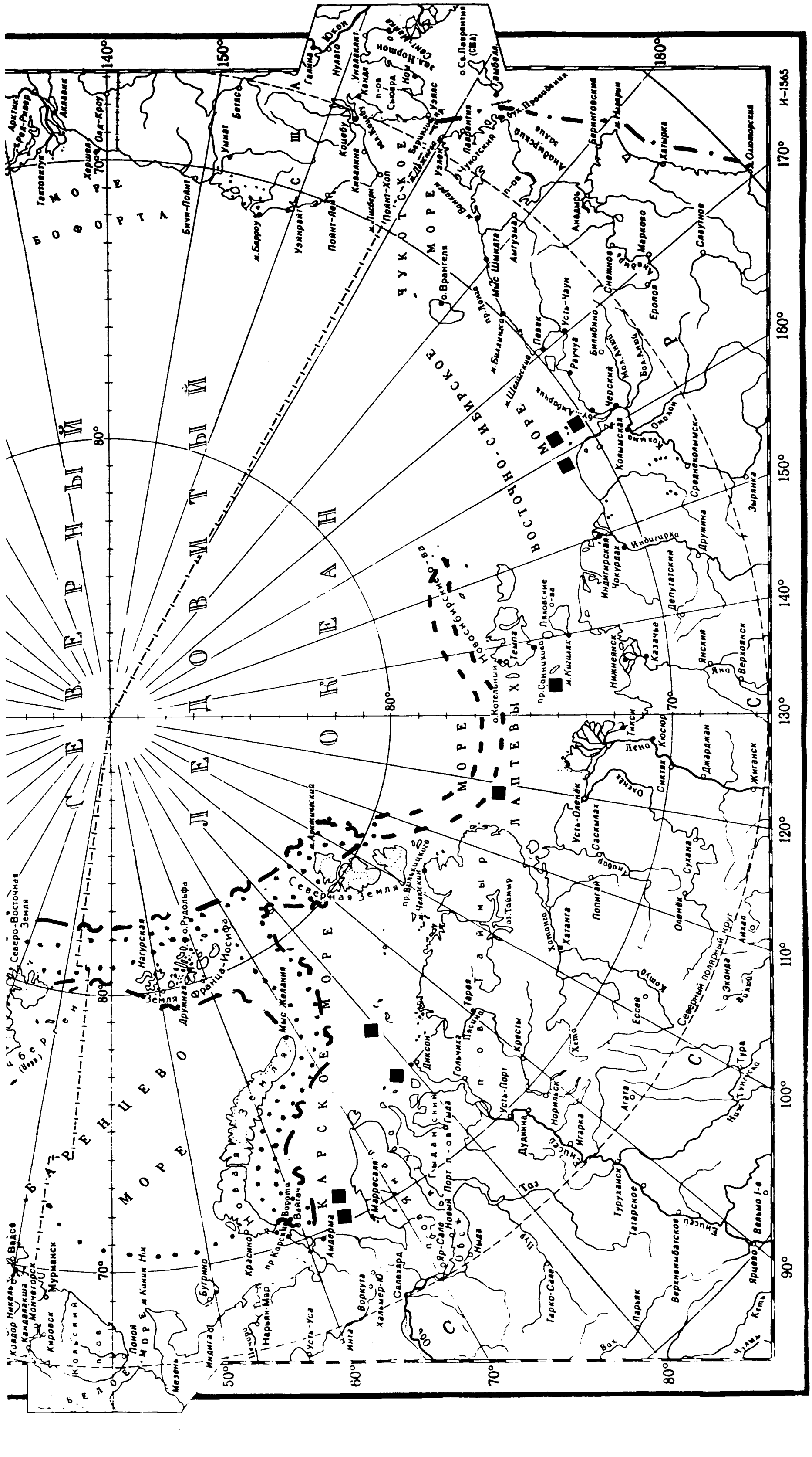
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КАРСКОЕ МОРЕ
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Северная Земля
Новая Земля
Земля Франца-Иосифа
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И-1565

MAP 15-2

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