

Session: Census of Marine Life: Community and species biodiversity in marine benthic habitats from the coastal zone to the deep sea (Session D)

Zoogeography of decapod crustaceans in the Euro-Asiatic Seas of Arctic region

Vasily Sokolov

All-Russian Research Institute of fisheries and oceanography (VNIRO), Moscow 107140, V.Krasnosel'skaja 17, Russia. e-mail: vsokolov@vniro.ru. tel. (+7 495) 264-93-87, fax. (+7 495) 264-91-87

ABSTRACT

All Russian collections of Arctic Decapoda in the Zoological Institute of Russian Academy of Sciences, S.-Petersburg, in Zoological Museum of Moscow State University, Moscow and in Institute of Oceanology, Moscow which were obtained during deferent expeditions in Norwegian, Greenland and north Russian Seas from 1880 to 1996 were examined. Besides the materials collected in coastal water of the Barents and White Seas during the diver investigations by Russian Federal Research Institute of Fisheries and Oceanography were analyzed. Approximately 100 species and subspecies of Decapoda were occurred in the area investigated.

The fauna of Decapoda of Euro-Asiatic Arctic Seas includes subtropical, boreal, arctic-boreal and arctic species. The percent of the Arctic species in decapod fauna increases from the Norwegian Sea to the East-Siberian Sea from 9.7 up to 68.8 % and then sharply decreases to 12.1 % in the southern part of the Chukchi Sea. All the Arctic species belong to group Caridea. A few species of Anomura and Brachyura were observed in the Barents and the White Seas, and also in the Chukchi Sea and in the eastern Laptev Sea. The endemics of the Arctic regions make approximately 3 % from all species. Two caridean genera *Bythocaris* and *Bythocarides* are presented the deep-water fauna in the Arctic Basin. On the basis of the results of the analysis of T-S pairs six ecological groups were identified for the decapod species from the Euro-Asiatic Seas basins.

Keywords: Decapoda, biodiversity, coastal zone, endemic, Arctic seas, species.

MATERIAL

The collections of Arctic Decapoda in the Zoological Institute Russian Academy of Science, St.-Petersburg (ZISP), in Zoological Museum of Moscow State University, Moscow (ZMMU) and in the Shirshov Institute of Oceanology Russian Academy of Science, Moscow (IORAS), were examined. The ZISP collection includes the material of various expeditions in the Norwegian and the north Russian seas collected between the years 1880 and 1995. These materials included collections which were obtained in expedition on boards of R/V "Andrey Pervozvanniy" in 1899, 1900, 1901 and 1908, R/V "Litke" in 1955, R/V "Lena" in 1958, R/V "Lomonosov" in 1931, R/V "Ob" in 1956, R/V "Rusanov" in 1931, R/V "Sedov" in 1934, R/V "Taymir" in 1913 and R/V "Polarstern" in 1993 and 1995. The most part of the ZISP material has been studied before.

The materials collected in the Norwegian, Greenland, Barents and White Seas during the expeditions aboard RV "Sevastopol" in 1958 (cruises 5, 8-10), 1959 (cruises 14 and 15) and 1960 (cruise 17), aboard RV "Persey" in 1921, 1923-1929, and aboard RV "Professor Mesyatsev" (cruise 5) were examined in ZMMU.

The collections of ZMMU and IORAS were examined for the first time. These material originated from the Norwegian and the Barents Seas. Most of the specimens in the ZMMU were

collected on board R/V "Sevastopol" in the expeditions organized by the Polar Research Institute of Fisheries and Oceanography, Murmansk (PINRO), and the Department of Hydrobiology of the Moscow State University in the years 1957-1959, and on board of R/V "Persey" in 1921-1928. The material from the IORAS collection was obtained in north-eastern part of the Norwegian Sea by R/V "Akademik Mstislav Keldysh" between 1991 and 1993. More than 7500 specimens of different species of Decapoda from the Arctic Seas were investigated and data from 530 stations were analyzed.

RESULTS

Zoogeography of Decapoda in the Euro-Asiatic Seas of Arctic region

In total 101 species and subspecies of Decapoda were noted in literature in the Eurasian Seas of the Arctic Ocean. Among them 73 forms were registered in the Norwegian Sea, 37 species- in the Barents Sea, 18 species- in the White Sea, 12 species- in the Kara Sea, 17 species- in the Laptev Sea, 15- species in the East Siberian Sea, 33 species- in the Chukchi Sea, and 7 species- in the High Arctic. At that, 36 species from the Norwegian Sea were never met in any other sea, and 26 species from them were noted only in the southern and southwestern Norwegian Sea and were not captured in other regions of this sea. The latter include the most of Brachyura.

From 26 species of Brachyura in the Norwegian Sea only 3 species (*Chionoecetes opilio*, *Hyas coarctatus*, *Hyas araneus*) penetrate far to the north and are constantly met in the Arctic Eurasian Seas. *Chionoecetes opilio* are registered in the Chukchi Sea where they penetrate via the Bering Strait, and also in the Barents Sea and in the Laptev Sea. The migration route of this species into the latter two seas is still under the question. *Hyas coarctatus alutaceus* also penetrate into the southern Chukchi Sea via the Bering Strait. Among Brachyura only *Hyas araneus* and typical form of *H. coarctatus* spread up to 80° N from the East Atlantic side and are met near the northern coast of the Spitsbergen. *H. araneus* is an arctic-boreal species and moves farther to the northeast compared with other crabs. This species is common for the Kara, White and Barents Seas. *H. coarctatus coarctatus* belongs to boreal species and its spreading to the northeast is directly associated with the advection of the warm Atlantic waters (Christiansen, 1969). This species was noted only in the southwestern and southern Barents Sea and it was not met either in the cold northeastern Barents Sea or in the fjords of northern Norway and in the White Sea basin. These three species are also live in the Northwest Atlantic.

Six crab species (*Cancer pagurus*, *Carcinus maenas*, *Liocarcinus holsatus*, *Liocarcinus depurator*, *Macropodia rostrata* and *Geryon trispinosus*), whose areal extends south of Spain and Portugal, migrate far to the north with the branches of warm currents along the northwestern coast of Norway, and *Geryon trispinosus* and *Macropodia rostrata* penetrate into the southwestern Barents Sea with the Nordcap current. *Carcinus maenas* and *Geryon trispinosus* are also met off the Icelandic coasts (Christiansen, 1969). Three deepwater species (*Bathynectes maravigna*, *Chaceon affinis* and *Dorhynchus thomsoni*) penetrate rather far to the north from the British Islands into the Norwegian Sea. The other crab species which are the representatives of low boreal and subtropical-boreal fauna have the northern boundary of their areal in the southern Norwegian Sea.

With the exception of five species (*Hyas araneus*, *H. coarctatus*, *Chionoecetes opilio*, *Geryon trispinosus*, *Liocarcinus pussilus*) all crabs enter or widely-spread in the Mediterranean basin, and *Polybius arcuatus* lives in the Black Sea. Three forms (*Carcinus maenas*, *Eurinome aspera* and Pacific subspecies *Hyas coarctatus*) are met in other oceans: *Carcinus maenas* was spontaneously introduced in Australia (possibly with ballast waters) and in waters off the Pacific coast of North America; *Eurinome aspera* was observed in the Indian Ocean off the coasts of Southeast Africa where this species obviously arrives from the Atlantic Ocean curving round the southernmost tip of the continent. *Bathynectes maravigna*, *Chaceon affinis*, *Dorhynchus thomsoni*, *Hyas araneus*, *H. coarctatus* and *Chionoecetes opilio* live both in the West and East Atlantic.

From 17 species of Anomura five species (*Pagurus capillatus*, *Pagurus rathbuni*, *Pagurus trigonocheirus*, *Labidochirus splendescens* and *Paralithodes platypus*) are the typical

representatives of Pacific boreal fauna and penetrate into the Arctic region only with the warm Pacific waters via the Bering Strait. They were also found in some areas of the Laptev Sea. Another representative of Pacific boreal fauna, *Paralithodes camtschaticus*, was introduced into the Barents Sea and was not met in the other Northern Seas of Eurasia.

From 11 species of Anomura representing Atlantic fauna 3 species (*Anapagurus laevis*, *Pagurus prideaux* and *P. alatus*) are met only in the southern and southeastern Norwegian Sea where they penetrate with warm Atlantic waters via the Faroe- Shetland Channel. *Galathea nexa* and *Munida rugosa* approach the northernmost tip of Norway with Atlantic waters also, and *Munida sarsi*, *Galathea strigosa* and *Pagurus bernhardus* may be advected by the branches of the Nordcap Current to the southeastern Barents Sea. Another low boreal species, *Munidopsis serricornis*, inhabits the deep waters and is met in the Norwegian Sea to the extent of the Lofoten Islands. Its areal is associated with the distribution of deepwater coral reefs. Only two representatives of Anomura, *Lithodes maja* и *Pagurus pubescens*, are common for the Barents and White Seas fauna, and their distribution is not related to warm Atlantic waters. The southern boundary of distribution of these two boreal-arctic species off the European coast goes along the Faroe-Icelandic threshold, though some individuals were found off the northern coasts of the British Islands. The Faroe-Icelandic threshold restricts the spreading of one more species, *Munida sarsi*, from the south. The other 8 species of Anomura penetrate far to the south and are widely-spread in the Mediterranean - Lusitanien province. From the above mentioned species of Anomura only *Pagurus pubescens* and *Lithodes maja* are met in the Northwest Atlantic.

In the northern Eurasian Seas shrimps are represented most widely. From Sergestidae only *Sergestes arcticus* is found in the region. However, this species does not penetrate east of the western Barents Sea and does not extend to the latitudes higher than the Spitsbergen. Only Caridae from all Decapoda inhabit the severe Eurasian Arctic Seas. Just this group includes endemic species of the Arctic Basin (*Bythocaris grumanti*, *B. irene*, *B. kobjakovae* и *Bythocarides menshutkinae*).

From 101 forms of Decapoda found in the Eurasian Seas of the Arctic region, 56 species belong to Caridea tribe. Among them 11 species (*Pandalus goniurus*, *Eualus suckleyi*, *Heptacarpus camtschaticus*, *Spirontocaris arcuata*, *S. dalli*, *S. murdochi*, *S. intermedia*, *Argis dentata*, *A. lar*, *Crangon communis*, *C. dalli*) are boreal Pacific animals which in the Arctic region are met only in the southern Chukchi Sea and are not known for the Atlantic Ocean.

Eualus fabricii, *E. macilentus* and *Lebbeus groenlandicus* are spread both in the North Pacific off the Asian and American coasts and in the Northwest Atlantic. Their areal is not interrupted near the Arctic coasts of Canada and Alaska. However, the spreading of these shrimps to the west in the Arctic basin is restricted with the southwestern Chukchi Sea.

Eualus pusiolus lives not only in the North Pacific and Northwest Atlantic but is widely-spread off the European coasts, where it was found in the area from the western Barents Sea to North Spain. However, unlike the above mentioned three boreal-arctic species this typical representative of boreal fauna does not inhabit waters off the Arctic coast of Canada and even does not penetrate into the Chukchi Sea, and its spreading in the Barents Sea is associated with warm Atlantic waters or mixed coastal waters.

Six species (*Eualus gaimardi*, *Lebbeus polaris*, *Spirontocaris phippisii*, *Sabinea septemcarinata*, *Sclerocrangon boreas*, *Sclerocrangon ferox*) have the circumpolar distribution. These shrimps are found in all Eurasian Arctic Seas and belong to arctic or arctic-boreal species. The areal of *Pandalus borealis* and *Spirontocaris spinus* is also very close to circumpolar. At present, northern shrimp was registered in all Eurasian Arctic Seas, except for the East Siberian Sea. Moreover, none of its subspecies has been noted off the Arctic coast of Canada yet. *Spirontocaris spinus* lives in the Northeast Pacific, and also in the Northwest and Northeast Atlantic and adjacent Arctic regions. This species extends to the east to Novaya Zemlya and possibly to the New Siberian Islands along the Asian coast. Thus, the discontinuity in the circumpolar distribution of this species occurs in the East Siberian and western Chukchi Seas.

Among Caridae of the region under discussion bathypelagial species have the widest areal. Thus, *Pasiphaea tarda* and *Hymenodora glacialis* are observed in the high-latitude Arctic, Atlantic, Pacific and Indian Oceans.

From fauna of the regions under consideration twenty nine species are not met in the Pacific Ocean. These are the representatives of Atlantic and Mediterranean fauna. Among them 10 species (*Pasiphaea multidentata*, *Atlantopandalus propinquus*, *Bythocaris leucopis*, *B. payeri*, *B. simplicirostris*, *Caridion gordonii*, *Eualus gaimardi gaimardi*, *Spirontocaris lilljeborgii*, *Ponthophilus norvegicus*, *Sabinea sarsi*) have amphi-Atlantic distribution, and the other species are found only in the East Atlantic and adjacent Arctic areas.

From the four Arctic endemics three species (*B. irene*, *B. grumandti* and *B. kobjakovae*) belong to genera *Bythocaris* and one species- to the very close genera *Bythocarides* gen. nov. *Bythocaris* is the most abundant genera of Decapoda in the Eurasian Arctic Seas (9 species) that allowed Guryanova (1957) to consider this genera as remains of the ancient autochthonous fauna which formerly inhabited the Arctic region. However, Burukovsky (1966) equitably pointed out that widely-spread species of this genera in the Arctic region were somehow related to Atlantic waters and, moreover, this genera had one tropical species (*B. cosmetops* Holthuis, 1951). It should be noted that from four species (*B. curvirostris*, *B. biruli*, *B. irene* и *B. grumandti*) indicated by Burukovsky (1966) as Arctic endemics (obviously, he did not include the Norwegian Sea in the Arctic basin), the first two species are met in the Northeast Atlantic as it was shown by the later investigations (Sokolov, 2000). Moreover, this genera is widely presented in the West Atlantic, where 8 species live (*B. leucopis*, *B. payeri*, *B. simplicirostris*, *B. nana* Smith, 1885, *B. gracilis* Smith, 1885, *B. floridensis* Abele&Martin, 1989, *B. gorei* Abele&Martin, 1989 and *B. miserabilis* Abele&Martin, 1989). Three of them are endemics of the West Atlantic and inhabit subtropical and southern boreal subareas. This confirms the conclusion about the Atlantic origin of the genera.

The northern boundary of areal of 5 Mediterranean-Atlantic species (*Processa canaliculata*, *Thorulus cranchi*, *Philoceras bispinosus*, *P. echinulatus* and *Ponthophilus spinosus*) is located in the southern Norwegian Sea. The areal of these shrimps stretches to the south to the Mediterranean Sea (*Thorulus cranchi* is met down to the West Sahara and Cape Verde Islands), and they enter the Norwegian Sea only with warm Atlantic waters). *Pasiphaea multidentata*, *P. sivado*, *Pandalina brevirostris* and *Crangon crangon* are also live in the Mediterranean basin but curving round the northernmost tip of Norway they penetrate into the Barents Sea. At that, *Crangon crangon* inhabited not only the southwestern Barents Sea but the White Sea also.

Five species (*Athlantopandalus propinquus*, *Dichelopandalus bonnieri*, *Pandalina profunda*, *Caridion gordonii* and *Crangon allmanni*) have the relatively narrow distribution only in the boreal area and are found from the Bay of Biscay to the northern Norwegian coast, and during the last three years they inhabited the southwestern Barents Sea which is under the influence of warm Nordcap Current waters.

When assessing the zoogeographical characteristic of species we used the scheme of identifying of biogeographical groups by areal types. Taking into account that the present study was devoted only to Decapoda, for which the number of species in the Arctic region was rather small, we used the developed denominations of areal types given in papers by Golikov (1982), Nesis (1982), Antipova et al. (1989), Kafanov and Kudryashov (2000). According to these ideas we used the following denominations for groups of species noted in the Eurasian Arctic Seas: arctic, boreal-arctic, boreal and subtropical-boreal species. These areal types can be divided into the smaller groups.

Species widely spread in the marginal seas of the Arctic Ocean with the exception of the southern Norwegian Sea were attributed to Arctic species. They can penetrate into the North Pacific via the Bering Strait and can be found in the northern Bering Sea. The following main groups of arctic Decapoda species may be identified in the Arctic basin: shelf arctic species (Fig.1) and deepwater species (Fig.2)

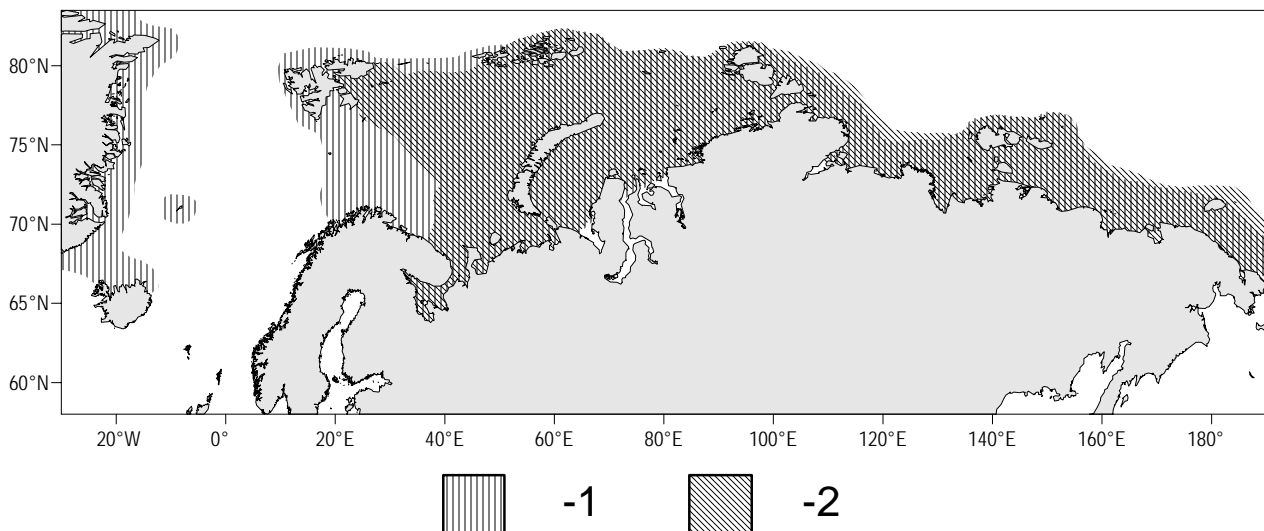


Fig.1. Types of areal for shelf arctic species. 1- pan-arctic, 2- arctic.

In turn, two relatively large groups may be distinguished among shelf arctic species:

1) widely-spread arctic species or pan-arctic species by Hofsten's classification (Hofsten, 1915) with additions by Semenov (1986), whose areal includes the whole Barents Sea. Though these species are also met in the southwestern Barents Sea they hold to cold waters.

2) Arctic species by classification of Semenov (1986) not entering the boreal zone, such as *Eualus gaimardi belcheri*. Decapoda of this group are not found in the western Barents Sea, and in the Pacific Ocean they do not penetrate south of the northern Bering Sea.

The deepwater arctic species are presented only by representatives of genera *Bythocaris* and *Bythocarides*. A part of them inhabited almost the whole deepwater Arctic along the Eurasian continent and deep waters of the marginal Arctic seas, including the Norwegian and Greenland Seas. The boundaries of their areal in the Central Arctic are still under the question.

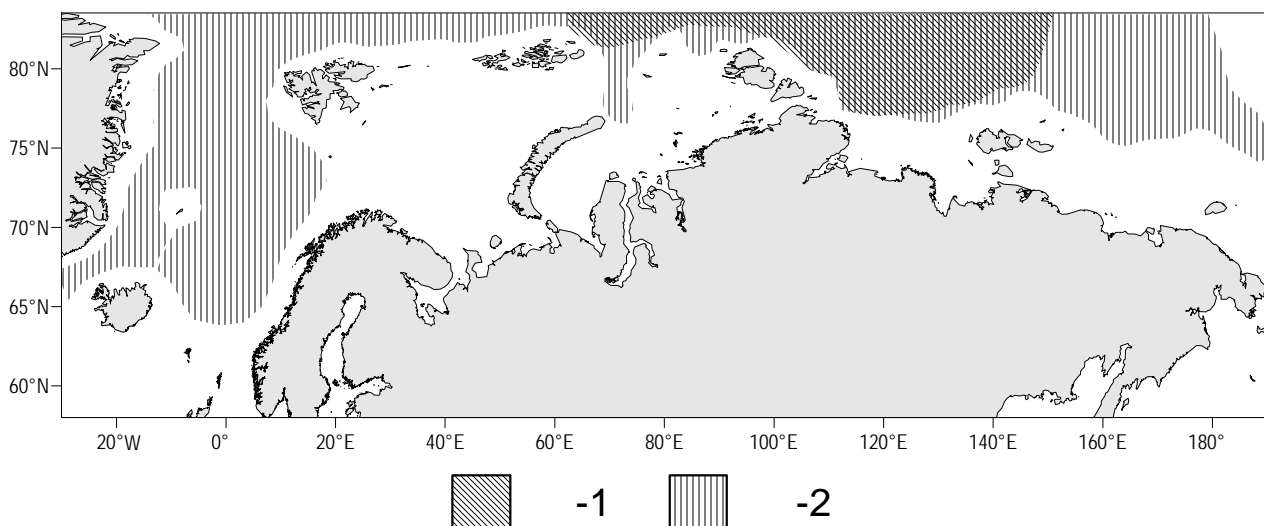


Fig. 2. Types of areal for deepwater arctic species. 1- deepwater endemics of Arctic, 2- widely-spread arctic deepwater species.

Three species (*Bythocaris irene*, *B. kobjakovae* and *Bythocarides menshutkinae*) are the endemics of the Arctic region and were registered only in the deepwater trenches of the Laptev

Sea, and *B. irene* was also observed near the northern boundary of the Kara Sea. However, it is possible that during the further investigations the areal of these species will be widened.

Under the boreal-arctic species we consider those inhabited the Boreal and Arctic areas (Fig.3). This group is divided into: 1) widely-spread high boreal-arctic species, including the circumpolar species. This group is widely presented in the Eurasian Arctic Seas. Their areal covers the whole Arctic region, and also a part or the whole high-boreal sub-area to the southern Norway, Faroe and Shetland Islands and the northern coasts of the British Islands in the Atlantic Ocean and to the Sea of Okhotsk in the Pacific Ocean basin; 2) Atlantic boreal or high-boreal - low-arctic species. They inhabit the area from England or the Bay of Biscay up to the northern and eastern boundaries of the Barents Sea; 3) Atlantic boreal-arctic species progress to the east to the eastern boundary of the Kara Sea and/or enter the Laptev Sea; and 4) Pacific boreal-arctic species which are common for the high-boreal zone of the Pacific Ocean, and in the Arctic they reach the Wrangel Island and the eastern Laptev Sea when moving in the northwestern direction and the Beaufort Sea moving to the northeast.

The boreal elements of Decapoda fauna in the Eurasia Arctic Seas were represented by the following types of areal: 1) Atlantic low boreal species distributed from the Bay of Biscay to the southern Norwegian Sea; 2) Atlantic high boreal species, whose areal stretches from the British Islands, Iceland and southwestern Norway to the southwestern Barents Sea and southwestern Spitsbergen; 3) Atlantic widely-spread boreal species inhabiting both the high- and low boreal subzones. In the Barents Sea the some representatives of this group were met up to the western coast of the Kaninsky Peninsula and they inhabited the White Sea.; 4) Pacific boreal and high boreal widely-spread species penetrating into the southern Chukchi Sea via the Bering Strait.

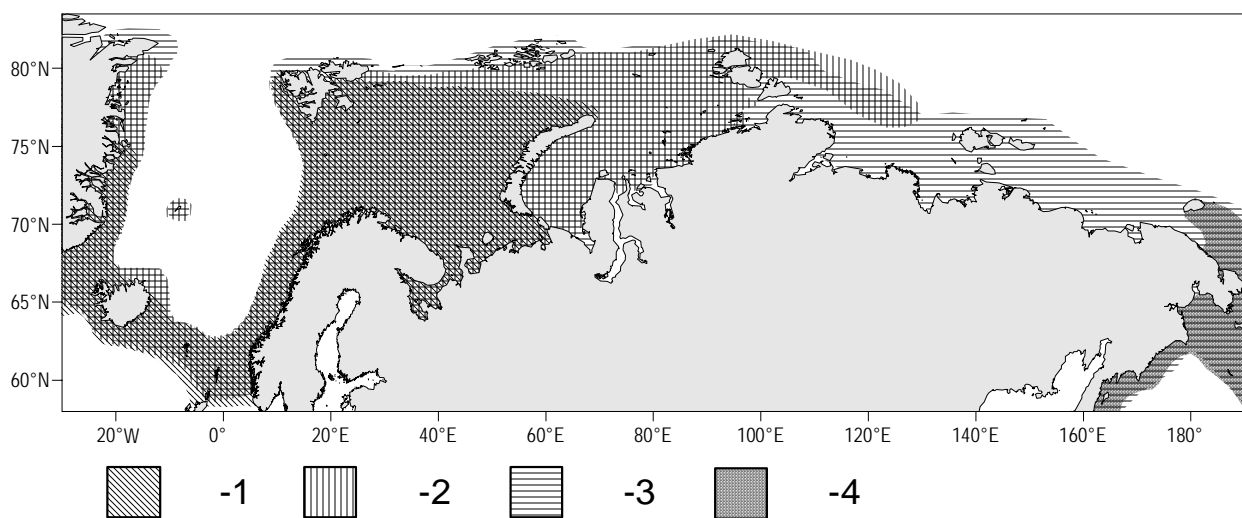


Fig.3. Types of areal for boreal-arctic species: 1- Atlantic boreal or high boreal- low arctic species, 2- Atlantic boreal-arctic species, 3- widely-spread high boreal- arctic species, 4- Pacific boreal-arctic species.

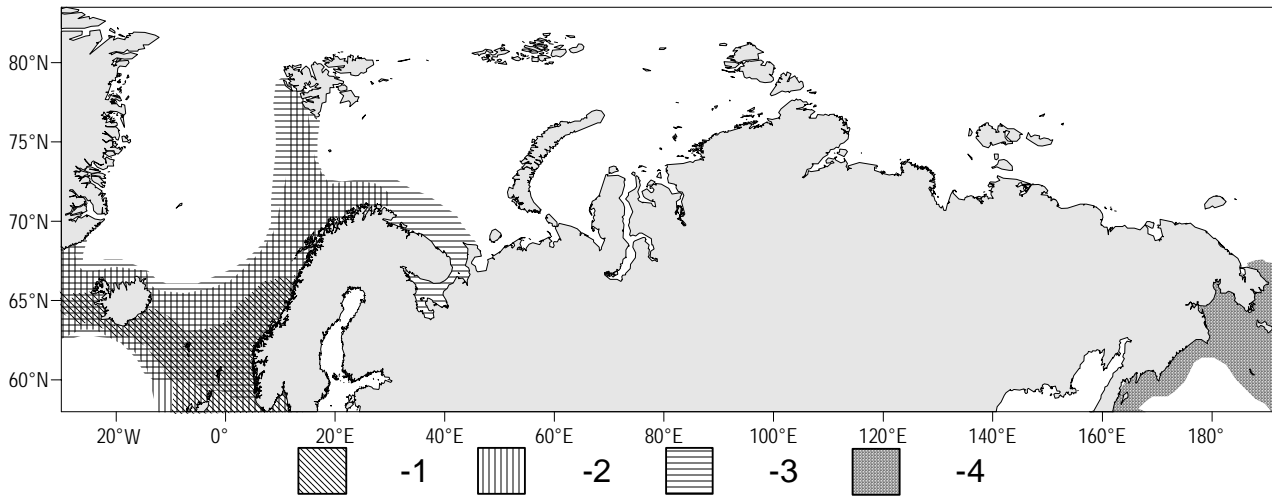


Fig. 4. Types of areal for boreal species: 1- Atlantic low boreal species, 2- Atlantic high boreal species, 3- Atlantic widely-spread boreal species, 4- Pacific boreal and high boreal species.

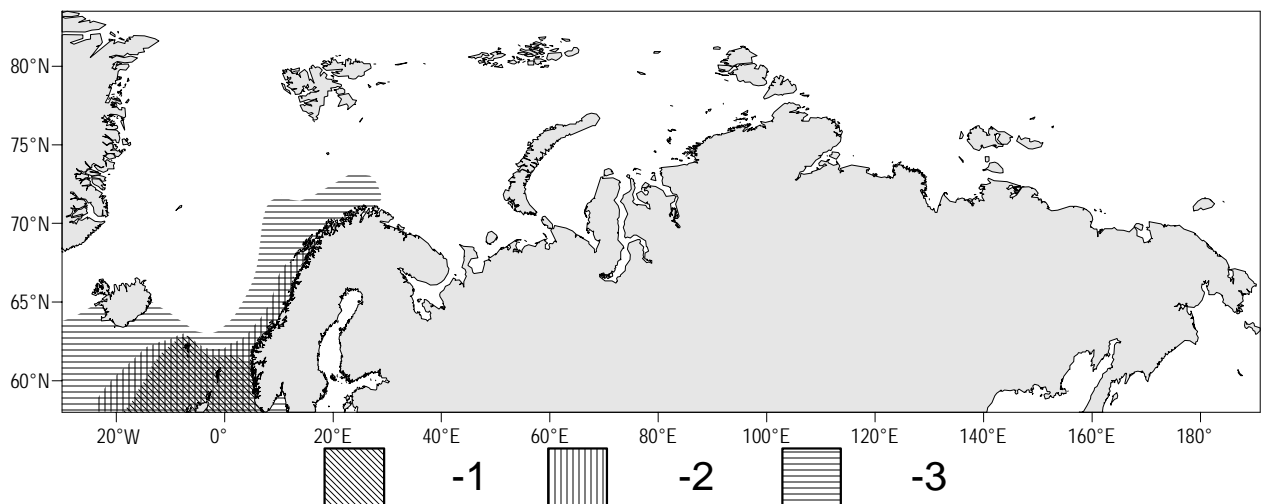


Fig.5. Types of areal for subtropical-boreal species: 1-subtropical- low boreal species, 2-subtropical- boreal benthic species, 3- subtropical- boreal pelagic species.

The subtropical-boreal elements of fauna are widely spread in the southern Norwegian Sea (Fig.5). Subtropical- low boreal species have the northern boundary of their distribution in the southern Norwegian Sea and usually are not met north of 62° N. These species may penetrate rather far to the north with warm waters along the western coast of Norway, and pelagic species *Pasiphaea sivado* and *P. multidentata* may enter the western Barents Sea.

Data on the number of arctic, arctic-boreal, boreal and subtropical-boreal species (as it was described above without the detailed dividing) for the different groups of Decapoda in the Eurasian Arctic Seas are presented in table 1. As seen from the Table, Arctic species constitute the minority in the investigated area. The most representative species are the boreal and in the lesser extent subtropical-boreal animals. However, the latter group is characteristic of the southern and southeastern Norwegian Sea (Table 2), where the Gulfstream waters have the maximal effect on the hydrological regime in the region under consideration. As it was mentioned above, all arctic species belong to Caridae. These shrimps constitute the majority among boreal and arctic-boreal species of the region. Among the subtropical-boreal species of Brachyura are on the first place (Table 1). This group abundant in the southern Norwegian Sea almost disappears in the Barents

and Kara Seas and is completely lacked in the Laptev and East Siberian Seas. One of the reasons why Brachyuran crabs did not penetrate into the cold Arctic Seas, while Caridea inhabited them widely, might be associated with differences in the larval development of these groups.

Practically, for all shrimp species inhabited the high-latitude Arctic the laying contains the low number of relatively large eggs. At that, this is observed not only for deepwater shrimps but for species living in sublittoral of the Siberian Seas. The number of eggs in laying for arctic species ranges from several tens for *Sclerocrangon boreas* and *Lebbeus polaris* up to 400-500 for *Spirontocaris phippisii* and *Eualus gaimardi belcheri* (Menshutkina, 1990). In contrast to these shrimps, crabs and hermit-crabs living in waters adjacent to the Arctic have small eggs, the number of which ranges from several thousands to several tens of thousand. Thus, if for the most Brachyuran species there is a planktotrophic larva, arctic and deepwater shrimps have an inclination to lecithotrophic at the planktonic stage development. Unfortunately, now practically there is no data on the duration of the planktonic stages of Decapoda in the Arctic Seas.

One more feature should be noted in the larval development of shrimps which together with lecithotrophic larvae may favor the survival at the early stages of development in the severe Arctic conditions: the most species of Macrura are characterized by a lack of sharp morphogenetic transformations between zoea and mysis stages and further to megalope in contrast to the sharp transitions for Brachyura and Anomura (R. Makarov, 1966). The diet composition for larvae of Brachyura and Anomura at the different stages may change drastically that under the rather poor food base of the Arctic Seas affects the survival of larvae. Some historical causes for the selective penetration of different Decapoda species in the Arctic (e.g., remoteness of the centers of species formation) are also possible. However, all these theories require the further development and detailed verification.

Table 1. The ratio (%) of the different zoogeographical groups among Caridea, Anomura and Brachyura in the Eurasian Arctic Seas

	Caridea		Anomura		Brachyura		Total number of species
	Number of species	%	Number of species	%	Number of species	%	
Subtropical - boreal	7	22,6	6	19,3	18	58,1	31
Boreal	18	51,4	10	28,6	7	20	35
Boreal- arctic	20	91	1	3,5	2	5,5	22
Arctic	11	100	0		0		11
Pan-oceanic	2	100	0		0		2

The zoogeographical composition of Decapoda in the Eurasian Seas of the Polar basin changes from the west to the east, which are characteristic of all other groups of benthic animals. From the Barents and Norwegian Seas to the East Siberian Sea the qualitative depauperization of fauna (Zenkevich, 1963) and an increase in a share of arctic species (Table 2) are observed.

As seen from Table 2, subtropical-boreal and boreal Atlantic species (42.5%) prevail in fauna of the Norwegian Sea, while Arctic animals constitute only 9.7% of the total number of species in this sea.

The Barents Sea is characterized by the clear influence of Atlantic waters that affects the zoogeographical composition of Decapoda fauna in this basin. In this sea boreal animals are dominant whose distribution is restricted, as a rule, by the western and southwestern parts of the basin. Moreover, subtropical-boreal species (5.4%) advected by the warm Nordcap Current were noted in the western and southern Barents Sea. However, the findings of the latter in the sea were registered only in the periods of warming when zoogeographical boundaries between Boreal and Arctic areas shifted to the northeast (Nesis, 1960a).

Table. 2. Zoogeographical composition (%) of Decapoda in the Eurasian Arctic Seas.

Seas	Subtropical-boreal	Boreal	Boreal-Arctic	Arctic
Norwegian Sea	42.5	31.5	16.3	9.7
Barents Sea	5.4	43.3	32	19.3
White Sea	0	29.4	47.1	23.5
Kara Sea	0	0	53.9	46.1
Laptev Sea	0	0	31.2	68.8
East Siberian Sea	0	0	36.4	63.6
Chukchi Sea	0	57.6	30.3	12.1

Moreover, subtropical-boreal species registered in the Barents Sea are the pelagic animals of genera *Pasiphaea* which are able to spread faster than benthic organisms using the currents. As a whole, the presence of subtropical-boreal species in the Barents Sea may be considered as a non-characteristic transitory event.

In the White Sea a share of arctic-boreal eurythermic species increases sharply. A share of arctic species is almost the same as in the Barents Sea. From the other hand, despite the rather severe continental regime of the White Sea a share of boreal species is rather high (29.4%). At that, such species as *Crangon crangon* common for this region has a discontinuous areal along the Barents Sea coast and is not met just in the vicinities of the White Sea Voronka. The penetration of this shrimp into the White Sea possibly occurred from the Baltic Sea during the period of the connection between two seas.

In the Kara, Laptev and East Siberian Seas a share of arctic species increases from the west to the east. Boreal animals disappear from their fauna completely and are found only in the southern and southeastern Chukchi Sea where the warm Pacific waters are advected via the Bering Strait.

Distribution of Decapoda in dependence on water temperature and salinity

The data on temperature and salinity of near-bottom waters in the sites of collections were available in the most complete forms. Though temperature and salinity are physically independent they are determined by the same physical-geographic conditions in the each specific region (Dobrovolsky, 1961) and are often used in the analytic methods for identification of water masses (Ozhigin and Ivshin, 1999). Each water mass affects the bottom population of the region where it contacts the bottom (Nesis, 1960b).

We constructed and analyzed the fields of T, S pairs for the most of Arctic-Atlantic, east Arctic and circumpolar species of Decapoda in the Eurasian Arctic Seas. On the basis of the results the following groups of Decapoda in the Eurasian Arctic Seas were identified:

1) Warm-water Atlantic or Atlantic-Mediterranean species living at the high temperature and salinity. This group includes *Processa canaliculata*, *Atlantopandalus propinquus*, *Pandalina brevirostris*, *Caridion gordonii*, *Spirontocaris lilljeborgi*, *Pontophilus spinosus*, *Philoceras bispinosus*, *Philoceras echinulatus*, *Anapagurus laevis*, *Munida rugosa*, *Pagurus alatus*, *Pagurus bernhardus*, *Pagurus prideaux*, *Galathea strigosa*, and also the most of *Brachyura* met in the region under consideration.

These species are associated with warm, high-salinity (35.0-35.4‰) Atlantic waters advected via the Faroe-Shetland threshold. In the Polar basin most of them are met only in the southern Norwegian Sea. However, some species such as *Pandalina brevirostris*, *Caridion gordonii*, *Spirontocaris lilljeborgi*, *Galathea strigosa*, *Munida rugosa*, *Munida sarsi*, *Pagurus bernhardus*, *Geryon trispinosus*, *Polybius holsatus* и *Polybius pussilus* progress with the branches of the Norwegian Current along the western coasts of Norway, and the others are spread to the Barents Sea or the White Sea Gorlo with the warm Nordcap Current.

2) Warm-water species met in the White Sea. They include *Crangon allmanni*, *Crangon crangon*, *Pandalus montagui* and *Lithodes maja*. These species of boreal fauna in the Norwegian and Barents Seas are associated with warm Atlantic waters characterized by high salinity and relatively high temperature. At the same time, in the White Sea they are found at the much more lower salinity. From the two factors the temperature is of the greater importance for their spreading.

3) Cold-water stenothermal and stenohaline species. This group is represented only by Caridae. It includes the most species of genera *Bythocaris* from the Eurasian Arctic Seas (*B. biruli*, *B. curvirostris*, *B. leucopis*, *B. irene* and, appearingly, *B. kobjakovae* and *B. cryonesus*), and also *Pasiphaea tarda*, *Hymenodora glacialis* and *Bythocaridis menshutkinae*. They live at large depths under the relatively stable environmental conditions with the temperature from -1 to $+1^{\circ}\text{C}$ and salinity of 34.7-34.98‰ (34.92‰, in average). If we take the characteristics of the Arctic water masses proposed by Timofeev (1960) as a basis, shrimps of this group are associated with intermediate waters between the bottom and Atlantic water masses, and their areal is directly related to the spreading of the latter in the Arctic basin.

4) Eurythermic stenohaline Atlantic species. This group includes mainly the boreal Atlantic species, such as *Pontophilus norvegicus*, *Sabinea sarsi*, *Hyas coarctatus coarctatus* and *Pandalus borealis borealis* living in the rather narrow range of salinity and in the wide range of temperature from 0°C (or even under the negative values of temperature) up to $8-10^{\circ}\text{C}$. However, they are mainly met in the relatively warm Atlantic waters. Because of their eurythermy animals of this group inhabit a wide range of depths, from the middle or upper littoral to bathyal. Among the representatives of this group shrimp *Pandalus borealis* spreads to the north most far and can be met at the rather low, even negative, values of water temperature but almost everywhere it holds on high-salinity Atlantic waters.

5) Cold-water stenothermal euryhaline species, including such shrimps as *Eualus gaimardi belcheri*, *Spirontocaris phippisii*, *Sclerocrangon ferox* and *Lebbeus polaris*. These species are found at the rather wide range of salinity that allows them to penetrate into the shallow freshened areas of the Euroasian Arctic Seas and into the White Sea. At the same time, shrimps of this group are an indicator of cold waters. In the Norwegian Sea these species may descend to a large depth where temperature is close to 0°C .

6) The group of eurythermic and euryhaline species, such as *Spirontocaris spinus*, *Eualus gaimardi gaimardi*, *Sclerocrangon boreas*, *Sabinea septemcarinata*, *Pagurus pubescens*, and *Hyas araneus*. The representatives of the group are widely spread in the eastern Arctic, and some of them (*Sclerocrangon boreas* and *Sabinea septemcarinata*) have a circumpolar distribution due to their unpretentious character. Because of the ability of species of this group to stand the substantial changes in salinity and temperature they widely inhabited the upper littoral of the White, Barents, and Norwegian Seas.

CONCLUSION

1. The fauna of Decapoda of Eurasian Arctic Seas includes 101 species and subspecies and presented by subtropical, boreal, arctic-boreal and arctic forms.
2. The percent of the Arctic species in decapod fauna increases from the Norwegian Sea to the East-Siberian Sea from 9.7 up to 68.8 % and then sharply decreases to 12.1 % in the southern part of the Chukchi Sea.
3. All the Arctic species belong to group Caridea. Anomura and Brachyura inhabit in the Barents and the White Seas, and also in the Chukchi Sea and in the eastern Laptev Sea.
4. The endemics of the Arctic regions make approximately 3 % from all species. Two caridean genera *Bythocaris* and *Bythocarides* are presented the deep-water fauna in the Arctic Basin.
5. On the basis of the results of the analysis of T-S pairs following six ecological groups were identified for the decapod species from the Euro-Asiatic Seas basins: a) Warm-water Atlantic or Atlantic-Mediterranean species living at the high temperature and salinity; b) Warm-water species met in the White Sea; c) Cold-water stenothermal and stenohaline species; d) Eurythermic stenohaline Atlantic species; e) Cold-water stenothermal euryhaline species; f) group of eurythermic and euryhaline species.

REFERENCES

- Antipova T.V., Denisenko N.V., Semenov V.N., 1989. [The distribution of benthic species and questions of biogeography of northern seas]// In: Life and habitat of Polar Seas. Leningrad: Nauka press, P. 146-157. (in Russian).
- Burukovsky R.N., 1966. A new species of shrimp of the genus *Bythocaris*, and some problems of zoogeography of the genus// Zoologicheskyyi Journal. XLV (4). P. 536-542. (in Russian with English summary).
- Christiansen M. E., 1969. Crustacea Decapoda Brachyura// Mar. Inverteb. off Scandinavia, № 2, 143 p.
- Dobrovolskii A.D., 1961. On the estimation of water masses// Oceanology, 1(1), P. 12-21. (in Russian with English summary).
- Gurjanova E.F., 1957. [On zoogeography of Arctic Basin]// In: [The material of observations on the scientific research drifting stations SP-3 and SP-4 1954/55]. 1, P. 343-362. (In Russian).
- Golikov A.N., 1982. [About principle of zoning and unification terms in marine biography]// In: Marine biography. Moscow: Nauka press. P. 94-98. (in Russian).
- Hofsten N., 1915. Die Echinodermen des Eisfjords// Kungl. Svensk Vetensk. Akad. Handl., 54(2), 286 p.
- Kafanov A.I., Kudryashov V.A., 2000. Marine Biogeography: A Text-book// Moscow: Nauka. 176 p. (in Russian).
- Nesis K.N., 1960a. Changes in the Barents Sea bottom fauna under the influence of fluctuations in the hydrological regime// In: Soviet fisheries investigations in North European Seas. Moscow, P. 129-138. (in Russian).
- 1960b. [Bottom fauna as a indicator of hydrological sea regime (by the example of northern-central area of the Barents Sea)]// Scientific-technician Bull PINRO. 3(13), P. 34-36. (in Russian).
1982. [Zoogeography of the World Ocean: comparison of pelagic zones and regional division of sea shelf (by the example of Cephalopoda)]// In: Marine biography. Moscow: Nauka press. P. 114-133. (in Russian).
- Ozhigin V.K., Ivshin V.A., 1999. Water masses of the Barents Sea// Murmansk: Pinro Press, 48 p. (in Russian).
- Menshutkina T.V., 1990. [Shrimps (*Macrura*) of the Laptev Sea, Novosibirskoe shoal and adjacent water]// In: Explorations of the fauna of the seas. 37(45), Leningrad: Nauka Press, P. 344-364 (in Russian).
- Semenov V.N., 1986. [Short review on the benthos zoography of the Barents Sea and system of biogeographic characteristic for the northern seas]// In: Life and habitat of Polar Seas. L.: Nauka press, P. 71-79. (in Russian).
- Sokolov V.I., 2000. Deep-sea shrimps of the genus *Bythocaris* G.O. Sars in the collections of Russian museums, with the description of a new species (Crustacea: Decapoda: Hippolytidae)// Zool. Med., Leiden 74 (24), P. 403-468.