CANADIAN TRANSLATION OF FISHERIES AND AQUATIC SCIENCES

No. 4848

Zoogeographic study of the arctic isopods

by

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Original Title: Zoogeograficheskiy ocherk fauny isopoda arktiki

From: Arctica (2): 127-152, 1934.

Translated by the Translation Bureau (NDE)
Multilingual Services Division
Department of the Secretary of State of Canada

Department of Fisheries and Oceans
Arctic Biological Station
Ste. Anne de Bellevue, Que.

1982

33 **pages typescript**

DEPARTMENT OF THE SECRETARY OF STATE
TRANSLATION BUREAU

MULTILINGUAL SERVICES DIVISION

CANADA

SECRÉTARIAT D'ÉTAT
BUREAU DES TRADUCTIONS

DIVISION DES SERVICES MULTILINGUES

TRANSLATED FROM – TRADUCTION DE	INTO – EN
Russian	English

AUTHOR – AUTEUR

Ye. V. Guryanova

TITLE IN ENGLISH – TITRE ANGLAIS

Zoogeographic study of the arctic isopods

TITLE IN FOREIGN LANGUAGE (TRANSLITERATE FOREIGN CHARACTERS)
TITRE EN LANGUE ÉTRANGÈRE (TRANSCRIRE EN CARACTÈRES ROMAINS)

Zoogeograficheskiy ocherk fauny Isopoda Arktiki

REFERENCE IN FOREIGN LANGUAGE (NAME OF BOOK OR PUBLICATION) IN FULL. TRANSLITERATE FOREIGN CHARACTERS.
RÉFÉRENCE EN LANGUE ÉTRANGÈRE (NOM DU LIVRE OU PUBLICATION), AU COMPLET, TRANSCRIRE EN CARACTÈRES ROMAINS.

Arctica

REFERENCE IN ENGLISH – RÉFÉRENCE EN ANGLAIS

Arctica

PUBLISHER – ÉDITEUR	DATE OF PUBLICATION / DATE DE PUBLICATION			PAGE NUMBERS IN ORIGINAL / NUMÉROS DES PAGES DANS L'ORIGINAL
not available	YEAR / ANNÉE	VOLUME	ISSUE NO. / NUMÉRO	127-152
PLACE OF PUBLICATION / LIEU DE PUBLICATION				NUMBER OF TYPED PAGES / NOMBRE DE PAGES DACTYLOGRAPHIÉES
USSR	1934	–	2	33

REQUESTING DEPARTMENT / MINISTÈRE-CLIENT: D F O

TRANSLATION BUREAU NO. / NOTRE DOSSIER N°: 860969

BRANCH OR DIVISION / DIRECTION OU DIVISION: S.I.P.B.

TRANSLATOR (INITIALS) / TRADUCTEUR (INITIALES): N. De.

PERSON REQUESTING / DEMANDÉ PAR: J.A. Percy

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YOUR NUMBER / VOTRE DOSSIER N°:

DATE OF REQUEST / DATE DE LA DEMANDE: April 19, 1982

UNEDITED TRANSLATION
For information only
TRADUCTION NON REVISEE
Information seulement

MAY / MAI 14 1982

SOS-200-10-6 (REV. 2/68)
7530-21-029-5333

Secretary of State | Secrétariat d'État

MULTILINGUAL SERVICES DIVISION – DIVISION DES SERVICES MULTILINGUES

TRANSLATION BUREAU | BUREAU DES TRADUCTIONS

Client's No.–N° du client	Department – Ministère	Division/Branch – Division/Direction	City – Ville
	D F O	S.I.P.B.	St.Anne de Bellv
Bureau No.–N° du bureau 860969	Language – Langue Russian	Translator (Initials) – Traducteur (Initials) N. De.	MAY MAI 14 1982

Arctica, 1934, No. 2, pp. 127-152

(127)*

Zoogeographic study of the arctic isopods

by Ye. Gur'yanova

The North Polar Basin, surrounded by three continents, is like a vast bay of the Atlantic Ocean, which is separated from it by the Wyville-Thompson Ridge and connected with the Pacific Ocean in the east by the Bering Strait. Owing to the peculiarities of the bottom relief, the distribution of the depths and islands and the distribution of the currents and salinities, the Polar Basin as a whole is not something homogeneous; it is divided into a number of very different areas or seas which for the most part have natural boundaries in the form of island chains, peninsulas projecting far out into the sea, etc. Each of these arctic areas has its own hydrologic conditions which impart an certain individuality to the *Isopoda* fauna inhabiting each of these areas.

On the whole, it can be said that the *Isopoda* fauna, which is of a purely Atlantic nature in the western part of the Arctic, is more original in its central part and serves as an example of the Arctic fauna in its pure form; in the eastern part, because of the

*The numbers in the right-hand margin are the pages of the Russian text - translator

existence of the Bering Strait, it bears a distinct imprint of the present-day Pacific fauna, some species of which pass through the strait into the Arctic Ocean and spread along the coast of North America.

Highly characteristic is the distribution of some Isopoda species, which has a clearly defined tendency. Both the newcomers from the Atlantic and the forms from the Pacific Ocean are quite clearly spreading from the west eastward, following the general direction of the currents and the distribution of the tidal wave in the Arctic. (128) Making its way into the Arctic from the southwest, the Atlantic fauna then spreads in the direction of the warm North Cape current along the shores of Europe and up to the shores of Novaya Zemlya. Some of the species find their way through the Matochkin Shar and Karskiye Vorota straits, and also to the north of Cape Zhelaniye and even into the Kara Sea. On the other hand, the typically marine isopods of the Pacific Ocean which find their way into the Arctic through the Bering Strait are forced to move eastward along the shores of North America. The shallow and highly freshened area of the Siberian Sea probably prevents them from spreading along the Asian coast west of the Bering Strait. Together with the warm current directed from the Pacific Ocean into the Arctic Sea through the Bering Strait, the Pacific forms move directly northward and eastward. However, there is a possibility that the Pacific forms move westward from the strait along the continental slope, beyond the boundaries of the shallow Siberian seas; however, no zoological specimens are available from this area so far.

Thus, because of the peculiarities of the coastline and the distribution of depths, currents and salinities, the entire Arctic is divided into individual regions, the main ones being 1) the comparatively shallow and warm Barents Sea, 2) the cold, isolated and to some extent relict White Sea, 3) the cold-water basin of the Kara Sea, 4) the shallow and highly freshened Laptev Sea (Nordenskjöld Sea), 5) the freshened, shallow East Siberian Sea, 6) the shallow Chukchi and Beaufort seas with intermediate salinities and temperatures, 7) the very cold region of the North American polar archipelago, 8) the deep and warm region of Davis Strait and western Greenland, 9) the cold and deep East Greenland Sea, 10) the deep and warm Norwegian Sea, and 11) the very deep and cold Polar Basin which surrounds the North Pole.

The Isopoda fauna is also distributed very unevenly, in accordance with this division of the Arctic Basin into individual seas. At first, we shall attempt to give a general characterization of the Isopoda fauna of the individual Arctic seas; we shall touch on the question regarding the exchange of forms between adjacent water bodies, and then we shall pass on to the zoogeographic characteristics of individual species.

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Isopoda fauna of individual Arctic seas

Barents Sea. The Barents Sea is surrounded by the shores of N Norway (Finnmark), Spitsbergen, Franz Josef Land, Novaya Zemlya and the Murmansk coast. This is a comparatively shallow basin, with depths of 100-200 m in most parts. Only in the western and northern parts of the sea (above 76° N) do the depths increase to

400-450 m. The depths in the southeastern part barely reach 100 m; along the western coast of Novaya Zemlya, there extends a deep (up to 200 m) trough which adjoins the central and southeastern shallow part of the sea from the east. Of major importance in the overall hydrologic regime of the Barents Sea are the warm and cold currents, the distribution of which largely determines the horizontal distribution of the benthopelagic fauna of the sea. As it passes through the Kola meridian (33°30' E), the strong Gulf Stream (North Cape Current) coming from the southwest separates into four main branches which diverge fanwise. From the northeast, cold arctic waters wedge between these separate branches of the North Cape Current. The latter turns the southwestern part of the Barents Sea into an ice-free basin with above-zero temperatures near the bottom.

On the other hand, the cold waters flowing from the northeast into the Barents Sea through the strait separating Franz Josef Land and Novaya Zemlya impart a highly arctic nature to the northeastern part of the sea, while the cold waters filling the Novaya Zemlya trough turn this region into a typically arctic basin. Because of this unusual distribution of cold waters and warm currents, the whole Barents Sea is divided into three different regions, i.e. 1) the comparatively warm and ice-free western part of the sea with depths of over 200 m and a high salinity, and the deep northwestern part (above 76° N, in the vicinity of the fourth branch of the North Cape Current), which are the most abundant in the composition of Isopoda; 2) the deep cold-water northeastern part of the Barents Sea, with a high-Arctic depauperate fauna of Isopoda, and 3) the shallow

and somewhat freshened southeastern part (Pechora Sea), with an arctic fauna of Isopoda and individual representatives of the boreal fauna.

The nonuniformity of the different regions of the Barents Sea with respect to hydrologic conditions has resulted in a clearly (130) defined patchiness in the distribution of isopods in it. So far, the following 41 species of Isopoda have been discovered in the Barents Sea:

Jaera albifrons
Janira maculosa
Janira laciniata
Janira tricornis
Munna kroyeri
Munna fabricii
Munna minuta
Munna pellucida
Munna hanseni
Munna acanthifera
Munna spitzbergensis
Munna romeri
Pleurogonium inerme
Pleurogonium spinosissimum
Ilyarachna hirticeps
Ilyarachna bergendali
Aspidarachna clypeata
Munnopsurus giganteus
Eurycope mutica
Munnopsis typica
Aega psora
Aega ventrosa
Calathura brachiata
Limnoria lignorum
Idothea baltica
Idothea granulosa
Idothea pelagica
Idothea emarginata
Idothea viridis
Mesidothea sabini sabini
Mesidothea sabini robusta
Mesidothea sibirica
Synidothea bicuspida
Synidothea nodulosa
Bopyroides hippolytes
Phryxus abdominalis
Dajus mysidis
Parapodascon stebbingii
Gnathia elongata
Gnathia arctica
Gnathia robusta

Spreading from west to east along the Murman coast, the littoral thermophilic species of the genus *Idothea* gradually drop out of the fauna. For instance, all five *Idothea* species are still encountered in the vicinity of Varanger Fjörd and western Murman (Rybachi Peninsula), but two of the most thermophilic of these (*Idothea baltica* and *Idothea viridis*) disappear in the Motovka and Kola gulfs, and only *Idothea granulosa, Idothea emarginata* and *Idothea pelagica* remain. *I. emarginata* and *I. pelagica* drop out of the fauna farther

east of the Kola Gulf. Only *I. granulosa* is encountered in abundance in the zone of *Fucus*; it extends to the meridian of Svyatoi Nos (40° E), and is not encountered at all farther east and north.

The opposite pattern is observed in the distribution of the littoral shallow-water arctic species of *Synidothea* and *Mesidothea sabini robusta* which inhabit the southeastern part of the sea and are not encountered west of Svyatoi Nos. They apparently find their way into the Barents Sea from the Kara Sea.

(132)

On the other hand, the Isopoda fauna of the open part of the Barents Sea displays an extremely interesting pattern of distribution of the thermophilic boreal-type species and the high-Arctic species, due to the distribution of the warm and cold waters. This relationship is especially pronounced along the Kola meridian (33°30' E). Thermophilic species such as *Calathura brachiata, Janira maculosa* and *Janira laciniata* are found here in the area exposed to the individual streams of the warm North Cape Current. On the other hand, the high-Arctic forms (*Mesidothea sabini sabini, Hyarachna hirticeps, Janira tricornis, Munnopsurus giganteus*) are encountered mainly in the places where cold arctic waters from the northeast wedge between the warm streams, and in the region of the cold Perseus Current (see map No. 1). Circumpolar species (*Munnopsis typica, Bopyroides hippolytes, Dajus mysidis, Phryxus abdominalis*) are distributed more or less evenly throughout the Barents Sea.

White Sea. This is a typically arctic basin, with depths of up to 340 m and a constant below-zero temperature in the near-bottom layers (-1.4°C), and very low salinities (maximum salinity barely reaches 27‰ at the bottom). Because of its narrow and shallow

strait (up to 40-100 m), the basin of the White Sea is almost isolated from the Arctic Sea. The exchange of animals between the Barents and White seas occurs with great difficulty, as the unusual hydrologic conditions of the "neck" of the White Sea, with its very intense and sudden seasonal fluctuations in temperature and strong currents, prevents the usual Barents forms from getting into the White Sea. Here the Isopoda fauna is exceptionally impoverished and unique, and consists only of eurybiontic forms. So far, only six species of isopods have been discovered in the White Sea; one of these (*Synidothea bicuspida*) is found only in the "neck", and never in the basin itself. The following are the six species:

Jaera albifrons
Limnoria lignorum
Synidothea bicuspida
Bopyroides hippolytes
Mesidothea entomon entomon natio *septentrionalis*
Phryxus abdominalis

Jaera albifrons, a typically littoral form which can survive a wide range of temperatures and salinities, found its way into the White Sea along the Murman Coast. (133) *Limnoria lignorum* was probably brought in from the Barents Sea by wooden boats, and began reproducing in the White Sea, colonizing wooden quays and posts. Both parasitic forms, *Phryxus abdominalis* and *Bopyroides hippolytes*, are eurybionts which found their way into the White Sea together with their eurybiontic hosts *Spirontocaris* and *Eulalus*, while *Mesidothea entomon entomon* is a typically relict form which has survived in the Northern Dvina estuary from the distant past when a connection was formed between the White and Baltic seas, and formed a special geographic race which differed insignificantly from the Baltic *Mesidothea entomon entomon* natio *septentrionalis*.

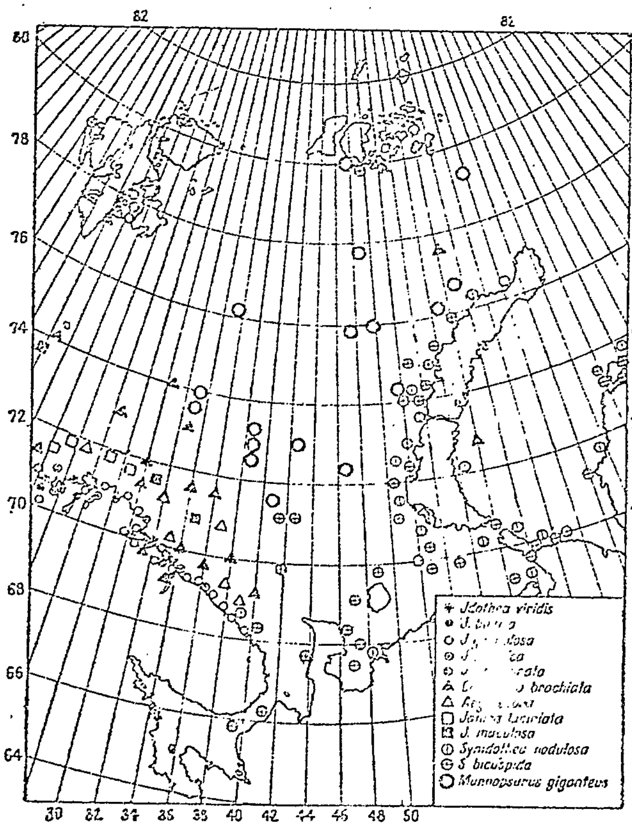

Fig. 1. Fauna arctica.

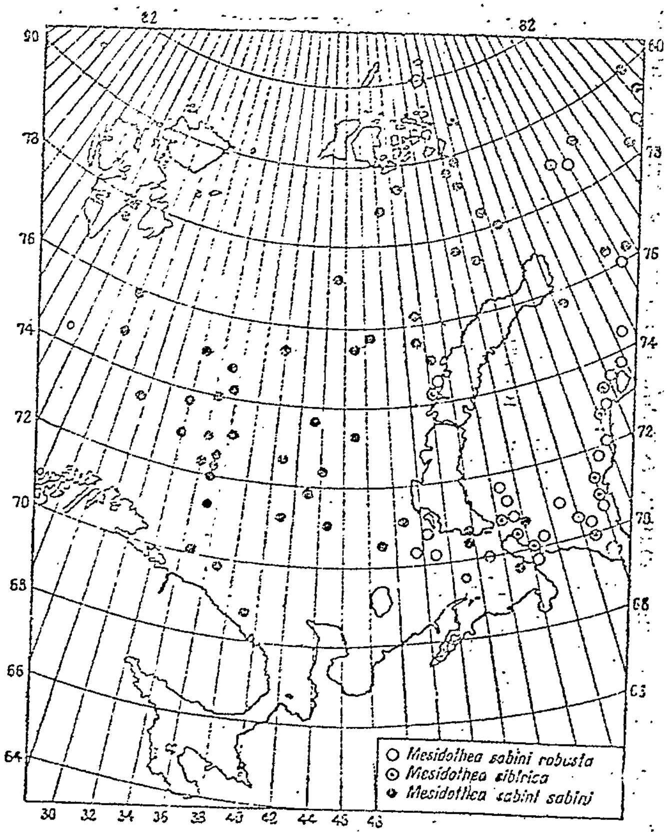

Fig. 2. Fauna arctica.

The Isopoda fauna of the White Sea is a brilliant example of how the history of the origin of this water body has affected the composition of its present-day fauna. On the basis of recent geological data, the present state of the White Sea and the composition of its fauna, K. Deryugin (1928) expresses the opinion that the present-day White Sea fauna is quite young, and began to form only during the postglacial period. The previous opinion that the fauna of the White Sea has preserved the remains of the interglacial fauna of the great boreal transgression must now be completely discarded in the light of the new geological facts acquired by Russian expeditions in recent years. The entire interglacial fauna of the White Sea was completely destroyed by the last glaciation when the basin of the White Sea was completely filled with ice. During the postglacial period which coincided with the joining of the White and Baltic seas (Loven's* views have been confirmed by recent geological data), *M. entomon* dispersed in the almost fresh water that filled the basin of the White Sea. As the sea grew saltier during its connection with the Arctic Sea, *Mesidothea* survived only in the parts freshened by rivers, particularly in what is now the estuary of the Northern Dvina. However, the further colonization of the White Sea by marine forms from the Barents Sea occurred with difficulty because of the narrowness of the channel connecting the two basins and the peculiarities of the hydrologic conditions. At the present time, the White Sea is quite isolated from the Arctic Ocean,

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*conjectural spelling - translator

as the high summer temperatures of the water in the "neck" of the White Sea keep the usual arctic forms from the Pechora Sea out (*Synidothea, Mesidothea sabini*), and the below-zero winter temperatures in the "neck" prevent the thermophilic boreal species of the western part of the Barents Sea (species of *Idothea, Janira, Aega*) from entering the basin of the White Sea. *Calathura brachiata* cannot gain access to the White Sea, probably because of the small depths, currents and sandy bottoms of the "neck". Thus, the present unusually poor composition of the Isopoda fauna of the White Sea can easily be attributed both to the history of its origin, and to the present state of the White Sea. (134)

Kara Sea. The Kara Sea is found between Novaya Zemlya and the western shore of Severnaya Zemlya. This sea is almost always covered with ice; it is ice-free for a short time only in its southern part as a result of the warming effect of large Siberian rivers. The near-bottom region of the Kara Sea is washed by very cold and saline water (temperature -1.5°C, salinity 34.5‰). From around Novaya Zemlya in the vicinity of Cape Zhelaniye in the north flows Atlantic water in the form of a weakly defined stream of the North Cape Current, which turns southward along the eastern shore of Novaya Zemlya. The temperatures here are above zero degrees Centigrade, and the salinity exceeds 33‰. The southern part of the sea up to a depth of 25 m warms up considerably in summer and the temperatures rise above zero, and the freshening of the water brings the salinity down below 25‰. Through the Novaya Zemlya straits, the Kara Sea also receives the waters of the Barents Sea, which together with the freshened waters of the Ob and Yenisei turn

northward, flowing in the direction of the Polar Basin from which they finally emerge in the Greenland Sea (Visé, 1924). In the northern part of the Kara Sea, there are two deep troughs up to 500 m in depth and divided by an underwater ridge which connects Visé Is. with Solitude Is. The deepest one of these troughs extends into the Kara Sea from the NW, between the northern tip of Novaya Zemlya and Visé Is. The second trough passes between Visé Is. and Schmidt Is. The slopes of these troughs are washed by the Atlantic waters that pass through the Polar Basin, while the floor of the troughs at a depth of over 500 m is directly affected by the waters of the Polar Basin. Thus, the Kara Sea has a highly complex hydrologic regime, and is divided roughly into at least two regions, i.e. a northern, typically polar region with cold saline waters, and a southern shallow region with a low salinity and above-zero summer temperatures. In accordance with this distribution of (135) warm and cold waters, the Isopoda fauna is also distributed unevenly. The following 24 forms of Isopoda have been discovered so far in the Kara Sea:

Munnopsurus giganteus
Eurycope cornuta
Eurycope hanseni
Munnopsis typica
Ilyarachna hirticeps
Ilyarachna bergendali
Munna fabricii
Pleurogonium spinosissimum
Mesidothea entomon glacialis
Mesidothea sabini sabini
Mesidothea sabini robusta
Mesidothea sibirica
Synidothea bicuspida
Synidothea muricata
Synidothea nodulosa
Calathura brachiata
Aega ventrosa
Phryxus abdominalis
Dajus mysidis
Bopyroides hippolytes
Clypeoniscus meinerti
Gnathia elongata
Gnathia robusta
Gnathia stygia

Arctic species (*Munnopsurus, Munnopsis, Mesidothea sabini sabini*) are distributed in the northern cold and deeper part of the sea. *Calathura brachiata* also finds its way into this sea

with the Atlantic waters. The southern freshened part of the sea is abundantly inhabited by shallow-water *Mesidothea sabini robusta, Mesidothea sibirica* and *Synidothea*. Of particular interest are the details of distribution within the Kara Sea of the Barents forms (shallow-water N Atlantic species that found their way into the Kara Sea through the Barents Sea) and the form from the Polar Basin. *Pleurogonium spinosissimum, Munna fabricii* and *Gnathia robusta* represent the fauna of the Barents Sea. *Pleurogonium* and *Munna* have been encountered in the overgrowth of Hydroidea in the Karskiye Vorota, while *Gnathia robusta* has been observed in a deep hole north of Cape Zhelaniye. Apparently, all of these enter the Kara Sea from the Barents Sea together with the streams of Barents waters and feeble branches of the North Cape Current, but do not spread extensively throughout the Kara Sea. On the other hand, isopods of the Polar Basin (*Eurycope hanseni* and *Gnathia stygia*) have been encountered only on the bottom of the deep (450-500 m) trough between Visé Is. and Cape Zhelaniye. The almost fresh water of river estuaries is inhabited by masses of *Mesidothea entomon glacialis*. Circumpolar, eurybiontic, parasitic forms (*Phryxus* and *Dajus*) are encountered both in the northern and southern parts of the Kara Sea. (136)

In comparison with the Isopoda fauna of the Barents Sea, the Isopoda fauna of the Kara Sea is highly depauperate (there are twice as many species in the Barents Sea), and this depauperation is due mainly or even exclusively to the dropping out of the N Atlantic forms, of which only a few find their way into the Kara Sea. Here we encounter a typically Siberian fauna with its characteristic species *M. sabini robusta, M. sibirica, M. entomon glacialis* and *Synidothea*.

Laptev Sea (Nordenskjöld Sea). This sea is bounded by the Taimyr Peninsula from the west, by the Novosibirsk Islands from the east, and by the boundary of the continental shelf from the north. This typical high-Arctic basin, which is almost always covered with ice, is very shallow. Its depth is less than 60 m almost everywhere. Because of the mass of the inflowing rivers, the surface layers of the sea are highly freshened, with a higher temperature in summer; at the same time, we observe a very marked stratification of both temperature and salinity. The highest salinity at the bottom was observed at 74° N, and was equal to 28.6‰ when the salinity at the surface was only 17.8‰. In the area affected by the Lena River (this effect is already quite evident at 77° N, 500 km from the mouth of the river), the salinities at the bottom drop to 4-6‰ at depths of up to 22 m.

The depauperation of the Isopoda fauna in the Laptev Sea progresses even further, as shallow-water species and species capable of surviving large fluctuations in salinity and considerable freshening are selected in this area from all the arctic species that are still encountered in the Kara Sea. So far, only ten species of Isopoda have been discovered in the Laptev Sea, but each of these species (especially those of the genus *Mesidothea*) is abundantly represented. All the researchers who have worked in the Laptev Sea say that the drag nets and trawls were always brought in full of live *Mesidothea*. The scarcity of species and the unusual abundance of individuals is highly characteristic of this sector of the Arctic, where the following species are encountered:

Munnopsurus giganteus
Munnopsis typica
Mesidothea sabini sabini
Mesidothea sabini robusta
Mesidothea sibirica
Mesidothea entomon glacialis
Synidothea bicuspida
Synidothea nodulosa
Phryxus abdominalis
Dajus mysidis

(137)

Their distribution within the Laptev Sea is highly characteristic, i.e. the typically marine and more or less deep-sea forms (*Munnopsurus, Munnopsis, Mesidothea sabini sabini*) and the marine parasitic *Phryxus* and *Dajus* are encountered in the deeper and more saline part of the sea, whereas all the other species (except *Synidothea*) abound in the southern, very shallow and highly freshened part; at the same time, *Mesidothea sabini robusta, Mesidothea sibirica* and *Mesidothea entomon glacialis* are encountered together at a salinity of 4-5‰, while *M. entomon glacialis* (small forms) enter the fresh waters of rivers, sometimes going up a river for thousands of kilometers (e.g. up the Lena to Yakutsk).

East Siberian and Chukchi Sea. The East Siberian Sea is bounded by the Novosibirsk Islands in the west, the meridian of Wrangel Is. in the east, and by the continental shelf in the north. The Chukchi Sea is located between Wrangel Is. and Alaska. Both seas are very shallow. As in the Laptev Sea, the depth of these two seas does not exceed 60 m anywhere. The salinities near the bottom are low (up to 24-25‰) and the temperatures are around -1.0°. The warm current flowing out through the Bering Strait into the Arctic Sea produces a feeble branch directed NW into Long Strait in summer, but its effect on the hydrologic conditions of the sea is very insignificant. In winter, we observe a cold refluence, and "one would think that the movement of the bulk of the water

in the eastern part of the East Siberian Sea is directed SE and S throughout the year, and that the retrogressive movement of the water in summer takes in only the surface layer" (Visé, 1926).[1] The ice remains all year round, sometimes forming vast polynias* and moving northwards. The conditions for existence are extremely unfavourable, and the Isopoda fauna reaches its highest level of depauperation here. It suffices to say , for example, that the 1929 Russian expedition on the "Litke" did not bring back a single specimen of Isopoda (even *Mesidothea*) from the vicinity of Wrangel Is., despite the fact that extensive zoological material (138) had been collected by numerous dredgings. So far, only the following five species of Isopoda are known from the East Siberian and Chukchi seas:

Munnopsurus giganteus
Mesidothea sibirica
Mesidothea sabini robusta
Mesidothea entomon glacialis
Synidothea bicuspida

As for the distribution of these species within the boundaries of the sea, we can only say that all of these species are encountered in the East Siberian Sea, and they disappear almost completely in the Chukchi Sea.

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[1]The investigations of a research team of the State Hydrologic Institute in the Bering Strait and the Chukchi Sea in 1932 and 1933 established without a doubt that the exchange of waters between the Arctic Ocean and the Bering Sea was a one-way process. A current from the Bering Sea into the Chukchi Sea was observed at all the 24-hr stations in the Bering Strait. Only a very feeble branch was detected flowing from the Chukchi Sea into the Bering Sea at Cape Dezhnev, but it quickly reversed its flow without entering the Bering Sea. Thus, the conditions are favourable to the penetration of Pacific forms into the Chukchi Sea and mainly farther east, to the Beaufort Sea.

*a space of open water in the midst of ice - translator

Beaufort Sea. This sea lies to the west of the Chukchi Sea. It is bounded by the North American archipelago from the east, and by the continental shelf from the north. The depths here are noticeably greater than in the Chukchi Sea. The salinity averages 32‰; the temperatures are below zero, and the ice is almost year-round. The hydrologic regime of the Beaufort Sea is greatly affected by the warm current which passes through the Bering Strait and heads partly straight northward, but mostly eastward along the arctic coast of Alaska. The Isopoda fauna in the Beaufort Sea (only the southern part was covered in the investigations) is far more abundant than in the East Siberian Sea. This is due mainly to the Pacific species which find their way to this region with the warm current, and partly to the N Atlantic species which come to this area from the east through the straits of the Canadian archipelago and, perhaps, from the west along the continental shelf. So far, the following 15 species are known from the Beaufort Sea:

Janira alascensis
Eurycope mutica
Munnopsis typica
Mesidothea entomon
Mesidothea sibirica
Mesidothea sabini robusta
Synidothea bicuspida
Synidothea laevis
Synidothea muricata
Synidothea picta
Pleuroprion murdochi
Arcturus baffini typica
Rocinela belliceps
Phryxus abdominalis
Dajus mysidis

As we can see, the main nucleus of the arctic fauna of Isopoda (species of *Munnipsis, Mesidothea, Phryxus, Dajus* and *Synidothea bicuspida*) is augmented here by Pacific forms (*Janira alascensis, Synidothea laevis, Synidothea picta, Rocinela belliceps*) and by Atlantic forms from Davis Strait (*Eurycope, Arcturus* and *Pleuroprion*). The Beaufort Sea has not been investigated very thoroughly so far, but a number of Pacific forms such as *Synidothea marmorata* (139)

and *Idothea phosphorea*, which have been encountered farther east in the vicinity of Davis Strait, will probably be found in this sea eventually.

Southwestern part of the Arctic (Baffin Bay, Davis and Denmark straits, western and southern Greenland, coast of Labrador up to Cape Cod). This warmest part of the Arctic Region, which is bounded by the Iceland—Cape Cod line from the south, is characterized by very great depths and warm salty waters of Atlantic origin, with a temperature of up to +4.4°C in the near-bottom layers at maximum depths and a salinity of 35‰. A very deep part of the Atlantic projects in vast tongues into the Davis and Denmark straits, so that depths of up to 3000 m are observed in Davis Strait. The Wyville-Thompson Ridge and an underwater ridge connecting Greenland and Iceland with depths not exceeding 565 m separate this region from the cold waters of the Polar Basin which move in close from the north along the depths. The distribution of the currents in this region is highly characteristic, and can be depicted in the following way. From the north through Smith Sound comes a cold current which presses against the western shore of Davis Strait, flows toward Newfoundland and forms the cold Labrador Current. The cold polar waters also penetrate this region from the Greenland Sea, through the Denmark Strait. This polar current, known as the East Greenland Current, moves from the north southward into the Denmark Strait, produces a powerful branch (the cold East Iceland Current) directed SE along the eastern shore of Iceland, and then turns northward again, rounding the southern tip of Greenland. Moving northward along the western coast of Greenland, these polar waters

of the East Greenland Current entrain the warm Atlantic water which comes from the south and reaches the benthopelagic region of the western coast of Greenland.

The Atlantic water, in the form of a powerful warm stream (Irminger Current) with a salinity of 35‰ and temperatures of +3 to +4°C, moves from the south and produces two branches. One of these turns eastward and moves along the northern shore of Iceland (eastern branch), while the second one (western branch) moves into Davis Strait, rounding Cape Farewell, and then continues farther north along the western coast of Greenland, entrained by the waters of the Greenland Current. The cold polar water with a low salinity stays in the surface layers, being the lighter water. The heavy salty Atlantic water reaches the bottom of the described region, which is why the warm currents determine the composition and distribution of the demersal fauna of the Davis and Denmark straits and the entire southwestern part of the Arctic. The following 107 species of Isopoda are encountered here: (140)

Jaera albifrons
Janira maculosa
Janira laciniata
Janira spinosa
Janira wilhelminae
Janira pulchra
Janira tricornis
Janira alta
Acanthaspidea typhlops
Janirella laevis
Janirella spongicola
Katianira chelifera
Haploniscus spinifer
Hydroniscus abyssi
Munna groenlandica
Munna fabricii
Munna minuta
Munna acanthifera
Haplomesus angustus
Haplomesus insignis
Haplomesus tenuispinis
Haplomesus modestus
Heteromesus dentatus
Heteromesus longiremis
Nannoniscus oblongus
Nannoniscus analis
Nannoniscus inermis
Nannoniscus plebejus
Nannoniscus minutus
Nannoniscus affinis
Nannoniscus armatus
Desmosoma latipes
Desmosoma insigne
Desmosoma laterale
Desmosoma longispinum
Desmosoma politum

Pleurogonium latimanum
Pleurogonium intermedium
Pleurogonium spinosissimum
Pleurogonium pulchrum
Dendrotion paradoxum
Schistosoma ramosum
Ischnomesus profundus
Ischnomesus armatus
Haplomesus quadrispinosus
Syneurycope parallela
Echinozone coronata
Storthyngura magnispinis
Munnopsurus longipes
Eurycope murrayi
Eurycope nodifrons
Eurycope cornuta
Eurycope inermis
Eurycope phallangium
Eurycope furcata
Eurycope mutica
Eurycope hanseni
Eurycope complanata
Eurycope parva
Eurycope producta
Paramunnopsis oceanica
Munnopsis typica
Munnopsoides eximius
Pseudomunnopsis beddardi
Cirolana schmidtii
Eurydice grimaldii
Aega crenulata
Aega arctica
Aega ventrosa
Aega gracilipes
Rocinela daumoniensis
Rocinela maculata
Desmosoma simile
Desmosoma natator
Desmosoma gracilipes
Macrostylis spinifera
Macrostylis abyssicola
Nannoniscella groenlandica
Ilyarachna hirticeps
Ilyarachna bicornis
Ilyarachna spinosissima
Calathura brachiata
Cyathura truncata
Idothea metallica
Idothea phosphorea
Mesidothea sabini sabini
Synidothea marmorata
Synidothea nodulosa
Arcturus baffini
Arcturus baffini tuberosus
Astacilla arietina
Astacilla granulata
Bopyroides hippolytes
Phryxus abdominalis
Dajus mysidis
Dajus profundus
Holophryxus richardi
Holophryxus acanthophyrae
Clypeoniscus meinerti
Arcturocheres pulchripes
Astacilloechus ingolfi
Cumaechus insignis
Gnathia elongata
Gnathia cerina
Gnathia robusta
Gnathia albescens
Gnathia bicolor

As we carefully examine this list, we see that an entire Isopoda fauna not encountered anywhere else in the Arctic Region finds its way to this part of the Arctic which is warmed considerably by Atlantic waters. Not only deep-sea species of the N Atlantic, but even subtropical forms (*Eurycope murrayi*, *Eurycope complanata*, *Eurydice grimaldii*) and one form of tropical origin (*Idothea metallica*) gain access to this area via great depths.

A large part of these species has been encountered in the southern parts of the Davis and Denmark straits, whereas the fauna in the northern part (Smith Sound, coast of Baffin Island and Labrador) is considerably poorer and of a distinctly arctic nature, (142) with typically arctic species such as *Munnopsis typica, Mesidothea sabini, Synidothea nodulosa,* etc. Here we also observe elements of the Pacific fauna which probably found their way to this area along the coast of Alaska and Polar Canada (*Synidothea marmorata, Idothea phosphorea, Arcturus*). In Denmark Strait where the Atlantic (northern branch of the Irminger Current) and polar (East Greenland Current) waters come together, the fauna is extremely abundant and consists of both deep-sea Atlantic species, and high-Arctic species (*Janira, Katianira, Ilyarachna, Gnathia, Dajus, Phryxus,* etc.). However, this abundant deep-sea Atlantic fauna does not spread farther north and eastward into the Greenland and Norwegian seas, probably because of the existence of a natural barrier, one that separates the waters of the Polar Basin from Atlantic waters, namely the underwater Greenland—Iceland—Faeroe Is. ridge. The same ridge probably prevents deep-sea forms of the Polar Basin (e.g. *Mesidothea megalura*) from spreading southward into the N Atlantic via great depths.

Norwegian Sea. The Arctic Region takes in only the northern part of the Norwegian Sea which is bounded in the south by the line extending from Bodö to the southern Icelandic coast. The part of the Norwegian Sea lying south of this line should be regarded as part of the Boreal Region both in hydrologic conditions and fauna. The Norwegian Sea

is comparatively warm, with above-zero temperatures at the bottom; its depths exceed 2000 m, and it has the usual ocean salinities which vary from 34 to 35‰. The composition of the Isopoda fauna and its distribution within the Norwegian Sea are determined by the distribution of the currents. The eastern, warmer part of the sea is affected by the powerful Gulf Stream directed NE along the Norwegian coast (warm region), while the western part of the sea is affected by the polar waters of the East Iceland Current which is directed along the northern and eastern coasts of Iceland ("cold region"). So far, the following 85 species have been encountered in the northern part of the Norwegian Sea:

Jaera albifrons
Janira maculosa
Janira laciniata
Haploniscus armadilloides
Munna boeckii
Munna kroyeri
Munna minuta
Munna nanseni
Pseudomunna hystrix
Pleurogonium inerme
Pleurogonium rubicundum
Pleurogonium spinosissimum
Dendrotion spinosum
Ischnomesus bispinosum
Haplomesus quadrispinosus
Haplomesus angustus
Heteromesus schmidtii
Heteromesus frigidus
Pseudomesus brevicornis
Macrostylis elongata
Macrostylis subinermis
Macrostylis longipes
Desmosoma globiceps
Desmosoma lineare
Desmosoma plebejum
Ilyarachna hirticeps
Ilyarachna dubia
Ilyarachna longicornis
Munnopsurus longipes
Janira pulchra
Acanthospidea typhlops
Haploniscus bicuspis
Eurycope megalura
Eurycope phallangium
Eurycope furcata
Eurycope mutica
Munnopsis typica
Cirolana microphthalma
Cirolana hanseni
Aega strömi
Aega crenulata
Aega monophthalma
Aega arctica
Aega ventrosa
Rocinela daumoniensis
Calathura brachiata
Limnoria lignorum
Idothea baltica
Idothea granulosa
Idothea emarginata
Idothea pelagica
Idothea viridis
Pleuroprion hystrix
Pleuroprion murdochi
Mesidothea megalura
Astacilla longicornis
Astacilla arietina
Astacilla intermedia

Nannoniscus simplex
Nannoniscus arcticus
Nannoniscus laticeps
Nannoniscus reticulatus
Nannoniscus equiremis
Nannoniscus spinicornis
Echinozone coronata
Echinozone arctica
Aspidarachna clypeata
Eurycope cornuta
Eurycope inermis
Eurycope hanseni
Eurycope brevirostris
Eurycope producta
Astacilla pusilla
Astacilla granulata
Bopyroides hyppolites
Pseudione hyndmanni
Phryxus abdominalis
Dajus mysidis
Notophryxus clypeatus
Aspidophryxus peltatus
Gnathia elongata
Gnathia robusta
Gnathia hirsuta
Gnathia abyssorum
Gnathia stygia

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In comparison with the Isopoda fauna in the vicinity of the Davis and Denmark straits and all of the southwestern Arctic up to the line extending from the southern Icelandic shore to Cape Cod, the northern part of the Norwegian Sea manifests the first degree of depauperation due to the dropping out of the majority of the more thermophilic and deep-sea Atlantic forms, especially in the "cold region" of the sea. High-Arctic species and forms of the Polar Basin such as the deep-sea *Mesidothea megalura, Munna hanseni, Eurycope cornuta, Munnopsis typica, Ilyarachna hirticeps,* etc. descend to this area along the depths. These forms are distributed here in the area affected by the polar East Iceland Current, the branches of the East Greenland Current which carries the main mass of the arctic waters flowing out of the Polar Basin into the Atlantic Ocean through the Denmark Strait. On the other hand, thermophilic Atlantic forms, as well as southern species such as *Eurycope megalura, Circolana hanseni, Munnopsurus longipes, etc.,* are encountered in the "warm region" of the Norwegian Sea, along the powerful Gulf Stream. Another extremely interesting and highly characteristic feature of the Norwegian Sea is the complete absence of the arctic species of

Mesidothea (with the exception of *M. megalura)* and *Synidothea*, which are almost circumpolar and abound in other parts of the Arctic.

Greenland Sea. This is a typical polar, hard-to-reach basin which is mostly covered with ice, deep (up to 3000 m), with high salinities and below-zero temperatures near the bottom. The Atlantic fauna of Isopoda is not encountered here at all, as the underwater Greenland-Iceland ridge with a depth of only 565 m prevents the warm Atlantic waters with the Irminger Current and the thermophilic deep-sea fauna from penetrating the depths of the Greenland Sea. This sea is inhabited almost exclusively by the high-Arctic species of Isopoda, and only *Calathura brachiata* probably found its way here with the warm stream of the Atlantic Current which reaches western Spitsbergen. The small number of species can probably be attributed in part to the insufficient research conducted in the deep regions of the Greenland Sea. The following 25 species are known from this sea:

Janira pulchra
Janira tricornis
Munna groenlandica
Munna minuta
Nannoniscus arcticus
Desmosoma globiceps
Desmosoma armatum
Ilyarachna bergendali
Munnopsurus giganteus
Eurycope cornuta
Munnopsis typica
Aega psora
Aega crenulata
Katianira lobata
Katianira cornifera
Aega arctica
Calathura brachiata
Arcturus baffini typica
Arcturus baffini **var.** *tuberosus*
Pleuroprion frigidum
Bopyroides hippolytes
Phryxus abdominalis
Dajus mysidis
Gnathia elongata
Gnathia robusta

Exchange of forms between the faunas of individual basins and general characteristics of the Isopoda of the Arctic Region.

Due to the intensive investigations conducted in the Arctic over the past decade to establish the general hydrologic conditions

and the fauna of its individual regions, a close relationship was established between the distribution of the currents and the distribution of not only the plankton, but the benthonic fauna as well. In many cases, a study of the distribution of the benthos pointed to the existence of currents and their direction, and in some cases served as evidence supporting important hydrologic assumptions. Of special significance in this respect is the question regarding the exchange of faunas between individual seas.

When examining the entire Isopoda fauna of the Arctic Region, we are struck by the abundance of forms in its western part adjacent to the Atlantic Ocean, and by the gradual decrease in species from west to east. For instance, 107 species of isopods are encountered in the vicinity of the Davis and Denmark straits, southern Greenland and Iceland; the number of species sharply diminishes farther eastward and to the north. Eighty-five species are known from the arctic part of the Norwegian Sea, only 41 species in the Barents Sea, 25 species in the Greenland Sea, 24 species in the Kara Sea, and only 10 species in the Laptev Sea. Depauperization of the Isopoda fauna reaches its maximum in the East Siberian and Chukchi seas (only 5 species), and the number of Isopoda species again increases to 15 species in the Beaufort Sea. This depauperization of the Isopoda fauna from west to east cannot be attributed only to the various degrees of research conducted in the individual regions of the Arctic.

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A number of recent Soviet expeditions to a part of the Arctic adjacent to the Asian coast added almost nothing to the lists of Isopoda known from these areas by the data of previous expeditions, and only underlined the extreme depauperization and monotony of the fauna.

This fact indicates that the western part of the Arctic Region is inhabited by isopods from the Atlantic Ocean, which find their way to this area with the warm currents that branch out from the Gulf Stream and flow into the Arctic Basin. A strong influx of thermophilic boreal forms heads north and northeast from the Atlantic Ocean along the layers washed by the Irminger Current to Greenland, to the region of the Davis and Denmark straits and along the shores of Scandinavia, following the Gulf Stream into the Norwegian and Barents seas. Not only boreal, but even subtropical Atlantic species (*Idothea metallica, Eurydice grimaldii, Cirolana hanseni, Eurycope complanata, Eurycope parva*) find their way into the Arctic Region along the deep areas that tongue out between America, Greenland and Iceland.

The Wyville-Thompson Ridge prevents the deep-sea Atlantic forms from proceeding farther into the Arctic with the Irminger Current; this ridge prevents these forms from spreading to the Norwegian and Barents seas, whereas they find their way into Davis Strait without obstacles. The same ridge interferes with the return of deep-sea polar forms (*Mesidothea megalura, Katianira*) to the depths of the N Atlantic, and only a few of the arctic species *(Munnopsis, Eurycope)* descend to the boreal region, sinking to even greater depths. Novaya Zemlya is the second barrier in the path of the Atlantic forms to the Arctic. Only one species of Atlantic origin, *Calathura brachiata*, is encountered east of Novaya Zemlya in the Kara Sea, whereas in the Laptev Sea, we already encounter the arctic fauna of Isopoda in its pure form. This fauna is extremely limited and uniform, consists of only seven species and is characterized by an abundance of individuals. Some species find their way into the

Kara Sea from the Barents Sea mainly by rounding Novaya Zemlya from the north (*Calathura, Gnathia robusta, Mesidothea sabini sabini*), whereas small straits such as Matochkin Shar, Karskiye Vorota and Yugorskiy Shar are apparently also inaccessible to them. On the other hand, the shallow-water *Pleurogonium* and *Munna* find their way into the Kara Sea from the Barents Sea, and the shallow-water species of the eastern part of the Arctic (*Synidothea, Mesidothea sabini robusta, Mesidothea sibirica*) pass into the Barents Sea from the Kara Sea through these comparatively small straits (*M. sibirica* discovered in Mashigina Bay on the western coast of Novaya Zemlya, and *Synidothea* and *M. sabini robusta* in the Pechora Sea). Thus, the Barents and Kara seas still exchange faunas. Barents species also find their way to the northern saltier and deeper part of the Laptev Sea. Here, the Isopoda fauna is a purely arctic one, without any admixture of Atlantic forms. Farther east, Pacific species intermingle and the Isopoda fauna becomes mixed again. While the warm currents transport boreal Atlantic forms to the Arctic, the cold currents help arctic forms gain access to the Atlantic Ocean. For instance, *Phryxus abdominalis, Bopyroides mysidis, Munnopsis typica, Aega psora* and *Synidothea nodulosa* reach Cape Cod with the cold Labrador Current; *Ilyarachna hirticeps, Munnopsurus giganteus* and *Mesidothea sabini* find their way to the southwestern part of the Barents Sea in the cold waters that wedge in between the individual streams of the North Cape Current; the high-Arctic species *Synidothea bicuspida, M. sibirica,* etc. gain access to the Pechora Sea through the straits of Yugorskiy Shar and Karskiye Vorota. The exchange of faunas between the Arctic and White seas is very diffi-

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cult. The most common forms inhabiting the region of the Barents Sea adjacent to the White Sea (*Munnopsis, Synidothea, Idothea granulosa*) are not encountered in the White Sea; the neck of the White Sea is probably an insurmountable barrier for them.

The entire Isopoda fauna of the Arctic Region is divided into the following three groups on the basis of origin: strictly arctic, autochthonous species (a few species), Atlantic forms (the majority of species) and Pacific forms (a few species). With respect to their geographic distribution, all the Isopoda species of the Arctic can be divided into the following four groups (with the exception of species with a poorly researched geographic distribution): 1) high-Arctic species, 2) predominantly arctic species, 3) arctic-boreal species and 4) boreal species. The first group inhabits the eastern Arctic and the northernmost areas of its western part; the second group can be found throughout the region and some of the species of this group are circumpolar; the third group is encountered in the Arctic and the northern part of the Boreal Region; the fourth group, which inhabits the Boreal Region, finds its way to the Arctic Region with the warm currents.

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Consequently, the entire Arctic can be divided into the following three main parts: 1) the high Arctic which takes in the Polar Basin and the seas adjacent to the Asian coast, 2) the Arctic proper, the region bounded from the east by Novaya Zemlya, and from the southwest by a line extending from meridian 35° E northward to latitude 75° N and turning west toward the southern tip of Greenland, and 3) the Subarctic which takes in the southwestern part of the Arctic (K. Deryugin, 1925).

The species common to the Arctic Region are not something uniform, but fall into a number of groups of a partly geographic order and, apparently, partly of an ecological order. *M. sabini* and the circumpolar species *Synidothea nodulosa* can serve as an example of this nonuniformity and intraspecific variability.

For instance, *M. sabini* forms two well-defined subspecies, i.e. *M. sabini sabini* which inhabits the western part of the Arctic region, and *M. sabini robusta* which is common in the eastern sector of the Arctic. The first subspecies, *M. sabini sabini*, is found at depths exceeding 100 m, and forms two races, i.e. *Mesidothea sabini sabini* natio *barentsi* which inhabits the western and northern parts of the Barents Sea, the Spitsbergen area, Franz Josef Land, the northern parts of the Kara Sea and the Laptev Sea, and *Mesidothea sabini sabini* natio *petschorica* which is found in the southeastern part of the Barents Sea and the southern part of the Kara Sea at depths ranging from 6 to 200 m. *M. sabini robusta* inhabits the somewhat freshened shallow waters of the southern part of the Kara Sea, the Laptev Sea, the East Siberian Sea and the Beaufort Sea, and to some extent finds its way through the Novaya Zemlya straits into the southeastern part of the Barents Sea (Pechora Sea).

Synidothea nodulosa forms at least five different groups. The first is found in the eastern part of the Barents Sea, in Yugorskiy Shar, Karskiye Vorota and along the southwestern coast of Novaya Zemlya; the second group inhabits the northern areas along the coast of Novaya Zemlya; the third group inhabits the northern part of the Barents Sea and Spitsbergen waters; the fourth group or race inhabits the northern regions of the Kara and Laptev seas, and the fifth

race is found off the shores of western Greenland. It is very likely that a more detailed study will show that other circumpolar species of isopods also fall into geographic races or ecological morphs. For example, *Munnopsis typica* and *Synidothea bicuspida* show a clear (149) tendency toward such a division. We should also note that the following bipolar forms also exist among the Isopoda: 1) *Paramunnopsis oceanica*, discovered in the Subantarctic Region at $\phi=61^{\circ}58'S$ and $\lambda=95^{\circ}01'E$, and 2) *Munnopsurus giganteus*, which forms a special form, *Munnopsurus giganteus* f. *australis*, in antarctic waters.

As we conclude our short review of the Isopoda fauna of the Arctic Region, we should note that the time has come to deal with the problem concerning the origin of the marine arctic fauna. While we can say with certainty that the Isopoda fauna in the western part of the Arctic is of a purely Atlantic origin, having found its way to the Arctic with the warm Atlantic waters during the postglacial period, and the paths of this colonization of the Arctic by foreign elements which forced the endemic inhabitants of the Arctic farther north and east can be traced, we still cannot solve the question regarding the origin of this endemic arctic fauna which includes the high-Arctic forms. First of all, we know nothing about the deep-sea fauna of the Polar Basin; we can only form our opinions to some extent on the data of the Norwegian Atlantic Expedition (Norske Nordhavs Expedition 1876-1878), collected in the deep tongue-like areas apparently connected with the depths of the Polar Basin, in the vicinity of the Denmark Strait and north of Iceland. Even on the basis of only this data, the fauna of the Polar Basin appears to be an original one. The originality of this arctic fauna is

also emphasized by the facts collected by the expeditions of the Arctic Institute over the past three years, which included material on a variety of new species from different groups of benthonic invertebrates.

Perhaps the roots of the arctic fauna lie in the fauna of the northern part of the Pacific, as conjectured by Prof. K.M. Deryugin on the basis of a study of the mollusk fauna in the northern and Far Eastern seas. It can be said that the "high-Arctic" genus *Synidothea* is actually of Pacific origin, as only 6 species of this genus are encountered in the Arctic (4 of these inhabit the Pacific Ocean), whereas 26 species of this genus are found in the northern part of the Pacific (only 2 species of *Synidothea* are encountered in the Atlantic Ocean). However, the problem concerning the origin of the arctic marine fauna cannot be solved at the present time for the simple reason that we still know nothing about the deep-sea (150) fauna of the Polar Basin. Dredging on the slope of the continental shelf and in the abyssal zone of the Polar Basin would immediately shed light on a string of questions related to the origin of the arctic fauna.

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ZOOGEOGRAPHICAL STUDY OF THE ARCTIC ISOPODS

BY E. GURIANOVA

SUMMARY

The fauna of *Isopoda* of the Arctic Regions consists of 182 species; their geographical distribution is very unequal and depends upon the distribution of the warm and cold currents in the Polar Basin. The true Arctic *Isopoda*-fauna is very poor and consists of a few numbers of species, though a great number of Atlantic species penetrate into the western part of the Arctic Regions; on the other hand a number of northern Pacific forms enter the eastern part of the Arctic.

The warm currents are the channels, by which the boreal Atlantic species penetrate into the Arctic. So, for instance, nearly the whole abundant Atlantic fauna of *Isopoda*, together with some Subtropical species, spread towards Davis Strait and Baffin Bay, along the warm Irminger current. Many of the Atlantic species enter the Barents Sea with the North Cape current, pushing the true Arctic forms farther to the north and to the east.

There are three great barriers on the way of penetration of the boreal Atlantic fauna into the Arctic. The first, and most important one, is the Wyville Thomson Range, which does not permit either the warm Atlantic waters, or the boreal fauna to go far north. On the other hand this barrier limits the descent of the true Arctic fauna into the great depths of the Atlantic Ocean. The sublittoral and shallow-water Atlantic fauna meets on its way from the Boreal region to the north-east, along the border of North Europe and Asia, two more barriers — firstly the islands of Novaya Zemlya and Vaigach, and secondly the Taimyr Peninsula. Some species of Atlantic *Isopoda* may be met with in the Kara Sea, but in the Nordenskjöld Sea we have to deal only with a typical Arctic fauna without any addition of either Atlantic or Pacific forms.

It seems that the penetration of the North-Pacific species into the Arctic takes place in the same manner, i. e. from the south-west to the north-east. Only a very few numbers of Pacific forms survive in the severe conditions of the East-Siberian Sea, in consequence of its low salinity and shallow depths. The greatest part of the Pacific species, entering the Arctic through Bering Strait, spread along the coast of Alaska into the Beaufort Sea. Only a limited number of shallow-water forms, as the species of the genus *Synidothea*, are able to spread their area of distribution both to the east and to the west from Bering Strait. Perhaps some of the Pacific species wander westwards, along the continental shelf, but to the present day we have no zoological material from these places. Summarizing the above data we may say: the further to the north and to the east, the poorer becomes the fauna of *Isopoda*.

Davis Strait and Baffin Bay possess 107 species, most of which are Atlantic forms (see list on pp. 140—141). The northern part of the Norwegian Sea has 85 species (see list on pp. 142—143); the Barents Sea has only 41 species, as most of the Atlantic forms are not able to support the Arctic conditions and disappear (see list on p. 130). In the Kara Sea there are but 24 species, as only 2—3 Atlantic species could penetrate through the shallow and narrow straits between the islands of Novaya Zemlya and Vaigach and spread over the Kara Sea. (A part of the Atlantic fauna, distributed along the Atlantic current, enter the Kara Sea, together with a feeble branch of this warm current around Desire Cape, as for instance, *Calathura brachiata* — see list on p. 135). The Nordenskjöld Sea possesses only 10 species of *Isopoda*. It is a true high-Arctic fauna of *Isopoda* without any admixture of either Atlantic or Pacific forms (see list on p. 136). The East-Siberian Sea is the poorest, as regards the number of *Isopoda* species, and only 5 species are known from there. Further to the east the number of *Isopoda* increases again, as some Pacific forms begin to appear. Thus, from the Beaufort Sea we know 15 species, a part of which is commonly found in the northern part of the Pacific Ocean, from where they penetrated into the Arctic.