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MARINE BIOLOGY

Macrobenthos of the Southern Part of St. Anna Trough and the Adjacent Kara Sea Shelf

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Abstract—Taxonomic composition and ecological structure of benthic communities of the southern part of St. Anna Trough were investigated during the 54th and 59th cruises of RV *Akademik Mstislav Keldysh*. Material was collected using Sigsbee trawl at 10 stations arranged in two transects (depth range 57–554 m). It was shown that benthic communities of the western arm of the St. Anna Trough differ considerably from the communities of the eastern arm. The western arm communities develop under the influence of active near-bottom hydrodynamics in conditions of rugged topography and a coarse-grained sediment or hard substrate. The wastern arm of the trough is characterized by the predomination of the soft sediment, smooth topography, and weak currents. In the western arm of the trough the influence of the Barents Sea fauna is traced down to the edge of the internal shelf (about 150 m depth). The community of the eastern arm of the trough situated out from the direct influence of the Barents Sea waters represents a continuation of the *Ophiocten sericeum* community, typical for external Kara Sea shelf. With increasing depth, *Ophiopleura borealis* becomes the dominant species of the community. In the greatest explored depths some deep-water High-Arctic species, such as echinoids *Pourtalesia jeffreysi*, were observed. The major factors determining the distribution of benthic communities in the investigated area are the microrelief pattern, the sediment structure, and near-bottom hydrodynamics.

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INTRODUCTION

The Kara Sea is one of the best-studied seas of the Russian Arctic in term of its fauna. Regular studies of benthic fauna of the Kara Sea have been performed since the expedition of A. Nordenskiöld on the whaler *Vega* in 1878. In the middle of the last century L.A. Zenkevich summarized all the existing data and published the scheme of distribution of the benthic biomass [8] and bottom biocoenoses for the entire sea [9]. Later, A.P. Kuznetsov examined the distribution of the trophic groups and performed hydrodynamic zoning of the Kara Sea according to zoobenthos trophic structure [12, 13, 14]. In subsequent years intensive studies of the Kara Sea benthos were carried out in PINRO cruises of the RV *Akademik Knipovich*, *Vychegda*, *Otto Schmidt*, and others. [12]. From 1991 to 1992 schematic maps of the distribution of total biomass, dominant species, and trophic groups of macrozoobenthos were prepared within the exploration program of VNIIOkeangeologia [5].

However, the distribution of the main types of benthic communities in the Kara Sea is still questionable. Due to the discrepancies in collecting and sample processing methods, many results obtained in different studies on this subject are contradictory. Boundaries of the benthic communities are often weak or demonstrate gradient distribution patterns. In addition, the direction and scales of seasonal and long-term changes in the position of these boundaries are still not solved. Therefore it is important to perform studies by using a uniform methodology as a part of the multidisciplinary program including the simultaneous acquisition of a wide range of environmental data. Such approach enables to identify different benthic communities and factors controlling the distribution of the communities. Composition and distribution patterns of macrobenthos establish a necessary baseline to evaluate the scales of long-term changes in the marine ecosystem under the influence of environmental and anthropogenic factors.

St. Anna Trough and adjacent areas of the outer shelf of the Kara Sea are of particular interest for several reasons. Due to the severe ice conditions this area is the least studied when compared with the other parts of the Kara Sea (South and Central) [16]. In particular, no benthic-oriented studies were performed in the St. Anna Trough in 1990-2003 [1]. The unique hydrological and geological characteristics of this area reflect in the species composition of benthic communities. The St. Anna Trough is separated in the south from the Novaya Zemlya Trough by a shallow threshold (100–150 m). The trough is regarded as a pathway

† Deceased.

to the Kara Sea for the Barents Sea waters and the Atlantic-Barents Sea benthic fauna. However, the extent of this penetration is poorly known. Data on the species composition and environmental conditions in the greatest depths of the trough are discrepant.

The aim of this study was to determinate the distribution patterns of the major macrofauna assemblages on the southern slope of the St. Anna Trough and to identify the main environmental factors responsible for this distribution. The following problems were also set: verifying the taxonomic composition of the dominant taxa, correlation of the identified macrofauna assemblages with the corresponding environmental conditions, comparing the patterns of assemblages in the western and eastern arms of the trough and adjacent areas of the Kara Sea. It should be emphasized that the subject of this study was the identification of the dominant taxa of macrofaunal assemblages and environmental characteristics of benthic communities. Our study does not include a complete species list of the macrobenthos at the present stage.

MATERIALS AND METHODS

The material for the present study was collected at 10 stations in the 54th and 59th cruises of RV *Akademik Mstislav Keldysh* in September 2007 and September 2011, respectively. The study area covers the southern part of the St. Anna Trough, the transects were made in the western (2007), and in the eastern (2011) arms of the trough. Samples were taken at the depth range 57–554 m.

To collect macrofauna we used a Sigsbee trawl with a steel frame 1.5 m wide and 35 cm high with a framing rope made of 3.5 mm steel wire (4 bights with double winding).

The trawl was equipped with a double bag: an outer bag was made of a double nodal caproic net made of 3.1 mm rope with a 45 mm mesh size; an internal bag was made of node-free net with 4.0 mm mesh size. The dredging was performed adrift at 0.2–1.0 kts. For the trawl launch and recovery a boat 10 t winch was used.

Each sample was washed through a system of steel sieves with a mesh size of 5.0 and 1.0 mm. Additional successive washing through a hand sieve with 0.5 mm mesh size was provided when required.

The material was fixed with 6% buffered formalin, followed by a transfer to 75% ethanol. Formalin neutralization was achieved by dilution with seawater with adjusting pH of 7 by addition of sodium tetraborate. For subsequent sorting and quantitative study the majority of samples were bulk-fixed after dividing into fractions according to the size of the sieves. Large and fragile animals were sorted manually and preserved separately. Washed sediments and rock material were transferred for geological studies.

Subsequent treatment in the laboratory included sorting into main taxonomic groups, taxonomic determination and also counting and weighing of specimens. Sorting was proceeded using stereomicroscope. Determination of the animals was done using manuals for identifications [2, 6, 7, 15].

RESULTS

Western arm. In the western arm of the St. Anna Trough macro- and megafauna was collected at five trawl stations located in the basin (one station), and on the southeastern slope of the trough (four stations) (Table).

The trawl from the deep part of the trough (station 4983, depth 554 m) was relatively well washed and contained a small amount of gray silt with a considerable amount of pebbles and gravel (some stones were waterworn). The sample contained numerous ophiuroids *Ophiura sarsi*, *Ophiacantha bidentata* and *Ophiopleura borealis* and polychaetes *Thelepus cincinnatus*. Pycnogonids *Nymphon spinosum hirtipes*, soft corals (*Gersemia* spp.), bivalves (*Nuculana pernula*, *Ennucula tenuis*, *Astarte crenata*) and several species of polychaetes were abundant. Small gastropods, echiurids, and hydroids were also detected. Few decapods (*Pandalus borealis*, *Eualus gaimardii*, *Eualus gaimardi* var. *belcheri*), amphipods (*Anonyx nugax*, *Stegocephalus inflatus*, *Halirages fulvocinctus*, *Acanthostepheia malmgreni*), echinoderms *Heliometra glacialis*, *Gorgonocephalus* sp., *Strongylocentrotus pallidus*, *Pontaster tenuispinus*, sponges (Demospongiae) and scaphopods (*Siphonodentalium lobatum*) were recorded.

The trawl from station 4985 (depth 460 m) returned poorly washed. Apart from invertebrates, the trawl bag contained dense gray silt, consisting of fine organic and inorganic particle and pebbles. Echinoderms *Ophiacantha bidentata* and *Heliometra glacialis* and sponges (Demospongiae) were abundant in the sample. Numerous *Strongylocentrotus pallidus*, pycnogonids (mainly, *Nymphon spinosum hirtipes*), ophiuroids (*Ophiopholis aculeata*, *Ophiura sarsi*) and polychaetes *Nothria hyperborea* were collected. Few sea anemones, errant polychaetes, decapods (Macrura Natantia), amphipods (at least one species), priapulids *Priapulus* sp., bivalves *Nuculana pernula*, Buccinidae gastropods, cephalopods *Bathypolipus arcticus* (two specimens), ophiuroids *Ophiopleura borealis*, asteroids *Ctenodiscus crispatus* and *Lophaster furcifer* were recorded. In contrast with the previous station, cephalopods were detected here for the first time. At this station *Ophiacantha bidentata* clearly dominated among ophiuroids, while *Ophiopleura borealis* specimens were rare. Ophiuroids *Ophiopholis aculeata* and *Ophiura sarsi* were very common and occurred in approximately equal amounts. No soft corals were recorded; fewer crustaceans and polychaetes were detected while *Heliometra glacialis* crinoids were more common when compared to the previous station. In comparison with station 4983, species richness (according to preliminary data) was lower. Large bur-

The main groups of macrobenthos and environmental characteristics in the southern part of the St. Anna Trough

Station no.	Coordinates: the beginning, the end		Depth, m	The dominant species	Characteristic of the surface (0–5 cm) sediment layer	Characteristics of the near bottom water layer		
	N	E				T, °C	S, ‰	0_2, mL/L
Western arm of the trough								
4990	76°09.2′ 76°08.0′	72°29.8′ 72°35.7′	106–127	*Ophiopleura borealis*, *Molpadia borealis*, *Nothria hyperborea*, *Astarte crenata*	Waterlogged dark-brown silty pelite	–0.9	34.27	6.92
4988	76°35.3′ 76°32.9′	71°15.4′ 71°21.8′	151–183	*Ophiacantha bidentata*, *Ophiura sarsi*, *Strongylocentrotus pallidus*	Dark grey silty pelite, with small pebbles (2–4 cm)	0.14	34.79	7.64
4987	76°39.5′ 76°42.7′	71°02.9′ 70°57.8′	255–300	*Ophiacantha bidentata*, *Ophiura sarsi, Heliometra glacialis*, *Strongylocentrotus pallidus*, Pycnogonida	Dark grey silty pelite, with pebbles	0.54	34.87	7.52
4985	76°47.0′ 76°42.7′	70°37.9′ 70°36.4′	440–465	*Ophiacantha bidentata*, *Heliome-tra glacialis*, Demospongiae	Dark grey silty pelite, with large pebbles	–	–	–
4983	76°55.2′ 76°57.4′	70°16.2′ 70°19.7′	550–555	*Ophiacantha bidentata*, *Ophiura sarsi, Thelepus cincinnatus*, *Ophiopleura borealis*	Dark grey silty pelite, with big pebbles (up to 15 cm)	0.20	34.91	7.07
Eastern arm of the trough								
5032	76°32.98′ 76°32.96′	080°44.88′ 080°45.86′	56–57	*Ophiocten sericeum, Ophiacantha bidentata, Similipecten green-landicus*	Sandy silt with small amount of pelite, about 1.5 dozen FMN	–1.4	34.04	6.80
5033	77°12.59′ 77°12.93′	078°07.66′ 078°08.93′	118–120	*Ophiocten sericeum*, *Ophiacantha bidentata*, *Similipecten green-landicus*, *Molpadia borealis*, *Urasterias lincki*	Sandy silt	– 1.1	34.4	7.43
5034	77°25.57′ 77°26.07′	077°34.04′ 077°34.13′	220	*Ophiopleura borealis*, *Saduria sabini*, *Yoldiella fraterna*	Silty pelite, bioturbated	–0.5	34.9	9.60
5039	78°00.44′ 78°01.12′	074°53.80′ 074°54.76′	364–365	*Ophiopleura borealis*, *Ophioscolex glacialis*, *Yoldiella fraterna*	Silty pelite, bioturbated	–0.3	34.9	8.77
5042	78°29.49′ 78°29.92′	072°48.28′ 072°51.23′	472	*Ophiopleura borealis*, *Ophioscolex glacialis*	Silty pelite, waterlogged, bioturbated	–0.4	34.9	6.29

rowing sediment feeders (bivalves, sedentary polychaetes) were very poorly represented; the dominating organisms were either inhabiting the seafloor surface or freely moving over it. In course of preliminary examination no Foraminifera tests were found in the mud, but a high content of organic matter (small fragments of animals and plants) was signaled.

At station 4987 (depth of 300 m) the trawl came back well washed; the sample contained a large number of pebbles. Echinoderms (*Ophiacantha bidentata* and *Heliometra glacialis*) and pycnogonids (*Nymphon spinosum hirtipes* and *N. elegans*) were numerous in the sample. Ophiuroids *Ophiopholis aculeata* and polychaetes *Nothria hyperborea* were also common in the sample. Significant amounts of tubes produced by the polychaete family Spirorbidae, gastropods Acmaeidae, sponges Demospongiae, ophiuroids *Ophiura sarsi* and echinoids *Strongylocentrotus pallidus* were found on stones. Few hydroids, polychaetes *Pectinaria hyperborea*, amphipods, decapods (Macrura Natantia), polyplacophores, bivalves (*Nuculana pernula* and Propeamussiidae), brachiopods, and asteroids *Ctenodiscus crispatus* and *Lophaster furcifer* were also found. Compared to the previous station a higher proportion of invertebrates in the trawl was found due to *Heliometra glacialis* crinoids. In comparison with station 4985, higher amounts of *H. glacialis* and *Ophiopholis aculeata*, lower amounts of *Ophiacantha bidentata*, *Ophiura sarsi*, and *S. pallidus* (all echinoids at this station were small) were found. Mobile and sessile filter feeders predominated in this sample.

At station 4988 the trawl from the depth of 215–220 meters came well washed. The trawl bag contained a significant amount of pebbles and gravel (mostly rounded stones). Ophiuroids *Ophiacantha bidentata*, *Ophiopholis aculeata* and *Ophiura sarsi* were numerous in the sample. The dominating forms were pycnogonids (*Nymphon spinosum hirtipes*, *N. elegans* and *N. giltayi*), echinoderms *Heliometra glacialis* and *Strongylocentrotus pallidus* and bivalves *Hiatella arctica*. Also, soft corals *Gersemia* spp., hydroids, polychaetes (Spirorbidae, *Pectinaria hyperborea*), polyplacophores, gastropods Acmaeidae, bivalves (*Nuculana pernula*, *Astarte crenata*), brachiopods, bryozoans, and amphipods were encountered. Very few bivalves Propeamussidae, cirripedians, decapods *Pagurus pubescens* and echinoids *Hymenaster pellucidus* were recorded. In comparison with station 4987 a lesser amount of *Heliometra glacialis* was found. A high number of *Hiatella arctica* was detected, while earlier only few specimens were found. Echinoids *Strongylocentrotus pallidus* were collected in higher numbers than at station 4987; the average diameter of their shells was also higher. The proportion of sedentary polychaetes in tubes and bivalves was higher than at the previous two stations of the transect. In contrast, a smaller amount of Pycnogonida was found. The amount of pebbles and gravel was slightly higher than that of station 4987, but their size was smaller (up to 2–4 cm in diameter). The foulers were represented by the same species as at the previous stations.

At station 4990 (depth of 127–121 m) the trawl came up well washed. Ophiuroids *Ophiopleura borealis*, bivalves *Astarte crenata* and polychaetes *Nothria hyperborea* were numerous in the sample. A great number of ophiuroids *Ophiura sarsi*, isopods *Saduria sabini*, Naticidae gastropods, bryozoans and holothurians *Molpadia borealis arctica*, mysids (bycatch) was collected. Few soft corals *Gersemia* spp., bivalves *Nuculana pernula*, amphipods and echinoderms (*Ophiacantha bidentata*, *Gorgonocephalus* sp. and *Pontaster tenuispinus*) were found. In comparison with station 4988 crinoids *Heliometra glacialis*, bivalves *Hiatella arctica*, echinoids *Strongylocentrotus pallidus* were not recorded in the sample; the dominant ophiuroid in the sample was *Ophiopleura borealis*. As at the previous stations of this transect, *Nothria hyperborea* was a predominant species. The foulers were poorly represented when compared to the previous stations of the transect.

Eastern arm. The material was collected in the 59th cruise from 5 stations arranged in a transect from the central shelf to the bottom of the Trough.

At station 5032 from a depth of 57 m about a dozen large iron-manganese nodules up to 15 cm in diameter were found. The most numerous species in the sample were ophiuroids *Ophiocten sericeum* and *Ophiacantha bidentata* and bivalves *Similipecten greenlandicus*. Isopods *Saduria sibirica* and *S. sabini*, asteroids *Ctenodiscus crispatus* and pycnogonids *Nymphon* spinosum *hirtipes* and *N. sluiteri* were common. The most common polychaetes belonged to families Polynoidae (*Bylgides* sp.) and Nephtyidae. Another common polychaete *Polyphysia crassa* was not previously reported from the Kara Sea. Small bivalves *Yoldiella* sp. were less numerous. Several tubes of polychaetes *Spiochaetopterus typicus* were encountered. Soft corals *Gersemia* spp., polychaetes *Nothria hyperborea*, cephalopods *Rossia palpebrosa*, amphipods *Anonyx nugax*, echinoderms *Molpadia borealis arctica*, *Myriotrochus* sp., *Pontaster tenuispinus*, *Ophiopleura borealis*, *Ophioscolex glacialis* and *Gorgonocephalus* sp. and ascidians were also present in the sample. Some nodules were covered with foulers, mostly composed of *Gersemia* spp., hydroids and bryozoans.

At station 5033 from a depth of 120 m a few iron-manganese nodules were collected. Ophiuroids *Ophiocten sericeum*, *Ophiacantha bidentata* and *Ophiopleura borealis* and bivalves *Similipecten greenlandicus* were dominant in the sample. Pycnogonids (*Boreonymphon robustum*, *Nymphon sluiteri*, *N. spinosum hirtipes*), decapods *Sabinea septemcarinata*, isopods *Saduria sabini*, bivalves *Astarte crenata*, *Nuculana pernula* and *Hiatella arctica* and echinoderms *Molpadia borealis arctica*, *Ophioscolex glacialis*, *Urasterias lincki*, *Hymenaster pellucidus* and *Icasterias panopla* were common but not numerous. Several specimens of ophuiroids *Gorgonocephalus* sp. were also collected. Apparently the station was taken within the same community as station 5032. The difference between these two stations was in the higher number of echinoderms (based both on the abundance and diversity), the lower number of crustaceans (amphipods and isopods, although large decapods were collected) and less abundant but more diverse pycnogonids. Numerous Foraminifera were recorded in the sample.

At station 5034 from a depth of 220 m *Ophiopleura borealis* was a dominant species. Isopods *Saduria sabini* and bivalves *Yoldiella fraterna* were numerous in the catch. Ophiuroids *Ophiocten sericeum* and *Ophiacantha bidentata* were also numerous but less abundant than two above mentioned species. A number of pycnogonids were collected presented by four species: *Boreonymphon robustum*, *Nymphon sluiteri*, *N. spinosum hirtipes* and *N. stroemi gracilipes*. Bivalves *Cuspidaria* sp. were rather common. Asteroids *Urasterias lincki*, *Icasterias panopla* and *Pontaster tenuispinus* and holothurians *Molpadia borealis arctica* represented a significant part of the catch. The only large bivalve collected was a single specimen of *Hiatella arctica*. Polychaetes of the family Nephtyidae were common but not abundant. Large hydroids on gastropod shells, polychaetes *Nothria hyperborea*, bivalves *Thyasira* sp., nemerteans, amphipods *Anonyx nugax* and echinoderms *Ophioscolex glacialis* and *Myriotrochus* sp. were also recorded. *Similipecten greenlandicus* bivalves were completely absent. Numerous foraminiferans *Rhabdammina abyssorum* were recorded in the sample

At station 5039 from a depth of 365 m ophiuroids *Ophiopleura borealis* and *Ophioscolex glacialis* were dominant. The fine fraction (<5 mm) contained very abundant bivalves *Yoldiella fraterna*. Numerous specimens of medium-sized isopods *Saduria sabini* and *S. sibirica* were almost equally abundant (*S. sibirica* was slightly less abundant). A number of polychaetes *Nothria hyperborea* and actinarians (up to 3 cm) were found attached to gastropods (Buccinidae). Polychaetes of the family Nephthyidae and tubes of *Spiochaetopterus typicus*, bivalves *Thyasira* sp., *Cuspidaria* sp. and echinoderms *Urasterias lincki* and *Gorgonocephalus* sp. (latter more than 30 cm in diameter) were also present. A few decapods *Sabinea septemcarinata* and amphipods *Acanthostepheia malmgreni* were found. All pycnogonids were small specimens represented by three species. Also many *Rhabdammina abyssorum* and *Saccorhyza ramosa* foraminiferans were present in the sample.

At station 5042 from a depth of 472 m the fauna was rich and diverse. Ophiuroids *Ophiopleura borealis* and *Ophioscolex glacialis* and bivalves *Similipecten greenlandicus* were dominant. Significant amounts of amphipods, holothurians *Molpadia borealis arctica*, pycnogonids (six species of two families) and ascidians were collected. Nephtyidae, *Spiohaetopterus typicus*, Maldanidae, Sabellidae and *Nothria hyperborea* were detected among polychaetes. Decapods *Chionoecetes opilio* and octocorals *Gersemia* spp. and *Virgularia mirabilis* were present. *Saduria sabini*, *Thyasira* sp., small *Cuspidaria* sp., Scaphopoda, *Gorgonocephalus* sp. were also reported. It is important to note the presence of such relatively deep-sea elements that were not found in previous catches: echinoids *Pourtalesia jeffreysi*, isopods *Calathura brachiata* and foraminiferans *Astrorhiza*, while *Rhabdammina* spp. that was common at previous stations was completely absent.

DISCUSSION

Final conclusions about the composition and borders of benthic communities can be made only after the final taxonomical treatment of the material, which has not yet been completed. However, identification of the main types of encountered communities based on the dominant taxa is already possible. Normally, dominance of certain species is strongly expressed. Our previous research in this area [3, 4] show that normally three or four major taxa represent 85–99% of the weight of the trawl catch. Thus even at the primary sorting stage it is possible to identify the dominant taxa in each sample. The data on these taxa and environmental characteristics are presented in the Table.

The studies carried out in the 54th RV *Akademik Mstislav Keldysh* cruise showed that the benthic populations of the channel and the slope of the western arm of the St. Anna Trough differ significantly by their composition and ecological structure from the communities distributed at similar depths in the Novaya Zemlya Trough [4]. In particular, the difference reflects in the higher species number in the St. Anna Trough. A number of taxa present in the St. Anna Trough are not known from the Novaya Zemlya Trough (echinoids, brachiopods and several species of ophiuroids). Some of these species are probably immigrants from adjacent areas of the Barents Sea, entered the northern part of the Kara Sea with the deep-water current around Cape Zhelaniya. Traces of this current can be seen in the distribution of the bottom temperature along the transect (data provided by P.N., Makkaveev, V.V. Kremenetsky). At greater depths of the St. Anna Trough a positive temperature (reaching 0.54°C at station 4987 at a depth of 285 m) was maintained. Closer to the surface (from 155 m) the temperature was steadily negative.

The proportion of Barents Sea and Atlantic taxa in the communities of the St. Anna Trough can be assessed only after a full taxonomic treatment of the collected material. However, the abundance of certain species (for example, the echinoids *Strongylocentrotus pallidus*) at the deeper stations of the transect is already obvious. Communities with the dominance of this species have not yet been described throughout the Kara Sea; however it is common and widely distributed in the Barents Sea [9]. This species has been found only at one station during the 49th expedition of RV *Dmitrii Mendeleev* (4376) near the Kara Strait in 1993 [3]. For the first time the immigration of Atlantic pycnogonid *Nymphon giltayi* in the western arm of the trough (stations 4983 and 4988) has been detected;

previously this species was known only in the Grand Banks of Newfoundland. In contrast to the Novaya Zemlya Trough the *Ophiopleura borealis-Elpidia glacialis* community has not been detected at any depth in the St. Anna Trough. At the same time *Ophiopleura borealis* being one of the main taxa at some stations of the western arm does not specify the communities in the trough. This is due to the least abundance of this species in comparison to *Ophiacantha bidentata*, *Ophiopholis aculeata*, and other ophiuroids ([9], Fig. 71). Only at the shallowest station of the transect located at the Kara Sea shelf *Ophiopleura borealis* dominated clearly. This community is consistent with the description of the ecological community named by this species [17]. On the other hand, *O. borealis* is well represented at the deepest station of the trough. At the same station bivalves and holothurians were among the leading taxa. All mentioned above data demonstrate the difference between the communities of the trough channel and the shallower parts and may be connected with the slightly weakened dynamics of bottom waters of the channel compared to the slope.

Preliminary treatment of the trawl samples showed that the channel and lower part of the slope of the St. Anna Trough are occupied by the community with the dominance of echinoderms, mainly ophiuroids with *Ophiacantha bidentata* and *Ophiopholis aculeata* being the most abundant. Echinoids *Strongylocentrotus pallidus*, crinoids *Heliometra glacialis* and pycnogonids play an important role in the community. At the channel of the trough *Ophiopleura borealis* is between the dominant taxa, bivalves also play a relatively important role. In the upper part of the slope (station 4988, from a depth of 215–220 m) the relative number of bivalves and sedentary polychaetes increases while the number of pycnogonids decreases. In station 4990, from a depth of 121–127 m the composition of the leading taxa varies considerably. The first place is occupied by *Ophiopleura borealis*, *Astarte crenata* is also dominant, polychaetes are present in considerable amounts, echinoids, crionoids and brachiopods are completely absent (Figure (a)).

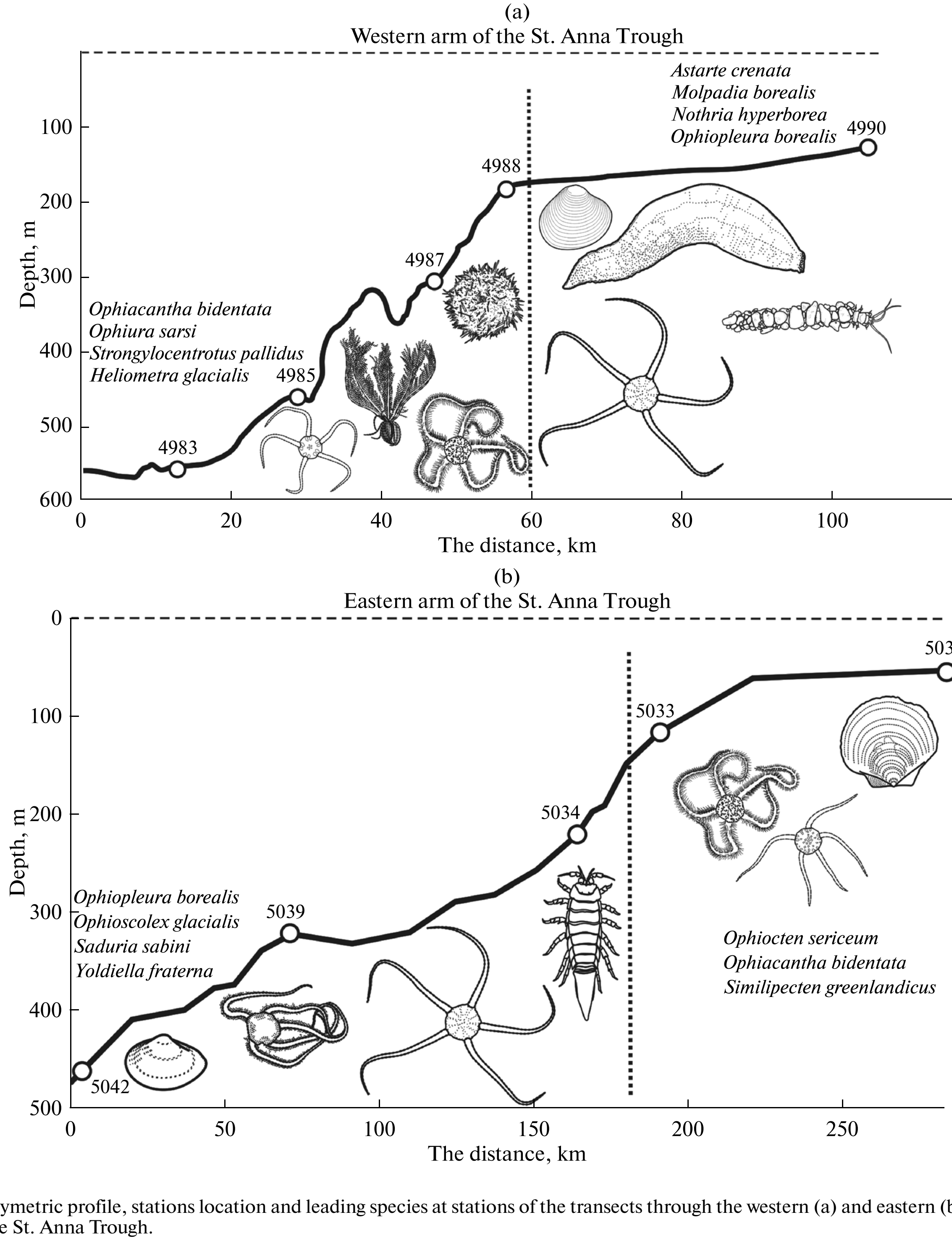
Based on our material we can conclude that the bottom community of the investigated part of the channel and the slope of the St. Anna Trough are formed under the influence of strong and steady bottom currents. This is evidenced by the abundance of sessile and mobile filter feeders which are clearly the dominant ecological group in the community. The proportion of selective deposit-feedeers is relatively small; non-selective deposit-feeders are almost absent. Burrowing forms are poorly represented; at the same time, the foulers inhabiting solid substrate (pebbles, shells of mollusks) play an important role in the samples.

The active dynamics of the bottom water is indirectly indicated by the composition of the sea floor sediments (data of V.A. Chechko). In the deeper stations of the transect dark-gray silty pelites with thin (1–2 mm) oxidized film at the surface are present. The presence of pebbles is significant in the upper layer (their average size decreases with depth). The absence of brown silt characteristic for the Novaya Zemlya Trough in the investigated area is probably the reason for the complete absence of *Elpidia glacialis* holothurians in our samples. This species is usually associated with the brown silts. In the shallowest station of the transect the sediment structure changes dramatically. In the upper layer of the geologic tube (0–5 cm) dark brown silty pelite underlined by soft uniform blue-gray silt is present. It should be noted that at this station the most notable changes in the benthic community were found.

Patterns of the transfer of suspended matter observed in the investigated part of the trough probably determine the trophic structure of the community and the distribution of the dominant taxa. In particular, among ophiuroids *Ophiacantha bidentata* and *Ophiopholis aculeata*, which have adaptations to filter food particles from the near bottom layer of water, are dominant by density. At the same time, *Ophiopleura borealis*, that do not possess long needles on its arms and focuses on the consumption of the organic debris, was found sporadically in the majority of samples. High abundance of the large crinoid *Heliometra glacialis* at deeper stations have been never previously reported in the Kara Sea. Small sessile filter feeders: bryozoans, hydroids, small sponges, Spirorbidae polychaetes and brachiopods are very numerous and diverse.

The most dramatic changes in the benthic community are observed in the transition zone from the slope of the through to the central plateau, where the fauna becomes quite typical for the central Kara Sea. No crinoids *Heliometra glacialis*, echinoids *Strongylocentrotus pallidus* and bivalves *Hiatella arctica* are found there. Changes are detected not only in taxonomic composition, but also in the ecological structure of the benthic community. The proportion of deposit-feeders increases (among ophiuroids *Ophiopleura borealis* starts to dominate). Foulers are less diverse compared to the slope stations of the transect: the initial examination did not reveal brachiopods or hydroids, and the abundance of bryozoans was much lower. It should be noted that this station substantially differs from the previous by the sediment composition. The upper layer of the sediment was oxidized brown silty pelite probably formed under conditions of weakened hydrodynamics. Apparently, the hydrodynamics create favorable conditions for deposit feeders (in particular large holothurians *Molpadia borealis*, asteroids *Ctenodiscus crispatus* etc.)

Trawl samples in the eastern arm of the trough taken during the 59th cruise (2011) were approximately evenly distributed along the depth (Figure (b)). The first two stations, 5032 and 5033, were located on the shelf within the *Ophiocten sericeum* community. Notable was the significant number of *Polyphysia crassa* polychaetes also known from the Barents Sea, but never reported from the Kara Sea. This finding sit-



Bathymetric profile, stations location and leading species at stations of the transects through the western (a) and eastern (b) arms of the St. Anna Trough.

uated almost in the geographical center of the Kara Sea basin is an example of the Barent Sea fauna penetration into the Kara Sea.

The benthic community of the eastern arm of the trough is a quite typical continuation of the communities inhabiting the outer continental shelf of the Kara Sea. As already mentioned, the first two stations of the transect (5032 and 5033) were situated in the region of the *Ophiocten sericeum* community. This is relatively rich and diverse community, which also includes different species of Pycnogonida, isopods *Saduria sibirica*, *S. sabini*, various Polychaeta etc. Asteroids are quite diverse. *Ctenodiscus crispatus*, *Hymenaster pellucidus*, *Icasterias panopla* and *Pontaster tenuispinus* play an important role in term of the biomass.

At depths of about 200 meters in the eastern arm of the trough (as in the other areas of the Kara Sea) *Ophiopleura borealis* begins to play a dominant role in the community while *Ophiocten sericeum* remains among the leading taxa. This transition is accompanied by a slight decrease of the near bottom temperature, as well as by some changes in the sediment structure (more fine-grained and waterlogged). It is known that *O. borealis* prefers soft silts. It should be noted that similar patterns in the vertical distribution of ophiuroid fauna (*Ophiocten sericeum* shallow complex being replaced by the *Ophiopleura-Opiacantha* bathyal complex) were described in the northern part of the Barents Sea [14]. Our data confirm that the community dominated by *Ophiocten sericeum* is probably the most common community throughout the whole western sector of the Arctic at depths less than 100 m, both on the mainland island shelf and on isolated elevations (banks) of the northern seas [18, 19].

Together with *Ophiopleura borealis* a small bivalve *Yoldiella fraterna* plays a significant role in the community at stations 5034 and 5039 demonstrating high abundance. Polychaetes of the family Nephtyidae, *Nothria hyperborea* and holothurians *Myriotrochus* sp. and *Molpadia borealis arctica* are quite common.

At the deepest station of section 5042 nearly the same community is found, however *Yoldiella fraterna* disappears from the leading species, and the place of the subdominant is occupied by large ophiuroid *Ophioscolex glacialis*. A significant role in the community belongs to the bivalves *Similipecten greenlandicus*, pycnogonids, holothurians *Molpadia borealis arctica*, various polychaetes and ascidians.

The trophic structure of the community of the eastern arm of the trough also differs from that of the western arm. A majority of the dominant forms are deposit feeders collecting deposited organic debris. This indirectly indicates that the processes of organic debris precipitation prevail over its transit in the investigated area. The deficit of the hard substrate in the eastern arm of the trough reflects in the weaker development of the sessile filter feeders. The opposite situation is observed on the slopes of the western arm.

The taxonomic composition of the fauna of the eastern slope is typical for the Kara Sea. Most of the species recorded there are well-known for the Kara Sea. Only at the deepest station of the transect (5042) some deep-sea species such as echinoids *Pourtalesia jeffreysi* and isopods *Calathura brachiata* were observed.

The biotopical distribution in the eastern arm of the trough is very different from the situation described for the western arm of the trough due to the mesorelief. In the western arm a relatively steep slope with alternating plow ridges and silty terraces was observed while in the eastern arm the slope was gentle with a subdued relief. The substrate is also drastically different. Samples from the western arm often contain pebbles and even large boulders. Hard material was virtually absent in the stations taken in the eastern trough. The vertical distribution of temperature at the stations of the eastern and western arms also varies considerably. In the western arm an influence of the warm intermediate water mass was clearly observed expressed in the increasing of temperature on the slope and on the channel of the trough. In the eastern arm of the trough the temperature gradually decreased along the transect during the transition from the edge of the shelf to the slope. Along the slope the temperature remains approximately constant and steadily negative. The near-bottom hydrodynamics was not measured, so the presence of the near-bottom currents of turbulence can be estimated only indirectly. However, the amount of the filter-feeders evidences that the community of the western arm is influenced by the relatively strong and steady near bottom currents. In the eastern arm of the trough, no such amount of the sestonofagous species were found; characteristics of the surface sediment layer correspond to the undisturbed hydrodynamic environment. At the same time, in the studies on the modern sedimentation dynamics in the St. Anna Trough, the eastern arm was characterized as a zone of stable accumulation, while the western arm belonged to the transit zone or transit-accumulation zone [10, 11].

We can conclude that the impact of the Barents Sea and High-Arctic fauna (clearly seen in the western arm) is insignificant in the eastern arm of the trough. The border of the Kara Sea based only on the benthic fauna distribution would be located at the edge of the western part of the St. Anna Trough (including the investigated part of the eastern arm slope).

At the deepest investigated depths in the St. Anna Trough several remarkable zoological discoveries were made. At the deepest station, 5042, echinoids *Pourtalesia jeffreysi* were present in the catch. Pycnogonid fauna at this station demonstrated another input of High-Arctic species: *Boreonymphon robustum* and *Cordylochele brevicollis*. We consider the presence of these deep-sea species to be an example of the penetration of High-Arctic deep-sea fauna into the Kara Sea.

CONCLUSIONS

The taxonomic composition and ecological structure of benthic communities of the eastern arm of the St. Anna Trough differ significantly from the communities of the western arm. The latter develop under the influence of an active near-bottom hydrodynamics, rugged topography and a coarse-grained sediment or a hard substrate. The eastern arm of the trough is characterized by the predomination of the soft sediment, smooth topography and weak currents. In the western arm the influence of Barents Sea fauna, which can be traced to the edge of the inner shelf (about 150 m), is significant. The edge of the shelf is the place where the warm intermediate water masses and Barents Sea fauna are replaced by cold water masses with a negative temperature and the fauna typical for the central

Kara Sea. The community of the eastern arm of the trough out of direct Barents Sea influence is a rather typical continuation of the *Ophiocten sericeum* community, which inhabits the outer continental shelf of the Kara Sea. *Ophiopleura borealis* becomes the dominant species of the community when the depth increases. In the greatest explored depths some deep-water High-Arctic species such as echinoids *Pourtalesia jeffreysi* can be observed. The major factors determining the distribution of benthic communities in the investigated area are the microrelief pattern, the sediment structure and near-bottom hydrodynamics.

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