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Meiobenthos and Nematode Community in Yenisei Bay and Adjacent Parts of the Kara Sea Shelf

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Abstract—Material is collected on a meridional profile from Yenisei Bay to adjacent parts of the Kara Sea shelf. The length of the profile is 550 km; 13 to 62 m depths. A multiple corer and Niemistö corer are used as sampling tools. The meiobenthos is represented by 13 taxa. Nematodes are the most abundant taxon, and harpacticoid copepods (Harpacticoida) are subdominant. The abundance and taxonomic diversity of meiobenthos and nematodes increases from the freshwater part of Yenisei Bay towards the Kara Sea shelf. Three types of taxocene are distinguished: freshwater, brackish-water, and marine. The taxocene of the estuary is not distinguished by any specific set of species and consists of species characteristic of the nematode community both in the freshwater and marine zones. The trophic structure of the taxocene of nematodes in Yenisei Bay is dominated by nematodes with well-defined stoma and are differently armed. The estuary and shelf are dominated by selective and nonselective deposit feeders.

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INTRODUCTION

The Kara Sea is a marginal shallow-water Arctic basin. A significant factor of the hydrological regime of the Kara Sea is river runoff. The two largest Siberian rivers—the Ob and Yenisei—flow into the Kara Sea. The Kara Sea receives more than half of river runoff from Siberian Arctic runoff and more than one-third of the total river runoff to the Arctic [38]. The history of hydrobiological studies in the Kara Sea covers almost 200 years. As a result of many expeditions, data on the taxonomic composition, spatial and temporal distribution, and influence of environmental factors on the distribution and morphological variability of organisms and on some macrobenthos taxa have been obtained [12]. Numerous studies were carried out in Ob and Yenisei bays, showing that an increase in diversity and the sequential succession of benthic biotic complexes, which is denoted in the succession of the leadership taxa in benthic communities, are observed in the transition zone from the Ob and Yenisei estuaries to open sea [1–3, 21–23, 32]. The meiobenthos in Russia's Arctic seas has been studied very irregularly compared to the macrobenthos. The meiofauna of the Barents, Pechora, and White seas has been studied particularly [9, 18], while significantly less investigations have been in the eastern sector of the Arctic Ocean [4, 6, 17]. Community of calcareous benthic foraminifera were examined from the southern Kara Sea [40]. The composition and distribution of meiobenthos in the Kara Sea were studied only in the disposal of radioactive waste along the eastern coast of the Novaya Zemlya archipelago from Abrosimov Bay to Stepovoi Bay and in the area of the Novozemelskaya Depression [5, 39]. Particular attention was given to assessing the impact of radioactive contamination on the meiobenthos community [18, 25].

The fauna of free-living nematodes in the seas of the Soviet Union was studied by I.N. Filipjev. He is the author of study on nematodes in the northern seas of the Soviet Union: nematodes of the order Enoplida [24] and nematodes of the Arctic Ocean [15]. Free-living marine nematodes of the family Leptosomatidae in the European Arctic [10] and of the order Enoplida in the seas of the former Soviet Union [11] were described by T.A. Platonova. The most complete taxonomic diversity of nematodes in the Kara Sea is presented by Galtsova and Kulangieva [4].

The purpose of our study was to detect the characteristics of the taxonomic composition and distribution patterns of meiobenthos and marine free-living nematodes in the Yenisei estuary and adjacent parts of the Kara Sea shelf.

MATERIALS AND METHODS

This study used material collected during cruise 59 of the R/V *Akademik Mstislav Keldysh* in September–October 2011. A meridional profile was made from 71°49.38′ to 75°59.82′ N. A total of 12 stations were taken (Fig. 1, Table 1). A multiple corer and Niemistö corer were used. The length of the profile was 550 km;

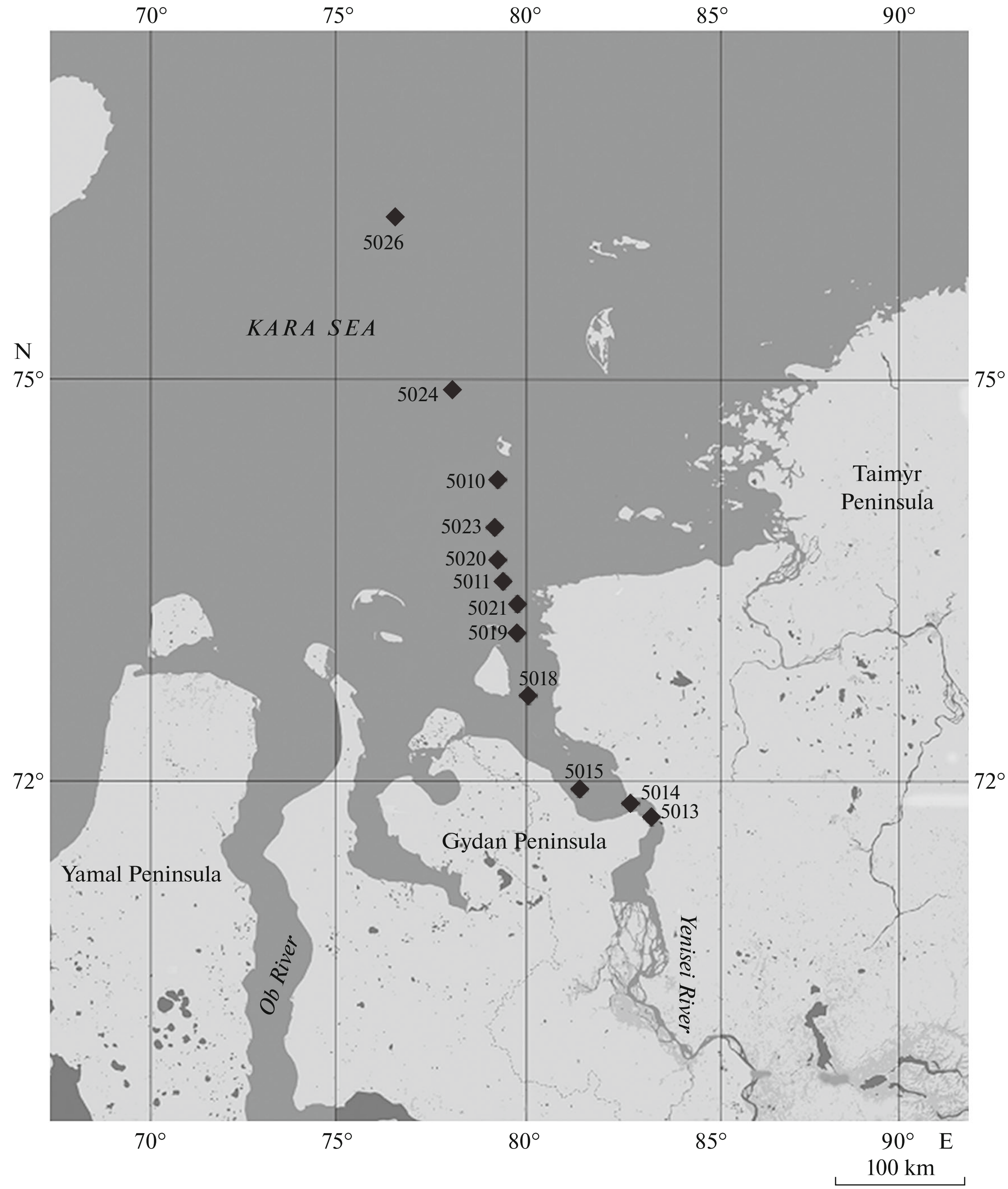

Fig. 1. Map of stations on Yenisei profile.

depths from 13 to 62 m. The distance between stations along the profile varied from 25 to 80 km.

We selected two cores with an area of 3 cm^2 at each station to a depth of 5 cm from the sediment surface for study the quantitative characteristics of the meiobenthos. Each sample was fixed with 4% formalin buffered in filtered sea water. All meiobenthos samples were stained with Rose Bengal and washed through a sieve with a 42-μm mesh in the laboratory. The organisms were extracted from the samples by centrifugation in the density gradient of a water colloid solution of silicates (LEVASIL®) [34]. The entire meiobenthos was calculated and classified by taxa. Two hundred nematodes were selected from each sample for identification. If the sample contained less than 200 nematodes, all nematodes were selected. According to the standard technique, the selected specimens were processed through Seinhorst's liquid (70 parts distilled water, 29 parts 95% ethanol, and 1 part glycerin) into glycerin [41] and mounted onto glass slides for micro-

Table 1. Characteristic of stations

Stations	Coordinates		Depth, m	Gear	Sediment			Water		
	N	E			characteristic of 0–5 cm layer of bottom sediments	moisture, %	Corg, %	salinity, psu: surface layer, 0–5 m	salinity, psu: near-bottom horizon	*T*, C°
5013	71 49′	82 59′	32	MC	Fine- and medium-grained sand with admixed pelitic material, vegetative detritus, and shell fragments; faint smell of hydrogen sulfide	–	0.623	0.069	0.07	9.5
5014	71 52′	82 11′	9	MC	Fine- and medium-grained sand with admixed pelitic material and vegetative detritus	21.9–32.7	0.34	0.06	0.07	9.23
5015	72 10′	80 59′	13.5	MC	Pelitic silt	55.1–68.4	2.55	0.52	23.4	4.4
5018	72 48′	79 59′	20	MC	Pelitic silt with admixed sand and silt material	–	2.404	13.3	31.1	0.33
5019	73 10′	79 51′	25.6	NC	Brown watered pelitic silt	–	–	–	31.6	–0.5
5021	73 23′	79 49′	34	NC	Pelitic silt	–	–	16.4	32.6	–0.38
5011	73 34′	79 46′	36	NC	Pelitic silt	–	1.515	13.6	32.5	–0.28
5020	73 43′	79 23′	30	NC	Heavily watered liquid aleuropelite	–	–	–	32.6	–1.4
5023	74 01′	78 53′	27	NC	Silt-rich sand	–	–	16.6	32.1	–1.4
5010	74 17′	78 37′	31	NC	Sandy aleuropelite, with large amount of vegetation remains	–	–	26.2	32.1	–1.4
5024	74 57′	77 53′	39	NC	Fine- and medium-grained sand with admixed aleurite	–	–	–	33.3	–1.5
5026	75 59′	76 40′	62	NC	Pelitic silt with admixed sandy–aleuritic material	43–47.8	0.347	24.1	34	–1.4

MC—multiple corer; NC—Niemistö corer. "–"—no data. Data on salinity, soil moisture, and C org. concentration were taken from Lein et al. [7].

scopic identefication. Nematodes were identified with an Olympus BX-51 microscope. As a result, there were 1500 slides. The similarity of samples was analyzed using Simpson, Shannon, Margalef, Dice, and Bray–Curtis indices index. Based on the obtained values, multidimensional scaling ordination was performed to reveal general trends in the distribution of communities. Statistical analysis was performed with PAST software [28].

FEATURES OF THE STUDY AREA

The areas of distribution of fresh (river) water masses → water masses of the mixing area (estuary) of river and marine waters → water masses of the inner shelf → water masses of the outer shelf are distinguished in the profile from the south to the north. The salinity of surface waters in the profile varies from 0.06 to 26.2, and there are almost no saline seawaters at the northernmost station of the transect (station 5013). The near-bottom water is more saline: from 0.07 psu in the estuary to 34 psu on the outer shelf (Table 1). During the expedition, the mixing area of river and marine waters had a complex structure and consisted of the vertical frontal zone passing between stations 5013 and 5018 and the horizontal frontal zone covering the southern part of the sea (up to station 5026) [7]. Three zones that differed greatly in their hydrophysical and hydrochemical conditions were clearly distinguished in the investigated area [7, 8]: the freshwater zone of the Yenisei estuary (stations 5013, 5014, and 5015); the estuary zone (stations 5018, 5019, and 5021); and the sea (stations 5011, 5020, 5023, 5010, 5024, and 5026) (the inner Kara shelf).

The profile has two main areas with mass sedimentation and oxidation of organic matter in the upper layer. The near-bottom waters at station 5015 are characterized by an increase in all nutrients and a decrease in the concentration of dissolved oxygen, which indicates a high intensity of destruction processes and the “young age” of the organic matter sediments. The second area of organic matter decomposition is located downstream (stations 5020 and 5021), where the bottom relief of the bay forms a depression separated from the seaward part by a site with small depths. The increase in the concentration of nutrients is lower here than upstream [8].

RESULTS

1. Taxonomic Meiobenthos Composition

The meiobenthos includes 13 taxa. The lowest number of taxa was recorded in the freshwater part of the bay, and the abundance of meiobenthos increased to ten taxa towards the north along the transect (Table 2). The dominant taxon in meiobenthos is Nematoda (86% of the total abundance). The second most abundant group is Harpacticoida copepods (9% of the total abundance). Comparison of all stations by cluster analysis using the Dice index showed that the taxonomic composition of meiobenthos in the freshwater part of Yenisei Bay significantly differs from the meiofauna of the estuary and shelf, while the similarity of the taxonomic composition between the stations constructed in the estuary and shelf of the Kara Sea was more than 75% (Fig. 2).

2. Quantitative Data on the Distribution of Meiobenthos and Nematodes

The average abundance of meiobenthos was 365.7 ± 281.8 ind/10 cm^2 in the freshwater part of Yenisei Bay (stations 5013, 5014, and 5015), 1165 ± 93 ind/10 cm^2 at the output from the bay (stations 5018, 5019, and 5021), and 1262.2 ± 889.4 ind/10 cm^2 on the Kara Sea shelf (stations 5011, 5020, 5023, 5010, 5024, and 5026). The average nematode abudance was 205 ± 150 ind/10 cm^2 in Yenisei Bay, 918 ± 71 ind/10 cm^2 at the output from the bay, and 1097.6 ± 825 ind/10 cm^2 on the shelf. The abundance of meiobenthos and nematodes increases from the freshwater part of Yenisei Bay towards the Kara Sea shelf (Fig. 3).

3. Nematode Community Characteristics

A total of 7246 nematodes were found. Seventy-four species belonging to 48 genera and 28 families were recorded in the Yenisei transect. The full list of species is given in Table 3. The number of species varied from four to 33 per station (Table 3). The highest species diversity was recorded in Oxystominidae and Xyalidae families (11 and 10 species, respectively). The analysis of the spatial distribution of the number of species showed the growth in the diversity in the direction from the freshwater zone of Yenisei Bay to the Kara Sea shelf through the estuary. The largest number of species was found at the deepest station on the shelf (station 5026—33 species), while the lowest number of species was recorded at the shallowest station in Yenisei Bay (station 5014—4 species) (Fig. 3). The expected average number of species (for 23 individuals) is 7 in the freshwater part of the bay, 11 in the estuary, and 10 on the shelf.

The integral characteristics of the nematode community at all stations are given in Table 3. Based on the presence/absence of species, the similarity indices were calculated at each station. In the freshwater part of the bay, the nematode taxocene is extremely poor (four to eight species); at the same time, the species are different at all three stations. An interesting feature of station 5013 is the dominance of the freshwater nematode species *Punctodora ratzemburgensis* not recorded anywhere else. Other nematode species not found anywhere else were recorded at station 5014 (*Anonchus* sp., *Daptonema* sp.3, *Dorylaimus* sp., and *Tripylla affinis*). With respect to abundance, *Chromadora* sp. is dominant at station 5015. However, both

Table 2. Distribution of meiobenthos with respect to stations. Nauplial stages are given in table; however, were not assumed to be a separate taxon

Abundance, spec./10 cm^2	Stations											
	5013	5014	5015	5018	5019	5021	5011	5020	5023	5010	5024	5026
Nematoda	270	33	312	973	943	838	396	281	1608	437	2215	1649
Harpacticoida	113	2	134	102	173	156	53	32	33	41	72	161
Nauplii Harpacticoida	135	0	60	56	46	33	5	6	19	29	21	150
Kinorhyncha	0	0	0	11	67	27	29	5	2	22	14	3
Ostracoda	0	0	0	0	9	2	14	6	13	11	24	45
Gastrotricha	0	0	0	0	5	2	0	0	0	5	0	3
Turbellaria	9	0	0	0	5	0	0	6	2	2	5	0
Oligochaeta	9	0	0	0	3	0	0	0	9	2	2	0
Tardigrada	2	0	0	0	0	0	0	0	0	0	0	0
Polychaeta	11	6	0	3	13	6	8	6	24	19	29	3
Bivalvia	0	0	0	0	0	6	3	3	2	0	2	3
Cyclopoida	0	0	0	3	0	9	2	0	2	5	0	8
Boreohydra sp.	0	0	0	3	0	0	0	0	0	0	5	6
Malacostraca	0	0	0	0	0	0	0	0	3	3	5	5
Total taxa	6	3	2	6	8	8	7	7	10	10	10	10

stations 5013 and 5015 include species that inhabit both estuaries and the shelf (e.g., *Sabatieria ornate* and *Sphaerolaimus* sp.). Therefore, the nematode community at these stations can be characterized as brackish-water. The estuary and shelf are characterized by a high similarity of species composition of the nematode taxocene (Fig. 4). *Microlaimus* sp., *Filipjeva arctica*, and *Cervonema brevicauda* are the dominants of the community in the estuary. The highest share in the nematode community at all shelf stations is represented by the species *Sabatieria ornata*, *Paramonhystera concinna*, and *Paramonhystera levicula*. Station 5010 is an exception, which is characterized by a low diversity, the dominance of *Filipjeva arctica*, and the presence of rare species not recorded at other stations (*Daptonema* sp.2, *Halalaimus turbidus*, and *Oxystomina cobbi*).

The degree of similarity of species composition in the investigated area was studied using the multidimensional scaling method. Three taxocene types were distinguished: freshwater (station 5014), brackish-water (stations 5013 and 5015), and marine (stations 5018, 5019, 5021, 5011, 5020, 5023, 5010, 5024, and 5026) taxocenes. The taxocene of the estuary zone is not distinguished by a specific set of species and consists of species characteristic of the nematode community both in the freshwater and marine zones (Fig. 5).

4. Trophic Structure of Nematode Taxocene

In almost all nematodes, the most anterior part is stoma, which initially grips food. The stoma is arranged differently in representatives of different families and genera. The stoma structure is determined by the range of food items and the feeding mode. Based on the stoma structure, we attempted to determine whether there is a difference between trophic types of nematodes inhabiting sediment along the profile [46]. The trophic structure of the nematode taxocene in Yenisei Bay is dominated by nematodes with a well-defined buccal cavity (1B and 2A), without armature (1B) and scrapers (2A). The estuary and the shelf are dominated by selective and deposite feeders s (1A and 1B). The share of nematodes with armature in the form of medium-sized mobile teeth in the buccal cavity (2A) increases at the deepest station (Fig. 6).

DISCUSSION

The qualitative composition and quantitative distribution of zoobenthos in the Kara Sea were studied along the eastern coast of the Novaya Zemlya archipelago from Abrosimov Bay to Stepovoi Bay (44–74 m) and in the area of the Novozemelskaya Depression (333–403 m) [5, 39]; a few stations were set up along the western coast of the Taimyr Peninsula, and one station in Yenisei Bay [18]. As a result of analyzing the taxonomic composition and spatial distribution of meiobenthos along the Arctic shelf, a total of nine pseudomeiobenthos taxa (microscopic macrobenthos larvae) and 12 eumeiobenthos taxa (constant meiofauna taxa) were revealed [18]. These results confirm the rather high diversity of the meiofauna on the Kara Sea shelf. The salinity regime has a very strong effect on meiofauna. The taxonomic structure of the meio-

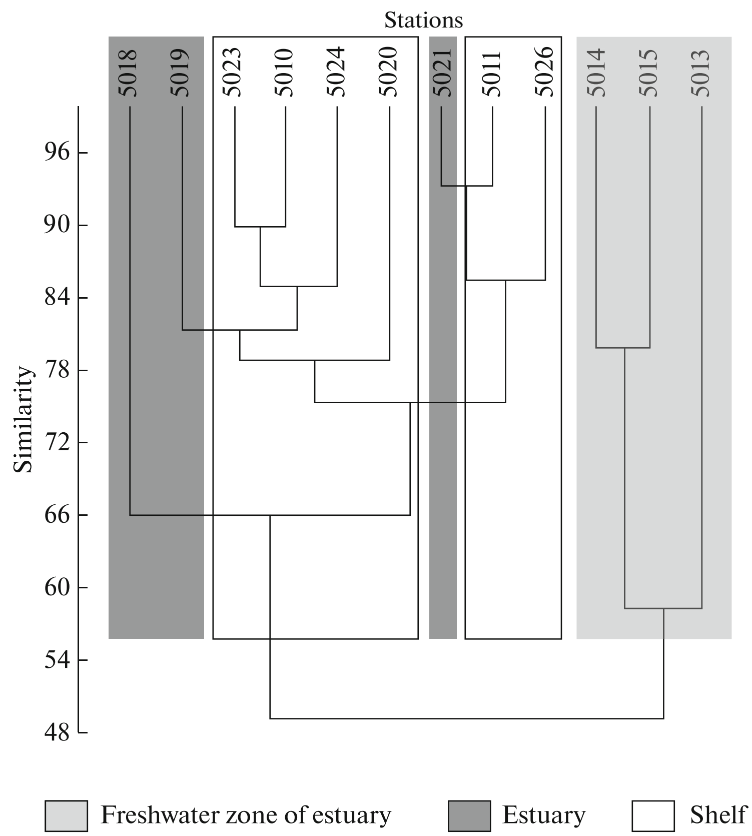

Fig. 2. Dendrogram of similarity of meiobenthos taxonomic composition. Dice index was used as similarity measure.

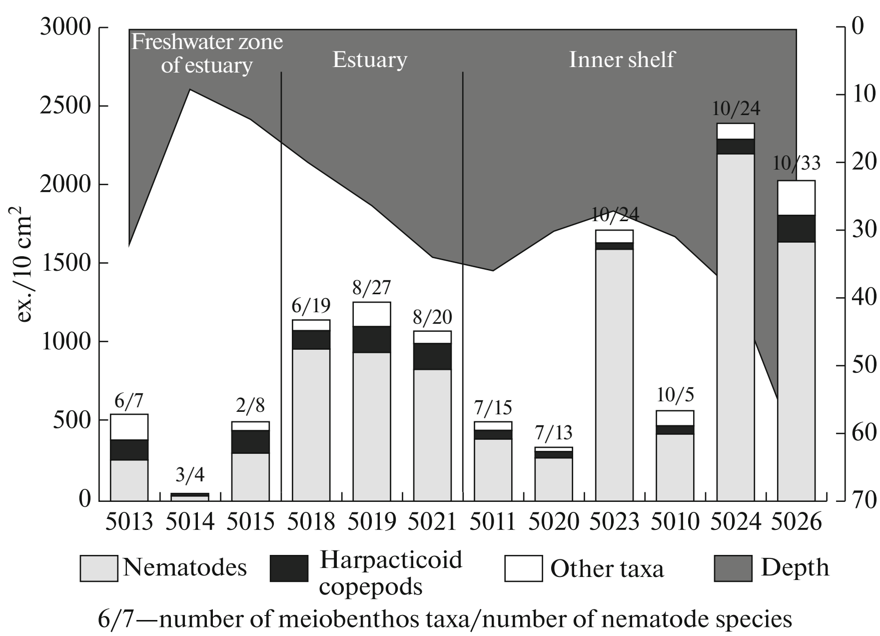

Fig. 3. Distribution of abundance of entire meiobenthos and dominant groups along Yenisei transect. Number of meiobenthos taxa and number of nematode species recorded for each station are given above columns indicating abundances.

Table 3. List of free-living nematode species as percentage of total abundance of nematodes identified at station

	5013	5014	5015	5018	5019	5021	5011	5020	5023	5010	5024	5026
Aegialoalaimidae												
Aegialoalaimus sp.	0	0	0	0	0	1.1	0	3.4	1.2	0	0	4.0
Anticomidae												
Anticoma sp.	0	0	0	0	0	0	0	0	1.2	0	0	0
Aphanolaimidae												
Anonchus sp.	0	16.7	0	0	0	0	0	0	0	0	0	0
Axonolaimidae												
Axonolaimus sp.	0	0	0	0	0	0	1.8	0	0	0	0	2.7
Ceramonematidae												
Pselionema simplex	0	0	0	0	5.4	0	0	0	0	0	0	0.7
Chromadoridae												
Chromadora sp.	0	0	35.5	3.9	10.7	2.1	0	10.3	0	0	0	0
Endeolophos sp.	0	0	0	0	0	0	0	0	0	0	1.5	1.3
Innocuonema sp.	0	0	0	0	0	0	0	0	8.2	0	4.6	17.3
Punctodora ratzemburgensis	37.5	0	0	0	0	0	0	0	0	0	0	0
Comesomatidae												
Cervonema brevicauda	0	0	0	1.3	6.3	29.5	9.1	0	0	0	1.5	4.0
Cervonema shiae	0	0	0	0	0	0	0	0	0	0	0	0.7
Cervonema tenuicauda	0	0	0	7.8	1.8	1.1	5.5	6.9	0	0	0	3.3
Sabatieria ornata	4.2	0	0	11.7	2.7	14.7	25.5	3.4	36.5	22.2	6.2	20
Sabatieria pulchra	0	0	3.2	1.3	0	0	0	0	0	0	0	0
Sabatieria punctata	0	0	0	0	1.8	1.1	0	0	0	0	0	0
Cyatholaimidae												
Cyatholaimus sp.	0	0	0	0	0	0	0	0	1.2	0	0	0
Marylynnia sp.	0	0	0	0	0	0	0	0	3.5	0	0	0
Pomponema sp.	0	0	0	0	0	0	0	0	2.4	0	0	0.7
Desmodoridae												
Desmodora sp.	0	0	0	0	0	0	0	0	0	0	0	0.7
Desmoscolecidae												
Desmoscolex sp.	0	0	0	0	0	1.1	0	3.4	3.5	0	0	0
Quadricomoides sp.	0	0	0	0	0.9	0	0	0	0	0	0	0
Diplopeltidae												
Campylaimus cylindricus	0	0	0	1.3	1.8	0	0	0	0	0	1.5	0
Campylaimus inaequalis	0	0	0	0	1.8	0	0	0	0	0	1.5	0
Diplopeltis ornatus	0	0	0	0	0	0	0	0	0	0	0	0.7
Diplopeltula incisa	0	0	0	0	0	0	0	0	0	0	0	0.7
Diplopeltula sp.n.1	0	0	0	1.3	0.9	0	0	0	0	0	1.5	0
Diplopeltula sp.n.2	0	0	3.2	0	0	0	0	0	0	0	1.5	0
Southerniella sp.	0	0	0	0	0	0	0	0	0	0	3.1	0

Table 3. (Contd.)

	5013	5014	5015	5018	5019	5021	5011	5020	5023	5010	5024	5026
Diplopeltoididae												
Diplopeltoides sp. n. 1	0	0	0	0	0	1.1	0	0	0	0	0	0
Dorylaimidae												
Dorylaimus sp.	0	16.7	0	0	0	0	0	0	0	0	0	0
Enchelidiidae												
Abelbola sp.	0	0	0	0	0	0	0	0	0	0	0	1.3
Enoplidae												
Enoplus sp.	0	0	0	0	1.8	0	1.8	0	0	0	0	0
Leptolaimidae												
Leptolaimoides sp.	0	0	0	0	0	1.1	0	0	0	0	0	0
Leptolaimus nobilis	0	0	0	0	0	0	0	0	2.4	0	0	0.7
Leptolaimus sp. 1	0	0	0	0	0	0	0	0	0	0	0	1.3
Leptolaimus sp. 2	4.2	0	3.2	0	2.7	0	0	3.4	0	0	0	0
Leptolaimus sp. n. 1	25.0	0	0	0	0	0	1.8	0	0	0	0	0
Linhomoidae												
Eleutherolaimus sp.	0	0	0	0	0	5.3	0	0	3.5	0	7.7	3.3
Linhomoeus sp.	0	0	0	0	0	0	0	0	0	0	1.5	0.7
Metalinhomoeus sp.	0	0	0	0	1.8	0	0	0	0	0	0	0
Terschellingia distlamphida	0	0	0	11.7	0	0	0	0	7.1	0	6.2	0
Terschellingia longicaudata	0	0	0	0	0	1.1	3.6	0	5.9	0	3.1	0.7
Microlaimidae												
Microlaimus sp.	0	0	19.4	14.3	6.3	2.1	1.8	6.9	2.4	0	6.2	10
Monhysteridae												
Diplolaimelloides sp.	0	0	0	0	0.9	0	0	0	0	0	0	0
Monhystrella sp.	0	0	0	0	0	0	0	0	0	0	0	2.0
Monoposthiidae												
Monoposthia sp.	0	0	0	0	0	0	0	0	0	0	0	0.7
Neotonchidae												
Comesa sp.	0	0	0	0	0	0	0	0	0	0	1.5	0
Oxystominidae												
Halalaimus americanus	0	0	0	0	0	0	0	0	0	0	6.2	0
Halalaimus comatus	0	0	0	0	1.8	0	3.6	3.4	0	0	1.5	0.7
Halalaimus gracilis	8.3	0	0	3.9	0.9	0	0	0	2.4	0	12.3	0
Halalaimus marri	0	0	0	0	0	0	0	0	0	0	0	1.3
Halalaimus thalassinus	0	0	0	0	0	0	0	0	1.2	0	0	0
Halalaimus turbidus	0	0	0	0	0	0	0	0	0	11.1	0	0
Halalaimus variabilis	0	0	0	0	0	0	0	0	1.2	0	0	0
Halalaimus sp. n. 1	0	0	0	0	0.9	0	0	0	1.2	0	0	0
Oxystomina alpatovi	0	0	3.2	0	0	0	0	0	0	0	0	0

Table 3. (Contd.)

	5013	5014	5015	5018	5019	5021	5011	5020	5023	5010	5024	5026
Oxystomina cobbi	0	0	0	0	0	0	0	0	0	11.1	0	0
Oxystomina elongata	0	0	0	0	3.6	1.1	0	3.4	1.2	0	1.5	6.7
Rhabdodemaniidae												
Rhabdodemania sp.	0	0	0	0	0	0	0	0	0	0	0	0.7
Selachinematidae												
Latronema sp.	0	0	0	0	0.9	0	0	0	1.2	0	0	0
Sphaerolaimidae												
Sphaerolaimus sp.	16.7	0	12.9	2.6	2.7	1.1	0	0	2.4	0	1.5	0.7
Thoracostomopsidae												
Epacanthion sp.	0	0	0	0	0	0	0	0	1.2	0	0	0
Paramesacanthion sp.	0	0	0	0	0	0	0	0	0	0	0	2.7
Tripylidae												
Tripyla affinis	0	50	0	0	0	0	0	0	0	0	0	0
Xyalidae												
Ammotheristus helgolandicus	0	0	0	1.3	0	0	0	0	0	0	3.1	0
Daptonema sp. 1	4.2	0	0	2.6	2.7	16.8	9.1	3.4	4.7	0	6.2	2.0
Daptonema sp. 2	0	0	0	0	0	0	0	0	0	11.1	0	0
Daptonema sp. 3	0	16.7	0	0	0	0	0	0	0	0	0	0
Daptonema sp. 4	0	0	19.4	1.3	1.8	1.1	1.8	0	0	0	0	2.0
Daptonema sp. 5	0	0	0	1.3	0	0	0	0	0	0	0	0
Filipjeva sp. n. 1	0	0	0	2.6	4.5	2.1	5.5	6.9	1.2	0	0	0.7
Filipjeva arctica	0	0	0	7.8	21.4	2.1	7.3	3.4	0	44.4	0	2.0
Paramonhystera concinna	0	0	0	13.0	6.3	3.2	7.3	41.4	0	0	3.1	0
Paramonhystera levicula	0	0	0	9.1	5.4	11.6	14.5	0	2.4	0	15.4	3.3
Number of species	7	4	8	19	27	20	15	13	24	5	24	33
Number of individuals per 10 cm^2	270	33	312	973	943	838	396	281	1607	437	2215	1649
Index of dominance	0.243	0.333	0.222	0.091	0.084	0.157	0.123	0.206	0.163	0.284	0.072	0.095
Simpson index	0.757	0.667	0.778	0.909	0.916	0.843	0.877	0.794	0.837	0.716	0.928	0.905
Shannon index	1.617	1.242	1.711	2.593	2.876	2.26	2.369	2.082	2.495	1.427	2.878	2.838
Margalef index	1.888	1.674	2.038	4.144	5.51	4.172	3.494	3.564	5.191	1.82	5.51	6.386
Evenness	0.831	0.896	0.823	0.881	0.873	0.755	0.875	0.812	0.785	0.887	0.905	0.812

benthos changes as desalination increases. According to our results, the number of taxa is lower at freshwater stations than in the estuary and on the shelf. However, all meiobenthos taxa recorded in the bay are also present on the shelf. Tardigrada are the exception, which were recorded only at station 5013. This is a small group that includes land, freshwater, and marine forms.

With respect to the species composition, two taxocenes are clearly distinguished in the investigated area: freshwater taxocene and marine taxocene. The nematode community in the estuary is not distinguished by a specific set of species; it consists of freshwater and marine euryhaline nematode species and represents a depleted variant of a marine community.

The freshwater zone of the estuary is characterized by a low taxonomic diversity of the meiobenthos and nematode community. The low density of nematodes and other groups playing an important role in marine meiobenthos is a general feature of freshwater communities [9]. In estuaries, the oligohaline zone is quite

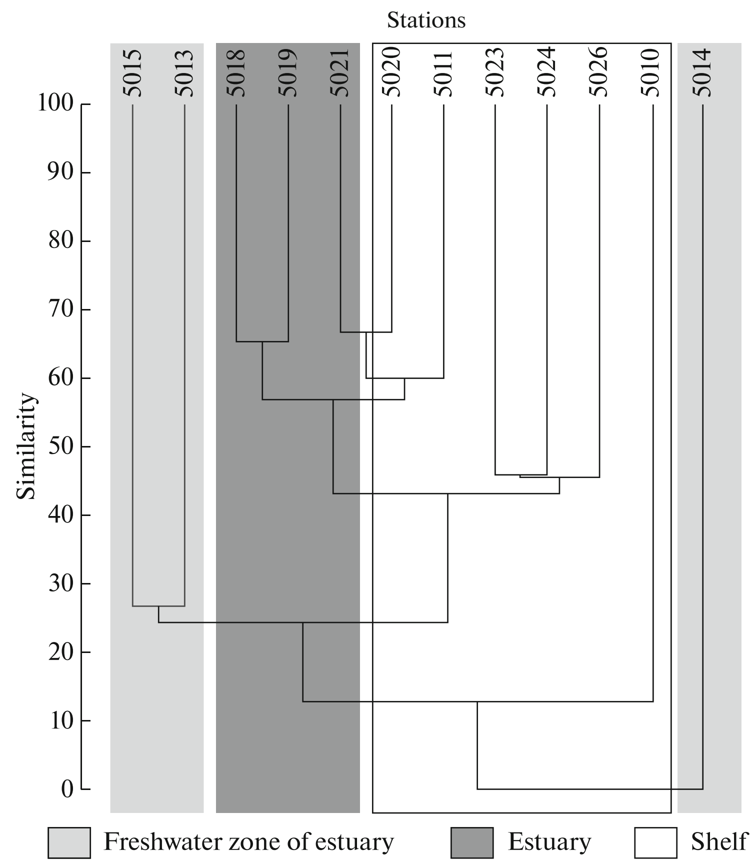

Fig. 4. Dendrogram of similarity of species composition of nematode taxocene. Dice index is used as similarity measure.

often exposed to the effect of critical salinity values (tidal, seasonal, and weather effects), which cannot be overcome by most of marine and freshwater species for physiological reasons. Therefore, salinity acclimatization is almost impossible in the freshwater area of the estuary, and the state of the meiobenthos community is extremely unstable here [14].

The distribution of the abundance of meiofauna according to sediment type shows that the mean values are maximum on silts and fine-grained sands and clearly decrease on sandy soils [9]. In addition to the sharp change in conditions due to salinity variations in the freshwater zone of the estuary, stations 5013 and 5014 have coarse sediment in which the role of common dominant groups of meiobenthos decreases. According to regional studies, other groups, first and foremost, oligochaetes, turbellarians, and macrobenthos larvae, begin to play the main role in meiofauna communities [13, 14].

The diversity increases at the passage of Yenisei Bay (station 5018), and *Boreohydra* sp., Kinorhynha, and Cyclopoida begin to be observed in the sediment. The taxonomic composition of the total meiobenthos and nematodes increases from south to north. However, the diversity and abundance of organisms decrease at three stations located on the shelf in the middle of the profile. As was noted above, there are two areas on the transect with mass sedimentation and oxidation of organic matter in the upper sediment layer at stations 5015 and 5020 [8]. Station 5020 changes the dynamic characteristics of the flow, and the especial bottom relief of the bay creates conditions for sedimentation of suspended solids brought by the water [8], leading to a decrease in the diversity and number of meiobenthos and nematodes. The low density of settlement and the low diversity of organisms at station 5010 is more likely caused by the presence of coarse sediment and a large number of plant remains, which are avoided and not colonized by meiobenthos.

Nematodes are an important component and the most abundant group of the meiobenthos. The first list of nematode species for the Arctic seas was published in 2001 [4]. One hundred four species of 50 genera were identified for the Kara Sea; 21 of these species were revealed for this region for the first time. However, no environmental monitoring have been published. Most of the large faunistic study have sections on the confinement of nematode species to certain substrates and the co-occurrence of species. The species composition and diversity of the nematode community are determined mainly by the substrate structure and the mobility of water flowing around it. In

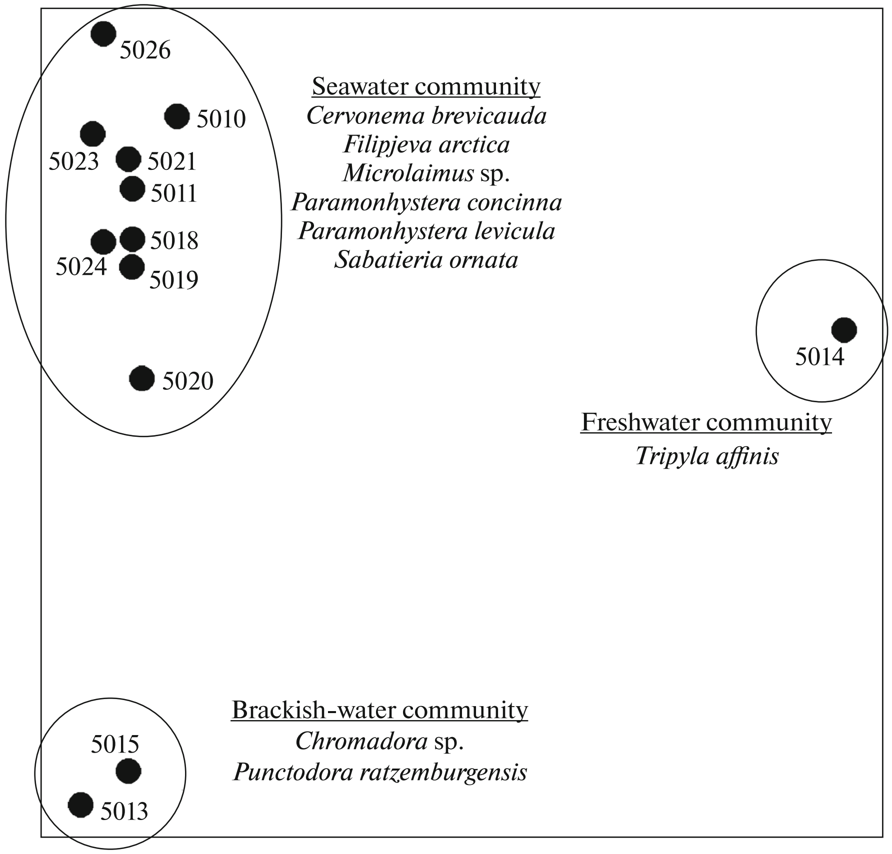

Fig. 5. Classification of stations by multidimensional scaling method. Type of nematode community and dominant species are indicated.

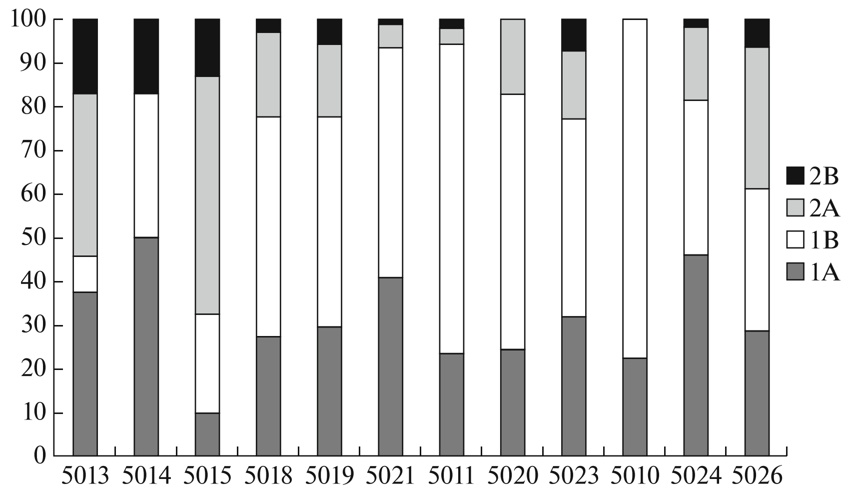

Fig. 6. Trophic structure of nematode taxocene on Yenisei transect. Axis, share of each trophic type at respective station. 1A, selective deposit feeders and 1B, nonselective deposit feeders ; 2A, scavenger and 2B, predators.

addition, nematode faunas of the same substrate from seas far from each other can be more similar in generic and species composition than a population from different habitats at a distance of 10 m from each other [16].

A widespread species of soil nematodes, *Tripylla affinis*, was recorded as dominant at station 5014. This species is more likely to have entered the sample together with plant remains. For the Arctic, *Tripylla affinis* was recorded on the Taimyr Peninsula and the islands of Severnaya Zemlya, Novaya Zemlya, and Vaigach [30]. The dominant nematode taxocene at station 5013, *Punctodora ratzemburgensis*, was previously recorded for fresh waters of the Taimyr Peninsula, Novaya Zemlya, and Vaigach [30]. Three types of marine nematode communities are traditionally distinguished according to the type of substrate. However, there are only transitions or intermediate states, rather than sharp boundaries between substrate types and communities. There are communities of coarse-grained sediments (coarse sand, broken shell, and gravel), fine-grained sediments (silty sand and silt), and phytal (population of the surface of macrophyte thalli and rhizoids). The second type of community is present on the whole profile. Widespread *Terschellingia longicaudata*, *T. distlamphida*, *C. tenuicauda*, and *C. brevicauda* and representatives of the genera *Sabatieria*, *Sphaerolaimus*, *Halalaimus*, *Paramonhystera*, *Cervonema*, and *Microlaimus* are characteristic forms of silty fauna. According to our results, all above species and genera are included in the first five forms at all stations in the estuary and on the shelf.

Three stations constructed in the oligohaline zone of Yenisei Bay are characterized by the species composition difference between communities due to the presence of both freshwater nematode species (*Anonchus* sp., *Punctodora ratzemburgensis*, and *Tripylla affinis*) and genera and species, living in the shelf (*Sphaerolaimus* sp., *Daptonema* spp., *Leptolaimus* spp., and *Halalaimus gracilis*). This is why we distinguished freshwater nematode taxocene at station 5014 and brackish-water nematode taxocene at stations 5013 and 5015. However, the nematode community in the mixing area of river and marine waters is not distinguished by a specific set of species and consists of species characteristic of nematode taxocenes both in the freshwater and marine parts of the transect. Our work confirms the data that the nematode taxocene is depleted as the water desalination increases and the largest diversity is recorded in the marine part of the estuary [16]. The share of predators is higher in the nematode taxocene in the freshwater zone of the estuary than in the mixing area of fresh and marine waters and on the shelf. This is more likely due to the granulometric soil composition. The share of predatory species significantly varies in different nematode communities; however, the largest number of predators is recorded in coarse-grained (sandy) soils [16]. In turn, the soil is finer towards the north along the transect, being preferable for selective strategists.

The nematode community in the estuary and shelf parts of the transect differs from that in the bay by a high species diversity, an even species composition, and the dominance of the species *Paramonhystera levicula*, *Paramonhystera concinna*, *Filipjeva arctica*, and *Sabatieria ornate*. A high share of the genus *Cervonema* in the community was recorded for all estuary stations. All these nematode genera and species belong to detritophages. The genus *Paramonhystera* most often occurs on sandy beaches and in the upper sublittoral zone [19, 36]. Both species *P. concinna* and *P. levicula* were previously found in the intertidal zone in the North Sea [29]. A high density of the population of this genus was recorded in the Norwegian Sea at depths of 970 and 2133 m [32] and on the Goban Spur submarine plateau in the northwestern Atlantic at a depth of 2182 m [44]. For the Kara Sea, the genus *Paramonhystera* was recorded for the first time. The genus *Filipjeva* is widespread in the North Atlantic, while *Filipjeva* is the dominant of nematode taxocene in the Kandalasha Bay of the White Sea at a depth of 251–288 m [35, 45]. For the Kara Sea, this genus was also recorded for the first time. The genus *Sabatieria* is often one of the most numerous from the shelf to the middle of the continental slope and in canyons [35, 42]. Three species—*S. punctata*, *S. pulchra*, and *S. Ornata*—were identified along the Yenisei transect; all of them were previously recorded for the Kara Sea. Another representative of the Comesomatidae family is the genus *Cervonema* including three species: *C. tenuicauda*, *C. brevicauda*, and *C. shiae*. Whereas the first two species are widespread and were recorded more than once on the shelf [19, 20, 26, 27, 31, 37, 43], *C. shiae* was described for the Bay of Bengal [19] and New Zealand at depths of 539 and 1240 m, respectively [33]. This genus has been recorded for the Kara Sea for the first time.

CONCLUSIONS

Our results confirm a high diversity of meiofauna in Yenisei Bay and on the Kara Sea shelf. An increase in the taxonomic diversity of the total meiobenthos is observed in the transition area from the freshwater zone of Yenisei Bay to open sea areas. All taxa recorded in the oligohaline area of the transect are present on the shelf. The meiobenthos of the investigated water area is dominated by nematodes reaching more than 80% of the total abundance. Harpacticoid copepods are the second most significant group, being 9% of the total abundance. The study area has 74 recorded species of free-living nematodes. The nematode taxocene in the estuary zone is not distinguished by a specific species set and consists of species characteristic of the nematode community both in the freshwater and marine zones. The species diversity of nematodes increases in the bay–estuary–shelf row. The freshwater estuary area is dominated by nematodes with a well-defined buccal cavity and armature in the form of differently-sized teeth, which indicates a wide spectrum of food items being consumed. The estuary and shelf have a larger share of nematodes with a small buccal cavity without armature, which are specialized in feeding on very small sediment particles or bacteria.

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