

Composition and location of trophic groupings of zoobenthos in the Arctic Ocean

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Abstract. This study is devoted to the distribution of trophic groups of zoobenthos in the Arctic Ocean. The patterns of distribution of detritus feeders, seston feeders, and predators along the bottom of the Arctic polar basin are analyzed. The object of the study is the geoecology of the distribution of food groups of benthic animals in the polar regions. The subject of the study is the methods used in assessing the distribution of zoobenthos with different types of nutrition in the polar regions. The results of the work are based on the analysis of the vertical and horizontal structures of the distribution of benthic fauna, reflected in the map of the distribution of trophic groups of zoobenthos and systematized in the distribution table of the leading species of zoobenthos in the Arctic Ocean. To assess the patterns of geoecological distribution of zoobenthos according to the method of feeding, the following were used: actual and cartographic scientific data on the relief, soils, waters, ice cover, maps on the distribution of plankton and the content of organic matter in bottom sediments, as well as data on the trophic characteristics of the benthic fauna of the polar regions, leading biocenoses of the polar regions and geoecological conditions for the existence of benthic fauna in the polar regions. This article presents a map of the distribution of zoobenthos in the Arctic Ocean (according to literary sources), developed by the author, and a table of distribution of guide species of zoobenthos trophic groups in various areas of the Arctic Ocean, compiled by the author based on literary sources. The obtained results of the distribution of food groups of zoobenthos can be used in further detailed assessment of food reserves of bioresources in the polar regions of the World Ocean and their consumption; when designing the economic development of the polar regions; during landscape monitoring. **KEYWORDS:** benthic fauna, zoobenthos, trophic structure, food groups, detritus feeders, seston feeders, predators.

1 Introduction

The trophic factor, which depends on relief features, hydrodynamics, sedimentation rates and organic matter content in bottom sediments, has a dominant influence on the distribution of oceanic zoobenthos in polar latitudes.

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The most favourable trophic conditions are formed in the near-continental region (1). It covers the shelf zone and the continental slope area. The benthos here is characterised by the highest qualitative and quantitative diversity. On shelves and continental slopes of the Arctic seas, the belt of modern brachiopods is particularly rich in North Atlantic boreal and circumpolar Arctic boreal species. The circumpolar species *Hemithyris psittacea* and *Glaciarcula spitzbergensis* reach the shallowest depths. *Hemithyris psittacea*, *Crania anomala*, *Terebratulina retusa*, *Liothyrella arctica*, *Cryptopora gnomon* occupy the shelf edge and upper slope areas. The fauna of isopods and tanaidacea (Isopoda and Tanaidacea) is represented by species of *Limnoria lidnorum*, *Jaera albifrons*, which are confined to sublittoral and littoral zones of the northern Arctic seas. Representatives of *Katianira*, *Everycope* and *Gnathia* occur at depths of 150 m of continental slopes. Arctic amphipods are represented by *Anonyx nugax*, *Rhachotropis aculeata*, *Acanthostepheia malmgreni*, *Aceroides latipes*, *Langunogammarus wilkitzkii* (Birula) and *Onisimidis* (Amphipoda) on continental and island shelves. *Mesidotea entomon glacialis*, *M. entomon orientalis*, *M. sabini sabini*, *M. megalura megalura* are widespread on the shelves of northern seas. Diverse gastropods - *Margarites helicina*, *Trichotropis borealis*, *Admeta couthougi*, *Criptonatica clausa*, *Tridonta borealis*, *Astarte elliptica*, *Ephera vineta*, *Mya truncata*, *Macoma calcarea*, *Lepeta coeca*, *Buccinum elatum*, *Astarte crenata*, *A. borealis* - are found in shallow shelf zones. And the representatives: *A. montagui*, *Cardium ciliatum*, *C. groenlandicum*, *Arca glacialis*, *Leda pernula*, *Yoldia hyperborea*, *Nucula tenuis*, *Portlandia arctica*, *P. intermedia* - in coastal areas of mainland and island zones. Lesser bivalves (Bivalvia) are *Portlandia arctica*, *Nucula pernula*, *Yoldia hyperborea*, *Nuculoma tenuis*, *Daeridium vitreum*, *Musculus discrepans*, *Pandora glacialis*, *Mya arenaria*. Plate-like molluscs are represented by *Hiatella arctica*, *Tridonta borealis*, *T. montagui*. Echinodermata are represented by the genera *Urasterias* and *Icasterias*, which inhabit coastal shelf areas and central shallow waters of shelf seas. In Arctic waters sponges, hydroid polyps, bryozoans, barnacle and cumaceans, crabs and some other relatively rare invertebrates are found.

The oceanic domain includes the floor of depressions of the ocean floor away from the continents. The benthos diversity in this area is noticeably poorer in quality and quantity [1]. The fauna of foraminifera (Foraminifera) includes the deep-sea species *Globigerina pachyderma* (Ehrenberg), *Eponides tenera* (Brady), and *Cibicides wuellerstorfi* (Schwager). They are confined to areas influenced by warm Atlantic waters. Numerous species of polychaete *Spiochaetopterus typicus*, *Maldane sarsi*, *Pectinaria hyperborea*, *Onuphis conchyiega*, *Thelepus cinnatus*, *Myriochele oculata*, *Owenia assimilis*, *Nereis pelagica*, *Scoloplos armiger*, *Terebratula stroemi*, *Eulalia viridis* are confined to areas of continental slope). Among the small bristleworms (Oligochaeta) species *Pachidrius lineatus*, *Pelosclex benedeni* are common. The marine spiders *Colossendeis angusta*, *Nymphon macronyx*, *C. proboscidea* and *B. robustum*, *Boreonymphon robustum*, *Nymphon macronyx*, *Nymphon* sp., *Colossendeis angusta*, *C. proboscidea* are widespread. Holothuroidea species *Ocnus lasteus*, *Mesothuria intestinalis*, *Thyonidium drummondi*, *Labidoplax buski*, *Psolus squamatus*, *Chiridota laevis* are found on slopes of deep hollows. Sea urchins (Echinoidea) species *Strongylocentrotus droebachiensis* and sea stars (Asteroidea) species *Astropecten irregularis* are found almost everywhere. Among the Ophiuroidea, the species *Ctenodiscus crispatus*, *Brisaster fradilis*, *Molpadia*, *Ophiura robusta*, *O. sarsi*, *Ophiopleura borealis* inhabit the slopes of inner-shelf depressions.

2 Materials and Methods

According to the trophic attribute, benthic marine animals can be divided into: sestonophages (filter feeders associated with the absorption of seston), detritophages

(collecting detritus on the bottom surface and in the sediment column (subsurface deposit feeder)), and predators (eating living individuals). Species are distinguished as trophically stable (Table 1), i.e. they feed only in a certain way and plastic species that feed in a combination depending on food availability.

Table 1. Trophic characteristics of benthic fauna of polar regions.

Troph. affiliation	Type		Nature of supply	
			Steady	Flexible
Sestonophages (1)	Stationary (1.1)	Porifera	+	Octachemidae, Hexactrobilidae (1.1/3)
		Brachiopoda	+	
		Cirripedia	+	
		Crinoidea	+	
		Ascidiae		
		Foraminifera	+	
		Hydrozoa	+	
		Hexacorallia	+	
		Actiniaria	+	
		Madreporaria	+	
		Antipataria	+	
		Octocorallia	+	
		Gorgonaria	+	
		Pennatularia	+	
		Alcionaria	+	
Bryozoa	+			
Pogonophora	+			

		Polichaeta	Sabellidae, Serpulidae, Chaetopterus	
		Gastropoda	Aporrhais, Struthiolaridae, Pectenidae, Mytilidae,	Owenidae, Myriochelidae (1.2/2/1)
		Bivalvia	Anomidae, Arcaidae, Astartidae, Venericardidae, Myidae, Cardiidae	Fissurellidae, Crepidulidae, Turritellidae, Littorinidae, Buccinumidae, Copulidae, Hipparyxidae, Hydrobiidae (1.2/2.1)
		Amphipoda		
		Cumacea	+	
		Holothuroidea	Pseudocucumiidae	Erictonidae, Haploopsisidae, Corophiidae (1.2/2.1)
		Echinoidea	Clypeasteridae, Encopidae, Mellitidae, Laganidae, Echinarachnidae, Dendrasteridae	
	Motile (1.2)			
		Polichaeta	Ariciidae, Spionidae, Crratulidae, Chioremiidae, Pectinariidae, Ampharetidae, Terebellidae	
		Scaphopoda	+	Nuculidae, Nuculanidae, Tellinidae (2.1/1.2)
		Bivalvia	Acilidae, Portlandidae, Yoldidae	Priapuloidae (2.1/2.2/3), Halicriptideae (2.1/3)
		Priapuloida		
		Ophiuroidea		Ophiopholidae (2.1/1.2), Ophiocomidae (2.1/1.2/3)
		Holothuroidea		
		Isopoda		Dendrochiroidea (2.1/1.2), Apodidae, Molpadidae, Dactilochirotidae, Elaspodidae (2.1/2.2)
		Mesidotea	+	
			+	
Detritophages (2)	Collecting (2.1)			

	Surface deposit feeder (2.2)	Polichaeta Oligochaeta Echinoidea Nematodes	Scalibregmidae, Opheliidae, Maldanidae Spatanoidae +	Artacamidae (2.2/2.1) Arenicolidae (2.2/1.2)
Canivores (3)		Polichaeta Decolopoda Pantopoda, Picnogonida Gastropoda Mesogastropoda Neogastropoda Nudibranchiata Ophiuroidea Asteroidea Echinoidea	Phyllocidae, Polynoidae, Glyceridae, Nephtyidae, Eunicidae + Grangonidae, Galatheidae, Paguridae, Majidae Naticidae Conidae, Nucellidae, Urosalpinidae, Velongenxidae, Fasciolariidae, Murexidae, Nassariidae, Turridae +	Nereidae (1.2/3), Harmothidae (2.1/3) Asteroidea (3/2.1), Ophiothridae (3/1.2) Poraniidae, Patiriidae, Odotasteriidae, Astropectenidae (3/1.2), Porcellanasteridae (3/2/1) Echinocardiidae, Echinidae, Strongyloicentratidae, Psammechiidae (2.1/3)

Mapping of the locations of various trophic groups made it possible to map the location of benthic fauna in the Arctic polar region (Fig. 1), as well as to identify guiding forms of zoobenthos food groups in the Arctic Ocean (Table 2).

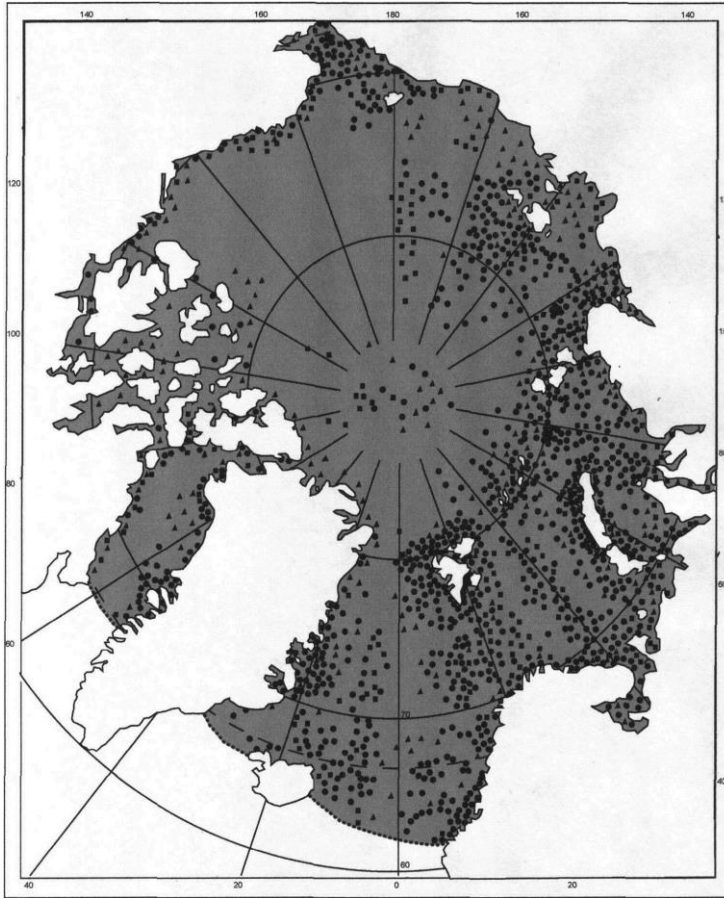


Fig. 1. Map of zoobenthos trophic groups in the Arctic Ocean (from literature sources).

The geodetic base of the Arctic contour map at a scale of 1:25 000 000 was taken as the working basis of the trophic map. The available material on zoobenthos distribution was preliminarily systematised based on the quantitative and qualitative composition of benthic animals. Subsequently, the obtained material was reflected in the iconic way, reflecting the trophic affiliation of the find with reference to the location of its detection. In the case of mass finds, trophic diversity was reflected on the map, while numbers were recorded separately. This explains the off-scale nature of the conventions, as it is not possible to reflect the actual number of data on a small-scale map in a pictorial way. A total of about 3,000 discoveries were recorded within the Arctic Ocean boundary.

3 Results and discussion

The trophic membership of benthic fauna includes: sestonophages (extracting food from benthic suspension), detritophages (feeding directly from the substrate) and carnivores (predators).

A more detailed classification of sestonophages includes mobile and stationary forms. Non-mobile sestonophages inhabit shallow waters, rocky and stony shores, as well as shelf and continental slope margins and submarine uplands, i.e. areas of coarse sediment distribution. Their spreading is confined to areas of interaction between coastal waters and deep subsurface water masses, as well as in zones of abrupt landform change accompanied

by intensified hydrodynamics. Areas of junction of waters of different origin, increased current velocities and intensive mixing lead to high concentrations of biogenic elements, increased suspended solids content in bottom waters, good aeration on stony and hard mixed sediments. Mobile sestonophages settle predominantly in sandy sediments under conditions of active mobility of benthic waters where the processes of organic suspended sediment transport over the bottom prevail over the processes of its settling.

Detritophages are classified as gatherers and selective swallows. Gathering detritophages feed on organic detritus and microflora from the surface of the bottom. They settle on fine-grained sediments (aleurite, silt) containing organic matter in areas with slow movement of bottom waters, where the process of settling of organic suspended matter prevails over the process of its transport. Detritophagous, indiscriminately ingesting substrate, inhabit the surface sediment column and use the substrate in which they live as food material. They settle predominantly in fine-grained sediments with organic matter content and retarded hydrodynamics that promote the settling of fine soil fractions.

Carnivorous zoobenthos feed on living and dead organic matter. Its distribution depends on food items.

However, the trophic classification of benthic marine invertebrates cannot have a clear system, as organisms with a stable and plastic type of feeding are distinguished, having the ability to switch, if necessary, from one type of food to another, to change the source and method of receiving food or to receive it simultaneously from several sources (Table 1). Thus, different feeding conditions have been created on the seabed in different parts of the ocean for the deep-sea bottom population.

The maximum quantitative distribution is observed for representatives of predators, which is explained by the almost ubiquitous availability of food resources represented by different species of animals. The distribution of detritivores is mostly confined to the slopes of depressions and in-shelf troughs, as well as to certain areas of coastal shallows [2]. This is facilitated by the high concentration of organic matter deposited in the fine fraction of the bottom sediments lining the deep sea benthic areas. The maximum input of nutrients in these areas is associated with divergence zones.

Table 2. Distribution of leading species of zoobenthos trophic groupings in different areas of the Arctic Ocean.

Seas, regions	Sestonophages	Detritophages	Predators
Barents Sea	West coast of Novaya Zemlya Island (E. ruformus). Northern shelf and continental slope (Gnathia stygia). Everywhere in shallow waters (A.borealis, A. montagui, M. calcarea, B.glacialis, C.Hyperborea)	The southwest coasts of the southern island of Novaya Zemlya (Portlandia arctica). Novaya Zemlya (Portlandia arctica). Scandinavian Shallow Water, Central Shallow Water and Coastal Areas (Mesidotea sabini sabini)	Central shallow waters and island. FJL (Ieasterias panopla). Coastal shallows of the Scandinavian Peninsula (Solaster endeca)
Kara Sea	Southern shallows (Onisime plautus). Northern shelf, continental slope (Eucope hanseni, Katinira chelifera). Western slopes of the Novaya Zemlya trough (Polimetra glorixa,	Coastal areas to the south, central shallow waters (P. arctica). Baidaratskaya Bay, Priyamalskaya shallow water (Mesidotea sabini sabini) Gulf of Ob, southern bays (Astarte borealis)	Central shallow waters (U.panopla, O.sericeum, U. lincki). North of Baidaratskaya Bay, western and eastern slopes of Novozemelsky Trough (E.glacialis, O.borealis)

	E.glacialis)		
Laptev Sea	Central shallow waters (Alcyonidium disciforma, Eucratea loricata, Perigonimus yoldia arctica)	South coastal and eastern shallow waters (M. entomon glacialis, S.armiger, N.lumbrialis, Maldane sarsi).	Central shallow waters (Urasterias panopla, Ophiocten sericeum)
East Siberian Sea	Northern shelf and continental slope (Eucope hansenii)	Shallow waters around the Novosibirsk islands (P. arctica, M.entomon glacialis, M. sabini sabini)	Central shallow waters (Urasterias panopla, Ophiocten sericeum)
Chukchi Sea	Coastal zones (O. turgidus, O. lautus). East of Wrangell Island (Onimis derjigini).	Central shallow waters (Portlandia arctica).	Everywhere (Chionoecets opiole)
White Sea	Central shallow waters of the Basin (Astarte montagui, A. borealis). Kandalaksha and Onega Bays (Mytilus edalis, Elpidium incertum, E. seminum)	Dva Bay, Mezenskaya Bay (M.sabini, P. arctica, Y.hyperborean, P. hyperborean). Ubiquitous in the central part (P. arctica, L. pernula, A.lincki).	Everywhere in the basin (Solaster endeca, Asterias lincki, Ophiopolis aculeate, Ophiura sarsi)
Beaufort Sea	Mainland slope and coastal shallow waters (Eunephtya rubiformis)	Mainland slope (Mesidotea sabini sabini). Coastal shallows (M. megalura megalura)	Coastal shallows (Polimetra prolixa, Elpidia glacialis).
Baffin Sea	Northern shelf and continental slope (Gnathia stygia)	Southeastern shallows, southern parts (A. baffini). Western littoral and bathyal (Mesidotea sabini sabini)	Coastal shallows (T. willei, O. arcticus, P. prolixa, E. glacialis). Central parts (Irpa abyssicola)
Canadian shelf	Coastal shallows (Onisimus edwardsi)	Coastal shallows and straits (O.caricus hansenii, M.megalura megalura)	Northern islands, shallow waters around the Mackenzie River (Urasterias lincki)
Lincoln Sea	Coastal shallows (Onisimus edwardsi)	Littoral everywhere (Onisimus sextonae)	Coastal shallows (P. prolixa, Elpidia glacialis).
Norwegian Sea	Coastal shallows (Onisimus edwardsi)	Western mainland slope everywhere (Katianira sadko, Onisimus sextonae). Eastern part (Eurycope hansenii, Cnathia stygia, Onisimus caricus hansenii)	South of Spitsbergen (S.endeca). Eastern slope (B. robustum, N. macronyx). Southeast coastal shallows (B.abysorum, A. mirabilis). East of Iceland (P.prolixa). West of FJL (P.prolixa, E.glacialis). Coastal shallows of the Scandinavian Peninsula (S.endeca, L.arcticus, Bathybiaster vexilifer)
Greenland Sea	North-eastern coastal shallows (Lagunogammarus wilkitzkii)	Southeast and eastern coastal shallows (Portlandia arctica). Foothills of the southeastern mainland slope, northern shallow waters of Iceland (Arcturus baffini)	Southwest mainland slope (Boreonymphon abysorum). Foothills of the western slope (P.prolixa). Shallow part of the western slope (Ophiopus arcticus)

Central Arctic Basin	Trans-Arctic Mendeleev (Lagunogammarus wilkitzkii)	Rise, Rise	Mainland slopes of the Barents Sea, Kara Sea and Laptev Sea (E.hanseni, Cnathia stygia, O.caricus hanseni)	Litke trough (E.glacialis). Lomonosov Rise, Trans-Arctic Rise (E.glacialis, Kolga hyalina)
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Sestonophages are observed in coastal areas, shallow waters, continental slopes and slopes of depressions. This fact is explained by the presence of rigid substrates and bottom currents in these areas, as well as by the high sedimentation rate (Fig. 1).

The coastal parts of the shelf zone of polar oceans with distribution of rigid soils are inhabited mainly by sestonophages [3,4]. In these areas both mobile and stationary sestonophages are present. Dominance of the former is confined to areas of ice spreading and erosion of bed rocks. Stationary sestonophages are maximally concentrated in areas of strong bottom currents and active wave processes.

The central parts of the shelf up to the continental slope are dominated by detritophages, with few sestonophages in some areas (Table 2). The mainland slope in the central part is inhabited by detritophages, the foreshore and foothill are zones of overlapping of sestonophages and detritophages, as they are areas of sand and pelitic soil fraction drift and underwater currents. The ocean floor is covered with fine-grained soils and is an area of detritophage distribution [5, 6]. The submarine uplands are inhabited by sestonophages (predominantly coarse-silty and sandy soils, washed away by the currents). The upper parts of the deepwater trough slopes are inhabited predominantly by detritivores, less so by sestonophages as they are lined by fine-grained substrates and have a low degree of sedimentation. The bottoms of depressions are generally hardly inhabited, as the content of organic matter in sediments and the bottom layer is minimal. In the Arctic Ocean, benthic fauna does not go below 3,500 m.

4 Conclusions

The following conclusions were drawn in the course of the study:

The most optimal conditions of existence are found in the near-continental area. It is here that the greatest species diversity of zoobenthos is represented.

Benthic fauna of the Arctic Ocean periphery is represented predominantly by sestonophages, the central part of the ocean is occupied by fine-grained ground fractions, which are inhabited predominantly by detritophages. Predators are widespread.

The distribution of the leading species of zoobenthos trophic groupings indicates the presence of representatives of bottom fauna in all areas of the Arctic Ocean.

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