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Materials to the Faunistic Study of the White and Barents seas sponges. 5.Quantitative Distribution

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Abstract: Data on Sponge biomass (g/m^2) (SB) distribution in different regions of the White and Barents Seas are presented. Maximal SB is registered off the Karela coast of the Kandalaksha Bay (500 g/m^2), in the western part of the Onega Bay (97 g/m^2) and in the north-eastern part of the Gorlo of the White Sea (49 g/m^2). The most favorable conditions for the Barents Sea sponges are in the East Murman coastal regions (25-50 g/m^2) and on the shelf and continental slope boundary in south-western region (80 g/m^2). For these regions active near-bottom water dynamics, gravelly and mixed sediments, high organic and biogenic elements concentration in the near-bottom and poor organic matter content in sediments are characteristic. The comparison of quantitative data obtained in 1960-1980 and in 1920-1950 revealed that during this period total SB had 6,6 times decreased - mainly due to the boreal-arctic species. During the same time SB part in the total benthic biomass in these areas practically did not change.

Zusammenfassung: Aus verschiedenen Bereichen des Weißen Meeres und der Barents See werden Daten zur Verteilung der Poriferen-Biomasse (g/m^2) mitgeteilt und interpretiert. Die höchsten Werte wurden innerhalb des Weißen Meeres in der Bucht von Kandalaksha vor der Karela-Küste (500 g/m^2), im Westteil der Onega-Bucht (97g/m^2) und im nordöstlichen Abschnitt des Weißen Meeres (49 g/m^2) registriert. In der Barents See wurden die günstigsten Lebensbedingungen für die Schwämme in den Küstenregionen vor Ost-Murmansk (20-50 g/m^2) und entlang der südwestlichen Schelfkante (80 g/m^2) angetroffen. Diese Regionen erhöhter Schwamm-Biomasse sind durch bewegtes Bodenwassers, in dem eine hohe biogene Aktivität kennzeichnend ist, und ein gut durchmischtes sandiges Substrat, das nur einen geringen C_{org}-Gehalt aufweist, charakterisiert. Der Vergleich der quantitativen Daten-Erfassung aus den Jahren 1960-1980 mit Werten, die zwischen 1920 und 1950 erhoben wurden, zeigt, daß die Schwamm-Biomasse vor allem infolge des Rückgangs boreal-arktischer Arten in dieser Zeitspanne um den Faktor 6,6 vermindert worden ist. Während desselben Zeitraumes hat sich aber die Gesamtbenthos-Biomasse in diesen Gebieten nicht nennenswert verändert.

Keywords: Barents Sea, White Sea, Porifera, Quantitative distribution, Biomass.

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1. Introduction

The study of the quantitative distribution of the prevailing groups in marine benthos (sponges in particular) in different physical, chemical, hydrological and biocoenological parts of the seas allows to understand the patterns of distribution of these animals and their penetration into the investigated areas. Furthermore the results of such investigations may serve as a base to the long-term monitoring of bottom ecosystems and prognostication of their possible transformation as a result of a global climate changes and increasing anthropogenic influence. The Barents Sea including 2 biogeographical regions and areas of broad commercial exploitation and the White Sea with its unique hydrological conditions are of particular interest from the discussed point of view.

Sponges (Porifera) - are one of the most widely distributed groups of marine bottom animals (rich in species number). The great variety of hydrological, physical and chemical conditions in different regions of the White and Barents Seas are reflected in heterogenity of sponge distribution (Ereskovsky, 1989, 1994a, 1994b, 1995). In many biocoenoses sponges play a dominant role in biomass. For instance in shallow-water coastal regions of the East Murman, the biocoenoses of *Halichondria panicea* is common in which this species together with *H. sitiens* form 71,9 % of the total biocoenoses biomass (Propp, 1966). In the Mesenskiy Bay of the White Sea the part of the sponges biomass in that of the biocoenoses of Porifera + *Lyonsia arenosa* + *Mya truncata* is about 36,5 % (Naumov et al., 1986). In some parts of the

Barents and White Seas the representatives of this taxonomic group create the spacious settlements with high biomass (Brotskaya et al., 1963; Filatova, 1938). The present study is an the attempt to give a generalized picture of the sponges biomass distribution based on the contemporary data (including literature information) and new collections.

2. Material and methods

The present study was performed on the base of collections, catalogues and trawl lists deposited in the Zoological Institute of the Russian Academy of Sciences (ZI, St. Petersburg), Murmansk Marine Biological Institute (MMBI, Murmansk), Polar Institute of Fisheries and Oceanography (PIFO, Murmansk) and the White Sea Biological Station of the Moscow State University (WSBS MSU, Pojakonda). A large part of the information on the Barents Sea sponges was obtained from the materials of the PIFO benthic survey in 1968-1970 on board the vessel RT-61 "Vodnik" and R/V "N. Maslov", collections of the expeditions in the Barents Sea on board the MMBI vessels during 1982-1987 (16, 24, 39 cruises of the R/V "Dalnie Zelentsy", 17 and 25 voyages of STV "Pomor"). The author's littoral, diving, grab and trawl collections performed on the MMBI base in 1987-1988 (Ereskovsky, 1995) were used as an additional material. Furthermore the literature data were enlisted (Zenkevitch, 1927; Filatova, 1938; Brotskaya & Zenkevitch, 1939; Leibson, 1939; Zatsepin, 1962; Zatsepin & Rittich, 1968a, 1968b; Propp, 1966, 1971; Pushkin, 1968; Golikov & Averintsev, 1977).

The main part of the White Sea material is composed from the collections of ZI expeditions on board R/V "Onega" and "Professor Mesjatsev" in 1960-1964, ZI hydrobiological expeditions in the Kandalaksha Bay (1967, 1968, 1981, 1985) and Onega Bay with the adjacent parts of the Basin (1982), WSBS MSU collections on board R/V STS-2032 in 1972-1975 and 1987, and MMBI collections on board STV "Pomor" in 1983. Additional information was obtained from literature (Zenkevitch, 1927; Gurvitch, 1934; Ivanova, 1957; Brotskaya et al., 1963; Kudersky, 1966; Miagkov, 1975, 1978; Lukanin et al., 1984; Golikov et al., 1984, 1985, 1988; Naumov et al., 1986a, 1986b, 1987). The sponges biomass (grams per square meter) was used as a comparison unit.

3. Results

White Sea.

Despite the long history of investigation of the Kandalaksha Bay benthos, the data on the quantitative distribution of sponges here are available only in the coastal and bay-head shallow parts. However even these materials show that the diversity of the environmental conditions reflects in the complicated distribution of sponges biomass (Fig. 1). Its maximal value (up to 1500 g/m^2) were recorded in the Velikaya Salma region which is characterized with hard bottom, strong currents and a high amount of the nourishing matter in near-bottom (Brotskaya et al., 1963). The least sponges biomass (2-3 g/m^2) is found in the freshened top part of the Bay. Unfavorable physical and chemical conditions in the deep zone of the Bay causes the poverty of its sponges fauna. As was revealed by some authors (Beklemishev et al., 1980; Maliutin, 1983) sessile sestonofeeders (to whom sponges belong) are either absent or poorly represented in central deep part of the gulf so as in the hollows in the coastal zone. The main cause of this probably is in the weaken hydrodynamics in near-bottom and prevailing of soft pelite-aleurite sediments with high organic carbon concentration.

The Onega Bay is the more completely investigated one and the sponges distribution here can be described with high validity. The maximal biomass values (up to 97 g/m^2) are recorded in the western part of the Bay between the Karela Coast and the Solovetskiye Islands (Fig. 1). Here the high hydrodynamics, rocky and gravelly bottom are common. In the refreshed and rich with the organic carbon top part of the Bay and near the Liamnitskiy Coast the minimal biomass is indicated (1 g/m^2). The least biomass values here are caused by the freshwater influence, weaken continental pollution and prevailing of soft bottom sediments unfavorable for sponges. The high speed of circulation current, hard bottom sediments and great depth range are characteristic for the Cape Gorbolukskiy region and the northern part of the Letniy Coast. These conditions are favourable for sponges and their mean biomass value here is about 6 g/m^2.

Despite the vast number of the bottom fauna collections in the Dvina Bay the quantitative data on sponges here are relatively poor. Probably it is due to the strong freshwater influence in near-bottom and prevailing of soft substrates in the greater part of this Bay. The mean sponges biomass in the open part of the Dvina Bay is about 6 g/m^2 that may be connected with the anticyclonic circulation of near-bottom current. In coastal biocoenoses inside the 40 m isobath off Cape Zimnegorskiy (up to Cape Intsy) the sponges biomass is relatively low and oscillate in the range from 1 up to 2 g/m^2.

The less investigated from the discussed point of view is the Basin of the White Sea. In its central deep part only few quantitative samples with sponges were collected. According to the trawl materials sponges are relatively rare in this region. As a cause of the weakened mobility of the near-bottom water layers, low oxygen and prevailing of pelite sediments with infrequent gravel intrusions (Maliutin, 1983) sponges biomass in the major part of the Basin and deep-water parts of the Kandalaksha Bay does not exceed 1 g/m^2 (Fig. 1). In these regions the most common are inhabiting the clayey substrates stenotopic species *Polymastia grimmaldi* and *Suberites domuncula* spermatozoon.

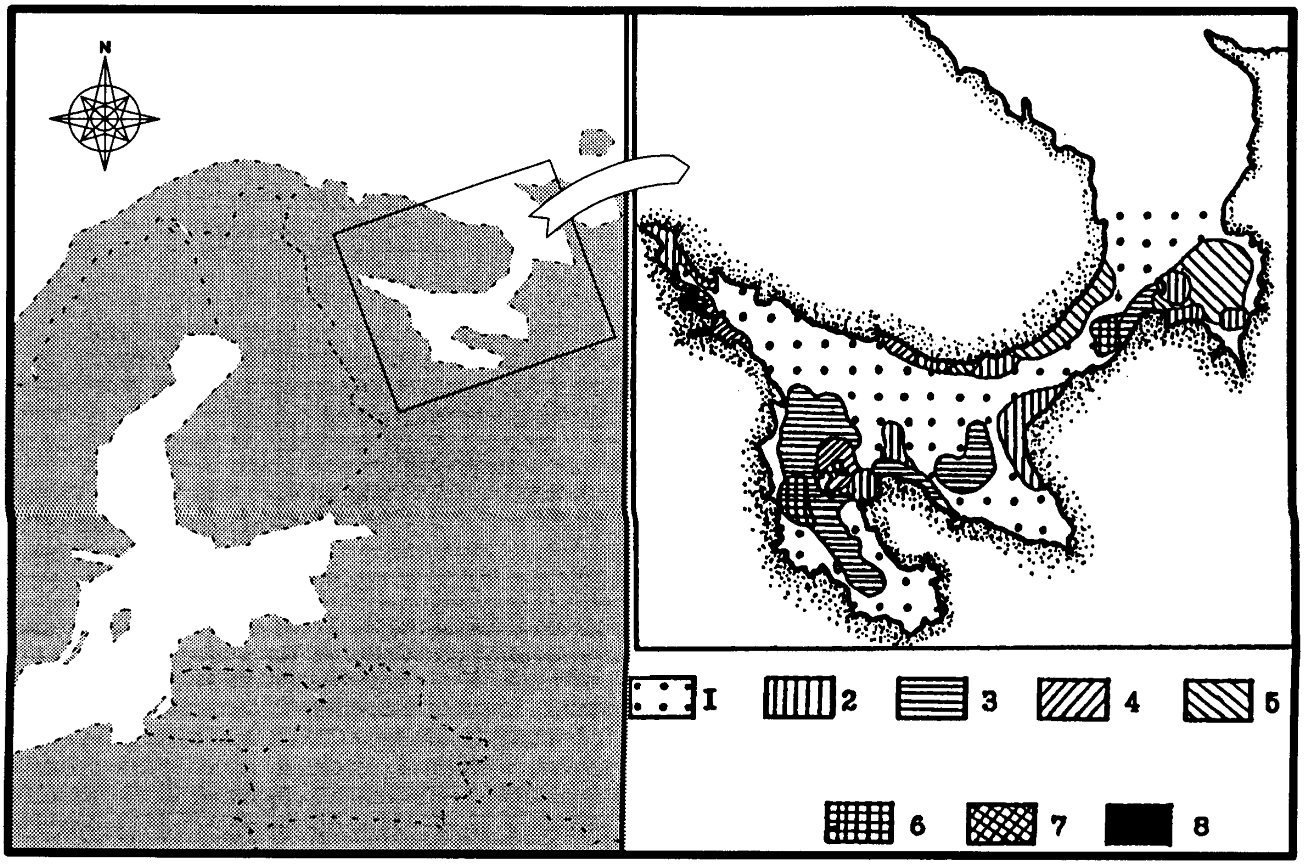

Fig.1. Distribution of mean sponges biomass in the White Sea.
1 - 1 g/m^2; **2** - 1-5 g/m^2; **3** - 5-10 g/m^2; **4** - 10-25 g/m^2; **5** - 25-50 g/m^2; **6** - 50-100 g/m^2; **7** - 100-500 g/m^2; **8** - >500 g/m^2.

In the northern part of the Basin and adjacent southern parts of the Gorlo of the White Sea sponges biomass is inside the limits of 0.07 and 0.9 g/m^2. However in shallows near the Terskiy Coast it may reach 110 g/m^2 that can be explained with the Gorlo's waters influence spreading in hydrological summer down to the depth of 25 m (Naumov et al., 1987).

The Gorlo of the White Sea is characterized with the complex hydrological regime strongly influencing the quantitative sponges distribution. Its north-western part is occupied with the communities with relatively high sponges biomass (49 ± 26 g/m^2). Similar values are recorded in the region of Tetrino settlement (48 ± 35 g/m^2) (Fig. 1). Relatively high sponges biomass is found in the north-eastern part of the Gorlo of the White Sea and off the Cape Voronov (7 ± 5 g/m^2) where the intensive outflow of circulation current is indicated. In the rest parts of this area sponges biomass is comparatively low (about 1 g/m^2). This is caused mainly by the prevailing of unfavorable for sponges substrates with vast sand fraction.

Barents Sea.

So as in the White Sea the character of the quantitative sponges distribution in the Barents Sea is closely related with the bottom relief, hydrodynamics, sediment character and the organic matter amount in the near-bottom water layers. Maximal value of sponges biomass (77 g/m^2) is recorded on the mixed substrates in the south-western part of the Barents Sea where the strong Nordcap current is present. The dense aggregations of these animals with mean biomass of about 25 g/m^2 inhabit the southern part of the Kopytov Plateau, the northern parts of the Malang, Fuley and Søre Banks, stretches along the southern slope of the Norwegian Trough and further on along the East Murman coast (Fig. 2). It is essential to emphasize that in 1920-1950 the sponges biomass in these regions was about 325 g/m^2 that is about 13 times higher than nowadays values. However the part of sponges biomass in the total biomass of bottom biocoenoses remains on near the same level: 46 % in 1920-1950 and 54 % in 1960-1970.

Along the west Barents Sea boundary the narrow zone with mean sponges biomass near 6 g/m^2 is stretched. It includes the northern part of the Kopytov Plateau, southern and western slopes of the Bear Bank, the mouth of the Zuidcap Trough and the coastal zone of the west Spitzbergen. These regions are influenced by the strong West-Spitzbergen current and are characterized with hilly-ridged bottom relief with fragmental rocks.

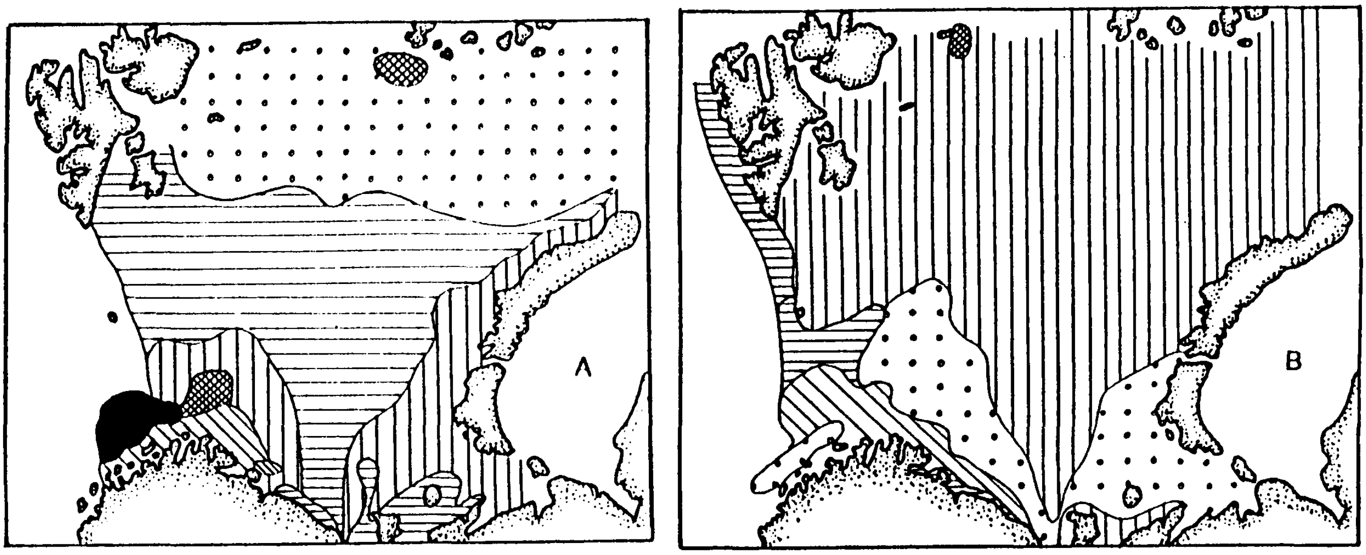

Fig. 2. Distribution of mean sponges biomass in the Barents Sea in 1920-1950 **(A)** and in 1960-1980 **(B)**. 1-8 - as in Fig.1.

In the coastal zone (about 15 miles) of the East Murman in the regions with steep slope, mixed sediments and strong water intermingling sponges biomass is relatively low (6 g/m^2) (Fig. 2). It is interesting that in the period of rise in temperature in Arctic in 1920-1950 sponges biomass value was nearly the same (7 g/m^2).

In the vast region in central, northern and north-eastern parts of the Barents Sea the rare sponges settlements with mean biomass about 1 g/m^2 are found (Fig. 2). According to the literature data in the last period of rise in temperature in Arctic sponges biomass about 2 g/m^2 was recorded in this region. However the mean part of sponges biomass in the total biocoenoses biomass here now (8%) is more than 3 times higher than in 1920-1950 (2 %).

The least sponges biomass value (0.2 g/m^2) is recorded in the south-eastern part of the Barents Sea (Fig. 2). Here, low water mobility, soft substrates and low salinity are common. In 1920-1950 sponges biomass in this region also was relatively low (1 g/m^2) but significantly higher than now (8 times). The mean sponges biomass part in total biocoenoses biomass in 1960-1970 (2.5 %) is about 4 times higher than during the warm period in Arctic (0.6 %).

4. Discussion

According to the results of many Barents Sea benthos investigations the most favorable for sessile sestonofeeders are the coastal regions together with shelf boundaries and continental slope (Filatova, 1938; Brotskaya & Zenkevitch, 1939; Zatsepin, 1962, 1970; Zatsepin & Rittich, 1968a, 1968b; Kuznetsov, 1970, 1980; Denisenko, 1989; and others). In these regions high water dynamics, stony, gravelly and rock substrates, high concentration of suspended and biogenic matter in near-bottom but low organic carbon concentration (<0.5%) in sediments are common. Optimal for the discussed trophic group near-bottom current speed (0.4-0.7 m/sec) (Kuznetsov, 1980) also is usual in these regions. Maximal sponges and other sessile sestonofeeders biomass is recorded in the areas of similar physical and hydrochemical characteristics in both Barents and White Seas.

The comparison of the quantitative features of the Barents Sea sponges settlements in 1960-1980 and in 1920-1950 revealed that their total biomass decreased 6.6 times in average (range from 1.2 times in the central and northern regions up to 14 times in the south-western region). However the part of sponges biomass in the total biocoenoses biomass here is nearly similar during two discussed periods. The comparison of leading species biomass during both periods revealed the decrease of its value mainly due to that of boreal-arctic sponges species. Our earlier publication shows that these species are the most abundant in the Barents Sea (Ereskovsky, 1994). The results of the present work confirm the hypothesis of Y.I. Galkin (1986, 1988) that the long-term periods of rise in temperature have a negative influence upon the boreal-arctic species which are prevailing in the Barents Sea benthos.

Fluctuations of thermic regime in the Barents Sea connected with the cooling or warming climate periods in Arctic and North Atlantic reflected only in the changes in distribution of different biogeographic groups of species and further on in the displacement of zoogeographical regions boundaries (Blacker, 1957; Nesis, 1960; Antipova et al., 1974; Galkin, 1986, 1988). However these fluctuations did not change the trophic structure of zoobenthos both in the White and Barents Seas at least for the last 60 years (Kuznetsov, 1970, 1976, 1980). Our data show the stability of sponges (as the elements of trophic structure of the Barents Sea benthos) part in the total biocoenoses biomass and confirm the data of A.P. Kuznetsov (1976, 1980) also making evident the stability of the marine benthos trophic structure. It is supported by the internal regulation mechanisms produced during the evolution of marine ecosystems. The parts of different trophic groups (in particular filtrators and sestonofeeders) as a functional components of stable systems must remain relatively constant even during the great environmental changes.

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6. References

ANTIPOVA, T.V., DEGTYARJOVA, A.A., TIMOCHINA, A.F.(1974) Long standing changes of the plankton and benthos biomass in the Barents Sea. Materiali ribochoz. issled. severnogo basseina. Murmansk. 21: 81-87. In russ.

BEKLEMISHEV, K.V., SYMEONOVA, N.L., MALIUTIN, O.I. (1980) Factors determining the biological structure of the White Sea. Biologia Morja. (1): 8-20. In russ.

BLACKER, R.W. (1957) Benthic animals as indicators of hydrographic conditions and climatic changes in Svalbard waters. Fisch. Invest. Ser.2. 20: 1-49.

BROTSKAJA, V.A., ZENKEVITCH, L.A. (1939) Quantitative calculation of the bottom fauna of the White Sea. Proc. VNIIRO. 4: 5-126. In russ.

BROTSKAJA, V.A., ZDANOVA, N.N., SYMEONOVA, N.L. (1963) Bottom fauna of the Velikaya Salma and adjacent regions of the Kandalaksha Bay of the White Sea. Proc. Kandalaksh. State preservation. 4: 159-182. In russ.

DENISENKO, N.V. (1989) Distribution and ecology of the Bryozoa of the Barents Sea. Apatiti. -157p. In russ.

ERESKOVSKY, A.V. (1989) Special composition, distribution and biogeographical structure of the White Sea sponges (Porifera). Proc. of Zool. inst. Acad. Sci. USSR. 192: 5-24. In russ.

ERESKOVSKY, A.V. (1994a) Materials to the faunistic study of the White and Barents Sea sponges. 2. Biogeographical and comparative-faunistic analysis. Vestnik St.Petersburg univ. Ser.3. 1(3): 13-26. In russ.

ERESKOVSKY, A.V. (1994b) Ibid. 3. Dependence of sponges distribution on the temperature and salinity. Vestnik St.Petersburg univ. Ser.3. 3(17): 3-10. In russ.

ERESKOVSKY, A.V. (1995a) Ibid. 4. Vertical distribution. Vestnik St.Petersburg univ. Ser.3. (in press). In russ.

ERESKOVSKY, A.V. (1995b) Special composition, distribution, biogeographical structure, seasonal dynamics of biomass and abundance of the Yarnishnaja Bay Sponges (East Murman). Pol.Arch.Hydrob. (in press).

FILATOVA, Z.A. (1938) Quantitative calculation of the bottom fauna in the south-western part of the Barents Sea. Trudi PINRO 2: 3-58. In russ.

GALKIN, J.I. (1986) Long-standing changes of the bottom fauna. Zhizn' i uslovia jee sushestvovania v bentali Barentseva morja. Apatiti. 43-52. In russ.

GALKIN, J.I. (1988) About times of changing of the areal boundaries of marine bottom invertebrates. Quaternary palaeoecology and palaeogeography of the northern seas. Moscow: Nauka. 68-72. In russ.

GOLIKOV, A.N., AVERINCEV, V.G. (1977) The biocoenoses of upper parts of the shelf of archipelago of the Franz-Joseph Land and some objective laws of their distribution. Issled. Fauni morey. Leningrad: Nauka. 14(22): 5-54. In russ.

GOLIKOV, A.N., SCARLATO, O.A., GALTSOVA, V.V., MENSHUTKINA, T.V. (0000) The ecosystems of the Chupa Bay of the White Sea and their seasonal dynamics. Issled. Fauni morey. Leningrad: Nauka. 31(39): 5-83. In russ.

GOLIKOV, A.N., BABKOV, A.I., GOLIKOV, A.A., NOVIKOV, O.K., SHEREMETEVSKY, A.M. (1985) The ecosystems of the Onega Bay and adjacent regions of the Basin of the White Sea. Issled. Fauni morey. Leningrad. 33(41): 20-87. In russ.

GOLIKOV, A.N., SIRENKO, B.I., GALTSOVA, V.V., GOLIKOV, A.A., NOVIKOV, O.K., PETRYASHEV, V.V., POTIN, V.V., FEDYAKOV, V.V., VLADIMIROV, M.V. (1988) The ecosystems of the south-eastern part of the Kandalaksha Bay of the White Sea off the Sonostrov. Issled. Fauny morey. Leningrad. 40(48): 1-135. In russ.

GURVITCH, G.S. (1934) The distribution of the animals in the tidal and subtidal zones in the Babje More Bay. Rab. Belomorsk. metod. st. GGI. (2): 15-32. In russ.

IVANOVA, S.S. (1957) Qualitative and quantitative characteristic of the benthos of the Onega Bay of the White Sea. Mater. po kompleksnomu izuchen. Belogo morja. 1: 355-380. In russ.

KUDERSKY, L.A. (1966) The bottom fauna of the Onega Bay of the White Sea. Trudy Karelsk. otd. GosNIORCh. 4(2): 204-371. In russ.

KUZNETSOV, A.P. (1970) The objective laws of the distribution of the trophic groups of bottom invertebrates in the White Sea. Proc. inst. Oceanol. 88: 5-80. In russ.

KUZNETSOV, A.P. (1970) The materials to the investigations of the Ermolinskaja Inlet as the ecosystem (Kandalaksha Bay, White Sea). 1. The bottom fauna. Tr.inst. Oceanol. 88: 98-112. In russ.

KUZNETSOV, A.P. (1976) The trophic structure of the sea bottom communities as the system with the ecological structure. Bottom fauna of the border seas of the USSR. Moscow: Nauka. 1-31. In russ.

KUZNETSOV, A.P. (1980) Ecology of the bottom associations of the shelf of the World Ocean. (The trophic structure of the marine bottom fauna). Moscow: Nauka. -240p. In russ.

LEIBSON, R.G.(1939) Quantitative calculation of the bottom fauna of the Motovsky Bay. Trudy VNIIRO. 4: 127-200. In russ.

LUKANIN, V.V., NAUMOV, A.D., FEDYAKOV, V.V. (1984) Quantitative distribution of the benthos in the Gorlo of the White Sea. Prirodn. sreda i biol. resursy morey i okeanov. Leningrad. 120-121. In russ.

MALIUTIN, O.I. (1983) Biological structure of the White Sea. IX. The trophical zonation of the bottom communities of the Kandalaksha Bay of the White Sea. Ecology and physiology of the animals and plants of the White Sea. Moscow. 41-62. In russ.

MJAGKOV, G.M. (1975) Composition and distribution of the fauna in the biocoenoses of Laminaria saccharina on the Chupa Bay (White Sea). Hydrobiol. journ. 11(5): 42-48. In russ.

MJAGKOV, G.M. (1978) To the characteristic of the Laminarian biocoenoses of the White Sea. Zakonomernosti raspredelenija i ecolog. pribreznich biocenozov. Leningrad. 75-77.In russ.

NAUMOV, A.D., BABKOV, A.I., LUKANIN, .V., FEDYAKOV, V.V. (1986) Hydrological and biocoenotical characteristic of the Mezen Bay of the White Sea. Ecological investigations of the benthic organisms of the White Sea. Leningrad. 64-90. In russ.

NAUMOV, A.D., BABKOV, A.I., FEDYAKOV., V.V. (1986) The biocoenoses of the Kolvitsa Inlet of the Kandalaksha Bay of the White Sea. Ecological investigations of the benthic organisms of the White Sea. Leningrad. 91-122. In russ.

NAUMOV, A.D., LUKANIN, V.V., FEDYAKOV,V.V. (1987) The bottom associations of the Basin of the White Sea near the Tersky Coast. Probl. izuchen., ratsional. ispolzovan. i ochrany prirodn. resursov Belogo morja. Kandalaksha. 204-207. In russ.

NESIS, K.N. (1960) The changes of the bottom fauna of the Barents Sea under the influence of the fluctuations of hydrological conditions. Soviet. ribchoz. issled.v morjach Evrop. severa. Moscow. 129-138. In russ.

PROPP, M.V. (1966) The bottom associations of the Laminaria and Lithothamnion in the upper sublittoral of the East Murman. Proc. MMBI. 11: 92-114. In russ.

PROPP, M.V. (1971) The ecology of the coastal associations of the Murman seaboard of the Barents Sea. Leningrad: Nauka. -128p. In russ.

PUSHKIN, A.F. (1968) The bottom associations of the Cheshskaja Bay . Proc. MMBI. 17(21): 48-57. In russ.

ZATSEPIN, V.I. (1962) The associations of the bottom invertebrate fauna in the Murman seaboard of the Barents Sea and their contact with the associations of Northern Atlantic. Proc. VGBO. 12: 245-344.

ZATSEPIN, V.I. (1970) The quantitative distribution of the different trophic groups of the benthic invertebrates in the Barents Sea. Oceanology. 10(1): 153-165. In russ.

ZATSEPIN, V.I., RITTICH, L.A. (1968a) The quantitative distribution of the bottom fauna and its different ecological groups in the region of Murman seaboard of the Barents Sea. Proc. MOIP. 30: 49-82. In russ.

ZATSEPIN, V.I., RITTICH, L.A. (1968b) The quantitative distribution of the main trophic groups of the bottom invertebrates in the Barents Sea. Proc.PINRO. 23: 527-545. In russ.

ZENKEVITCH, L.A. (1927) The quantitative calculation of the bottom fauna of the Petchora region of the Barents Sea and the White Sea. Moscow. -64p. In russ.