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SPECIES COMPOSITION AND BIOGEOGRAPHIC STRUCTURE OF THE POLYCHAETE FAUNA OF THE PECHORA SEA DURING WARMING IN THE ARCTIC

© 2022 **S. Yu. Gagaev[1], S. G. Denisenko[1], N. A. Strelkova[2], E. A. Frolova[3], and A. V. Sikorski[4]**

[1]Zoological Institute of Russian Academy of Sciences, Saint Petersburg, Russian Federation
[2]Polar branch of VNIRO ("PINRO" named after N. M. Knipovich), Murmansk, Russian Federation
[3]Murmansk Marine Biological Institute, Kola Scientific Center of the Russian Academy of Sciences, Murmansk, Russian Federation
[4]Akvaplan-niva AS, Framsenteret, Tromsø, Norway
E-mail: *gagaev24@yahoo.com*

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A comprehensive study of benthos allows not only to see the current changes in benthic communities and better understand what happened to them in the past, but also to predict their future with a certain degree of reliability. Polychaete worms are one of the most numerous and significant groups of benthos, and those can serve as bioindicators of the state of the environment. This article attempts to analyze changes in the biogeographic groups of polychaetes in the Pechora Sea over a relatively long time period (~ 50 years) in order to understand whether the climate change affects the ratio of these groups and, consequently, whether polychaetes can serve as bioindicators to a certain degree. Based on the analysis of new data and material obtained earlier, a general list of polychaete worms of the Pechora Sea was formed. The list includes 198 taxa (out of them, 186 are identified down to a species level) belonging to 127 genera, 37 families, and 15 orders. The ratio of biogeographic groups of polychaetes in the Pechora Sea indicates the consistency of their biogeographic structure over the past 50 years and confirms the cyclicity of processes occurring in the Arctic.

Keywords: biogeography, bioindicators, Pechora Sea, polychaete worms

For understanding natural processes occurring in the Arctic, hydrobiological indicators are of key significance. Those allow to reconstruct the past and record the present; moreover, those help to predict changes in ecosystems. No wonder that A. I. Vilkitsky wrote in the early XX century that "plant and animal life are closely related to physical properties of water, and therefore, when studying biological conditions, information significant for hydrography is found at the same time" (Evgenov & Kupetskiy, 1985).

The interest of researchers in the groups of polychaete worms is due to a noticeable role those play in benthic communities – both in the entire World Ocean and in the Arctic seas. Polychaetes prevail in macrozoobenthos of shelf and continental slope: they usually make up 45–50 % of the total species number and up to 80 % of the total number of multicellular consumers (Blake, 1997 ; Zhirkov, 2001). Several works were focused on studying the species diversity and quantitative development

of polychaetes in the southeastern Barents Sea, specifically in the Pechora Sea; the taxonomic composition and distribution of these worms in the 1950s and 1990s were characterized (Frolova, 1996 ; Petrovskaya, 1963 ; Sikorski, 1989 ; Streltzov, 1966). Based on new material, the modern taxonomic and biogeographic composition of polychaete worms of the Pechora Sea was examined.

In the Pechora Sea, 107 species were recorded in 1959; 113 species in 1993; and 163 species in 2004, 2006, and 2016. The ratio of biogeographic groups of polychaete worms in the Pechora Sea indicates the consistency of their biogeographic structure over the past 50 years and can be considered as another argument in favor of the idea of cyclical climatic processes in the Arctic.

The aim of the study is to establish the possibility of using polychaete worms as bioindicators of the ongoing climate change in the Arctic.

MATERIAL AND METHODS

Sampling. To study the fauna and analyze the quantitative distribution of polychaetes within the Pechora Sea, material was used from 214 quantitative zoobenthic samples collected by PINRO staff at 44 stations onboard the RV “Smolensk” (2004 and 2006), as well as material sampled at 26 stations by ZIN RAS staff onboard the RV “Professor Vladimir Kuznetsov” (August 2014 and September 2016).

The sampling was carried out at depths from 6 down to 120 m with a Van Veen grab sampler (0.1 m^2), 5 samples at each station; those were washed through a sieve with a mesh of 0.5 mm. The material was fixed with buffered 4–5 % formaldehyde; in 3–4 months, samples were transferred to 75 % ethanol and identified down to the lowest taxonomic level possible.

The biogeographic nature of each species was determined in accordance with generally accepted schemes for biogeographic zoning of the northern seas (Buzhinskaja, 2001 ; Frolova, 1996 ; Sirenko et al., 2009):

a) Arctic species (a) which are exclusively restricted to the Arctic Ocean north of the Iceland–Faroe Ridge;
b) widespread boreal–Arctic species (wb-a) inhabiting mainly temperate waters of the Atlantic, Pacific, and Arctic;
c) high-boreal–Arctic species (hb-a) which occur mainly in the high latitudes, northern boreal waters of the Atlantic and Pacific, and the Arctic Ocean;
d) subtropical boreal–Arctic species (sb-a) which are distributed from the subtropic Pacific and Atlantic oceans up to the Arctic Ocean;
e) Atlantic high-boreal–Arctic species (atlhb-a) whose distribution is similar to that of the high boreal–Arctic species (hb-a), except in Pacific waters;
f) Pacific boreal–Arctic species (pwb-a) which, in contrast, are found in all the areas except for the Atlantic Ocean;
g) cosmopolitan and bipolar species (c&bip) which occur throughout the World Ocean and/or in temperate and polar latitudes of the Northern and Southern hemispheres.

RESULTS

Based on taxonomic identification of the samples and considering the material collected during expeditions in the XX century, a general list of polychaete worms from the Pechora Sea was formed. The list includes 198 taxa (with 186 out of them identified down to a species level) belonging to 127 genera, 37 families, and 15 orders (Table 1).

Table 1. List of polychaetes of the Pechora Sea: a, Arctic; atlb-a, Atlantic boreal–Arctic; atlhb, Atlantic high-boreal; atlhb-a, Atlantic high-boreal–Arctic; atlwb, Atlantic widespread boreal; atlwb-a, widespread Atlantic boreal–Arctic; amph, amphiboreal; b-a, boreal–Arctic; c, cosmopolitans; hb-a, high-boreal–Arctic; phb-a, Pacific high-boreal–Arctic; psb-a, Pacific subtropical boreal–Arctic; pwb-a, Pacific widespread boreal–Arctic; sb-a, subtropical boreal–Arctic; wb-a, widespread boreal–Arctic; and whb-a, widespread high-boreal–Arctic. ? denotes species with unclear distribution. Finding of each species in the corresponding period is marked with +; absence is marked with –. See text for other explanations

Order	Family	Genus	Species	1959	1996	2000s	Biogeographic group
Phyllodocida	Phyllodocidae Örsted, 1843	*Eteone* Savigny, 1882	*E. flava* (Fabricius, 1780)	+	+	+	wb-a
			E. longa (Fabricius, 1780)	+	+	+	sb-a
			E. spetsbergensis Malmgren, 1865	+	+	+	psb-a
		Eulalia Savigny, 1882	*E. bilineata* (Johnston, 1840)	–	+	+	sb-a
		Eumida Malmgren, 1865	*E. arctica* (Annenkova, 1946)	–	–	+	atlhb-a
		Mysta Malmgren, 1865	*M. barbata* Malmgren, 1865	+	+	+	sb-a
		Mystides Théel, 1879	*M. borealis* Théel, 1879	–	–	+	amph
		Phyllodoce Lamarck, 1818	*P. citrina* Malmgren, 1865	–	–	+	wb-a
			P. groenlandica Örsted, 1842	+	+	+	wb-a
			P. maculata (L., 1767)	–	+	+	sb-a
	Polynoidae Kinberg, 1856	*Bylgides* Chamberlin, 1919	*B. elegans* (Théel, 1879)	+	+	+	hb-a
			B. groenlandicus (Malmgren, 1867)	–	–	+	hb-a
			B. promamme (Malmgren, 1867)	+	–	+	a
		Enipo Malmgren, 1865	*E. torelli* (Malmgren, 1865)	+	+	+	wb-a
		Eucranta Malmgren, 1865	*E. villosa* Malmgren, 1867	–	–	+	a
		Gattyana McIntosh, 1900	*G. amondseni* (Malmgren, 1867)	–	–	+	wb-a
			G. cirrhosa (Pallas, 1866)	+	+	+	wb-a
		Eunoe Malmgren, 1865	*E. nodosa* (M. Sars, 1861)	–	+	–	wb-a
		Harmothoe Kinberg, 1855	*H. aspera* (Hansen, 1878)	–	–	+	wb-a
			H. imbricata (L., 1767)	+	+	+	sb-a
			H. impar (Johnston, 1839)	+	–	+	wb-a
			H. rarispina (M. Sars, 1861)	+	–	–	wb-a
		Melaenis Malmgren, 1865	*M. loveni* Malmgren, 1865	–	–	+	a
	Pholoidae Kinberg, 1858	*Pholoe* Johnston, 1839	*P. assimilis* Örsted, 1845	–	–	+	wb-a
			P. longa (O. F. Müller, 1776)	+	+	+	wb-a
	Chrysopetalidae Ehlers, 1864	*Dysponetus* Levinsen, 1879	*D. pygmaeus* Levinsen, 1879	–	–	+	sb-a
	Glyceridae Grube, 1850	*Glycera* Lamarck, 1818	*G. capitata* Örsted, 1842	+	+	+	wb-a
			G. lapidum Quatrefages, 1866	–	–	+	atlwb-a
	Goniadidae Kinberg, 1866	*Goniada* Audouin et Milne-Edwards, 1833	*G. maculata* Örsted, 1843	–	+	–	amph
	Syllidae Grube, 1850	*Myrianida* Milne-Edwards, 1845	*M.* sp.	–	–	+	?
		Erinaceusyllis San Martin, 2003	*E. erinaceus* (Claparède, 1863)	+	–	–	wb-a
		Eusyllis Malmgren, 1867	*E. blomstrandi* Malmgren, 1867	–	–	+	sb-a
		Pionosyllis Malmgren, 1867	*P.* sp.	–	–	+	?
		Proceraea Ehlers, 1864	*P. cornuta* (Agassiz, 1862)	–	–	+	hb-a
			P. prismatica (Fabricius, 1780)	+	–	–	wb-a
		Syllis Lamarck, 1818	*S. oerstedi* nom. dub. (Malmgren, 1867)	+	–	–	sb-a
	Hesionidae Grube, 1850	*Gyptis* Marion et Bobretzky, 1875	*G. vittata* Webster et Benedict, 1887	–	–	+	sb-a
		Nereimyra Blainville, 1828	*N. aphroditoides* (Fabricius, 1780)	–	–	+	phb-a
	Nereididae Savigny in Lamarck, 1818	*Nereis* Linnaeus, 1758	*N. pelagica* L., 1758	–	–	+	amph
			N. zonata Malmgren, 1867	+	+	+	sb-a
	Nephtyidae Grube, 1850	*Aglaophamus* Kinberg, 1866	*A. malmgreni* (Théel, 1879)	+	–	+	wb-a
		Micronephthys Friedrich, 1937	*M. minuta* (Théel, 1879)	+	+	+	a
			M. neotena (Noyes, 1980)	–	–	+	atlwb-a
		Nephtys Cuvier in Audouin et Milne-Edwards, 1833	*N. ciliata* (O. F. Müller, 1776)	+	+	+	wb-a
			N. longosetosa Örsted, 1841	+	+	+	wb-a
			N. paradoxa Malmgren, 1874	+	+	+	sb-a
			N. pente Rainer, 1984	–	+	+	wb-a

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Order	Family	Genus	Species	1959	1996	2000s	Biogeographic group
Phyllodocida	Sphaerodoridae Malmgren, 1867	*Sphaerodoropsis* Hartman et Fauchald, 1971	*S. philippi* (Fauvel, 1911)	+	–	+	wb-a
		Sphaerodorum Örsted, 1843	*S. gracilis* (Rathke, 1843)	+	+	+	wb-a
Eunicida	Onuphidae Kinberg, 1865	*Nothria* Malmgren, 1867	*N. hyperborea* (Hansen, 1878)	+	+	+	phb-a
	Lumbrineridae Schmarda, 1861	*Abyssoninoe* Orensanz, 1990	*A. hibernica* (McIntosh, 1903)	–	–	+	atlhb-a
		Lumbrineris Blainville, 1828	*L. mixochaeta* Oug, 1998	–	–	+	atlhb-a
		Paraninoe Levenstein, 1977	*P. minuta* (Théel, 1879)	+	+	+	wb-a
		Scoletoma Blainville, 1828	*S. fragilis* (O. F. Müller, 1776)	+	+	+	wb-a
	Dorvilleidae Chamberlin, 1919	*Ophryotrocha* Claparède et Mecznikow, 1869	*O.* sp.	–	–	+	?
		Protodorvillea Pettibone, 1961	*P. kefersteini* (McIntosh, 1869)	–	–	+	sb-a
		Parougia Wolf, 1986	*P. caeca* (Webster et Benedict, 1884)	–	–	+	atlhb-a
Amphinomida	Amphinomidae Lamarck, 1818	*Paramphinome* Sars, 1869	*P. jeffreysii* (McIntosh, 1868)	+	–	–	atlwb
Orbinida nomen dubium	Orbiniidae Hartman, 1942	*Orbinia* Quaterfages, 1865	*O. glebushki* Averincev, 1990	–	–	+	a
		Leitoscoloplos Day, 1977	*L. acutus* (Verrill, 1873)	–	–	+	sb-a
		Scoloplos Blainville, 1828	*S. armiger* (O. F. Müller, 1776)	+	+	+	c
Spionida	Spionidae Grube, 1850	*Dipolydora* Verrill, 1881	*D. coeca* (Örsted, 1843)	–	+	+	wb-a
			D. caulleryi (Mesnil, 1897)	–	–	+	sb-a
			D. quadrilobata (Jacobi, 1883)	+	+	+	wb-a
			D. socialis (Schmarda, 1861)	–	–	+	atlwb
		Laonice Malmgren, 1867	*L. cirrata* (M. Sars, 1851)	+	+	+	sb-a
		Marenzelleria Mesnil, 1896	*M. arctia* (Chamberlin, 1920)	–	+	+	phb-a
			M. wireni Augener, 1913	–	+	+	a
		Prionospio Malmgren, 1867	*P. cirrifera* Wirén, 1883	+	+	+	wb-a
		Pygospio Claparède, 1863	*P. elegans* Claparède, 1863	+	+	+	wb-a
		Scolelepis Blainville, 1828	*S. burkovskii* Sikorski, 1994	–	+	+	a
			S. laonicola (Tzetlin, 1985)	–	–	+	a
		Spio Fabricius, 1785	*S. armata* (Thulin, 1957)	–	–	+	wb-a
			S. arctica (Söderström, 1920)	–	+	+	wb-a
			S. filicornis (Müller, 1776)	+	–	+	wb-a
			S. theeli (Söderström, 1920)	–	+	+	wb-a
		Spiophanes Grube, 1860	*S. kroyeri* Grube, 1860	+	+	–	amph
	Trochochaetidae Pettibone, 1961	*Trochochaeta* Levinsen, 1884	*T. multisetosa* (Örsted, 1844)	–	+	+	amph
	Apistobranchidae Mesnil et Caullery, 1898	*Apistobranchus* Levinsen, 1883	*A. tenuis* Orrhage, 1962	–	–	+	atlwb
			A. tullbergi (Théel, 1879)	–	+	+	wb-a
Chaetopterida nomen dubium	Chaetopteridae Audouin et Milne-Edwards, 1833	*Spiochaetopterus* M. Sars, 1853	*S. typicus* M. Sars, 1856	+	+	+	wb-a
Cirratulida nomen dubium	Paraonidae Cerruti, 1909	*Aricidea* Webster, 1879	*A. (Acmira) catherinae* Laubier, 1967	–	+	+	atlwb
			A. hartmanae (Strelzov, 1968)	–	–	+	atlwb-a
			A. (Acmira) laubieri Hartley, 1981	–	–	+	atlb-a
			A. nolani taxon inquirendum Webster et Benedict, 1887	+	+	+	wb-a
			A. (Strelzovia) quadrilobata Webster et Benedict, 1887	–	–	+	wb-a
		Cirrophorus Ehlers, 1908	*C. branchiatus* Ehlers, 1908	–	–	+	c
			C. lyra (Southern, 1914)	+	+	+	atlwb
		Levinsenia Mesnil, 1897	*L. gracilis* (Tauber, 1879)	+	+	+	c
		Paraonides Cerruti, 1909	*P. nordica* (Strelzov, 1968)	–	–	+	hb-a
	Cirratulidae Ryckholt, 1851	*Aphelochaeta* Blake, 1991	*A.* cf. *marioni* (Saint-Joseph, 1894)	–	–	+	?
		Chaetozone Malmgren, 1867	*C. setosa* Malmgren, 1867	+	+	+	?
		Cirratulus Lamarck, 1801	*C. cirratus* (O. F. Müller, 1776)	+	+	+	sb-a
		Tharyx Webster et Benedict, 1887	*T. killariensis* (Southern, 1914)	–	–	+	atlwb

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Order	Family	Genus	Species	1959	1996	2000s	Biogeographic group
Ctenodrilida nomen dubium	Ctenodrilidae Kennel, 1882 taxon inquirendum	*Raricirrus* Hartman, 1961	*R.* sp.	–	–	+	?
Cossurida nomen dubium	Cossuridae Day, 1963	*Cossura* Webster et Benedict, 1887	*C. longocirrata* Webster et Benedict, 1887	+	+	+	wb-a
Flabelligerida nomen dubium	Flabelligeridae Saint-Joseph, 1894	*Brada* Stimpson, 1854	*B. granulosa* Hansen, 1880	–	+	+	wb-a
			B. inhabilis (Rathke, 1843)	+	+	+	wb-a
			B. nuda Annenkova, 1922	–	–	+	phb-a
		Bradabyssa Hartman, 1967	*B. villosa* (Rathke, 1843)	+	+	+	wb-a
		Diplocirrus Haase, 1915	*D. glaucus* (Malmgren, 1867)	–	+	–	atlhb
		Saphobranchia Chamberli, 1919	*S. hirsuta* (Hansen, 1879)	+	+	–	atlhb-a
			S. longisetosa (Marenzeller, 1890)	–	+	+	a
		Flabelligera M. Sars, 1829	*F. affinis* M. Sars, 1829	–	–	+	sb-a
		Pherusa Oken, 1807	*P. plumosa* (O. F. Müller, 1776)	+	+	–	sb-a
Opheliida nomen dubium	Scalibregmatidae Malmgren, 1867	*Polyphysia* Quatrefages, 1865	*P. baffinensis* (Blake, 1972)	+	–	+	a
		Scalibregma Rathke, 1843	*S. inflatum* Rathke, 1843	+	+	+	wb-a
	Opheliidae Grube, 1850	*Ophelia* Savigny, 1818	*O. limacina* (Rathke, 1843)	+	+	+	c
		Ophelina Örsted, 1843	*O. acuminata* Örsted, 1843	+	+	+	a
			O. cylindricaudata (Hansen, 1878)	–	+	+	wb-a
	Travisiidae Hartmann-Schröder, 1971	*Travisia* Johnson, 1840	*T. forbesii* Johnson, 1840	+	+	+	wb-a
Capitellida nomen dubium	Capitellidae Grube, 1862	*Capitella* Blainville, 1828	*C. capitata* (Fabricius, 1870)	+	+	+	sb-a
		Heteromastus Eisig, 1887	*H. filiformis* (Claparède, 1864)	+	+	+	sb-a
		Notomastus M. Sars, 1850	*N. latericeus* M. Sars, 1851	+	+	+	c
	Maldanidae Savigny in Lamarck, 1818	*Axiothella* Verrill, 1900	*A. catenata* (Malmgren, 1865)	+	+	–	wb-a
		Clymenura Verrill, 1900	*C. polaris* (Théel, 1879)	+	+	+	atlwb-a
		Euclymene Verrill, 1900	*E. droebachiensis* (M. Sars in G. O. Sars, 1872)	–	–	+	atlwb-a
		Lumbriclymene Sars, 1872	*L. cylindricauda* M. Sars in G. O. Sars, 1872	–	–	+	atlhb-a
			L. minor Arwidsson, 1906	–	–	+	atlhb-a
		Maldane Grube, 1860	*M. arctica* Detinova, 1985	–	–	+	hb-a
			M. sarsi Malmgren, 1865	+	+	+	wb-a
		Microclymene Arwidsson, 1906	*M. acirrata* Arwidsson, 1906	–	–	+	a
		Nicomache Malmgren, 1865	*N. lumbricalis* (Fabricius, 1780)	+	–	+	wb-a
			N. (Nicomache) minor Arwidsson, 1906	–	–	+	wb-a
		Notoproctus Arwidsson, 1906	*N. oculatus arcticus* Arwidsson, 1906	–	–	+	wb-a
		Petaloproctus Quatrefages, 1865	*P. tenuis* (Théel, 1879)	+	+	+	wb-a
		Praxillella Verrill, 1881	*P. gracilis* (M. Sars, 1861)	+	+	+	wb-a
			P. praetermissa (Malmgren, 1865)	+	+	+	sb-a
		Praxillura Verrill, 1880	*P. longissima* Arwidsson, 1906	+	+	+	hb-a
		Asychis Kinberg, 1867	*A. biceps* (M. Sars, 1861)	+	–	–	atlhb
		Rhodine Malmgren, 1866	*R. gracilior* Tauber, 1879	+	+	+	wb-a
			R. loveni Malmgren, 1865	–	+	+	amph
Oweniida nomen dubium	Oweniidae Rioja, 1917	*Galathowenia* Kirkegaad, 1956	*G. oculata* (Zachs, 1923)	+	+	+	sb-a
		Myriochele Malmgren, 1867	*M. heeri* Malmgren, 1867	+	+	+	wb-a
		Owenia Delle Chiaje, 1844	*O. polaris* Koh, Bhaud & Jirkov, 2003	–	–	+	a
Terebellida	Pectinariidae Quatrefages, 1865	*Cistenides* Malmgren, 1866	*C. hyperborea* Malmgren, 1866	+	+	+	hb-a
		Lagis Malmgren, 1866	*L. koreni* Malmgren, 1866	–	+	–	atlhb
	Ampharetidae Malmgren, 1865	*Amage* Malmgren, 1866	*A. auricula* Malmgren, 1866	+	–	–	atlwb
		Ampharete Malmgren, 1865	*A. acutifrons* (Grube, 1860)	+	+	+	wb-a
			A. borealis (M. Sars, 1856)	+	+	+	hb-a
			A. finmarchica (M. Sars, 1865)	–	+	+	wb-a
			A. goesi Malmgren, 1865	+	+	+	phb-a
			A. lindstroemi Malmgren, 1867	–	+	+	wb-a
			A. octocirrata (M. Sars, 1835)	–	–	+	atlwb
			A. vega (Wirén, 1883)	–	+	+	a

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Order	Family	Genus	Species	1959	1996	2000s	Biogeographic group
Terebellida	Ampharetidae Malmgren, 1865	*Amphicteis* Grube, 1850	*A. gunneri* (M. Sars, 1835)	+	+	+	wb-a
			A. sundevalli (Malmgren, 1866)	+	+	–	a
		Anobothrus Levinsen, 1884	*A. gracilis* (Malmgren, 1865)	+	+	+	wb-a
		Glyphanostomum Levinsen, 1884	*G. pallescens* (Théel, 1879)	+	–	–	wb-a
		Lysippe Malmgren, 1866	*L. labiata* Malmgren, 1866	+	+	+	pwb-a
		Melinna Malmgren, 1866	*M. cristata* (Sars, 1851)	+	–	–	wb-a
			M. elisabethae McIntosh, 1914	+	+	+	wb-a
	Trichobranchidae Malmgren, 1866	*Terebellides* M. Sars, 1835	*T. gracilis* Malm, 1874	–	–	+	wb-a
			T. stroemii M. Sars, 1835	+	+	+	c
		Trichobranchus Malmgren, 1866	*T. glacialis* Malmgren, 1866	–	+	+	wb-a
	Terebellidae Grube, 1850	*Amphitrite* O. F. Müller, 1771	*A. birulai* Ssolowiew, 1899	+	+	+	sb-a
			A. cirrata Müller, 1776	+	+	–	atlwb-a
			A. groenlandica Malmgren, 1866	+	+	–	wb-a
		Artacama Malmgren, 1866	*A. proboscidea* Malmgren, 1866	+	+	+	wb-a
		Axionice Malmgren, 1866	*A. flexuosa* (Grube, 1860)	–	+	+	pwb-a
			A. maculata (Dalyell, 1853)	+	+	+	sb-a
		Lanassa Malmgren, 1866	*L. nordenskioldi* Malmgren, 1866	–	–	+	whb-a
			L. venusta (Malm, 1874)	–	+	+	wb-a
		Laphania Malmgren, 1866	*L. boecki* Malmgren, 1866	+	+	+	wb-a
		Leaena Malmgren, 1866	*L. ebranchiata* (M. Sars, 1865)	+	+	–	wb-a
		Lysilla Malmgren, 1866	*L. loveni* Malmgren, 1866	+	–	–	wb-a
		Nicolea Malmgren, 1865	*N. zostericola* (Örsted, 1844)	+	+	+	wb-a
		Pista Malmgren, 1866	*P. bansei* Saphronova, 1988	–	+	+	hb-a
		Polycirrus Grube, 1850	*P. medusa* Grube, 1850	+	+	+	sb-a
			P. norvegicus (Wollebaek, 1912)	–	–	+	atlhb-a
		Proclea Saint-Joseph, 1894	*P. graffii* (Langerhans, 1884)	+	+	+	wb-a
			P. malmgreni (Ssolowiew, 1899)	–	+	–	b-a
		Thelepus Leuckart, 1849	*T. marthae* Jirkov, 2018	+	+	+	a
Sabellida	Sabellidae Latreille, 1825	*Bispira* Krøyer, 1856	*B. crassicornis* (M. Sars, 1851)	–	–	+	wb-a
			B. fabricii (Krøyer, 1856) Knight-Jones, 1990	+	–	–	wb-a
		Branchiomma Kölliker, 1858	*B. arcticum* (Ditlevsen, 1937)	+	–	–	atlhb-a
		Chone Krøyer, 1856	*C. duneri* Malmgren, 1867	+	+	+	sb-a
			C. infundibuliformis Krøyer, 1856	+	+	+	sb-a
			C. oculata Annenkova, 1952	+	+	+	a
		Euchone Malmgren, 1866	*E. analis* (Kröyer, 1856)	+	+	+	sb-a
			E. papillosa (M. Sars, 1851)	+	+	+	wb-a
			E. perseyi (Zenkevitch, 1925)	–	–	+	hb-a
		Laonome Malmgren, 1866	*L. kroyeri* Malmgren, 1866	+	+	+	sb-a
		Myxicola Koch in Renier, 1847	*M. infundibulum* (Montagu, 1808)	+	–	–	amph
	Serpulidae Rafinesque, 1815	*Chitinopoma* Levinsen, 1884	*C. serrula* (Stimpson, 1853)	–	–	+	atlhb
	Spirorbidae Pillai, 1970	*Bushiella* Knight-Jones, 1973	*B. (Jugaria) granulata* (L., 1767)	+	–	+	atlwb-a
			B. (J.) quadrangularis (Stimpson, 1854)	–	–	+	sb-a
		Circeis Saint-Joseph, 1894	*C. spirillum* (L., 1758)	+	+	+	wb-a
		Paradexiospira Caullery et Mesnil, 1897	*P. (Paradexiospira) violacea* (Levinsen, 1883)	+	–	+	hb-a
			P. (Spirorbides) vitrea (Fabricius, 1780)	–	+	+	hb-a

Out of the entire list, 81 % of species are classified as boreal–Arctic, with boreal, Arctic, and cosmopolitan species amounting to approximately 6.3 %.

Based on the analysis of all the taxonomic levels, a formula was used (Fig. 1) which shows the dependence of each taxon on its rank for the water area studied. A conclusion was made on insufficient investigation of the polychaete population (Golikov, 1976).

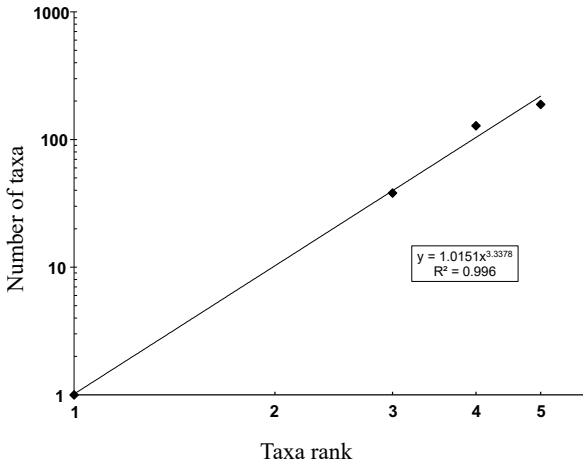

Fig. 1. Relationship between number of taxa and their ranks. X-axis: 1, class; 2, order (this taxon is not used on the graph since the issue of belonging to a particular order causes disagreement among specialists); 3, family; 4, genus; and 5, species

DISCUSSION

As indicated in the last review most fully characterizing the state of knowledge of the Pechora Sea (Denisenko, 2013), there are 176 polychaete taxa, and out of them, 129 are identified down to a species level. Based on our own data collected since the early XXI century, we came to a conclusion that the diversity of polychaetes in the studied area is even higher. To a greater extent, the data include taxa of the lowest ranks – species and genera. The rise in figures does not result from increasing warming of the Arctic alone: it is also a consequence of the progress in polychaete taxonomy and the improvement of methods for collecting worms, *inter alia* higher intensity of sampling and use of fine mesh for sediment flushing. Definitely, the latter contributes to discovery of new Polychaeta species (not recorded in the Pechora Sea earlier) and will expand the total list by several dozen.

At the same time, despite the increasing number of polychaete species recorded in the studied fauna, the ratio of the main biogeographic groups remains approximately the same since the 1950s (Fig. 2). In the sea fauna, boreal–Arctic species of polychaete worms prevail, and their ratio has changed insignificantly from the late 1950s to the early XXI century – from 82 to 77 %. The ratio of Arctic species increased from 6 to 10 %. The ratio of pan-oceanic and bipolar species (those are designated as cosmopolitan ones) decreased over the same period; importantly, the main reason was the progress in polychaete taxonomy, not the effect of abiotic factors. The ratio of boreal species remained approximately at the same level – 5–7 %.

Conclusion. The number of polychaete species constantly increases, to a greater or lesser extent due to environmental warming since the 1950s. Despite this, the ratio of the main biogeographic groups of species remains relatively stable, and this indicates a balanced mechanism for the regulation of internal processes in taxocenes of the Pechora Sea polychaetes. In other words, the ongoing climate change is neither unexpected nor extraordinary for the populations of polychaete worms. Those are genetically expected, are not new in the general history of the development of polychaetes, and are easily compensated by their innate tolerance abilities.

Apparently, the remarks given in the article on the stability of the biogeographic structure of the fauna and some other characteristics of polychaete worms, as well as other groups playing a noticeable role in benthic invertebrate communities, show that those can serve as a kind of a status indicator of natural processes in various areas of the World Ocean.

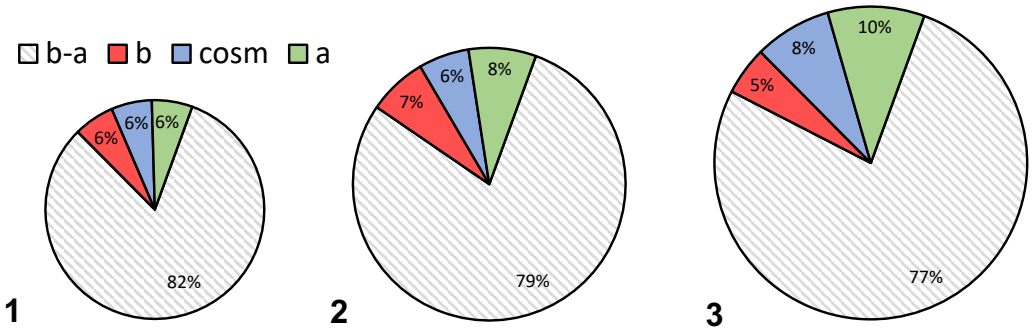

Fig. 2. Ratio of various biogeographic groups in the polychaete fauna in different periods: 1, 1959; 2, 1993; and 3, 2004, 2006, and 2016 (107, 113, and 163 species, respectively, with the circle diameter proportional to the species number)

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ВИДОВОЙ СОСТАВ И БИОГЕОГРАФИЧЕСКАЯ СТРУКТУРА ФАУНЫ POLYCHAETA ПЕЧОРСКОГО МОРЯ В ПЕРИОД ПОТЕПЛЕНИЯ АРКТИКИ

С. Ю. Гагаев[1], С. Г. Денисенко[1], Н. А. Стрелкова[2], Е. А. Фролова[3], А. В. Сикорский[4]

[1]Зоологический институт Российской академии наук, Санкт-Петербург, Российская Федерация
[2]Полярный филиал ФГБНУ «Всероссийский научно-исследовательский институт рыбного хозяйства и океанографии» («ПИНРО» имени Н. М. Книповича), Мурманск, Российская Федерация
[3]Мурманский морской биологический институт Кольского научного центра РАН, Мурманск, Российская Федерация
[4]Акваплан-нива, Тромсё, Норвегия
E-mail: *gagaev24@yahoo.com*

Всестороннее изучение бентоса позволяет не только видеть текущие изменения донных сообществ и лучше понимать, что́ происходило с ними в прошлом, но и с некоторой степенью достоверности прогнозировать их будущее. Многощетинковые черви являются одной из самых многочисленных и значимых групп бентоса, способных выступать своеобразными биоиндикаторами состояния среды. В настоящей статье предпринята попытка проанализировать изменения биогеографических групп полихет Печорского моря в сравнительно длительный период времени (около 50 лет), чтобы понять, ка́к влияют изменения климата на соотношение биогеографических групп многощетинковых червей и, как следствие, могут ли полихеты в той или иной степени выступать в качестве биоиндикаторов. На основе анализа новых и прежних данных составлен список многощетинковых червей Печорского моря. Он насчитывает 198 таксонов (из них 186 определены до вида), относящихся к 127 родам, 37 семействам и 15 отрядам. Соотношение биогеографических групп полихет Печорского моря указывает на постоянство их биогеографического состава в течение последних 50 лет и является ещё одним подтверждением цикличности процессов, происходящих в Арктике.

Ключевые слова: биогеография, биоиндикаторы, Печорское море, многощетинковые черви