Трансформация экосистем
Ecosystem Transformation

ISSN 2619-0931 Online
www.ecosysttrans.com

DOI 10.23859/estr-230124
EDN OEWLYC
UDC 591.524.11: 556.51(282.247.211)

Article

Current state of macrozoobenthos in Lake Munozero

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Аннотация. The article presents the study results (summer-autumn of 2017–2022) of macrozoobenthos in the Lake Onega basin (Lake Munozero, Republic of Karelia). The average biomass of macrozoobenthos in the littoral zone made up 3.6 g/m^2, while in the deep-water part of the lake – 2.7 g/m^2. The average number of benthic organisms in the coastal and profundal zones of the reservoir reached 2.7 and 1.1 thous. ind./m^2, respectively. Gastropods (34.9%) and isopods (22.4%) played a significant role in the formation of macrozoobenthos biomass in the coastal zone of the lake. In the deep part of the reservoir, amphipods, valuable in terms of food resources, developed in large numbers. With a population of 1 thousand ind./m^2 (89.5%), their biomass accounted for 2.7 g/m^2 (98% of the total). Thus, amphipods formed the feed base for fish in the profundal zone. Insect larvae, mainly of the family Chironomidae, provided the taxonomic richness of the lake macrozoobenthos.

Keywords: biomass, abundance, taxonomic composition, benthic communities

Funding. The work was carried out within the State Task No. FMEN-2021-0019 of the Northern Water Problems Institute, Karelian Research Centre of the Russian Academy of Sciences.

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To cite this article: Sidorova, A.I., Georgiev, A.P., 2024. Current state of macrozoobenthos in Lake Munozero. *Ecosystem Transformation* **7** (4), 174–186. https://doi.org/10.23859/estr-230124

Received: 24.01.2023
Accepted: 11.05.2023
Published online: 06.12.2024

DOI 10.23859/estr-230124
EDN OEWLYC
УДК 591.524.11: 556.51(282.247.211)

Научная статья

Макрозообентос оз. Мунозера на современном этапе

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Аннотация. Представлены результаты исследования макрозообентоса на водосборе Онежского озера (оз. Мунозеро, Республика Карелия) в летне-осенний период 2017–2022 гг. Средняя биомасса макрозообентоса в литоральной зоне составила 3.6 г/м^2, в глубоководной части –2.7 г/м^2. Средняя численность донных организмов достигала в прибрежной зоне водоема 2.7 тыс. экз./м^2, в профундали – 1.1 тыс. экз./м^2. Существенную роль в формировании биомассы макрозообентоса прибрежной зоны озера играли брюхоногие моллюски (34.9%) и равноногие раки (22.4%). В глубоководной части водоема в массе развивались ценные в кормовом отношении амфиподы. Их биомасса составляла 2.7 г/м^2 (98% от общей) при численности 1 тыс. экз./м^2 (89.5%); таким образом, они формировали основу кормовой базы рыб в профундали. Основу таксономического богатства макрозообентоса водоема составляли личинки насекомых, главным образом, семейства Chironomidae.

Ключевые слова: биомасса, численность, таксономический состав, донные сообщества

Финансирование. Работа выполнена в рамках Государственного задания № FMEN-2021-0019 Института водных проблем Севера КарНЦ РАН.

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Для цитирования: Сидорова, А.И., Георгиев, А.П., 2024. Макрозообентос оз. Мунозера на современном этапе. *Трансформация экосистем* **7** (4), 174–186. https://doi.org/10.23859/estr-230124

Поступила в редакцию: 24.01.2023
Принята к печати: 11.05.2023
Опубликована онлайн: 06.12.2024

Introduction

Industrial and agricultural expansion in the highly developed countries inevitably leads to increasing anthropogenic loads on natural landscapes. Being accumulating systems, the reservoirs undergo anthropogenic impacts to the gtreatest extent (Georgiev et al., 2021). Numerous current research carried out in the Republic of Karelia are focused on finding the ways of the best and rationally organized fisheries. Hence, the studies of feed base peculiarities were and still remain crucial in fish resource investigations (Georgiev et al., 2021). The results obtained can be used in developing acclimatization measures and analyzing the reasons for fluctuations in the number and growth rate of fish. Studies of feed objects are of key importance both for the exploitation of the existing and for the creation of new fish resources subject to multifactorial effects (Cherepanova et al., 2020). The knowledge about the living conditions of fish (their feed base and fattening, in particular) makes it possible to determine the ways of rational use of natural resources of the reservoirs (Georgiev et al., 2021). Many fish at different age stages can feed on benthic organisms. In this regard, the monitoring of feed base, especially macrozoobenthos, is needed when characterizing the conditions for the formation and functioning of fish communities. On large water bodies of Karelia, such works are implemented annually and even seasonally, but on smaller ones much less often. The relevance of hydrobiological monitoring increases if any small reservoir is a source of water supply and water consumption for the nearby settlements. Anthropogenic impacts on such reservoirs manifest themselves much stronger and faster than on large reservoirs. A vivid example is Lake Munozero situated in the Lake Onega catchment area.

The aim of the work is to assess the taxonomic composition and quantitative characteristics of macrozoobenthos communities in Lake Munozero.

Materials and methods

Characteristics of the studied reservoir

Lake Munozero (N 62°14' E 33°51) is located in the low left-bank part of the Shuya River basin, which in turn belongs to the Lake Onega catchment. The lake stretches from north to south. Its total length is 17.5 km, the greatest width – 1.9 km, the average width – 0.81 km, the surface area – 14.2 km^2. The average depth of the lake reaches 14.4 m, the maximum – 50.0 m. Its catchment area is 48.3 km^2 (Ozera Karelii, 2013).

In the southwestern and western sites of the lake basin, there are some settlements, the “Martsial Waters” sanatorium and agricultural lands. The northern and north-eastern parts and the adjacent water area are a part of the “Kivach” Nature Reserve. The lake is used for water supply, recreation, and wastewater discharge. The southern and south-western areas of its basin, including the water area, are subject to anthropogenic impacts because of domestic wastewater discharges from the village of Martsial Waters and sanatoriums “Martsial Waters” and “Dvortsy”, as well as runoff from the agriculturally developed areas. In 2003, a small trout farm was built in the north-eastern section of the lake water area. As a result, the enrichment of lake waters with organic residues owing to farming of commercial trout in cages occurs (Sabylina and Ikko, 2019).

The lake occupies the upper part of the Konchezersk lake-river system (Munozero, Pertozero, Gabozero, Konchezero, Ukshezero). The Konchezersk group of lakes in Karelia is unique; it includes Lake Munozero, which stands out for its high mineralization (100 mg/l), low content of organic (C_{org} = 2–4 mg/l) and biogenic substances. Its waters are characterized by low color values (20–30 degrees) and high transparency (4–5 m). In terms of the drinking water quality, this is one of the best water bodies in Karelia (Sabylina and Ikko, 2019).

According to microbiological indicators, the northwestern reach of the reservoir can be characterized as transitional from oligotrophic to mesotrophic (Makarova, 2019), and the southern one as mesotrophic (Makarova, 2020).

By plankton indicators, the pelagic system is oligo-mesotrophic (Fomina et al., 2022). Phytoplankton is represented by 147 algal taxa of the rank below the genus, belonging to 9 divisions. Representatives of centric diatoms, blue-green algae, dinoflagellates and chlorococcal greens determine the structure of algocenoses in terms of species richness and abundance that is important for the formation of feed base. In 2018, the average abundance of phytoplankton in the northwestern part reached 492 thous. cells/l, the average biomass – 0.468 g/m^3, while in the southern area these indicators accounted for 589 thous. cells/l and 0.459 g/m^3, respectively. According to the saprobity index, the water quality in the northwestern and southern parts corresponds to water class III, although biomass values characterize both sections of the reservoir as oligotrophic. The Shannon index, quantitative and structural features of phytoplankton differ for the northwestern and southern reaches; the observed seasonal dynamics is not typical for phytoplankton of an oligotrophic Karelian lake (Slastina, 2021).

By biomass, the current state of zooplankton in the northwestern and southern sites of the reservoir correspond to the oligo- and mesotrophic types of lakes according to the Shannon–Weaver index (Syarki and Fomina, 2020).

First materials on the macrozoobenthos studies of Lake Munozero were published in 1957 (Gordeeva-Pertseva, 1957). Then, the taxonomic composition of the benthic community was profoundly studied by G.V. Nikolsky (1980). Later, the investigations were conducted only in 2000–2001. The literature reports only about the biomass of benthic organisms (Kulikova and Ryabinkin, 2008). The data for 2005 are given in the monograph of N.V. Ilmast et al. (2008).

Methods for studying macrozoobenthos

Sampling in the coastal and deep-water zones of Lake Munozero was made in the summer-autumn of 2017–2022 using an automatic box grab (with a capture area of 0.025 m^2). Quantitative benthic samples were taken at 5 stations in the littoral (stations M1, M2, M3, M4 with a depth of up to 1.5 m) and deep-water (station M5, depth 19 m) zones of the northwestern reach of the lake (Fig. 1). Two samples were collected at each station. After sampling, the specimens were immediately washed through No. 23 gas sieve (mesh size 0.333 mm) and fixed in 4% formalin. Laboratory processing of the samples was carried out based on the generally accepted methods (Methodicheskie rekommendatsii..., 1984; Opredelitel'..., 2016; Pankratova, 1970, 1977, 1983; Polyakova, 2007). For organisms selection from soil, we used a stereoscopic microscope MSP-2 (option 2) in a modified Bogorov chamber (specially installed for microscope-based sorting of benthic specimens) and for species identification – a LOMO Mikmed-6 microscope. Raw organisms were weighed on a VL-124V laboratory analytical scale (accuracy: 0.0001 g).

Fig. 1. Location sites of macrozoobenthos sampling stations on Lake Munozero in 2017–2022.

Table 1. Taxonomic structure, abundance, and biomass of macrozoobenthos communities of Lake Munozero.

No.	Species/taxon	1950 (Nikolsky, 1980)		2017–2022 (own data)	
		Littoral zone	Deep-water zone	Littoral zone	Deep-water zone
	Oligochaeta				
1	Oligochaeta varia	+	+	–	–
2	*Spirosperma ferox* Eisen, 1879	–	–	+	+
3	*Tubifex tubifex* (Müller, 1774)	–	–	+	–
4	*Limnodrilus udekemianus* Claparede, 1862	–	–	+	–
5	*Stylodrilus heringianus* Claparede, 1862	–	–	+	–
6	*Nais simplex* Piguet, 1906	–	–	+	–
	Gastropoda				
7	*Bithynia tentaculata* (Linnaeus,1758)	+	–	+	–
8	*Lymnaea stagnalis* (Linnaeus,1758)	+	–	–	–
9	*Lymnaea ovata* (Draparnaud, 1805)	+	–	–	–
10	*Lymnaea terebra* (Westerlund, 1885)	+	–	–	–
11	*Gyraulus borealis* (Loven in Westerlud, 1875)	+	–	–	–
12	*Bathyomphalus crassus* (Da Costa, 1778)	+	–	–	–
13	*Planorbis complanatus* (Linnaeus,1758)	+	–	–	–
14	*Armiger bielzi* (Kimakowicz, 1884)	+	–	–	–
15	*Valvata cristata* O.F. Müller, 1774	+	–	–	–
16	*Valvata sibirica* Middendorff, 1851	+	–	–	–
17	*Amphipeplia glutinosa* (O.F. Muller, 1774)	+	–	–	–
	Bivalvia				
18	*Pisidium* sp.	+	+	+	+

No.	Species/taxon	1950 (Nikolsky, 1980)		2017–2022 (own data)	
		Littoral zone	Deep-water zone	Littoral zone	Deep-water zone
	Amphipoda				
19	*Monoporea affinis* (Lindström, 1855)	+	+	+	+
20	*Pallaseopsis quadrispinosa* (G.O. Sars, 1867)	+	+	+	–
21	*Mysis relicta* Loven, 1862	+	+	–	–
	Isopoda				
22	*Asellus aquaticus* (Linnaeus,1758)	+	–	+	–
	Chironomidae				
23	*Polypedilum bicrenatum* Kieffer, 1921	+	–	+	–
24	*Chironominae* gr. *genuinae №3* Lipina, 1926	–	–	+	–
25	*Procladius* sp.	+	+	+	–
26	*Limnophyes karelicus* (Tshernovskij, 1949)	+	–	+	–
27	*Microtendipes* gr. *chloris*	+	–	+	–
28	*Psectocladius* sp.	–	+	+	–
29	*Cricotopus* gr. *sylvestris* Fabricius, 1794	–	–	+	–
30	*Micropsectra* gr. *praecox* (Meigen, 1818)	+	–	+	–
31	*Cladotanytarsus* gr. *mancus* (Walker, 1856)	–	+	+	–
32	*Zavrelia* sp.	+	–	+	–
33	*Chironomus* sp.	–	–	+	–
34	*Monodiamesa bathyphila* (Kieffer, 1918)	+	+	–	–
35	*Orthocladius* sp.	+	–	–	–
36	*Tanytarsus* gr. *gregarius* Kieffer, 1905	–	+	–	–
37	*Tanytarsus gr. lobatifrons* Kieffer, 1914	–	+	–	–
38	*Cladopelma lateralis* (Goetghebuer, 1934)	–	+	–	–
39	*Tendipes* f.l. *semireductus* Lenz, 1924	–	+	–	–

No.	Species/taxon	1950 (Nikolsky, 1980)		2017–2022 (own data)	
		Littoral zone	Deep-water zone	Littoral zone	Deep-water zone
40	*Tendipes* f.l. *plumosus* Lenz, 1912	–	+	–	–
	Megaloptera				
41	*Sialis* sp.	+	–	+	–
	Coleoptera				
42	Coleoptera	+	–	–	–
43	*Dytiscus* sp.	–	–	+	–
	Ephemeroptera				
44	Ephemeroptera varia	+	–	–	–
45	*Baetis* sp. Leach, 1815	–	–	+	–
46	*Caenis* sp. Stephens, 1835	–	–	+	–
	Ceratopogonidae				
47	Ceratopogonidae varia	–	–	+	–
	Odonata				
48	*Leucorrhinia* sp.	–	–	+	–
	Trichoptera				
49	Trichoptera varia	+	–	–	–
50	*Oxyethira* sp.	–	–	+	–
51	*Ecnomus* sp.	–	–	+	–
	Hydracarina				
52	Hydracarina varia	+	–	+	–
	Nepomorpha				
53	Nepomorpha varia	+	–	–	–
	Hirudinea				
54	Hirudinea varia	+	–	–	–

Table 2. Taxonomic structure, abundance, and biomass of macrozoobenthos communities of Lake Munozero.

Taxon	Littoral zone				Deep-water zone			
	Abundance		Biomass		Abundance		Biomass	
	thous. ind./m^2	share, %	g/m^2	share, %	thous. ind./m	share, %	g/m^2	share, %
Chironomidae	2.01	73.63	0.39	10.74	0.00	0.00	0.00	0.00
Oligochaeta	0.12	4.40	0.11	3.03	0.06	5.26	0.00	0.15
Gastropoda	0.03	1.10	1.25	34.90	0.00	0.00	0.00	0.00
Bivalvia	0.15	5.31	0.19	5.37	0.06	5.26	0.06	2.12
Ephemeroptera	0.14	5.13	0.19	5.37	0.00	0.00	0.00	0.00
Amphipoda	0.01	0.18	0.00	0.06	1.02	89.47	2.67	97.73
Trichoptera	0.05	1.65	0.08	2.20	0.00	0.00	0.00	0.00
Ceratopogonidae	0.03	0.92	0.02	0.42	0.00	0.00	0.00	0.00
Hydracarina	0.01	0.37	0.04	1.06	0.00	0.00	0.00	0.00
Isopoda	0.17	6.23	0.80	22.35	0.00	0.00	0.00	0.00
Coleoptera	0.02	0.73	0.04	1.20	0.00	0.00	0.00	0.00
Odonata	0.01	0.18	0.03	0.78	0.00	0.00	0.00	0.00
Megaloptera	0.01	0.18	0.45	12.52	0.00	0.00	0.00	0.00
Итого	**2.73**	**100**	**3.59**	**100**	**1.14**	**100**	**2.73**	**100**

Results

In zoobenthos of Lake Munozero (2017–2022), we identified 13 taxonomic groups of invertebrates common to water bodies of Northwest Russia: oligochaetes (Oligochaeta), gastropods (Gastropoda), bivalves (Bivalvia), amphipods (Amphipoda), isopods (Isopoda), chironomids (Chironomidae), megaptera (Megaloptera), beetles (Coleoptera), mayflies (Ephemeroptera), biting midges (Ceratopogonidae), dragonflies (Odonata), caddis flies (Trichoptera), and water mites (Hydracarina) (Table 1). Water bugs and leeches discovered by Nikolsky in 1980 were not found in our hydrobiological samples.

Chironomid larvae provided the largest number of macrozoobenthos in the coastal zone, while amphipods – in the deep-water zone. In terms of abundance, bivalve mollusks, oligochaete worms, mayflies and isopods also played a significant role here.

The basis of the taxonomic diversity of the macrozoobenthos of the studied lake was made up of aquatic insect larvae. Among all groups of zoobenthos, larvae of chironomids quantitatively dominated, being widespread in the lake and distinguished by fairly high qualitative diversity (Table 1).

In the studied samples from the coastal stations, larvae of *Procladius* sp., *Micropsectra* gr. *praecox, Chironomus* sp., *Psectrocladius* sp., *Polypedilum bicrenatum*, *Cladotanytarsus* gr. *mancus* and *Zavrelia* sp. were ubiquitous, whereas *Chironominae* gr. *genuinae №3*, *Cricotopus* gr. *sylvestris*, *Limnophyes karelicus* and *Microtendipes* gr. *chloris* were rarely found.

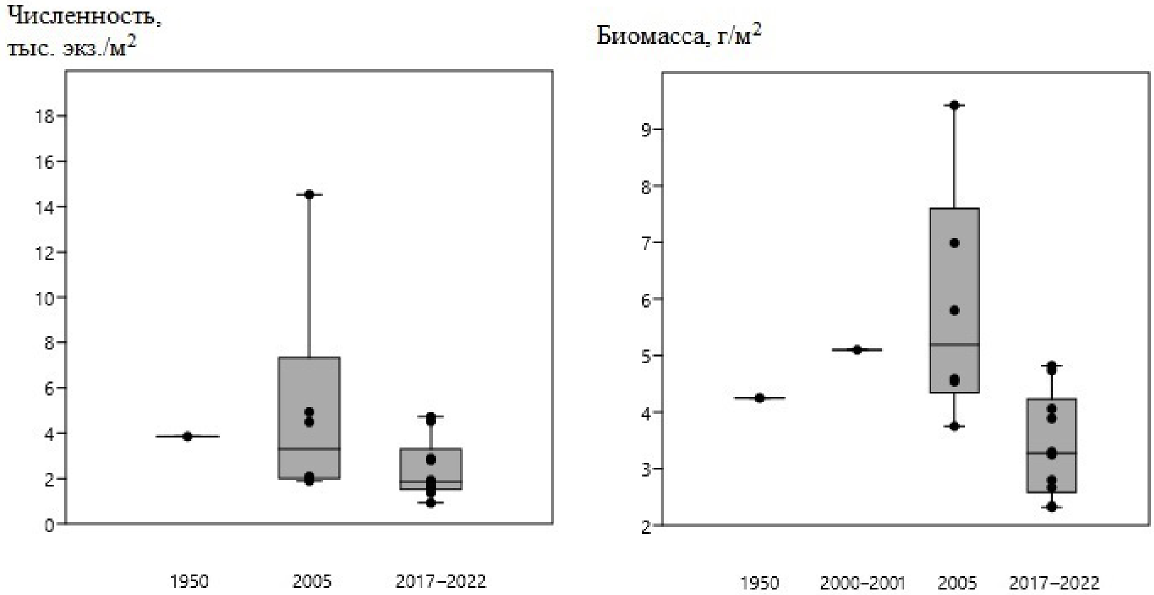

Fig. 2. Dynamics of number (thous. ind./m^2) and biomass (g/m^2) of macrozoobenthos of Lake Munozero from 1950 to 2017–2022. 1950 – according to Gordeeva-Pertseva, 1957; 2000–2001 – by Kulikova and Ryabinkin, 2008; 2005 – by Ilmast et al., 2008; 2017–2022 – own data.

The average biomass of macrozoobenthos in the coastal zone of Lake Munozero made up 3.6 g/m^2, corresponding to the mean-feed base reservoirs. In the deep-water part, the reservoir demonstrated the features of a low-feed type with the average biomass of the bottom cenosis amounting 2.7 g/m^2.

Gastropods (34.9%) and isopods (22.4%) played the major role in the formation of macrozoobenthos biomass in the coastal zone of the lake. Larvae of macropterous insects accounted for 12.5% of the total biomass, and chironomid larvae – 10.7%.

In the deep-water part of the reservoir, the highest biomass value was recorded for amphipods: 2.7 g/m^2 (98% of the total macrozoobenthos biomass) with a population of 1 thous. ind./m^2 (89.5% of the total number of macrozoobenthos) (Table 2).

Discussion

In 2000–2001, the biomass of the Munozero bottom fauna reached 5.1 g/m^2. Relict crustaceans contributed more than 50% of abundance and over 60% of the total biomass (Kulikova and Ryabinkin, 2008) (Fig. 2). In October 2005, macrozoobenthos biomass was equal to 5.8 g/m^2 at the number of 4.9 thous. ind./m^2 (Ilmast et al., 2008).

As in our studies, larvae of *Procladius* sp. were noted everywhere on silty and silty-sandy soils of the lake in 1950. *Zavrelia* sp., *Micropsectra* gr. *praecox*, *Microtendipes* gr. *chloris*, *Polypedilum* sp., *Cladotanytarsus* gr. *mancus* and *Psectocladius* sp. (Gordeeva-Pertseva, 1957) were also detected. High frequency of chironomids occurrence is associated with a long-lasting stage of their development in the aquatic environment where they spend most of their life cycle (Sokolova, 1985).

In the lake, we discovered 5 species of oligochaetes. *Spirosperma ferox* was found throughout, whereas *Tubifex tubifex*, *Limnodrilus udekemianus*, *Stylodrilus heringianus* and *Nais simplex* only in the coastal part of the lake. In 1950, oligochaetes were not identified to species.

Crustaceans were mainly represented by the relict widespread *crustaceans Monoporea affinis*, *Pallasea quadrispinosa* and *Asellus aquaticus*. In contrast to the data of L.I. Gordeeva-Pertseva (1957), the absence of *Mysis relicta* in our macrozoobenthos samples was, apparently, caused by its migration in the water column. Of gastropods, the species *Bithynia tentaculata* was detected in 50% of the specimens. Bivalves were represented by the genus *Pisidium*.

Conclusion

Biomass of macrozoobenthos in the littoral and deep-water zones of Lake Munozero made up 2.73 g/m^2 or 27.3 kg/ha and 3.6 g/m^2 or 36 kg/ha, respectively. Thus, Lake Munozero may be classified as the reservoir with a low-feed base. The average number of benthic organisms in the coastal and profundal zones reached 2.73 and 1.14 thous. ind./m^2.

During the study period, a total of 30 taxa of macrozoobenthos of different taxonomic ranks were identified in the lake. The richest and most diverse fauna of macrozoobenthos was noted in the coastal part of the reservoir. Relict crustaceans *Monoporea affinis* were extremely abundant. In other groups, bivalves and rarely encountered oligochaete worms are worth noting. The littoral zone turned out to be the richest qualitatively. With depth, the qualitative composition of the bottom population becomes more uniform, especially in the deep parts of the profundal zone.

Gastropods (34.9%) and isopods (22.4%) played the main role in the biomass formation of the coastal zone. Other groups of macrozoobenthos were inferior to them. For instance, the larvae of large-winged insects made up 12.5% of the total biomass, and chironomids larvae – 10.7%. Representatives of other groups of aquatic invertebrates, i.e. oligochaetes, beetles, mayflies, etc. made little contribution to feed base (less than 6% of benthic biomass).

As feed resources, relict crustaceans in the macrozoobenthos composition of the deep-water part of the reservoir are of great importance. Amphipods significantly dominated by biomass (98%) among all other groups of bottom communities responsible for the formation of a feed base of the ichthyofauna.

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