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Article

Current state of the Pandozero Lake ecosystem, Kivach State Nature Reserve, Karelia

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Abstract. The composition of the benthic fauna of the fish population of Pandozero Lake (Onega Lake basin), located in the Kivach State Nature Reserve, Republic of Karelia, was studied. The abundance indices of its macrozoobenthos are consistent with an oligotrophic type of water bodies, and its chironomid index value with that of a moderately contaminated water body. The lake's fish population consists of 13 species (6 families) dominated by perch, bream and roach. Valuable fish species, such as whitefish and pike-perch, also occur. Ide was found in the lake for the first time. The studies have shown that Pandozero Lake's ecosystem is now in satisfactory condition.

Keywords: lake ecosystem, phytoplankton, zooplankton, zoobenthos, ichthyofauna, protected area

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Научная статья

Современное состояние экосистемы оз. Пандозера (Государственный заповедник «Кивач», Карелия)

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Аннотация. В статье исследован состав бентофауны и рыбного населения озера Пандозера (бассейн Онежского озера), расположенного на территории Государственного природного заповедника «Кивач» (Республики Карелия). Количественные показатели макрозообентоса соответствуют олиготрофному типу водоемов, величина хирономидного индекса – умеренно-загрязненному водному объекту. Рыбное население озера представлено 13 видами рыб (6 семейств), среди которых преобладающими являются окунь, лещ и плотва. Отмечены ценные виды рыб: сиг и судак. Язь обнаружен в озере впервые. В целом проведенные исследования показали удовлетворительное состояние экосистемы оз. Пандозера на современном этапе.

Ключевые слова: озерная экосистема, фитопланктон, зоопланктон, зообентос, ихтиофауна, заповедная территория

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Introduction

The biodiversity of Northern Europe's water bodies is controlled by many factors. The main factor is human economic activity. The consecutive transformation of their hydrological, hydrochemical and hydrobiological regimes affected by growing human activity is characteristic (Dgebuadze, 2014; Ilmast et al., 2021; Kriksunov et al., 2010 et al.). To address issues related to biodiversity conservation within the framework of establishing a network of specially protected natural areas, the Kivach State Nature Reserve was created in 1931 under the Academy of Sciences of the USSR. The biggest water body in the reserve is Lake Pandozero. The lake was granted a special nature conservation status to eliminate the human factor and to obtain unique data on the native (background) features of its aquatic organisms.

The Pandozero Lake ecosystem has been poorly studied. Little is known about its hydrochemical regime and fish fauna (Ivanter, 1969; Misiyash et al., 2011; Popova and Sukhov, 2011; Shcherbakov, 1988). The purpose of the present contribution is to estimate the current hydrobiological indices (phyto- and zooplankton, macrozoobenthos) and structure of Pandozero Lake's fish population.

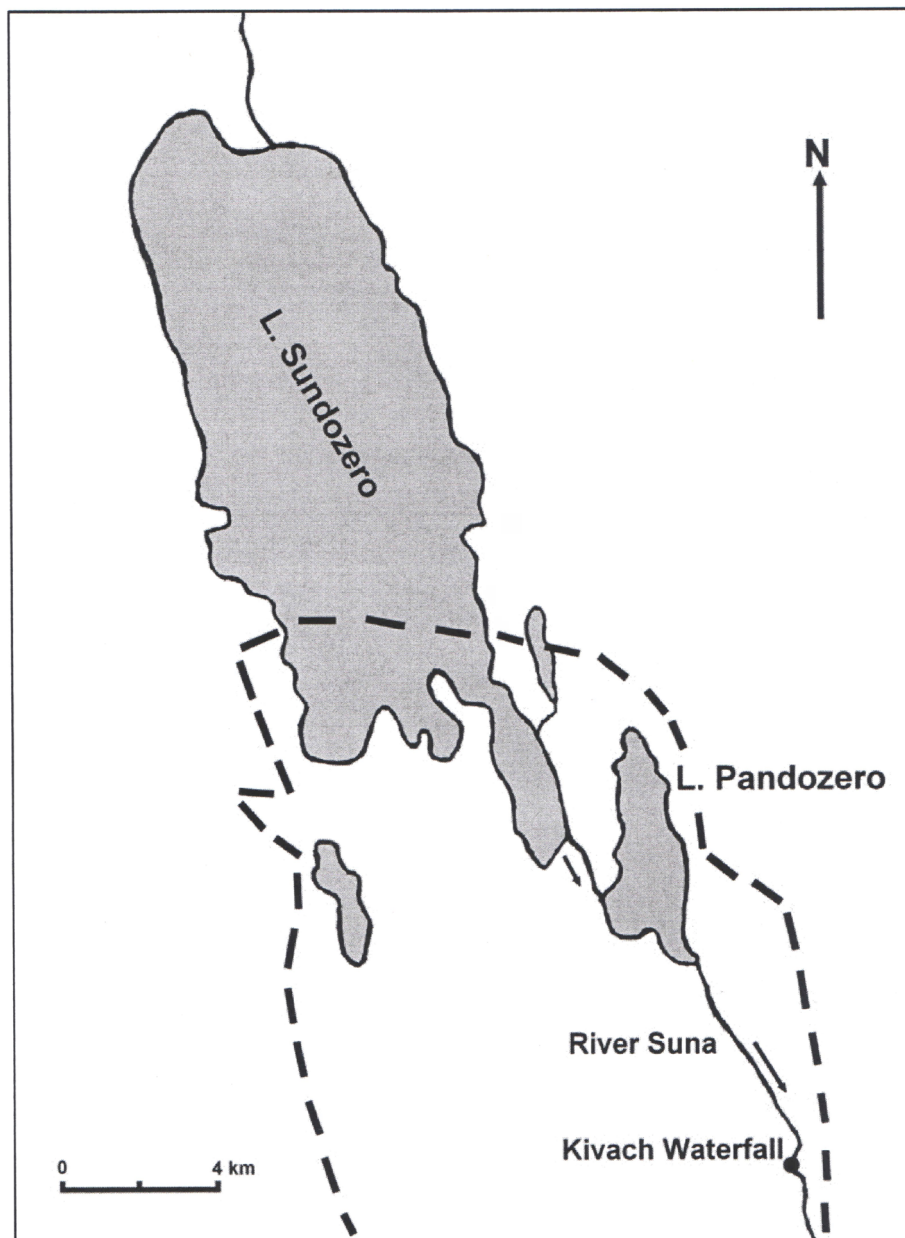


Fig. 1. Scheme of Lake Pandozero. The dotted line indicates the boundary of the Kivach Nature Reserve.

Materials and methods

Pandozero Lake, located in the Kivach Reserve, is part of the Onega Lake basin. The River Suna, one of Karelia's biggest and fullest rivers, flows across the lake. Large-scale studies on the lake were conducted in July–August 2017–2018.

Pandozero Lake is the biggest water body located entirely in the Kivach Reserve (Fig. 1). Its elongated northern area, as well as shallow bays in the southern part of the lake where large zones overgrown with higher aquatic vegetation, are fish's spawning grounds. The lake has a sandy-pebbly, muddy bottom. Its shores are slightly elevated, locally rocky, and are covered with coniferous forest (Resursy poverkhnostynk vod..., 1972).

Pandozero Lake's water is poorly mineralized, has a low colour index and near-neutral pH values (Kuchko et al., 2018). Its nutrient abundances and organic matter structure are characteristic of water bodies with low content of humus (Mosiyash et al., 2011). Allochthonous organic matter from Sundozero Lake, where a trout farm is located, flows with Suna River water into Pandozero Lake.

Samples were taken at 8 stations located in deep open (pelagic) and shallow (littoral) zones. Macrozoobenthos was sampled with a DAK-250 bottom drag; ground was washed through a 0.5 mm mesh sieve and fixed in 8% formaldehyde solution. Samples, taken at each station were replicated twice. The material was then treated in the laboratory by standard methods (Bakanov, 2000; Metodicheskie rekomendatsii..., 1984; Rukovodstvo po metodam..., 1983; Rukovodstvo po gidrobiologicheskomu..., 1992; Zhadin, 1956;). After drying on filtration paper the samples were weighed on a Techniprot torsion balance (Poland, scale factor 0.1 mg). Bottom organism species were identified using some identification guides and manuals (Brinkhurst, 1971; Opredelitel'..., 2010. 2016; Timm, 2009). The degree of organic water pollution was determined using E.V. Balushkina's index (1987).

The lake's saprobity index was calculated by Pantle–Bukk's method modified by Sladeček's method (Sladeček, 1973). The lake's trophic status was estimated using trophic scale (Kitaev, 2007).

Pandozero Lake's fish fauna was studied by analyzing net catches from various depths in the littoral and pelagic zones of the study area. Fish samples were treated by standard methods (Dgebuadze and Chernova, 2009; Mina, 1981; Pravdin, 1966; Reshetnikov, 1980). The age of all fish samples was estimated using registering structures (scale, gill covers (operculum) and otoliths), as well as the body length, body mass, standard length (SL) and fork length (FL) of whitefish (Smitt's length). In addition, the number of gill rakers on the first gill arch of each whitefish caught was estimated as a diagnostic character. A total of 54 fish of various species were collected and treated.

Results and discussion

Phytoplankton and zooplankton

The results of 2017 studies have shown that the biodiversity of the lake's phytoplankton is dominated by three systematic groups: diatomaceous, dynophytic and green algae (Kuchko et al., 2018). A total of 26 species were identified. Pandozero Lake's saprobity indices show that its water is consistent with that of α -oligosaprobic zone of quality class 2 ("clean") (Kitaev, 2007). The lake's zooplankton was also studied in detail in 2017. It was determined that its foundation is made up of widely distributed species of temperate latitudes. The abundance of the planktonic fauna indicates that the central zone of Pandozero Lake is consistent with a β -oligotrophic water body and its shallow-water littoral zone overgrown with aquatic vegetation with a β -mesotrophic water body. The Shannon's index, which shows species abundance, suggests that it is a mesotrophic lake and the lake's saprobity shows that it is a β -mesosaprobic type of lake (Kuchko et al., 2018).

Benthic fauna

The Pandozero Lake's benthic fauna has been poorly studied. The pioneer study of zoobenthic communities conducted in 2005 showed that Chironomidae larvae dominated in abundance and biomass. The relict amphipod *Monoporeia affinis* made up a large part of the biomass (Lindström, 1855). The abundance values for macrozoobenthos were generally low (Kulikova and Ryabinkin, 2008).

In 2017, the benthic fauna of Pandozero Lake consisted mainly of insect larvae (chironomids and caddis flies), oligochaetes and bivalve molluscs. The average benthos biomass in the summer season was 0.52 g/m² and its abundance was 500 individuals/m². Chironomids made up about ½ of the total biomass and over 70% of their abundance (Kuchko et al., 2018).

In 2018, the Pandozero Lake's benthic fauna was studied again. The lake's species composition, the correlation of dominant species and major benthocenotic complexes were assessed in detail. In the above study period about 20 macrozoobenthos species were identified (Table 1).

The dominant chironomid complex is formed of Tanypodinae (*Procladius* sp.) and Orthocladiinae larvae (*Psectrocladius* sp., *Psectrocladius sordidellus*, *Psectrocladius barbatipes*, *Psectrocladius psi-lopterus*). Chironominae were most commonly present as *Microtendipes pedellus* and *Tanytarsus* sp.

On trophic scale (Kitaev, 2007), Pandozero Lake is an oligotrophic water body, as indicated by the abundance of its benthic fauna. Balushkina's index shows that the lake is moderately polluted. Analysis of the data obtained showed that the lake's taxonomic composition is typical of northern water bodies in the taiga zone (Yakovlev, 2005a, b) and is formed of species widespread in most Karelia's lakes. Earlier contributions showed that the ecological conditions of the lake are responsible for the generally low abundance indices of macrozoobenthos (Kulikova and Ryabinkin, 2008).

Fish fauna

Some data on the Pandozero Lake's fish population were published earlier. 12 species were identified (Ivanter, 1969; Popova and Sukhov, 2011; Shcherbakov, 1988). During the study period 9 fish species were caught from the lake. The ide *Leuciscus idus* (Linnaeus, 1758), which did not occur earlier in the lake, was caught for the first time. Thus, in the past few years the Pandozero Lake's fish population consisted of 13 fish species of six families.

The Pandozero Lake's fish fauna forms 4 faunistic complexes (Nikolsky, 1980; Sterligova et al., 2014). It is dominated by fish characteristic of a boreal plain complex (perch *Perca fluviatilis* (Linnaeus, 1758), ruffe *Gymnocephalus cernuus* (Linnaeus, 1758), pike *Esox lucius* (Linnaeus, 1758), roach *Rutilus rutilus* (Linnaeus, 1758), dace *Leuciscus leuciscus* (Linnaeus, 1758), ide) made up 46% of the total number of species. Also present in equal amount (23% each) are two freshwater complexes: Arctic (whitefish *Coregonus lavaretus* (Linnaeus, 1758), burbot *Lota lota* (Linnaeus, 1758), vendace *Osmerus eperlanus* (Linnaeus, 1758)) and Pontic (bleak *Alburnus alburnus* (Linnaeus, 1758), bream *Abramis brama* (Linnaeus, 1758) and white bream *Blicca bjoerkna* (Linnaeus, 1758)). Pike-perch (*Sander lucioperca* (Linnaeus, 1758)), which belongs to an amphiboreal freshwater complex, made up 8%. Pandozero Lake's biomass is dominated by fish of boreal plain and pontic freshwater complexes (Fig. 2).

Perch is the most abundant species in Pandozero Lake. It is ubiquitous and is highly abundant. Like perch in most northern lakes, Pandozero perch has a long life cycle. It is represented in catches by the age groups 2+ to 16+ with a body length (SL) of 11 to 36 cm and a body mass of 19 to 1050 g (Table 2). Senior age groups of 6+ to 12+ (85%) dominated in catches, suggesting no effect of commercial fishing on the population. This is characteristic of water bodies in nature reserves and poorly accessible lakes where fishing is done on a small-scale.

Bream is abundant. It occurs in both the littoral and open lake zones. The bream caught varied in age from 4+ to 12+ and had a body length (SL) of 15.5 to 36.5 cm and a body mass of 80 to 990 g. Breams aged 4+...8+ accounted for 87% of catches, suggesting a small impact of commercial fishing.

Another common fish species in Pandozero Lake is roach. It inhabits typically near the shore heavily overgrown with macrophytes and seldom occurs in the pelagic zone. It varied in age from 4+ to 12+. Roaches aged 8+ to 10+ with a body length (SL) of 11.6 to 26.0 cm and a body mass of 28 to 315 g dominated.

Table 1. Species composition of zoobenthos of Lake Pandozero.

Taxon
CLASS OLIGOCHAETA
<i>Limnodrilus hoffmeisteri</i> (Claparede, 1862)
<i>Lumbriculus variegatus</i> (Muller, 1774)
CLASS NEMATODA
CLASS INSECTA
Order Diptera
Family Chironomidae
<i>Cryptochironomus obreptans</i> (Walker, 1856)
<i>Cladotanytarsus mancus</i> (Walker, 1856)
<i>Microtendipes pedellus</i> (De Geer, 1776)
<i>Cladopelma lateralis</i> (Goetghebuer, 1934)
<i>Cricotopus intersectus</i> (Staeger, 1839)
<i>Polypedilum pedestre</i> (Meigen, 1830)
<i>Psectrocladius psilopterus</i> (Kieffer, 1906)
<i>Psectrocladius sordidellus</i> (Zetterstedt, 1838)
<i>Psectrocladius barbatipes</i> (Kieffer, 1923)
<i>Procladius</i> sp.
<i>Tanytarsus</i> sp.
Family Ceratopogonidae
<i>Bezzia</i> sp.
Order Ephemeroptera
<i>Ephemera vulgata</i> (Linnaeus, 1758)
<i>Baetis</i> sp.
<i>Caenis rivulorum</i> (Eaton, 1884)
Order Trichoptera
<i>Cyrnus trimaculatus</i> (Curtis, 1834)
<i>Ecnomus tenellus</i> (Rambur, 1842)
CLASS HIRUDINEA
<i>Glossiphonia complanata</i> (Linnaeus, 1758)
CLASS BIVALVIA

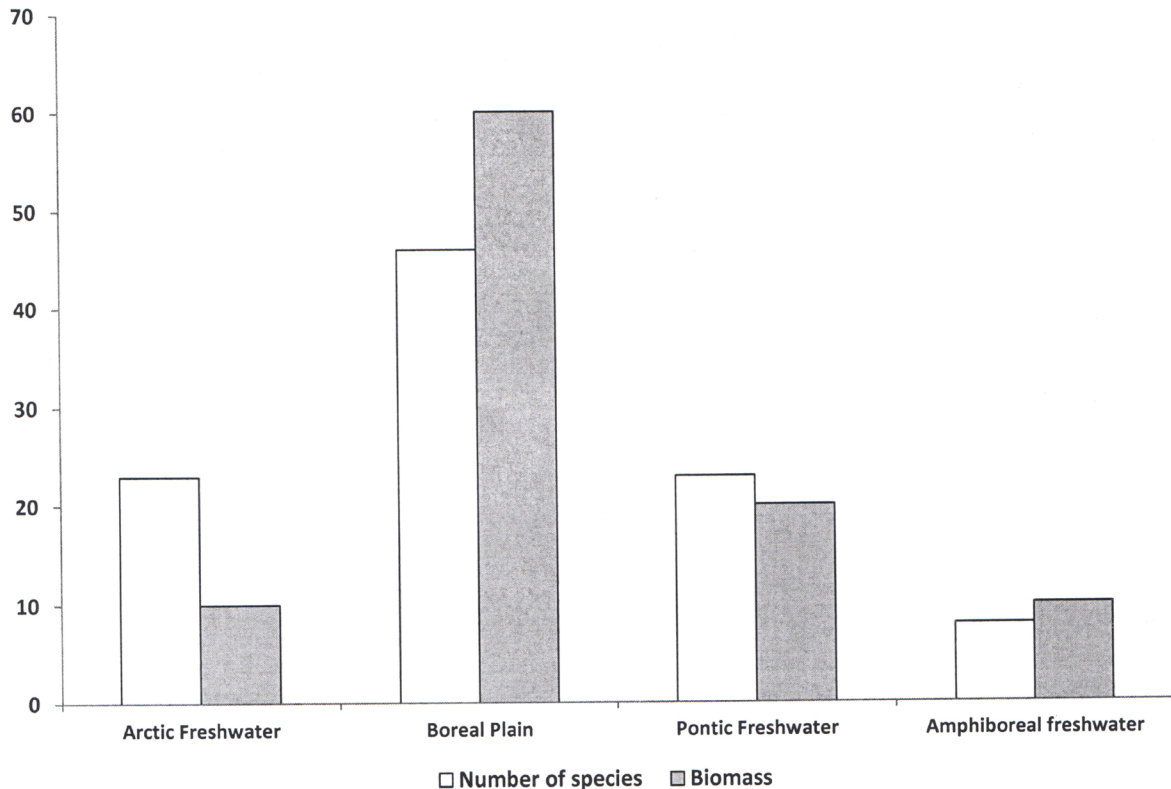


Fig. 2. Percentage ratio of fish of different faunistic complexes of Lake Pandozero.

Pike inhabits throughout the entire lake. A pike aged 3+ to 10+ years with a body length (SL) of 32.0–68.0 cm and a body mass of 260–2500 g was caught. The data published show that pikes in Pandozero Lake may have a body mass of 10 kg. However, it is not the limit: some people saw a pike with a body mass of 15 kg caught in the summer of 1988 (Popova and Sukhov, 2011).

Pandozero white bream is not abundant. It occurs at a shallow depth in the highly overgrown littoral zone. White breams aged 6+ to 11+ years with a body length (SL) of 15.0–22.0 cm and a body mass of 40–140 g were caught.

Pandozero whitefish is not abundant. It inhabits in the open zone of the lake with a sandy-pebbly bottom and in rocky shallows. Whitefish aged 2+...6+ had a body length (FL) of 22 to 35 cm and a body mass of 105 to 400 g. Pandozero whitefish is a medium-rakered form, as indicated by the number of its rakers (29–33) (Reshetnikov, 1980).

Pandozero pike-perch invaded the River Suna from Sundozero Lake, where fish management was done in 1965–1970. To increase the biodiversity of the fish population, 6.8 million pike perches of different ages were released into Sundozero Lake (Popova and Sukhov, 2011). As a result of the introduction, pike-perch has become common in both lakes. In experimental catches, pike-perch has an age of 4+...9+, a body length (SL) of 25.6–48.0 cm and a body mass of 220–1500 g.

Pandozero ruffe is not abundant. It populates mainly in the central deep-water zone and is scarce in shallows. It prefers a sandy or rocky-sandy bottom without abundant aquatic vegetation. Two ruffes aged 5+ and 6+ with a body length (SL) of 8.2 and 9.0 cm and a body mass of 7 and 12 g were only caught.

Pandozero ide is represented by the only individual caught for the first time. It had an age of 6+ a body length (SL) of 24 cm and a body mass of 310 g.

Table 2. Linear-weight growth of fish in Lake Pandozero. Numerator – fish length (cm), denominator – mass (g).

Age of fish, years										
2+	3+	4+	5+	6+	7+	8+	9+	10+	11+	12+
Perch (220 ind.)										
–	$\frac{11.0}{19}$	$\frac{16.0}{58}$	$\frac{18.2}{88}$	$\frac{20.4}{140}$	$\frac{22.8}{200}$	$\frac{25.0}{253}$	$\frac{27.8}{340}$	$\frac{28.3}{390}$	$\frac{29.0}{458}$	$\frac{30.4}{540}$
Bream (170 ind.)										
–	–	$\frac{15.5}{80}$	$\frac{17.6}{120}$	$\frac{21.0}{200}$	$\frac{23.7}{280}$	$\frac{27.0}{440}$	$\frac{29.5}{600}$	$\frac{33.0}{770}$	$\frac{34.5}{830}$	$\frac{36.5}{990}$
Roach (70 ind.)										
–	–	$\frac{11.6}{28}$	$\frac{12.3}{35}$	$\frac{14.7}{54}$	$\frac{16.8}{80}$	$\frac{17.8}{100}$	$\frac{21.0}{144}$	$\frac{22.0}{172}$	$\frac{23.3}{205}$	$\frac{26.0}{315}$
White bream (30 ind.)										
–	–	–	–	$\frac{15.0}{40}$	$\frac{16.5}{60}$	$\frac{17.5}{75}$	$\frac{18.0}{90}$	$\frac{20.0}{110}$	$\frac{22.0}{140}$	–
Pike (28 ind.)										
–	$\frac{32.0}{260}$	$\frac{38.5}{520}$	$\frac{44.0}{760}$	$\frac{51.0}{1100}$	$\frac{55.4}{1645}$	$\frac{58.2}{1800}$	$\frac{62.5}{2200}$	$\frac{67.3}{2500}$	–	–
Pike-perch (18 ind.)										
–	–	$\frac{25.6}{220}$	$\frac{28.5}{290}$	$\frac{34.5}{500}$	$\frac{40.0}{790}$	$\frac{41.5}{1045}$	$\frac{43.5}{1300}$	$\frac{48.0}{1500}$	–	–
Whitefish (7 ind.)										
$\frac{22.0}{105}$	$\frac{26.3}{182}$	$\frac{27.8}{240}$	–	$\frac{35.0}{400}$	–	–	–	–	–	–

Conclusions

Analysis of phytoplankton-indicating species in Pandozero Lake has shown that its water is consistent with quality class 2, indicating α -oligosaprobic zone. The abundance indices for the zooplankton in the open zone of the lake were indicative of β -oligotrophic type of water and those for the littoral zone β -mesotrophic type of water. Pandozero Lake corresponded in the abundance of zoobenthos to oligotrophic water bodies and in Balushkina's index to moderately polluted water bodies.

Pandozero Lake's fish fauna consists of 13 fish species of 6 families. Perch, bream and roach are the most abundant species. Pandozero ide was caught for the first time. Whitefish and pike-perch, introduced into the Suna River system, are valuable species.

The above studies have shown that Pandozero Lake is now in satisfactory condition. As the lake is in the nature reserve and has a source of organic pollution (fish farm), it is recommended to launch permanent hydrobiological monitoring on the lake for a better understanding of possible successions in the aquatic protected ecosystems.

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