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Article

The Lake Pizanets (Republic of Karelia, Russia) – a new site for establishing the protected area

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Abstract. A survey of the morphological and hydrological characteristics of the lake and analysis of the species composition, abundance, and biomass of phytoplankton, phytoperiphyton, zooplankton, and zoobenthos were carried out as a part of the complex study for establishing a new protected area “Lake Pizanets”. The effect of natural and anthropogenic factors on the hydrochemical regime and structure of aquatic ecosystems of the lake was assessed. The trophic status of the lake, its saprobity, and the significance of particular communities and bioindication indices were estimated. The species composition and dominant species of the studied communities of the lake were quite typical for freshwater bodies of the region. Despite the fact that the abundance and biomass of macrozoobenthos turned out to be lower than in other lakes of Eastern Fennoscandia, generally, the abundance and biomass of phytoplankton, phytoperiphyton, zooplankton, and zoobenthos evidenced on relatively high degree of their development in the lake Pizanets, as well as on their activity and stability. At the same time, the species, forming the communities, differed in size noticeably; therefore, significant discrepancies were found between the lists of taxa dominating by abundance and by biomass. The biotic indices and hydrochemical indicators indicated mainly a low degree of pollution, so the lake waters could be classified as belonging to water purity class II. Nowadays, the lake is not affected by significant anthropogenic load. However, according to the program of establishing new protected areas, further control of the hydrobiological and hydrochemical indicators of the reservoir, as well as its inclusion in the environmental monitoring program is undoubtful.

Keywords: ecological state, abiotic characteristics, biotic components, biodiversity.

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Introduction

The Republic of Karelia has a well-developed hydrographic network belonging to the basins of the White and Baltic seas. More than 60 thousand lakes located on the territory of the republic, most of them are picturesque and have great scientific and recreational value. Lakes of tectonic origin look especially attractive. These include the Lake Pisanets, which in recent years has been actively visited by tourists. However, hydrochemical and hydrobiological studies have never been carried out here, there is no ongoing protection program for the lake, and no data exist in the scientific literature (Lakes of Karelia, 2013).

Human activities have seriously affected the state of the local water bodies. Habitat loss is observed due to the changes in hydrological regime, water withdrawal, and pollution. In addition, the populations of freshwater species are often at a higher risk of extinction than the inhabitants of terrestrial ecosystems. At present, the protection of valuable water bodies in the Republic of Karelia is carried out within the framework of integrated protected areas (Nauchnoe obosnovanie..., 2009). However, the number of water bodies and watercourses within the existing protected areas is clearly insufficient, especially considering the abundance of water bodies on the territory of the republic and the importance of conservation not just water as a resource, but the entire aquatic environment as a habitat for different organisms (Revenga et al., 2005).

Based on the results of research work, the scientific grounds were given for establishing a new, 3-cluster protected area (PA; suggested names are indicated):

No. 1 – a landscape reserve of regional significance “Lake-low-mountain complexes of central Karelia”;

No. 2 – a landscape natural monument of regional significance “Lake Pizanets”;

No. 3 – a landscape natural monument of regional significance “Mount Vottovaara”.

The total area of these sites is 13982.3 hectares. The distance between the centers of clusters no. 1 and no. 2 is 55.2 km, clusters nos. 2 and 3, 22.9 km, and clusters nos. 3 and 1, 53.4 km. This protected area will be the first cluster object created in the territory of the Republic of Karelia.

The concept of ecological monitoring, including that of the protected areas, includes an analysis of the state of the water bodies (Bayanov, 2013; Semenchenko and Razlutsky, 2011). The latter are the accumulating systems that serve as a source of information on the changes in the entire catchment area. The species composition and quantitative characteristics of communities of aquatic organisms are applied in various methods of bioindication of aquatic ecosystems and are the starting point in the development of ecological typification of the water bodies. The availability of regular information on the long-term dynamics of communities of aquatic organisms makes it possible to assess the ecological state of monitored water bodies.

The study aims to assess the current hydrochemical and hydrobiological state of the Lake Pizanets, to identify the patterns of the formation of the lake ecosystems, and thus to obtain background data for their subsequent use for organizing monitoring and including the lake into a newly establishing PA.

Materials and methods

The Lake Pizanets is located in the Medvezhyegorsk District of the Republic of Karelia. The coordinates of the geographical center are N 63°12,868′, E 32°57,911′; the altitude is 178 m (Baltic Normal Height System 1977). The lake belongs to the White Sea basin and is located in the upper (southwestern) part of the catchment area of the Vyg River (White Sea-Baltic Canal) (Fig. 1C) within the catchment of the Luzhma River, which is a tributary of the Lake Segozero (Segozero Reservoir).

Morphological and hydrological survey of the lake has been carried out in August 2020. The lake fills the tectonic fault basin, oriented NNW. According to our data, the area of the lake does not exceed 0.825 km^2, the length is 5.7 km, the maximum width, 370 m, the average width, 145 m, and the coefficient of elongation exceeds 39. The bottom relief is complex; in the northern and southern parts of the lake, the depths reach 30–40 m, the maximum depths (up to 70 m) locates in the central part of the lake. The littoral zone is practically absent. The lake is connected by a channel (possibly of artificial origin) with a nameless stream, and then, through a system of lakes (Kalg’yarvi, Kyatkiozero, Kerdano, Tumasozero, and Unutozero), with the Songo River, Lake Songo, and Lake Seletskoe, from which the Luzhma River flows.

Geomorphologically, the area of the Lake Pizanets belongs to the southeastern part of the West-Karelian Upland, to the junction zone of the central and eastern chains of ridges. According to the geomorphological map given in the “Atlas of the Karelian ASSR” (1989), the relief here is characterized as a denudation-tectonic ridge-hilly and hilly (150–300 m) with pronounced faults on the Precambrian crystalline rocks. According to the map of Quaternary deposits (Atlas..., 1989), glacial Quaternary deposits (gIII-IVos) are widespread on the northwest coast, and pre-Quaternary rocks, on the southeast coast.

The lake shores are covered with forest, they are partly swampy (swampiness of the territory is 6–7%), and there are no settlements nearby. The shores of the northern part of the Lake Pizanets are low; in the south, they are high; here, rocks up to 50–60-m high hang over the water. Traces of palaeoseismic dislocations are observed in the central and southern

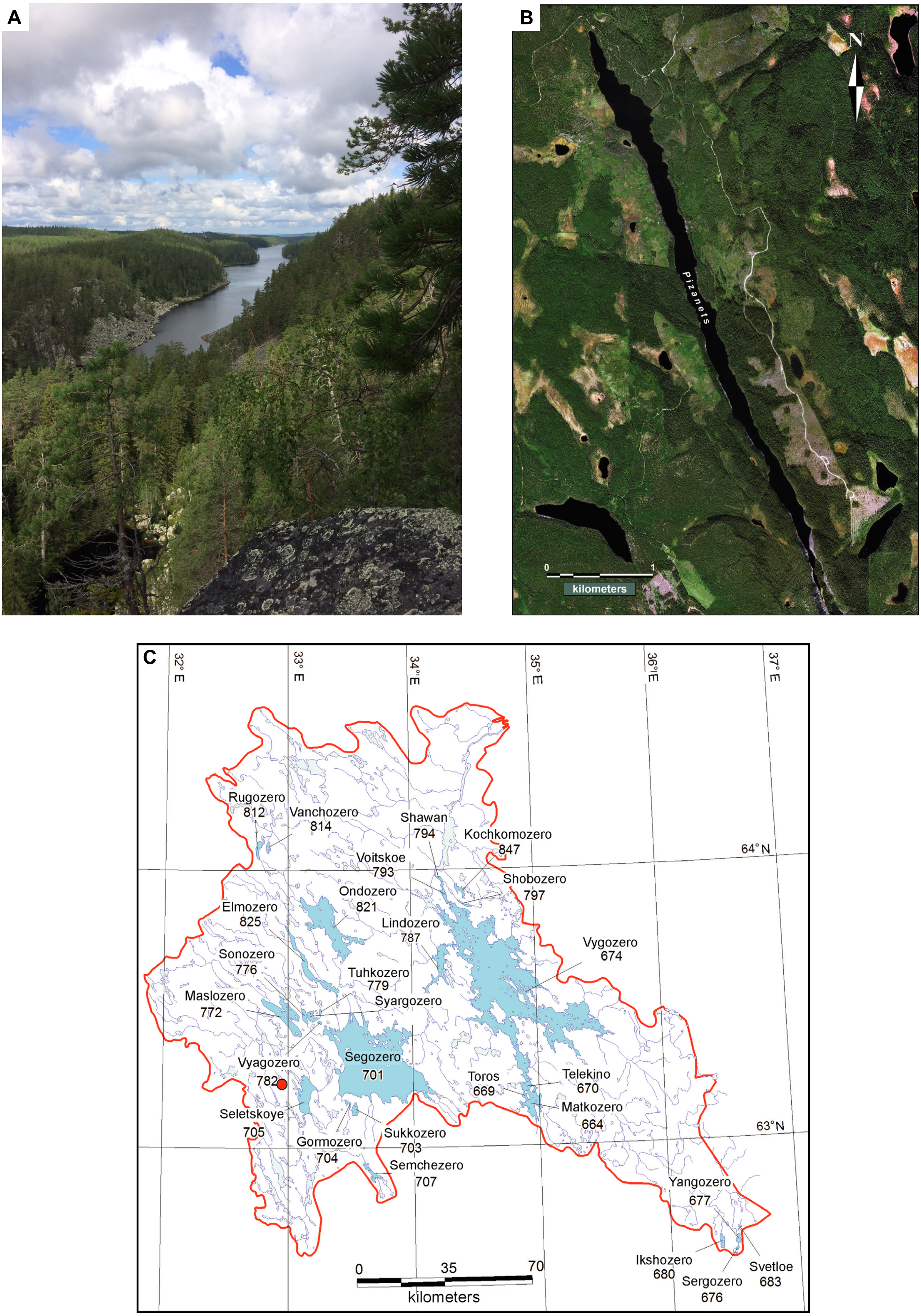

Fig. 1. The Lake Pizanets and the basin of the White Sea-Baltic Canal (the Vyg River) (Lakes of Karelia, 2013). **A** – lake appearance, **B** – schematic map of the lake, **C** – schematic map of drainage basin. The location of the Lake Pizanets is marked with a red dot.

parts. Seismic gravity falls up to 150-m wide cover the sediments of the fluvioglacial delta and lake, indicating postglacial formation (Lukashov, 2004). The radiocarbon dating of the formation of the overlying sapropels dates back to 8500 ± 150 years (sample no. TA-1742) and refers to the preboreal-boreal boundary (Prorodnyi kompleks..., 2009).

Sampling for biological analysis was performed on August 2–3, 2020 according to the standard methods (Guidelines..., 1983; Komulaynen, 2003; Komulaynen et al., 1989). Three sites located in the northern, southern, and central parts of the lake were studied to reveal the role of biotopic heterogeneity, to obtain additional data on the taxonomic structure of aquatic communities, and to assess the level of anthropogenic load. At each site, samples were taken in the pelagic zone and the coastal zone. Samples of phyto- and zooplankton were taken in the surface water layer (0–2 m); phytoperiphyton, from macrophytes, wood, and stones; zoobenthos, from sandy and silty sediments and in the detritus accumulations. When analyzing samples of phytoplankton, phytoperiphyton, zooplankton, and zoobenthos, the species composition, abundance and biomass of organisms were determined; dominant species were set if the abundance or biomass exceeded 10% of the total.

Algae and invertebrates were identified using an Olympus CX41 microscope equipped with an Espa digital camera (D30-D3Cplus).

For algae identification several taxonomic keys were used:

Cyanophyta: Komárek & Fott (1983), Komárek & Anagnostidis (1998, 2005), Komárek (2013);

Bacillariophyta: Krammer & Lange-Bertalot (1986, 1988, 1991a, b);

Chrysophyta: Starmach (1985);

Dinophyta: Kiselev (1954);

Chlorophyta: Kosinskaya (1952, 1960), Palamar'-Mordvintseva (1982, 1984), Moshkova and Gollerbakh (1986), Rundina (1998);

Rhodophyta: Eloranta & Kwandrans (2007);

Euglenophyta: Popova (1955).

The taxonomy of algae is given according to the scheme suggested in the series "Süsswasserflora von Mitteleuropa" with modern modifications in species names. The ecological characteristics of algae is given according to S.S. Barinova et al. (2006).

The zooplankton and zoobenthos species were identified in accordance to recent taxonomic keys (Opredelitel'..., 2010, 2016).

The chemical composition of water was analyzed, including pH, electrical conductivity, ion composition, and concentration of biogenic elements, BE (P_{min}, P_{tot}, NH^{4+}, NO^{2-}, NO^{3-}, and N_{tot}), Fe_{tot} and Mn, as well as indirect indicators of the content of organic matter, OM (chromaticity, CW; permanganate index, PO; and chemical oxygen demand, COD). A 2-L water sample for chemical analysis was taken from the surface in the central part of the lake. The hydrochemical analysis was carried out in the Laboratory of Hydrochemistry and Hydrogeology of the Institute of Water Problems of the North, Karelian Research Center of the Russian Academy of Sciences, according to standard up-to-date methods (Analyticheskie..., 2017). The water quality was assessed in accordance with environmental regulations[1]. The Pantle – Buck index modified by Sládeček was calculated to assess the water quality by the composition of indicator species (Pantle and Buck, 1955; Sládeček, 1973); in addition, the TDI diatom index was applied for phytoplankton and phytoperiphyton (Kelly and Whitton, 1995); for zoobenthos, these were Goodnight-Whitley index (GW), Biologique Global Normalize index (BMWP), Average Score Per Taxon index (ASPT), Family Biotic index (FBI), and Indece Biologique Global Normalize (IBGN) (Osnovy Geoekologii..., 2004; Vvedenie v monitoring..., 2019). Additionally, the concentration of heavy metals in water, silt, and periphyton algae was determined by atomic absorption spectrometry (AA-7000 Shimadzu spectrophotometer, Japan) with flame atomization[2].

Results and discussion

Waters of the Lake Pizanets are slightly mineralized (Σ_{ion} = 8.5 mg/L), belong to hydrocarbonate class, calcium group (Alekin, 1970); ionic composition may be expressed as follows:

$$\Sigma_{cation} = 0.14\ \text{mmol-ekv/L} \quad \frac{Ca^{2+}(43)\ Na^{+}(31)\ Mg^{2+}(18)\ K^{+}(9)}{HCO_3^{-}(38)\ SO_4^{2-}(24) A_{org}(21)\ Cl^{-}(14)}$$

According to the pH = 6.1, the waters are slightly acidic. The P_{tot} concentration is 16 μg/L; therefore, the lake is mesotrophic according to the classification suggested by P.A. Lozovik (2013). Distribution of nitrogen forms in the Lake Pizanets is similar to that in the surface waters of the Republic of Karelia (Table 1).

The chromaticity of water (CW) in the lake is high, 65 points by Pt-Co scale; COD is 23.5 mgO/L, permanganate index (PO), 10.0 mgO/L.

The humus content of water (*Hum*) was calculated using the equation (Lozovik, 2006):

$$Hum = \sqrt{\mathrm{CW} \cdot \mathrm{PO}}$$

Hum is 15 units; therefore, the Lake Pizanets is mesohumic according to the classification by P.A. Lozovik (2013).

An increased concentration of Fe_{tot} (0.18 mg/L) is observed; this value exceeds the maximum permis-

[1] GOST 17.1.3.07-82. Protection of Nature. Hydrosphere. Water quality control rules for reservoirs and watercourses. Approved and put into effect by the Decree of the USSR State Committee for Standards on March 19, 1982 No. 1115; effective from 01.01.1983.

[2] Standard SFS 5075, 1990. Water analysis. Metal content of biological material determined by atomic absorption spectrometry. Digestion.

Table 1. Distribution of nitrogen forms in the Lake Pizanets.

Anion/Cation	NH_4^+	NO_2^-	NO_3^-	N_{opr}
Concentration of nitrogen, mg N/L	0.08	<0.001	0.01	0.25

sible concentration for fishery reservoirs (0.1 mg/L)[3]. This is a geochemical feature of the waters in the region, but not an indicator of their pollution (Lozovik, 2006). The P_{min} and Mn concentrations were below the detection limit.

In the phytoplankton of Lake Pisanets, 38 species of algae belonging to seven divisions have been identified (Cyanophyta – 4, Cryptophyta – 1, Ochrophyta – 23, Chlorophyta – 7, Dinophyta – 1, Euglenophyta – 2); in addition, eight more forms were identified only down to the genus level (see the taxonomic list below).

List of phytoplankton taxa of Lake Pisanets

ORDER CYANOPHYTA

Class Cyanophyceae: *Aphanocapsa grevillei* (Berkeley) Rabenhorst, *Coelosphaerium dubium* Grunow, *Merismopedia tenuissima* Lemmermann, *Microcystis viridis* (A. Braun) Lemmermann, *Anabaena* sp., *Lyngbya* sp.

ORDER CRYPTOPHYTA

Class Cryptophyceae: *Cryptomonas ovata* Ehrenberg

ORDER OCHROPHYTA

Class Raphidophyceae: *Gonyostomum semen* (Ehrenberg) Diesing

Class Chrysophyceae: *Dinobryon divergens* O.E. Imhof, *Dinobryon sociale* (Ehrenberg) Ehrenberg, *Dinobryon suecicum* Lemmermann, *Kephyrion baciliforme* Conrad, *Kephyrion* sp.

Class Bacillariophyceae: *Cyclotella stelligera* Cleve et Grunow, *Cyclotella radiosa* (Grunow) Lemmermann, *Aulacoseira alpigena* (Grunow) Krammer, *Aulacoseira distans* (Ehrenberg) Simonsen, *A. islandica* (O. Müller) Simonsen, *A. italica* (Ehrenberg) Simonsen, *Meridion circulare* (Greville) Agardh, *Asterionella formosa* Hassall, *Tabellaria fenestrata* (Lyngbye) Kützing, *T. flocculosa* (Roth) Kützing, *Eunotia praerupta* Ehrenberg, *Diploneis elliptica* (Kützing) Cleve, *Navicula cuspidata* (Kützing) Kützing, *Stauroneis anceps* Ehrenberg, *Frustulia rhomboides* (Ehrenberg) De Toni, *Gomphonema gracile* Ehrenberg, *Pinnularia interrupta* W. Smith, *Pinnularia* sp., *Nitzschia* sp., *Epithemia adnata* (Kützing) Brébisson

ORDER DINOPHYTA

Class Dinophyceae: *Peridinium cinctum* (O.F. Müller) Ehrenberg

ORDER CHLOROPHYTA

Class Trebouxiophyceae: *Actinastrum hantzschii* Lagerh.

Class Chlorophyceae: *Scenedesmus ecornis* (Ehrenberg) Chodat, *Ankyra lanceolata* (Korschikov) Fott, *Monoraphidium contortum* (Thuret) Komárková-Legnerová, *Monoraphidium* sp., *Chlamydomonas* sp., *Gonium pectorale* O.F. Müller

Class Conjugatophyceae: *Mougeotia* sp., *Closterium acutum* Brébisson, *Staurodesmus incus* (Hassal ex Ralfs) Teiling

ORDER EUGLENOPHYTA

Class Euglenophyceae: *Euglena ehrenbergii* G.A. Klebs, *Trachelomonas volvocina* (Ehrenberg) Ehrenberg

The identified plankton algal flora is characterized by significant asymmetry at the order level. Order Ochrophyta, which includes 21 species belonging to three classes, dominates by species richness. Class Bacillariophyceae (67.7%) has a leading role, which is typical for the phytoplankton structure of freshwater systems in the Republic of Karelia (Genkal et al., 2015).

Diatoms also dominate in the samples by biomass (82%); blue-green algae (47%) and diatoms (39%) algae, by abundance. The dominant complex includes *Aulacoseira alpigena, Aulacoseira islandica, Aulacoseira distans, Tabellaria fenestrata, Aphanocapsa clathrata,* and *Merismopedia tenuissima*. The species composition of green algae is quite diverse. Chlorococcales (*Scenedesmus ecornis, Monoraphidium contortum*) and Desmidiales (*Staurodesmus incus*) algae are constantly found, but they do not make a significant contribution to the total abundance and biomass. The class Raphidophyceae (*Gonyostomum semen*), as well as the orders Dynophyta (*Peridinium cinctum*) and Cryptophyta (*Cryptomonas ovata*) are poorly represented (Table 2).

In the phytoperiphyton of the lake, 51 species were identified: Cyanophyta – 6 (12%), Ochrophyta – 39 (76%), Chlorophyta – 5 (10%), Euglenophyta – 1 (2%). In addition, the total number of taxa includes filamentous algae in the sterile stage and those identified dow to the genus level: *Spirogyra* sp. ster., *Mougeotia* sp. ster., *Zygnema* sp. ster. и *Oedogonium* sp. ster. (see the taxonomic list below).

[3] Water quality standards for fishery water bodies, including standards for maximum permissible concentrations of harmful substances in the waters of fishery water bodies. Appendix to the Order of the Ministry of Agriculture of the Russian Federation of December 13, 2016, No. 552.

Table 2. Dominant phytoplankton species and chlorophyll concentration in the Lake Pizanets. N – abundance, B – biomass.

N, 10^4 cells/L	Dominant species, by abundance (N > 10%)	B, mg/m^3	Dominant species, by biomass (B > 10%)	Chlorophyll *a*, mgO$_2$/m^3
3.2–4.5	*Aulacoseira alpigena* *Aulacoseira distans* *Aulacoseira islandica* *Aphanocapsa grevillei* *Merismopedia tenuissima*	0.3–0.6	*Aulacoseira distans* *Aulacoseira islandica* *Tabellaria fenestrata*	1.1–1.4

List of phytoperiphyton taxa of Lake Pizanets

ORDER CYANOPHYTA

Class Cyanophyceae: *Merismopedia elegans* A. Braun, *Snowella lacustris* (Ghodat) Komarek et Hindák, *Tolypothrix tenuis* Kützing ex Bornet et Flahault, *Dolichospermum flos-aquae* Brébisson (ex Bornet et Flahault) Waecklin et al., *Planktothrix agardhii* (Gomont) Anagnostidis et Komárek, *Oscillatoria limosa* Agardh ex Gomont

ORDER OCHROPHYTA

Class Bacillariophyceae: *Aulacoseira distans* (Ehrenberg) Simonsen, *A. islandica* (O. Müller) Simonsen, *A. italica* (Ehrenberg) Simonsen, *Tabellaria fenestrata* (Lyngbye) Kützing, *T. flocculosa* (Roth) Kützing, *Fragilaria arcus* (Ehrenberg) Cleve, *F. capucina* Desmazieres, *F. crotonensis* Kitton, *F. ulna* (Nitzsch) Lange-Bertalot, *Eunotia monodon* Ehrenberg, *E. pectinalis* (Kützing) Ehrenberg, *E. serra* var. *diadema* (Ehrenberg) Patrick, *E. sudetica* O. Müller, *Achnanthes minutissima* Kützing, *Navicula cryptocephala* Kützing, *N. rhynchocephala* Kützing, *Stauroneis anceps* Ehrenberg, *Frustulia rhomboides* (Ehrenberg) De Toni, *Cymbella cessatii* (Rabenhorst) Grunow, *C. minuta* Hilse, *C. naviculiformis* (Auerswald) Cleve, *C. silesiaca* Bleisch, *Gomphonema acuminatum* Ehrenberg, *G. gracile* Ehrenberg, *G. olivaceum* (Hornemann) Brébisson, *G. truncatum* Ehrenberg, *Pinnularia divergens* W. Smith, *P. interrupta* W. Smith, *P. major* (Kützing) Rabenhorst, *P. microstauron* (Ehrenberg) Cleve, *P. nobilis* (Ehrenberg) Ehrenberg, *P. stomatophora* (Grunow) Cleve, *P. viridis* (Nitzsch.) Ehrenberg, *Nitzschia linearis* (Agardh) W. Smith, *Surirella bifrons* Ehrenberg, *S. linearis* W. Smith, *S. splendida* (Ehrenberg) Kützing, *Stenopterobia anceps* (Lewis) Brébisson ex Van Heurck, *S. curvata* (W. Smith) Krammer

ORDER CHLOROPHYTA

Class Chlorophyceae: *Oedogonium* sp.

Class Conjugatophyceae: *Spirogyra* sp., *Zygnema* sp., *Mougeotia* sp., *Closterium juncidum* Ralfs, *Closterium gracile* Brébisson, *Closterium navicula* (Brébisson) Lütkemüller, *Tetmemorus laevis* (Kützing), Netr*ium digitus* (Brébisson ex Ralfs) Itzigsohn et Rothe

ORDER EUGLENOPHYTA

Class Euglenophyceae: *Trachelomonas volvocina* (Ehrenberg) Ehrenberg

In fact, ten taxa made the basis of the periphyton community (Table 3), they dominated in the algae communities and were constantly found in different proportions at the studied sites. These species are widespread in the oligotrophic lakes of Karelia (Komulaynen et al., 2006). Their presence and dominance emphasizes that the taxonomic structure of phytoperiphyton is primarily preconditioned by the geographic location of the water body and the chemical composition of the water.

The biomass of phytoperiphyton in lakes is formed primarily by filamentous species: *Oedogonium* sp., *Mougeotia* sp., and *Zygnema* sp. Their ability to form clusters on and above the substrate, which increases the area available for the secondary epiflora, plays a great ecologic role (Komulaynen, 2008). The impact of blue-green algae (Cyanophyta / Cyanoprokaryota) in the fouling algae communities is insignificant. In the periphyton of the Lake Pisanets, only six species of this taxon have been identified, and only *Oscillatoria limosa* dominated in the periphyton communities in shallow water in the northern part of the lake.

In the zooplankton communities of the lake, 11 invertebrate species have been identified down to a species level: in particular, 2 rotifer species, 5 cladoceran species, and 4 copepod species; one of the latter have been identified down to the genus level. Crustaceans dominated by species richness. The highest zooplankton abundance and biomass were registered in the central part of the lake, where cladocerans dominated by abundance (61.5%) and biomass (more than 98%) (see the taxonomic list below).

List of zooplankton taxa of Lake Pisanets

Rotifera: *Ascomopha ovalis* (Bergendal, 1892), *Kellicottia longispina* (Kellicott, 1879)

Cladocera: *Ceriodaphnia* cf. *dubia* Richard, 1894, *Ceriodaphnia guadrangula* (O.F. Müller, 1785), *Scapholeberis mucronata* (O.F. Müller, 1776), *Bosmina (Eubosmina)* cf. *coregoni* Baird, 1857, *Polyphemus pediculus* (Linaeus, 1761)

Table 3. Dominant phytoperiphyton species in the Lake Pizanets. N – abundance, B – biomass.

N, 10^4 cells/cm^2	Dominant species, by abundance (N > 10%)	B, µg/cm^2	Dominant species, by biomass (B > 10%)
0.8–3.6	*Oscillatoria limosa* *Aulacoseira islandica* *Tabellaria fenestrata* *Tabellaria flocculosa* *Fragilaria arcus* *Achnanthes minutissima* *Frustulia rhomboides*	18.0–49.8	*Tabellaria flocculosa* *Frustulia rhomboides* *Oedogonium* sp. *Zygnema* sp. *Mougeotia* sp.

Copepoda: *Eudiaptomus* sp., *Thermocyclops oithonoides* (Sars, 1863), *Mesocyclops leuckarti* (Jurine, 1820), *Megacyclops viridis* (Jurine, 1820)

The zooplankton species, dominating by abundance and biomass at particular sites, were represented by three species only (Table 4).

In benthic communities, 23 invertebrate taxa have been found, 14 of which were identified down to the species level. Most taxa were amphibiotic insects at the larval stage. The species composition and the structure of the dominant species complex of benthic communities of the Lake Pizanets was similar to that in the lakes of Eastern Fennoscandia, since it included common species that usually dominated in the benthos (see the taxonomic list below).

List of zoobenthos taxa of Lake Pisanets

(L – larva; Im – imago)

Oligochaeta: *Lumbriculus variegatus* (Müller, 1774), *Spirosperma ferox* Eisen, 1879

Hirudinea: *Erpobdella* sp.

Bivalvia: *Euglesa* sp.

Gastropoda: *Gyraulus* sp.

Trichoptera: *Limnephilus* sp. (L), *Molanna* sp. (L), *Stenophylax sequax* (McLachlan, 1875) (L)

Coleoptera: *Hydroporus* sp. (L), *Hygrotus quinquelineatus* (Zetterstedt, 1828) (Im), *Ilybius fenestratus* (Fabricius, 1781) (L), *Oulimnius tuberculatus* (Müller, 1806) (L)

Megaloptera: *Sialis sordida* Klingstedt, 1933 (L)

Ephemeroptera: *Ephemera vulgata* Linnaeus, 1758 (L), *Habrophlebia fusca* (Curtis, 1834) (Im)

Odonata: *Paraleptophlebia cincta* (Retzius, 1783) (L), *Aeschna* sp. (L)

Diptera: *Heterotanytarsus apicalis* (Kieffer, 1921) (L), *Heterotrissocladius marcidus* (Walker, 1856) (L), *Orthocladius* sp. (L), *Paratendipes albimanus* (Meigen, 1818) (L), *Procladius* sp. (L), *Stictochironomus crassiforceps* (Kieffer, 1922) (L)

A higher species richness was observed for the zoobenthos of sandy sediments, where 17 taxa were recorded; on silty sediments, there were 8 species, and in the detritus accumulations, only 4 species. The abundance and biomass of macrozoobenthos were lower compared to other lakes of Eastern Fennoscandia (Table 5). The maximum abundance and biomass was recorded on the silted sediments.

In total, 63 indicator species of saprobity were identified in the studied communities of aquatic organisms. The most diverse were the groups of β-mesosaprobes (60.3%) and oligosaprobes (28.6% of the total number of indicator species) (Table 6).

Since β-mesosaprobes and oligosaprobes prevailed, being dominant and subdominant species, it was not surprising that the values of the indices calculated for phytoplankton, phytoperiphyton, and zoobenthos were characteristic of the β-mesosaprobic zone (Table 7). At the same time, the ASPT and FBI indices calculated for zoobenthos indicated moderate level of pollution; however, most likely, these values were a consequence of the high content of organic substances (humic acids) of natural origin in the water. Thus, the indicator aquatic species made it possible to classify the waters of the Lake Pizanets as belonging to water purity class II.

An increase in the concentration of heavy metals in a water body is also an indicator of anthropogenic impact (Komulaynen and Morozov, 2007). The concentrations of zinc, copper, and lead (Table 8) in water, silt and in the thalli of green filamentous algae (*Zygnema* sp.) were significantly lower than the values noted earlier for the water bodies of the Republic of Karelia and especially the Murmansk Oblast, subjected to intense anthropogenic impact (Komulaynen and Morozov, 2010).

Conclusions

Generally, the structure of aquatic communities is typical for boreal and subarctic cold-water oligotrophic lakes with low mineralization, which are not affected by significant anthropogenic pressure. High stability of the structure of the dominant complex, taxonomic homogeneity of groups of organisms, as well as the absence of mass development of indicator species of pollution and eutrophication are the main peculiarities of the studied ecosystems.

Table 4. Dominant zooplankton species in the Lake Pizanets. N – abundance, B – biomass.

N, ind./m^3	Dominant species, by abundance (N > 10%)	B, mg/m^3	Dominant species, by biomass (B > 10%)
590–26000	*Bosmina coregoni* *Kellicottia longispina*	42–1708	*Bosmina coregoni* *Polyphemus pediculus*

Table 5. Dominant zoobenthos species in the Lake Pizanets. N – abundance, B – biomass.

N, ind./m^2	Dominant species, by abundance (N > 10%)	B, g/m^2	Dominant species, by biomass (B > 10%)
700–1500	*Spirosperma ferox* *Euglesa* sp. *Heterotrissocladius marcidus* *Procladius* sp.	0.7–1.8	*Euglesa* sp. *Stenophylax sequax* *Hygrotus quinquelineatus*

Table 6. Saprobity indicator species in the communities of aquatic organisms of the Lake Pizanets (o – oligosaprobic species; β – betamesosaprobic species; α – alphamesosaprobic species).

Community	Saprobity indicator			Total number of species
	o	β	α	
Phytoplankton	6	12	4	22
Phytoperiphyton	6	18	1	25
Zooplankton	3	2	–	5
Zoobenthos	3	6	2	11
Total number of species	18	38	7	63
%	28.6	60.3	11.1	100.0

Table 7. The saprobity indices calculated for phytoplankton, phytoperiphyton, and zoobenthos of the Lake Pizanets.

Community	Index	Value
Phytoplankton	P&B	1.4–2.0
	TDI	2.2–2.3
Phytoperiphyton	P&B	1.0–1.3
	TDI	1.7–1.8
Zoobenthos	P&B	1.9
	GW	13
	BMWP	87
	ASPT	5.8
	FBI	5.9

Table 8. The average concentration of heavy metals in water, silt, and phytoperiphyton of the Lake Pizanets. Mean ± standard deviation (m ± SD) are given.

Element	Sample		
	Water, µg/L	Phytoperiphyton (*Zygnema* sp.), mg/kg	Silt, mg/kg
Zn	28.5 ± 6.2	27.4 ± 7.4	6.6 ± 1.1
Cu	4.4 ± 1.8	3.2 ± 2.1	3.0 ± 0.8
Pb	0.6 ± 0.3	3.7 ± 1.7	15.4 ± 2.3

There are no significant differences in the structure of communities of aquatic organisms at the studied sites. This can be explained by the small size of the reservoir, the absence of bays and a narrow littoral zone, which does not contribute to the formation of biotope diversity. Some differences in the qualitative composition and quantitative indicators of communities are preconditioned by the depth and distance from the shoreline; in addition, the sediment type is important for benthic communities, and wind mixing, for plankton.

Relatively high values of the abundance and biomass of phytoplankton, phytoperiphyton, zooplankton, and zoobenthos in the Lake Pizanets comparing to the average values for the studied region make it possible to conclude on the favorable conditions in the lake and on the stability of communities. The peculiarity of the structure of aquatic communities may be explained by the fact that they are formed by species that differ markedly in size: from several micrometers to several centimeters. Therefore, the lists of the species dominating by abundance and by biomass do not coincide.

The composition of indicator species of pollution suggests that the Lake Pizanets corresponds to clean waters (water purity class II) and are suitable for all types of water use. The results of the chemical analysis of the waters of the Lake Pisanets also confirms the absence of anthropogenic load.

The eurybiont species, characterized by wide optima of temperature, current intensity, and water salinity, are the most diverse aquatic organisms, represented by a significant number of acidophilic and halophobic forms. This group does not any rare species or taxa new for the aquatic ecosystems of the region.

Economic activities in the catchment area of the Lake Pizanets is practically absent and has not yet caused changes in the water quality and the structure of communities of aquatic organisms. However, the increase in anthropogenic pressure, which is inevitable in the development of tourism activities in the protected areas, may negatively affect the ecosystem. In this regard, the relevance of monitoring of the state of the lake will definitely increase. It should be noted that the elongation of the lake and the dominance of northwestern winds may lead to the accumulation of debris in its southern part.

We consider continuing of the lake monitoring and including this water body to the analysis of aquatic communities typical for inland water bodies as expedient, especially since the number of biotic indicators, along with standard abiotic ones, is already listed by environmental regulatory documents[4]. However, using only biological criteria does not allow to unambiguously assess the quality of a water body. A reliable and effective assessment of the water quality is possible only when both biological and chemical methods are applied together.

It should also be noted that the Lake Pizanets undoubtedly requires further detailed geomorphological and hydrological studies, including that of the structure peculiarities of the basin and sedimentation processes. Unfortunately, we were unable to take samples from the depths greater than 10 m. It is possible that the planned studies of bottom sediments in deep-water areas will expand the list of taxa (primarily diatoms), and certain species, associated with the tectonic origin of the lake, will be found.

Including the Lake Pizanets as a part of the planned protected areas may become a good example of complementing the environmental and hunting sustainable management approaches prevailing in Russia, as well as aesthetic and historical, typical for many European countries and North America. It is assumed that a single protected area, consisting of several closely located clusters, has great prospects in the development of tourism, nature protection and research activities.

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