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Research Article

State of spring phytoplankton and quality of the Kenozero waters in 2018

NG Otchenash[1], GA Dvoryankin[2,3], EN Imant[2]

1 *Northern Branch of the Polar Research Institute of Marine Fisheries and Oceanography (Arkhangelsk, Russia)*
2 *N. Laverov Federal Centre for Integrated Arctic Research, Russian Academy of Sciences (Arkhangelsk, Russia)*
3 *Kenozersky National Park (Arkhangelsk, Russia)*

Corresponding author: *Natalia Otchenash* (otchenasch@pinro.ru)

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Abstract

Phytoplankton constitutes a key part of all aquatic ecosystems. It produces organic matter, thus forming the first level of food chains in water bodies. In addition, phytoplankton plays a major role in the water quality formation. The studies of algocoenosis always remain relevant, since the obtained data provides important information on the ecological status of water bodies. This information can subsequently be used for planning and implementing environmental measures, which are particularly significant for water bodies located in specially protected areas. National parks existing for the purposes of nature preservation, education and research are also designed for tourism, which makes their ecosystems more vulnerable. Population residing in such territories and its economic activity may also carry some environmental risks, which necessitates regular complex observations. This paper covers the state of spring phytoplankton community of Lake Kenozero in 2018, its qualitative and quantitative characteristics (species composition, abundance and biomass). In the course of research, we identified 70 phytoplankton taxa belonging to seven divisions: Bacillariophyta, Dinophyta, Chlorophyta, Cyanophyta, Chrysophyta, Xanthophyta and Euglenophyta. The dominant species complex included diatoms (*Asterionella formosa*, *Melosira granulata*, *Tabellaria fenestrata*), representatives of Dinophyta (*Gymnodinium* sp.), as well as small euglenoids. Species diversity was estimated using the Shannon-Weaver index. Aquatic environment contamination was assessed, i.e. the saprobity index was calculated and the class of surface water quality was determined. According to the water quality classification of water bodies and watercourses by hydrobiological indicators, Lake Kenozero was assigned the second class of water quality (moderately polluted).

Keywords

Lake Kenozero, phytoplankton, abundance, biomass, surface water quality, saprobity index

Introduction

Lake Kenozero is one of the largest lakes in the Arkhangelsk Region, as well as the biggest one in the Kenozersky National Park. It has a total area of approximately 75 km^2, with water surface covering 66.3 km^2. Numerous islands and peninsulas divide the lake into separate stretches and bays (Fig. 1). A notable feature of the lake consists in a very complex bottom relief and close proximity of deep waters to the shores and shoals. The lake is characterized by good flowage; however, partially isolated bays and stretches of its northern and southern parts can possess their local hydrological and hydrochemical features, which sometimes differ greatly from each other (Dvoryankin 2016). Biomonitoring of algal flora allows the overall state of a water body to be controlled, along with its state in individual locations. The composition of phytoplankton community most accurately reflects the current state of biogeocoenosis, which is essential in the context of national parks. Initial studies of phytoplankton in Lake Kenozero were carried out at the end of August 2001 by an expedition from the Northern Water Problems Institute, Karelian Research Centre (Dvoryankin 2016). Subsequently, biomonitoring of algal flora was carried out two more times: in October 2009 and in June 2018 (present study). This work is aimed at characterising the phytoplankton community, as well as assessing the quality of the Kenozero waters according to hydrobiological indicators.

Materials and methods

Hydrobiological research was carried out within the programme for hydrobiological and ecological study of Lake Kenozero (Kenozersky National Park).

Samples for the quantitative and qualitative analysis of phytoplankton were taken from the surface water in a volume of 1 litre; the material was fixed with 40% formaldehyde solution. The samples were concentrated up to 1 ml using the traditional sedimentary method (Abakumov 1992). Structural analysis of the material was performed in a laboratory using temporary preparations and a BiOptik S-300 laboratory light microscope (with magnifications of X100 and X400). The number of microalgae cells was counted under the entire surface of the coverslip. The cell was chosen as a counting unit. Phytoplankton abundance (N) per unit of water volume was calculated using the following formula

$$N=\left(\frac{V_{conc}\cdot S}{a\cdot V_{sub}\cdot V_{in}\cdot S_c}\right)\cdot n$$

where S – total area of the coverslip; S_c – area of the coverslip under which phytoplankton was counted; n – number of counted cells; V_{conc} – volume of the concentrated sample; V_{in} – initial sample volume (1 litre); V_{sub} – subsample volume (0.05 ml); a – number of calculated subsamples (Frank 1988).

The Shannon-Weaver index was calculated as follows

$$H' = -\sum p_i \ln p_i$$

H' – index; p_i – proportion of individuals belonging to the *j*-th species. The true value of p_i in samples is unknown, but is estimated as n_i/N (where N – abundance, ind./m^3; n_i – number of individuals of one species, ind./m^3).

The contamination of aquatic environment was estimated by calculating the saprobity index S according to the Pantle–Buck's method modified by Sladechek using the following formula

$$S=\frac{\sum sh}{\sum h}$$

where S – indicator value of each species (Unified methods for the study of water quality1977a, b); h – relative frequency of occurrence.

The higher the saprobity index, the higher the level of water pollution is. The saprobity indices for five classes of water quality are as follows: class I (conditionally clean) – less than 1.5; class II (moderately polluted) – from 1.5 up to 2.5; class III (polluted) – from 2.5 up to 3.5; class IV (dirty) – from 3.5 up to 4.0; class V (extremely dirty) – more than 4.07 (RD 52.24.309-2016). Previously, this method was successfully used on the territory of the Arkhangelsk Region to determine the water quality of the Northern Dvina in 2014 (Zmetnaya and Novikova 2015).

Fig. 1. Map of phytoplankton sampling sites (Kenozero, June 2018)

The composition of phytoplankton species was determined using identifiers of microalgae. The biomass was calculated using the tables for phytoplankton size and weights (mass) (Mikheeva 1999).

Results

Hydrobiological studies of phytoplankton were carried out on 13–14 June (hydrobiological spring) in the Kenozero water area. Samples were taken from the surface water at 15 points over the entire surface of the water body (Fig. 1). The analysis revealed that the phytoplankton community in Lake Kenozero was represented by microalgae belonging to seven groups: Bacillariophyta, Dinophyta, Chlorophyta, Cyanophyta, Chrysophyta, Xanthophyta and Euglenophyta. A total of 70 species and super taxa of microalgae were found. Diatoms were found to be the most diverse in terms of species composition – 50 species, which accounted for 72% of the total number of found and identified taxa (Fig. 2). Green and blue-green algae were represented by a significantly smaller number of species (7 and 4 species, respectively). Dinoflagellates and yellow-green algae accounted for 3 representatives each, whereas only 2 species of golden algae and 1 taxon of euglenoids were found (Gollerbakh and Polyansky 1953, Komarenko and Vasilyeva 1975, Komulaynen et al. 2006, Krishtovich 1949a, b, Kursanov 1953).

The number of identified microalgae at individual stations ranged from 14 (station 14) to 35 (station 5) averaging 22 species.

Discussion

The most common types of planktonic algae included Melosira granulata and Fragilaria crotonensis (present at all stations), as well as Tabellaria fenestrata, Gymnodinium sp., Asterionella formosa, Closterium acutum and Protoperidinium bipes, which were encountered less frequently (Table 1).

The presence of golden algae (Dinobryon), which prefer water bodies having a minimum content of inorganic phosphorus, indicates oligotrophic conditions

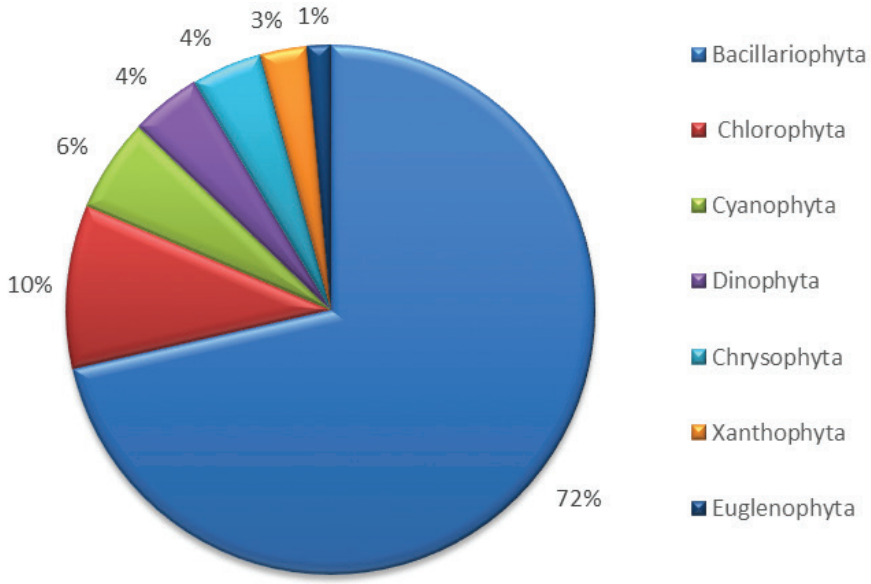

Fig. 2. Taxonomic composition of phytoplankton in Lake Kenozero (June, 2018)

throughout most of the lake (Barinova et al. 2006). Most of the identified microalgae have the status of widespread species or cosmopolitans and are common representatives of lake algal flora (Komulaynen et al. 2006).

The total abundance of planktonic microalgae in Kenozero (June 2018) varied from 3,520 to 50,960 cells/L. The highest and the lowest abundances were registered at stations 3 and 15, respectively. Such a significant difference is due to the complex bottom relief and strong coastline indentation, which result in local hydrological and hydrochemical features and, consequently, variations in the phytoplankton community. The average abundance amounted to a very low value of 23750 cells/L, characteristic of oligotrophic water bodies, whose algal flora is outside the vegetation peaks (Fig. 3) In general, the level of phytoplankton abundance was very low.

The total biomass of phytoplankton organisms in the studied area varied from 8.01 to 138.56 μg/L. The highest value of total biomass was registered at station 3, located in the northern part of the lake, whereas station 15 showed the smallest value. The average phytoplankton biomass amounted to 47.61 μg/L (Fig. 4).

Representatives of Bacillariophyta (*Melosira granulata*, *Asterionella formosa*) and euglenoids, whose species could not be identified, were found to be the most numerous at all stations of the studied area. In addition, a significant number of Fragilaria, Tabellaria and Nitzschia representatives were found. At most stations, the maximum biomass was observed for representatives of Bacillariophyta (*Melosira granulata*, *Tabellaria fenestrata*), Euglenophyta and Dinophyta. It should be noted that representatives of Euglenophyta were predominant at stations 1, 2, 3 and 11. Euglenophyta grow in areas affected by organic pollution (Barinova et al. 2006).

The values of the Shannon-Weaver diversity index by phytoplankton abundance ranged from 1.9 (station 3) to 3.6 (station 12), whereas calculated by biomass it varied from 1.9 (stations 3 and 14) to 3.5 (station 6). The diversity indices by abundance and by biomass averaged 2.9 and 2.8, respectively.

The saprobity index according to V. Sladechek ranged from 1.57 to 1.8 (station 1) averaging 1.6. The saprobic state of the Kenozero waters corresponded to the oligo-β-mesosaprobic conditions (saprobity index 1.5–2.5), or class II of water quality (moderate content of organic substances) (Abakumov 1992, RD 52.24.309-2016).

Table 1. Taxonomic composition of phytoplankton in Lake Kenozero (June, 2018)

Taxon	Occurrence
Bacillariophyta	
Achnanthes sp.	60%
Amphoracoffeaeformis (C.Agardh) Kützing, 1844	60%
Amphora exigua Gregory, 1857	7%
Amphora ovalis (Kützing) Kützing, 1844	20%
Asterionella formosa Hassall, 1850	87%
Caloneis bacillum (Grunow) Cleve, 1894	27%
Caloneis silicula (Ehrenberg) Cleve, 1894	47%
Caloneis sp.	20%
Cocconeis sp.	20%
Cyclotella bodanica Eulenstein ex Grunow, 1878	13%
Cyclotella comta (Ehrenberg) Kützing, 1849	33%
Cyclotella planctonica Brunnthaler, 1901	47%
Cyclotella sp.	13%
Cymbella ventricosa (C.Agardh) C.Agardh, 1830	7%
Diatoma hiemale (Lyngb.) Heiberg, 1863	33%
Diploneis interrupta (Kützing) Cleve, 1894	7%
Diploneis ovalis (Hilse) Cleve, 1891	13%
Eunotia pectinalis (Kützing) Rabenhorst, 1864	20%
Eunotia praerupta Ehrenberg, 1843	7%
Eunotia sp.	40%
Fragilaria bicapitata Mayer, 1917	7%
Fragilaria capucina Desmazières, 1830	53%
Fragilaria construens (Ehrenberg) Grunow, 1862	7%
Fragilaria crotonensis Kitton, 1869	100%
Gomphonema acuminatum Ehrenberg, 1832	7%
Gomphonema gracile Ehrenberg, 1838	13%
Gyrosigma acuminatum (Kützing) Rabenhorst, 1853	7%
Melosira granulata (Ehrenberg) Ralfs, 1861	100%
Meridion circulare (Greville) C.Agardh, 1831	13%
Navicula gastrum Lauby, 1910	7%
Navicula lanceolata Ehrenberg, 1838	13%
Navicula mutica (Kützing) Frenguelli, 1924	40%
Navicula placentula Pantocsek, 1902	20%
Navicula sp.	20%
Navicula tuscula Pantocsek, 1902	40%
Nitzschia acuminata (W.Smith) Grunow, 1880	7%
Nitzschia gracilis Brébisson ex H.L. Smith, 1874–1879	27%
Nitzschia holsatica Hustedt, 1930	53%
Nitzschia linearis W.Smith, 1853	40%
Nitzschia longissima (Brébisson) Ralfs, 1861	40%
Nitzschia palea (Kützing) W.Smith, 1856	27%
Nitzschia sigmoidea (Nitzsch) W.Smith, 1853	7%
Nitzschia sp.	7%
Nitzschia subtilis (Kützing) Grunow, 1880	7%
Nitzschia tryblionella Hantzsch, 1860	7%
Nitzschia vermicularis (Kützing) Hantzsch, 1860	13%
Stauroneis anceps Ehrenberg, 1843	13%
Stephanodiscus hantzschii Grunow, 1880	13%
Synedra ulnasensu Hustedt, 1942	53%
Tabellaria fenestrata (Lyngbye) Kützing, 1844	93%
Chlorophyta	
Ankistrodesmus convolutus Corda, 1838	13%
Ankistrodesmus falcatus (Corda) Ralfs, 1848	7%
Closterium acutum Brébisson, 1848	87%
Closterium sp.	13%
Crucigenia tetrapedia (Kirchner) Kuntze, 1898	7%
Dictyosphaerium sp.	20%
Scenedesmus quadricauda (Turpin) Brébisson, 1835	13%
Chrysophyta	
Dinobryon spirale Iwanoff, 1899	73%
Dinobryon divergens O.E.Imhof, 1887	60%
Mallomonas sp.	60%
Cyanophyta	
Anabaena sp.	27%
Aphanizomenon flos-aquae(Linnaeus) Ralfs ex Bornet & Flahault, 1888	7%
Gloeocapsa sp.	7%
Microcystis sp.	7%
Dinophyta	
Gymnodinium sp.	93%
Peridinium sp.	7%
Protoperidinium bipes (Paulsen, 1904) Balech, 1974	80%
Euglenophyta	
Euglena sp.	33%
Xanthophyta	
Centritractus sp.	40%
Tribonema sp.	7%

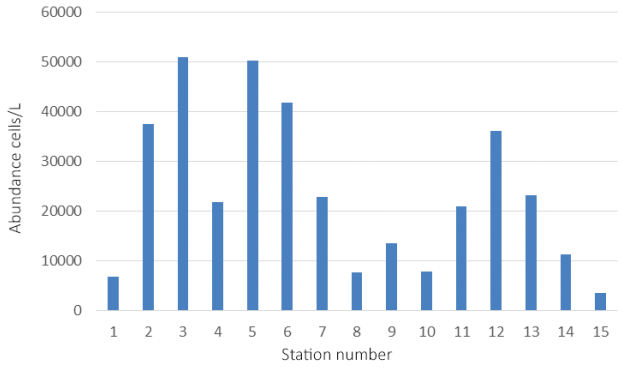

Fig. 3. Abundance of phytoplankton in Lake Kenozero (June, 2018)

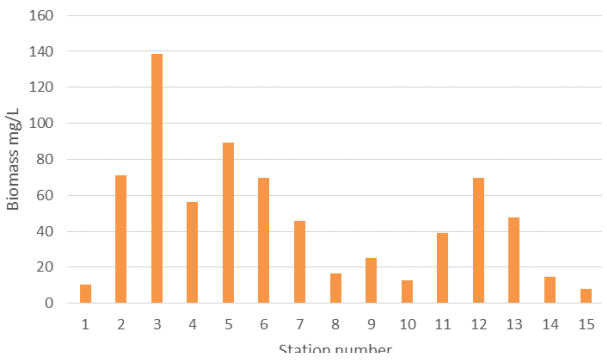

Fig. 4. Biomass of phytoplankton in Lake Kenozero (June, 2018)

Table 2. Saprobity index according to V. Sladechek. Shannon-Weaver diversity index by abundance and by biomass

Station number	S	H'_1	H'_2
1	1.805	3.16	3.088
2	1.715	3.086	2.745
3	1.541	1.933	1.945
4	1.63	3.554	3.402
5	1.679	3.379	3.152
6	1.564	3.232	3.526
7	1.648	3.335	3.167
8	1.57	2.402	2.704
9	1.691	2.318	2.354
10	1.603	2.013	2.043
11	1.64	3.435	3.26
12	1.626	3.573	3.19
13	1.569	2.349	2.17
14	1.567	2.063	1.929
15	1.594	3.194	2.84
Average value	1.629	2.868	2.768

S – values of saprobity index according to V. Sladechek, H'_1 – values of Shannon-Weaver diversity index by abundance, H'_2 – values of Shannon-Weaver diversity index by biomass.

Conclusion

The obtained data show that the dominant phytoplankton complex of Kenozero in June 2018 was represented by diatoms (Melosira granulata, Fragilaria crotonensis, Tabellaria fenestrata, Asterionella Formosa), by dinoflagellates (Gymnodinium sp, Protoperidinium bipes), green algae (Closterium acutum) and, zonally, by small small euglenoids. Quantitative indicators of phytoplankton were extremely low. In addition, the values of species diversity indices were also modest.

Therefore, Lake Kenozero belongs to floristically depleted oligotrophic water bodies with a significant predominance of diatoms and low quantitative indicators (abundance and biomass). A slight zonal pollution of the water body by organic wastewater can be assumed. In order to identify the vegetation peaks in the development of phytoplankton community in Kenozero, to collect more information on its species composition and quantitative indicators, as well as to monitor the ecological state of the lake, extensive year-round research is required.

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