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SUMMER ASPECT OF PHYTOPLANKTON COMMUNITIES IN SOME MONTENEGRIN LAKES: ARE THERE CHANGES AFTER MORE THAN TWO DECADES?

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Abstract – Qualitative and quantitative phytoplankton compositions of 10 Montenegrin lakes were investigated in the summer of 2007. The obtained results were compared with a previous study-period that was undertaken two decades ago. In the first period, diatoms numerically dominated the phytoplankton community in all studied lakes, while in the second period, the same was observed only in three of the ten lakes; in other studied lakes the relative contributions of green algae, dinoflagellates and/or cyanobacteria increased, while the contribution of diatoms decreased. The shift observed in phytoplankton composition and diversity in some of the studied lakes indicates an increase in the trophic level over the two decades. The sustainable management plan of the aquatic ecosystems in Montenegro should include the establishment of an environmental monitoring system in order to record any alterations that may take place in water quality.

Key words: phytoplankton, diversity, functional groups, lakes, Montenegro

INTRODUCTION

The state of lake ecosystems and their changes can be evaluated on the basis of biotic and abiotic elements. Phytoplankton are the main primary producers in open waters. They condition the structure and density of consumers as well as the physicochemical properties of water. Moreover, phytoplanktonic organisms are sensitive indicators, as phytoplankton structure and metabolism changes quickly in response to environmental changes (Padisak et al., 2006).

Each level along the continuum from oligotrophic to hypereutrophic conditions can be characterized by the succession and composition of algal communities, an observation that has been expanded towards a classification of freshwater phytoplankton using functional groups. Reynolds et al. (2002) and Padisak et al. (2009) stated that a functional classification approach proved to be more useful for ecological purposes than the previously applied taxonomic grouping of phytoplankton (Kruk et al., 2002; Salmaso and Padisak, 2007). This approach assumes that the characteristics of the phytoplankton community can be better understood and managed if species are grouped into classes that possess similar characteristics or behave similarly. The functional group approach constitutes a useful tool not only for understanding the phytoplankton community in every system, but also for comparison between various aquatic systems of different regions.

The phytoplankton of Montenegrin lakes and reservoirs began to be studied at the end of the 1950s and then periodically continued until the end of eighties. The majority of these investigations was qualitative and based on the making of taxonomic lists. Quantitative analyses of phytoplankton were just occasional, based exclusively on the determination of phytoplankton abundance and they rarely comprised more than one season (especially for mountain lakes). After a break of more than 2 decades, investigations into the phytoplankton in Montenegrin lakes have continued. One of the most consistent effects of eutrophication (both natural and anthropogenic) on phytoplankton is a shift in species composition. However, bibliography concerning the eventual changes in biodiversity and trophic conditions in Montenegrin lakes is missing because of the lack of repeated investigations. To partly fill this gap, the aim of the present study was to analyze summer phytoplankton community structure of some lakes in Montenegro, to assess their trophic level and water quality using phytoplankton as a bioindicator and to estimate eventual changes that occurred in these lakes during the last two decades. The last was achieved by comparing the results of this study with the data reported up to the end of eighties of the last century for the selected lakes.

MATERIALS AND METHODS

Water samples were collected during summer 2007 (3 samples per lake) from 10 Montenegrin lakes (Fig.1): 4 mountain lakes (Crno, Zmijinje, Biogradsko and Plavsko), 5 reservoirs (Otilovici, Piva, Krupac, Slano and Liverovici) and one lowland lake (Lake Skadar). The summer was selected for sampling in order to compare obtained results with old phytoplankton data, since the majority of former phytoplankton investigations (especially for mountain lakes) were carried out in summer.

There are 30 mountain lakes in Montenegro that are usually glacial in origin, small and difficult to access. The distinctive characteristic of the landscape results from a combination of glacial origin and later strong erosion that together with the calcareous rock composition accounts for the typically very dilute waters of the lakes. For this investigation, 4 mountain lakes were chosen – all were located within national parks: Biogradsko Lake, located in the heart of the Biogradska Gora national park (mountain Bjelasica), Crno Lake and Zmijinje Lake, located in the national park Durmitor, and Plavsko Lake, situated in the northeastern part of Montenegro within the national park Prokletije.

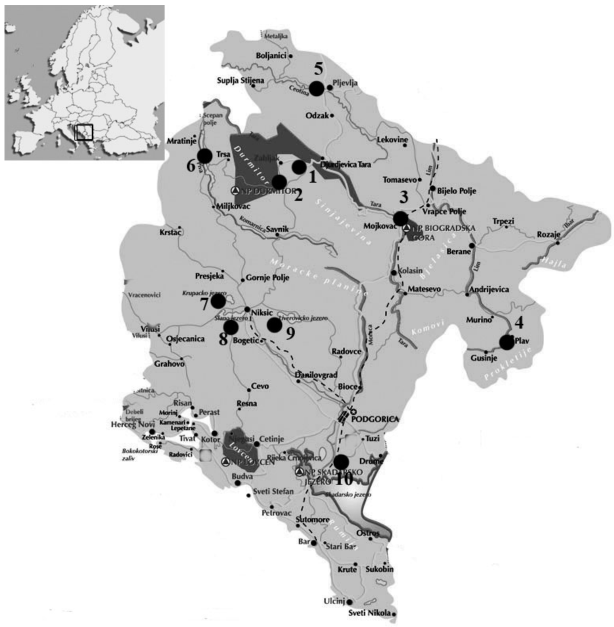

Fig.1. Map of Montenegro with marked locations of the studied lakes (1 – Zmijinje, 2 – Crno, 3 – Biogradsko, 4 – Plavsko, 5 – Otilovići, 6 – Piva, 7 – Krupac, 8 – Slano, 9 – Liverovići, 10 – Skadar)

All Montenegrin reservoirs were included in this investigation – 3 of them formed by river impoundment and 2 by the damming of fields on karst springs. Piva Lake is the largest artificial lake in Montenegro with a length of 42 km. It was created on Piva River in the period 1967-1975 for the needs of hydropower plant "Mratinje", and its concrete arch dam of 220 m in height is the fifth largest of its kind in the world. Piva reservoir is the deepest lake in Montenegro. Otilovici reservoir was built in 1981 on the upper part of the Ćehotina River and has a length of 10 km. The main purpose of the reservoir was to supply water to TPP "Pljevlja". The construction of the hydroelectric power plant "Perućica" in 1960 resulted in the creation of 2 artificial lakes near the city Nikšić, Krupac and Slano. In their vicinity is Liverovici reservoir, built on the river Gracanica for the needs of the iron plant "Boris Kidrič".

Table 1. Some morphometric characteristics of the studied lakes

Lake	Type of lake	Elevation (m)	Surface area (km^2)	Average depth (m)	Maximum depth (m)
Zmijinje	Mountain glacial	1520	0.17	3	7.7
Crno	Mountain glacial	1422	0.52	16.8	49.1
Biogradsko	Mountain glacial	1094	0.23	4.5	12.1
Plavsko	Mountain glacial	950	1.99	2	9.1
Otilovici	Reservoir	920	2	10	40
Piva	Reservoir	675	12.5	58	188
Krupac	Reservoir	623	5.7	8	20
Slano	Reservoir	630	8.9	1.6	12
Liverovici	Reservoir	691	0.93	9.6	20
Skadar	Lowland lake	6	370-530	6	44

There are only 2 lowland lakes in Montenegro, of which only Lake Skadar (the biggest lake in Balkan peninsula) was chosen for this study. It is a wetland located on the border between Montenegro and Albania. The frequent winds and shallow depths do not permit the formation of permanent thermal stratification in this lake. Strong water-level fluctuations have resulted in a large wetland area sustaining dense macrophytic vegetation.

Morphometric data for all studied lakes are summarized in Table 1.

Water samples were collected using a Ruttner hydrobiological bottle and transported to the laboratory for the counting of phytoplankton and chlorophyll *a* determination. Samples for determining the qualitative composition of algae were collected with a 28 µm-mesh, with a Wisconsin plankton net drawn from the bottom to the top of the water column and fixed with formalin. The chlorophyll *a* concentration of the prepared samples was determined spectrophotometrically using the ethanol extraction method (ISO 1992). Phytoplankton abundance was performed using the sedimentation method (Utermöhl, 1958). Species diversity (H), based on abundance of the species, was calculated according to Shannon-Weaver (1949) and species evenness (E) according to Pielou (1977). The saprobity in terms of phytoplankton was evaluated according to Pantle and Buck (1955) and trophic state indices (TSI) were computed from chlorophyll *a* according to Carlson (1977). Reynolds et al. (2002) functional groups classification was applied to the phytoplankton species and supplemented by the review of Padisák et al. (2009).

Comparisons were conducted between the published data of the previous phytoplankton studies and data collected in this study. Due to complete lack of chlorophyll *a* and algal volume-data in all previous studies of phytoplankton in Montenegrin lakes, comparisons were not possible for these parameters. As a result, this study does not include the calculation of algal biovolume. Obtained values of chlorophyll *a* concentration were used as an indirect measure of the algal biomass and for trophic state estimation of the studied lakes.

RESULTS AND DISCUSSION

A total of 85 taxa from five algal divisions were identified in investigated lakes (Table 2). The highest percentage (47%) of the taxa identified were members of Chlorophyta. Four other groups were represented to a lesser extent: Bacillariophyta 29%, Cyanobacteria 15%, Dinophyta 7% and Chrysophyta 2%. Chlorophyta (namely Chlorococcales) was the most diverse group. Chlorococcales are typical representatives in mesotrophic and eutrophic freshwaters. Neverthe-

Table 2. List of phytoplankton taxa identified in 10 studied lakes during summer 2007. (Lake codes as in Figure 1; + = present, ++ = frequent, +++ = abundant)

TAXON	LAKES									
	1	2	3	4	5	6	7	8	9	10
CYANOBACTERIA										
Merismopedia tenuissima Lemm	+	+	+	+	+	+	+	+	+	+
M. glauca (Ehr.) Nag					+	+	+	+	+	+
M. punctata Meyen										+
Microcystis incerta (Lemm.) Starm							+	+		+++
M. pulverea (Wood) Forti & Elenk										++
M. aeruginosa (Kutz) kutz										+
Oscilatoria limosa f. *typica* Elenk						+	+		+	+
O. irrigua (Kutz.) Gom										+
O. tenuis Ag				+						+
O. lacustris (Kleb.) Geitl.						+				+
O. rupicola Hansg.						+				
Anabaena variabilis Kutz.										++
Anabaena affinis Lemm.										++
CHLOROPHYTA										
Pediastrum simplex v. *simplex* Meyen	+	+	+	+	+	+	+	+	+	+
P. simplex var. *biwaense* Fukush										+
P. duplex var. *duplex* Meyen			+	+	+		+	+	+	+
P. duplex var. *gracilimum* W & G.S.West							+	+		+
P. boryanum (Turp.) Menegh.					+					+
Micractinium pusilum Fres										+
Dictyosphaerium pulchellum Wood				+	+		++	+	+	+
D. echrenbergianum Nag.							+	+		+
Oocystis lacustris Chod	+	+	+	++	+	+	+++	++	+	+
O. marsonii Lemm	+	+	+	++	+	+	++	++	+	+
O. borgei Snow.		+				+				
Willea wilhelmii (Fott) Kom.					+	+	+	+	+	+
Eutetramorus planctonicus Bour						+	+	+	+	
Coccomyxa lacustris (Chod) Pasch.				+		+				
Coenochloris pyrenoidosa Korš.				+		+	+			
Coenocystis planktonica Korsh.	++	++	++	+++	++	+	++	++	++	+
Sphaerocystis schroeteri Chodat	+	+	+	+++	++	++	+++	+++	+++	+
Monoraphidium contortum Kom.-Legn.							+		+	+
Ankistrodesmus fusiformis Corda								+	+	+
A. gracilis (Reinsch) Korš										+
Chlorolobion braunii (Nag.) kom.	+	+		+		+	+	+		+
Kirchneriella contorta (Schmidle) Bohlin										+
Tetraedron minimum var. *minimum* Hansg.										+
Coelastrum microporum var. *microporum* Nag	+			+			+		+	++
C. pseudomicroporum Korš.					+					+
C. reticulatum (Dang.) Sen.						+	+			
Scenedesmus acutus var. *acutus* Meyen							+			+
S. acuminatus var. *acuminatus* (Lagerh.) Chod										+

Table 1. *Continued*

TAXON	LAKES									
	1	2	3	4	5	6	7	8	9	10
S. spinosus Chod.					+				+	+
S. obtusus Meyen							+	+	+	+
S. disciformis f. *disciformis* Fott & Kom.										+
S. ecornis var. *ecornis* (Ehrenb.) Chod				+	+		+		+	++
S. acunae Comas				+		+	+	+	+	++
Crucigeniella pulchra (W.& G.S.West) Kom							+	+		++
Crucigenia rectangularis (Nag.) Gay							+	+	+	+++
Eudorina elegans Ehr.							+			+
Pandorina morum (O.F.Muller) Bory.					+		+	+		+++
Planktonema lauterbornii Schmidle										++
Gleotila turfosa Skuja										+
BACILLARIOPHYTA										
Cyclotella comensis Grunow.	+++	+++	+++	+	++	++	+	+	+	+
C. glomerata Bachmann	+++	+++	+++	+	++	+++	+	+	+	+
C. ocelata Pantocsek	+		+			+	+	+	+	+
C. radiosa (Grun) Lemm.		+	+		+	+				+
C. krammeri Hak.					+	+				
Stephanodiscus medius Hakansson				+	+			+		+
Aulacoseira italica (Ehr.) Sim.				+	+		+	+	+	+
Asterionella formosa Hassall	+	+	+		+	+				+
Tabellaria floculosa (Roth.) Kutz	+	+	+			+				+
T. fenestrata (Lungbye) Kutz.		+								+
Diatoma vulgare Bory.										+
D. mesodon (Ehr.) Kutz.		+	+							+
Fragilaria capucina var. capucina Desm.	+	+	++		+					+
F. capucina var. vaucheriae (Kutz.) L.-B.		+	+				+	+	+	+
F. crotonensis Kitton					+	+	+	+++	+++	+
F. ulna var. *biceps* (Kutz.) L.-B.			+		+					+
F. ulna var. *ulna* (Nitz.) L.-B.										+
F. ulna var. *acus* (Kutz.) L.-B.				+		+	+	+	+	+
Navicula cryptocephala Kutz.										+
N. tripunctata (O.F.Mull) Bory				+						+
N. cari Ehr.							+		+	+
Cymbella cymbiformis Agardh			+						+	+
C. affinis Kutz.										+
C. aspera (Ehr.) Pergallo				+						+
C. cistula (Ehr) Kirch.							+	+		+
DINOPHYTA										
Ceratium hirundinella Schroeder	+	+	+	+	+	+	+	+	+	+
Peridinium umbonatum F.Stein	++	++	++	++	+++	+++	+++	+++	+++	+
P. willei Huitfeld-Kass						+				+
P. cinctum Ehr.	+				+	+	+	+	+	+
P. bipes Stein						+	+			
Peridiniopsis cuningtonii Lemm.	+	+	+	+	+	+	+	+	+	+
CHRYSOPHYTA										
Dynobryon divergens Imh.	++	++	+	+	+	+	+	+	+	+
D. bavaricum Imh.	+	+	+		+	+			+	+
TOTAL:	20	22	23	28	31	35	43	36	35	77

less, some small chlorococcalean species may also be well represented in nutrient-poor waters since their small cells have a high surface-area-to-volume ratio, and thus an advantage in nutrient uptake (Happey-Wood, 1988). Probably for this reason, Chlorococcales were the most diverse algal group in the majority of the lakes from this research, regardless of trophic conditions.

Throughout the summer of 2007, the phytoplankton-species number and composition in the studied lakes was somewhat similar: the main difference was the greater species number in Lake Skadar than in the other lakes (2- to 3-fold, Table 2). Species richness was inversely correlated with the elevation of the lakes ($r = -0.85$, $p<0.05$). The lower number of phytoplankton taxa recorded in mountain lakes confirms the important role of altitude and related climatic conditions, particularly the duration of the winter ice cover, in the determination of the phytoplankton species composition of high mountain lakes (Nauwerck, 1994; Padisak and Koncsos, 2002). Phytoplankton richness and the amount of chlorophyll *a* showed a significant positive correlation ($r = 0.81$, $p<0.05$), confirming that communities consisting of a higher number of species were able to produce higher levels of biomass (Dodson et al. 2000).

According to Reynolds (2002) and Padisak et al. (2009), 17 functional groups of phytoplankton were identified during this investigation. For all the lakes the common functional groups were **A**, **F**, **Lo**, **J** and **E,** from which the **F** and **J** groups were the most diverse in the majority of studied lakes.

Chlorophyll *a* concentration in the studied lakes was in a range from 0.43 to 10.24 µg/l. The lowest chlorophyll *a* concentrations characterized the mountain lakes (apart from Plavsko). The low chlorophyll concentrations and low TSI values in these lakes (Table 3) suggest oligotrophic conditions. The somewhat higher chlorophyll *a* concentrations recorded in reservoirs (apart from the deep Piva Lake) indicated mesotrophic conditions. The highest chlorophyll *a* concentration was recorded in the lowland lake (Lake Skadar) and suggested moderately eutrophic conditions in this lake. From the above it is evident that the trophic state of the studied lakes was inversely correlated with the lake's elevation (chl *a*: $r = -0.84$; $p < 0.05$ and TSI: $r = -0.55$, $p < 0.05$).

The diversity index of the studied lakes ranged from 1.75 to 3.9 (Table 3). Many researchers have found eutrophic lakes to have lower diversity then oligotrophic ones (Reynolds et al., 2000a). The negative correlation between phytoplankton diversity and trophic state index (TSI) observed in this research provided further support for this generalization ($r = -0.53$; $p < 0.05$).

The saprobic index-values for the studied lakes ranged from 1.3 to 2.4 (Table 3). The values of *S*, used for assessing the level of water pollution by organic matter based on phytoplankton characteristics, characterized the water of the investigated lakes as oligo- to β-mesosaprobic, or in other words, very slightly to moderately polluted by organic matter (I – II class). The saprobic indices of studied lakes corresponded well with the trophic state indices ($r = 0.84$; $p < 0.05$).

The total phytoplankton abundance of the studied lakes was in a range from 8.7×10^3 cells/l to 2×10^6 cells/l. The highest total abundance characterized Lake Skadar and Plavsko Lake, and the lowest characterized Piva reservoir (Table 4). Species of 3 divisions, Bacillariophyta, Chlorophyta, and Dinophyta, numerically dominated in all the investigated lakes, comprising on average 95% of the total abundance. The average contribution of diatoms decreased, while contributions of greens and blue-greens increased from oligotrophic toward eutrophic lakes – a pattern well documented in many literature data (Naselli-Flores and Barone, 2005). Phytoplankton species from four functional groups (**A**, **P**, **F**, and **Lo)** were the main contributors to phytoplankton abundance in the majority of the investigated lakes. The exception was the phytoplankton community of Lake Skadar which was dominated mostly by species from **J**, **M,** and **G** functional groups.

Table 3. Some biological parameters of the studied lakes (H - diversity index, E – evenness, S – saprobity index, Chl.*a* – chlorophyll *a* concentration, TSI – trophic state index)

Lake type	Lake	Number of taxa	H	E	S	Chl. a (μg/l)	TSI	Trophic state
Mountain lakes	Biogradsko	23	3.90	89.30	1.4	0.43	14.27	oligotrophy
	Crno	22	3.89	82.80	1.7	1.30	31.50	oligotrophy
	Zmijinje	20	3.60	88.10	1.3	1.90	36.86	oligotrophy
	Plavsko	26	1.75	51.70	2.0	6.67	49.18	mesotrophy
Rervoirs	Piva	35	2.16	66.82	1.3	1.10	31.50	oligotrophy
	Otilovici	31	2.86	85.70	2.0	5.06	46.47	mesotrophy
	Krupac	43	3.20	81.60	2.4	6.10	48.31	mesotrophy
	Slano	36	3.01	81.30	2.1	4.20	44.64	mesotrophy
	Liverovici	35	3.14	82.10	2.2	5.10	46.55	mesotrophy
Lowland lake	Skadar	77	2.7	74.13	2.1	10.24	53.39	eutrophy

In oligotrophic mountain lakes (Biogradsko, Crno and Zmijinje), Bacillariophyta comprised on average 72% of the total phytoplankton abundance (Fig. 2). They were mostly represented with 2 species: *Cyclotella glomerata* Bachm. and *C. comensis* Grunow. Reynolds (2002) classified these two species as taxa related to ultraoligotrophic, clear-water lakes, belonging to functional group **A**. *C. glomerata* and *C. comensis* are prominent in the plankton of many medium-to-large high-latitude lakes that are typically clear, dilute in solutes and deficient in phosphorus. In general, the species in group **A** have a high affinity for nutrients (though not for carbon) and their populations tend to be greatest in deep mountain lakes, especially in the period of thermal stratification (Reynolds et al. 2002).

Unlike the other three mountain lakes, Plavsko Lake had a very low proportion of Bacillariophyta in total phytoplankton abundance – only 7% (Fig. 2). The reason for this was the marked development of 2 chlorococcalean species, *Coenocystis planktonica* Korsh. and *Sphaerocystis schroeteri* Chodat. Their joint contribution to the total phytoplankton abun-

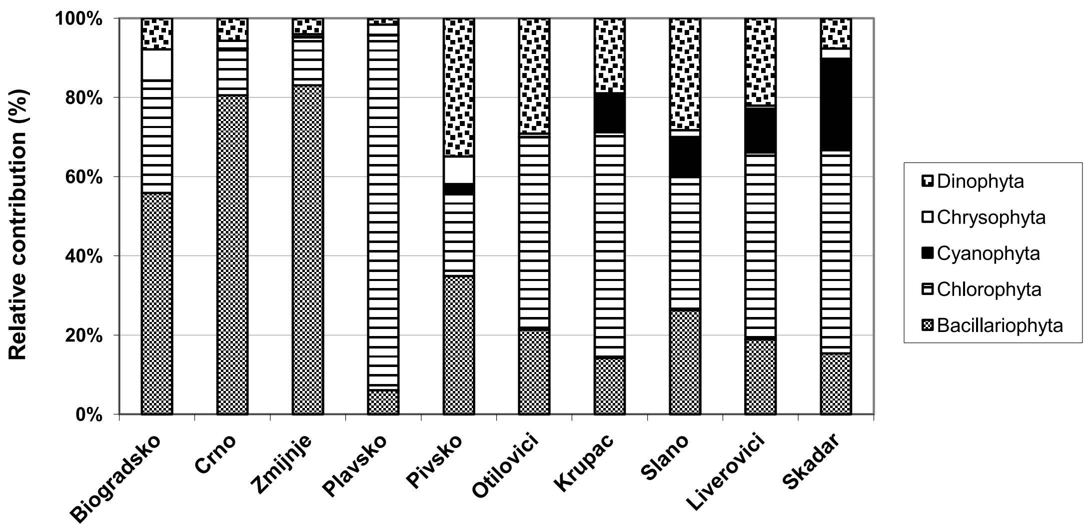

Fig.2. Relative contribution of algal divisions to total phytoplankton abundance in 10 investigated lakes (summer 2007)

dance reached 84% in this lake and caused a low diversity index and low evenness in summer (the lowest from all studied lakes, Table 3). *Coenocystis planktonica* and *Sphaerocystis schroeteri* together with *Oocystis lacustris* Chodat. and *Oocystis marsonii* Lemm. were the most abundant greens in all the studied mountain lakes. These non-motile but near-neutrally-buoyant colonial green algae belong to functional group **F** that perform better in clear waters and are tolerant of deep mixing and low nutrient concentrations (Reynolds et al., 2000). Thus, they have a strong representation among mesotrophic lakes but, having a high surface-area-to-volume ratio and thereby an advantage in the nutrient uptake, they were also the main representatives of greens in the studied oligotrophic lakes, though with a small relative contribution.

In the investigated reservoirs, Chlorophyta (from group **F**), Dinophyta (from group **Lo**) and Bacillariophyta (from groups **P** and **A**) numerically dominated the phytoplankton community, comprising on average 41%, 27% and 23% of the total abundance, respectively (Fig. 2). In comparing the reservoirs with the oligotrophic mountain lakes, it can be seen that the proportion of diatoms in total phytoplankton abundance decreased, although their abundance in reservoirs could be large. Concurrent with the decrease in diatoms proportion were increases in the proportion of greens and dinoflagellates in the reservoirs. *Coenocystis planktonica*, *Sphaerocystis schroeteri, Oocystis lacustris* and *Dictyosphaerium pulchellum* were the most abundant greens in all studied reservoirs, similar to the mountain lakes, but with a distinctly higher proportion.

Peridinium umbonatum F.Stein and *Ceratium hirundinella* (O.F.Mull.) Dujard (both from group **Lo**), were the most abundant dinoflagellates in all the studied lakes, reaching the highest proportion in the reservoirs. Both species are motile and thus have selective advantages over non-motile species; for this reason, they are common for stratified lakes. Features such as low P consumption, vertical migration capability, and the relatively great life span of their generations, give them great competitive advantage over other algae under conditions of nutrient depletion (Oda and Bicudo, 2006). It should be added that, due to their relatively large size, dinoflagellates are less susceptible to zooplankton grazing, minimizing their losses.

Cyanobacteria had a significant contribution only in some reservoirs and in Lake Skadar. *Merismopedia tenuissima* Meyen and *Merismopedia glauca* (Ehr.) Kutz. on average comprised 97% of Cyanobacteria abundance in all reservoirs. These species also belong to the **Lo** functional group (characterized by tolerance to a low nutrient level) usually represented in oligo-mesotrophic lakes.

In the investigated lowland lake (Lake Skadar), the predominantly represented groups were Chlorophyta and Cyanobacteria, comprising 51% and 25% of the total phytoplankton abundance, respectively. The main representatives of greens were species from genera *Pandorina*, *Crucigenia*, *Scenedesmus* and *Coelastrum* (**G** and **J** groups), all characteristic for shallow, mixed and nutrient-rich lakes (Padisak et al., 2009). The most abundant Cyanobacteria were species from genera *Microcystis* (**M**) and *Anabaena* (**H1**), both associated with eutrophic conditions.

When comparing the present and former phytoplankton communities in the studied lakes, several conclusions can be derived. In almost all the studied lakes, Bacillariophyta numerically dominated in the phytoplankton community in previous times (Table 4), usually with small *Cyclotella* species (*C. glomerata*, *C. comensis*) and *Asterionella formosa* Hassall. These species were predominantly indicators of oligotrophy. In the reservoirs, *Ceratium hirundinella* was usually subdominant. In terms of functional groups, **A**, **C** and **Lo** members were the most represented. The present investigation generally identified **A**, **P**, **F** and **Lo**-species as the most abundant in phytoplankton communities of the majority of the lakes (Lake Skadar was the exception to the pattern).

In some of the lakes, a similar phytoplankton abundance (the same order of magnitude) to the former period of investigation was observed. This

Table 4. Total phytoplankton abundance, dominant species and their functional groups in 10 investigated lakes in different periods of investigation

	1970 - 1985			2007		
Lake	Total abundance	Dominant taxa	Funct. gr.	Total abundance	Dominant taxa	Funct. gr.
Biogradsko	9.4×10^5	*C. comensis* *A. formosa*	A C	1.3×10^5	*C. glomerata* *C. comensis*	A
Crno	2×10^5	*C. comensis* *A. formosa*	A C	3×10^5	*C. glomerata* *C. comensis*	A
Zmijnje	1.5×10^5	*C. comensis* *A. formosa*	A C	4.5×10^5	*C. glomerata* *C. comensis*	A
Plavsko	5.5×10^4	*C. comensis* *A. formosa*	A C	1×10^6	*Coenocystis ,* *Sphaerocystis*	F
Piva	9×10^5	*C. comensis* *A. formosa* *Ceratium*	A C Lo	8.6×10^3	*P. umbonatum* *C. glomerata* *Sphaerocystis*	Lo A F
Otilovici	1×10^5	*Ceratium* *Dinobryon*	Lo E	9.2×10^5	*Sphaerocystis* *P. umbonatum*	F Lo
Krupac	1.6×10^4	*C. comensis* *Ceratium* *Dinobryon*	A Lo E	2.2×10^5	*Sphaerocystis* *Oocystis* *P. umbonatum*	F F Lo
Slano	6×10^3	*C. comensis* *Ceratium* *C. glomerata*	A Lo A	3×10^4	*Sphaerocystis* *F.crotonensis* *P. umbonatum*	F P Lo
Liverovici	4×10^3	*C. comensis* *C. glomerata* *Ceratium*	A A Lo	7×10^4	*Sphaerocystis* *F.crotonensis* *P. umbonatum*	F P Lo
Skadar	$2\text{-}6 \times 10^5$	*C. glomerata* *A. formosa* *F.crotonensis* *Ceratium*	A C P Lo	$1\text{–}2 \times 10^6$	*Scenedesmus* *Crucigeniela* *Mycrocystis* *Pandorina* *Anabaena*	J J M, G H_1

was the case for the oligotrophic moutain lakes, Biogradsko, Crno and Zmijinje. Bacillariophyta still numerically dominated, but the proportion of *Asterionella formosa* (group **C**) has been reduced in favor of small *Cyclotella* species (**A** group). The predominance of oligotrophic indicator species and the similarity in phytoplankton abundance showed that the oligotrophic character of these mountain lakes had not changed with time. The values of chlorophyll *a* concentration and TSI comply with this assumption. The reasons for species replacements other than eutrophication include changing contributions to different functional groups, shifting nutrient requirements and grazing pressure (Dokulil and Teubner, 2003).

In only one of the studied lakes, Piva reservoir, had phytoplankton abundance declined (2-3 orders of magnitude) in comparison with former times (Table 4). This was probably due to the stabilization of the reservoir as a consequence of the consumption of nutrients that were present in higher concentration at the beginning of the reservoir formation. Reservoirs formed by river impoundment undergo great changes in trophic levels during the early stages of their formation when a new ecological balance is established (Thornton et al., 1996). The release of organically bound elements from flooded vegetation and soils could result in an initial high level of biological production (sometimes called a trophic surge), suggesting a very different trophic level than would actually be seen in the future. That was probably the case with Piva in the first years of the reservoir's formation, considering the distinctly higher phytoplankton density than at the present time (1 x 10^6 cells/l). The duration of this increased productivity varies with the amounts of source material present within the flooded river basin, the nature of the soils and previous land uses, and the elemental concentrations in the source waters. At the present time, Piva reservoir has probably reached an ecological equilibrium and established a stable phytoplankton community with lower abundance (8.6 x 10^3 cells/l) and the domination of Bacillariophyta (*Cyclotella glomerata*, *Cyclotella comensis*) and Dinophyta (*Peridinium* species). The low total abundance and the type of dominant functional groups (**A** and **Lo**) were a consequence of the very poor lakebed and specific morphometry of the reservoir that resulted in oligotrophy. The last complies with the trophic state indicators (TSI and chlorophyll *a* concentration).

In all the other studied reservoirs, phytoplankton abundance increased (1-2 orders of magnitude) in comparison with former times (Table 4). Diatoms (**A** group) have decreased in importance while greens (**F** group) have increased in both absolute and relative abundance. The latter was the most expressed in Plavsko Lake where **F** species comprised more than 95% of the total phytoplankton abundance. Besides, within the diatoms, there was observed a shift from group **A** to group **P**, the latter usually being associated with higher trophic states. The observed shift in phytoplankton species suggests an increase in the trophic status of these lakes. Trophic state indicators (chlorophyll *a* concentration and TSI) confirmed this assumption.

Lake Skadar showed the most distinct changes in phytoplankton community structure. Here, Bacillariophyta were replaced by Chlorophyta and Cyanobacteria belonging to functional groups with higher nutrient demands than was the case in the other lakes. Previously dominant functional groups (Table 4) were indicators of mesotrophy. Species dominant now (**J**, **M** and **G**) are characteristic for shallow, mixed and nutrient-rich lakes. This suggests that the trophic level of Lake Skadar has distinctly increased in the last 2 decades and that the lake has generally deteriorated. Observed changes were in agreement with the trophic level indicated by observed chlorophyll *a* concentration and TSI value (eutrophy).

Considering this study comprised only one season (data represent only summer values of the studied parameters) and was carried out after a long break in the phytoplankton investigations of Montenegrin lakes, the obtained results should be nonetheless interpreted with caution and improved through detailed comprehensive investigations in future. Currently it is difficult to say if the observed changes are a symptom of water quality deterioration as a result of the growing human impact, or a phase in a cyclic course, or – perhaps – it is somehow related to more favourable weather conditions. Long-term monitoring with high temporal resolution, including other members of pelagic biocenosis, is required to separate natural sources of variability from the effects of anthropogenic disturbance.

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