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PHYTOPLANKTON DISTRIBUTION AND ABUNDANCE IN RELATION TO PHYSICO-CHEMICAL FACTORS IN LAKE SEVAN, ARMENIA

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ABSTRACT

Soviet-era geoengineering projects initiated in the 1930's resulted in a dramatic lowering of water levels in Lake Sevan, Republic of Armenia. This process promoted eutrophication. Marked increases in the level of nitrogen and synchronous decreases in that of phosphorus in the lake were reflected by qualitative and quantitative changes in the structure of the phytoplankton community. We monitored phytoplankton (biomass, abundance, and concentrations of chlorophyll-a), water transparency and temperature, and concentrations of phosphorus and nitrogen at two sites (Major and Minor Sevan) in Lake Sevan during June-October 2005. During the study period, the successional development of phytoplankton exhibited a dominance of *Chlorophyta* in early summer, *Cyanophyta* in mid- and late summer, and of *Bacillariophyta* in autumn. Concentrations of chlorophyll-*a* (Chl-*a*) were greatest at depths of 10-20 *m* (euphotic zone) of the lake. Statistic analysis indicates a strong and positive correlation between phytoplankton biomass and Chl-*a* concentration in Major Sevan, and a weak but positive correlation between those variables in Minor Sevan. A negative correlation between the average values of Chl-*a* and the ratio of N:P was observed in both sites of the lake. *Cyanobacteria* abundance was positively correlated with the ratio of N:P in Major Sevan, and cyanobacterial average biomass was positively correlated with the nitrogen content of the water in Minor Sevan. The analysis of the average values of phytoplankton biomass and those of its individual taxonomic groups indicates that the development of the phytoplankton community was conditioned by the development of green algae in Minor Sevan, and by diatoms in Major Sevan. The presence of toxic cyanobacterial taxa in the community illustrates the non-stable state of phytocenosis of Lake Sevan. Our study provides a baseline with which we can monitor the rehabilitation of Lake Sevan by examining its phytoplankton community.

Key words: *phytoplankton, algae, density, biomass, vertical distribution, chlorophyll-a, nutrients*

INTRODUCTION

Phytoplankton occupy the base of the traditional food web and represent an important source of organic matter in aquatic ecosystems. The structure and functional properties of phytoplankton usually reflect the trophic state of an aquatic ecosystem [1, 16, 19, 21, 25, 26].

Lake Sevan is a high-mountainous freshwater reservoir in the Republic of Armenia (*Fig. 1*). It consists of two morphometrically different parts – the deeper Minor and comparatively shallow Major Sevan. Lake Sevan is the largest freshwater reservoir in the Caucasian region and thus has strategic consideration the economy of the Armenian Republic [4]. Originally in its natural regime Lake Sevan was considered a unique water reservoir. It was characterized by anomalous high phosphorus concentrations and low nitrogen concentrations. Phytoplankton was characterized by poor taxonomic structure and low quantity indices in that period [16, 21]. Representatives of *Bacillariophyta* had the greatest contribution, leading to winter-spring and autumn quantitative maxima. Phylum *Chlorophyta* was in second place quantitatively, although it had the greatest taxonomic diversity. One of the typical features of Lake Sevan was the low quantitative and qualitative development of *Cyanophyta*.

Soviet-era geoengineering projects initiated in the 1930's resulted in a dramatic lowering of water levels in the lake, a process that promoted eutrophication [4]. Marked increases in level of nitrogen and synchronous decreases in that of phosphorus in the lake were reflected by qualitative and quantitative changes in the structure of the phytoplankton community. Particularly significant changes have been recorded for the period 1956-1960, when the level of the lake was lowered by 12 *m* [4, 9] and eutrophication processes increased in the lake. Several reorganizations have occurred in the lake phytoplankton community: it was enriched with new species, especially from phyla *Chlorophyta* and *Cyanophyta*, and some typical species disappeared. The most serious changes in the phytoplankton community have been recorded since 1964, when water level was lowered an additional 4-5 *m*, and "blooms" of cyanobacterial species (*Anabaena lemmermanii, A.flos-aquae, Aphanizomenon flos-aquae*) occurred in the lake up until the end of 1970s. Qualitative and quantitative changes in the phytoplankton continued in that period. In general, the phytoplankton community was dominated by diatoms up to 1983, and then by green algae in the second half of 1980s. Primary production by phytoplankton increased and then decreased in the process of eutrophication [2, 5, 7, 9-12, 16, 21]. Recent attempts to rehabilitate the lake to its natural regime by gradually raising of the water level will undoubtedly lead to new reconstructions in the phytoplankton community.

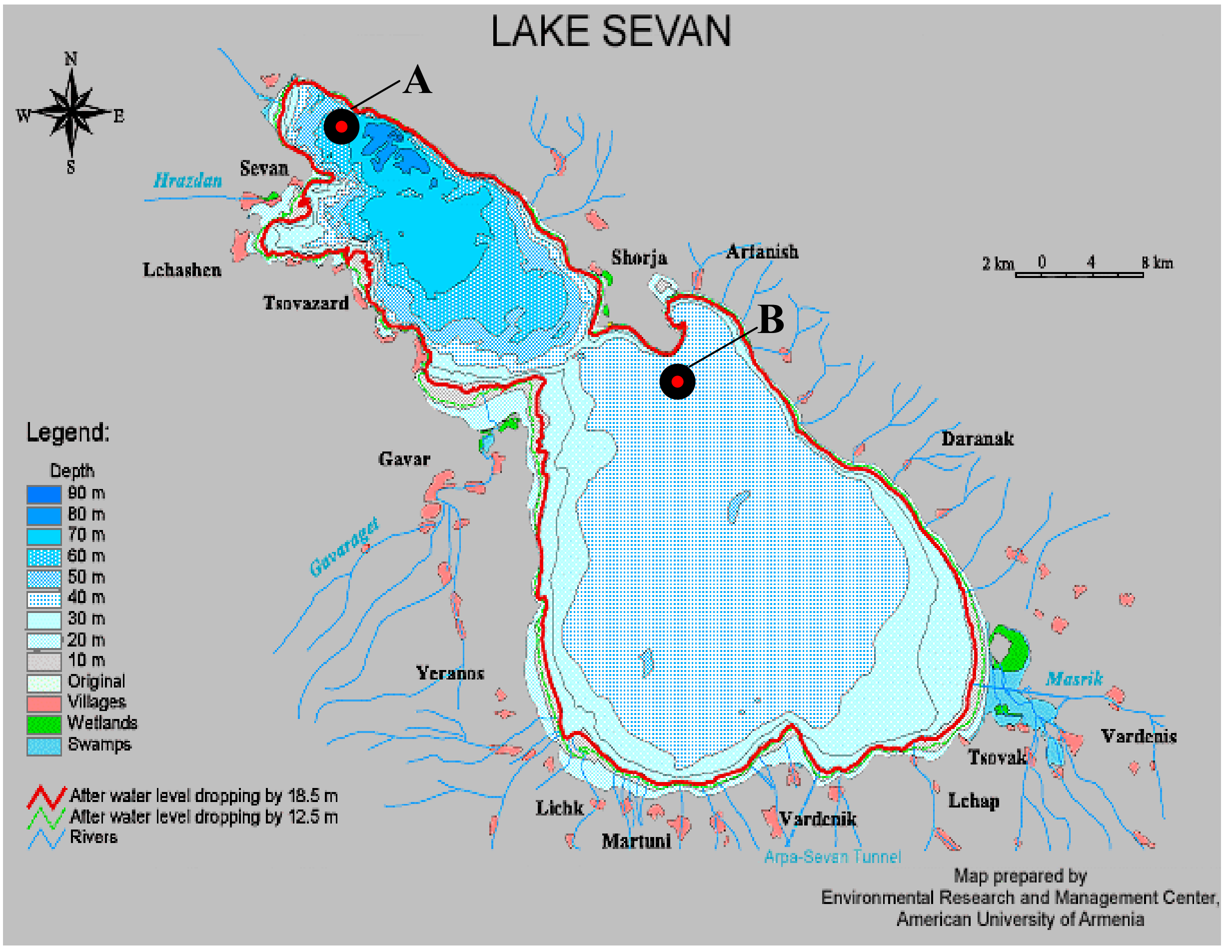


Fig. 1. Map of Lake Sevan, Republic of Armenia. A - site N 4 (Minor Sevan), B - site N 22 (Major Sevan). Map prepared by Enviromental Research and Management Center, American University of Armenia.

The purpose of this study was to determine the vertical distribution and abundance of phytoplankton in relation to several abiotic factors (water temperature, transparency, nitrogen and phosphorus concentrations etc.). Understanding these relationships will make it possible to work out relevant measures for controlling the eutrophication processes, in the lake, and therefore enhance rehabilitation.

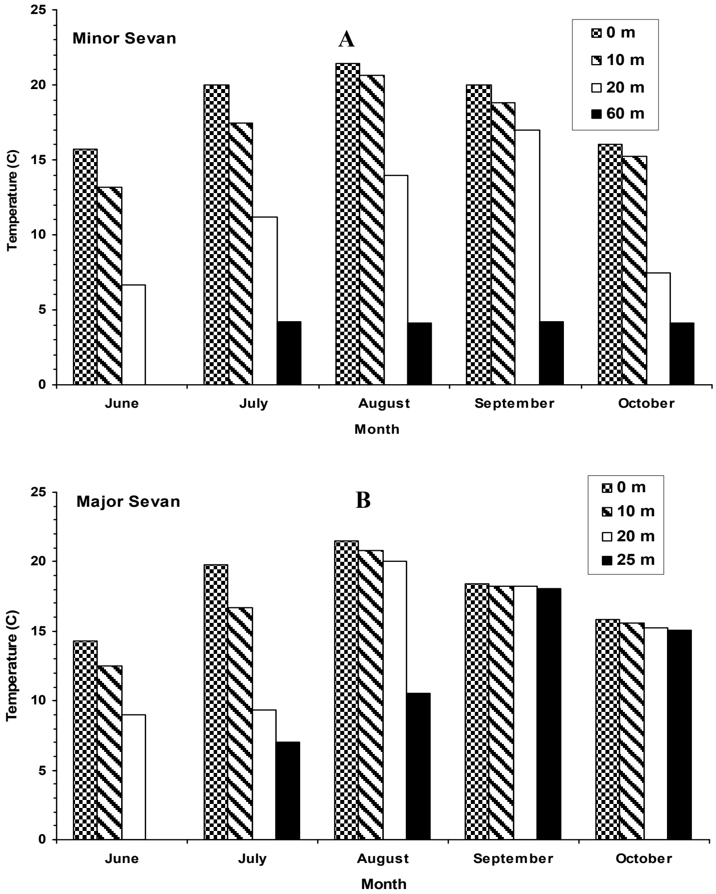
MATERIALS AND METHODS

Phytoplankton and water for Chl-a quantification were collected between June to October, 2005 using a Ruttner type sample bottle from four depths (0, 10, 20 *m* and bottom zone) in two regions of Lake Sevan: Minor Sevan site №4 and Major Sevan site №22 (*Fig. 1*). Samples were not taken from bottom zone in both sites of the lake in June or from bottom zone in Major Sevan in October. Phytoplankton samples were preserved in a 4% formalin solution and analyzed according to sedimentation method [1, 17]. Planktonic algae were identified using relevant keys [14, 20, 28]. For this study, phytoplankton were assigned to three groups: *Chlorophyta*, *Cyanophyta*, *Bacillariophyta*. Phytoplankton enumeration was determined by direct counts with biomass estimates made according to the individual volumes of species. For determination of phytoplankton volumes each cell was assimilated to a certain geometrical figure. The volume of each species was determined by mean of relevant measurements and formulae [1].
Water for chlorophyll-a (Chl-a) determination was stored in the dark until returned to the laboratory. Chl-a was determined using the acetone extraction procedure by spectra-photometrical method [1]. In total, 107 samples were analyzed.
Simultaneously, several physical and chemical variables were measured. Water transparency was measured using Secchi disc, and pH was determined electrochemically using glass combination electrode [23]. All the chemical reagents used were of analytical grade and the reagent water used was distilled water [8, 23]. For determination of dissolved oxygen the volumetric method was used [8, 23]. Concentration of NH_4^+ was measured by direct Nesslerization

[8, 23]. Determination of NO_2^- was implemented by reaction of nitrite with a Greece type reagent, NO_3^- – by cadmium redaction method and determination as nitrite ion, and PO_4^{3-} was determined by the ammonium molybdate method [8, 23]. All the ions determination was implemented using UV-VIS Spectrophotometer (Shimadzu 1650PC) 5 *cm* path length quartz cell [23]. Permanganate oxidizability (PO) was determined by volumetric methods.
Univariate regression analyses were conducted to determine the relationships between phytoplankton abundance and the abiotic and biotic factors we measured. *MULTIPLY STATISTICA* program was used for statistical analyses.

RESULTS

The average index of temperature was 13.2°*C* in Minor Sevan and 15.4°*C* in Major Sevan (*Fig. 2*). Annual temperature ranged from 4.1 to 21.4°*C* in Minor Sevan and from 7.0 to 21.5°*C* in Major Sevan. Minor Sevan was characterized by well expressed temperature stratification during the study period. In contrast, stratification was comparatively weak in Major Sevan and only occurred during summer. Associated with warmest water temperatures was conditioned dominance of cyanophyte *Aphanothece clathrata* during August and September in Minor Sevan (15°*C*) and during August in Major Sevan (18.2°*C*) [18]. Water transparency was highest during July (11 *m* in Minor Sevan and 12 *m* in Major Sevan), when the abundance of phytoplankton decreased by more than half of the maximum (*Fig. 3-5*).



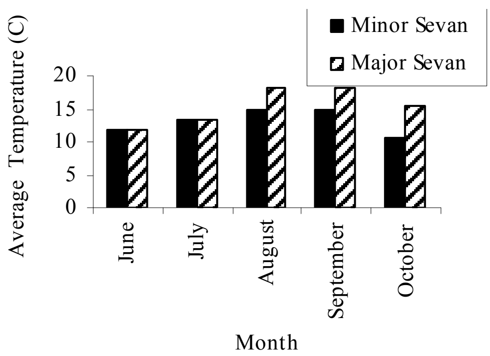


Fig. 2. Temperature values in Lake Sevan in 2005. A - Minor Sevan, B – Major Sevan, C – Lake Sevan.

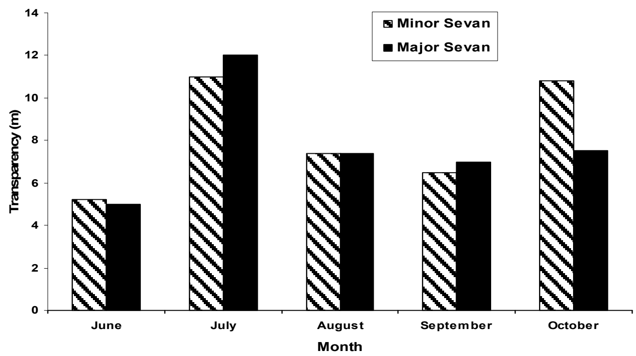


Fig. 3. Transparency values in Lake Sevan in 2005.

The comparative abundances of the three major groups changed during the season. *Chlorophyta* dominated the phytoplankton at all depths in Minor Sevan during June (no samples taken at 60 *m*, however) and July (*Fig. 4, 6*). *Cyanophyta* dominated in August at all depths, and *Aphanothece clathrata* was identified as the most abundant species. *Bacillariophyta* dominated the phytoplankton at all depths in October. Total density during the study period varied with depth. Density was greatest at 0 *m* in September, at 10 *m* in June, at 20 *m* and 60 *m* in October. Overall, the maximal total density recorded was in October at 20 *m* (997,000 L^{-1}).

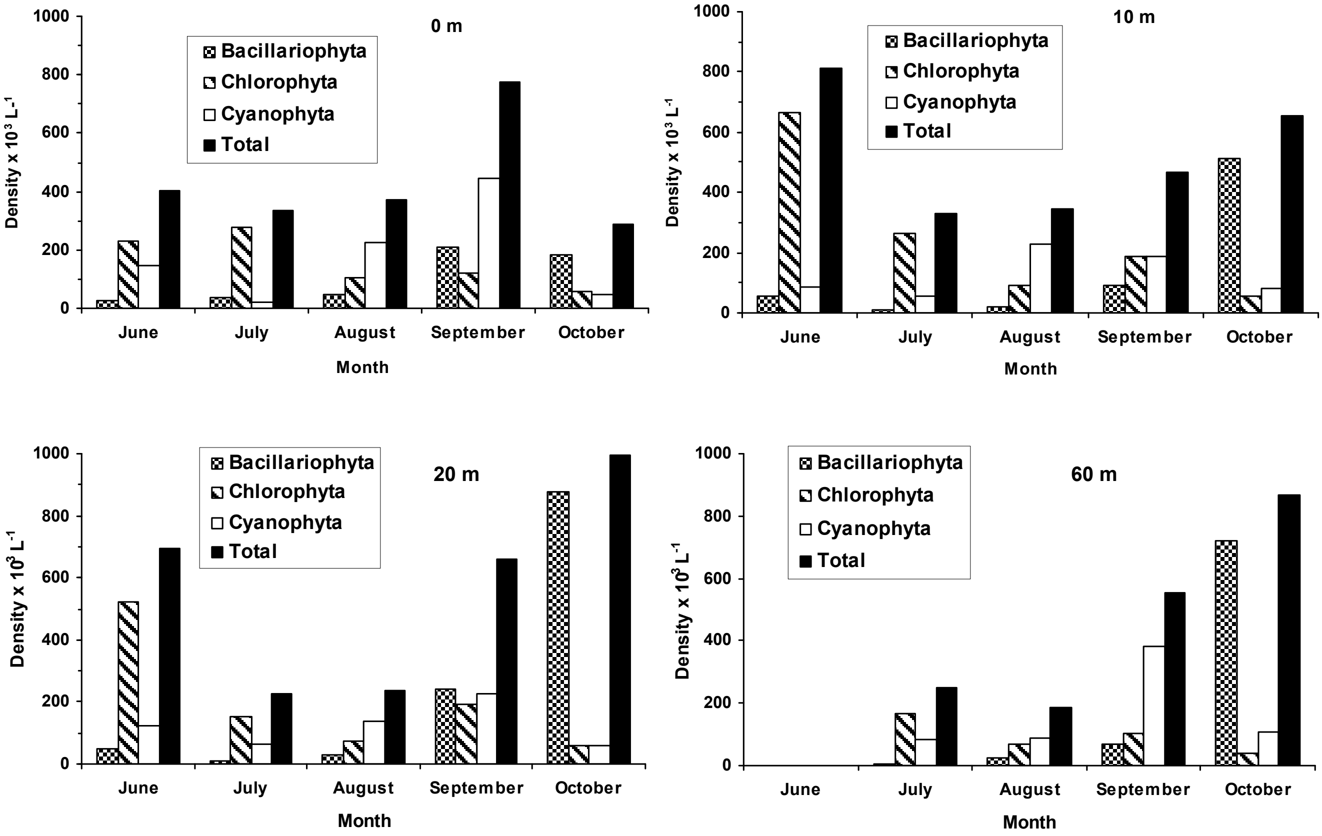


Fig. 4. Distribution of phytoplankton density in 2005 in Minor Sevan.

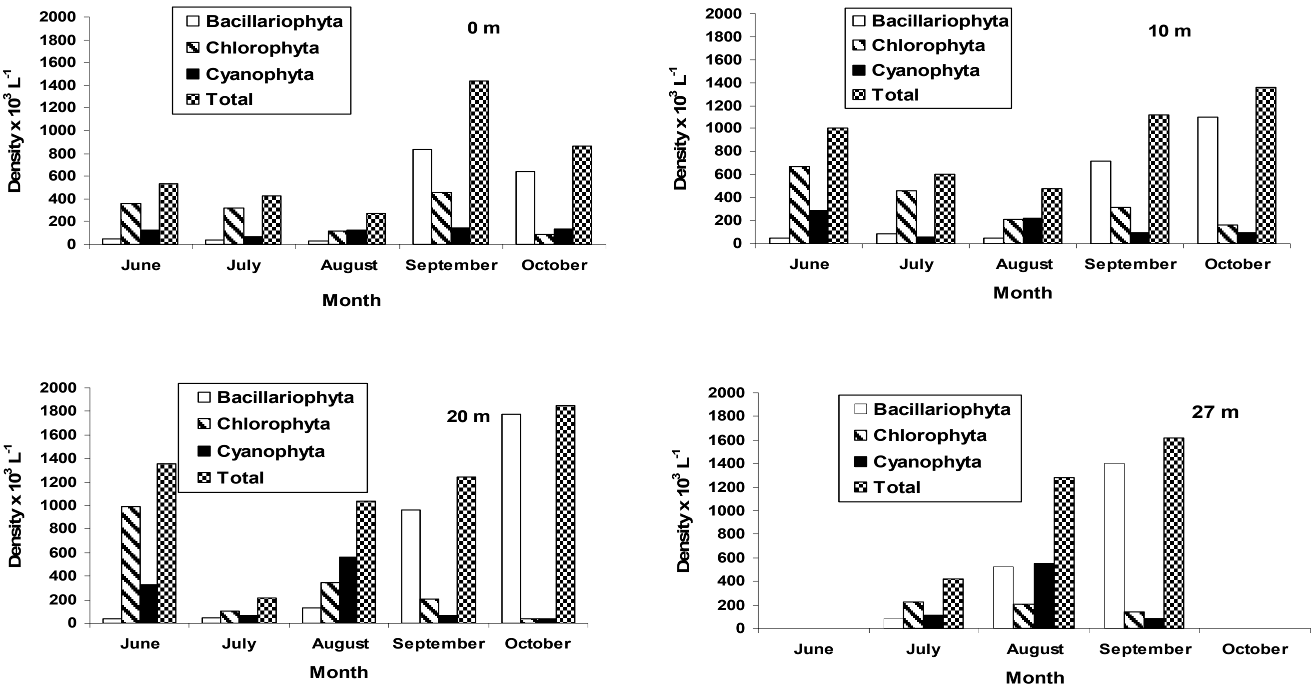


Fig. 5. Distribution of phytoplankton density in 2005 in Major Sevan.

Phytoplankton densities at 0-20 *m* were generally higher in Major Sevan than in Minor Sevan (*Fig. 4, 5*). Although samples were obtained from 0-25 *m* in Major Sevan (as opposed to 0–60 *m* in Minor Sevan), similar patterns with respect to comparative abundances during the study period (*Fig. 4, 5*). *Chlorophyta* dominated the phytoplankton at all depths during June and July, *Cyanophyta* dominated at all depths in August, and *Bacillariophyta* dominated at all depths in September and October. Maximal total density occurred during October at 20 *m* (1851 x 10^3 L^{-1}). On the whole green algae dominated in summer season and representatives of genus *Oocystis* (*O. lacustris, O. gigas, O. submarina, O. Novae-Semliae, O. solitaria, O. elliptica*) dominated the community [3]. In autumn, *Melosira granulata* was the dominant species and *Bacillariophyta* was the dominant phylum of the community. Green algae *Coelastrum microporum* and cyanophytes *Aphanothece clathrata* and *Microcystis aeruginosa* were also comparatively abundant.

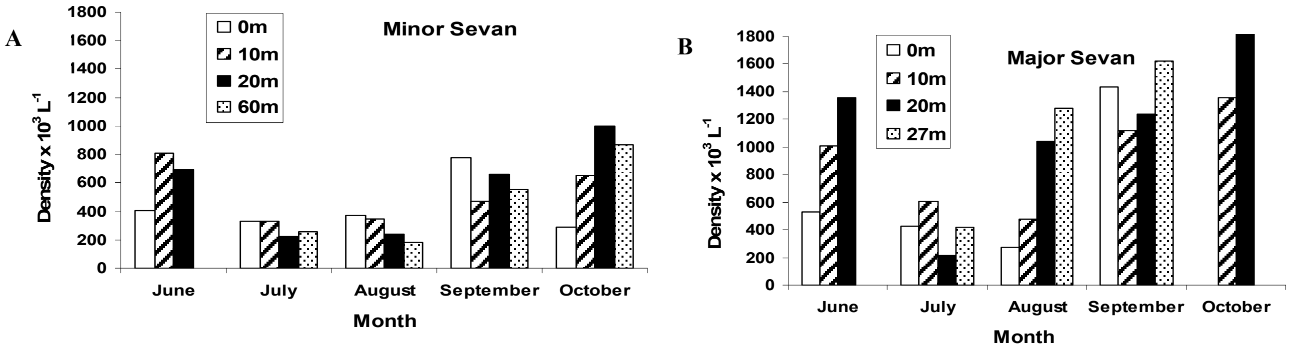


Fig. 6. Distribution of phytoplankton density in 2005 in Lake Sevan. A - Minor Sevan, B – Major Sevan.

Distribution of phytoplankton biomass also varied during the season (*Fig. 7-9*). In Minor Sevan maximal biomass was recorded at 10 *m* in June, at 0 *m* in July, and at 20 *m* in September and October. Biomass at all depths was generally least in August. In Major Sevan maximal biomass occurred at 20 *m* in June, at 10 *m* in July, at 25 *m* in August and September, and at 20 *m* in October. Biomass was not measured at 25 *m* in October. Mean biomass for the study period was 2.19 $g\ m^{-3}$. A similar distribution was recorded as part of previous investigations [5, 9].

Phytoplankton were mainly distributed at depths of 10-20 *m* in Minor Sevan and below 10 *m* in Major Sevan (*Fig. 9*). Maximal biomass was recorded at 20 *m* at both sites with averages of 2.19 $g\ m^{-3}$ in Minor Sevan and 2.73 $g\ m^{-3}$ in Major Sevan.

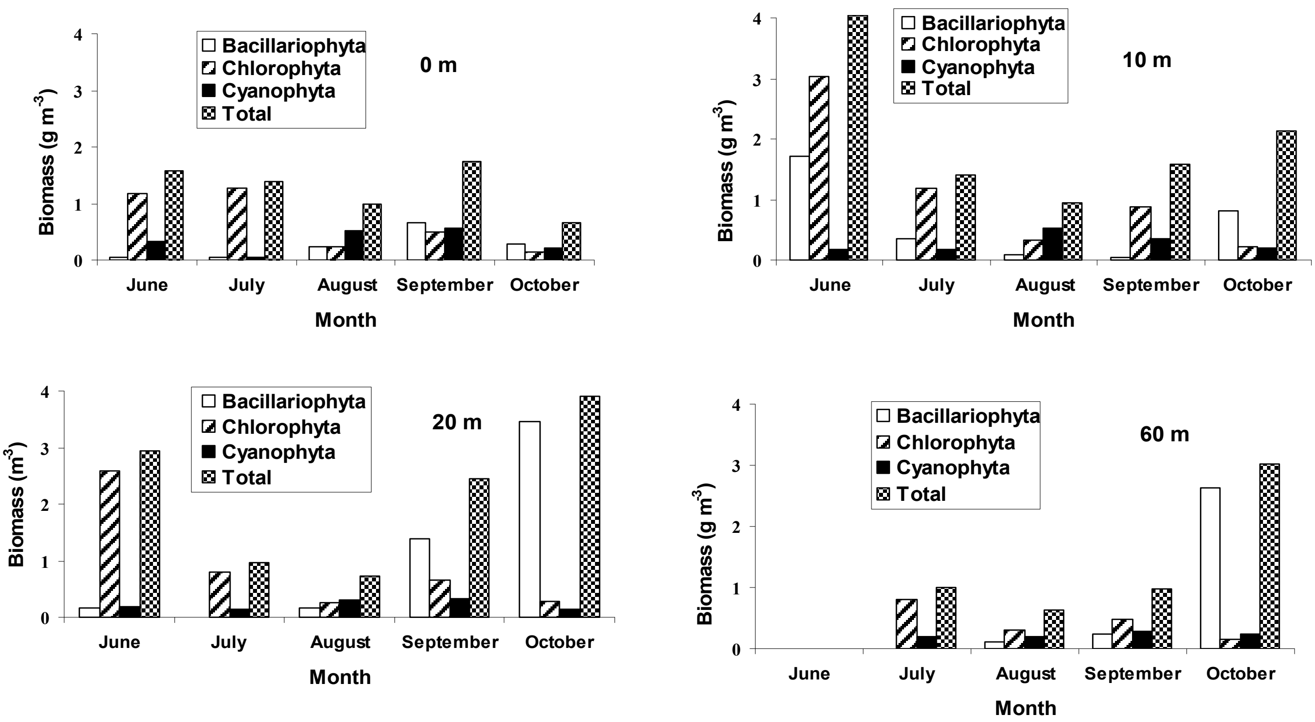


Fig. 7. Distribution of phytoplankton biomass in 2005 in Minor Sevan.

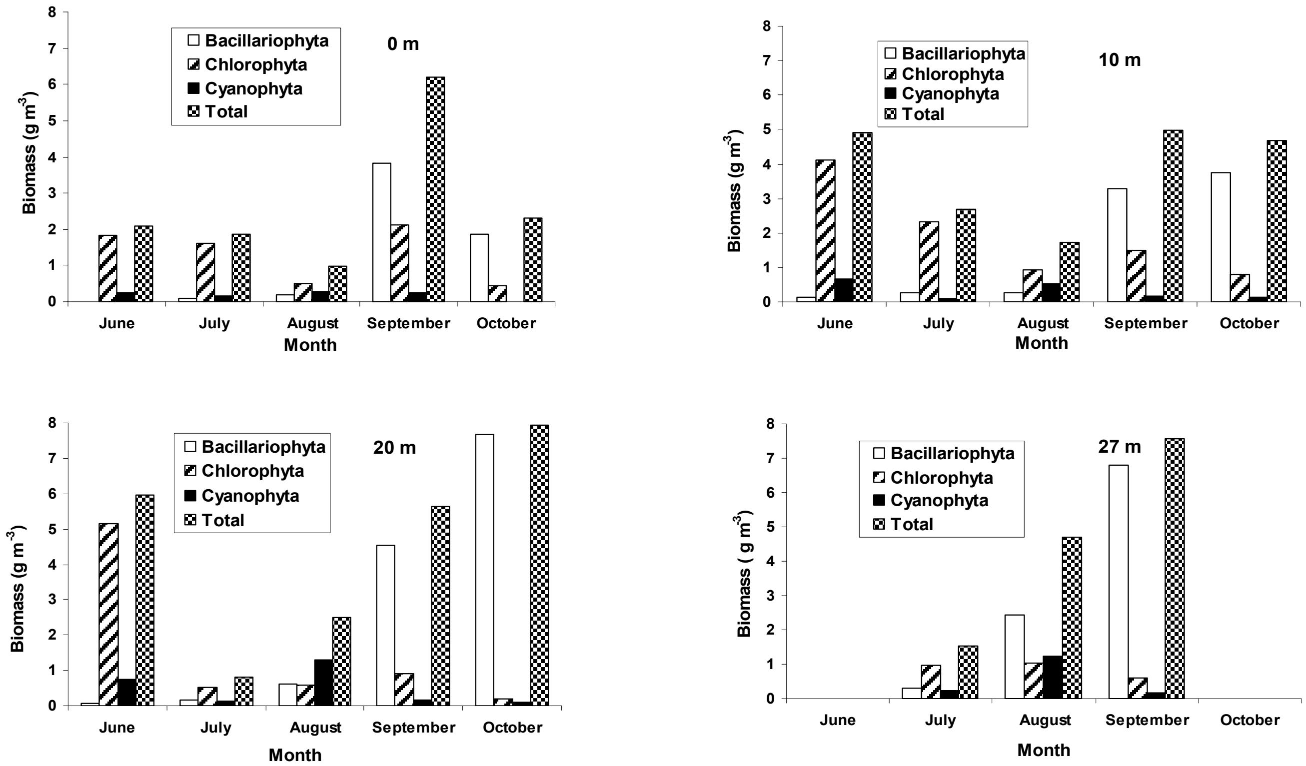


Fig. 8. Distribution of phytoplankton biomass in 2005 in Major Sevan.

Similarly, Chl-*a* concentrations were greatest at depths of 10-20 *m* (euphotic zone) of the lake, whereas minimal values were recorded at the bottom area (*Fig. 10*). The annual average value of Chl-*a* in Minor Sevan (1.12 $\mu g\ L^{-1}$) was about half of that for Major Sevan (2.11 $\mu g\ L^{-1}$). Chl-*a* concentration during the study year varied more in Major Sevan (range: 0.49-4.89 $\mu g\ L^{-1}$) than in Minor Sevan (range: 0.38-1.98 $\mu g\ L^{-1}$).

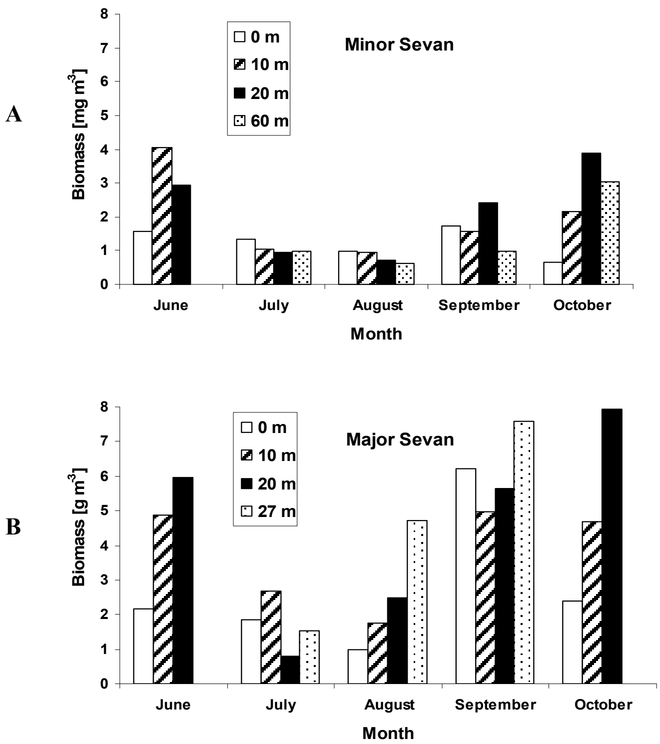


Fig. 9. Distribution of phytoplankton biomass in Lake Sevan in 2005. A - Minor Sevan, B – Major Sevan.

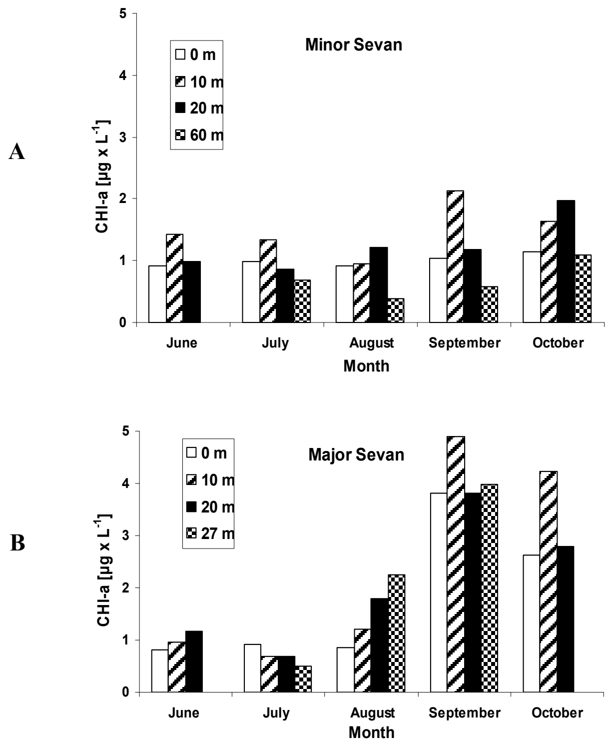


Fig. 10. Distribution of phytoplankton according to Chl-a quantity. A – Minor Sevan, B – Major Sevan.

The distribution of nutrients also varied by season and depth (*Fig. 11, 12*). Overall, the nitrogen concentrations were greatest in the bottom zone and least in surface waters. Phosphorus was mainly allocated at 20m to the bottom zone. The annual fluctuations of nitrogen in the lake water were from 0 to 0.475 *mg* L^{-1} (0.005-0.127 *mg* L^{-1} range for seasonal average), and for phosphorus from 0 to 0.140 (0,003-0.047 range for seasonal average).The average values of biogenic elements in Minor Sevan (0.053 *mg* L^{-1} nitrogen and 0.210 *mg* L^{-1} phosphorus) exceeded those in the other part of the lake (0.078 *mg* L^{-1} nitrogen and 0.019 *mg* L^{-1} phosphorus). The maximal values of nitrogen and phosphorus (0.475 and 0.140 *mg* L^{-1} respectively) in Minor Sevan were recorded in September in the bottom zone. The mean maximal values of biogenic elements also were recorded in September: 0.127 and 0.047 *mg* L^{-1} respectively. In Major Sevan the maximal values of nitrogen (0.231 *mg* L^{-1}) and phosphorus (0.062 *mg* L^{-1}) were in August in the bottom zone, whereas their mean maximal indices were recorded in July (0.088 and 0.033 *mg* L^{-1} respectively). Both elements had their least values in July in Minor Sevan. Nitrogen had its minimal value in October in Major Sevan, when an insignificant concentration (0.019 *mg* L^{-1}) was recorded only in the bottom zone, and there was not recorded any quantity in the other depths.

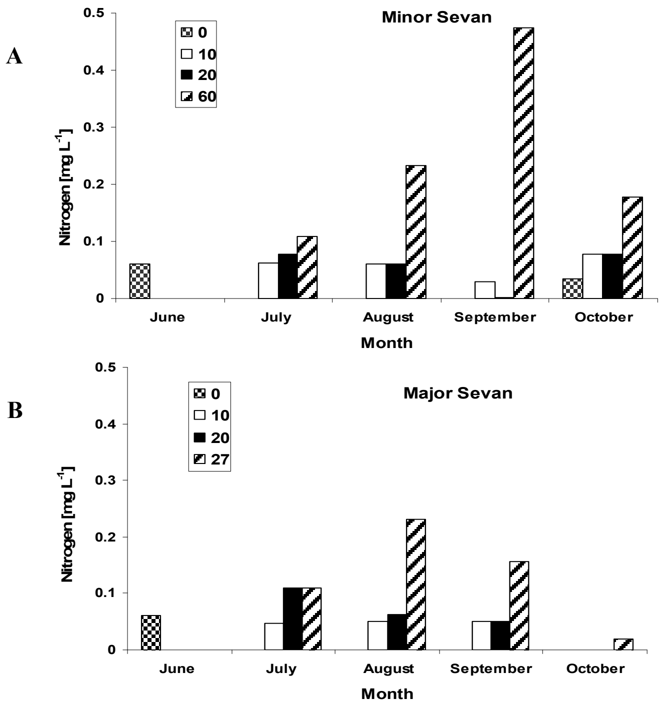


Fig. 11. Distribution of nitrogen in Lake Sevan in 2005. A – Minor Sevan, B – Major Sevan.

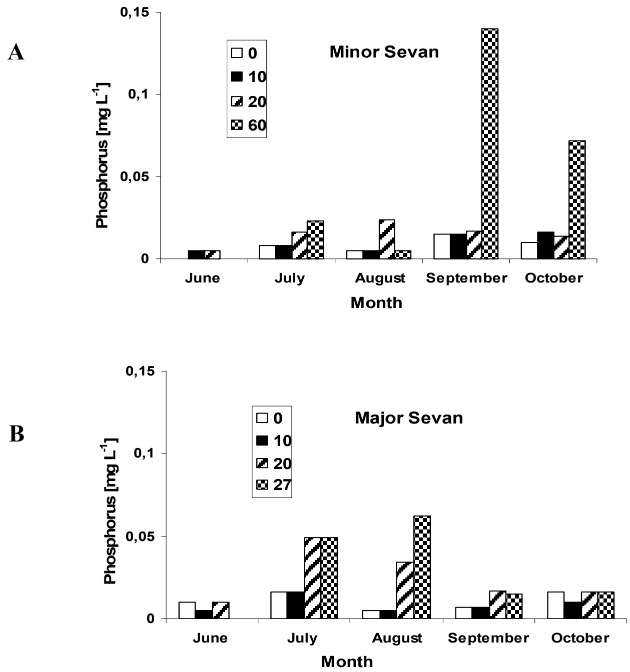


Fig. 12. Distribution of phosphorus by month in Lake Sevan in 2005. A – Minor Sevan, B – Major Sevan

Regression analyses indicated that during the study period of 2005 in Major Sevan, a strongly positive correlation (r=0.84) between the average values of phytoplankton biomass and Chl-a occurred, whereas in Minor Sevan this correlation was less pronounced (r=0.54). Monthly analyses indicated that such strong relationships were rare in both parts of the lake: in June in Minor Sevan (r=0.90) and in June and August in Major Sevan (r=0.93 and 0.95, respectti-vely). Average Chl-*a* concentration was moderately correlated (r=0.56) with phosphorus concentration in Minor Sevan, a comparatively strong association was observed for Major Sevan (r=0.87). Nitrogen content and Chl-*a* concentration were positively correlated (r=0.90) only during August in Major Sevan, whereas during previous months a negative correlation was observed. In Minor Sevan, these two variables were negatively correlated. In 2005, negative correla-tions between the average values of Chl-*a* and the ratio of N:P were observed in both basins. With respect to individual phytoplankton taxa, average biomass of cyanobacteria was strongly associated with N:P in Major Sevan. Average bio-mass of cyanobacteria was moderately associated with nitrogen content in Minor Sevan (r=0.58). No other strong statistical associations were observed between other taxa and the physical/chemical variables measured.

In Major Sevan, water temperature and Chl-*a* concentration were positively related only during July. In contrast, these variables were negatively correlated during June and August. Further, water temperature and Chl-*a* and water tempera-ture were positively correlated in Minor Sevan from July to September. A similar relationship was recorded between phytoplankton biomass and water temperature. The analysis of average values revealed a dependence of Chl-*a* concent-ration on water temperature in Major Sevan.

Dependence between temperature and blue-green bacteria biomass was revealed in Minor Sevan, and dependence between temperature and diatom biomass in Major Sevan. A positive association between Chl-*a* and green algae biomass was observed in most instances (with the exception of August in Minor Sevan and July and September Major Sevan). Positive associations between Chl-*a* concentration and the respective biomasses of diatoms and cyanobactera were rare. Moreover, a negative association between Chl-*a* concentration and biomass of cyanobacteria was recorded in Minor Sevan. The analysis of the average values indicated a strong dependence between the diatom algae biomass and the Chl-*a* concentration in both parts of the lake.

The analysis of the average values of phytoplankton community biomass and those of its major taxonomic groups indicated that in Minor Sevan the development of the entire community was conditioned by the development of green algae, like as in the periods of stabilization and recurring lowering. In Major Sevan development was dominated by diatoms, which is similar to the period up to 1985.

DISCUSSION

Eutrophication of freshwater bodies is a very important issue for many regions. Increasing anthropogenic load and pollution create conditions for ecosystems degradation. In this connection "blooms" of *Cyanobacteria* deteriorate the water quality and pollute the water body with toxins dangerous for hydribionts and man [15]. Vertical distributions of phytoplankton in lake ecosystems depend on a range of abiotic and biotic factors such as basin morphometry, dynamics of water masses, light, temperature, availability of nutrients, and food web dynamics [16, 19, 22, 29].

During June in Minor Sevan, maximal phytoplankton biomass of >4 $g\ m^{-3}$ was recorded at 10 *m*, whereas surface waters supported the lowest biomass. July and August were marked by an increase in temperature and transparency, and a concomitant reduction in phytoplankton biomass. Phytoplankton was mainly accumulated at the surface. At the same time well expressed temperature stratification was observed. The biomass of the dominant group and the phytoplankton community as a whole did not depend on nitrogen content, because the maximal concentration of nitrogen was at the bottom zone whereas the maximal concentration of phosphorus was at 20 *m*. These trends in phytoplankton may have been influenced by the ratio N:P rather than nitrogen or phosphorus separately because the ratio has considerable influence on phytoplankton nutrition and reproduction [24]. From June to July, green algae (*Chlorophyta*) dominated at all depths and *Cyanophyta* dominated during August. In Major Sevan the development regime of planktonic algae was similar.

In autumn, phytoplankton in Minor Sevan were distributed mostly at the depths of 20-60 *m* (60 *m* is the bottom layer of Minor Sevan). In September, maximal biomass was recorded at 20 *m* whereas biomass was lowest associated with the bottom depths. The highest values of nutrients were in the bottom area. This can be due to more intensive consumption of these nutrients by planktonic algae at 20 *m*. During September the average water temperature remained stable, and blue-green algae were still the dominant group. Among all phytoplankton, the diatom *Melosira granulata* was most abundant [3], and exhibited maximal accumulation at 20 *m* with little *M. granulata* detected at the bottom. This coincides with the beginning of the vegetative period for this species.

Phytoplankton *Melosira, Oocystis, Anabaena,* and *Microcystis* sp. dominated the phytoplankton community during 2005. These taxa were species-indicators of eutrophication during different stages of the lake eutrophication. Only *Aphanothece clathrata* has been typical for Lake Sevan since its oligotrophic stage. According to Kazaryan [5], representatives of genus *Oocystis* had the greatest abundance among the *Chlorophyta* during 1970s, depressing the previous dominant taxon. During our investigation period species of genus *Oocystis* have always been among the most abundant recorded in the lake. According to Vladimirova [21] Lake Sevan during its oligotroph period was characterized by the absence of several taxa, (e.g., *Anabaena* sp. [Cyanophyta], *Melosira* sp., and *Tabellaria* sp. [*Bacillariophyta*]), that are typical for the majority of West European lakes. Those taxa entered into the lake from bays when the water level was lowered and have developed considerably. Our investigations also have revealed the presence of *Tabellaria* sp. in the lake although it had little contribution on the quantity of the community. The diatom *Melosira* sp., was first recorded in the lake in 1966 and by the 1970s was displaying great quantitative development. During 2005 *Melosira* sp. also had a dominant position in autumn phytoplankton. Two representatives of the genus *Anabaena* (*A. flos-aquae* and *A. lemmermanii*) exhibited seasonal "blooms" from 1964 until the 1970s, corresponding to the most eutrophic period of the lake.

Noticeable growth of *Cyanobacteria*, including toxic representatives (e.g. *Anabaena* sp., *Aphanizomenon* sp., and *Microcystis* sp.) was recorded in 2005 during conditions of increased temperature and changes in nutrient regime. This result indicates that in favorable conditions "blooms" can be re-occur in the lake, as an increase in water level may lead to further enrichment of the lake with additional quantity of biogenic elements. Compared to previous years [2], biomass of the green algae *Binuclearia lauterbonii*, was reduced in the present study. This species was first recorded in the lake in 1983, had great quantitative development during the recurring lowering of lake level, and was the dominant phytoplankton species in spring and summer [2]. In 2005 *B. lauterbonii* was recorded occasionally with very low quantitative indices.

One of the important expressions of Lake Sevan eutrophication was the phytoplankton quantity increase: 0.2-0.5 $g\ m^{-3}$ (1937-1962), 2.0-3.0 $g\ m^{-3}$ (1976-1983), 2.4 $g\ m^{-3}$ (1995-1999) and 3.8 $g\ m^{-3}$ (2005) [2-4, 10, this study].

Chlorophyll-a concentration was similar to that of algae biomass in that it was greatest at depths of 10-20 m in the euphotic zone and minimal index at bottom waters. This testifies to a strong dependence between these two variables and high indices of water transparency and light conditions. Chlorophyll a is the main photosynthetic pigment of planktonic algae (irrespective of their taxonomy), thus providing a tool to assess the trophic status of a hydroecosystem [1, 12, 27]. According to Parparov [12] during 1975 Chl-*a* average concentration was 7.8 $\mu g\ L^{-1}$ in Minor Sevan and 9.4

$\mu g\ L^{-1}$ in Major Sevan. Based on Chl-*a* mean value of 6.0 $\mu g\ L^{-1}$ the author classified Lake Sevan as mesothrophic, although "blooms" of Cyanobacteria were recorded. Our results indicate that Chl-*a* concentrations have decreased (1.12 $\mu g\ L^{-1}$ in Minor Sevan and 2.11 $\mu g\ L^{-1}$ in Major Sevan), but Lake Sevan can still be classified as mesotrophic. Some quantity of Chl-*a* has been recorded even at the bottom waters. Lake Sevan was always characterized by the presence and normal vegetation of planktonic algae in the deepest waters.

The average seasonal value of Chl-*a* of phytoplankton depends on phytoplankton biomass and the total quantity of phosphorus [19]. Our results did not meet this expectation. In Minor Sevan, a slight and positive association occurred between Chl-*a* and phosphorus, whereas in Major Sevan, a negative association was observed. During the period of 1959-1978, concerns over eutrophication in Lake Sevan were addressed by targeting a decrease of phosphorus concentrations with a synchronous increase of nitrogen concentration. Correspondingly, an increase of N:P ratio was observed [4]. Hovhannisyan's [4] results indicate that nitrogen had the most important role in the eutrophication of Lake Sevan during that period, while during the recurring lowering of the lake water level the main consideration in eutrophication process was phosphorus [2].

In 2005, a negative association between the average values of Chl-*a* and the ratio of N:P was observed. Dependence on N:P was observed only for *Cyanobacteria* in Major Sevan, and a slight dependence of cyanobacterial average biomass was observed in relation to the nitrogen content in lake water in Minor Sevan.

Several researchers have shown that the average seasonal values of Chl-*a* concentration are higher in green algae than in other groups of algae [19]. Again, our results did not meet this expectation. In 2005, a positive association with high regression coefficients between Chl-*a* concentration and green algae biomass was observed (with the exception of August in Minor Sevan and July and September in Major Sevan). In contrast, dependence between Chl-*a* concentration and the respective biomasses of diatoms and cyanobacteria were rare. Moreover, a negative association between Chl-*a* concentration on cyanobacteria biomass was recorded in Major Sevan. The analysis of the average values has shown some dependence between the diatom algae biomass and the Chl-*a* concentration in both parts of the lake.

The analysis of the average values of phytoplankton community biomass and those of its individual groups have shown that in Minor Sevan the development of the entire community was conditioned by the development of green algae, and in Major Sevan, by diatom algae, which is similar to the period up to 1985 [26].

CONCLUSION

During the study period of 2005 in Lake Sevan, the successional development of phytoplankton demonstrated seasonal features typical for hydroecosystems. In particular, there was a dominance of green and blue-green algae in summer and of diatom algae in autumn. In summer, the dominant taxa were the green algal genus *Oocystis* sp. and the cyanobacterium *Aphanothece clathrata*. In autumn, the dominant position was occupied by the diatom *Melosira granulata*. Clear trends for the vertical distribution of planktonic algae were not observed. The maximal value of phytoplankton biomass was at a depth of 20 *m* (in Minor Sevan 2.18 $g\ m^{-3}$ and in Major Sevan 2.73 $g\ m^{-3}$).

Based on Chl-*a* quantity, phytoplankton were most abundant at the depths of 10-20 m (euphotic zone) of the lake whereas minimal values were recorded at the bottom area. This testifies the presence of favorable light conditions for phytoplankton photosynthesis. According to Chl-*a* quantity Lake Sevan can be classified as mesotrophic lake [1, 12].

During the investigated period any clear correlations between phytoplankton abundance, vertical distribution, and abiotic factors were observed. We suspect that data were insufficient to draw detailed conclusions about the effects of nutrients or other factors on phytoplankton vertical distribution in both parts of the lake. Future studies should include taking samples on more days in each month and at different times of the day. Finally, our univariate analysis was probably oversimplified. Future studies should include more complex models. However, our study provides a baseline with which we can monitor the rehabilitation of Lake Sevan by examining its phytoplankton community.

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