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Phytoplankton of Lake Bol'shie Shvakshty (Belarus) during the Shift of the Ecosystem from a Macrophyte–Weakly Eutrophic to a Phytoplankton–Hypereutrophic State

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Abstract—Changes in the quantitative characteristics and functioning of phytoplankton in Lake Bol'shie Shvakshty have been assessed. The changes are evoked by the introduction of herbivorous fishes into the lake and the resulting disturbance of ecological balance in the ecosystem and the shift of the lake into a hypertrophic state from a weakly eutrophic state. Human interference has caused the cyanobacteria density (abundance) and biomass values in the overall phytoplankton composition to strongly exceed (3.5×10^9 cells/L and above 68 μg/L chlorophyll-*a,* respectively) the threshold value for safe recreational use of water bodies (20 million cells/L and 10 μg/L chlorophyll-*a*) established by the World Health Organization (WHO). The lake can be assigned to the third level of hazard to human health within the classification proposed by the WHO, as the cyanobacteria density is higher than 100 million cells/L and chlorophyll-*a* content is higher than 50 μg/L. MC-producing *Microcystis* species were identified among the cyanobacteria that has propagated in the lake in recent years, and five microcystin variants, including the highly toxic MC-LR, have been detected in the water.

Keywords: Belarus, Lake Bol'shie Shvakshty, trophic status shift, phytoplankton, cyanobacteria, microcystin
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INTRODUCTION

Lakes are relatively well-balanced natural ecosystems, with external and internal factors defining their functioning. The impact of even a single factor on individual ecosystem components can disrupt the balance of the entire system and induce its transition into a different ecological state (Scheffer et al., 1993; Scheffer and van Nes, 2007). Changes in the composition of commercial and recreational fishing objects, the introduction of herbivorous fishes in particular, can be such a factor.

Lake Bol'shie Shvakshty (Belarus) has been used as a fishery for many years. The lake was stocked with herbivorous fishes (grass carp and bighead carp) for several years since 2003, and this has caused substantial rearrangements in virtually all components of the lake ecosystem. The Stracha River, which flows from a lake system that includes Lake Bol'shie Shvakshty, is a refuge for protected salmonid fish (grayling and trout) populations. River water quality and, therefore, the state of the natural populations depends directly on the quality of water in the Lake Bol'shie Shvakshty runoff.

The rapid expansion of cyanobacteria has begun in the lake in recent years, along with overall expansion of phytoplankton. Water "blooms" caused by the rapid growth of cyanobacteria are observed all over the world (Chorus and Bartram, 1999). The explosive increase of cyanobacteria causes the deterioration of water quality and problems in water usage and can lead to mass fish mortality. Since cyanobacteria can produce multiple biologically active metabolites, including toxins that pose a health risk for humans and animals (microcystin (MC), saxitoxin, anatoxin, cylindrospermopsin, and others), the World Health Organization (WHO) recommends the monitoring of cyanotoxin levels in water using immunochemistry, liquid chromatography, mass spectrometry, and biotests on mice and other animals. The allowed thresh-