ECOLOGICAL REGIMES IN SALINE SHALLOW LAKES: MECHANISMS OF STABILIZATION AND DYNAMICS ALONG A SALINITY GRADIENT

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EXTENDED ABSTRACT

Variability is one of the basic characteristics of shallow saline lakes. Fluctuations of salinity, water chemistry and nutrient dynamics seem to be the main constrains of biodiversity, food web structure and functional patterns in saline lake ecosystems (Golubkov et al., 2007). Due to considerable inter and intra annual fluctuations in abiotic characteristics ecological regime shifts are common event in these lakes. In fact, saline shallow lakes may be considered as one of the most sensitive type of water bodies regarding climate changes and anthropogenic impacts (Timms et al., 2005). On the other hand, great variability, poor ecological resilience and food-web simplicity make ecosystems of shallow saline lakes very appropriate to investigation of establishment of different ecological regimes. However, mechanisms of establishment of ecological regime especially in naturally driven ecosystem are not fully understood. Meanwhile, in ecological management of shallow waters macroalgae/macrophyte-dominated ecological regime is often considered as a highly desirable state due to higher water quality (clear water, low cyanobacteria biomass, etc.) as compared to phytoplankton-dominated ecological regime.

Six saline lakes of Crimea (Black Sea) with salinity ranges from 24 to 340 ‰ were investigated in the spring, winter and the late summers of 2004-2005. These investigations have shown that there are several ecosystem stable states along a salinity gradient: turbid phytoplankton-dominated state at relatively low salinity (lower than 60 ‰), clear-water macroalgae-dominated or microbial community-dominated stage at intermediate salinity (about 100 ‰), and turbid-water stage in highly saline lakes (more then 150 ‰). Further increase of salinity in lagoon derived lakes led to collapse of benthic eukaryote communities and development of planktonic energy pathways due to a few phytoplankton species and dense population of *Artemia* species. This stage was observed in highly saline Lake Kojashskoe. In spite of high concentration of nutrients in water column of this lake, up to 700 mg P/m^3, the biomass of phytoplankton for the most of the year corresponds to clear water stage due to a high clearance rate of zooplankton. Therefore, shifts from the dominance of planktonic to benthic and again to planktonic energy pathways along a salinity gradient were observed, with a general tendency to an increase of importance of energy pathways through planktonic food-web due to positive buoyancy for benthic species and their incapacity to colonize bottom environments in highly saline lakes.

Considerable interannual fluctuations of ecological regime were observed in some investigated lakes. Sharp ecosystem shift from phytoplankton-dominated ecological regime to macroalgae-dominated regime was observed in Lake Tobechikskoe in 2005. There was considerable decrease of phytoplankton primary production and PM, POM, chlorophyll *a* concentration and increase of Secchi depth in August 2005 as compared with August 2004. That was a result of filamentous macroalgal (*Cladophora vadorum* and *Cl. albida*) blooms at the bottom of the lake in 2005. The average biomass of *Cladophora* spp. reached 392 ± 25 g DW/m^2 in August 2005 and their primary production – 47 gC m$^-$

$^{2}d^{-1}$, which was much higher then the plankton primary production: 0.68 gC $m^{-2}d^{-1}$. Concentration of chlorophyll *a* in the water column decreased 9 times. Therefore, there was definite ecosystem shift from turbid-water to clear-water state in the lake. Changes in ecological regime in Lake Tobichikskoe were consistent with between annual differences in weather conditions. Average NAO (North Atlantic Oscillation) index for spring and summer months was positive (0.35) in 2004 and negative in 2005 (-0.60). A positive NAO index corresponds to cyclonic windy and rainy conditions, a negative one – to anti cyclonic conditions and relatively sunny weather in the temperate zone of Europe. Indeed, there were much more windy days in the eastern Crimea in April 2004 (monthly NAO index was 1.15) as compared with April 2005 (monthly NAO index was -0.30) in the period of intensive algal growth, which should lead to intensive resuspension of bottom sediments in the shallow lake, decrease of water transparency, and light limitation of *Cladophora* growth at the bottom of the lake in windy 2004.

Another between annual differences was higher air temperatures in 2005 in comparison with 2004. As a result, salinity in Lake Tobichikskoe increased from 58 ‰ in August 2004 to 100 ‰ in August 2005. This led to elimination of the population of omnivores *Gammarus aequicauda* and establishment of *Artemia parthenogenetica* in the lake because predation of *G. aequicauda* was probably the main factor impeding the development of large planktonic grazer *Artemia* in the lake. Establishment of *Artemia* population in Lake Tobichikskoe resulted in increase of grazing pressure upon phytoplankton and clearance of the water in the lake, which should facilitate stabilization of clear water stage. Strong negative relationships between biomass of *Artemia* spp. and phytoplankton primary production were observed both in Lake Tobichikskoe and in highly saline Lake Kojashskoe. An increase of water transparence in Lake Tobichikskoe facilitated the growth of bottom filamentous *Cladophora* spp. Therefore, the investigations have shown that climatic fluctuation may be a trigger factor, which induces changes in biotic and abiotic interactions in ecosystem of saline lakes, and results in ecological regime shift of the lakes.

Similar regime shift resulted from secondary (anthropogenic) salinization earlier was observed in ecosystem of another Crimean lake, Lake Saki (Ivanova et al., 1994).

Severe eutrophication, considerable increase of salinity and decrease of the water volume in the lakes in droughty 2005 resulted in anoxic condition and collapse of food web energy pathways in the ecosystems of hypereutrophic highly saline Lake Marfovskoe.

Therefore, climate mediated fluctuations in weather conditions are the principle factor, which is responsible for great variability of energy fluxes and path-ways and ecosystem regime shift in hypersaline lakes and lagoons. This shows that ecosystems of hypersaline lakes have low resilience to external factors. Processes of eutrophication and secondary salinization of saline water bodies resulted from anthropogenic impacts may easily distort their natural dynamics and stabilized inappropriate for human ecological regimes.

KEYWORDS: hypersaline lakes and lagoons, ecological regime shift, climatic fluctuation, food-web structure