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Shifts in phenology of zooplankton due to climate change

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ABSTRACT. Freshwater zooplankton is recognized as sensitive indicator of environmental changes. Climate change has already altered abundance, species composition, structure of freshwater zooplankton and the timing of seasonal behavior, events and life-history parameters. In recent decades, due to climate warming, the ice-free period, the «biological summer» period, the river runoff have increased in Lake Onego. We have identified 5 phenological phases (winter, spring, early summer, late summer, autumn) on the base of the ratio of the main taxonomic groups of zooplankton using discriminant analysis. The date of the beginning and the end of each phenophase, the duration of the phenological phases were determined. Comparison of long-term data with current data showed a phenological phases shifts. Early summer phenophase has occurred about 30 days earlier. Autumn phenophase has occurred on average 23 days earlier. Knowledge of phenology zooplankton in Petrozavodsk bay of Lake Onego makes it possible to detail the mechanisms of its functioning and to describe the response to climate change.

Keywords: phenology, phenological phase, freshwater zooplankton, Onego

There is substantial evidence that climate warming is driving changes in zooplankton. Freshwater zooplankton is recognized as sensitive indicator of environmental changes. Climate change has already altered abundance, species composition, structure of freshwater zooplankton (Adrian and Deneke, 1996; Lazareva and Sokolova, 2013; Izmest'eva et al., 2016), and the timing of seasonal behavior, events and life-history parameters (Gerten and Adrian, 2002; Winder et al., 2009; Lazareva and Sokolova, 2013). Phenology is the study of seasonally recurring events in nature and it has been widely used to assess the consequences of climate changes (Vadadi-Fülöp et al., 2012). Lake Onego is a large freshwater reservoir. In recent decades, due to climate warming, the ice-free period, the «biological summer» period, the river runoff have increased in the lake (Filatov et al., 2018).

Petrozavodsk Bay is a large north-western bay of Lake Onego with water surface area about 125 km^2 and mean depth 18,5 m. Sampling and laboratory processing were carried out by generally accepted methods (Metodicheskiye rekomendatsii…, 1984). Zooplankton samples were collected using a quantitative Juday plankton net (diameter of 18 cm and a mesh size of 0,1 mm). The catches were performed by water layers (0–5 m, 5–10 m, and 10 m–bottom). Fixation was performed with 4% formalin. Detailed series are needed to study phenology. We used the Database (1988-2011) «Plankton of the pelagic zone of Lake Onego» (Syarki et al., 2015) and current samples collected from 2014 to 2017. Smoothed seasonal trajectory of abundance was obtained using the moving average method in the modification of double smoothing (Syarki, 2013).

The annual zooplankton cycle is characterized by high seasonal fluctuations in relation to abundance and biomass. We examined individual periods (phenophases) in the seasonal dynamics of zooplankton. Each phenophase is characterized by a special species composition, structure and quantity. We have identified 5 phenological phases (winter, spring, early summer, late summer, autumn) on the base of the ratio of the main taxonomic groups of zooplankton using discriminant analysis. The date of the beginning and the end of each phenophase, the duration of the phenological phases were determined (Fomina and Syarki, 2018).

Comparison of long-term data with current data showed that in June 2016 a phenological phase shift was noted. Early summer phenophase has occurred about 30 days earlier than it did in 1988-2011. In the spring of 2016, an extremely high water temperature was observed, it reached 15 ˚C, while the average water surface temperature in June in the Petrozavodsk Bay is about 6-7 ˚C. The biomass of phytoplankton and bacterioplankton was lower than long-term average values, the number of saprophytic bacteria was almost 2 times higher. Saprophytic bacteria can be used as indicator of the presence in the water of easily

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degradable organic matter introduced by river waters. In our view, phenological shift in the community occurred due to an increase in temperature and the abundance of saprophytic bacteria.

In the first half of August 2014–2017 the community structure corresponded to the autumn phenophase. Autumn phenophase has occurred on average 23 days earlier than it did in 1988-2011. Summer temperatures in 2014-2017 corresponded to long-term average temperatures. The values of bacterioplankton, saprophytic bacteria, and the content of chlorophyll "a" in the 2000s markedly decreased compared to the 1990s due to a decrease in the anthropogenic load in the bay. Only the total abundance of zooplankton, the abundance of cladoceran and the abundance rotifera were significantly lower than the long-term average values. From our point of view, the shift in autumn phenophase may be associated with a decrease in the level of trophy and / or a shift in the date of the beginning of the late summer phenophase. Further research is required to provide evidence. Dates of other phenological phases have not changed compared to 1988-2011.

Knowledge of phenology zooplankton in Petrozavodsk bay of Lake Onego makes it possible to detail the mechanisms of its functioning and to describe the response to climate change.

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