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Potentially toxic cyanobacteria in winter plankton of the Curonian Lagoon, Baltic Sea

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Summary
The winter phytoplankton of the Russian part of the hyper-trophic Curonian Lagoon (Baltic Sea) was studied in 2010. The dominant species, vertical distribution in the water column and quantitative development of the winter phytoplankton community have undergone some changes in the Curonian Lagoon in present time compared with the situation 30 years ago. Cluster analysis revealed the spatial heterogeneity of the phytoplankton distribution in winter 2010. The structure of the phytoplankton taxonomic composition in the central and southern parts is different in aspect of horizontal distribution, surface and bottom horizons – in the vertical one. Potentially toxic cyanobacteria *Aphanizomenon flos-aquae* predominated in summer season, but in winter it did not have any significance in plankton. In contrast, cyanobacteria *Planktothrix agardhii* was widespread in the lagoon in February and prevailed in some sampling sites.

Introduction
The seasonal dynamics of phytoplankton communities in the hyper-trophic Curonian Lagoon is typical of eutrophic freshwater of the temperate zone Harmful algal blooms (HABs) were regularly observed in summer-autumn period in the lagoon. Generally, it is caused by the potentially toxic cyanobacteria *Aphanizomenon flos-aquae*, species of the genus Microcystis and, starting from 2001, *Planktothrix agardhii*. Toxic cyanobacteria blooms were observed in 2010-2011 (Ezhova, Lange 2011). The phytoplankton biomass in the lagoon can exceed 100 g·m^{-3} (Olenina, 1998). Usually, most of hydrobiological studies are limited by the vegetation season. However, reliable predictions of ecosystem parameters, ecological modelling and aquatic system sustainable use must be based on the year-round data sets. The phytoplankton development during the vegetation season is sufficiently defined by its winter characteristics. In the Curonian Lagoon phytoplankton succession is studied mainly during the iceless period, from March to November, whereas phytoplankton data from the winter seasons are limited only one paper (Krylova 1985).

Materials and methods
Material was taken during the multidisciplinary winter field cruise of AB IO RAS in the Russian part of the Curonian Lagoon in the second half of February 2010. 15 phytoplankton samples (0.5 l volume) from the surface and near-bottom layers were collected by Frantsev bathometer at 11 sampling sites and fixed by modified Lugol's solution. The microalgae were counted in the Nageotte chamber (0.02 ml volume) under the light microscope (Ergaval Karl Zeiss, Jena), magnification x256 and x640. Wet weight phytoplankton biomass was assessed from cell geometry and using a cell biovolume date (HELCOM 1988). The Bray-Curtis index of similarity was used to evaluate the level of similarity between phytoplankton communities of sampling sites. Cluster analysis was carried out in software PRIMER v.5.2.3.

Results and Discussion
Winter phytoplankton was represented by 58 taxa including the largest variety of different cyanobacteria (22 taxa). The following taxa were arranged in the descending order: green algae (15), diatoms (11), cryptophytes (6), dinophytes (3), euglenophytes (1), as well as unidentified flagellates

forms ascribed as the Flagellata group. The highest diversity was recorded in the near-bottom layer, where water temperature (2.3-4.0 °C) was higher than that in the surface layer (0.1-0.6 °C).

In the upper layer the phytoplankton abundance and biomass were 512 thous.cell·l^{-1} and 0.43 g·m^{-3} an average; in the bottom layer – 447 thous.cell·l^{-1} and 0.07 g·m^{-3} correspondingly. Phytoplankton productivity was higher in the southern part of the lagoon. As in 2010, in the second half of 1970 the amount of phytoplankton in the southern part of the lagoon was higher than in the central deep zone (Table 1). However, phytoplankton, unlike the present situation, was concentrated in the bottom layers (Krylova, 1985).

Table 1. Quantitative parameters of the winter phytoplankton in the Russian part of the Curonian Lagoon in different years (surface layer)

Parameter	Whole ? Lagoon		Central area		Southern area	
	Last time [1)]	2010	Last time	2010	Last time	2010
Abundance, thous.cell·l^{-1}	40	512 (106-1240)[2)]	– (до 100)	191 (106-275)	– (1000-5000)	739 (143-1240)
Biomass, g·m^{-3}	0.10	0.43 (0.02-1.76)	– (до 0.10)	0,03 (0.02-0.03)	– (0.05-1.00)	0.81 (0.12-1.76)

[1)] – 1975, 1976, 1982 (Krylova, 1985); [2)] – average (range)

Cyanobacterium *Aph. flos-aquae* in winter was found in two samples only and didn't have any significance in the plankton, although in 1975-1976 it was one of the dominant species, the frequency of occurrence year-round was over 70 % (Krylova 1985). In contrast, another summer dominant in recent years – non-N_2-fixing cyanobacterium *P. agardhii,* in February was widespread in the lagoon, and prevailed on one of the southern sampling sites. Formerly these species were not found in the plankton. *P. agardhii* can grow in mass over a wide temperature range from 6 to more than 20 °C, i.e. refers to eurythermic organisms. Similar to other Oscillatoriales species, *P. agardhii* is a species with a low light-energy growth requirement and is the 'turbulent' species (Stefaniak 2005). It is shown that in the hypertrophic lake fishpond (Central Moravia, Czech Republic), this species may occurs in the plankton throughout the year, while its winter population is concentrated at the bottom of the form hormogoniae and filaments, which begin to grow in March, reaching a maximum filaments length in April, and the greatest abundance – in August (Poulickova et al. 2004). Such a scenario of development of the annual *P. agardhii* can be assumed for the Curonian lagoon.

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