EGU21-9741, updated on 22 Jan 2022
https://doi.org/10.5194/egusphere-egu21-9741
EGU General Assembly 2021

Dissolved oxygen variability in a small ice-covered lake during the spring under-ice convection

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A decrease in the ice-period on lakes against the background of climate warming improves its oxygen regime in the cold half of the year by reducing the winter anoxia. A decrease in the thickness of the snow-ice cover can contribute to an increase in under-ice irradiation, which can provoke an earlier onset of spring under-ice convection and activation of algal blooms. Do these processes affect the oxygen content in ice-covered lakes? This study examines the variability of dissolved oxygen, water temperature, currents, chlorophyll "a" and under-ice irradiation according to field measurements carried out in 2007-2020 during spring under-ice convection in a small Lake Vendyurskoe (northwestern Russia). Field data were obtained at autonomous stations with an interval of one minute. Measurements of temperature and dissolved oxygen (RBR TR- and DO-sensors) were carried out from October to May, covering the entire ice-period, while measurements of currents (ADCP), solar radiation fluxes («Star-shaped pyranometer» «Theodor Friderich & Co, Meteorologishe Gerate und Systeme»), and chlorophyll "a" (BBE Moldaenke) were carried out for 3-12 days from late March to the third decade of April in different years. The thickness of the snow-ice cover was also measured. Analysis of the data showed that in 2007-2020 the thickness of the snow-ice cover of Lake Vendyurskoe in spring (late March – mid-April) varied significantly from 35 to 70 cm, depending on weather conditions. The under-ice solar radiation fluxes varied from close to zero to more than 150 W/m2. The duration of spring under-ice convection ranged from two to seven weeks. Chlorophyll "a" was fairly uniformly distributed within the convective layer, even below the photic zone. We assume the dual role of convective currents in the development of subglacial plankton: ascending currents facilitate the entry of algal cells and nutrients into the photic zone, activating photosynthesis, while descending currents carry them out of it, suppressing photosynthesis. With well-developed convection, oscillations of dissolved oxygen were recorded with a daily frequency, reaching 1 mgO2/L in the upper part of the convective layer. Presumably, an increase in the content of dissolved oxygen is associated with a daytime increase in photosynthesis against the background of an increase in under-ice radiation, and a decrease is associated with the destruction of organic matter. Convective currents also affect the vertical distribution of dissolved oxygen, involving the oxygen-depleted bottom waters in mixing, which leads to a certain decrease in oxygen concentrations in the convective layer. The total amount of oxygen in the water column during the period of spring under-ice convection can

increase by 10% due to the photosynthesis of phytoplankton. Oxygen fluctuations from minutes to hours were identified, which can be caused by seiche activity, the convective cells, advective transport, and the dynamics of internal waves. The results obtained in this work will contribute to a better understanding of the variability of oxygen in ice-covered lakes, caused by the total impact of biological and hydrophysical processes. The study was supported by an RFBR grant 18-05-60921.