

# Ice-covering hydrological and hydrochemical investigations on the Lena River delta

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**Abstract.** The study reported here was conducted on the channels of the Lena River delta in April 2019. The water temperature, specific conductivity, dissolved oxygen, PAR fluxes, and currents were measured on the cross-sections in the Olenekskaya and Bykovskaya channels, as well as in the main channel of the Lena River near Samoilov Island using the multiparameter probes CTD-48M, CTD-90M and RBR-Concerto. An analysis of the data showed that the water in the channels of the Lena River delta in winter is well saturated with oxygen (4.9-6.3 ml/l), has a very low temperature (from -0.1°C to +0.8°C). The specific conductivity of water Lena River delta channels changed from 460 to 530 µS/cm. A thick layer of snow 0.1-0.5 m with an ice thickness of more than 1.5 m prevents the penetration of solar radiation into the subglacial layer, where the PAR fluxes does not exceed 10 µmol/m<sup>2</sup>s. Current velocities reached 20–25 cm/s in the Bykovskaya channel, in Olenekskaya channel – 5-11 cm/s, and in the main channel – 12-18 cm/s. The currents data obtained made it possible to calculate the discharge in the channels during the ice-period.

## 1 Introduction

In recent years, in the wake of increased interest in the Polar Regions, special attention has been paid to the study of terrestrial hydrology of the Arctic coasts [1, 2]. The most important part of the land hydrological network is the Arctic rivers. The volume of Arctic river runoff has obviously increased over the past years [3, 4], which makes it important to study their annual regime. The least studied is the winter (ice-covering) period, when field measurements are associated with a number of difficulties [5].

In this paper we present the results of spring hydrological investigations carried out on three channels of the Lena River delta in ice-covered period (April 2019). This study is the continuation of a multi-year multidisciplinary research project carried out at the scientific base of Samoylov Island in the Lena River delta, bringing together scientists from different countries [6, 7].

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### 1.1 Study sites and methods

The study was conducted on the cannels of the Lena River delta on 10-17 April 2019. The Lena River delta is a site typical of Northern Yakutia, playing a huge hydrological and environmental role in the natural functioning of the large river basin and also affects the climate and ice processes in the Laptev Sea. Measurements of water temperature, conductivity, dissolved oxygen, PAR and currents were carried out in the Bykovskaya and Oleneskaya channels as well as in the main channel of the Lena River near Stolb Island (Fig. 1). Profiles on the main channel and Bykovskaya channel were located at representative (standard) channel positions according to Russian Hydrometeorological Service. At each profiles 5-7 stations were done at a distance of about 75-150 m from each other. Multiparameter probes CTD-48M, CTD-90M and RBR-Concerto were used. The vertical soundings were carried out from the lower boundary of the ice to the bottom sediments with a vertical step of 5-8 cm – horizons on 15, 65 and 85% of a depth. Measurements of a snow and ice thickness were done at each station additionally. Water discharge ( $Q$ ) have been calculated by the equation  $Q=F*v$ , were  $F$  – is a square of a channel profile, and  $v$  is the current velocity (Fedorova et al., 2015).



Fig. 1. The position of the measurement stations on the channels of the Lena River delta in April 2019.

## 2 Results and discussion

### 2.1 Ice and snow thickness

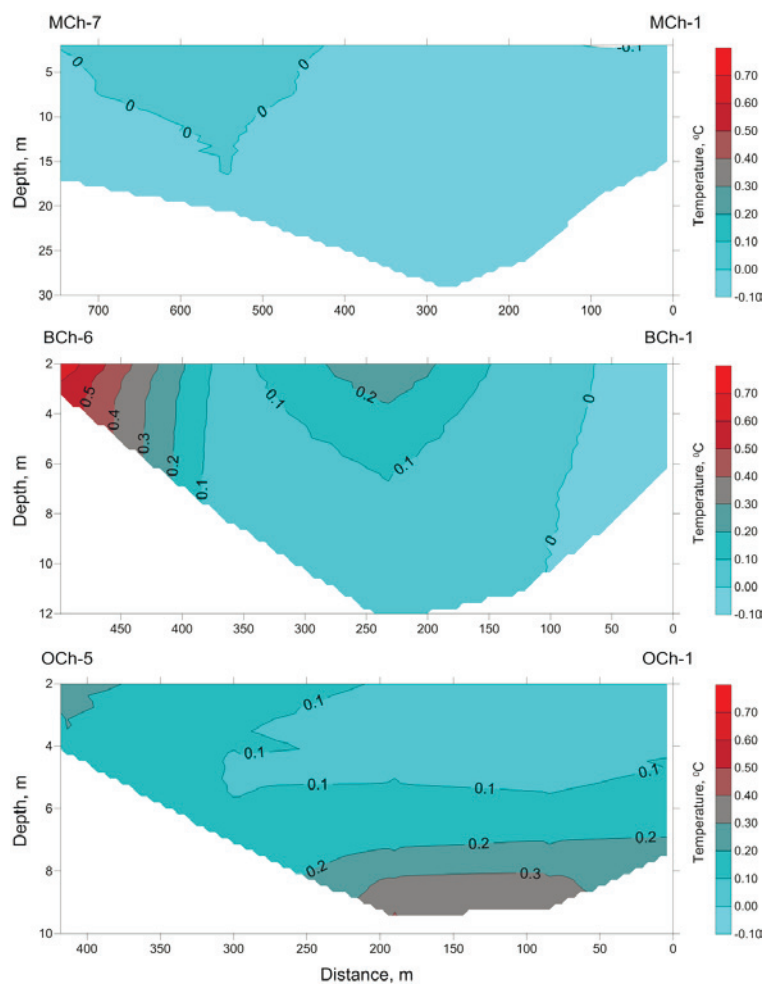
During the measurements on the channels of the Lena River delta in April 2019, the ice surface was covered with a layer of snow 0.01-0.8 m thick. The thickest layer of snow was observed on the ice of the Main channel, the smaller - on the ice of the Bykovskaya channel. The ice thickness valued 1.38-2.14 m at the stations.

### 2.2 Water temperature and specific conductivity

Measurements of water temperature were carried out using CTD-48M. The temperature of water did not exceed 0.8°C in the stations of all channels (Fig. 2). The lowest water temperature was in the main channel and varied along the section from -0.11°C to +0.01°C.

The water temperature was higher (up to 0.07°C) only in a thin surface 3-5 meter layer near the left bank of the main channel. The water temperature ranged from -0.05°C to +0.05°C in the central part and near right bank of the Bykovskaya channel. A stream of the more warm waters was observed near the left bank of the Bykovskaya channel, where the water temperature exceeded 0.6°C. At the all stations of the Olenekskaya channel the water temperature did not exceed 0.1°C at a depth of 6 m, deeper at 8 m it was higher 0.2°C.

Measurements of specific conductivity were carried out using RBR-Concerto. The specific conductivity of water Lena River delta channels changed from 460 to 530  $\mu\text{S}/\text{cm}$ . Highest values of this parameter were observed in the Bykovskaya channel, smallest – in the Olenekskaya channel. Increase of water temperature from the shallow left bank of Bykovskaya channel means substantial solar radiation penetration under river ice. Higher thermic regime near the Olenekskaya bottom correspond to intensive water flux exactly according to the Fig. 3. Inclination of temperature near the bottom could be the results of talik sub channel water vertical elevation.

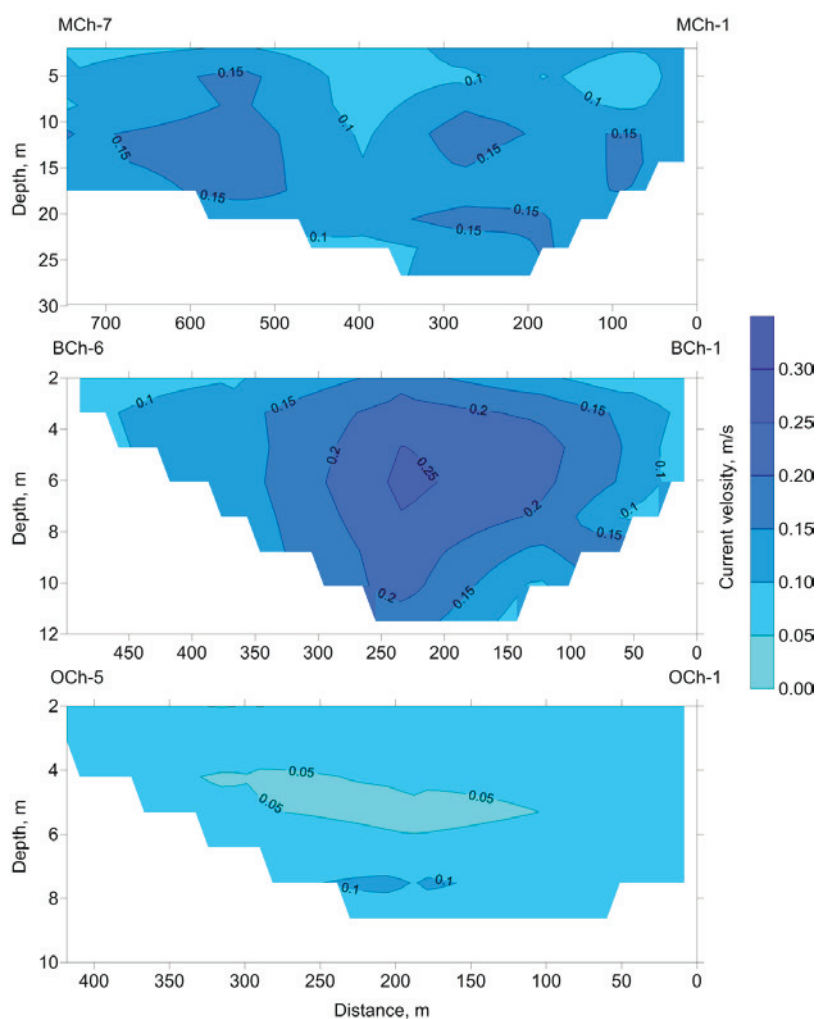


**Fig. 2.** Water temperature (°C) on the sections across main channel (MCh1- MCh7), Bykovskaya channel (BCh1-BCh6), and Olenekskaya channel (OCh1-OCh5), April 12-17, 2019.

### 2.3 Currents

Measurements of currents were carried out using a CTD-90M. An analysis of the data showed that at stations of the main channel, velocities averaged 12-18 cm/s. The highest current velocities were observed in the Bykovskaya channel, reaching 20-25 cm/s in its central part, and decreasing to 5-15 cm/s near shores (Fig. 3). The current velocities were noticeably lower (5-8 cm/s) in the Olenekskaya channel; a jet of water with velocities of 10-11 cm/s was observed in the bottom layer of this channel.

The maximum water discharge of 2883 m<sup>3</sup>/s was calculated for the main channel. The water discharge in the Bykovskaya channel amounted to 688 m<sup>3</sup>/s, in the Olenekskaya channel – 274 m<sup>3</sup>/s. The water discharges was bigger than perennial average for the April.



**Fig. 3.** Current velocity (m/s) on the sections across main channel (MCh1- MCh7), Bykovskaya channel (BCh1-BCh6), and Olenekskaya channel (OCh1-OCh5), April 12-17, 2019.

## 2.4 Dissolved oxygen

Measurements of dissolved oxygen concentrations were carried out using a RBR-Concerto. This parameter varied within 4.9-6.3 ml/l in all channel in April 2019. In the main channel, the concentration of dissolved oxygen was distributed relatively evenly over the section, not exceeding 5.5 ml/l, with the exception of a thin stream in the ice layer in the vicinity of station MCh-1 - MCh-3, where it increased to 5.7 ml/l. In the Bykovskaya channel, the oxygen concentration was 5.1–5.6 ml/l in the main stream, increasing to 6.2 ml/l near the station BCh-6. In the Oleneskaya channel the oxygen concentration varied within 5.5–6.2 ml/l to a depth of 8 m, decreasing to 4.9 ml/l only in the near-bottom 2-m layer of the central part of the channel.

## 2.5 PAR fluxes

Measurements of PAR fluxes were carried out using CTD-48M. Since the ice was covered with a thick layer of snow, the PAR fluxes at the lower boundary of ice were negligible and did not exceed 10  $\mu\text{mol}/\text{m}^2\text{s}$ . The greatest amount of solar energy penetrated under the ice of the Bykovskaya channel, the smallest - into the water column of the main channel. The attenuation coefficient of solar radiation in the upper 3-m layer of the water column of the Bykovskaya channel reached 1.5  $\text{m}^{-1}$ . Due to the small values of the PAR fluxes in the Oleneskaya channel and the main channel, it was not possible to calculate the values of the attenuation coefficient.

## 3 Conclusions

In this study, we present the results of hydrological investigations carried out on the Lena River delta channels during ice-covered period. Along with such traditional parameters as the temperature and specific conductivity of water, we studied the distribution of dissolved oxygen and solar radiation fluxes in ice-covered channels. Particular attention was paid to the measurement of currents, which made it possible to obtain estimates of the water discharge in the channels in ice period.

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