Ice alga, *Detonula confervacea*, changes its cell and colony size depending on the vertical position of sea ice in Saroma-ko lagoon

Kyoko Kawanobe[1], Kosuke Aratani[2], Shunsuke Sakai[2], Kazuki Hoshi[2], Sakae Kudoh[3], Yoshihiro Suzuki[1,2]
[1]*Graduate School of Kanagawa University*
[2]*Kanagawa University,* [3]*National Institute of Polar Reserch*

Introduction

Saromako-Lagoon in Japan, is an area where seasonally sea ice development is observed, and is considered as a southern edges of Arctic seas, then, could be affected by the recent climate change. The sea ice algal communities distributed in all layers of the thin sea ice less than 50 cm (Kawanobe and Kudou, 1995), with showing the variety of their photosynthesis and growth in response to the sorrounding sea ice environment (Suzuki et al., 1995). Especially in the surface layer of the sea ice, fluctuation of temperature frequently occurs caused by the temporal variability of air temperature, sometimes it drops far low (<-20℃) of the freezing temperature of seawater in winter. Then the liquid part (brine) in the upper sea ice could be freezed occationally and brine channels and pockets decrease its volume. The sea ice algae living there are need to respond these characteristic environmentral change.

In this study, we focused on the dominant diatom species *Detonula confervacea* in Saromako-Lagoon and studied its morphological change in the sea ice.

Materials and methods

From February to March 2020, samples were collected from sea ice about 3 km off from Sakaeura on the eastern shore of Saromako-Lagoon. The sea ice samples were shaved and collected using a diameter of 10 cm hand auger from the top in every 10 cm depth. A plastic sheet with a 10cm hole in the center of the sheet was placed on the sea ice beforehand, and all shaved sea ice sample were carefully collected, stored in plastic bags, and transferred to the laboratory in a light-shielded cool box quickly. Sea water sample was collected from the bottom of sea ice, to compare with these sea ice samples. In a large beaker 1000 ml of filtered seawater at 0 ° C was added to 300 g of the shaved sea ice sample of each layer, gently mixed and ice algae between the ice crystal and slush were allowed to release in seawater. The residual ice was removed, and the released ice algae was allowed to settle overnight under dark condition. Then, 700 ml of supernatant was removed and the settled ice algal samples were used to photosynthetic measurement and morphological analysis as follows.

The photosynthetic characteristics of sea ice algae samples were measured at ca. 0 ° C by a pulse amplitude modulation method (WATER-PAM, WALZ Germany).

Each sample was stored in a dark place at ca.4 °C after fixing with low-concentration formalin (0.1% Paraformaldehyde-0.025% Glutaraldehyde) until observation. The species composition of the sea ice algae was microscopiccally determined according to the Utermöhl method. Images taken with a phase-contrast microscope were analyzed using software (ImageJ, NCBI, USA) to determine the diameter of valve and cell length of gardle of *D. confervacea* and the number of cells per colony.

Results and discussions

Ice algae were found in all layers from the surface to the bottom of sea ice in our samples. The samples of all layers kept the maximum quantum yield of photosystem II at around 0.6, which was similar to the values determined with planktonic samples collected from the open sea area near to Sakaeura (Fig. 1A), and suggested active photosynthesis. The relative electron transport rate (ETR) measured at light intensities from 0 to 2000 μmol-photons m^{-2} s^{-1} indicated that the algae in the upper layers was acclimated to stronger light intensity, while the algae at bottom ice showed rather sade-adapted responces. ETR values of communities collected from upper layers were saturated at high light intensities. Maximu value of ETR decreased from upper layers to the bottom ones (Fig.1B).

Length and diameter of the top circle of the cylindrical cells of *D. confervacea* were measured. Compared to the cells in the sea water sample under the bottom part of the sea ice, the cells on the top of the sea ice had a 11.2% decrease in length and a 18.0% decrease in diameter (Fig. 2A, 2B), resulting in a 44.1% decrease in volume (Fig. 2C). The number of cells per colony was measured for a chain-like colony of this species. Only short chain colonies as 3 cells/colony at most (1.7 cells/colony on average) were found in the upper surface of the sea ice, although those of up to 25 cells/colony (9.5 cells/colony on average) were found from the sea water under the bottom of the sea ice (Fig. 2D). These results corresponded well with the possible decrease in the volume of the liquid part (brine) in the surface layer due to low temperature.

In this study, we found that *D. confervacea* maintains high activity throughout the sea ice, and showed decrease of cell size and reduction of the number of cells per colony; these properties may be important for responding to the surrounding sea ice environmental condition such as the living space in sea ice.

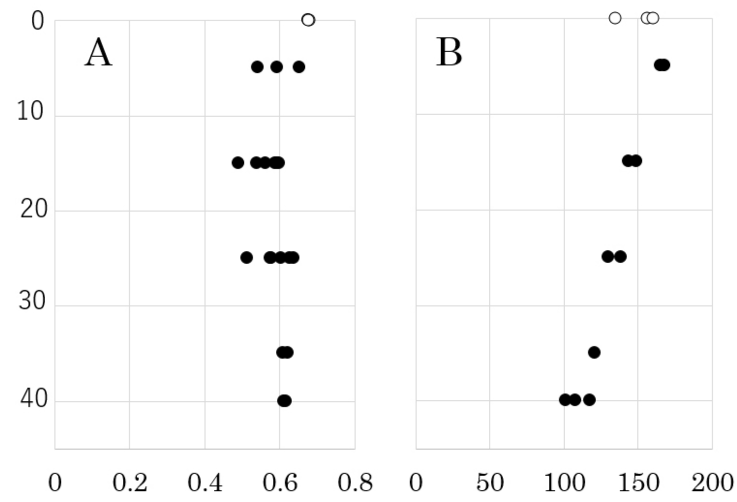

Figure 1. Photosynthetic indexes of the ice algal communities in each layer of sea ice (closed circles) and planktonic algae in a surface water collected from the open sea area near to Sakaeura (open circles) A: Maximum Quantum yield of photosystem II, B: Maximum rates of relative electron transport (ETR).

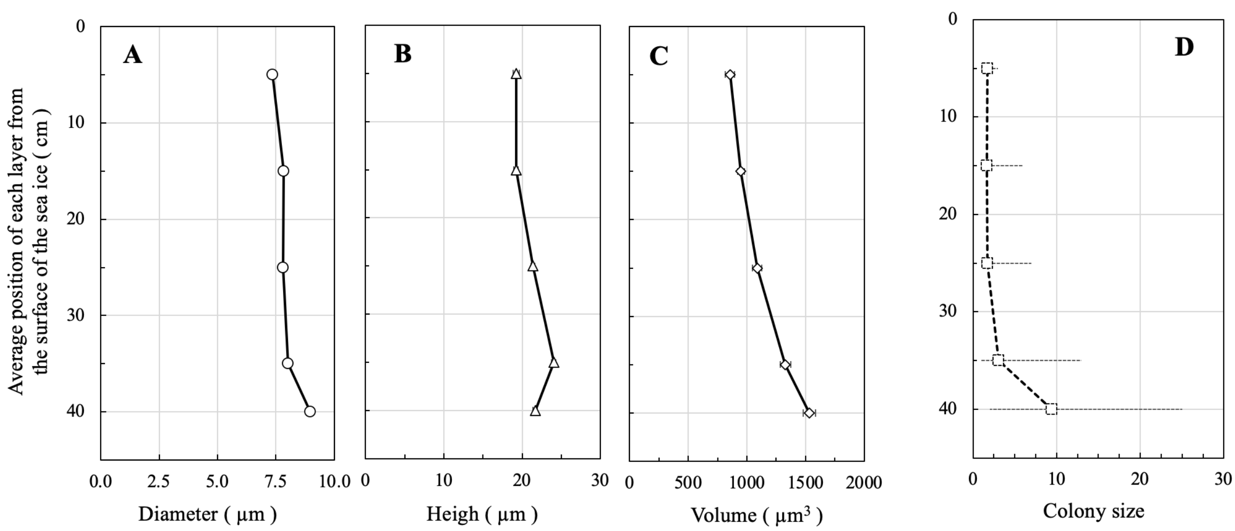

Figure 2. Morphological indexes of the ice algal species *D. confervacea* in each layer of sea ice A: Diameter of valve (μm) B: Heigh of girdle (μm) C: Estimated cell volume (μm^3) D: Colony size (cell colony^{-1}).

References

Kawanobe K. and S. Kudou, Species composition of ice algal assemblages in Saroma ko lagoon and resolute passage, 1992 (extend abstract), Proc. NIPR Symp. Polar Biol., 8, 59-63, 1995

Suzuki, Y. and S. Kudou, M. Takahashi, Photosynthesis characteristics of ice algal with special emphases on temperature and light conditions (extend abstract), Proc. NIPR Symp. Polar Biol., 8, 57-58, 1995