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PHOTOSYNTHESIS CHARACTERISTICS OF ICE ALGAE WITH SPECIAL EMPHASES ON TEMPERATURE AND LIGHT CONDITIONS (EXTENDED ABSTRACT)

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Under the sea ice of polar oceans, temperature is restricted to the range −1.8 to −1.5°C and light is also limited to low intensities due to reflection and absorption by snow and ice. As temperature and light are both essential conditions for photosynthesis, ice algae are expected to be affected by the low temperatures and low light intensities under sea ice (BUNT *et al.*, 1966; EPPLEY, 1972; COTA, 1985). In this study, photosynthetic responses to temperature and light intensities were analyzed using natural ice algal communities collected at Resolute Passage in April and May 1992 with particular emphases on the effects of low temperatures and low light intensities on photosynthesis.

Light saturated gross-photosynthetic rates of ice algae determined at various temperatures between −1 and 20°C by means of the oxygen electrode method showed continuous increase along with increases of temperature from −1 to 18°C. Higher gross–photosynthetic rates observed at higher temperatures indicated depression of photosynthesis by temperature within the experimental temperature range. Moreover, it has become clear that the photosynthetic rate increased exponentially from −1 to 10°C but the increasing rate slowed down above 10°C. Above 18°C no further increase was observed and finally photosynthetic rate decreased rapidly and stopped within few hours at 19°C. These results revealed that the observed inhibitions due to high temperatures on ice algal photosynthesis occurred at a temperature as low as 10°C.

Characteristics of ice algal photosynthesis for low light intensities were then determined by the photosynthesis *vs* light intensity responses with the ^{14}C method, and some parameters characterizing the fitted curves by means of the Gauss-Newton method were determined following the method of PLATT *et al.* (1980). During the experimental period from April 23 to May 21, the half saturation light intensity (Im) was maintained at low levels and the average value was 16.6±4.4 (S.D.) μmol photons $m^{-2} s^{-1}$ ($n=12$). As 3.0 to 7.5% of total PAR (photosynthetically active radiation) reaching the ice surface penetrated the sea ice during the experiment, the light intensity under the ice reached the Im whenever the light intensity on the surface of the ice was 550 μmol photons $m^{-2} s^{-1}$ or over. This indicated that the ice algal photosynthesis sometimes had a chance to reach saturation even under the sea ice. The initial slopes of the light response curve (α) were maintained at high levels during the experimental period, and the average value obtained was 0.21 ± 0.06 (S.D.) mgC (mg Chl. *a*)$^{-1}$ hour^{-1} (μmol photons m^{-2} s^{-1})$^{-1}$, which was much higher than for the other unicellular algae (*e.g.* PLATT *et al.*, 1980). This steep initial slope suggested efficient light harvesting mechanisms of ice algae at low light intensities and corresponded well to the high efficiency of Antarctic phytoplankton determined by SEABURG *et al.* (1983). Furthermore, the maximum photosynthetic rates (Ps) determined showed a significant decrease ($p < 0.05$) from 0.83 mgC (mg Chl. *a*)$^{-1}$ hour^{-1} on April 23 to 0.52 mgC (mg Chl. *a*) hour^{-1}, and the average was 0.71 ± 0.14 mgC (mg Chl. *a*)$^{-1}$ hour^{-1} ($n = 12$). This decrease of Ps correlated well with the decrease of light intensity under sea ice during the development of ice algal communities. However, the maximum photosynthetic rates per cellular organic carbon, which was well correlated to the algal growth (EPPLEY, 1972), did not show any significant decrease ($p > 0.05$), because chlorophyll *a* contents in the ice algal cells increased from 43 μg Chl. *a* (mg C)$^{-1}$ on April 23 to 82.3 μg Chl. *a* (mg C)$^{-1}$ on May 11 accompanying the decrease of photosynthetic rate based upon chlorophyll *a*. Unicellular algae are expected to acclimate to the growth environment to some extent by changing their cellular chlorophyll *a* contents (YODER, 1979; GEIDER, 1987). The ice algae in this study are also expected to maintain their photosynthetic rate and their growth responding to the lowered light intensity under sea ice at least partly by means of increasing chlorophyll *a* content in each cell.

In this study it was shown that:

1) Light saturated photosynthesis of ice algae is regulated by low ambient temperatures.

2) Ice algae adapt well to low light intensities under sea ice and achieve high photosynthetic rates even under low temperature.

References

BUNT, J. S., VON H. OWENS, O. and HOCH, G. (1966): Exploratory studies on the physiology and ecology of a psychrophilic marine diatom. J. Phycol., **2**, 96–100.

COTA, G. F. (1985): Photoadaptation of high Arctic ice algae. Nature, **315**, 219–222.

EPPLEY, R. W. (1972): Temperature and phytoplankton growth in the sea. Fish. Bull., **70**, 1063–1085.

GEIDER, R. J. (1987): Light and temperature dependence of carbon to chlorophyll *a* ratio in microalgae and cyanobacteria: Implications for physiology and growth of phytoplankton. New Phytol., **106**, 1–34.

PLATT, T., GALLEGOS, C. L. and HARRISON, W. G. (1980): Photoinhibition of photosynthesis in natural assemblages of marine phytoplankton. J. Mar. Res., **38**, 687–701.

SEABURG, K. G., KASPAR, M. and PARKER, B. C. (1983): Photosynthetic quantum efficiencies of phytoplankton from perennially ice covered antarctic lakes. J. Phycol., **19**, 446–457.

YODER, J. A. (1979): Effect of temperature on light-limited growth and chemical composition of *Skeletonema costatum* (Bacillariophyceae). J. Phycol., **15**, 362–370.

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