南大洋の亜表層クロロフィル極大層に生息する植物プランクトン群集の光適応

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Photoacclimation of phytoplankton assemblages in the subsurface chlorophyll maximum layer in the Southern Ocean

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Light is an essential resource for phytoplankton, and it varies from extremely low to relatively high irradiance in the ocean environment. Light can be also harmful at supraoptimal irradiance such as surface water column, leading to a damage of photosystem II (PSII). One of the most important protection mechanisms against high light intensity is the thermal dissipation of excess energy by xanthophyll pigments in the de-epoxidated state. The photoprotection through non-photochemical quenching (NPQ) of chlorophyll (Chl) fluorescence is dependent on the presence of the de-epoxidated xanthophyll pigments (Lavaud et al. 2004). In this study, we investigated the responses of photoacclimation to natural sunlight in phytoplankton assemblages during the austral summer in the Southern Ocean, and whether they can recover under the three light conditions.

Water sampling for the incubation experiments were carried out at three stations, 45°S (Stn KC2), 61°S (Stn M03) 65°S (KC6) of 110°E (Fig. 1), during cruises of the TR/V Umitaka-maru in the austral summers of 2014. The samples of phytoplankton assemblages, collected from subsurface chlorophyll maximum layer under low light conditions of <3% of the surface irradiance, were exposed to sunlight for 2 hours. Subsamples were collected after light exposure to measure variable Chl fluorescence and pigments of phytoplankton. Chlorophyll fluorescence are employed to estimate maximum quantum efficiency (F_v/F_m) of PSII and NPQ. The degree of damage and recovery of PSII can be examined by variation in F_v/F_m. At the end of exposure experiments, for 2 hours, the cells were incubated further in the continuous darkness, and 14% (low light) and 57% (middle light) irradiance of sunlight for 3 days.

After the phytoplankton assemblages were exposed to sunlight, NPQ significantly increased, whereas F_v/F_m decreased around 50% compared to initial values in the all experiments at three stations (Fig. 2). These results suggested that, despite the phytoplankton assemblages could perform photoprotection as thermal dissipation of excess heat, the reaction centers of PSII could be severely damaged by high light conditions. When the light-exposed cells were stored in the three light conditions within 3 days,

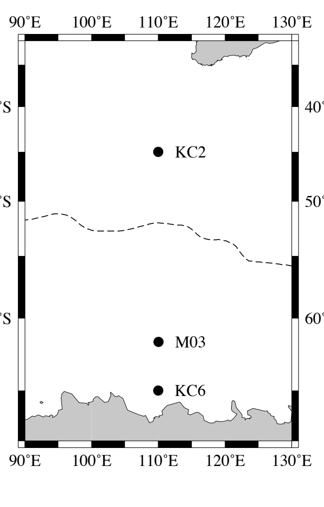

Fig. 1. Location of sampling stations in the Southern Ocean. The broken line indicates the position of the Antarctic Convergence.

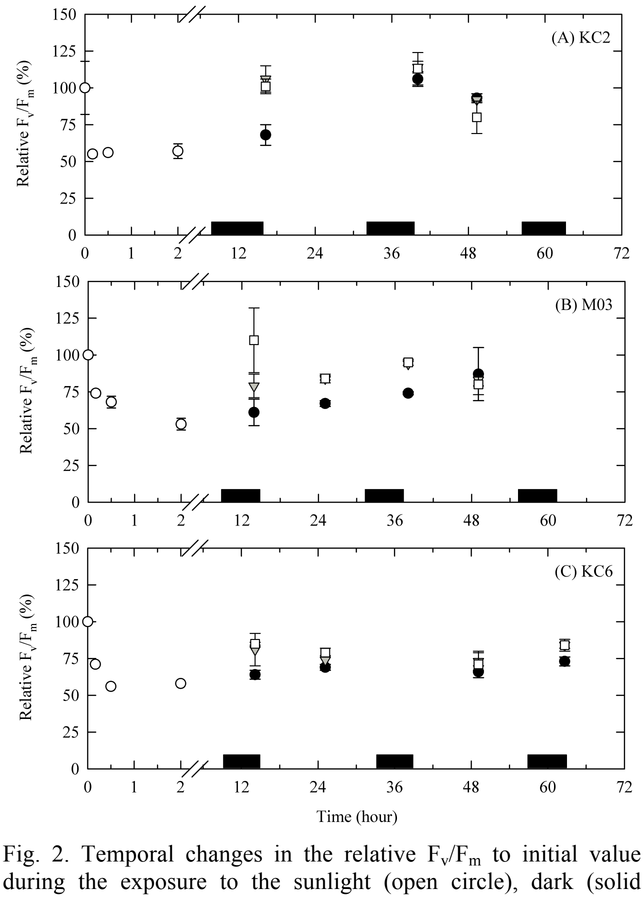

Fig. 2. Temporal changes in the relative F_v/F_m to initial value during the exposure to the sunlight (open circle), dark (solid circle), low light (shading reversed triangle), and middle light (open square). Black bars indicate the length of night.

F_v/F_m increased to more than initial values in the experiment at KC2, but did not reached to initial values at M03 and KC6 except after 12 hours in the experiment at M03. F_v/F_m values showed no significant difference between two light conditions in the all experiments at three stations. Under the total dark condition, F_v/F_m did not significantly exceed those in low and middle light except after 49 hours in the experiment at KC2. Therefore, the recovery of damaged PSII might be driven by the effect of light exposure. Variability in the recovery of F_v/F_m among three stations could be related with different water masses.

References

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