学 位 論 文 内 容 の 要 旨

博士（環境科学）　　氏 名 閻 冬

学 位 論 文 題 名

Effect of sea ice melt on growth and photophysiological performances of sea ice diatoms in the Sea of Okhotsk

(オホーツク海における海氷融解が海氷珪藻類の増殖と光合成生理能力に及ぼす影響)

Sea ice microalgal communities are dominated by diatoms and they play important roles in primary production at high latitudes. Growth of microalgae in ice-covered areas is primarily controlled by seasonal light climate. In Arctic and subarctic seas, more light penetrates through sea ice at the end of winter. This increase in light availability is a key driver of blooms in ice-covered seawaters. During ice melt in spring, ice algae are released from the ice and could be exposed to changeable temperature and irradiance in surface water. Large variations of light and temperature are likely to influence photophysiological performance of ice algae, where species with greater flexibility in photoacclimation are afforded a higher chance of survival.

Saroma Lagoon is an embayment with two inlets leading to the Sea of Okhotsk. With seasonal development of sea ice. To investigate the living and photoprotective strategies of ice algae in such a coastal water system, we grew *Nitzschia* cf. *neglecta*, an ice diatom isolated from the sea ice of this lagoon, under irradiance levels of 30 and 100 μmol photons m^{-2} s^{-1}, and temperatures of 2 and 10 °C. Then the acclimated cells were exposed to high light in order to investigate the plasticity of their photosynthetic apparatus. At 10 °C, cells grew faster and showed a weaker susceptibility to high light. Highly efficient photoprotection was achieved through the diadinoxanthin-diatoxanthin cycle-dependent non-photochemical quenching. The wide tolerance to both temperature and light changes suggests that the thinning of sea ice and higher temperatures in a warmer world will lead to more intense blooms in Saroma Lagoon.

The Sea of Okhotsk is the southernmost sea ice zone in the northern hemisphere with a sizeable seasonal ice cover, thus ice algae of the Sea of Okhotsk have a large potential to seed the early spring diatom bloom in the water column. However, little is known about the Okhotsk ice algal communities and their seeding effects. We investigated the dynamics of the composition and the corresponding photophysiological performances of an Okhotsk ice algal community in a 6-day laboratory incubation experiment that simulated the natural ice melt conditions. Centric diatoms, especially *Thalassiosira* spp., overwhelmingly dominated the ice algal community throughout incubation, whereas pennate diatoms, mostly *Navicula* and *Nitzschia*, showed little growth with much higher mortality. The maximum photochemical efficiency of Photosystem II (F_v/F_m) was the lowest at the beginning of the ice melt, suggesting a suppressed photosynthetic functioning by changes in salinity. The cellular pigment contents decreased by 30% due to physical damage of the cellular membrane, evidenced by deformed plastids under a microscope. The transcript level of the *rbcL* gene that encodes the large subunit of RubisCO was significantly higher during ice melt and decreased in the no-ice period, suggesting an urgent need for osmoprotectants under the melt condition. Full recovery of the photosynthesis and growth was also made after complete ice melt. Our results indicated high seeding potential of *Thalassiosira* to spring blooms owing to their photophysiological plasticity to dynamic salinity changes.