Formation of vertical silicate maxima in the sea-ice reduction region of the western Arctic Ocean

Shigeto Nishino[1]; Koji Shimada[1]; Motoyo Itoh[1]; Sanae Chiba[2]

[1] IORGC, JAMSTEC; [2] FRCGC, JAMSTEC

Since the late 1990s, catastrophic sea-ice reduction during summer has been observed in the Pacific sector of the Arctic Ocean (western Arctic Ocean), and the spatial pattern of the ice reduction is well correlated with the spatial distribution of temperature of warm water from the Pacific Ocean [Shimada et al., 2006]. Such a sea-ice reduction region is also a region where biological production could increase from that of the ice-covered ocean due to the intensification of light in the water column [Lee and Whitledge, 2005]. In the present study, we examine a change of silicate distribution at a shelf slope of the East Siberian Sea (ESS) and its relation to biological responses to the sea-ice reduction. Furthermore, we study a role of ESS in formation of silicate maximum layers in the sea-ice reduction region.

The data used here are obtained from modern hydrographic observations including chemical and biological surveys from the shelves of ESS and western Chukchi Sea to the Canadian Basin. The observational cruises are as follows: Larsen93 by a Canadian icebreaker, Henry Larsen, in 1993; AOS94 (Arctic Ocean Section 94) by US and Canadian icebreakers in 1994; CBL02 (Chukchi Borderland cruise 02) by a US icebreaker in 2002, and Mirai04 by a JAMSTEC vessel, R/V Mirai, in 2004.

We compare silicate profiles obtained by Larsen93 and CBL02 at almost the same locations in a shelf slope of ESS. The surface silicate concentration in CBL02 is lower than that of Larsen93. This probably reflects biological uptake of silicate in CBL02 due to the resent sea-ice reduction in summer. At deeper depths, the silicate concentration in CBL02 is higher than that of Larsen93, suggesting the silicate regeneration at the bottom of shelf and slope caused by decomposition of organic matters with opal, which are transported from the surface in CBL02 (enhanced biological pump due to the sea-ice reduction). There are two vertical maxima of the silicate concentration in CBL02. The upper maximum corresponds to an $N*$minimum, which is a signal of denitrification at the bottom of the shelf. Therefore, the upper silicate maximum is caused by the spreading of shelf water. On the other hand, the lower silicate maximum is thought to be formed on the shelf slope.

The data of Mirai04 indicates that the silicate distribution over shelf slopes is different between east and west of the Chukchi Plateau. West of the plateau, as well as CBL02, we found the double silicate maxima. On the other hand, east of the plateau there is a single silicate maximum in a layer of Pacific-origin winter water (PWW) as previously studied by many researchers [e.g., Jones and Anderson, 1986]. The silicate distribution is consistent with the chlorophyll a distribution. West of the plateau, large size phytoplankton (diatom) is predominant. The diatom plays an important role in the vertical transport of opal, which are dissolved on the shelf slope so as to produce the silicate maximum. The diatom bloom is maintained by the nutrient supply from the upper silicate maximum layer west of the plateau. Therefore, the upper silicate maximum and the accompanying diatom bloom result in the formation of the lower silicate maximum.

Nutrients from the Pacific Ocean are mainly carried by PWW into the western Arctic Ocean and form a nutrient maximum layer. However, the depth of the nutrient maximum layer (100 - 150 m) is deeper than the euphotic layer (˜50 m), and therefore, the nutrients are not effectively used for primary production. Nutrient concentrations in ESS are also high but the salinity is lower than that of PWW due to freshwater inputs form Siberian rivers. Because of the low salinity (density), the water from ESS could supply nutrients to the euphotic layer. Therefore, we have prospects that the primary production and biological pump are the highest on the pathway of water delivered from ESS among the sea-ice reduction regions.