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Silicoflagellate fluxes and environmental variations in the northwestern North Pacific during December 1997–May 2000

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Abstract

Time-series sediment traps were deployed during 1997–2000 in the northwestern North Pacific. The samples from 3000 m depth were investigated in order to study the silicoflagellate skeleton fluxes, the relationships with the geographical differences of their distribution, and their responses to temporal climate variations. At Station 50N (50°N, 165°E), located near the center of the Western Subarctic Gyre (WSG), subarctic-water taxa *Distephanus speculum* and *Distephanus boliviensis* dominated in the sinking assemblage. At Station KNOT (44°N, 155°E), located in the southwestern edge of the WSG, *D. speculum* also dominated throughout the sampled period. The warm-water taxon *Dictyocha mandrai* increased from the second half of 1998 to the first half of 1999, and the subtropical-water taxon *Dictyocha messanensis* also increased after the maximum period of *D. mandrai* flux. Not an obviously discernible seasonality was observed in the assemblages at Stations 50N and KNOT. At Station 40N (40°N, 165°E), at the south of the Subarctic Boundary, both the subarctic-water and the subtropical-water taxa dominated in winter and spring, and in summer and fall, respectively. The temporal assemblage variations at Station 40N significantly reflected the change of Sea Surface Temperature (SST) anomaly. This assemblage variation also implies which water mass, subarctic or subtropical, had more influence at Station 40N. The temporal successions of silicoflagellate assemblages at Station 40N are most likely due to the temporal oceanographic variability caused by global atmospheric changes. The differences of the seasonal flux pattern and the biogeochemical contribution of silicoflagellates at each station were due to the differences of ecosystem at each station.

Keywords: Silicoflagellates; KNOT; Sediment trap; Oceanographic variability; Northwestern North Pacific

1. Introduction

Silicoflagellates are microflagellate phytoplankton, which dwell in the euphotic layer of the world oceans. Silicoflagellates have siliceous skeletons

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after the naked stage in their life history (Henriksen et al., 1993). Although they generally represent a minor component in the total microplankton assemblage in the pelagic environment (e.g., Taylor and Waters, 1982; Takahashi, 1991a; Eynaud et al., 1999), they sometimes represent a major constituent in coastal and estuarine waters (e.g., Jochem and Babenerd, 1989).

Silicoflagellates have also been studied as indicators of water masses and applied to reconstructions of the paleoenvironment. The growth rates of silicoflagellates are influenced by water temperature and salinity (Boney, 1973; Henriksen et al., 1993). Takahashi and Blackwelder (1992) showed a close relationship between living silicoflagellate assemblages and seawater temperature across a warm-core ring within a relatively closed meso-scale system. In the paleoceanographic field since Mandra (1969), silicoflagellate taxa have been applied to reconstruct paleo-temperatures (e.g., Bukry and Monechi 1985; Ciesielski and Weaver, 1974) and to establish biostratigraphy (e.g., Ling, 1977; Perch-Nielsen, 1985; Tappan, 1980). Poelchau (1976) showed that the latitudinal distribution of the Holocene silicoflagellates in the North Pacific sediments corresponds to latitudal temperature zones. Shitanaka (1983) also suggested that silicoflagellates are a salinity indicator, because the frequency of aberrant skeletons reflected the difference in salinity, more abundant in neritic waters than pelagic waters (e.g., Takahashi, 1987, 1991b). Takahashi et al. (1989) suggested that the interannual quantitative variability of siliceous phytoplankton flux, including silicoflagellates, at Station PAPA in the Gulf of Alaska was due to climate change. The significant relationships between El Niño events and siliceous plankton (diatom, silicoflagellate, and radiolarian) fluxes have been studied in the Santa Barbara Basin (Lange et al., 2000) and in the southeastern South Pacific (Romero et al., 2001). These previous studies showed that the silicoflagellate taxa are useful indicators of water temperature, salinity, and other environmental signals.

The western subarctic Pacific is located in the upwelling area of the global circulation system. This area is characterized by high nutrient and high productivity in all seasons except for summer (Harrison et al., 1999). The oceanographic and atmospheric variations in the North Pacific may be well linked to a large-scale climate change such as El Niño and La Niña events from 1995 to 2001 (e.g., Schwing et al., 2002). The satellite images suggested variability in primary productivity, SST and its anomaly, sea surface wind, and major nutrients in 1997, 1998, and 1999 in the western subarctic Pacific (Goes et al., 2001; Sasaoka et al., 2002).

In the sinking particle flux studies in the northwestern North Pacific, Honda et al. (2002) suggested that the annual mean flux in 1998 was smaller than that in 1999, possibly a result of the relatively calm 1997/1998 winter (less surface mixing) associated with El Niño from 1997 to 1998. Planktonic foraminifer, radiolarian, and diatom fluxes also reflected the oceanographic variations in the northwestern subarctic Pacific during 1997–2000 (Kuroyanagi et al., 2002; Okazaki et al., 2005; Onodera et al., 2005). These results suggest that the oceanographic variability is also reflected in the silicoflagellate fluxes and assemblages. In the subarctic Pacific, silicoflagellate flux studies were carried out previously only in the eastern subarctic Pacific (e.g., Takahashi, 1985, 1987, 1989). The relationships between silicoflagellate flux and oceanographic variability were also discussed (Takahashi, 1997; Takahashi et al., 1989). This is the first report of a similar study from the western subarctic Pacific.

There are two objectives for this silicoflagellate skeletal flux study: first, to characterize the biogeographic and temporal variation of the silicoflagellate assemblage fluxes; and second, to decipher the relationships between silicoflagellate assemblage fluxes and the ocean environments in the euphotic layer of the northwestern North Pacific.

2. Materials and methods

Time-series sediment traps were deployed at Station 50N (50°01′N, 165°00′E; water depth 5546 m), Station KNOT (43°58′N, 155°03′E; water depth 5375 m), and Station 40N (40°00′N,