

## Centennial-scale variability in lower trophic level productions off Tomakomai, Hokkaido

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Nutrients in the surface marine waters support lower trophic productivity and fisheries productivity through food webs. In the latter of 20th century, nutrient levels represented by PO<sub>4</sub> showed a decreasing trend in the western North Pacific (Limsakul et al., 2001; Minobe, 2013; Tadokoro et al., 2009). This decreasing trend is the largest rates in the world ocean; decreases in productivity of lower trophic levels have also been reported in this area (Boyce et al., 2010; Tadokoro et al., 2009). The decreasing trend of nutrients may be attributed to intensification of subtropical gyre circulation and Kuroshio-Oyashio Extension due to global warming; the effect extends basin-wide (Minobe, 2013). Heretofore, it is unclear that this nutrient decreasing trend results from global warming or is in case of natural variability. Understanding to what extent nutrient depletion due to natural variability contributes to this decreasing trend is important to predict oligotrophication in the North Pacific in the 21st century. However, only 40-year records from observations of nutrients have prevented us from unraveling patterns of long-term natural variability and its amplitude. Here we present long-term record of nutrient levels in the Coastal Oyashio region, western North Pacific, by using proxies of lower trophic levels which sensitively responds to nutrient levels, in order to elucidate long-term natural variability of nutrients and its amplitude.

Results of biogenic opal, algal- and zooplankton-derived pigments showed centennial- or millennial-scale variability for the last 3000 years. Based on flux of biogenic opal, chlorophyll a + derivatives and SCEs, the centennial-scale variability caused depletions from a peak to a trough by 19-42%, 12-19% and 11-65%, respectively. This indicates that diatom productions have substantially varied on centennial timescales. Assuming that amplitude of the diatom production variations was directly attributed to nutrient levels, the depletions on centennial timescales is as large magnitude as that in PO<sub>4</sub> (23%) in the late 20th century. The biogenic opal flux is low level at present and the decreasing trend since 19th century is considered to be part of centennial natural variability. Similar centennial-scale variability is also found in the sardine fossil scale records from Japan and off California, records of salmon abundance from Alaska, and PDO index reconstructed from tree ring width from the North America. Centennial climate changes over the Pacific may be associated with the centennial variability in the biological productivity in each region of the North Pacific and PDO. Further studies on this centennial natural variability, including a network of more productivity reconstructions in the western North Pacific and the driving mechanisms, are needed for long-term predictions of nutrient level and fisheries productions.

Keywords: centennial variability, lower trophic level production, Coastal Oyashio, nutrients, PDO