Interannual variation of seasonality of primary production in the subarctic region of western North Pacific

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The subarctic region of western North Pacific is one of High Nutrient Low Chlorophyll (HNLC) seas because iron is consumed by phytoplankton during spring and primary productivity is restricted even if macro nutrients and light are sufficient. In the strait of the Kuril Islands, vertical mixing generated by internal waves broken at complicated ocean topography is bringing intermediate water to the surface. However, little is know about relationship between primary production and nutrients exported by intermediate water and vertical mixing. In this study, we classified study area with similarity analysis of seasonal change in primary production climatology and then determined its seasonality (peaks, period) to investigate interannual change in the seasonality and relation to nutrients.

We used the remote sensing reflectance and photosynthetic available radiation of the MODerate resolution Imaging Spectroradiometer (MODIS)/Aqua for 13 years from 2003 to 2015. Absorption coefficient of phytoplankton was retrieved from remote sensing reflectance using the Quasi-Analytical Algorithm (QAA). Absorption Based Production Model was applied to the absorption coefficient to derive daily net primary production. Climatological value of primary production for each week was calculated as a logarithmic mean for the 13 years dataset.Sea ice concentration of AMSR-E/Aqua from 2003 to 2010, sea surface temperature of AVHRR/NOAA from 2003 to 2012, net heat flux of the NCEP from 2003 to 2015 and the Pacific Decadal Oscillation (PDO) index from 2002 to 2015 were also analyzed. Based on the similarity of the seasonal variability in the primary production climatology, study area was classified using the cluster analysis (K-means method). Then, we defined 3 terms (1st term: width of 1st peak, 2nd term: period from the end of 1st peak and the start of 2nd peak, 3rd term: width of 2nd peak).

The study area was classified into 12 regions. In the region covered by sea ice seasonally, primary production increased immediately after sea ice retreat. Around the northern Kamchatka Peninsula, peaks in spring and autumn with similar level of production were recognized. The second peak was higher than the first peak around the southernmost part of the Kamchatka peninsula and the Aleutian Islands. In the central and eastern part of the Okhotsk Sea, the western and central part of the Bering Sea, and Oyashio region, the first peak was higher than the second peak.
In all regions, increase of primary production for the first term started, when the net heat flux and SST in winter show minimum values, probably due to stop of cooling and mixing. Principal component analysis for the interannual variability of the primary production showed a contribution rate of the 1st mode was more than 70% for each term. While the PDO had antiphase against SST and the net heat flux during the 1st and 2nd terms, significant relationship between PDO and primary production was found.Therefore, it was suggested that the interannual variability of primary production from spring to summer in the 1st and 2nd terms are greatly affected by climate change.

Keywords: Primary Production, Remote sensing, HNLC sea