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Temporal and spatial variability of chlorophyll a concentrations and primary productivity in the Bering Sea

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1. Introduction

In this presentation we will introduce our latest results of marine ecosystem studies in the Bering Sea. First of all, we will describe the synoptic phytoplankton variability in the entire Bering Sea using a mathematical analysis of remotely sensed data. In the second part, we focus on the phytoplankton dynamics in summer around the Bering Sea Green Belt. The Bering Sea Green Belt named by Springer et al. (1996) is well known as an extremely high productivity region around the Bering Sea shelf break. We investigated eddy-related cross-slope exchange along the Bering Sea shelf break using Altimeter satellite data, ship observation data and numerical model. Finally we will discuss the mechanisms maintaining high primary productivity in the Bering Sea Green Belt.

2. Data and Methods

To examine the variability of chlorophyll a (chl-a) concentrations and identify the factors controlling phytoplankton variability, we applied multi-sensor remote sensing including chl-a (SeaWiFS), PAR (Photosynthetically Active Radiation) (SeaWiFS) and sea wind (SSM/I) to EOF (Empirical Orthogonal Function) analysis. EOF analysis is a useful method for expressing the spatial and temporal variability of time-series data.

Ship observation of Bering Sea anti-cyclonic eddies by T/S Oshoro-maru (Faculty of Fisheries, Hokkaido University) were conducted at the shelf break from July 25 to 26, 2001, and from August 8 to 9, 2002. To detect the location of mesoscale eddies, we utilized TOPEX/ERS-2 daily sea level anomaly (SLA) images from the CCAR (Colorado Center for Astrodynamics Research) Altimeter Data Sets. To simulate the eddy field and the cross-slope exchange at the Bering Sea shelf break, we applied the Estuarine, Coastal and Ocean Model with a semi-implicit scheme (Blumberg, 1991, Wang and Ikeda, 1997).

3. Results and discussions

3-1. Seasonal and interannual variability of chl-a in the Bering Sea using EOF analysis

Chl-a concentrations derived from satellite data tend to reach a peak during the spring bloom, decrease in summer depending on the shortage of nutrient, and increase again in the fall. At the shelf break, chl-a concentrations did not decline, even in summer. Spring bloom in the Bering Sea features an east-west chl-a dipole among years that accounts for 47% of the covariance in interannual variability. The amplitudes of this dipole pattern differed among years. Spring bloom started from the western region in 1998 and 2001, from the eastern region in 1999 and over the whole Bering Sea in 2000 and 2002. The controlling factors of the spring bloom are wind and solar radiance in shelf region mainly. The period of stratification is an important factor for the timing and magnitude of spring blooms in shelf region in the Bering Sea.

3-2. Mechanisms maintaining the high primary productivity in the Bering Sea Green Belt

Results of observations in summer of 2001 showed a shelf break front that formed at a shelf break near an anti-cyclonic eddy, high nitrate-nitrite concentrations in the subsurface layer, and high chl-a concentrations (over 6mgm^{-3}) in the surface layer. A hydrographic observation in summer of 2002 exhibited relatively high chl-a concentrations at the surface around the anti-cyclonic eddy. Tracer experiments revealed two types of cross-slope exchange. Under isopycnals, nutrient-rich water in the basin is transported to the shelf and there is about a 64.53% increase in integrated nitrate-nitrite on-shelf flux (50m depth to bottom), when mesoscale eddies are formed and propagated along the shelf break. At the surface, high chl-a waters in the shelf are advected to the deep basin area by eddy transport and propagation. These indicate that 1) mesoscale eddies supply nutrients and sustain primary productivity at the shelf break, and 2) eddies expand the high chl-a area to the basin, then to the highly productive area, so that the Green Belt is maintained.