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学 位 論 文 要 旨
Dissertation Summary

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論 文 名: Numerical simulation of the low-trophic ecosystem in the East China Sea

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East China Sea (ECS), located in the northwest Pacific Ocean, is a continental shelf sea with high productivity and is well known as a good fishery and the nursery ground for larvae of many marine species. Dynamic environment there is complicated due to the influences of East Asian monsoon, rivers, Kuroshio and other currents those being the inflow or outflow through its lateral boundaries or being a part of the current system in the ECS. Biogenic nutrients (e.g., nitrate, phosphate, silicate) and primary production there exhibit apparent seasonal variations. To sustain high productivity in the ECS, nutrients from external nutrient sources including nutrients from riverine input, atmospheric deposition, Taiwan Strait waters, Kuroshio waters and sediment remineralization are supplied via different pathways.

In order to get a deep understanding about functions of the ECS low-trophic ecosystem, nutrient budget should be calculated at first. With end-number mixing box models, few previous studies have calculated the nutrient budget in the ECS. But nutrient transports from external nutrient sources mentioned above in these studies show large discrepancy although the same conclusion is that Kuroshio is the biggest nutrient source for the ECS. Besides, this kind of studies can not examine the contributions of these external nutrient sources to primary production in the ECS. Furthermore, unlike the input processes of nutrients to the ECS, people know little on the output processes of biogenic nutrients and particles (i.e., phytoplankton and detritus) from the ECS. From a viewpoint of steady state, the input of nutrients to the ECS must be balanced by an output of nutrients and biogenic particles from the ECS. Therefore, detailed calculation about biogenic nutrients and particles budgets is needed.

In this dissertation, budgets of biogenic nutrients and particles in the ECS were calculated by using a three dimensional low-trophic model. The model consists of two modules, hydrodynamic model and biogeochemical module. After validating the model results with observational data in publicly published database and literatures, budgets of biogenic nutrients and particles were calculated. Especially, the ECS was divided into two layers, upper and lower layers, which represent for euphotic and aphotic layers, respectively, unlike previous studies those taking the ECS as a whole. Model results suggested that exchange of nutrients and biogenic particles between upper layer and lower layer are comparable with or much larger than the lateral transport with adjacent seas along

boundaries of the ECS. Two-way transport, which is onshore transport of biogenic nutrients and offshore transport of biogenic particles in the ECS, is suggested by our model results. Besides the shelf break in the ECS, Tsushima Strait is another important exit for export of biogenic particles and its annual mean transport is ~1.8 kmol s^{-1} N.

Using the three dimensional low-trophic model as the base case and excluding the external nutrient sources (i.e., riverine nutrient, atmospheric deposition, Taiwan Strait waters, Kuroshio waters and sediment remieralization) case by case, we estimated relative contributions of these nutrient source on nutrients and primary production in the ECS based on difference between the base case and numerical experiments mentioned above. Model results suggested that nutrients from Kuroshio waters contributed ~50% for nitrate, phytoplankton and ~70% for phosphate and silicate, which indicated that Kuroshio nutrient is most important for both nutrients and primary production in the ECS. Besides, the response of three nutrients (i.e., nitrate, phosphate and silicate) depends on pre-exist ratios of these three nutrients in seawater and ratios of nutrients in each nutrient source. For example, in the upper layer without atmospheric deposition, nitrate concentration decreased in the whole ECS while concentrations of phosphate and silicate at middle and outer shelf regions increased. This indicated not only the absolute fluxes of nutrients from each nutrient source but also ratios of nutrients therein should be considered when estimating the contributions of external nutrient sources for the ECS.

Among these nutrient sources, Changjiang (Yangtze River) is the largest river in terms of river discharge and sediment load in the ECS. Nutrient load from the Changjiang in the past decades underwent large variability. The responses of the ECS ecosystem to changes in nutrient load from the Changjiang over the period of 1960–2005 were examined with the numerical model mentioned above. Two major factors affected changes in nutrient load: changes in river discharge and the concentrations of nutrients in the river water. A cluster of numerical experiments was conducted by changing river discharge and nutrient concentration in the river water. Responses of nutrients and biogenic particles were different in these cases. It is interesting that an increase in the Changjiang discharge did not always lead to an increase in phytoplankton levels in the ECS. Phytoplankton decreases could be found in some areas close to the river mouth. Increases in nitrate and phosphate concentrations in the river water primarily led to increases in nitrate, phosphate, phytoplankton, and detritus levels in the ECS, whereas decreases in the silicate concentration in river water led to lower silicate concentrations in the ECS.

ECS is one of the largest marginal seas in the northwestern Pacific Ocean and is important for adjacent countries. I hope this study could deepen our understanding about the basic functions of the ECS low-trophic ecosystem and give an insight for predicting the response of the ECS ecosystem to long-term changes in anthropogenic activities and climate.