1. Title

Study on the Response Mechanism of Primary Production in the East China Sea to the Change of Nutrient Inputs from the Yangtze River

2. Members' names and affiliations

SHI Jie Ocean University of China

Gao Huiwang Ocean University of China

3. Aim

This project aims to explore the effects of changes in nutrient fluxes and ratios of rivers on nutrient structure and primary production in East China Sea. What's more, it promotes cooperation and student exchange between the College of Environmental Science and Engineering of Ocean University of China and the Center for Marine Environmental Studies (CEMS) of Ehime University.

4. Procedure

First, we used a 3-dimensional physical-biogeochemical coupling model to simulate the nutrient structure and primary production of East China Sea forced by climate conditions. Then, we analyzed the seasonal characteristics of DIN, DIP, and SIL on the surface and bottom layers. Finally, we validated the model by comparing the simulated results and observed results. We showed the seasonal characteristics of DIN, DIP, and SIL in Section 5 for the space limitation.

5. Results

Figure 1, Figure 2, and Figure 3 show the seasonal changes in the distribution of DIN, DIP, and SIL concentrations on the surface and bottom layers, where February represents winter, May represents spring, August represents summer, and October represents Autumn; water depth of 2 m represents the surface layer, and the vertical 20th layer of the model (the last layer of water column) represents the bottom layer.

Figure 1 shows the seasonal changes in the distribution of DIN on surface and bottom layers. In winter, the surface high DIN concentration areas are mainly distributed in the Yangtze River estuary, Hangzhou Bay, and northern Jiangsu shoal area. Secondly, the high DIN concentration areas along the coast of Fujian and Zhejiang are distributed in stripes, reaching the Taiwan Strait all the time. The trend of the southward expansion of the edge is consistent. The area outside the middle shelf of the East China Sea (under 100 m deep) has a lower concentration, and the lowest concentration occurs in the slope-break area of the continental shelf. In the shallow water of northern Jiangsu Shoal, the Yangtze River estuary, and Hangzhou Bay, strong winter monsoon and tidal processes bring strong mixing, making the distribution of DIN concentrations at the bottom and surface layers similar; while in areas outside the continental shelf in the East China Sea (under 50 m deep), the bottom DIN concentration is much higher than that on the surface layer, especially in areas outside the land slope, the highest DIN concentration is greater than 25 $mmol/m^3$.

In spring, the DIN concentration in the surface layer was lower than in winter, and areas with high DIN concentrations still appeared in the Yangtze River estuary, Hangzhou Bay, and the northern Jiangsu shoal area; the DIN concentrations in the central East China Sea and the Korean Peninsula coast decreased significantly, and the concentration values were less than 2 $mmol/m^3$; area of high DIN concentration is strip-shaped in the coastal areas of Fujian and Zhejiang, and it retracts northward in winter. The distribution of DIN concentration in the bottom layer is basically the same as that in winter, but the concentration value is different from that in winter. The DIN concentration in the northern part of the East China Sea shelf decreases and the central part increases. The DIN concentration in the region from the northern part of Taiwan Island to 28°N increases from ~ 2 $mmol/m^3$ to ~ 5 $mmol/m^3$. The reduction of surface DIN concentration is affected by both biological and physical processes. Phytoplankton growth activities enhance the absorption of large amounts of nutrients and lead to a reduction in DIN concentration. On the other hand, the increase in solar radiation in spring and the seasonal stratification of seawater gradually form, and the stability of the water body makes it difficult to supplement the high DIN concentration in the bottom layer to the upper layer, resulting in a reduction in the DIN surface layer concentration. At the same time, DIN, which is produced by the decomposition of granular organisms that settle to the bottom, is retained, which increases the bottom DIN concentration. In addition, the intrusion of the Kuroshio subsurface water into the East China Sea shelf intensified in the spring, and water transport brings more nutrients, which also makes The DIN concentration in the middle shelf and outer shelf of the East China Sea increased.

In summer, the Yangtze River dilutes water with a large amount of nutrients into the sea, and expands eastward and northeastward. At the bottom, the DIN concentration in the northern part of the East China Sea shelf (southwest of Jeju Island) increased, which was caused by the increase in salt transported by Kuroshio subsurface water to the shelf; the DIN concentration in the Yangtze River estuary and the northern Jiangsu shoal area also increased slightly due to the water depth is shallow, and the DIN concentration in the surface layer can reach the bottom layer through vertical mixing.

In the autumn, as the Yangtze River dilute water extends south along the shore, the DIN concentration in the surface layer of the Fujian-Zhejiang coast increases, and the DIN concentration in the northern layer of the East China Sea shelf decreases, but the DIN concentration in the East China Sea inland shelf still maintains a high value; at the bottom layer, the DIN concentration increased from the south of Jeju Island to the shelf slope break area compared to summer, but decreased in the offshore area outside the Yangtze River Estuary.

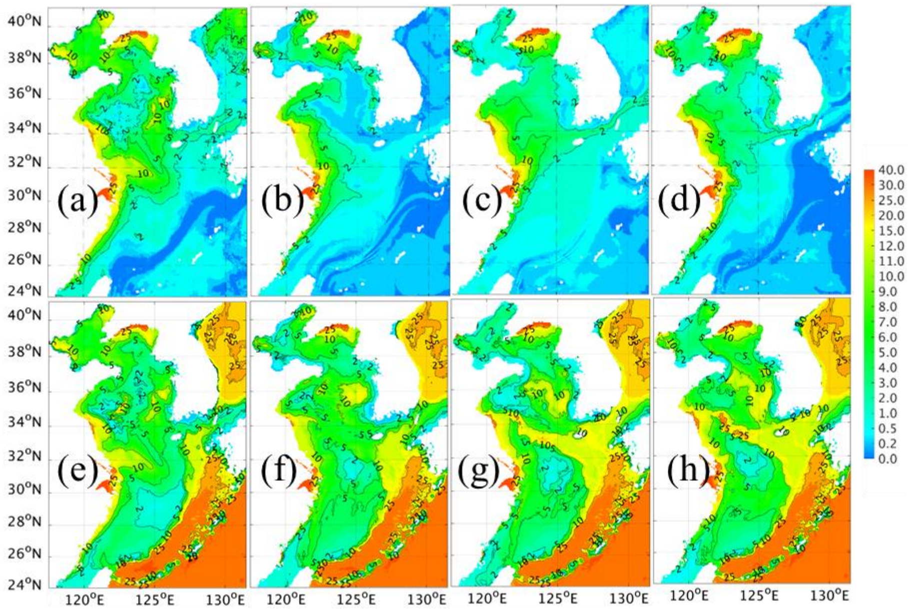

Figure 1. Seasonal distribution of DIN concentration on the surface layer (2 m) and bottom layer (mmol/m^3). (a) ~ (d) represent the surface layer in February, May, August, and October, respectively, and (e) ~ (f) represent the bottom layer in February, May, August, and October, respectively.

The seasonal changes in the distribution of DIP concentration levels (Figure 2) are different with DIN. Looking at the whole year, the surface DIP concentration is generally lower than the bottom layer, especially DIP concentration on the bottom layer in the outer shelf area can reach 2 mmol/m^3, while the surface DIP concentration is only ~ 0.2 mmol/m^3, and the former is ten times the latter. In winter, due to the low water temperature and weak light, the growth of phytoplankton is limited, and the consumption of nutrients is low, which makes the surface DIP concentration reach the highest level throughout the year. Due to the strong vertical mixing in winter, the surface and bottom layers of DIP concentrations in the inland shelf area are similar. In spring and summer, the temperature rises and the light increases. Phytoplankton grows vigorously and absorbs a large amount of DIP. Due to the apparent lack of DIP from the Yangtze River compared to DIN, DIP has become a limiting nutrient for phytoplankton growth in areas affected by the Yangtze River's diluted water. The concentration of DIP along the Yangtze River's dilute water expansion path to the Tsushima Strait is very low, while DIN is relatively abundant and still maintains a high value. This is also a significant difference between the surface distribution of DIP and DIN concentrations; the bottom layer, the northern part of the East China Sea shelf (Southwest of Jeju Island) DIP concentration increased, and the increased area extended northwest to 34°N. In autumn, due to the reduction of phytoplankton consumption, the surface DIP concentration in the northern East China Sea slightly increased; at the bottom, the high-value DIP area was stripe-shaped, along the shelf slope break north to southwest of Jeju Island and then to the northwest, with high DIP concentration bands The distribution indicates the intrusion path of Kuroshio subsurface water in the East China Sea shelf area.

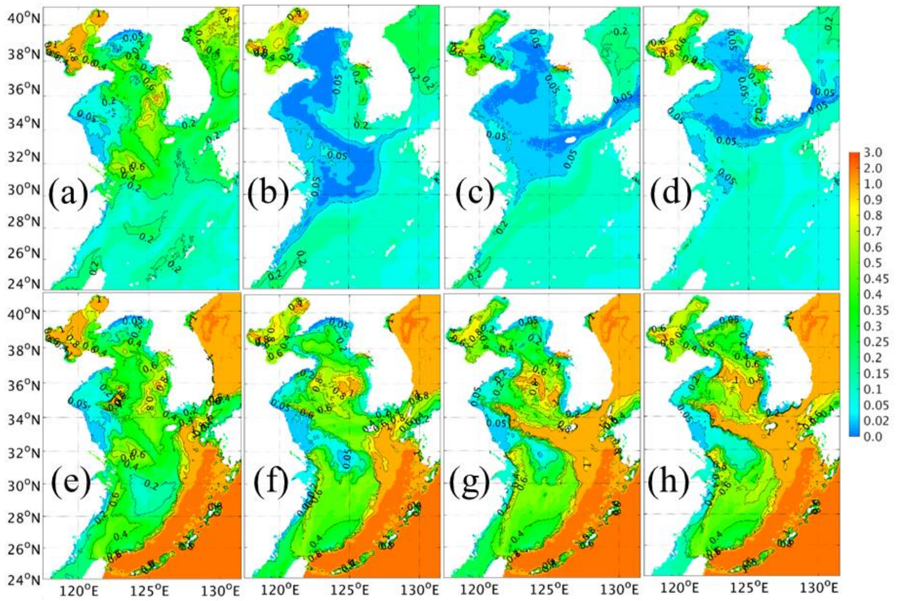

Figure 2. Seasonal distribution of DIP concentration on the surface layer (2 m) and bottom layer (mmol/m^3). (a) ~ (d) represent the surface layer in February, May, August, and October, respectively, and (e) ~ (f) represent the bottom layer in February, May, August, and October, respectively.

The distribution characteristics of SIL concentration on the surface layer and bottom layer (Figure 3) are almost the same as DIN. This is because the main sources of both are the Yangtze River and Kuroshio subsurface water inputs, and they are not restricted nutrients for phytoplankton growth in the shelf area. The concentration distribution is mainly controlled by changes in nutrient sources and physical processes in the sea.

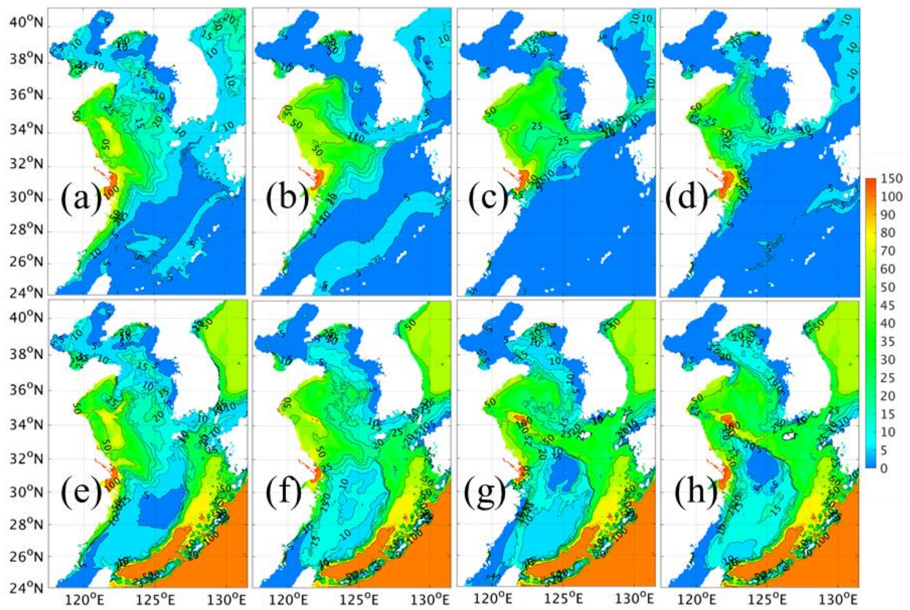

Figure 3. Seasonal distribution of SIL concentration on the surface layer (2 m) and bottom layer ($mmol/m^3$). (a) ~ (d) represent the surface layer in February, May, August, and October, respectively, and (e) ~ (f) represent the bottom layer in February, May, August, and October, respectively.

6. Publication/Conference presentation

Conference presentation (poster presentation)

Title: Study on the Response Mechanism of Primary Production in the East China Sea to the Change of Nutrient Inputs from the Yangtze River

Lecturer: LENG Qian

Time: 14~15 November 2019.

Location: Ehime University.

7. Perspectives in Future

To explore the mechanism about Yangtze River nutrient flux influencing the nutrient structure and primary production of East China Sea.

To enhance the cooperation researches and exchanges of faculties and students between the Ocean University of China and CEMS of Ehime University.