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Phosphate boundary transport of the East China Sea and its influence on biology

Zhijian Lin[1], Xiaochun Wang[1], Peng Xiu[2], Fei Chai[3]

1.Nanjing University of Information Science and Technology, 2. South China Sea Institute of Oceanology, Chinese Academy of Sciences, 3. Second Institute of Oceanography, State Oceanic Administration

Key Points:

- The Kuroshio intrusion phosphate transport into the East China Sea shows great interannual variability in the northeast of Taiwan.
- On interannual timescale, the variation of the Kuroshio intrusion phosphate transport into the East China Sea is dominated by the volume transport.
- When the Kuroshio main axis is closer to the East China Sea shelf, there is more phosphate transport into the East China Sea, and chlorophyll increases around the Zhoushan Islands and Yangtze estuary.

Introduction

The East China Sea (ECS) is one of the most productive regions of the global ocean and relys on a huge amount of externally sourced phosphate. The phosphate of the ECS is mainly from the Kuroshio intrusion phosphate transport (KIPT), which supplies about 71% phosphate of the ECS (Chen et al., 2008).

Motivation

1.There is a lack of discussion for the interannual variation of the KIPT.

2.It is unclear how the variation of the KIPT affects the ECS biological process on interannual time scale.

Model

A physical-biological oceanic model: Regional Ocean Modeling System (ROMS) and Carbon, Silicate, Nitrogen Ecosystem (CoSiNE)

Results and Discussions

1. Kuroshio intrusion volume and phosphate transport across the EB section

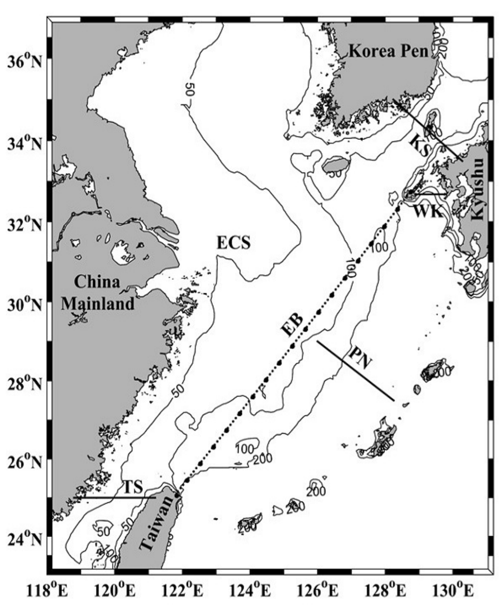

Figure 1. Map of the East China Sea (ECS). Here, TS is the Taiwan Strait; EB is the eastern boundary section of the ECS (EB section); PN is the PN section; WK is the west of the Kyushu; KS is the Korea Strait. The small black dots denote the EB section; the big black dots are plotted every 5 grid points from Taiwan coast. The Kuroshio intrusion volume transport (KIVT) and phosphate transport (KIPT) are studied in present research.

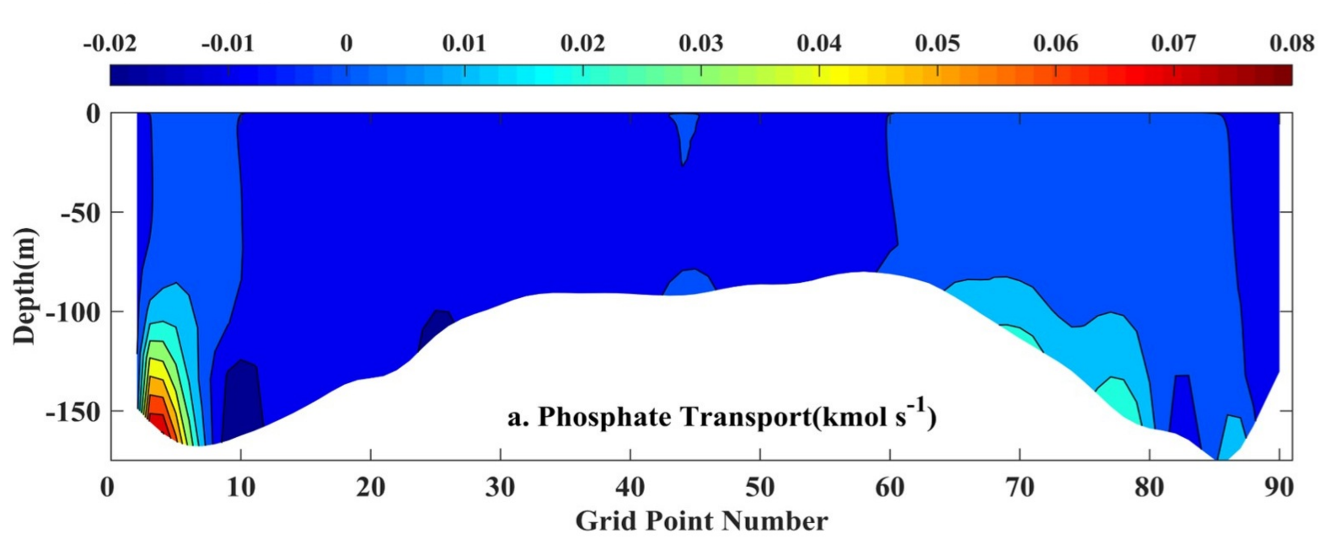

Figure 2. The distribution of 20-year averaged phosphate transport along the eastern boundary section of the East China Sea. For the volume and phosphate transport, positive means that the transport is into the East China Sea. Contour interval is 0.01 kmol s^{-1}. The position of grid points is shown in Figure 1.

2. Interannual variation of the KIPT across the EB section

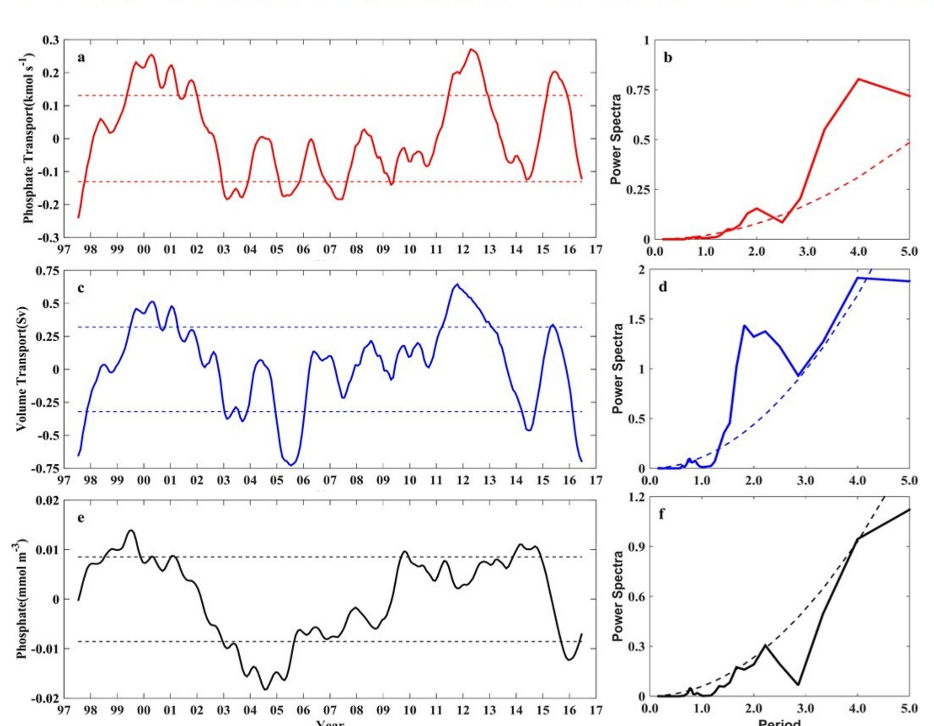

Figure 3. The monthly interannual component (MIC) of **(a)** the total KIPT through the eastern boundary section of the ECS, **(c)** the total KIVT through the EB section, and **(e)** the section-averaged phosphate concentration with their power spectral density shown in **(b)**, **(d)** and **(f)**, respectively. The dash lines in **(a)**, **(c)**, and **(e)** represent the 20-year averaged value of the KIPT, KIVT, and phosphate concentration plus and minus their one standard deviation. In **(b)**, **(d)**, and **(f)**, the dash line denotes the 90% confident level of the power spectral density.

To explore the dominant factor of the variation of KIPT, the variance of the MIC KIPT were decomposed into 6 terms [Guo et al., 2012], which can be expressed as

$$\sigma_{PT}^2 = \overline{P}^2\sigma_T^2 + \overline{T}^2\sigma_P^2 + 2\overline{T}\overline{P}\sigma_{TP}^2 + 2\overline{P}\sigma_{TG}^2 + 2\overline{T}\sigma_{PG}^2 + \sigma_G^2 \quad (1)$$

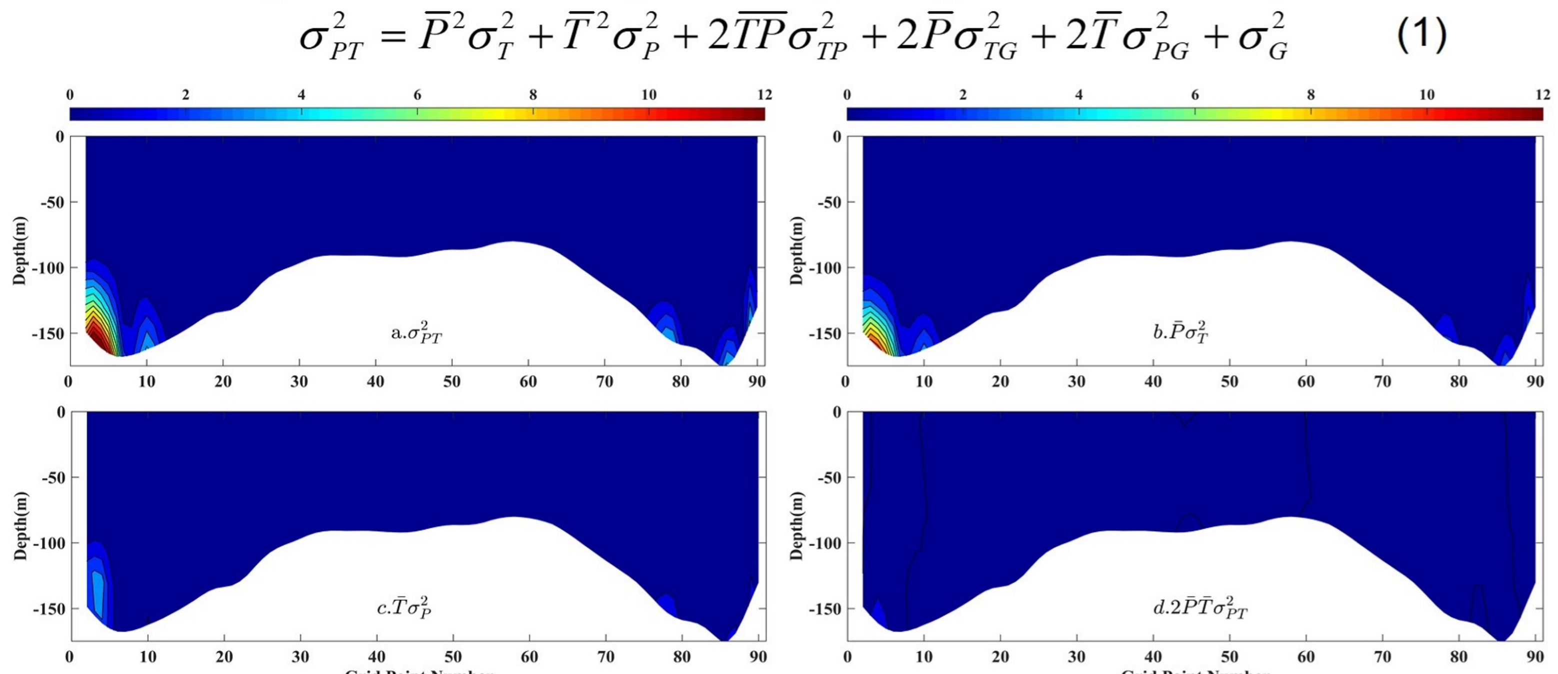

Figure 4. The variance of the interannual component of phosphate transport **(a)** and its decomposed term $\overline{P}^2\sigma_T^2$, $\overline{T}^2\sigma_P^2$ and $2\overline{T}\overline{P}\sigma_{TP}^2$ **(b-d)** following the variance equation at each grid along the eastern boundary section of the East China Sea. The other three terms at the right hand side of equation (1) are negligible. For convenience, the value has been magnified 10^5 times. The unit is $kmol^2\ s^{-2}$.

3. Relationship of phosphate transport and ECS chlorophyll

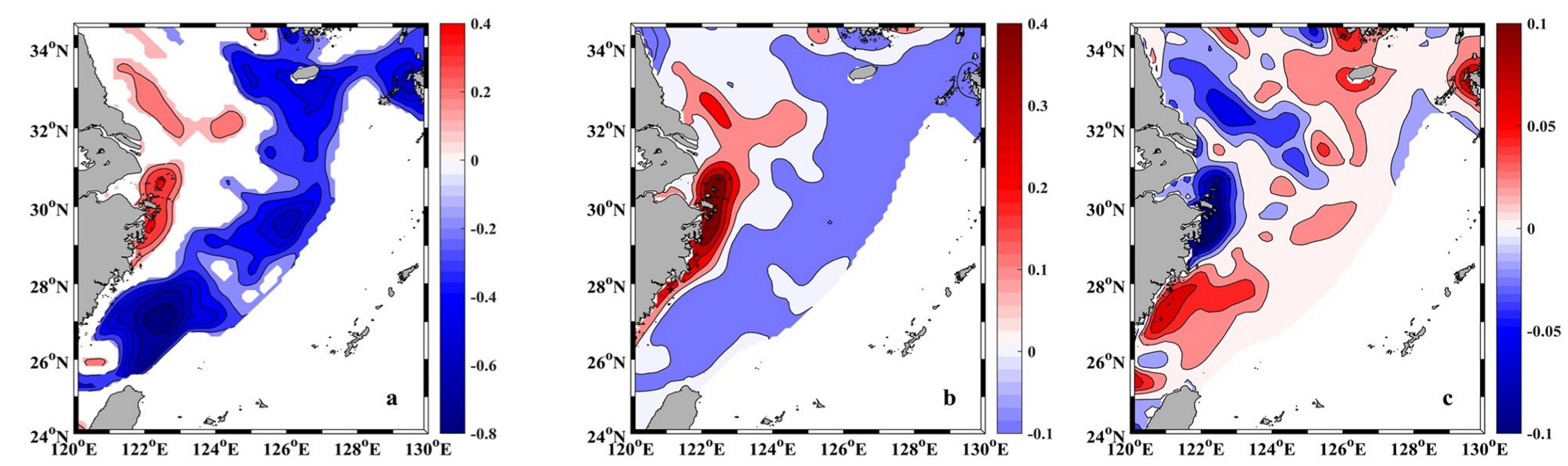

Figure 5. (a) Correlation coefficient between the phosphate transport through the EB section and the ECS chlorophyll for the period from 1997 to 2016. Surface chlorophyll anomaly for periods when the phosphate transport is more than the mean plus 1 standard deviation **(b)** and less than mean minus 1 standard deviation **(c)**. The two periods have been shown in Figure 3a. Only the shelf region of ECS (depth < 200m) is shown in the figure. The unit is mg m^{-3}.

4. Possible mechanism for the KIPT influence on the ECS chlorophyll

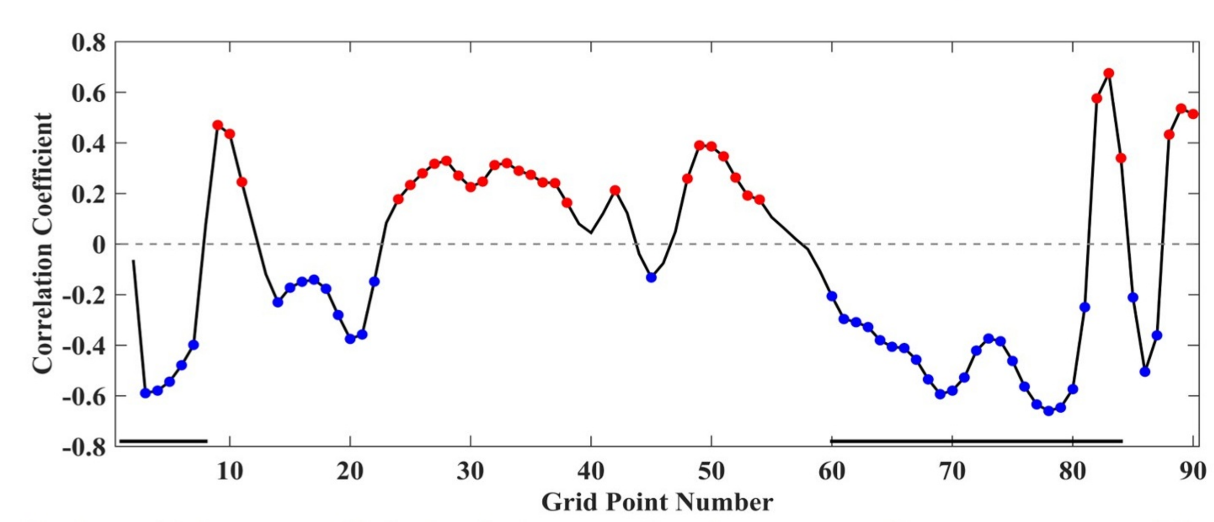

Figure 6. Correlation coefficients between the interannual component of the Kuroshio main axis index and the integrated phosphate transport along the eastern boundary of the East China Sea. Red and blue dot denote significant positive (negative) correlation at 95% confidence level (±0.13). The grid points are shown in Figure 1. The Kuroshio main axis index was defined as the longitude of the maximum velocity alone the PN section

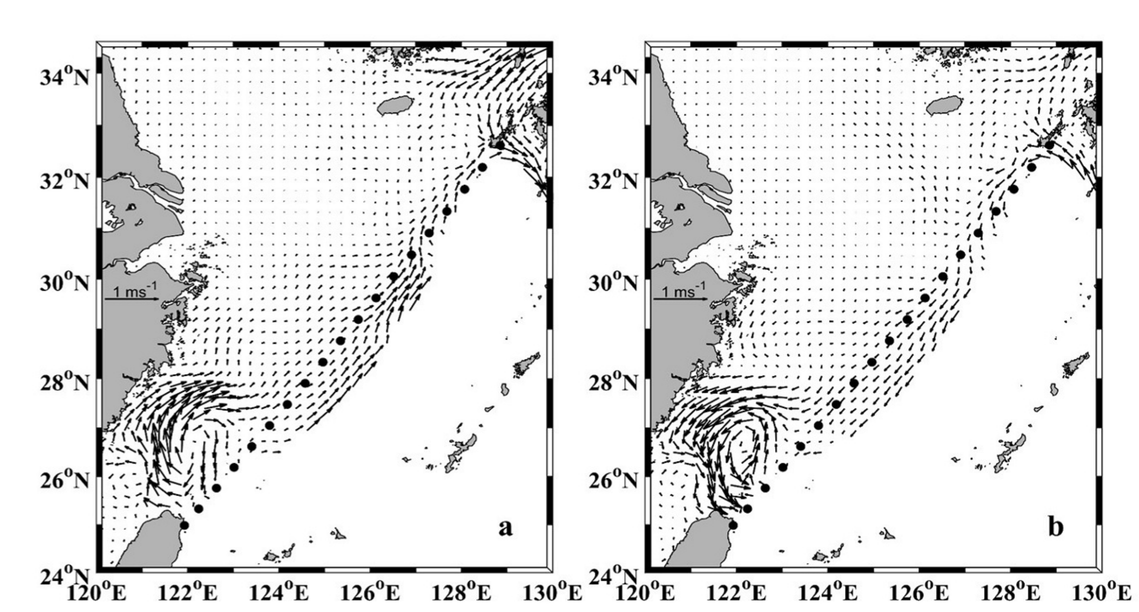

Figure 7. The bottom velocity anomaly for periods when the phosphate transport is more than the mean plus 1 standard deviation (a) and less than mean minus 1 standard deviation (b). The two periods have been shown in Fig. 3a. Only the shelf region of ECS (depth < 200m) is shown in the figure.

According to the topographic beta spiral theory [Yang et al., 2018], the Kuroshio intrusion is regulated by the bottom upwelling.

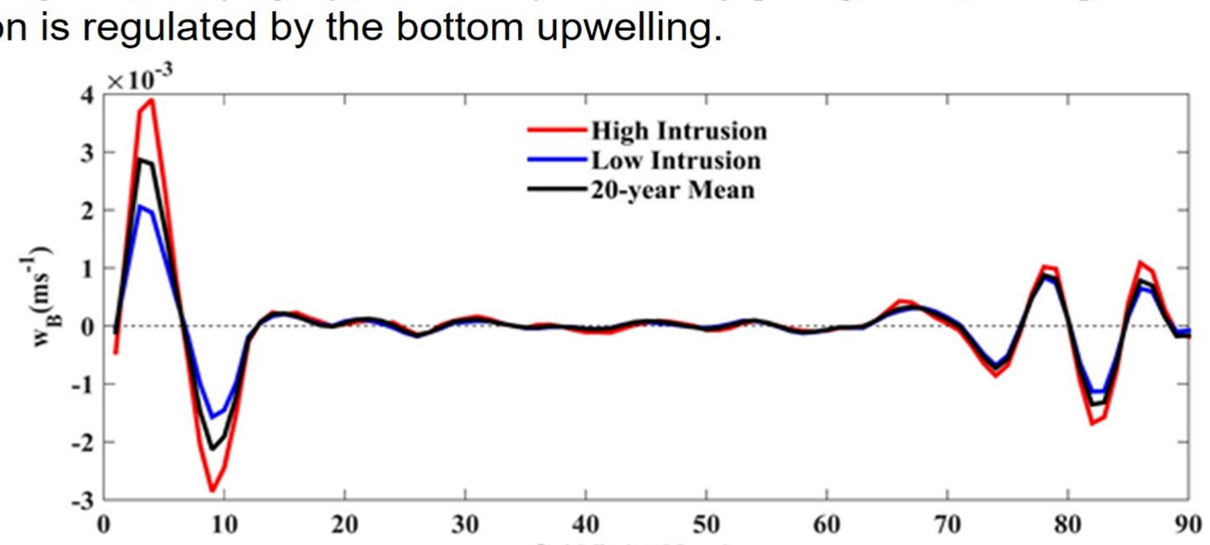

Figure 8. The bottom upwelling velocity of 20-year mean (black line), high intrusion period (red line) and low intrusion period (blue line) at each grid of the eastern boundary section of the East China Sea. The different periods are selected as Figure 7. The grid points are shown in Figure 1.

Reference

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