Influence of offshore transportation across continental shelf in East China Sea on the Kuroshio south of Japan and its extension

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1 Aims

Many studies have shown that the Kuroshio carries out multi-scale exchange with the East China Sea (ECS) in the process of heading north, and the substances such as nutrients are of great significance to support the biogeochemical process in the ECS. On the other hand, the influence of the Kuroshio current and the existence of the Tsushima Warm Current (TWC) make the exchange affect not only the ECS, but also the downstream of it. Up to now, however, there is still a lack of quantitative understanding of the temporal and spatial variation of material flux in this process as well the mechanism behind it. In this study we will reveal the distribution characteristics of the ECS Shelf Water in the downstream area, which refers to the Kuroshio Current (including Kuroshio in the ECS and in south of Japan) and its extension. Besides, the flux of ECS Shelf Water in the typical sections and the percentage that the ECS Shelf Water take in these sections in different months will be calculated. The works mentioned above are helpful to understanding of the interaction between the Kuroshio and the coastal ocean and establish a good background for further research on the spatial and temporal variations of nutrients and primary production in the northwestern Pacific.

2 Procedure

To simulate the water exchange between the ECS and the Kuroshio more accurately and meet the needs of high-precision 3D ecological dynamics model in a further study, the horizontal resolution of the Princeton Ocean Model (POM) is improved to 1/18°, and the sigma coordinate is increased to 65 layers. Combined with historical data and numerical experiments, our project expounds the temporal and spatial characteristics of the distribution of the ECS Shelf Water in the downstream area after the cross-shelf transportation in different seasons. Then compares the influence of the ECS Shelf Water at the typical section in different months and reveals the role of the underlying mechanism. It should be noted that the "downstream area" in this study refers to the area located downstream of the continental shelf of the ECS on the concept of geographical location Namely the Kuroshio in the ECS, the Kuroshio in south of Japan and Kuroshio Extension.

3. Results

3.1 Offshore transportation of ECS Shelf Water in 2006

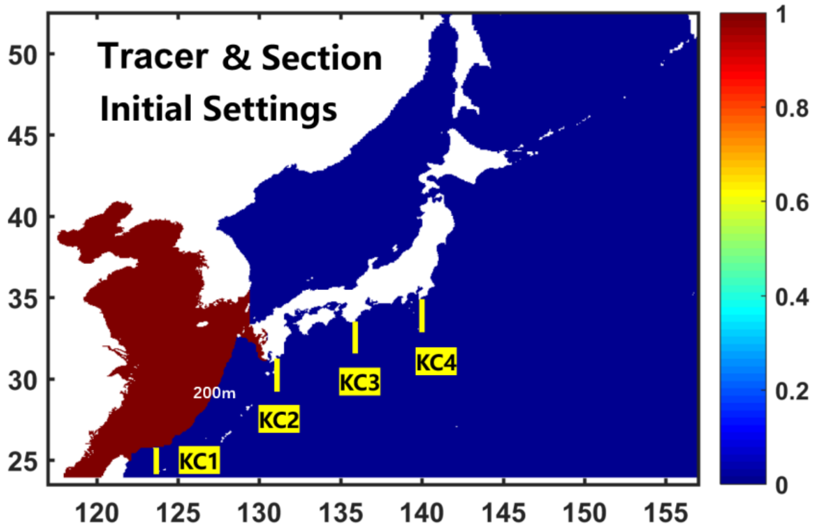

Fig.1 Model domain. Here the red area is set with tracer in all depth, and the yellow solid line represents the taken sections: KC1 is the beginning of Kuroshio in ECS, KC2 is located at Osumi-kaikyo, KC3 is at the middle of the Kuroshio in south of Japan, KC4 is the location to entering the Kuroshio Extension

Firstly, the cross-shelf transportation in the ECS in 2006 is simulated. In the model, tracer with a value of 1 is set in the continental shelf area of the ECS (within 200 m isobath and in all depth, Fig. 1) and remain unchanged for one year, and the initial value of tracer in other area is set to 0. The distribution in each season during the period is shown in Fig.2. It is obvious that the offshore transportation of ECS Shelf Water exits all year and mainly includes two branches: one is to pass through the Tsushima Strait and entering Japan Sea, the other is entering the Kuroshio through the Osumi-kaikyo. The former has been studied in many researches and will not be repeated here. The high value of tracer passing through the Osumi-kaikyo exist along the Kuroshio and extends north and south to 45°N and 25°N under the effect of the high velocity of the Kuroshio and eddies. Moreover, it can be seen from the time that the cross shelf transportation is weak in winter (February), the strongest in summer (August), and in the transitional stage in spring and autumn.

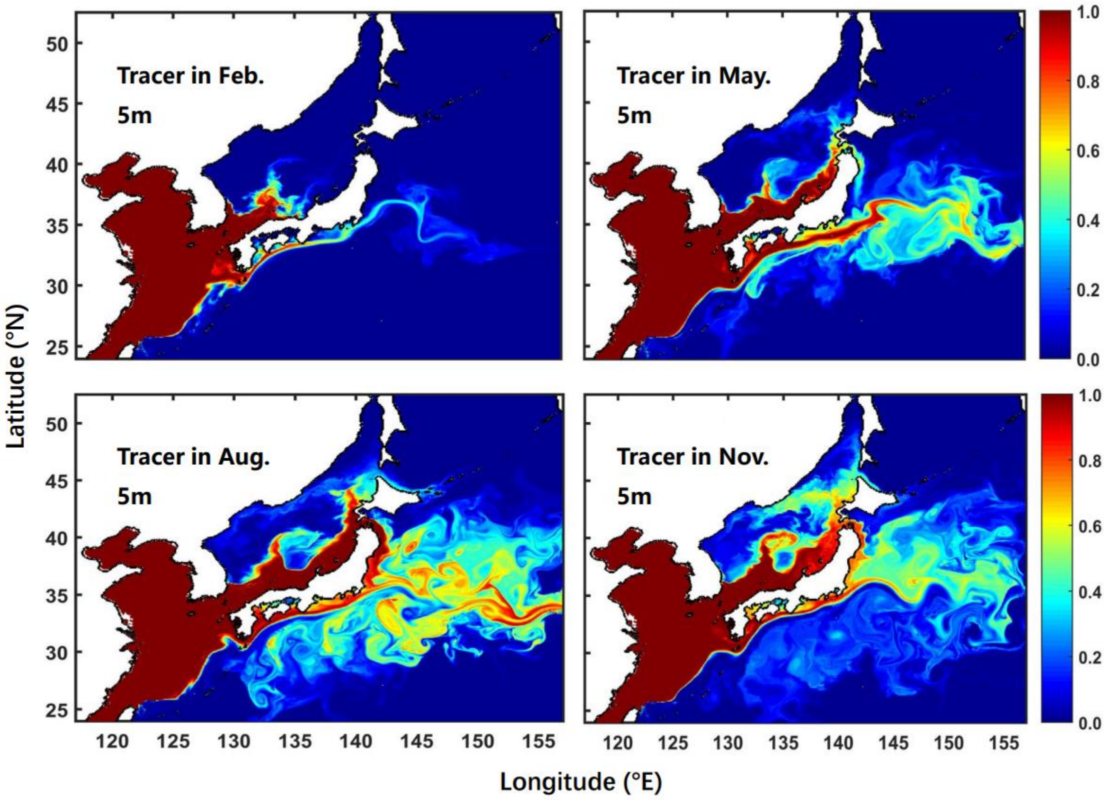

Fig.2 Surface distribution of tracer in different seasons

3.2 Distribution characteristics of ECS Shelf Water after in the next months

The temporal and spatial distribution characteristics of ECS Shelf Water transport in the next year are compared through numerical experiments. It consists of 12 cases: The tracer with a value of 1 on the ECS continental shelf area is given from January to December, respectively, and its value remains unchanged in this month. Then the tracer on the ECS continental shelf area is cleared at the beginning of the next month. At this time, the tracer contained in the model represents the offshore transportation of the ECS Shelf Water in this month. The temporal and spatial characteristics of distribution beginning in different seasons in next months are compared (Fig. 3).

It is obvious that the offshore transport of the ECS Shelf Water is stronger in spring and summer. Besides, eddies or the high velocity of the Kuroshio make it easier for tracer to expand or maintain a high concentration and enter the Kuroshio Extension, especially in spring; On the contrary, the offshore transport in autumn and winter is weak. All the tracer decreased to a lower level in the fourth month.

In addition, taking the Osumi-kaikyo section (KC2) as an example (Fig.4), it can be clearly seen that the tracer started to pass through the Osumi-kaikyo (with a core inside and outside the strait respectively) into the Kuroshio in south of Japan in the beginning month. Then its flux increased with the effect of the current field, and the transportation cores mentioned above were at about 50 m. The high flux can be maintained until the next month (i.e. the first month after emptying the tracer on the ECS continental shelf), and then began to decrease. At the beginning of the third month, the tracer has basically passed through the Osumi-kaikyo, when the flux is very low. In terms of seasonal variation, the tracer transport in Osumi-kaikyo when the tracer is first released is the strongest in winter, but the overall transportation is stronger in spring and summer than in autumn and winter.

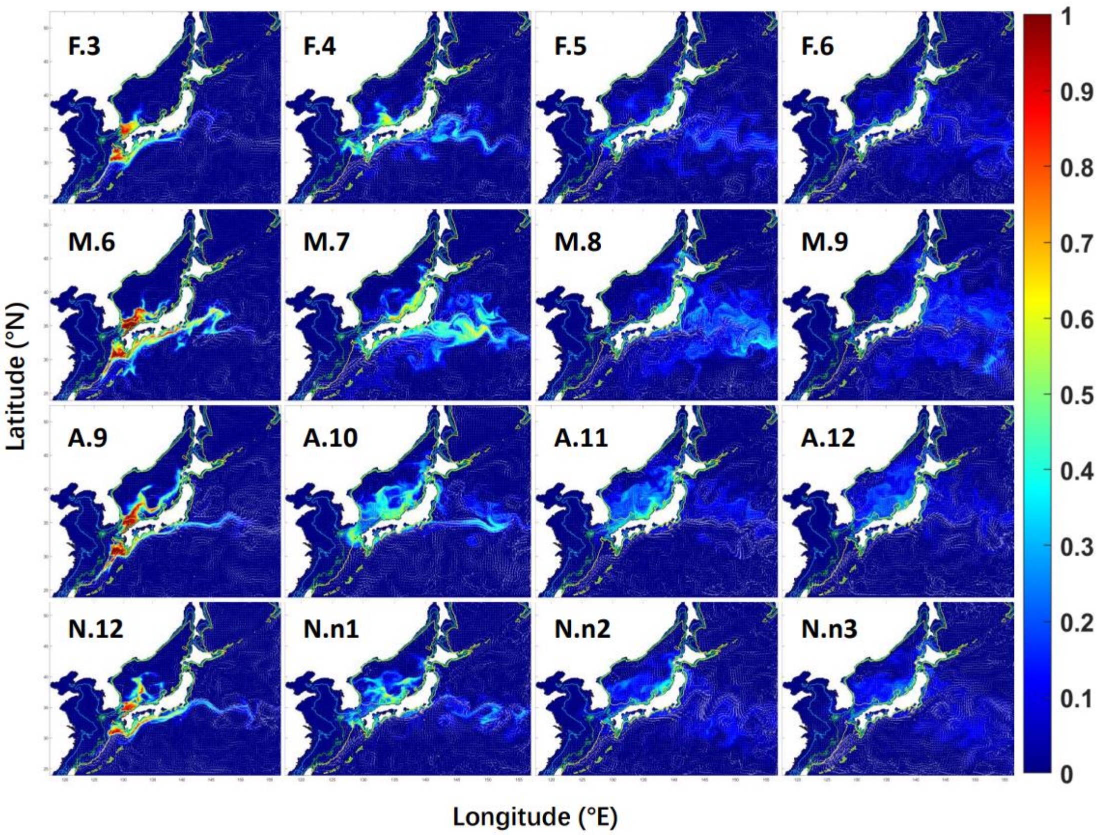

Fig.3 Distribution characteristics of ECS Shelf Water after in the next months. The blue, green and yellow solid lines in the figure are 50m, 100m and 200m isobaths respectively. The white arrow indicates the surface current field. As for the name of sub-fig, F/M/A/N indicate that tracer was released in February (winter)/May (spring)/August (summer)/November (Autumn), The number after the point represents the next month (n means next year).(e.g. "N.n1" means tracer was released at November, the picture shows the distribution in January of the next year)

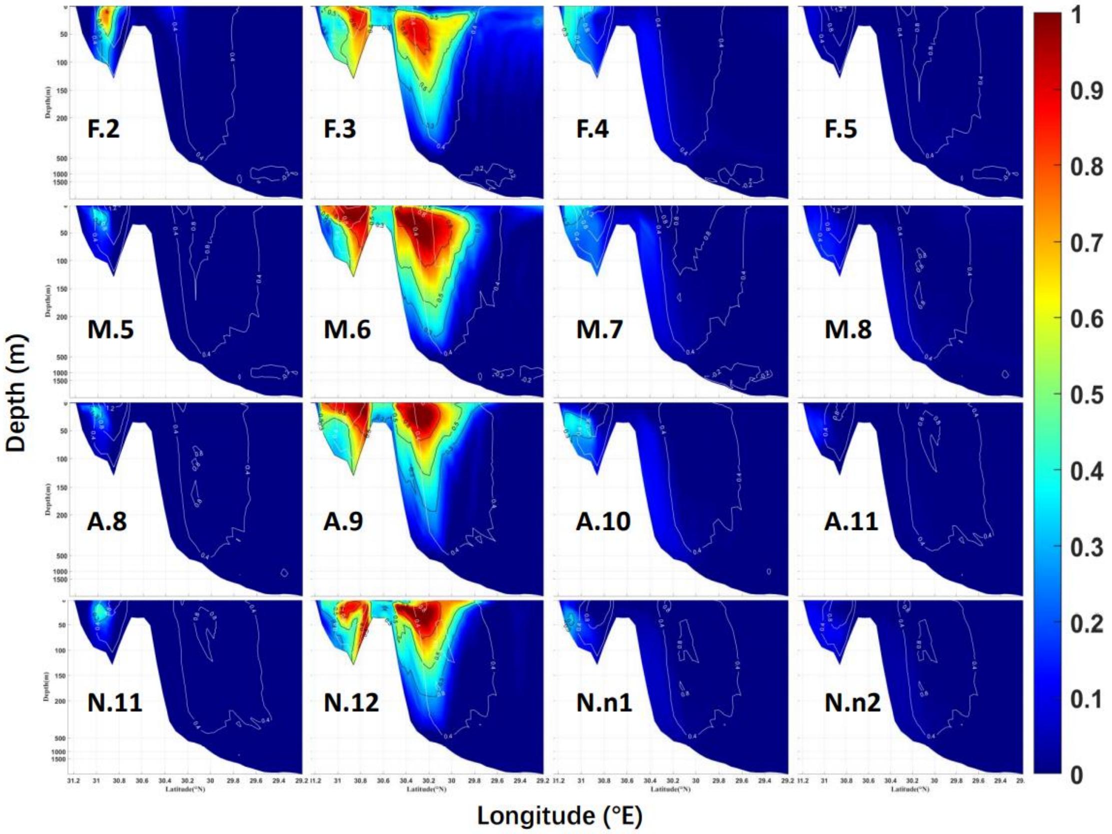

Fig.4 Distribution characteristics of ECS Shelf Water after in the next months in KC2. White solid line represents the current velocity. Naming method is consistent with Fig.3

3.3 Percentage of ECS Shelf Water in typical sections in different seasons.

Take Osumi-kaikyo section (KC2) as an example as above, to calculate the percentage of ECS Shelf Water in the past year at the same typical section in different seasons. The result shows that the percentage of ECS Shelf Water at KC2 in all months of the previous year is 4.08% (winter), 5.04% (spring), 7.00% (summer) and 4.19% (Autumn) respectively. It can be seen from Fig.5 that the law of affection of ECS Shelf Water in different seasons is generally the same. The most significant one is the latest month, its percentage of ECS Shelf Water is much higher than that in other months; And the percentage of the last three months reached 84.5% (winter), 78.2% (spring), 76.1% (summer) and 89.9% (Autumn) of all shelf water in KC2. Combined with the above calculation, it can also be found that the impact of shelf water in the last few months is significantly inversely proportional to the total amount of all shelf water in the section.

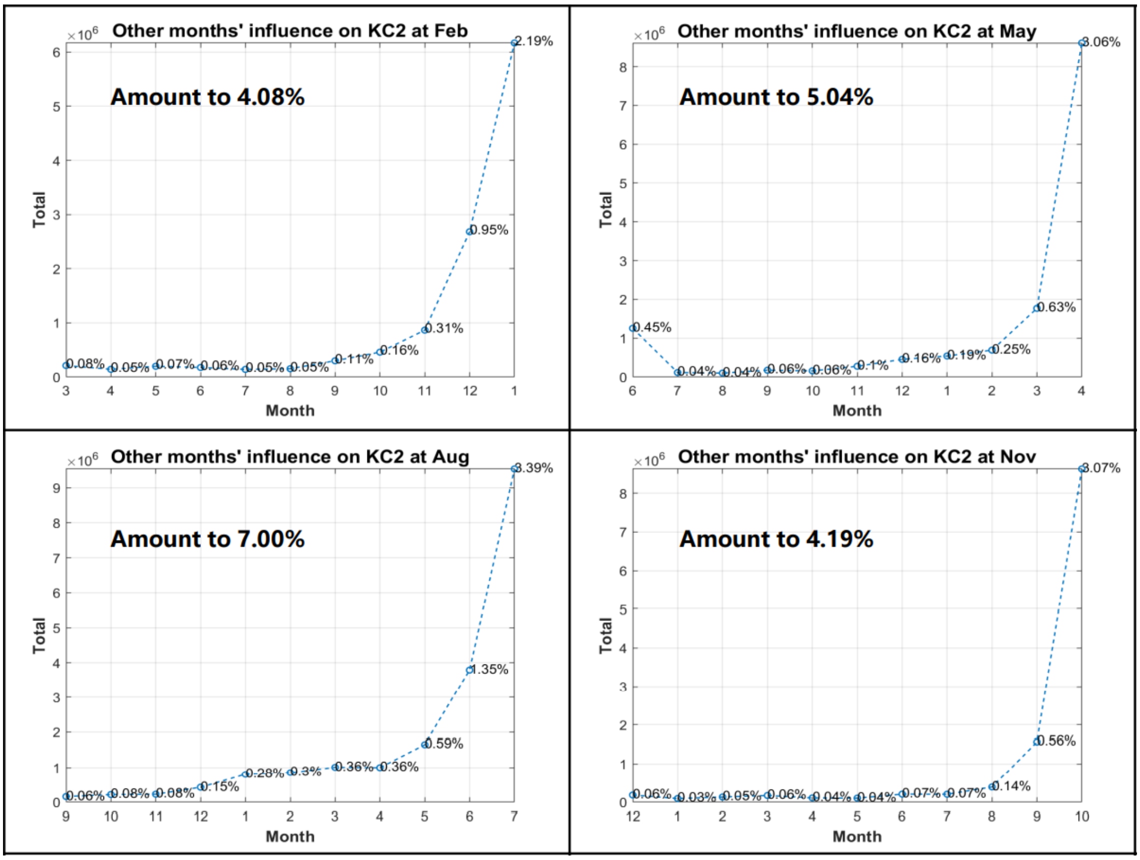

Fig.5 Percentage of ECS Shelf Water in typical sections in different seasons.

4 Publication/conference presentation

Currently, the results have not been published.

5 Perspectives in future

In the future, we will pay more attention to the temporal variation of nutrient flux and primary production in the northwestern Pacific.