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Monthly Change of Nutrients impact on Phytoplankton in Kuroshio of East China Sea

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Abstract

Using the Nutrients data from World Ocean Atlas 2009 issued by NOAA in 2010 to analyze the monthly change of nutrient content, nutrient proportion and nutrient limitation in Kuroshio East China Sea, the results show that: (1)The ratios of N/P, Si/N, Si/P in shallow waters of 250m with a significant spatial differences. The spatial differences of Si/N and N/P are most obvious in March to April and August to September, the smaller differences occurs in October to December. The spatial distribution of Si/P is different from N/P and Si/N, Strong regional differences appears in September, the relatively uniform spatial distribution appears in May to June. (2)The major nutrient concentrations limit in Kuroshio of East China Sea are N and P, which impact in shallow of 300m. The nutrient concentrations are higher than threshold concentration in 300m to deeper area, so it could not appear the phenomenon of nutrient limitation. Phytoplankton growth mainly occurs in the range of 100~200m in April to November.

Keywords: ECS Kuroshio; Nutrient; Sea Environment.

1. Introduction

Nutrients are basic marine ecosystem element, they participate in the whole process of marine life. Their content distribution and ratio are not uniform, if the nutrient content and ratio lower or higher than a certain percentage, it will be restrict the growth of marine plankton material and affect the status of regional marine primary productivity, thereby affecting the stability of marine ecosystem and fisheries development. So the role of nutrients and their limitation are paid highly attention by marine researchers.

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The change of nutrients and nutrient limitation in coastal waters of china were studied by Zhiliang Shen [1], Haiming Shi [2], Xiaoyong Shi [3], Xiulin Wang [4], Weihong Zhao [5], Xu[6] and other scientists. The results show that nutrient limitation of china's coastal waters is mainly by P, the high degree of eutrophication and harsh marine environment makes inshore fisheries resources continue to decline[7].Therefore, the development of marine fisheries resources in offshore area become the focus of attention[8].However, the previous studies of nutrients in this area especially in Kuroshio East China Sea(ECS Kuroshio) are limited to the distribution of individual times, which lack in the study of monthly change about nutrient concentrations, nutrient ratio and nutrient limitation, So this paper studies the above situation to provide a scientific basis of marine ecosystem and marine fisheries in offshore sea.

2. Data and Analyzing

2.1. Data

The nutrients data are from World Ocean Atlas 2009 issued by NODC in 2010, and the database grid is 1°×1° [9]. The topography data is from ETOPO2v2 Global Database issued by NGDC in 2006, and it's grid is 2'×2' [10]. Refering to Ren Huiru et al's stduy on spatial distribution of warm core of ECS Kuroshio [11], selecting the region between the slope line of East China Sea continental shelf which is 160m underwater and the isobath western of Ryukyu Islands which is 500m underwater as this study area of ECS Kuroshio in Fig.1.

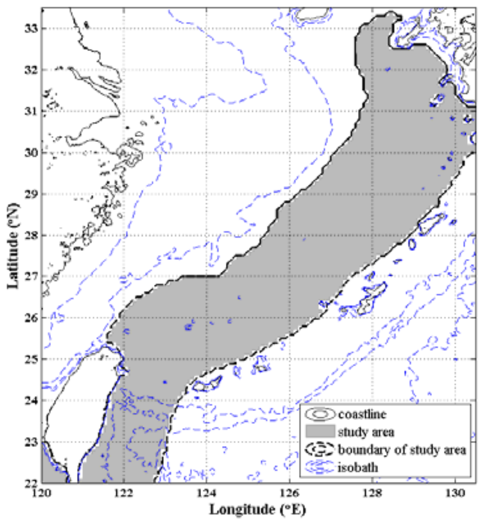

Fig.1. Research Region

2.2. Analyzing

Using Matlab computer program to select the nutrients data of January to December between 120º~130.5ºE, 22º~33.5ºN, depth of 0~500m from the WOA09 database and pick out the topography data for same region from ETOPO2v2. Then unified grid for two data to remove the influence of islands and interpolated the nutrients data into 0.1°×0.1° for forming a regional three-dismensional database which include nutrients, N/P, Si/N, Si/P . Through the analysis of the database to study the monthly change of nutrient and nutrient limitation impact on phytoplankton in ECS Kuroshio.

3. Results and Discussion

3.1. Monthly Change of N/P, Si/P, Si/N

The proportion of nutrients in ECS Kuroshio with regional differences. For quantitative analysis of the spatial fluctuations in nutrient ratio differences, this paper use the coefficient of variation to show the monthly spatial distribution change of N/P, Si/N, Si/P, the formula is as follows in Eq. 1 [12]:

$$Cv=S^2/\overline{X} \tag{1}$$

In this formula, $\overline{X}$ is the spatial sequence average value of N/P, Si/N, Si/P in each layer. S^2 is the standard deviation of N/P, Si/N, Si/P in each layer. Cv is the coefficient of variation. The greater value of coefficient of variation show that, the regional differences of N/P, Si/N, Si/P is more intense and the spatial distribution is more apparent.

The Table 1 shows the monthly change of variation coefficient of nutrients proportion for each layer. Combining the Table 1, it could be seen that the maximum range of Cv about N/P is 0.29~2.18. 250m is the dividing line, in upper of 250m, the maximum value of Cv appears in August to September, and in deeper of 250m, the maximum value of Cv appears in March to April. The minimum value of Cv about N/P decreases with increasing depth trend and mainly appears in October to December with no obvious stratification, it's range is 0.07~0.49.

The maximum range of Cv about Si/N is 0.45~7.62. In upper of 250m, the maximum value of CV appears in July to August, and in deeper of 250m, the maximum value of CV appears in January to Febuary. The minimum range of Cv about Si/N is 0.24~0.59 and it mainly appears in October to December.

The Cv trends of Si/P is similar with N/P, but they have a big difference on the appearance time of maximum and minimum. The maximum range of Cv about Si/P is 0.43~1.78. In upper of 250m, the maximum value of Cv appears in September, and in deeper of 250m, the maximum value of Cv appears in July to September. The minimum range of Cv about Si/P is 0.19~0.57, it mainly appears in May to June on upper and deeper waters, however, on middle waters it appears in October to December.

Table.1 Monthly change of variation coefficient

Depth	N/P (C_V)				Si/N (C_V)				Si/P (C_V)			
	Max	Month	Min	Month	Max	Month	Min	Month	Max	Month	Min	Month
0m	1.95	Aug	0.44	Oct	2.01	Aug	0.59	Dec	1.78	Sep	0.46	May
50m	1.1	Aug	0.49	Dec	2.85	Aug	0.55	Nov	1.24	Sep	0.57	Jun
100m	1.18	Sep	0.35	Oct	7.62	Jul	0.52	Dec	1.36	Sep	0.38	Jun
150m	2.18	Sep	0.26	Nov	3.56	Jul	0.43	Nov	1.56	Sep	0.39	Nov
200m	1.93	Sep	0.22	Dec	3.05	Jul	0.29	Nov	1.72	Sep	0.39	Dec
250m	0.6	Sep	0.18	Dec	1.42	Oct	0.44	Nov	0.86	Sep	0.3	Nov
300m	0.61	Apr	0.14	Oct	1.18	Jun	0.33	Oct	0.88	Jul	0.21	Dec
350m	0.44	Apr	0.11	Oct	0.83	Feb	0.28	Oct	0.63	Sep	0.21	Dec
400m	0.49	Mar	0.11	Oct	0.79	Jan	0.27	Oct	0.64	Aug	0.23	Dec
450m	0.29	Mar	0.07	Nov	0.48	Feb	0.25	Oct	0.44	Sep	0.19	Oct
500m	0.32	Mar	0.07	Dec	0.45	Jan	0.24	Mar	0.43	Aug	0.19	May

3.2. Monthly Change of Nutrient Limitation

When the nutrient concentration is lower than a certain value, it will limit the growth process of phytoplankton. Nelson proposed Si=2μmol/L, DIN=1μmol/L, P=0.1μmol/L is the minimum threshold of the lowest nutrient content based on kinetic theory of phytoplankton growth, which recognized by many experts[13].

Table 2 shows the ratio of sea area under the nutrient concentrations threshold. It could be seen, the concentrations of DIN and P are very low in 0m layer, the area of DIN concentration below 1μmol/L is more than 80% and above 50% of the sea it's P concentration less than 0.1μmol/L. In 50m layer, nutrient status better than 0m layer, about 71% of the area is limited by DIN and limited by P is close to 36%. The limitation by nutrient concentrations continue to decrease in 100m and 150m layer, in addition to the sea area limited by DIN is greater than 30% in 100m layer, the rest areas are less than 20%. With the depth increases, there is almost no nutrient limitation in 200m~300m layer.

In summary, the main area affected by nutrient limitation is in upper of 300m layer, nutrient limitation will not appear in deeper of 300m layer because of the nutrient contents are higher than the threshold concentrations. The main nutrient restriction elements are N and P in ECS Kuroshio, which is mainly due to there is no obvious source of N in upper waters and complex distribution of P[14].

Table.2 The ratio of sea area under the nutrient concentrations threshold

Threshold of nutrient concentrations	Percent(%)						
	0m	50m	100m	150m	200m	250m	300m
N<1μmol/L	89.32	70.86	33.72	10.86	1.77	1.21	0
Si<2μmol/L	21.96	23.77	16.92	17.20	8.81	3.60	2.72
P<0.1μmol/L	54.60	35.84	17.71	10.73	4.64	0.78	0.22

Except the nutrient threshold concentrations, if the imbalance between nutrients also limit the growth of phytoplankton. Justic and Dorch proposed a evaluation standard of nutrient stoichiometric based on previous studies: (1) when Si/P >22 and N/P >22, P is the limiting factor. (2) when N/P <10 and Si/N >1, N is the limiting factor. (3) when Si/P <10 and Si/N >1, Si is the limiting factor[15,16].

Table.3 The ratio of sea area beyond nutrient limitation

Depth	Percent(%)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
0m	13.22	16.29	3.02	0	0	0	0	0	0.29	0	0	7.78	3.38
50m	13.99	22.01	6.60	12.96	10.13	11.45	3.18	5.26	4.38	4.41	4.50	10.39	9.10
100m	19.31	33.58	12.83	40.33	35.19	46.90	52.69	49.28	15.64	40.45	37.60	11.71	32.96
150m	20.78	54.03	19.91	55.25	53.49	30.18	75.04	59.04	16.84	53.13	60.36	51.52	45.80
200m	44.67	75.07	39.09	73.43	74.91	36.98	76.51	67.85	23.57	68.33	76.86	59.11	59.70
250m	45.85	79.19	57.80	43.83	69.63	58.81	67.41	71.98	24.87	70.39	85.11	70.97	62.15
300m	55.42	62.38	34.00	46.74	62.03	65.05	71.27	61.51	38.06	81.17	81.25	90.84	62.48
350m	64.12	83.77	27.88	64.30	76.30	74.17	78.70	68.74	65.50	97.20	97.42	99.96	74.84
400m	68.31	87.06	26.43	68.27	81.53	73.07	79.93	66.44	42.11	98.95	96.30	99.27	73.97
450m	77.95	90.94	46.51	86.96	88.24	75.30	86.72	79.66	82.65	100	100	100	84.58
500m	76.36	90.57	66.68	93.29	90.13	76.60	90.87	83.91	78.58	89.73	99.36	100	86.34

Using the above criteria to statistics the percent of region with no nutrient limitation in ECS Kuroshio. Table 3 shows that, because of nutrient concentrations are very low, most of the area has been limited by nutrients, there are only 3.38% and 9.10% of the area suitable for phytoplankton growth in 0m and 50m layer. The percent of suitable for phytoplankton growth is increasing fast from 32.96% to 59.70% in 100m~200m layer, April to August and October to November are the months without nutrient limitation in this area. In deeper of 250m, there is more than 62% of the area without nutrient limitation and the proportion of each month is relatively stable.

Through the above analysis, it could be seen that, there is significantly affected by nutrient limitation and the phytoplankton growth is limited in 0~50m layer. The 100~200m layer with high content of nutrients and it's also the depth which sunshine can be achieved, so the growth of phytoplankton occurs in this depth range. In deeper of 250m layer, it limits the growth of phytoplankton, because of the proportion and concentrations of nutrient fit the growth of phytoplankton, but the sunlight can not reach this depth.

4. Conclusions

The N/P, Si/N and Si/P have a significant spatial differences during upper of 250m layer in ECS Kuroshio. the spatial differences of Si/N and N/P are most obvious in March to April and August to September, the smaller differences occurs in October to December. The spatial distribution of Si/P is different from N/P and Si/N, Strong regional differences appears in September, the relatively uniform spatial distribution appears in May to June.

The major nutrient concentrations limit in ECS Kuroshio are N and P, which impact in shallow of 300m. The nutrient concentrations are higher than threshold concentration in 300m to deeper area, so it could not appear the phenomenon of nutrient limitation. Phytoplankton growth mainly occurs in the range of 100~200m in April to November.

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