Distribution of chlorophyll and phytoplankton in Xiapu, Fujian

Zhe Hao¹,²,³*, Ziyue Feng¹, Xinqing Zou¹,³,⁴, Weihua Feng² and Hengtao Xu²

¹School of Geographic and Oceanographic Sciences, Nanjing University, Nanjing 210093, China
²Key Laboratory of Engineering Oceanography, Second Institute of Oceanography, SOA, Hangzhou 310012, China
³Collaborative Innovation Center of South China Sea Studies, Nanjing University, Nanjing 210093, China
⁴Key Laboratory of Coast and Island Development (Nanjing University), Ministry of Education, Nanjing 210093, China

*Corresponding author’s e-mail: fishhaozhe@163.com

Abstract. Phytoplankton is the primary productivity of the ocean, increasing their biomass through accumulating organic matter synthesized by photosynthesis. Chlorophyll a and pheophytin will all bring important influence on the recognition of biological optical information for phytoplankton. So it’s necessary to analyse distribution of chlorophyll and phytoplankton. In this study, the concentration distributions of chlorophyll a and pheophytin in Xiapu were obtained. As a result, the overall trend of concentrations showed summer > spring > autumn > winter. This was mainly because of the difference of seawater temperature. The distribution of chlorophyll and phytoplankton varied with time. And they share a similar trend, indicating that chlorophyll content directly affects phytoplankton content.

1. Introduction

Marine phytoplankton is the primary productivity of the ocean, increasing their biomass through accumulating organic matter synthesized by photosynthesis. The growth of marine phytoplankton is inhibited, and one of the main reasons is that photosynthesis is affected by other factors [1]. Chlorophyll a is the main pigment for photosynthesis of phytoplankton. As a basic parameter of marine ecology, concentration of chlorophyll a is an important indicator for whether the photosynthesis of phytoplankton is normal or not [2]. The high concentration of pheophytin will change the absorption characteristics of phytoplankton, which will bring important influence on the recognition of biological optical information in water [3]. Temperature, light and zooplankton predation might also modulate the phytoplankton biomass in local regions [4].

This paper analyzed distribution of chlorophyll and phytoplankton in Xiapu, Fujian Province. It will help understand the potential effect factors for chlorophyll and phytoplankton.

2. Materials and method

2.1. Study area
The study area is located in Xiapu county, Ningde city, Fujian Province. It is located about 15km southeast of Xiapu county, and about 59km as the crow flies from Ningde city (southwest of the factory). There were 48 large observation stations, 2 fixed point continuous observation stations (Station 5 and Station 6). The location of the study area and the survey stations were shown in figure 1.

Figure 1. Study Area and survey stations

2.2. Sample collection for chlorophyll a and pheophytin
Sea water samples for concentration analysis of chlorophyll a were collected at corresponding levels with spherical cover HQM-1 plexiglass sampler. 100cm³ water samples were filtered by Whatman GF/F glass fiber membrane under negative pressure, and the filter membrane containing photosynthetic plankton was immediately frozen and stored until analysis. Samples were collected every 3 hours at the observation stations day and night in continuous observation stations (Station 5 and Station 6). Concentration of chlorophyll a was analyzed and determined by extractive fluorescence method with 90% acetone extract. The contents of chlorophyll a and pheophytin were determined by Turner Designs Fluorometer and Model 10 for the extracted samples. The collection, storage, transportation, pretreatment, analysis, determination and calculation of samples were all carried out in strict accordance with the requirements of the Code of Marine investigation.

2.3. Sample collection for phytoplankton
500mL sea water samples from 0.5m to the surface were collected with plexiglass water sampler for quantitative analysis in the large-area observation stations. Shallow water type III plankton net with flow meter was used for vertical trawling from bottom to surface to collect once for species composition analysis. Water samples of 0.5m layers were collected every 3 hours at the observation stations day and night in continuous observation stations (Station 5 and Station 6). The samples were fixed with neutral formaldehyde. The samples were concentrated and observed, identified and counted under a nissan Nikon microscope.

3. Results

3.1. Horizontal distribution of chlorophyll a and pheophytin in summer in the large-area observation station
Specific survey statistics of chlorophyll a and pheophytin in the study area were shown in Fig. 2. The increase of sea water temperature in summer promoted the growth and reproduction of photosynthetic plankton. The concentration of chlorophyll a in sea area was 0.990–27.488 mg/m³, with an average value of 10.149 mg/m³. The concentration of pheophytin was 0.640–16.360 mg/m³, with an average value of 4.184 mg/m³. The concentrations of chlorophyll a was higher than those of pheophytin.
3.2. Comparison for concentrations in different seasons

Comparison for concentrations in different seasons were shown in Table 1. Overall trend of the concentrations showed summer > spring > autumn > winter. This was mainly because in summer the increase of seawater temperature promoted the growth and reproduction of photosynthetic plankton, and the whole sea area was in the range of relatively high chlorophyll concentration. While the seawater temperature is low in winter, and the chlorophyll content is relatively low.

Table 1. Comparison for concentrations in different seasons

|                | Spring | Summer | Autumn | Winter |
|----------------|--------|--------|--------|--------|
| chlorophyll a  |        |        |        |        |
| Min            | 0.58   | 0.31   | 0.41   | 0.61   |
| Average        | 2.95   | 3.05   | 1.78   | 1.28   |
| Max            | 10.92  | 9.16   | 8.67   | 2.54   |
| Min            | 1.16   | 0.15   | 0.07   | 0.17   |
| pheophytin     |        |        |        |        |
| Average        | 4.47   | 1.22   | 0.48   | 0.45   |
| Max            | 11.52  | 5.45   | 1.85   | 1.15   |

3.3. Concentrations of chlorophyll a and pheophytin variation with time in continuous survey stations

In summer, the surface chlorophyll a and pheophytin concentration at each moment of No. 5 continuous station was shown in Fig. 3(up). The concentration of chlorophyll a ranged from 1.924 to 18.033 mg/m³, with an average value of 9.633 mg/m³. The concentration was lowest at 16:00 and highest at 10:00. Pheophytin concentration was 1.613~7.605 mg/m³, with an average value of 4.540 mg/m³. The concentration was lowest at 13:00 and highest at 22:00. The changes of chlorophyll a and pheophytin concentrations were similar, showing a trend of peak and valley alternations. However, at 19:00, the concentration of chlorophyll a significantly decreased, while pheophytin concentration still increased slightly, and showed a decreasing trend until 22:00.

Fig. 3 (down) showed the surface chlorophyll a and pheophytin concentration at each moment of No. 6 continuous station. The concentration of chlorophyll a ranged from 1.496 to 11.769 mg/m³, with an average value of 4.670 mg/m³. Pheophytin concentration was 0.990~6.204 mg/m³, with an average value of 2.240 mg/m³, and the lowest concentration was at 18:00, and the highest at 09:00. The fluctuation trend of chlorophyll a and pheophytin concentrations with time is almost the same, reaching extremely high values at 21:00 and 09:00.
Figure 3. Concentrations variation with time in continuous survey 5 station (up) and 6 station (down). The blue line represents chlorophyll a while the red one represents pheophytin.

3.4. Concentrations of phytoplankton variation with time in continuous survey stations

At station 5, the abundance of phytoplankton cells was $0.874 \times 10^6$ ~ $3.756 \times 10^6$ /m$^3$, with a small variation, reaching $3.756 \times 10^6$ /m$^3$ at 16:00. The abundance of 10:00 is the second highest, $3.148 \times 10^6$ /m$^3$; 13:00 and 1:00 have the lowest abundance, $1.085 \times 10^3$ and $0.874 \times 10^6$ /m$^3$ respectively. The trend was shown in figure 4 (up).

The diurnal variation of phytoplankton cell abundance at station 6 is relatively smaller compared with that at station 5, between $0.119 \times 10^6$ and $0.854 \times 10^6$ /m$^3$. The abundance reached the highest level at 15:00 on the second day ($0.904 \times 10^6$ /m$^3$); The second highest abundance is at 15:00 on the first day ($0.78 \times 10^6$ /m$^3$). 0:00 phytoplankton abundance reaches a minimum of $0.119 \times 10^6$ /m$^3$. The trend was shown in figure 4 (down).

During the continuous observation day and night, the abundance of phytoplankton was higher in the afternoon to evening due to the strong photosynthesis during the day. At night, photosynthesis is weakened and phytoplankton abundance is low. It can be seen that photoperiod is the main factor affecting the diurnal variation of phytoplankton abundance. The trend of phytoplankton was similar with that of chlorophyll, indicating that chlorophyll content directly affects phytoplankton content.
Figure 4. Concentrations variation with time for phytoplankton in continuous survey 5 station (up) and 6 station (down)

4. Conclusions
The concentration distributions of chlorophyll a and pheophytin were obtained. The overall trend of concentrations showed summer > spring > autumn > winter. This was mainly because of the difference of seawater temperature. The distribution of chlorophyll and phytoplankton varied with time. And they share a similar trend, indicating that chlorophyll content directly affects phytoplankton content.

Acknowledgments
This work was supported by the National Natural Science Foundation of China [grant numbers 41601560].

References
[1] L.Zhang, X.L.Wang, X.R.Han. C.J.Zhu, X.Y.Shi, F.H.Jiang, R.J. Yang (2010). Effects of petroleum hydrocarbon on the growth of marine algae: Experiment versus model. Journal of ocean university of Qingdao, 32(5):804-810.
[2] F.B. PéR. (2010) Fuel toxicity on Isochrysis galbana and a coastal phytoplankton assemblage: Growth rate vs. variable fluorescence [J]. Ecotoxicology and Environmental Safety, 73(3):254-261.
[3] L. Wang, D.Z. Zhao, X.G. Xing, J.H. Yang, Y.N. Fu (2009). The effects of pheophytin on absorption characteristics of phytoplankton. Oceanologia et Limnologia Sinica, 40(5):596-602.
[4] M.Z. Fu, Z.L. Wang, P. Sun, Y.Li, R.X.Li (2009). Spatial distribution characteristics and the environmental regulation mechanisms of phytoplankton chlorophyll a in Southern Yellow Sea during summer 2006. Acta Ecologica Sinica, 29(10): 5366-5373.