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Phytoplankton biomass and production in northern South China Sea during summer: Influenced by Pearl River discharge and coastal upwelling

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ABSTRACT

Chlorophyll a and primary production were studied in northern South China Sea during summer from 2007 to 2008. Microplankton dominated total phytoplankton biomass in the coast, while picoplankton dominated in the offshore. Algae bloom caused by *Thalassionema nitzschioides* was found at the subsurface of upwelling regions (D2, C2) in 2008, and maximum of phytoplankton abundance reached 1.58×10^6 ind L^{-1}. Integrated primary production ranged from 189.3 to 976.2 mg m^{-2} d^{-1} in 2007, and ranged from 652.1 to 6601 mg m^{-2} d^{-1} in 2008. PP showed positive relationship with IPP ($p < 0.01$) and negative relationship with SST ($p < 0.05$). Coastal upwelling and Pearl River discharge sustained high PP, and played important role in regulating the phytoplankton biomass and production.

1. Introduction

Seasonality of reversing monsoon plays an important role in determining the upper ocean circulation [1]. Physical factors control the distribution of chlorophyll a (chl a) and primary production (PP) not only by affecting nutrients transportation, light penetration and temperature etc., in the euphotic zone, but also by affecting the diffusion and aggregation of phytoplankton directly [2–3].

The Pearl River empties into the northern South China Sea (nSCS), which receives a heavy load of nutrients from increased agriculture fish farming and sewage effluents due to population growth and economic development in southern China [4–5]. Although there were reports that Pearl River discharge heavily impacted its estuarine and neighboring coastline area [6], it is not clear how far-reaching the impact on the PP and chl a in nSCS, especially during summer when river flux is maximum.

Coastal upwelling areas are among the most productive habitats of marine ecosystems [7]. During the upwelling events along the coast of central Chile, elevated levels of PP and chl a concentration have been registered [7]. Yuedong and Taiwan bank upwelling were regarded as an important part of the nSCS upwelling systems [8], but information on PP and chl a in upwelling system in nSCS were rare.

In present study, we aimed to understand the modulation mechanism of Pearl River discharge and upwelling on PP during summer.

2. Material and methods

2.1. Study site and sampling strategy

The 2007 open cruise was conducted between August 10th and 30th, whose coverage was influenced by the Pearl River discharge and Yuedong upwelling. Sampling was taken in upwelling region between June 28th and July 15th 2008 (Fig. 1).

Discrete samples were collected at various depths using a Rosette sampler fitted with 2.5-L Niskin Bottles and mounted on the Sea-Bird CTD (Seabird, USA) for the determination of salinity and temperature. Water samples for nutrients analyze were collected with 300 mL polypropylene bottles from each sampling depth and frozen immediately, and analyzed by a Lachat QC8500 flow injection analyzer.

2.2. Chl a and PP

Seawater sample for chl a analysis were immediately filtered through GF/F filters, and stored at −20 °C. The phytoplankton pigments retained on filters was extracted in 90% acetone [9]. Chl a in the extract was measured before and after acidification with a fluorometer (Turner-10-AU). Size fractionated chl a was measured

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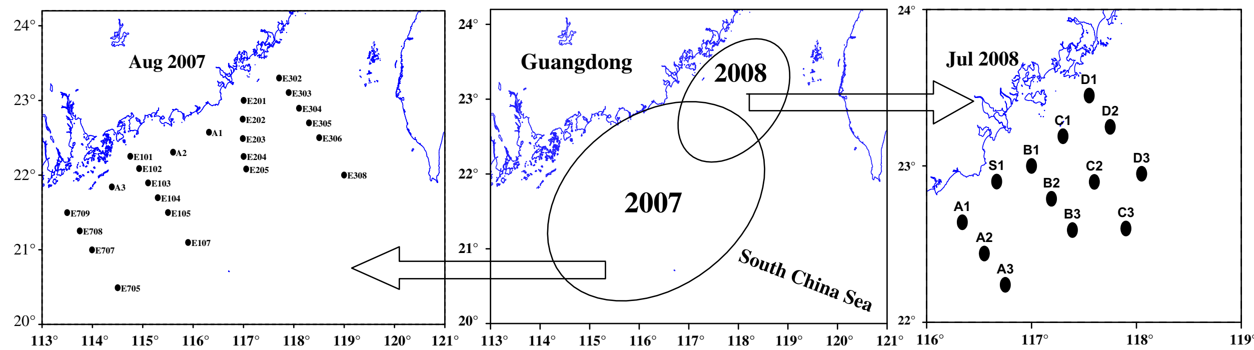

Fig. 1. Sampling map in northern South China Sea. Oval 2007: sampling region of 2007 cruise; Oval 2008: sampling region of 2008 cruise.

through filtrating the water samples onto 25 mm polycarbonate filters (20 μm, 3 μm, 0.7 μm) by steps, pico-, nano- and micro-plankton were represented by the 0.7 μm, 3 μm and 20 μm size fractions respectively.

Nine sites were chosen to carry PP incubation in two cruises, 4 sites in 2007 cruise and 5 sites in 2008 cruise. PP was measured by the ^{14}C assimilation method, and estimated by a method on the base of JGOFS protocol [10]. Seawater at the depth of 100%, 50%, 32.5%, 10%, 1% of surface irradiance were collected, each water sample was transferred to 500 mL bottles (Nelgene), 2 of them as light bottles and one as dark bottle. All bottles were filled into 4 μCi $NaH^{14}CO_3$, and incubated for 4–6 h in a shade free area on the deck with the running surface seawater for temperature control. The cells were filtered onto a GF/F filter after the incubations, then immediately frozen and stored at −20 °C for later analysis. The incorporated radiocarbon was detected using a Beckman L6500 liquid scintillation counter.

2.3. Statistic

The correlation between variables was established using SPSS 12.0 software.

3. Results

3.1. 2007 Cruise

In 2007, surface sea temperature (SST) ranged from 25.29 to 29.46 °C, SST was lower than 27 °C in the coast and upwelling regions (Fig. 2), and increased from inshore to offshore. Low SST centre located in eastern Guangdong coast and Taiwan bank, and minimum was observed at E302. Surface sea surface salinity (SSS) ranged from 30 to 34, low SSS centre located outside of the mouth of the Pearl River estuary (PRE).

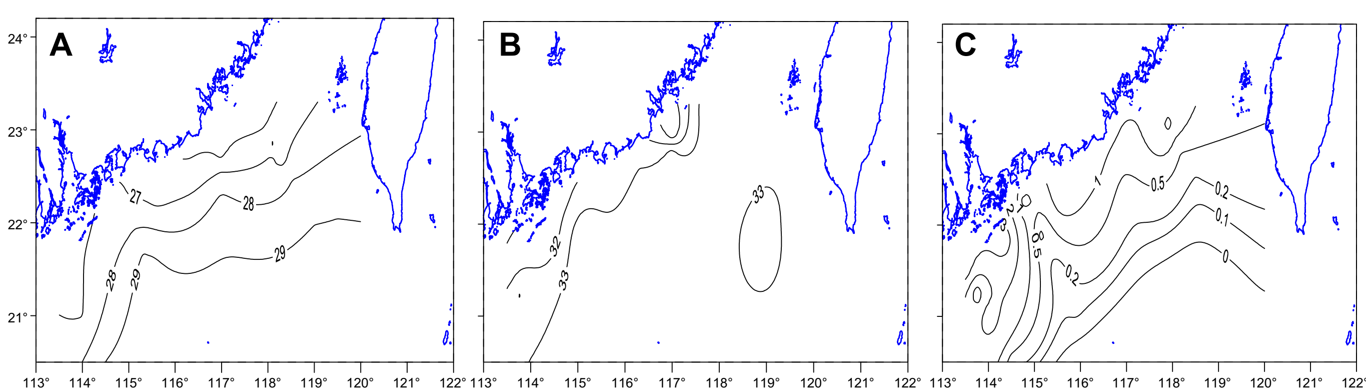

Fig. 2. Spatial distribution of temperature, salinity and chl a in nSCS in 2007. A: temperature (°C); B: salinity; C: chl a (mg m^{-3}).

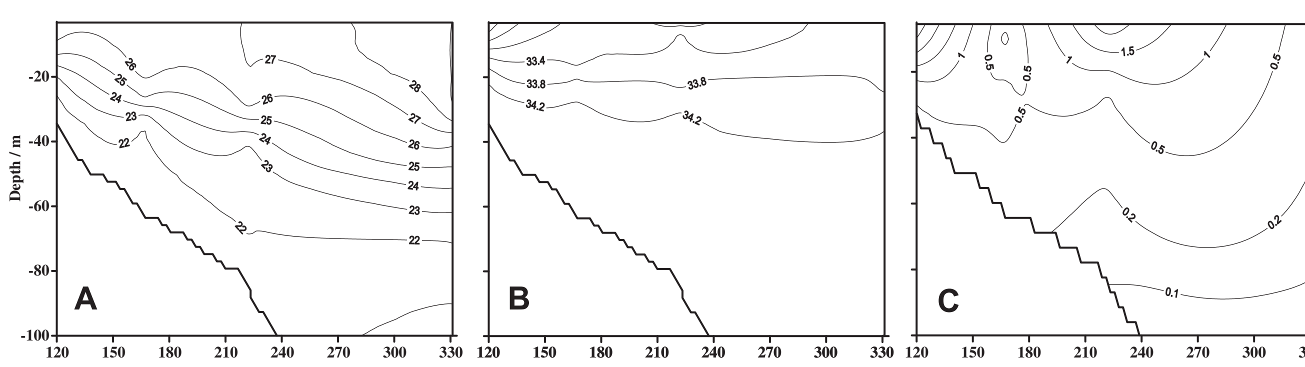

Fig. 3. Vertical distribution of temperature, salinity and chl a in E7 transect in 2007. A: temperature (°C); B: salinity; C: chl a (mg m^{-3}).