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Characteristics of nutrients and phytoplankton productivity in Guangdong coastal regions, South China

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ABSTRACT

In order to evaluate the levels and the influence on phytoplankton productivity of dissolved nutrients, concentrations and distribution of N, P and Si were studied in coastal areas profoundly influenced by human activities in Guangdong Province, South China. Generally, concentrations of dissolved inorganic nitrogen were high in wet periods because of the inputs from strong seasonal land runoff. Si and P concentrations were generally low in summer due to the consumption by phytoplankton growth. Dissolved organic N and P were important in study area. Chl *a* and primary productivity (PP) were relatively high and showed seasonal and geographical variations. Concentrations of Chl *a* were the highest in summer, and the high water temperature and sufficient illumination accelerated the growth of phytoplankton, especially in surface water. Additionally, water stratification in summer decreased mixed layer depth and trapped PP in upper layer.

In recent decades, population growth and related nutrient sources such as effluents from agriculture and wastewater treatment plants, urban runoff, and waste caused by consumption of fossil fuels, have dramatically increased nutrient inputs to estuaries and coastal waters (Bizsel and Uslu, 2000; Wu and Chen, 2013). These anthropogenic loadings are now strongly interfering with the global biogeochemical cycles of such elements in the marginal seas (Garnier et al., 2010; Li et al., 2013). Nutrient concentrations have exceeded water quality standards and eutrophication has imposed influences on marine phytoplankton biomass and primary productivity (PP) in many coastal areas in China (Yin et al., 2004; Qiu et al., 2010).

The Pearl River Delta (PRD) is the most developed industrial and agricultural area in China. With the development of PRD, the coastal regions of Guangdong Province were polluted by nutrients as the important supporting-areas to the PDR. These nutrients accumulated in seawater and sediments, intensifying oceanic pollution and threatening the sustainable development in Guangdong coastal region. In this paper, we mainly collected seawater during the periods of 2006–2007 to observe the characteristics of dissolved inorganic nutrients in relation to phytoplankton biomass and PP in Guangdong coastal area, and the objectives were mainly to (i) follow the seasonal and regional characteristics of nutrients and discuss their possible sources; (ii) investigate the variations in Chl *a* and PP, and discuss how inorganic nutrient influenced the phytoplankton biomass. The results of this paper will be significant to study the changing rules and the affecting factors of the nutrients and PP, as well as to the sustainable development of marine ecosystems in Guangdong coastal regions.

Guangdong is adjacent to the South China Sea (SCS) with a coastline of 3.37×10^6 m, and Guangdong coastal regions were characterized by relatively shallow water receiving freshwater from precipitation and river discharges. Winds are relatively strong all year (northerly during winter and southerly in summer). We divided the study area into four parts from east to west along the Guangdong coastline (Fig. 1). Water (surface and bottom) and surface sediment were sampled in spring, summer, autumn and winter, and the location of sampling sites and the water depth were recorded in Table 1.

Seawater salinity and temperature were measured in situ. Alkalinity (Alk) was determined using potentiometric titration and pH values were determined by a pH meter, with the precisions being ± 0.01 pH and ± 1 μmol/L for pH and Alk measurement, respectively. We used the value of Alk/Cl (Cl: chlorinity, calculated according to Liang and Wang (1983)) to characterize the seawater. Dissolved oxygen (DO) was determined immediately using the Winkler titration method (Gao and Song, 2008). The filter membranes for suspended particulate material (SPM) analysis were dried and weighed to determine the amount in mg/L of samples. Concentrations of NO_3, NO_2, NH_4, SiO_4, PO_4, TDN (total dissolved nitrogen), TDP (total dissolved phosphorus), TN (total nitrogen), TP (total phosphorus) in seawater (and in digested sediment) were determined according to the methods described by Grasshoff et al. (1983). The precisions of duplication for NO_3, NO_2, NH_4, SiO_4, PO_4, TDN, TDP, TN, TP were 3%, 1%, 1%, 4%, 4%, 5%, 5%, 5%, 5%, respectively. Sedimentary organic matter (OM) was determined using the method

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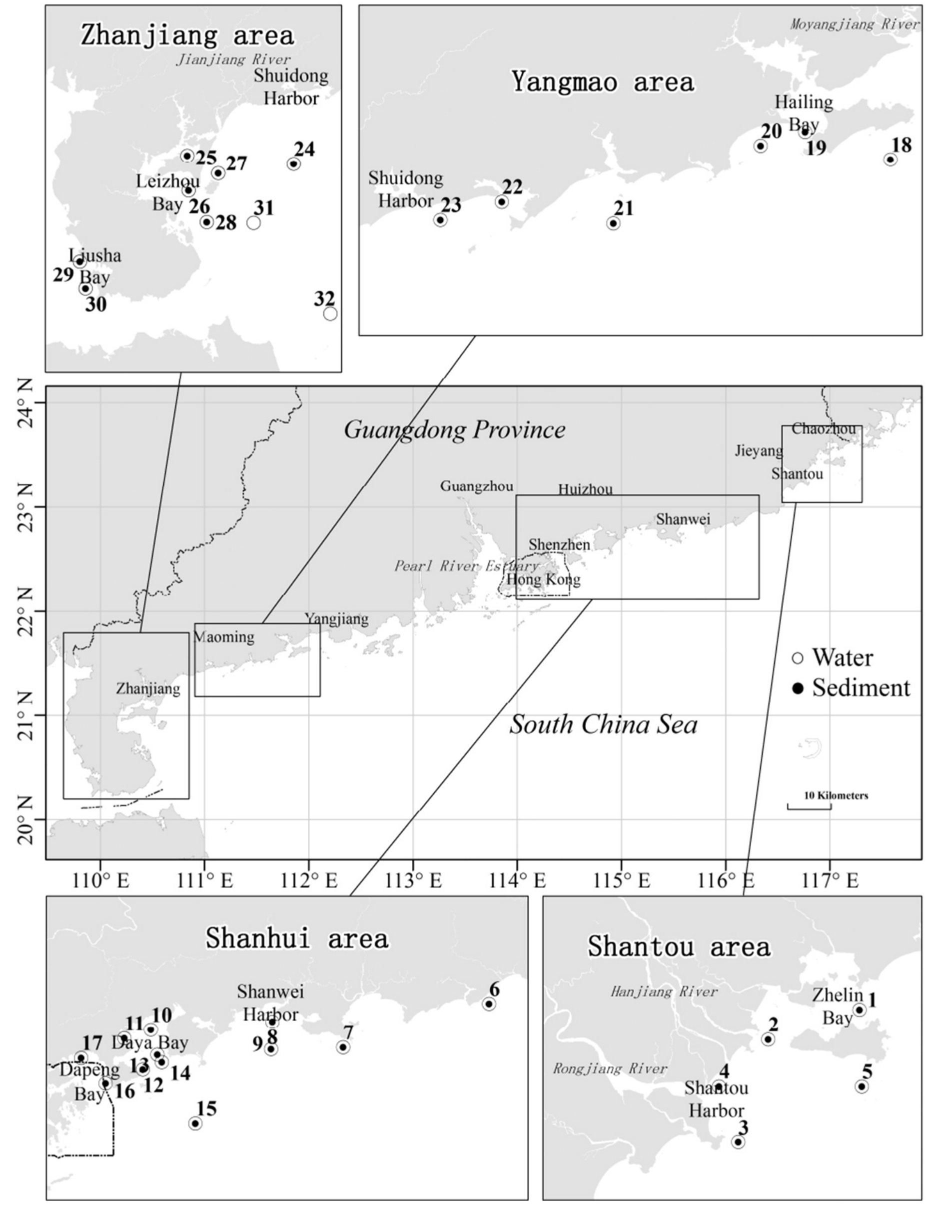

Fig. 1. Map showing Guangdong coastal regions and the study area with sampling sites.

Table 1
The location of sampling sites and the water depth.

Site	Location	Water depth/m	Site	Location	Water depth/m
	E N			E N	
1	117°04′56″, 23°30′08″	10	17	114°52′07″, 22°17′36″	32
2	116°53′50″, 23°26′24″	7	18	111°48′54″, 21°37′19″	5
3	116°50′07″, 23°13′11″	12	19	111°43′33″, 21°34′23″	11
4	116°47′45″, 23°20′38″	5	20	111°14′23″, 21°28′07″	4
5	117°05′24″, 23°20′38″	25	21	110°07′15″, 21°26′22″	4
6	115°31′41″, 22°37′55″	22	22	111°56′42″, 21°33′01″	19
7	115°12′38″, 22°44′54″	11	23	111°26′46″, 21°25′10″	21
8	114°40′00″, 22°42′53″	10	24	110°27′00″, 21°05′01″	12
9	114°32′55″, 22°40′54″	6	25	110°27′00″, 20°53′07″	10
10	114°38′01″, 22°32′00″	17	26	109°49′43″, 20°29′01″	11
11	114°43′03″, 22°34′01″	17	27	109°51′37″, 20°18′36″	20
12	114°27′27″, 22°28′13″	20	28	111°04′04″, 21°00′53″	25
13	114°21′04″, 22°34′54″	15	29	110°41′32″, 20°58′30″	17
14	116°14′47″, 22°50′06″	13	30	110°50′05″, 20°41′59″	30
15	115°14′27″, 22°38′54″	18	31	111°17′12″, 20°10′03″	62
16	114°41′54″, 22°35′06″	16	32	110°33′51″, 20°42′01″	7

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