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Phytoplankton abundance, community structure and nutrients in cultural areas of Daya Bay, South China Sea

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Abstract

In order to provide a better understanding of phytoplankton structure and their relationship with environmental parameters in typical maricultural areas in Southern China, observations were carried out to estimate the phytoplankton structure and nutrients in eight stations in annual survey from July 1997 to June 1998 and three springs from 1998 to 2000 in Daya Bay, South China Sea. Phytoplankton and ambient chemical, physical, meteorologic data were examined. A total of 198 species of phytoplankton were identified. Diatom was the most diversified group in which 98 species in 39 genera were observed, while dinoflagellate was the second one with 83 species in 14 genera. The annual mean chlorophyll *a* concentration and cell density was 4.7 mg/m^3 and 425 cells/ml, respectively. The abundance of total phytoplankton ranged from 10 cells/ml to 6698 cells/ml. Water temperatures were mostly over 20 °C with the annual average of 25.0 °C. Salinities remained constant except for the rainy typhoon season from July to September. DSi was sufficient in Daya Bay, and never limited for the growth of diatoms. Diatoms were preponderant in all seasons, while dinoflagellates were prevalent only in spring. Dominant diatoms included *Asterionella japonica*, *Chaetoceros* spp., *Pseudo-nitzschia* spp., *Skeletonama costatum* and *Thalassiosira subtilis*, which predominated alternately or co-dominated together. An unidentified dinoflagellate, *Gymnidinium* sp., was the dominant dinoflagellate, causing two blooms in May 1998. Results from statistical analyses revealed that DIN and DSi had high loadings in population dynamics of diatoms, and DIP was important for dinoflagellates. Meanwhile, peak abundances of diatoms were coinstantaneous with the low values of DIN and DSi concentrations, while high abundances of dinoflagellates with low levels of DIP. The variety in nutrient requirement and utilization by diatoms and dinoflagellates resulted in frequent occurrence of spring blooms caused by them. From the results of this survey, it could be suggested that appropriate water temperature, salinity, sufficient DSi, as well as quick recovery of nutrients, played important roles in the high abundance of phytoplankton and frequent outbreak of blooms in Daya Bay.

Keywords: Phytoplankton community; Algal bloom; Nutrient; Eutrophication; South China Sea

1. Introduction

Increasing nutrient inputs to coastal marine environments have been reported in most parts of the world. The rapid change in nutrient status influences the phytoplankton community structure, and thus leads to the growing frequency and magnitude of nuisance and harmful algal blooms (Hallegraeff, 1993; Richardson, 1997; Béthoux et al., 2004; Piehler et al., 2004). Nutrient enrichment has been greatly accelerated by anthropogenic activities in the Chinese coasts especially South China Sea during the last two decades (Hodgkiss and Ho, 1997; Peng et al., 2002; Huang et

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al., 2003; Hodgkiss and Lu, 2004; Shen et al., 2004; Wang et al., 2004). Meanwhile, harmful algal blooms have occurred frequently since the end of the 1990s, and have caused great damages in marine environments and huge economic losses. Series of dinoflagellate blooms, which occurred in cultural areas of the Pearl River estuary and Hong Kong coasts of the South China Sea in the spring of 1998, had caused massive death of cultural fishes, and the economic losses were up to 4 billion RMB (about 483 million US dollar) (Lu and Hodgkiss, 1999; Qi et al., 2004). While a *Phaeocystis* blooms occurred in the east part of South China Sea from October 1997 to February 1998 caused 35 million RMB losses (Qi et al., 2004).

Daya Bay is a semi-enclosed coastal inlet characterized by poor exchange with the seawaters, and is considered to have undergone eutrophication, which is caused by increased nutrient loading as a result of rapidly expanding mariculture and human population growth in this region since 1990s. Area of aquaculture increased rapidly from 540 m^2 in 1994 to 1300 m^2 in 1998. The nutrient discharge from aquaculture and other anthropogenic activities has greatly increased inorganic nitrogen, however, dissolved inorganic phosphorus concentrations decreased during the same time interval (Peng and Wang, 1999; Qiu, 2001; Peng et al., 2002; Wang et al., 2004). The changes in nutrients have strongly influenced the phytoplankton community structure in this area. Many reports have studied the phytoplankton structure and it relationships with variations of the environmental factors in Daya Bay (Zhou et al., 1998; Chen et al., 2000; Wang et al., 2001; Xu et al., 2001; Zheng et al., 2001; Wang et al., 2004b). Most of these works have been focused on population and bloom dynamics of a single phytoplankton species. However, the phytoplankton communities are composed of dynamic, multispecies assemblages characterized by high diversity and rapid successional shifts in species composition in response to various environmental changes.

In order to understand the trophic status and the mechanisms of harmful algal blooms in typical maricultural areas in Southern China, which is one of the most fast developing areas in China, investigations were carried out in cultural areas of Daya Bay from July 1997 to June 1998 and three springs of 1998–2000 with high frequency measurements and sampling of environmental and biological variables (physical, chemical and meteoclimatic factors, phytoplankton abundance and composition). In this paper, we give an overview of phytoplankton abundance, community structure, water temperature, salinity, nutrients and their relationships, to assess the general features of phytoplankton succession and bloom dynamics in typical fish farm waters of Southern China.

2. Materials and methods

2.1. Site description

Daya Bay is one of the biggest inlets and also an important cultural area in Guangdong province, which is located in the northeast part of the South China Sea, from 114°29″ to 114°49″E and from 22°30″ to 22°52″N. It is a semi-enclosed shallow embayment with water depth from 4 to 15 m. It covers 650 km^2, and is separated into several small sub-basins. The climate of Daya Bay gives mild, wet subtropical weather. About 80% of the freshwater discharge occurs in the flood season (April–September), and only 20% in the dry season (October–March) (Cai et al., 2004).

The study site is at the Aotou area of Daya Bay, which is the most extensive cultural area in the northwest part of Daya Bay. The nutrient contents are much higher than other regions in the bay.

2.2. Sampling and analysis

Eight stations (St.1–St.8) were set in Daya Bay (Fig. 1): St.1 was located near a dense residential area; St.2, St.7 and St.8 were in the fish caged areas; Sts.3–5 were situated in the nearshore areas; and St.6 was a control area located in an offshore area. Samples were collected every 3 days in Sts.1–6 from April 2nd to June 1st 1998, from March 18th to June 1st 1999, and monthly in St.7 and St.8 during the

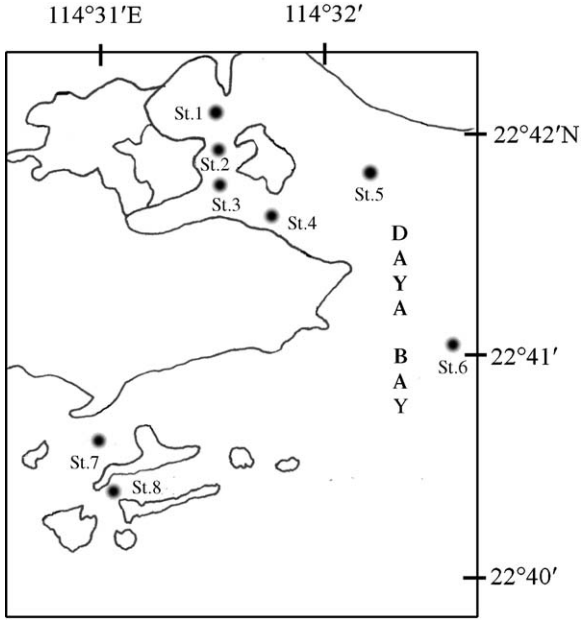

Fig. 1. Sampling stations in Daya Bay, South China Sea.