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Seasonal variations in cell abundance of *Noctiluca scintillans* in the coastal waters off Chonburi Province, the upper Gulf of Thailand

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Abstract—Seasonal variations in cell abundance of *Noctiluca scintillans* was studied from June 2003 to November 2004 in the coastal waters off Chonburi Province, the upper gulf of Thailand. Eight stations from Bangpakong River mouth to Angsila were designed to cover the area where red tides often occurred and were under the influence of Bangpakong River. Numerical abundance was analyzed in relation with some environmental parameters. A total of 9 *N. scintillans* red tides, 7 *Ceratium furca* red tides and 4 diatom red tides were found in this study. *Noctiluca* and *Ceratium* red tides were often found when salinity was in the range of 22 to 33 psu. and 12 to 27 psu., respectively. Those red tides were not associated with apparent negative effects to marine animals. *N. scintillans* cells could be observed almost all year round at offshore stations where the water depth was more than 10 meters except strong wind periods, suggesting that *Noctiluca* in coastal waters were supplied by cells from offshore stations. In contrast, no consistent pattern was observed in the distribution of *N. scintillans* in coastal waters, in particular near the river mouth. Only the relationship between phosphate concentrations and cell densities of *Noctiluca* has been found statistically significant. However, the high cell densities of both *Noctiluca* and *Ceratium* were often observed in the rainy season, especially on the calm day after heavy rain. These observations suggested that the red tides of those two species in coastal waters were growth response to the influence of freshwater run off from Bangpakong River.

Key words: seasonal variations, cell abundance, *Noctiluca scintillans*, gulf of Thailand

Introduction

A red tide is a common phenomenon in the Gulf of Thailand and has been noticed for long time. The most important red tide causative organism is *Noctiluca scintillans*, which forms green discoloration. This green *Noctiluca* red tide occurred seasonally. The blooms often occurred during July to October and December to February in the eastern and western part of the Gulf, respectively (Lirdwitayaprasit et al. 1994). *Noctiluca* red tides occasionally cause damage to fisheries.

The relationship between the environment parameters and cell density of this organism was investigated by a number of authors (e.g. Tada et al. 2004, Cruz et al. 2002, Uhling and Sahling 1990). Those studies aimed to observe the occurrence and explain population dynamics of *Noctiluca*. However, such kinds of studies in the Gulf of Thailand were still rare and almost all red tides studies were conducted only in the near shore waters. Recently, blooms of *Ceratium furca* became more often observed in the upper Gulf, especially in the vicinity of river mouth (Rungsupa 1997, Thongra-ar et al. 1996, Lirdwitayaprasit et al. 1994). Increased frequency of red tides suggested that the area had a high competition among causative red tide organisms. To clarify the distribution pattern and population dynamics of *Noctiluca* in the eastern part of upper Gulf, this study was carried out. It also aimed to observe the relationship between water quality and cell density of *Noctiluca*.

Materials and Methods

This study was conducted from June 2003 to November 2004 in the coastal waters off Chonburi Province, the upper Gulf of Thailand. Eight stations, from Bangpakong River mouth to Angsila, were designed to cover the area where red tides often occurred The area was under the influence of Bangpakong River (Fig. 1). The environmental parameters such as DO, salinity, pH and temperature were measured *in*

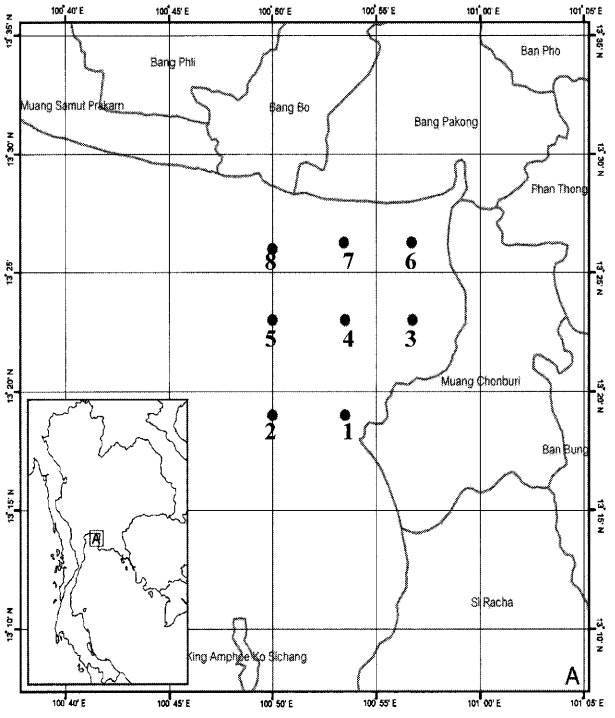

Fig. 1. Study area and stations.

situ by YSI Model 650 at water depth of 0.5, 5, 10 meters and 1 meter above the bottom. The nutrient concentrations were analyzed by Skalar Auto-nutrient analyzer and phytoplankton samples were classified and enumerated under a light microscope in laboratory.

Results and Discussion

Occurrence of red tides

A total of 9, 7 and 4 red tide cases of *Noctiluca*, *C. furca* and diatom, respectively, were found in this study (Table 1 and Fig. 6) and most of those red tides occurred in the rainy season. Red tides were often observed at shiny calm day and one or two days after heavy rain. These red tides seemed to be harmless because no fish kill was found.

Temporal changes in *Noctiluca* cell abundance and environmental parameters

A total of 32 field trips were conducted in the study area wherein *Noctiluca* was found at all stations, but not all the period of the study. High cell densities of the symbiont, *Pedinomonas noctilucae*, were observed in *Noctiluca* host cells and very few cells of *Noctiluca* had fed organisms inside the cells. This finding implied that *Pedinomonas* could provide enough nutritional sources for the host cell to grow. This mutual benefit between this two species was first mentioned by Sweeny (1971), but recently Furuya and his group (i.e. Furuya and Lirdwitayaprasit 2000, Furuya et al. 2005) observed the biology and ecology of the host and the symbiont.

Table 1. Occurences of red tides in the study area during June 2003 and November 2004.

Case	Date	Seawater Color	Causative Organism
1	14/6/03	station 5 : green	*Noctiluca scintillans*
2	28/6/03	station 5 : green	*Noctiluca scintillans*
3	10/8/46	station 1 : red	*Ceratium furca*
		station 2 : red	*Ceratium furca*
		station 4 : red	*Ceratium furca*
4	31/8/46	station 1 : red	*Ceratium furca*
		station 5 : red	*Ceratium furca*
5	7/9/03	station 2 : red	*Ceratium furca*
		station 5 : red	*Ceratium furca*
6	21/9/03	station 3 : red	*Ceratium furca*
		station 4 : red	*Ceratium furca*
7	5/10/03	station 3 : green	*Noctiluca scintillans*
		station 5 : green	*Noctiluca scintillans*
		station 8 : green	*Noctiluca scintillans*
		station 1 : red	*Ceratium furca*
		station 4 : red	*Ceratium furca*
		station 6 : red	*Ceratium furca*
8	26/10/03	station 8 : green	*Noctiluca scintillans*
		station 4 : red	*Ceratium furca*
9	4/4/04	station 1 : green	*Noctiluca scintillans*
		station 2 : green	*Noctiluca scintillans*
		station 5 : green	*Noctiluca scintillans*
10	26/4/04	station 3 : red-brown	*Skeletonema costatum*
			Nitzschia longissima
11	9/5/04	station 3 : red-brown	*Nitzschia longissima*
12	26/5/04	station 3 : red-brown	*Nitzschia longissima*
13	6/6/04	station 1 : green	*Noctiluca scintillans*
		station 2 : green	*Noctiluca scintillans*
		station 5 : green	*Noctiluca scintillans*
14	20/6/04	station 1 : green	*Noctiluca scintillans*
		station 5 : green	*Noctiluca scintillans*
		station 8 : green	*Noctiluca scintillans*
		station 3 : red-brown	*Nitzschia longissima*
15	3/7/04	station 2 : green	*Noctiluca scintillans*
16	17/7/04	station 2 : green	*Noctiluca scintillans*
17	3/8/04	station 2 : red	*Ceratium furca*
18	15/10/04	station 6 : brown	*Chaetoceros* spp.
		station 7 : brown	*Chaetoceros* spp.
		station 8 : brown	*Chaetoceros* spp.

Noctiluca cells were found 22, 21 and 22 times among 32 field trips at station 1, 2 and 5, respectively (Fig. 2).

Salinity showed a very wide range of variation at all stations during rainy season. In 2003 between June and September, any *Noctiluca* cell could not be found at all station. At the same period in 2004, the temporal changes of *Noctiluca* cell density at all stations showed similar patterns to the salinity changes (Fig. 2). Relationships between the cell number of *Noctiluca* and *Ceratium* and salinity were shown in Fig. 3. Both species could be observed in a wide range of salinity. *Noctiluca* formed red tides at the salinity in range of 22 to 30 psu, while *Ceratium* red tides were found at the salinity in range of 12 to 27 psu. This range of salinity was not so different from that of red *Noctiluca* in temperate wa-

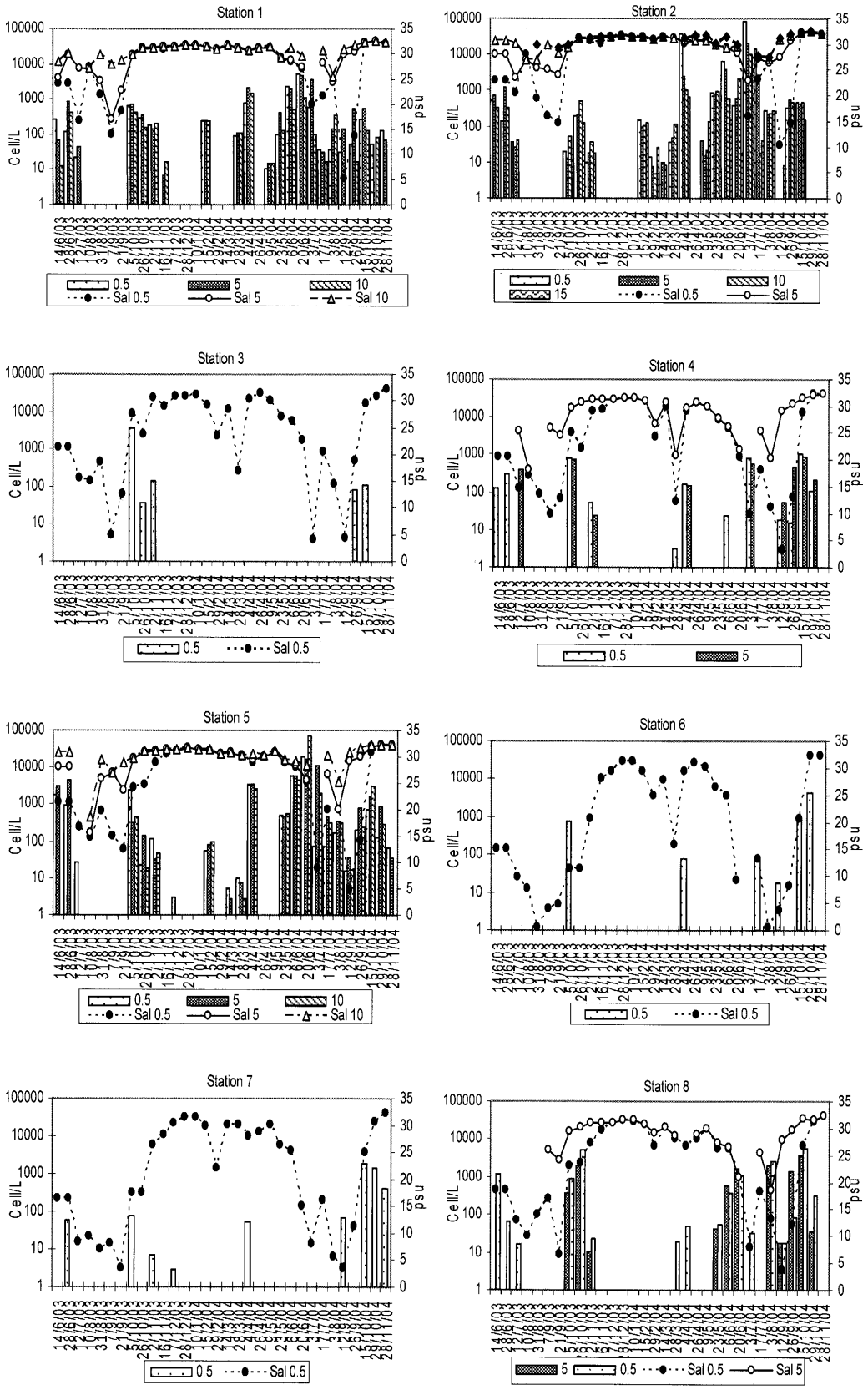

Fig. 2. Temporal changes of *Noctiluca* cell abundance and salinity.

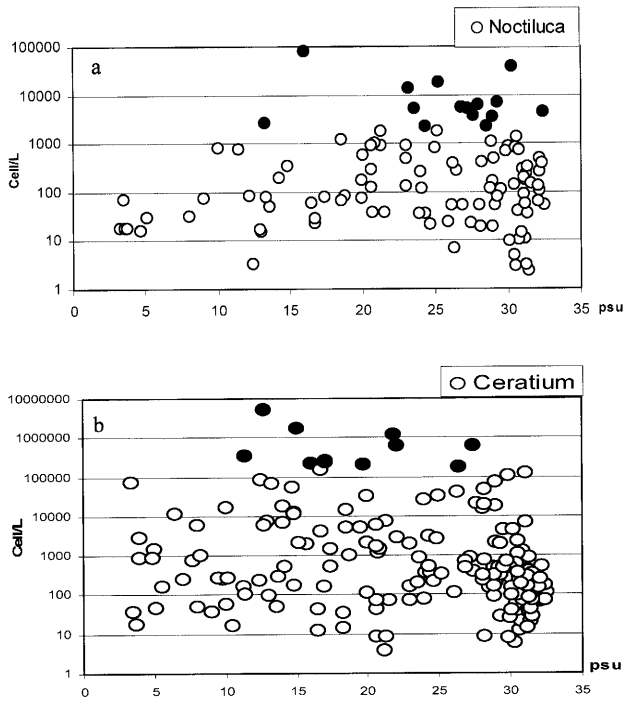

Fig. 3. The relationship between salinity and cell densities of *Noctiluca* (a) and *Ceratium* (b). Solid circles indicate cell densities showing red tides.

ters that have the optimal range of 21 to 25 psu. (Elbrächter and Qi 1998). The study on succession of dinoflagellate blooms in Chesapeake Bay by Marshall (1995) also showed that the bloom of *C. furca* appeared in July and the salinity at the bloom was in the range of 18.1–28.6 psu and *Noctiluca* bloom, in September, associated with salinity more than 22 psu. However, Tada et al. (2004) have shown using over 6 years' observation that the range of salinity optimum for red *Noctiluca* in Harima Nada was about 31 to 33 psu.

Noctiluca and *Ceratium* could be found almost throughout the year at off shore stations that were deeper than 10 meters and far from the river mouth. It suggested that *Noctiluca* and *Ceratium* in coastal waters and in the river mouth were supplied by cells from the off shore stations. The water circulation might be the main process that brought the cells to bloom in the eastern part of the inner Gulf. This water circulation pattern from south-west direction to the east of the upper Gulf was clearly shown by Buranapratheprat and Yanagi (2003).

Nitrate and phosphate concentrations were high in rainy season and high cell densities of *Noctiluca* were also found during this period. The changes of cell abundance at station 1, 2 and 5 are shown in relation to nitrate and phosphate con-

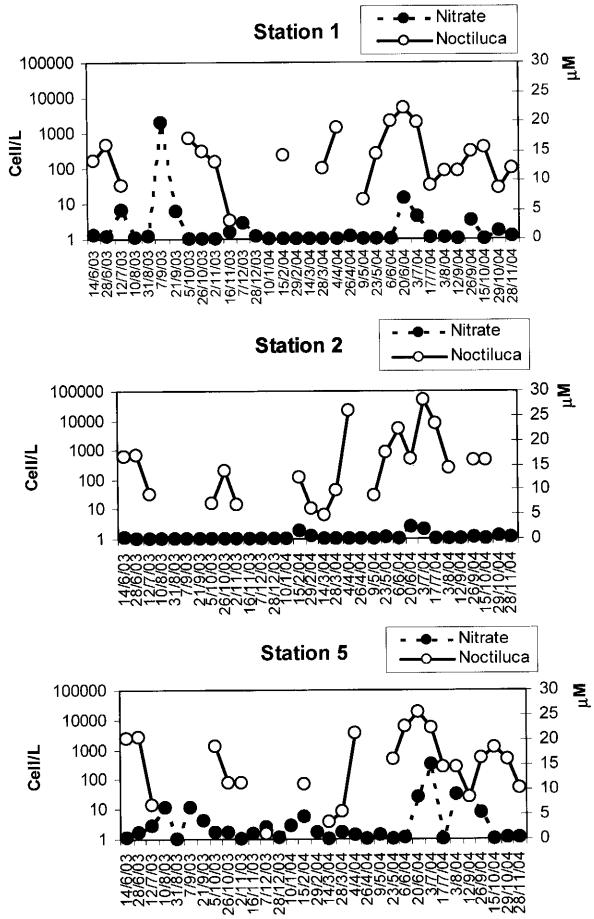

Fig. 4. Temporal changes of *Noctiluca* cell density and nitrate concentrations.

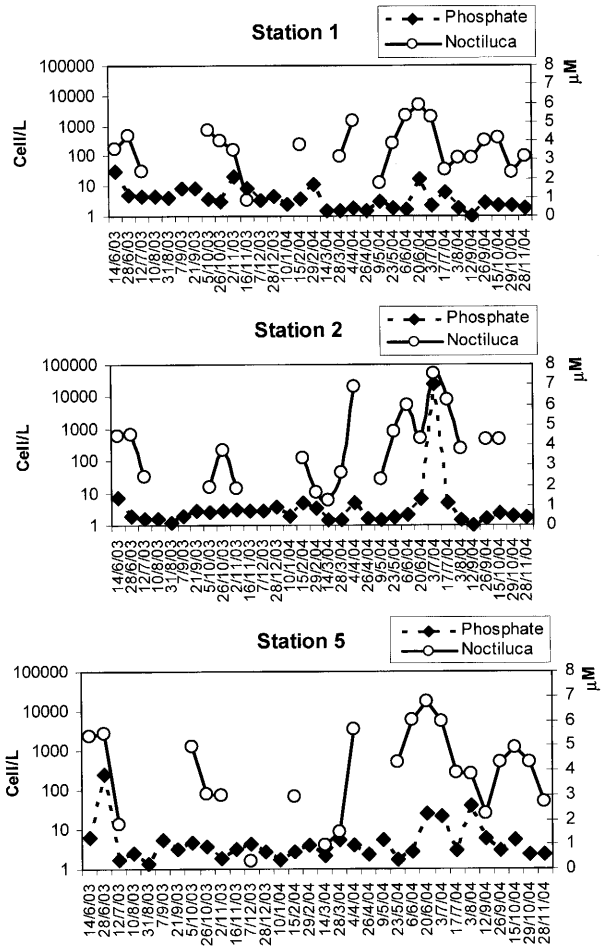

Fig. 5. Temporal changes of *Noctiluca* cell density and phosphate concentrations.

centrations during the rainy season of 2005 in Figs. 4 and 5. The temporal changes of cell numbers of *Noctiluca* showed the same pattern as reported in the previous studies conducted by Thongra-ar et al. (1995 and 1996). As mentioned by Elbrächter and Qi, (1998), a clear relationship between bloom frequency or duration to eutrophication has so far not been established. However, the temporal changes in abundance pattern of *Noctiluca* in rainy season show relationship to the changes of salinity, phosphate and nitrate concentrations at some stations to some degree (Fig. 3 and 4). *Noctiluca* and other red tides were also observed more often in rainy season period. As showed in Fig. 6, the blooms of *Ceratium* and diatoms occurred sometimes instead of those by *Noctiluca*. These results suggested that the competition and succession among those causative red tide organisms were also high and their abrupt growths were made in response to the changes of salinity and nutrient concentrations caused by river run off.

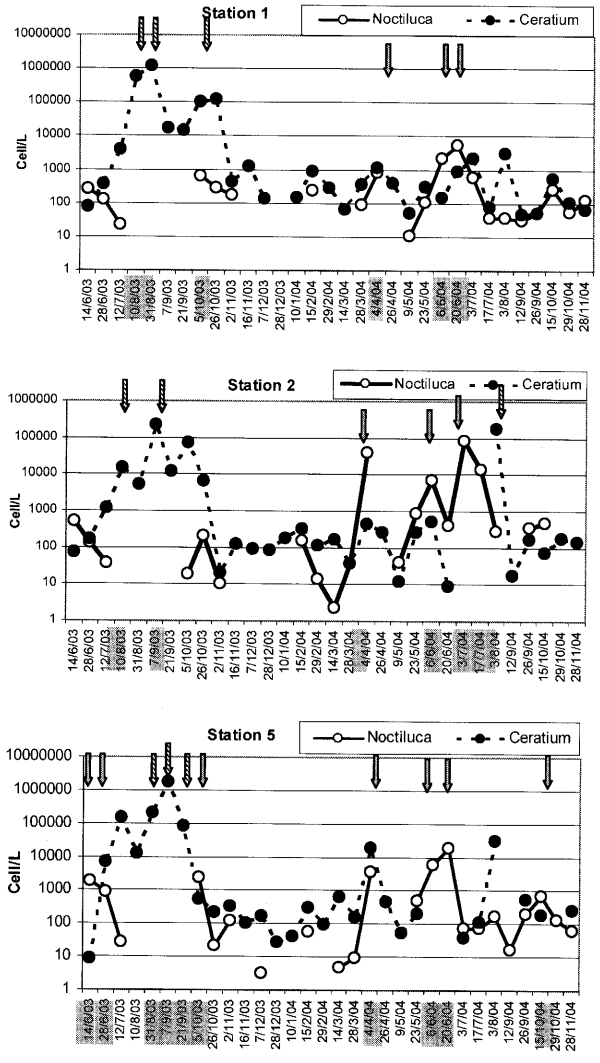

Fig. 6. Temporal changes of *Noctiluca* and *Ceratium*: arrows with oblique lines indicate the *Ceratium* red tides arrows with light shade indicate the *Noctiluca* red tides.

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