TEMPORAL VARIATION IN *CERATIUM* SPP. ABUNDANCE RECORDED IN JAKARTA BAY

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ABSTRACT

Ceratium is non-toxic dinoflagellate which has been regarded as the most common bloom–forming species in the coastal waters around the world. Eventhough research and monitoring on phytoplankton in Jakarta Bay have been conducted for long enough, no specific attention has been given to *Ceratium* community. Therefore, a research was set up in order to understand the dynamic of *Ceratium* population and its regulating factors. A serial sampling was conducted in 10 stations during 2009 and 2010. Phytoplankton was sampled in horizontal towing using Kitahara plankton net (80 µm mesh size, 0.5 m mouth diameter and 1 m length). Phytoplankton enumeration and identification were done by applying Fraction Method on Sedgewick Rafter Counting Chamber (SRCC). The result showed clear temporal variations in *Ceratium* absolute density, relative density, relative frequency and importance value. When phytoplankton bloomed in August 2009, no *Ceratium* bloom observed. High density of *Ceratium* was observed in November 2009 and May 2010, but it contributed relatively small proportion to phytoplankton as a whole (relative density <1%). Due to its low density and relatively limited distribution in Jakarta Bay, *Ceratium* may demonstrate limited ecological role to the phytoplankton community.

Keywords: *Ceratium*, Jakarta Bay, temporal variation

INTRODUCTION

Ceratium was categorized as non-toxic dinoflagellate but its blooms could cause ecological problems in many aquatic ecosystems (Praseno and Sugestiningsih, 2000; Orellana-Cepeda et al., 2002; Baek et al., 2008a, b; Baek et al., 2011). Some species of *Ceratium* such as *Ceratium furca* and *C. fusus* were regarded as the most common bloom-forming species in the coastal waters around the world. Persistent and frequent blooms of *Ceratium* have been reported in many oceans including the North Sea, the North Atlantic Ocean, the Indian Ocean, and the South Eastern Asia. Many of those blooms have severed on the aquatic ecosystem and coastal communities. One common phenomenon due to *Ceratium* blooms is mass fish mortality (Baek et al., 2008a, b). *Ceratium* blooms generate oxygen depletion in the water or physically damage fish gills which later cause secondary infection and kill the fish. Such cases have been recorded in Todos Santos Bay, Manzallino and South Africa (Orellana-Cepeda et al., 2002). Similar to most cases of phytoplankton blooms, blooming of *Ceratium* is triggered by nutrient enrichment including nitrates, nitrites, phosphates and silicates. Warm water and relatively low water turbidity are also important triggering factors (Orellana-Cepeda et al., 2002; Baek et al., 2008a, b; Perez-Martinez & Sanchez-Castillo, 2001).

Jakarta Bay is a shallow water coastal ecosystem, located at the northern side of Jakarta, the capital city of Indonesia. It has been known as eutrophicated and polluted aquatic ecosystem.

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Most pollutants and nutrients are discharged by thirteen rivers that flow to the bay (Simanjuntak, 2010; Muchtar, 2008; Arifin, 2004; Hadikusumah, 2012). Eutrophic condition has resulted in frequent cases of phytoplankton bloom and mass fish mortality (Thoha et al., 2007; Sidabutar, 2010). Mass fish mortality frequently occurs concurrently with phytoplankton blooming which cause oxygen depletion (Thoha et al., 2007). During the blooming in May and September 2007 in Jakarta Bay, *Skeletonema* and *Chaetoceros* have been suspected as the main cause of fish mortality. *Ceratium* distributes relatively wide over the bay, but its density was very low (Thoha et al., 2007).

Monitoring on phytoplankton blooms in this area has been continuously carried out but no specific attention has been given to the temporal variation of *Ceratium* abundance in the system. Consequently, there was no adequate information on the ecological roles of *Ceratium* in phytoplankton community on this area. Thus, a study has been set up to understand the dynamic of *Ceratium* spp. in Jakarta Bay and its possible relationship with other phytoplankton genera, from which the results are presented in this paper.

MATERIALS AND METHOD

Study Area

Jakarta Bay is a shallow water coastal ecosystem with approximate depth varied from 5 to 30 m (Fig. 1). The seabed of Jakarta Bay was gently slopping and the sampling was set up between the depth 5 and 25 m. The width of Jakarta Bay is approximately 22 miles, with 13 big and small rivers ending on the bay: Citarum, Bekasi, Marunda, Ciliwung, Angke, Kamal, Cengkareng, Karang, Ancol, Sunter, Cakung, Blencong, Grogol and Pesanggrahan (Fig. 1).

Plankton Samplings Methods

A serial sampling was conducted in 10 stations in July, August, September, October and November 2009, and May, July 2010. The sampling sites were located north of Pluit (1, 2), Bidadari Island (3), Sunda Kelapa (4, 5), Tanjung Priok (6, 7, 10) and Muara Gembong (8, 9) (Fig. 1). Phytoplankton were collected using Kitahara plankton net, with 80 µm mesh size, 0.5 m mouth diameter and 1 m length. An analog steel flow

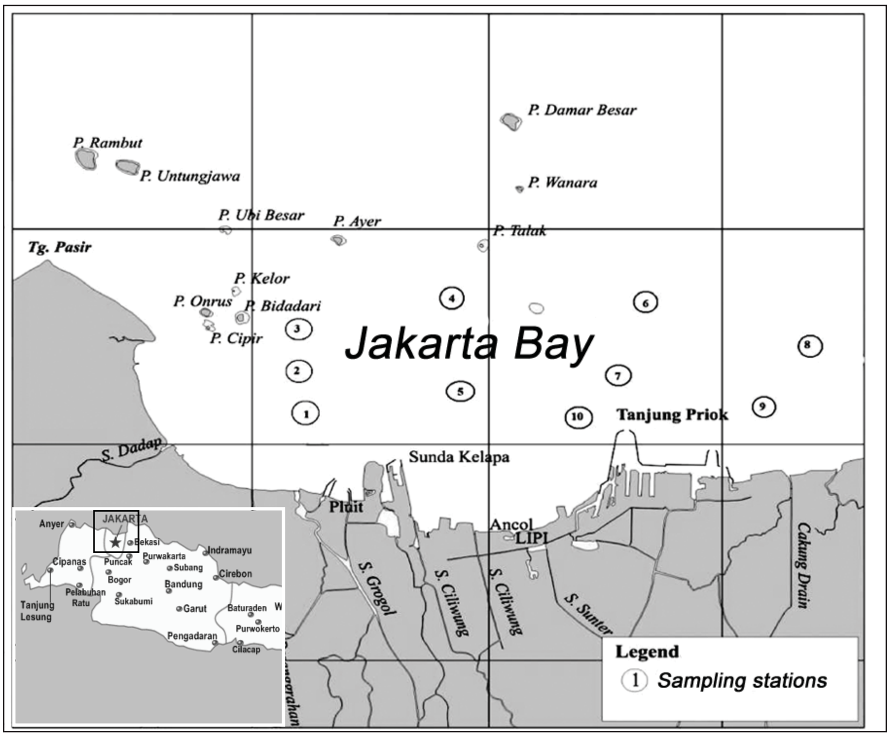

Figure 1. Sampling sites around Jakarta Bay, which is located around Pluit, Bidadari Island, Sunda Kelapa, Tanjung Priok and Muara Gembong.

meter was attached to the center of plankton net's mouth, to measure the volume of filtered water. Samples were collected during horizontal towing in 1 m depth for 5 minutes at 2–knot speed of a small fisherman motor boat. The collected samples were placed in 250 cc glass bottle and preserved in 4% formaldehyde.

Phytoplankton Observation and Counting Methods

Phytoplankton enumeration was done by taking 0.1 ml fraction from the sample with stample pipette. Such small volume of sample examined was determined in consideration with extremely dense phytoplankton cells in the waters. The sample fraction was placed on a Sedgewick Rafter Counting Chamber (SRCC) and observed under Nikon Diaphot inverted—phase contrast microscope with 200–400 X magnification. Identification of phytoplankton taxa was done up to genus, then grouped into diatoms, dinoflagellates and other phytoplankton, referring to Praseno and Sugestiningsih (2000), Shirota (1966), Yamaji (1966), and Nontji (2008).

In this research, our focus was the *Ceratium* genus. The number of *Ceratium* and other phytoplankton cells in the samples were counted and then converted into cell. m^{-3} by equation following Arinardi (1997). The data were further analyzed by generating biological parameter of all phytoplankton genera, such as relative density, relative frequency and importance value (Cox, 1976).

Relative density was calculated according to formula described in Cox (1976):

Relative Density =

$$\left(\frac{\textit{Density of species or genus A}}{\textit{Total density of phytoplankton}}\right) \times 100\% \quad \text{.........................(1)}$$

Frequency and relative frequency were often used to quantify the spatial distribution of particular phytoplankton genus proportionated to other genus. These values, according to Kohli *et al.* (2013), could show genera with either widespread or limited distribution. Both frequency and relative frequency were calculated using equations adopted from Cox (1976):

Frequency =

$$\left(\frac{\textit{Number of stations which species or genus A present}}{\textit{Total number of station in study area}}\right) \quad \text{…………… (2)}$$

Relative Frequency =

$$\left(\frac{\textit{Value of species or genus A frequency}}{\textit{Total value of phytoplankton frequency}}\right) \times 100\% \quad \text{..................... (3)}$$

Importance value was calculated to measure the importance of one genus of phytoplankton and adopting Cox (1976):

$$\frac{(\textit{Relative density of A} + \textit{relative frequency of A})}{2} \quad \text{…………… (4)}$$

Bray-Curtis clustering analysis (group average link) was then conducted using phytoplankton density data collected from all stations during the study periods, referring to McAleece *et al.* (1997). This analysis was conducted by operating Biodiversity Professional ver. 2.

RESULTS

Temporal Variation on *Ceratium* Biotic Parameters

In general, it was found that *Ceratium* density, relative frequency, and importance value were higher during September–November 2009, compared with June–August 2009 (Fig. 2). Similar trend was also observed in 2010 (Fig. 2). Total absolute density from 10 sampling stations was fluctuating during the research period (Fig. 2A). The lowest value was observed in October 2009 (104,582 cells. m^{-3}) and the highest was observed in May 2010 (1,191,273 cells. m^{-3}) (Table 1). The results showed that the fluctuation of *Ceratium* total density (Fig. 2A) was different from its relative density (Fig. 2B). In this research, *Ceratium* relative density was very low (< 1%) compared with other phytoplankton genera in Jakarta Bay (Table 2). Based on those value there was no *Cera-*

tium bloom observed in Jakarta Bay during the research period. Even during phytoplankton bloom in August 2009 (Fig. 3), *Ceratium* total density was much lower than other non-blooming genera, such as *Bacteriastrum*, *Stephanophyxis*, and *Thalassiosira* (Table 1). During the phytoplankton bloom event in August 2009, *Ceratium* total density was only 514,909 cells. m^{-3}. On the other hand, the density of two blooming phytoplankton genera, *Nitzchia* and *Chaetoceros*, were over 10^9 cells. m^{-3} a month before and after blooming (Table 1).

The result showed that *Ceratium* relative density was higher during September–November 2009 period, compared with that of during June–August 2009 and that of during May–July 2010 (Fig. 2B). The highest *Ceratium* relative density was observed in November 2009, with value of 0.35%, while the lowest was observed during phytoplankton bloom event in August 2009, with value of 0.01% (Fig. 2B). Although occurred in very low relative density, *Ceratium* were always present in Jakarta Bay (Table 2). Other dinoflagellate that was always present was *Protoperidinium* (Table 2). The data showed a possible relationship between high *Ceratium* density and the absent of *Nitzschia* in Jakarta Bay during May 2010 (Table 1). Based on the pattern in *Ceratium* total absolute density, it seemed that *Ceratium* demonstrated repeating cycle, with low density condition occurred between two high density conditions (Fig. 2A). This trend was not observed in the dynamic of its relative density, relative frequency, and importance value (Fig. 2B, 2C, & 2D).

The value of relative frequency, which represented the rate of occurrence of *Ceratium* in the area of study, was also fluctuating (Fig. 2C). A decline in *Ceratium* relative frequency was observed during June to August 2009 (Fig. 2C), which was similar to the pattern in its relative density (Fig. 2B). The highest *Ceratium* relative occurrence frequency was observed in September 2009, and the lowest was observed in August 2009 (Fig. 2C), which coincided with phytoplankton bloom event in Jakarta Bay (Fig. 3). Based on Fig. 4, it was clear that *Ceratium* was always present in station 1 and 2. The area with the highest *Ceratium* density was found around those two stations, while the lowest density was found in the water around station 4 and 5. Based on the value of *Ceratium* relative frequency (Fig. 2C) and distribution pattern, it was found that *Ceratium* have a wide distribution in Jakarta Bay during September 2009, compared with other months. In September 2009, *Ceratium* could be found in all sampling stations in Jakarta Bay. The result also suggested that *Ceratium* tended to be found in higher density around western area of Jakarta Bay.

In general, *Ceratium* importance value was very low compared with other phytoplankton

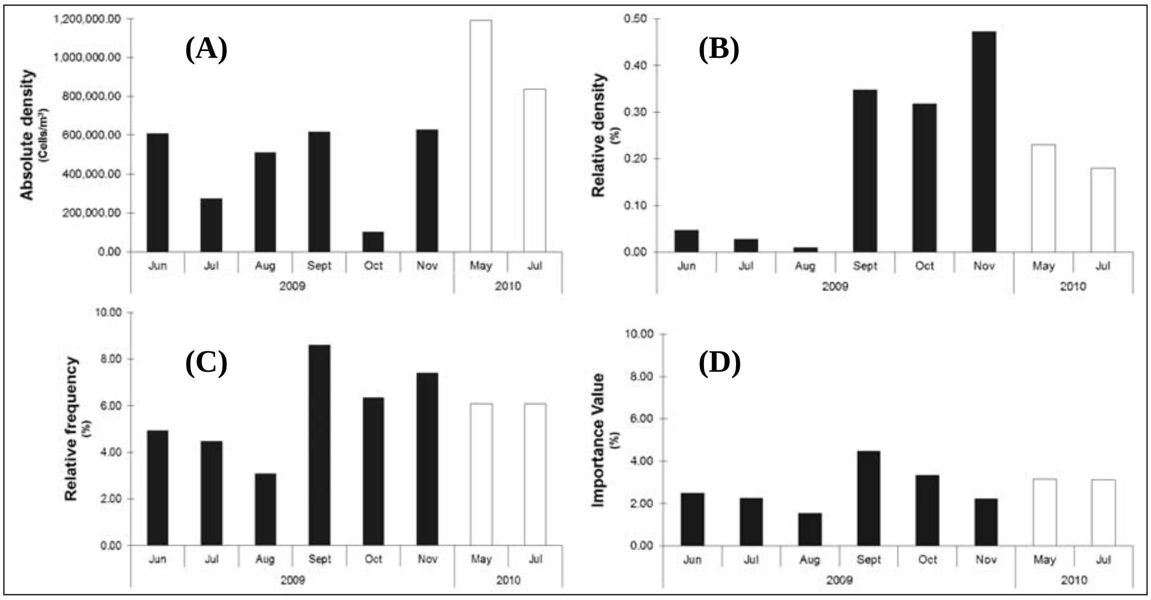

Figure 2. *Ceratium* biotic parameters in Jakarta Bay, which were: (A) total absolute density (n = 10), (B) relative density, (C) relative frequency and (D) importance value.

Table 1. Total absolute density (cells. m^{-3}) of all phytoplankton genera in Jakarta Bay during this research period. The total absolute density was counted by adding up cell density from 10 sampling stations during each sampling month.

Phytoplankton	2009						2010	
	Jun	Jul	Aug	Sept	Oct	Nov	May	Jul
DIATOMAE								
Asterionella	0	101,818	0	0	0	0	0	0
Amphora	946,909	22,400	0	0	0	0	0	0
Bacillaria	0	342,112	0	0	0	0	0	0
Bacteriastrum	10,713,309	4,370,041	1,914,764	12,562,618	98,909	16,291	1,969,164	567,370
Chaetoceros	739,500,873	117,725,972	1,867,259,345	79,106,182	721,018	4,858,424	265,853,382	224,409,600
Coscinodiscus	110,982	186,182	61,091	162,909	33,745	65,164	0	36,655
Dytilum	348,218	89,600	12,218	0	0	0	0	0
Eucampia	3,306,545	1,215,710	24,436	0	0	0	297,309	130,909
Guinardia	875,127	439,564	635,345	0	0	0	67,200	0
Hemiaulus	11,491,200	2,260,076	329,891	0	24,436	65,164	146,618	18,327
Lauderia	6,129,455	2,216,437	375,273	389,818	378,182	885,818	515,200	1,765,624
Leptocylindrus	2,407,491	5,618,349	745,309	2,828,655	8,223,418	2,842,424	1,120,000	134,400
Nitzschia	22,429,527	12,287,712	3,213,032,727	2,997,091	454,400	1,916,897	0	52,267
Navicula	0	0	48,873	0	0	4,073	8,489,600	19,156,848
Odontela	185,309	87,564	36,655	0	0	0	10,182	0
Pleurosigma	56,509	274,909	134,400	0	2,036	23,418	12,218	0
Rhizosolenia	7,191,418	5,957,529	2,555,345	643,636	108,727	400,145	1,655,564	1,062,594
Skeletonema	113,118,473	154,764	192,000	0	0	0	427,636	0
Stephanopyxis	25,455	756,477,417	315,288,436	71,241,309	13,107,127	97,406,400	207,912,727	220,563,879
Thalassiosira	65,280,727	58,637,105	42,545,455	4,200,291	2,055,273	15,761,115	38,155,345	1,078,594
Thalassiothrix	5,404,509	4,268,803	2,000,291	8,145	188,364	48,873	419,491	0
DINOFLAGELLATA								
Alexandrium	0	0	0	679,273	6,719,273	6,157,624	0	0
Ceratium	**468,873**	**274,618**	**514,909**	**616,145**	**104,582**	**627,539**	**1,191,273**	**835,200**
Cyst	14,255	0	36,655	26,182	0	0	0	0
Dinophysis	30,545	8,146	24,436	41,891	83,491	51,588	0	43,636
Diplopsalis	0	0	0	0	0	0	10,182	0
Gonyaulax	48,873	0	12,218	76,509	24,436	34,279	59,055	37,818
Gymnodinium	37,164	12,218	0	10,182	8,000	250,473	83,491	242,230
Noctiluca	120,145	81,455	36,655	637,818	294,473	290,521	20,364	139,927
Prorocentrum	384,364	47,709	97,745	201,891	75,055	159,855	122,182	100,267
Pyrophacus	61,091	0	0	50,909	2,036	0	20,364	0
Pyrodinium	24,436	0	0	0	0	0	405,236	101,818
Protoperidinium	710,691	380,800	588,218	459,345	47,927	419,830	175,127	658,812
Screriepsiella	177,164	0	256,582	52,655	80,727	202,958	0	24,436
Total Phytoplankton Density	**991,599,636**	**973,539,009**	**5,448,759,273**	**176,993,455**	**32,835,636**	**132,488,873**	**529,138,909**	**471,161,212**

Table 2. Relative density (%) of all phytoplankton genera in Jakarta Bay during this research period.

	2009						2010	
Phytoplankton	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**May**	**Jul**
DIATOMAE								
Asterionella	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Amphora	0.10	0.002	0.00	0.00	0.00	0.00	0.00	0.00
Bacillaria	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Bacteriastrum	1.08	0.45	0.04	7.10	0.30	0.01	0.37	0.12
Chaetoceros	74.58	12.09	34.27	44.69	2.20	3.67	50.24	47.63
Coscinodiscus	0.01	0.02	0.001	0.09	0.10	0.05	0.00	0.01
Dytilum	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Eucampia	0.33	0.12	0.00	0.00	0.00	0.00	0.06	0.03
Guinardia	0.09	0.05	0.01	0.00	0.00	0.00	0.01	0.00
Hemiaulus	1.16	0.23	0.01	0.00	0.07	0.05	0.03	0.00
Lauderia	0.62	0.23	0.01	0.22	1.15	0.67	0.10	0.37
Leptocylindrus	0.24	0.58	0.01	1.60	25.04	2.15	0.21	0.03
Nitzschia	2.26	1.26	58.97	1.69	1.38	1.45	0.00	0.01
Navicula	0.00	0.00	0.001	0.00	0.00	0.003	1.60	4.07
Odontela	0.02	0.01	0.001	0.00	0.00	0.00	0.002	0.00
Pleurosigma	0.01	0.03	0.002	0.00	0.01	0.02	0.00	0.00
Rhizosolenia	0.73	0.61	0.05	0.36	0.33	0.30	0.31	0.23
Skeletonema	11.41	0.02	0.004	0.00	0.00	0.00	0.08	0.00
Stephanopyxis	0.00	77.70	5.79	40.25	39.92	73.52	39.29	46.81
Thalassiosira	6.58	6.02	0.78	2.37	6.26	11.90	7.21	0.23
Thalassiothrix	0.55	0.44	0.04	0.005	0.57	0.04	0.08	0.00
DINOFLAGELLATA								
Alexandrium	0.00	0.00	0.00	0.38	20.46	4.65	0.00	0.00
Ceratium	**0.05**	**0.03**	**0.01**	**0.35**	**0.32**	**0.47**	**0.23**	**0.18**
Cyst	0.001	0.00	0.001	0.01	0.00	0.00	0.00	0.00
Dinophysis	0.003	0.001	0.00	0.02	0.25	0.04	0.00	0.01
Diplopsalis	0.00	0.00	0.00	0.00	0.00	0.00	0.002	0.00
Gonyaulax	0.005	0.00	0.00	0.04	0.07	0.03	0.01	0.01
Gymnodinium	0.004	0.001	0.00	0.01	0.02	0.19	0.02	0.05
Noctiluca	0.01	0.01	0.001	0.36	0.90	0.22	0.004	0.03
Prorocentrum	0.04	0.01	0.002	0.11	0.23	0.12	0.02	0.02
Pyrophacus	0.01	0.00	0.00	0.03	0.01	0.00	0.004	0.00
Pyrodinium	0.002	0.00	0.00	0.00	0.00	0.00	0.08	0.02
Protoperidinium	0.07	0.04	0.01	0.26	0.15	0.32	0.03	0.14
Screriepsiella	0.02	0.00	0.01	0.03	0.25	0.15	0.00	0.01
Total Relative Density	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

genera as a whole (Fig. 2). This value was declining during June to August 2009 period, which was similar with the pattern of its relative density and relative frequency. The highest *Ceratium* importance value was observed in September 2009, with only 4.49%, while the lowest importance value was observed in August 2009 (1.55%).

Based on Bray-Curtis clustering analysis, it was found that *Ceratium* distribution pattern in Jakarta Bay during this research periods was very similar with *Protoperidinium* (over 80% similarity) (Fig. 5), also with some common diatoms of Jakarta Bay such as *Rhizosolenia*, *Nitzschia*, *Stephanopyxis*, *Thalassiosira* and *Chaetoceros*.

The Existence of Other Phytoplankton in Jakarta Bay

The dominant phytoplankton genera in Jakarta Bay during this research period were diatoms, with *Chaetoceros* and *Stephanopyxis* occurred

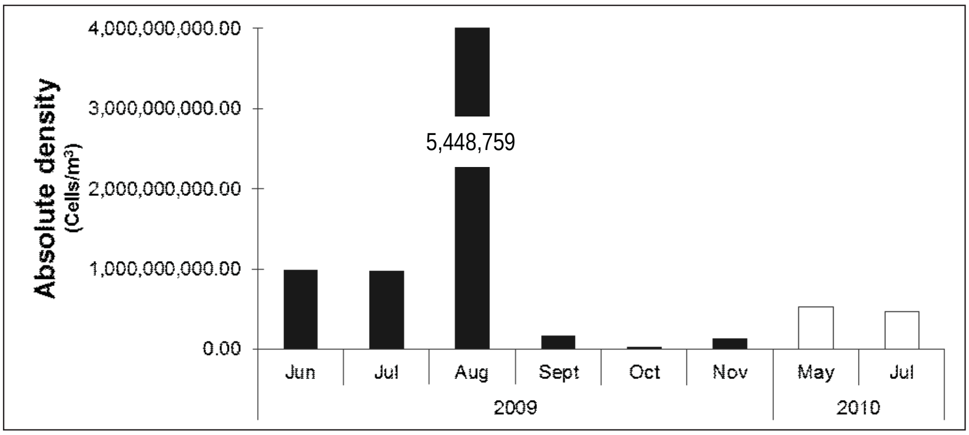

Figure 3. Phytoplankton absolute density in Jakarta Bay during June to November 2009 and Mei to July 2010.

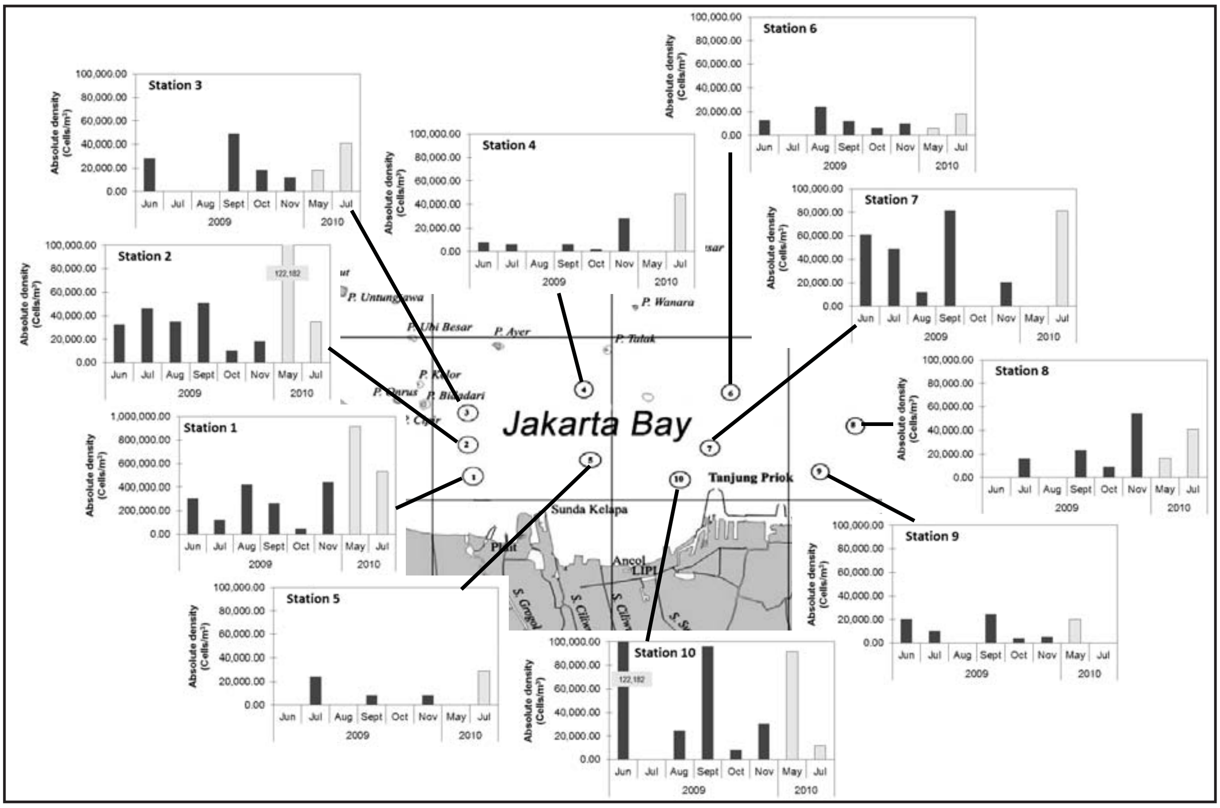

Figure 4. Detail information on *Ceratium* absolute density in each sampling station in Jakarta Bay.

in very high density in the water during most of sampling periods (Table 1, 2). Exception occurred when *Leptocylindrus* relative density overcame *Chaetoceros* in October 2009, and became the dominant phytoplankton genera along with *Stephanopyxis*. Another exception was observed during phytoplankton blooming in August 2009, when *Nitzschia* population bloomed with total absolute density over 3×10^9 cells. m^{-3} (Table 1), and became the dominant phytoplankton genera in the bay (Table 2). During this blooming period, *Chaetoceros* density also reached over 10^9 cells. m^{-3} (Table 1).

Alexandrium and *Protoperidinium* were two genera that have relatively high abundance in dinoflagellates group during this research period (Table 1, 2). *Protoperidinium* was observed in Jakarta Bay during the entire research period, while *Alexandrium* was only found during September–November 2009, but total density reaches over 5×10^6 cells. m^{-3} in October and November 2009 (Table 1). Similar with *Ceratium* and *Protoperidinium*, *Noctilluca* always present in the bay. *Noctilluca* population was found reaching its peak in September 2009 after phytoplankton bloom event, with total absolute density of 637,818 cells. m^{-3} (Table 1) and relative density of 0.36% (Table 2). On the contrary, during the peak of *Ceratium* density in May 2010, *Noctilluca* population reached its lowest density (Table 2). Meanwhile, *Gymnodinium* which was always detected through the whole observed months, was absent during the phytoplankton blooming in August 2009.

DISCUSSIONS

Although *Ceratium* was also known as a common bloom-forming phytoplankton in coastal ecosystems (Baek et al., 2008a, b), there was no *Ceratium* bloom observed during this research period. Even during phytoplankton bloom in August 2009, with total density over 10^9 cells. m^{-3}, *Ceratium* total density remained far below blooming threshold according to Spatharis and Tsirtsis (2010). A peak in *Ceratium* total absolute density was observed in May 2010, but this peak was not regarded as a *Ceratium* bloom event. Based on

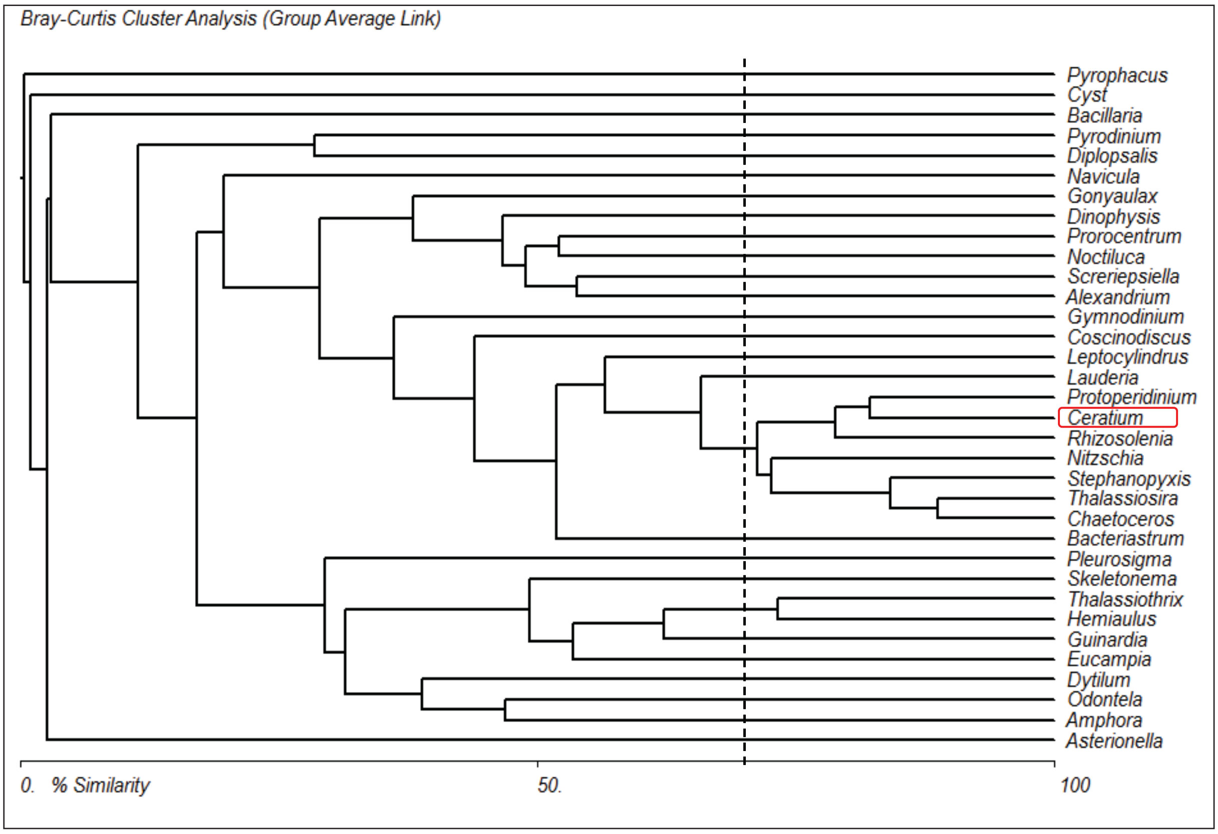

Figure 5. Bray-Curtis clustering analysis from temporal data of all phytoplankton genera in Jakarta Bay. Dashed line indicates 70% similarity.

the general cause of phytoplankton bloom in most coastal ecosystem (Glibert et al., 2002; Baek et al., 2008b), a bloom event that occurred during August 2009 in Jakarta Bay was probably related to high nutrient concentration in the water. This nutrient enrichment might come from many rivers that flowed to Jakarta Bay and intensive anthropogenic activities along the coast of the bay (Arifin, 2004; Simanjuntak, 2010; Muchtar, 2008). The blooming event in August 2009 might be an anomaly since it was occurring during dry season. Lower rainfall in dry season should reduce the nutrient input from the rivers and surface run-offs, and in consequence it should prevent any phytoplankton to bloom.

The lack of *Ceratium* bloom even during hypothetical eutrophic water condition in August 2009 might be related to dinoflagellates slower reproductive rate compared to diatoms in the bay (Hikmah, 2010; Smayda and Trainer 2010; Baek et al., 2008b; Baek et al., 2011). It was possible that *Ceratium* population was unable to compete with the rapid growth of *Nitzschia* and *Chaetoceros* during the hypothetical eutrophic condition in August 2009. Termination of phytoplankton blooming in September 2009 might be caused by nutrient depletion in the water. Meanwhile, dinoflagellates such as *Ceratium*, had an ability to grow and reach high cell density in oligotrophic water condition (Baek et al., 2009b; Alkawri and Ramaiah, 2010). Therefore, *Ceratium* had a chance to increase its population during hypothetical nutrient depletion event in September 2009. The lowest *Ceratium* density was observed in October, which also coincided with lowest total phytoplankton density in the bay. This condition might be the result of prolonged nutrient depleting condition in the water. Based on the result of this research, there seemed to be a correlation between *Ceratium* highest density in May 2010 and the absent of *Nitzschia* in the bay. But this correlation needed to be studied further.

The Bray-Curtis analysis in this research also indicated that *Ceratium* temporal variation in its density and distribution seemed to have similar pattern with *Protoperidinium* and some common diatoms, such as *Rhizosolenia*, *Nitzschia*, *Stephanopyxis*, *Thalassiosira* and *Chaetoceros* in Jakarta Bay. This closely similar group (> 70% similarity) indicated that those genera might have similar niche in the community; thus they might also form some biological interactions. This biological interaction probably occurred in the form of competition, especially for nutrients in the water of Jakarta Bay. This hypothetical interaction need to be proved in next research.

Although *Ceratium* was considered common phytoplankton for Jakarta Bay (Thoha, 2010; Sidabutar, 2010), it was present in very low density and with relatively restricted distribution in most sampling periods. *Ceratium* distributed widely in Jakarta Bay only in September 2009, one month after phytoplankton bloom occurred in the bay. Based on the result, *Ceratium* population was likely to have clumped distribution type, since its distribution was centered mainly on western area of Jakarta Bay. This type of distribution might occur due to the pattern of currents in the bay, which could cause the *Ceratium* population to aggregate around western area. Research by Hadikusumah (2007) suggested that surface current of Jakarta Bay varied depending on the season. In general, water current of Jakarta Bay was circulating inside the bay during dry season (June–August) and transitional II season (September–October). The surface water current during those seasons was mainly flowed from north east to south west area. In contrast, the surface current flowed out of the bay during transitional I season (March–May) (Hadikuksumah, 2007). This physical factor might limit the distribution of *Ceratium* in the bay. However, it was unknown why its distribution was much wider during September 2009.

Ceratium plays an important role as one of the main substantial part of annual primary production in most marine ecosystem. It was grazed by some heterotrophic dinoflagellates such as *Protoperidinium* and some herbivory copepods (Olseng et al., 2002; Baek et al., 2008b; Baek et al., 2011). Despites its important ecological role, *Ceratium* population in Jakarta Bay seemed to have little value to the ecosystem. Unlike in some temperate coastal ecosystem such as Sagami Bay – Japan, Southern California Bright – USA, and Jinhae Bay – Korea, *Ceratium* in this tropical ecosystem of Jakarta Bay was suggested to have insignificant ecological role among phytoplankton community of the bay (Orellana-Cepeda et al., 2002; Baek et al., 2008; Baek et al., 2011). Thus it was doubtful whether *Ceratium* could actually cause severe ecological problem such as red tide or mass fish mortality in Jakarta Bay. Nevertheless, as the ecosystem has been heavily affected and frequently enriched by anthropogenic activities, there was a possibility that dinoflagellates such as *Ceratium* could take over the diatoms in a phytoplankton blooming event and cause problem in the future.

CONCLUSIONS

From this research, it could be concluded that there were three different *Ceratium* population dynamic trend in Jakarta Bay. The first trend occurred during June to August 2009, the second occurred during September to November 2009 and the third trend occurred during May to June 2010. The lack of *Ceratium* bloom during hypothetical eutrophic water condition in August 2009 might be related to its slow reproductive rate and competition with blooming *Nitzschia*. Although *Ceratium* was considered as common phytoplankton of Jakarta Bay, the density was very low and the distribution was relatively limited; thus it assumed that *Ceratium* might only have small to insignificant ecological role in the ecosystem of the bay.

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