RECENT BLOOMING OF *PYRODINIUM BAHAMENSE* VAR. *COMPRESSUM* IN AMBON BAY, EASTERN INDONESIA

Sem Likumahua

Technical Implementation Unit for Marine Life Conservation
Research Center for Oceanography-Indonesian Institute of Sciences
Jln. Y. Syaranamual, Guru-Guru Poka, Ambon 97233, Indonesia
E-mail: sem.liku@yahoo.co.id

Received: December 2012 Accepted: February 2013

ABSTRACT

In Indonesia, *Pyrodinium bahamense* var. *compressum* was first recorded in Kao Bay in 1994. In 1996 the illness of more than 30 people and the death of 3 children after consuming shellfish from Ambon Bay was reported. Until the shellfish poisoning cases was reported, occurrences and blooms of *P. bahamense*, neither its toxic events had never been known in Ambon Bay. It has generated monitoring on the species occurrence which has been carried out since 2008. The bloom of *P. bahamense* was detected in July 2012. During the bloom event, concentrations of phosphate, nitrate and dissolved oxygen were measured. Vertical profiles of temperature, salinity, turbidity and chlorophyll *a* were also measured during the red tide. Cells of *P. bahamense*, the PSP responsible species, were recorded abundant up to 2,496 cells/ml when red-brown water discoloration was observed in Ambon Bay. After the toxic red tide, human illness of 7 people due to shellfish consumption was also reported. In addition, the bloom event has damaged aquaculture products, due to mass mortality of cultured fish in inner Ambon Bay.

Keywords*:* Ambon Bay, discoloration, human illness, *Pyrodinium bahamense* var. *compressum*.

INTRODUCTION

Ambon is a small island located in eastern Indonesia with a population of about 600,000 people. Annual rainfall is approximately 600 mm, mainly in wet season from May to September, associated with the southeast monsoon of cooler air from Australia. Dry season is associated with the northwest monsoon from October to March, characterized by high temperature and less rainfall.

Ambon Bay is a silled estuary consisting of an inner part about 6 km^2 and averaging 30 m in depth, and an outer part about 25 km long connected to the Banda Sea. A narrow and shallow sill connects these two parts, 300 m wide and 12 m deep; it is thus limiting water circulation and making stagnation in the inner bay. Increased development in the coastal area of the inner bay and associated pollution inputs may alter the chemical regime of this area.

The chain-forming dinoflagellate *Pyrodinium bahamense* var. *compressum* (PBC) is responsible for paralytic shellfish poisoning (PSP) especially in the tropical Pacific. This armored, bioluminescent dinoflagellate, has caused toxic red tides in coastal waters of several countries in Southeast Asia, since the first red tide event was reported in Papua New Guinea in 1972 (Usup et al., 1994). This toxic species appears to distribute in Southeast Asia, as it occurs in the Philippines, Malaysia, Indonesia and other countries in the region. In Indonesia, an incident of PSP caused by PBC was first recorded in Kao Bay in 1994 (Mizushima et al., 2007). Subsequently, the first PSP in Ambon Bay which led to the illness of more than 30 people and the death of 3 children after consuming shellfish (*Hiatula chinencis*) collected in this area (Wiadnyana et al., 1996). There has never been any report about the occurrence and blooms of this toxic species until

DOI: 10.14203/mri.v38i1.54

the first case, as well as human illness because of PSP in Ambon Bay.

Due to recent land development and massive sedimentation in inner Ambon Bay, fisheries production and water quality were getting worse. Local people recognizing the coastal and marine environment disturbance is the main cause for these problems. High precipitation in southeast monsoon triggers immense run–off of some river that influences high nutrition level suitable for algae to bloom. Being experienced in PSP accidence, monitoring of water quality and plankton community in Ambon Bay has been conducted since 2008. This paper reports the monitoring results as well as the massive bloom of PBC in Ambon Bay in 2012, and the water condition which may trigger the bloom formation.

MATERIAL AND METHODS

Ambon Bay is located in Ambon Island which consists of inner and outer part separated by a shallow narrow sill of approximately 12 meters deep. On this bay, 18 permanent monitoring stations have been set up composed of 7 stations at inner bay and 11 stations at outer bay (Fig. 1). The main focus of this study was the inner bay at village of Latta and Lateri due to the former incident of human illness. Sampling was carried out monthly from 18 stations from 2008 to 2012.

Plankton samples were collected using a Van Dorn Water Sampler of 2.5 L at appropriate depth of blooming. All plankton samples were preserved in 4% formalin and determined under a Nikon Eclipse 50-I microscope. Environmental parameters, such as temperature, salinity, chl *a*, and turbidity were recorded using Compact CTD model ASTD687 (Alec Electronics, Japan). By using Nansen bottle, water sample was collected to measure phosphate and nitrate concentration as well as dissolved oxygen by Winkler method following Strickland and Parsons (1968).

RESULTS

During monitoring average abundances of all phytoplankton in Ambon Bay were fluctuated between 6.85 and 10.31×10^5 cells/m^3. The occurrence of *Pyrodinium bahamense* var. *compressum* (PBC) was recorded abundant in June 2009, June 2012 and July 2012, with the cell concentrations of 0.35, 1.30 and 5.99 cells/ml, respectively. The highest abundance of PBC reached 2,496 cells/ml, when water discoloration in inner bay was detected on 12 July 2012 (Fig. 2). In the center of bloom, PBC was estimated >1,000 cells/ml (Figure 3). Cells of PBC were typical armored dinoflagellate forming cell chains up to 4 cells with conspicuous singular list and antapical spine especially those

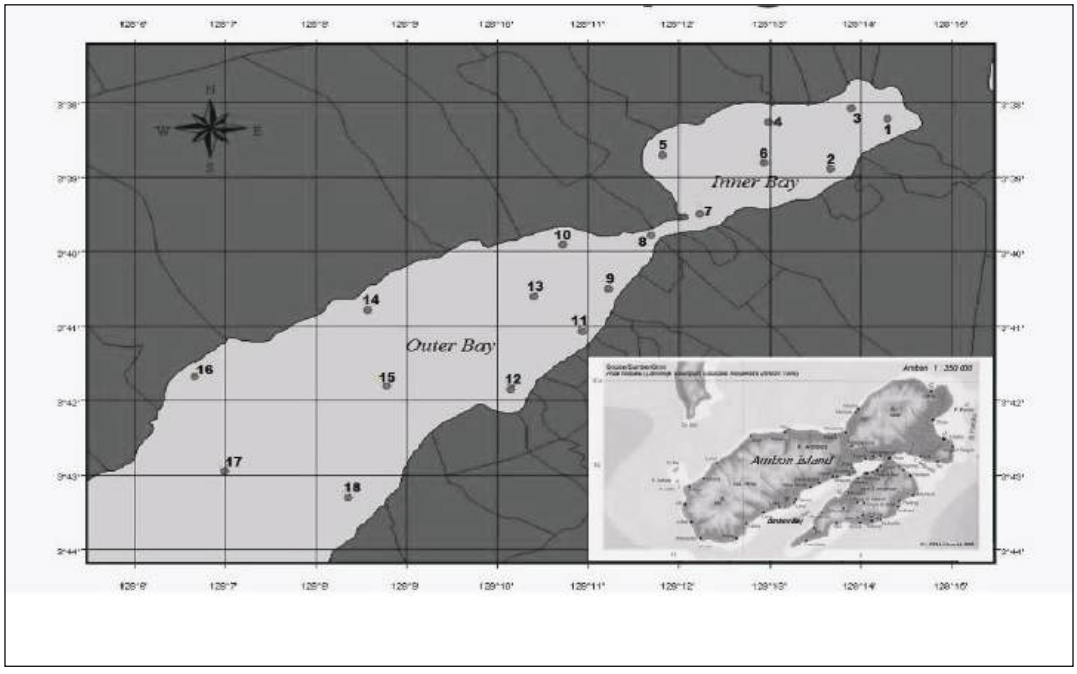

Figure 1. Location of sampling stations in Ambon Bay, Ambon Island.

Figure 2. Water discoloration due to red tides of *Pyrodinium bahamense* var. *compressum* in Ambon in July 2012 (A: red-brown water discoloration in Lateri Village, B: brown-black water discoloration in Passo Village, C: Sample collected using net, D: floating fish cages at Passo Village and E: at Lateri Village).

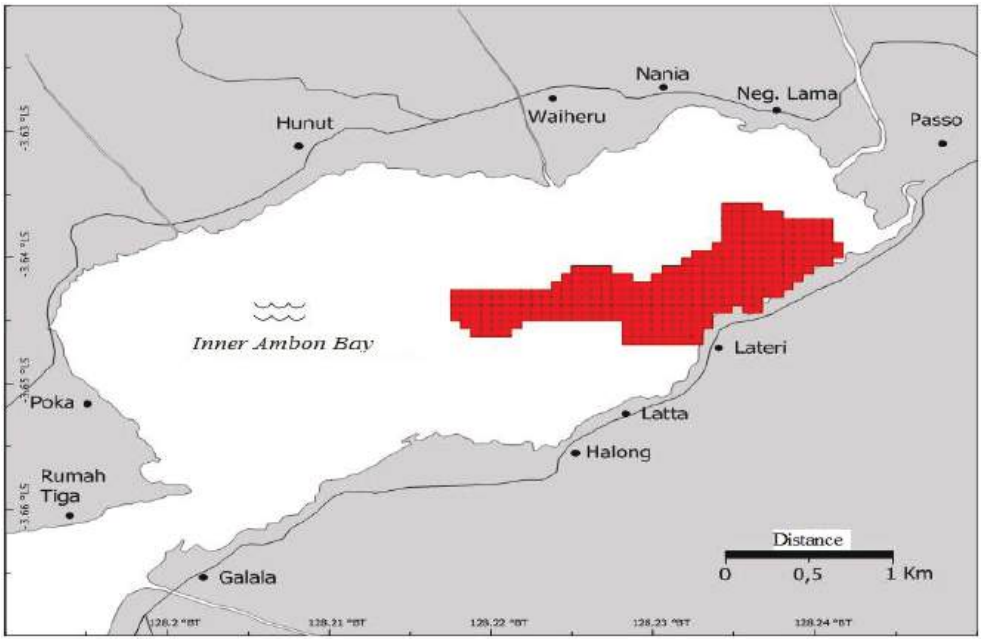

Figure 3. Area of *Pyrodinium bahamense* var. *compressum* bloom (squares >1,000 cells/ml) in inner Ambon Bay, 12 July 2012.

in the posterior of the chain (Fig. 4). Sea surface temperature and salinity during the PBC bloom were 29.13°C and 30.56 psu, in the depth of 0.75 m (Fig. 5). At the same depth, high concentration of Chl. *a* was recorded 27.84 ppb, and the value of high turbidity was 13.25 NTU (Fig. 6).

During the PBC bloom, phosphate and nitrate concentration were measured at 2 stations in inner bay (Table 1). At these stations, concentrations of phosphate were 0.003 and 0.008 ppm, and those of nitrate were undetected. On the other hand, nutrients were high on sea floor, concentrations of

phosphate were 0.011 and 0.040 ppm, and those of nitrate were 0.067 and 0.079 ppm. Dissolved oxygen (DO) was 6.00–6.03 ppm at surface and 3.63–4.22 ppm on sea floor. Phosphate and nitrate concentration in Ambon Bay decreased during February to April 2012, and then increased in May to June (Fig. 7).

DISCUSSION

Monitoring on phytoplankton community in Ambon Bay revealed the recent algal blooms, which led to aquaculture damages and human illness. During blooms of PBC, water discolorations were observed yellow-brown to red, and black around floating fish cages in inner Ambon Bay.

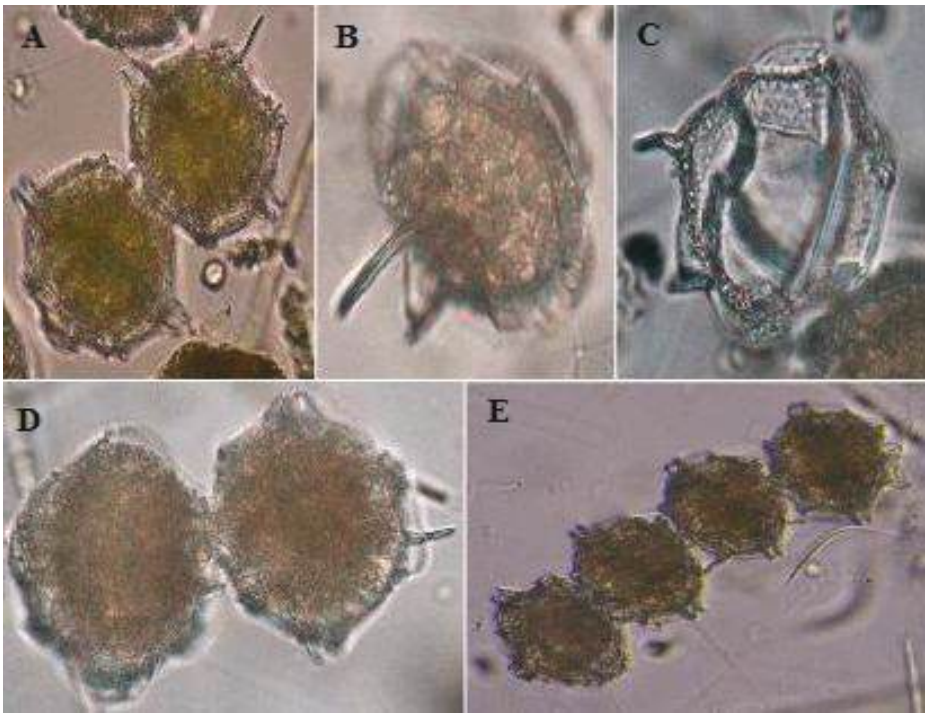

Figure 4. Light microscopy of *Pyrodinium bahamense* var. *compressum* (34–35 µm long and 39–41 µm wide) collected from Ambon Bay in July 2012.

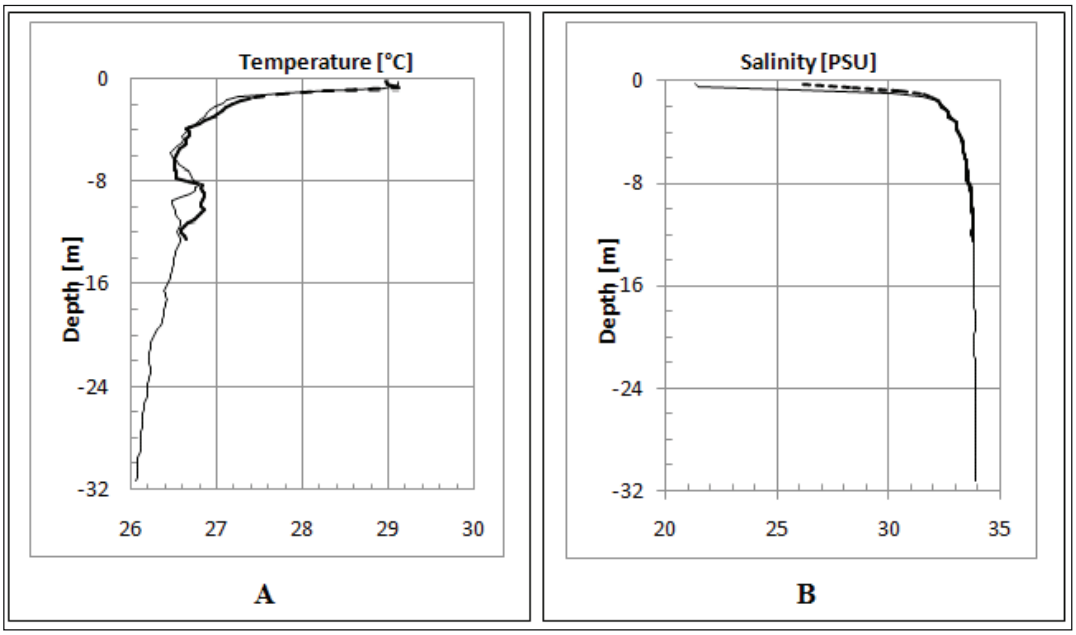

Figure 5. Vertical profiles of temperature (A) and salinity (B) during the occurrence of *Pyrodinium bahamense* var. *compressum* red tide in Ambon Bay, July 2012.

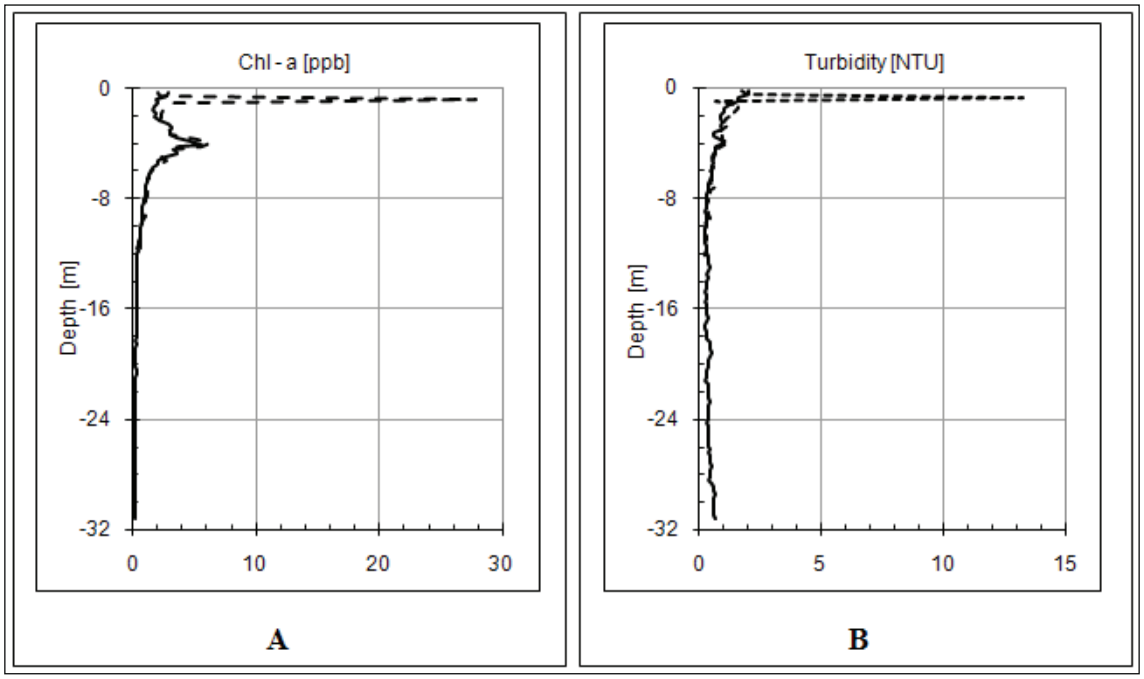

Figure 6. Vertical profiles of chlorophyll *a* (A) and turbidity (B) when *Pyrodinium bahamense* var. *compressum* red tide occurred in Ambon Bay, July 2012.

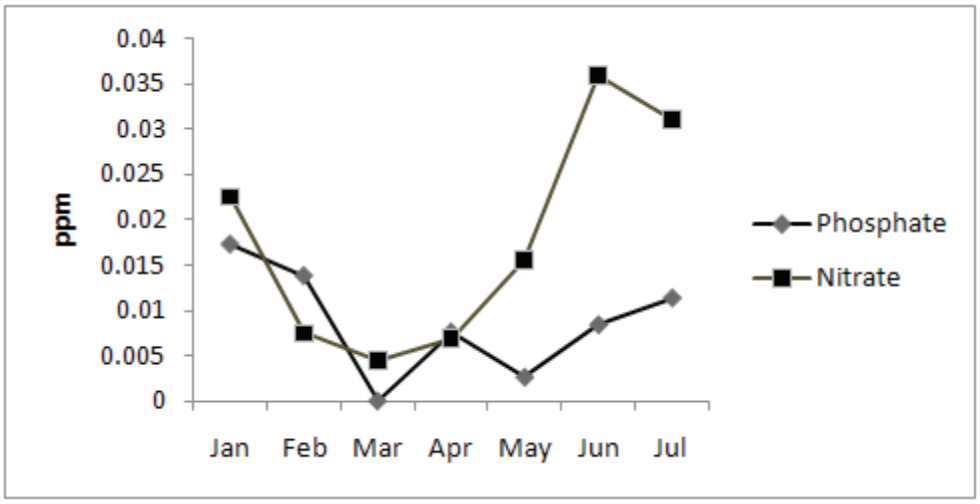

Figure 7. Average concentration of phosphate and nitrate at the surface water of Ambon Bay, 2012.

Table 1. Concentration of phosphate (PO_4), nitrate (NO_3) and dissolved oxygen (O_2) when *Pyrodinium bahamense* var. *compressum* red tide occurred in Ambon Bay, July 2012.

Station	Depth	PO_4 (ppm)	NO_3 (ppm)	O_2 (ppm)
1	Surface (0 m)	0.002763349	Undetected	6.00
	Near Bottom (B-1m)	0.010807101	0.067388337	4.22
2	Surface (0 m)	0.0075896	Undetected	6.03
	Near Bottom (B-1m)	0.020459603	0.079066367	3.63

Thousands of cultured fish, e.g., *Caranx* sp. and *Chromileptes altivelis* were found dead and floated on water surface. This accidence occurred in mid–June 2012, just before the catch for market, resulted in the loss of million Rupiahs. Since fish killing was never reported in this area, fish mortality due to blooms of PBC was the first report in Ambon Bay.

In the early of July 2012 data on human getting–poisoned cases after consuming shellfish collected from the inner Ambon Bay were initiated by visiting and interviewing their family members as well as visiting hospital to estimate the number of sufferers. Seven people, i.e. 2 children and 5 adults, were hospitalized for a week. They were residents who lived in the villages near the coast of inner Ambon Bay, such as Lateri Village, Waiheru Village and Latta Village. Human illness after shellfish consumption was reported in Ambon Island in 1996, which claimed 3 children, lives, and caused more than 30 people hospitalized (Wiadnyana et al., 1996). This phenomenon might be the consequences of a bloom of toxic PBC phytoplankton in the area. In Indonesia, 427 cases of paralytic shellfish poisoning (PSP) and 17 deaths have so far been recorded (Azanza and Taylor, 2001).

Wiadnyana et al. (1996) reported that the illness led to human killing in Ambon Bay was caused by PBC, mostly found near Latta village. The cell concentration of PBC in the case ranged 0.4–1.6 cells/ml, which occupied 1–41% of the total phytoplankton cells. In the recent event, *Pyrodinium bahamense* var. *compressum* was found abundant, which exceeded 1,000 cells/l. The highest cell concentration of PBC occurred in Lateri Village, near Latta Village, with approximately 110 hectares wide. Yet, these dense bloom events were found only in particular season in Ambon Bay, i.e. in June to July when southeast monsoon blew with high precipitation.

Mizushima et al. (2007) revealed the first occurrence of PBC cysts in Ambon Bay 1850, which reached 33cysts/g (g weight of dry sediment) at the depth of 56–58 cm. Furthermore, it became more abundant in 1940, which was above 22–24 cm depth with density of 2,124–3,477 cysts/g. Vegetative cell from these cysts might led to the bloom event in 1994 in Ambon Bay, since the deposited cysts play role in initiating toxic bloom (Sombrito et al., 2004). Moreover, this recent bloom indicated the favorable condition for PBC cysts to be active, supported by high concentration of nutrient. Villanoy et al. (2006) suggested that strong vertical mixing triggered by wind results in the increasing of bottom current velocity, which may influence nutrient and plankton populations. The vegetative cells of PBC will be pushed to the upper water column where favorable condition is available.

Monitoring for phosphate and nitrate in 2012 showed the increase of both in May to June, just before the bloom event. The value of nitrate began to increase from May, and reached 0.02–0.04 ppm in June. High precipitation during southeast monsoon in Ambon Island provoked high nutrient load to be charged in inner bay by run–off of some rivers. However, when the bloom event occurred, nutrient value initiated to decrease and nitrate was undetected at surface layer. This may indicate that nutrient uptake process of phytoplankton was already done before we conducted sampling.

Since there is heavy precipitation during southeast monsoon season from May to August, salinity decreases due to massive run–off of rivers in Ambon Island. When the bloom of PBC occurred, salinity was decreased to 29.56 psu and temperature was 29.13 °C at surface layer. According to Gedaria et al. (2007), fluctuation of temperature and salinity, 23–36 °C and 26–36 psu, were favorable for growth of PBC. Yet, the optimum condition for PBC growth was found in high salinity at broad temperature range. Usup et al. (2012) also reported PBC forms bloom only in conditions with salinity higher than 20 psu and temperature above 20 °C. Moreover, Garate and Gonzales (2011) reported that the solitary cells of *P. bahamense* emerged at temperature ranging 24.5–31.0 °C in the southern coast of the Baja California Peninsula which indicated tropical nature.

As the conclusion, Ambon Bay has recently experienced bloom of the marine toxic dinoflagellate *Pyrodinium bahamense* var. *compressum* in which the abundance exceeded 1,000 cells/ml. This event affected aquaculture production and caused human illness. To reduce risk caused by PBC bloom in Ambon Bay, early warnings have been

announced by the Ambon city local administration, i.e. not to harvest shellfish in inner Ambon Bay prior and during the blooming. However, the PBC bloom and its toxin management are poorly understood. Thus, monitoring of this species occurrence, abundance and hydrological conditions should be continued in order to understand relevant environmental parameters to the bloom formation.

ACKNOWLEDGEMENT

This study was partly supported by the Japan Society for the Promotion of Science for the Asian CORE Program (Coastal Marine Science in Southeast Asia: COMSEA).

REFERENCES

Azanza, R.V. and F.J.R. Taylor. 2001. Are *Pyrodinium* blooms in the Southeast Asian region recurring and spreading? A view at the end of the millennium. *AMBIO* 30: 356–364.

Garate-Lizarraga, I. and R. Gonzales-Armas. 2011. Occurrence of *Pyrodinium bahamense* var. *compressum* along the southern coast of the Baja California Peninsula. *Mar. Pollut. Bull*. 62: 626–630.

Gedaria, A.I., B. Lukas, K. Reinhardt and R.V. Azanza. 2007. Growth response and toxin concentration of cultured *Pyrodinium bahamense* var. *compressum* to varying salinity and temperature conditions. *Toxicon* 50: 518–529.

Mizushima, K., K. Matsuoka and Y. Fukuyo. 2007. Vertical distribution of *Pyrodinium bahamense* var. *compressum* (Dinophyceae) cysts in Ambon Bay and Hurun Bay, Indonesia. *Plankton Benthos Res*. 2: 163–174.

Sombrito, E.Z., A.dm. Bulos, E.J. Sta Maria, M.C.V. Honrado, R.V. Azanza and E.F. Furio 2004. Application of ^{210}Pb-derived sedimentation rates and dinoflagellate cyst analyses in understanding *Pyrodinium bahamense* harmful algae bloom in Manila Bay and Malampaya Sound, Philippines. *J. Environ. Radioactiv.* 76: 177–194.

Strickland, J.D.H. and T.R. Parsons. 1968. Determination of dissolved oxygen. *In*: J.C. Stevenson, L.W. Billingsley, R.H. Wigmore, R.L. Mac intyre, M. Glassford and M. Skulski (Eds). A practical handbook of seawater analysis. Fish. *Res. Board Can*: 21–26.

Usup, G., D.M. Kulis and D.M. Anderson. 1994. Growth and toxin production of the toxic dinoflagellate *Pyrodinium bahamense* var. *compressum* in laboratory culture. *Nat. toxins* 2: 254–262.

Usup, G., A. Ahmad, K. Matsuoka, P.T. Lim and C.P. Leaw. 2012. Biology, ecology, and bloom dynamics of the toxic marine dinoflagellate *Pyrodinium bahamense*. *Harmful Algae* 14: 301–312.

Villanoy, C.L., R.V. Azanza, A. Altemerano and A.L. Casil. 2006. Attempts to model the bloom dynamics of *Pyrodinium*, a tropical toxic dinoflagellate. *Harmful Algae* 5: 156–183.

Wiadnyana, N.N., T. Sidabutar, K. Matsuoka, T. Ochi, M. Kodama, Y. Fukuyo. 1996. Note on the occurrence of *Pyrodinium bahamense* in eastern Indonesian waters. In: Yasumoto, T., Y. Oshima and Y. Fukuyo (eds), Harmful and Toxic Algal Blooms. IOC/UNESCO Paris, pp. 53–56.