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Review

THE CURRENT STATUS OF RESEARCH ON HARMFUL ALGAL BLOOM (HAB) IN INDONESIA

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ABSTRACT

Harmful Algal Bloom (HAB) is a natural phenomenon, however its incident increases both in term of cases and areas. When HAB outbreaks occur it will usually damage the environment and create economic losses. Environmental damage and economic losses are caused by the harmful aspects of the HAB organisms due to both of environmental alterations and toxin productions. In Indonesian seas, HAB has become more frequent and spread through out the country since 1970s. But there are still lacks of: number of researcher and research, funding support, awareness, and integrated national agenda with regard to HAB in Indonesia. In contrast, worldwide research and researchers, funding, awareness, and national agenda have become common and more advance. Hence, there are some opportunities for Indonesian researchers on HAB to: join (international) research projects, gain research funding, experience advance training, and pursue scholarships (for Masters and PhDs degree) from institutions abroad.

Keywords: HAB, Phycotoxin, Coastal Areas, Ecosystem and Economic loss

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INTRODUCTION

Harmful Algal Bloom (HAB) phenomenon becomes an important subject among marine scientists worldwide recently. Such natural phenomenon appeared almost unnoticed in 1793 when some boatmen were reported to be intoxicated after consuming marine seafood, specifically shellfish, captured from British Columbia sea. Hence, the name Poison Cove was given by Captain George Vancouver for the place (Anonymous, 1998). Some of the toxins produced by the harmful algae were usually accumulated in shellfish and other seafood organisms through marine food-chains and undergone biomagnification processes in human body.

From then on, HAB outbreaks seem to be common incidences in the marine environments and surprisingly HAB has been spread out and now becoming more extensive worldwide. Anderson (1995) noticed that HAB outbreaks in the United States of America's seas have been distributed widely in this country since 1970's. Other important things to note in HAB outbreaks are the number of harmful algal species which also increases and the impacts become more severe, because HAB was not only affected ecosystem but also human health, which means huge economic loss. Additionally, shellfish consumption banned during the outbreak will increase the economic loss from the seafood industry, mostly the fishermen.

In term of economic loss caused by HAB outbreaks, Anderson et al. (2000) has calculated that in the USA alone, it reached the value as big as US$50 million per year. On the other hand, human beings who were intoxicated by contaminated seafood commonly experienced the decrease of their

life quality. Therefore, it was not surprised if APEC (Asia Pacific Economic Council), as one of the bonafide international economic fora, since 1997 has given a strong support to HAB scientists to conduct such an international conference (International Conference on Marine Shellfish Safety/ ICMSS). HAB study has also developed intensively worldwide in order for a country to predict, prevent, and mitigate HAB outbreaks (Anderson et al. 2001).

HAB outbreaks, hence, are closely linked to coastal-related, we activities, for instance aquaculture/marineculture, marine pollution, seafood industry and consumption, transportation (ship's ballast water) and tourism (Hallegraeff, 1995). HAB occurrences were predicted to be caused by global climate change, eutrophication, and man-made (such as industries and domestic) activities in the coastal areas (Anonymous, 1998). Therefore, many studies on HAB are now being carried out worldwide.

In accordance to the development of HAB study, there were some supporting activities, such as international trainings, dissemination of informations through internet (and mailing lists such as Phyco-toxins, Algae-L, and Indonesia_HAB@yahoogroups. com), intergovernmental join programs, scientific publications, international peer-reviewed journal, etc.

Henceforth, the purpose of this review article is to examine the current status of HAB in Indonesia.

HARMFUL ALGAL BLOOM (HAB) RESEARCH WORLD-WIDE

Worldwide studies of HAB have been done as early as this phenomenon appeared to become one of the important problems in coastal-related activities. As mentioned in the above paragraphs, HAB outbreak in an area does not only damage marine environments, but also at the same time created very complicated socio-economic problems. Closing off a shellfish aquaculture during HAB outbreak for instance can cause an economic loss to the fishermen and/or the shellfish industry and consequently gives the fishermen no job to do, no money to gain, and usually no alternative income (Corrales and Maclean, 1995).

Hallegraeff (1995) and Anderson (2004) reported that the increased numbers of case of HAB outbreaks were correlated with the increase of species numbers of harmful algae as the causative organisms. Therefore, one key factor to understand and to mitigate the outbreak is to study the biological aspects of the causative organisms for example a toxin-producing *Alexandrium* spp.

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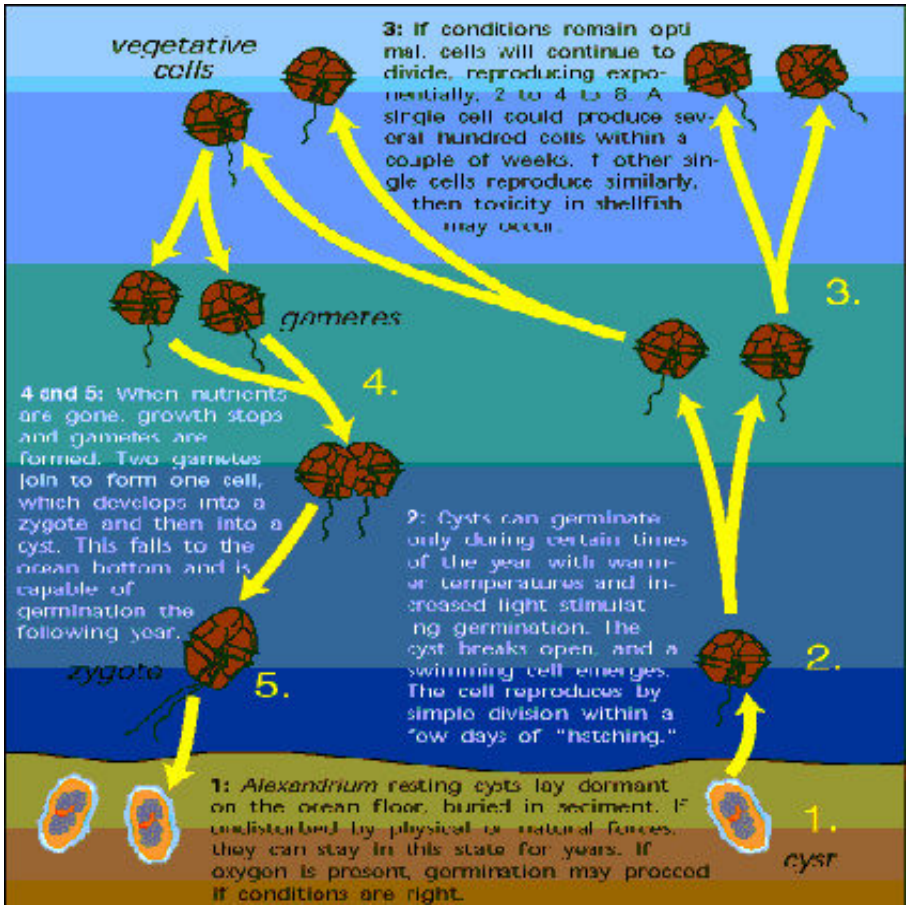

Fig. 1. A life cycle of *Alexandrium* spp (see the sequence numbers from 1 to 5), one of the PSP producing dinoflagellate occur in Jakarta Bay, Indonesia. Picture courtesy of Woodshole Oceanographic Institution (http://www.whoi.edu/redtide).

The biological aspects include: taxonomy and ecology, physiology (toxin production, reproduction), symbiosis (endosymbiont bacteria), genetics (DNA mutation and evolution), and biotechnology (toxins antidote production and biological control) (Burkholder, 2000).

Study in taxonomic aspect is very important, because if one failed to identify and determine the causative organism(s) correctly, it will lead to the mismanagement of the treatment done. However, in some cases, there were noticed cases that several species appeared in two conditions: toxin-producers and non-toxin producers, both in the laboratory and in nature (Gonzales et al., 1995; Burkholder, 2000). Species identification and determination are related closely to their ecological aspects such as distributions, factors influencing the outbreaks (nutrients-eutrophication, climate-El Niño, water current-ship transportation, etc), species succession, and community structure (Burkholder, 2000; Anderson, 2004).

Related to these two aspects is the study on HAB cyst. Study on HAB cyst has now become very important, because it can reveal not only the history (vertical distribution) of the occurrence of an HAB species in an area, but also its horizontal (and worldwide) distribution of the microalgal species (Fukuyo and Matsuoka, 1987; Anderson et al., 1995). Modern HAB cyst studies were believed to be able to predict HAB outbreaks in the future (Matsuoka and Fukuyo, 1987).

Toxins' production from the harmful algae has become very interesting aspect to study. Until recently, there were already some toxins revealed from the harmful algae (**Table 1**) and it is predicted to increase in term of toxins' numbers in the present time (Jellet, 1993; Plumley, 1997).

Table 1. Phycotoxins produced by HAB organisms and their adverse impacts

Type of Poisonings	Causative organisms	Toxins Produced	Symptoms
ASP (Amnesic Shellfish Poisoning)	*Pseudonitszchia* spp	Domoic Acid	In 24 hours: nausea, vomiting (76%), abdominal cramp (50%), diarrhea (4%). In 48 hours: neurological symptoms such as dizziness, headache, seizures, disorientation, short-term memory loss (25%), respiratory difficulty, and coma
DSP (Diarrhetic Shellfish Poisoning)	*Dinophysis* spp *Prorocentrum lima*	Okadaic Acid	Within 30 minutes: incapacitating diarrhea (92%), nausea (80%), vomiting (79%), abdominal cramps and chills
NSP (Neurotoxic Shellfish Poisoning)	*Gymnodinium breve*	Brevetoxins	Initially diarrhea, vomiting and abdominal pain, followed by neurological dysfunction
PSP (Paralytic Shellsfish Poisoning)	*Alexandrium* spp, *Gymnodinium catenatum, Pyrodinium bahamense var. compressum*	Saxitoxins	Potentially fatal (8.5 – 14%), death occur within 24 hours. In non-lethal cases: tingling, numbness, ataxia, giddiness, drowsiness, fever, rash, and staggering.
CFP (Ciguatera Fish Poisoning)	*Gambierdiscus toxicus, Prorocentrum* spp, *Ostreopsis* spp, *Coolia monotis*	Ciguatoxin, Maitotoxin	Initially diarrhea, vomiting and abdominal pain (± 12%), followed by neurological or temperature sensation, muscular aches, dizziness, anxiety, sweating and numbness and tingling of the mouth and digits.

Source: Jellet (1993) and Baden et al. (1995, with minor modifications)

The toxins produced by HAB organisms are known as phycotoxin. So far, phycotoxins produced by the algae were used as their biological defense mechanisms to their predators. Physio-logical aspect of toxins production in harmful algae still need to be explored, since it has been reported that in some HAB species the toxins were produced by their endosymbiont bacteria (Doucette, 1995; Kodama et al. 1996, Sidharta, 1999), hence, the term Bacterial Hypothesis appeared in this respect (de Traubenberg and Lassus, 1991).

There were some studies, and some others are still in progress, on the production of HAB toxins antidote (Fleming et al., 1995; Plumley, 1997). No cure and exact treatments for those who experienced HAB toxins fatality so far. Expert in toxins biochemistry are trying to find such an antidote (and if they succeed, it will become a good business in pharmaceutical industries in the near future) to help the victims to regain their quality of life.

Biological control has now become an interesting aspect in HAB biotechnology, which includes DNA manipulation. Some researchers have found that HAB outbreaks were able to be minimized utilizing other marine microalgae, marine bacteria, and marine viruses (Imai et al. 1993; Yoshinaga et al. 1995). In addition to that biological control treatment is safe and more convenience to be done, compare to other treatments (Burkholder, 2000).

Physical aspects of HAB studied intensively were algae distributions. HAB organisms which were small in size were very easy to be transported by water currents and thus, water currents were one of the physical aspects studied with respect to HAB organism distributions worldwide. Recently there is a new finding noticed that ballast water from the

ships may take the role as the transportation tools of HAB organisms and/or cysts from one coastal area to another (Hallegraeff, 1995).

Physical control was done by utilizing clay mineral to remove the HAB organisms from the sea waters (Yu et al. 1995; Sengco, 2004). Spraying of clay on the surface sea water may trap the microalgae and suddenly they will sink into the bottom. Microalgae will eventually dead because of crushing weight and lack of sun for photosynthetic activities (Sengco, 2004). However, this technique still needs to be studied further in term of the impact of the clay to the bottom dwelling organisms.

Socio-economic aspects studies have also been done by many researchers worldwide. Socio-economic studies done were as follows: the aims to find alternative jobs and/or create alternative incomes for the fishermen and the way to detoxify shellfish utilizing ozone (Corrales and Maclean, 1995; Shumway et al., 1995). Detoxification-depuration using ozone gas was expected to help the fishermen, the very susceptible group in coastal area business site, when HAB outbreaks occurred.

INDONESIAN HAB RESEARCH & RESEARCHERS

Study on HAB in Indonesia has been done as early as 1979 (Dahril, 1981; Adnan, 1989; Praseno and Adnan, 1994). The type of research done at that time was focused on the ecological aspects of the harmful microalgae. So far, no reports and studies on HAB toxins production, encystment and excystment, live culture of HAB organisms, etc. were available in the country. Thus, the studies done on HABs phenomena in Indonesia were more on the ecological aspects and did not touch the application aspects (Wiadnyana et al. 1994; Wiadnyana et al. 1996; Praseno, 1995; Damar, 2003; Faisal et al., 2003; Sidharta et al. 2005, see also **Table 2**).

Table 2. Research Topics on HAB in Indonesia

Research Topic	Coastal Area	Source
Red tide Ecology	Jakarta bay	Dahril (1981), Adnan (1994)
Succesion pattern of Pyrodinium bahamense	Hurun bay, Lampung	Widiarti et al. 2000
Red tide and Fish Kill	Jakarta bay	Adnan (1989), Panggabean (2004)
Impacts of red tide on fisheries	-	Wiadnyana & Praseno (1997)
Phytoplankton productivity, primary productivity	Jakarta bay	Damar (2003), Nontji (1984)
		Kaswadji (1976)
	Upang Delta, South Sumatera	Kaswadji et al. (1993)
	Bekasi bay	Tambaru (2000)
	Hurun bay, Lampung	Sunarto (2001)
		Ahyadi & Sidharta (2004)
Phytoplankton distributions, HAB organisms occurrence	Lombok strait	Sidharta et al. (2005)
	Ciamis bay	
Dinophysis bloom	Jakarta bay	Praseno (1981)
Pyrodinium bahamense bloom	Ambon bay	Wiadnyana et al. 1994
Dinoflagellate's cyst	Cirebon bay	Faisal et al. (2003)
Pyrodinium bahamense cyst	Hurun bay, Lampung	Widiarti (2004)
Monitoring activity	Jakarta bay	Praseno & Kastoro (1980)

Seawatch activity		Darmawan (2002)
Perna viridis (shellfish) predation on *Chaetoceros* spp and other microalgae	-	Suryono & Suryono (1997) Suryono et al. (1999)

Note: - : no data available

There was also an attempt to apply an optical apparatus as an "early warning system" for HAB outbreak, but so far not succeed yet (Darmawan, 2002).

In the early 1970s, the research in this field was done mostly by individual researcher who did not have partners, both within and outside an institution. Researchers worked for Indonesian Institute of Sciences (LIPI), who studied HAB, started to work in groups in 1990s. However, with the huge and wide area of the Indonesian waters, i.e. approximately 81,000 km coastal length, there is still a need to create more multidiscipline research groups to work on HAB in Indonesia. Therefore, support from government (especially Ministry of Marine Affairs and Fisheries and Department of Environment) will be very important to create more research groups and alleviate people's awareness on HAB impacts from the whole stake holders in this field. Such a nationwide task force on HAB is really in need to create when the HAB outbreaks increasingly occur throughout the country (Sidharta 2004, see also **Figure 2 and 3**).

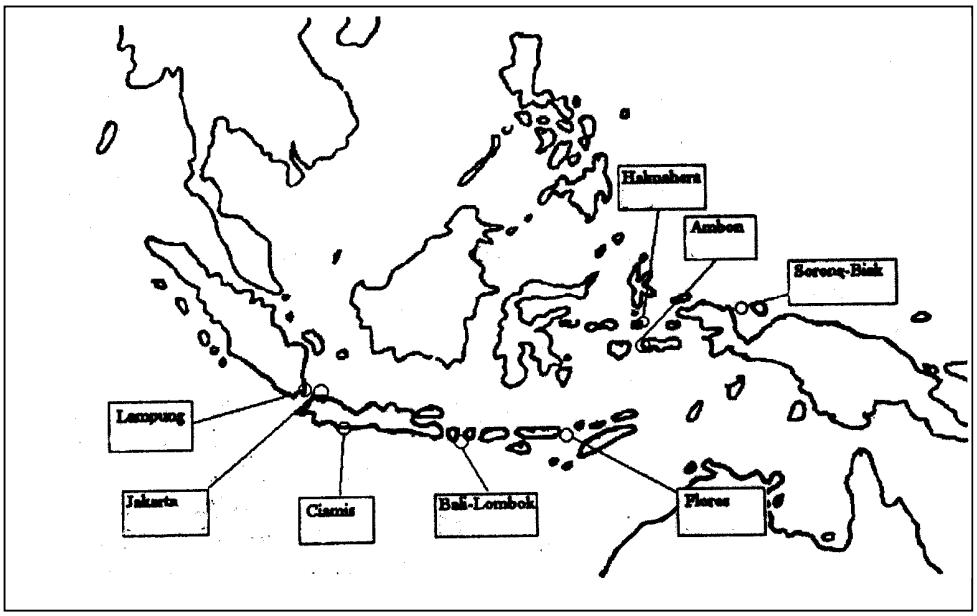

Fig. 2. Map showing HAB outbreaks at some coastal areas of Indonesia (Reprinted from Sidharta, 2004 and take also note on the bibliography there in)

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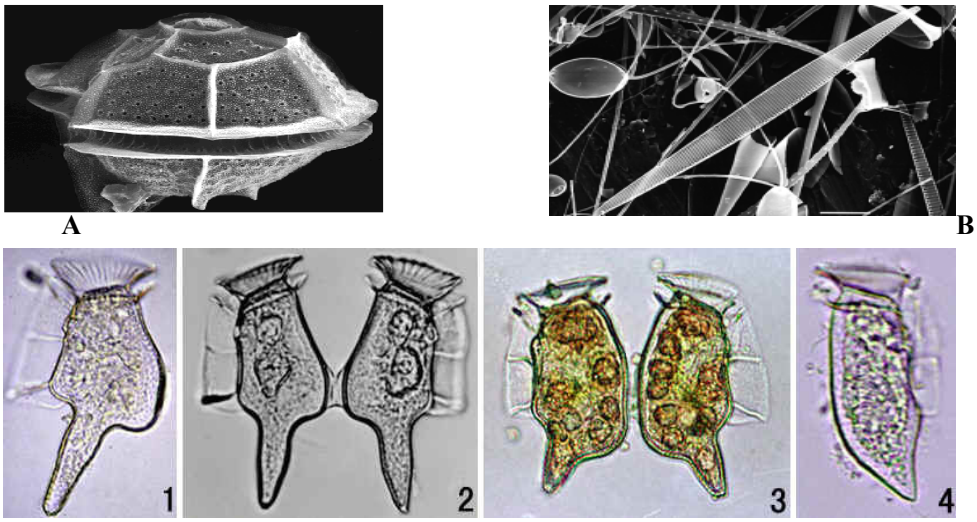
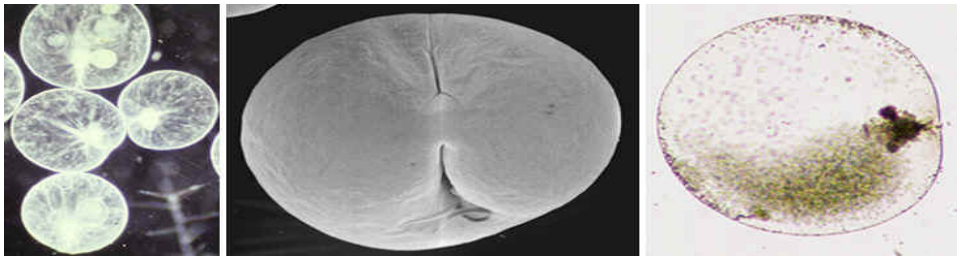


C. *Dinophysis caudata* Saville-Kent. 1: Left lateral view, 2,3: Lateral view of two cells couple, 4: Gamete, Length: 70-170 µm, Photo credits: 1-3 (Yasuwo Fukuyo), and 4 (Hiroaki Inoue)



D. *Noctiluca scintillans* (Ehrenberg) Macartney. Diameter: 100-1200 mm, Photo credits: left and right (Yasuwo Fukuyo), center (Haruyoshi Takayama)

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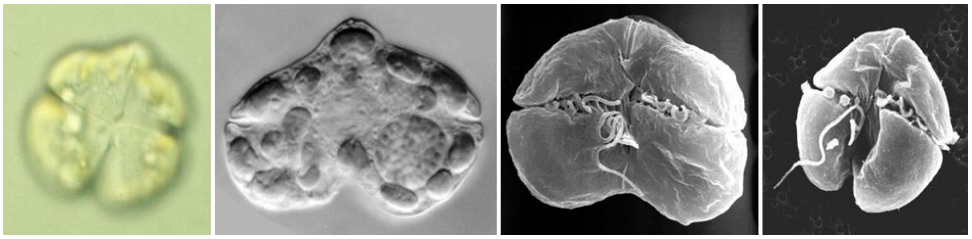

E. *Gymnodinium breve* Davis. Ventral view, Length: 18-40 µm, Width: 15-70 µm. Photo credits: 1 (Jacob Larsen), 2-4 (Haruyoshi Takayama)

F. *Ceratium tripos* (Muller) Nitzsch. Width: 60-93 µm, Photo credit: Yasuwo Fukuyo

Fig. 3. **A**. *Pyrodinium bahamense* var. compressum one of the most toxic PSP producing dinoflagellate that occured in some Indonesian waters, such as Ambon Bay, Kao Bay, and Lampung Bay. **B**. *Pseudo-nitszchia sp* belongs to the toxic diatom that produces domoic acid and occur in Jakarta Bay and Ciamis Bay. **C.** *Dinophysis caudata* Saville-Kent frequently found in Jakarta Bay and reported to occur at Bali-Lombok strait. **D**. *Noctiluca scintillans* (Ehrenberg) Macartney is the common redtide organism in Jakarta Bay. **E**. *Gymnodinium breve* Davis reported to occur in Jakarta Bay and Bali-Lombok strait. **F**. *Ceratium tripos* (Muller) Nitzsch is found in Jakarta Bay and Ciamis Bay. Picture sources (**C-F**): http://dinos.anesc.u-tokyo.ac.jp/

However, there were some obstacles to be solved. First of all is government funding. Limited numbers of funding for HAB research in the country seems to be the ultimate weakness related to the low number of research on HAB (**Table 2**). Secondly, low support from government agencies to do research on HAB, due to lack of data/information, lack of knowledge, lack of equipment, lack of policy, and lack of awareness, which are considered as the important obstacles to be faced. Third, based on the limited data available, there were only a few numbers of researchers on HAB in the country. Hence, more students need to be included and recruited to work on HAB, though it will also need more budget to spend, both to study (in term of scholarship) and do research (in term of research funding).

On the other hand, there are so many opportunities and chances for Indonesian researchers who have worked on HAB. There have been disseminated worldwide via internet many interesting opportunities such as joint work or research, research funding, study (Masters and PhDs), and trainings from institutions abroad. Intergovernmental Oceanographic Commission (IOC) through its Western Pacific (WESTPAC)-HAB office in Bangkok has offered training on the taxonomy of HAB organisms two times since 2003. In addition to that WESTPAC-HAB supported by University of Tokyo and Nagasaki University gave opportunities for researchers on HAB to experience both training and research activities (it is so called training through research/TTR) and created a group of researchers on HAB, consisting of ASEAN nationalities, as the first TTR group to study Dinoflagellate's cyst in this area. With the development of information technology (IT) in the country, Indonesian researchers are getting easier to gather more materials, news, articles, journals, books, magazines, proceedings, publications, etc. on HAB.

One positive thing, if we could say it, is that no fatal case of HAB in the country, especially related to human victims and environment disasters. However, increasing HAB outbreaks in Indonesian waters were

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getting serious and thus it warns the Indonesian people to prevent such a fatal incident of HAB in the country. Therefore, more efforts must be done to monitor, study, and do more research on HAB through out the Indonesian seas. The strong point in this respect is that the government has established a "new" ministry (i.e. Ministry of Marine Affairs and Fishery) that has a strong commitment to protect, develop, and manage Indonesian ocean resources to support the development of the nation. Through its research board (Agency for Marine and Fisheries Research in this Ministry, there is a real hope that Indonesian researchers can do much in term of HAB aspects in the country.

CONCLUDING REMARKS

HAB phenomena are increasing in the country and thus more research, study, and monitoring activities need to be done. Such activities will be helpful in order to alleviate the awareness of the people and the whole stake holders in coastal-related field of works. Some opportunities and chances are open to Indonesia in term of research and training funds from foreign institutions. Therefore, Indonesian researchers on HAB need to have better preparations to grab the opportunities.

It is recommended that government institutions, specifically Ministry of Marine Affairs and Fisheries and Department of Environment give more support to study and monitor HAB phenomena through out the Indonesian waters. These two departments should work hand-in-hand with Indonesian researchers to find and draw better ways to predict, prevent, and mitigate the coming of HAB outbreaks in an area. Thus, a national level of HAB Task Force need to be established soon.

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