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(Tinjauan Singkat tentang Permasalahan *Red Tide* di Teluk Jakarta:
Pengaruh *Red Tide* Terhadap Ikan dan Manusia)

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A SHORT REVIEW ON THE RECENT PROBLEM OF RED TIDE IN JAKARTA BAY: EFFECT OF RED TIDE ON FISH AND HUMAN

(Tinjauan Singkat tentang Permasalahan *Red Tide* di Teluk Jakarta: Pengaruh *Red Tide* Terhadap Ikan dan Manusia)

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ABSTRACT

Red tide or marine phytoplankton blooms is a naturally occurring phenomenon. It appears that frequency, intensity and geographical distribution of harmful algae (i.e. red tide) have increased over the last few decades. Red tide is the condition of the microscopic, single-celled plant that live in the sea grows very fast or 'bloom' and accumulate into dense, visible patches near the surface of the water. The occurrence of red tide close related to the eutrophication and right environmental conditions, such as adequate light, high water temperatures and an input of organic compounds from the land after heavy rains. Direct effect of red tide to the fish are seriously damage fish gills, either mechanically or through production of harmful chemicals, neurotoxin, hemolytic or blood agglutinating substances that cause physiological damage gill, major organs (liver etc.), intestine, circulatory or respiratory systems or interfere with osmoregulatory processes. In other hand, indirect effect of red tide to the fish is anoxia due to the over-use of oxygen for respiration and decay of dense phytoplankton. The red tide organisms could harm human through consumption on filter feeder animals (e.g. fish or mussels) that contain 'red tide' toxins previously absorbed by those animals.

Key words: red tide, eutrophication, Jakarta Bay.

ABSTRAK

Red tide atau sering disebut *blooming* fitoplankton merupakan fenomena alam yang sering terjadi. Nampaknya frekuensi, intensitas dan distribusi *blooming* fitoplankton meningkat dalam 10 tahun belakangan ini. *Red tide* dapat didefinisikan sebagai suatu kondisi dimana tanaman sel satu berukuran kecil yang hidup di laut dan tumbuh dengan sangat cepat dan terakumulasi dalam suatu kumpulan yang mudah terlihat di permukaan air laut. Kejadian *red tide* sangat terkait dengan eutrofikasi dan kondisi lingkungan yang mendukung, seperti kecukupan cahaya, kondisi suhu yang sesuai, dan masukan bahan organik dari daratan setelah hujan besar. Efek langsung *red tide* terhadap ikan sangat merusak insang, baik secara mekanis ataupun melalui pembentukan bahan kimia beracun, neurotoksin, hemolitik atau bahan penggumpal darah, yang dapat menyebabkan kerusakan fisiologi insang, organ utama (seperti hati), usus, sistem sirkuler atau pernapasan, ataupun mengganggu proses osmoregulasi. Sebaliknya, efek tidak langsung *red tide* adalah akibat penggunaan oksigen yang berlebihan untuk respirasi dan pembusukan kumpulan fitoplankton. Beberapa organisme penyebab *red tide* dapat membahayakan manusia apabila manusia makan hewan *filter feeder* (seperti ikan atau kerang) yang mengandung racun organisme *red tide* yang telah dimakan ikan atau kerang tersebut.

Kata kunci: *red tide*, eutrofikasi, Teluk Jakarta.

INTRODUCTION

Red tide is the condition of the microscopic, single-celled plant that live in the sea grows very fast or bloom and accumulate into dense, visible patches near the surface of the water (Franks and Anderson, 1992). About 300 species are reported at times to form blooms or red tide with cell concentrations of several millions per litre. Red tides are usually look spectacular but are harmless. The species that are harmful may never reach the densities required to discolour the water (Richardson, 1997). Unfortunately, close to one fourth of the 'red tide species' is known to produce potent neurotoxins that can be transferred through the food web, where they affect and even kill the higher forms of life such as flora and fauna including human being that eat directly or indirectly on them.

As a matter of fact, red tide is a common name for such phenomenon where certain phytoplankton species like *Gymnodinium breve,* contain reddish pigments and bloom such that the water appears to be coloured red (Franks

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and Anderson, 1992a). It is a natural phenomenon, apparently unrelated to anthropogenic pollution and not associated with tides, so in term red tide is a misnomer because they are not associated with tide. Some red tides have covered up to several hundred square miles of water. No one can predict when or where red tides will appear or how long they will last since they are affected by many variables, such as weather and sea currents (Franks and Anderson, 1992b).

In the last few decades, red tide became the most important subject of the coastal environment monitoring and management. It appears that frequency, intensity and geographical distribution of harmful algae (i.e. red tide) have increased over the last few decades. Red tide or marine phytoplankton blooms is naturally occurring phenomenon. This phenomenon was actually not presence only in last few years but it was occurred about 130 million ago as Richardson (1997) explained there is fossil evidence that harmful algal blooms (involve red tide) were occurring long before this.

The microscopic single celled plant referred to be as harmful if those which are noticeable, particularly to the general public, directly or indirectly through their effects such as visible discoloration of the water, foam production, fish or invertebrate mortality or toxicity to humans. Hallegraeff (1995) pointed out that, of the approximately 1500 species floating in the world's oceans, only 40 or so species have the capacity to produce potent toxins that can find their way through fish and shellfish to human. Sournia *et al.* (1991) noted, the greatest number, by far, of identified toxic species are found within the Dinophyceae.

Red tides occur throughout the world, drastically affecting Scandinavian and Japanese fisheries, Caribbean and South Pasific reef fishes and shellfishing along U.S. coasts. Most recently, it has been implicated in the deaths of hundreds of whales, dolphins, and manatees in North American waters. In 1972 in Japan, a bloom of the raphidophyte flagellate *Chatonella antiqua* thus killed 500 million US dollars worth of caged yellowtail fish in the Seto Island Sea (Okaichi, 1989).

In Indonesia, the recent case of fish mortality in Jakarta Bay in May 2004 is believed to be due to harmful algae, even though strong debate on it is still remain on the trot. The weak response and lack of continuous monitoring on the coastal phytoplankton community in Jakarta Bay and in the country hamper to get the precise answer on specific harmful algae problems. In the case of fish mortality in Jakarta Bay, the government elucidated that this was due to the red tide phenomenon. But, some other institutions claimed that this was due to lethal-acute contaminants, instead of algae bloom. However, for the hyper-eutrophic waters like Jakarta Bay (Damar, 2003), where huge volume of organic compounds incessantly enters the bay, the bloom of algae, including red tide is plausible. As have been revealed by Damar (2003), a non-toxic algae bloom, e.g. *Skeletonema costatum* in Jakarta Bay is a routine phenomenon, which might be as a consequence of high nitrogen content in its water.

A number of scientist often argued that the apparent increase in the occurrence of harmful blooms is linked to eutrophication. Indeed, in some areas -especially those with limited water exchange such as fjord, estuaries and inland seas, there does seem to be good evidence for a stimulation of the number of algal blooms occurring by eutrophication. However, the relationship between the occurrence of harmful phytoplankton blooms and environmental conditions is complicated, and anthropogenic perturbation of the environment is a certainly not prerequisite for all harmful algal blooms. Thus, the occurrence of a harmful bloom may or may not have as one its underlying causes a change in human activities or behaviour (Richardson, 1997).

In general, algae proliferation is driven by two main factors: underwater light and nutrient availabilities (Cloern, 2001). Koizumi *et al.* (1996) suggested that little rainfall, high water and a low water exchange rate in the area were responsible for the occurrence and the later development of the red tide of *Gymnodinium polygramma* in Uwajima Bay Japan in 1994. However, in tropical environment such as in Indonesia, where light availability is not a prominent factor regulating the bloom occurrences, the nutrient availability seems to be the important factor, of which in coastal waters is mainly brought by the incoming rivers (Damar, 2003). Specific to the causing red tide algae (i.e. dinoflagellates), its grow is also regulated by the N/P and N/Si ratios (Downing, 1991). He stated that the decrease of N/P ratios (below Redfield's 16:1) was accompanied by an increase in flagellates and cyanobacteria, instead of diatoms.

In Jakarta Bay, Damar (2003) revealed that the decrease of N/P ratio stimulated the grow of red tide dinoflagellate species. As well as N and P, silicon availability also plays significant role in regulating the growth of red tide species (e.g. Margalef, 1978). In his research, Damar (2003) revealed that silicon availability regulated the occurrence of diatoms, which is commonly grouped as a non-red tide species. The excess N loads in Jakarta Bay resulted in high N/Si ratios. For comparison, in Semangka and Lampung Bays, he found relatively low N loads compared to those of Si, resulted in low N/Si ratios (<1). Low N/Si ratios in Lampung and Semangka Bays allowed the diatoms to dominate the phytoplankton community. This is in conformity with Justic *et al.* (1995), which hypothesised that silicon availability might promote the importance of diatoms in coastal waters. Altogether, changes towards a high N/Si load are held responsible for dramatic shifts in the phytoplankton composition from diatoms to flagellates (Kocum *et al.*, 2002), including the more frequent occurrence of harmful algae species (Glibert and Terlizzi, 2002).

In summary, the triggering factor for red tide is not solely governed by the absolute amount of nutrient, but also the composition of these nutrient species in the water and underwater light availabilities.

For the case of fish mortality in Jakarta Bay, it seems to us that public has been satisfied after the Government stated that the factor causing the fish mortality was the blooming algae (not pollution), and fish in Jakarta Bay is safe to consume. However, there is still lack of information how the algae could kill the fish. The matter is discussed below. The effect of the red tide on human is also described.

EFFECT OF RED TIDE ON FISH

The impact of harmful phytoplankton is particularly evident when marine food resources, e. g. aquaculture, are affected. Shellfish and in some cases finfish are often not visibly affected by the algae, but accumulate the toxin in their organ. In most cases, the proliferation of plankton algae (so called algae bloom; up to millions of cell per litre) could be beneficial for aquaculture and wild fisheries operation (Hallegraeff, 1995). However, in some situation algal blooms can have negative effect, causing severe economic loses to aquaculture, fisheries and tourism operation and having major environmental and human health impacts. The affect of red tide on fish can be separated into direct and indirect ways.

Direct effect. Fish kill due to the effect of harmful algal bloom (i.e. red tide) could be caused by algae production of harmful chemicals, neurotoxin, haemolytic or blood agglutinating substances that may cause physiological damage in gill, major organs, intestine, circulatory or respiratory systems or interfere with osmoregulatory processes (Rensel, 1995) (see Figure 1).

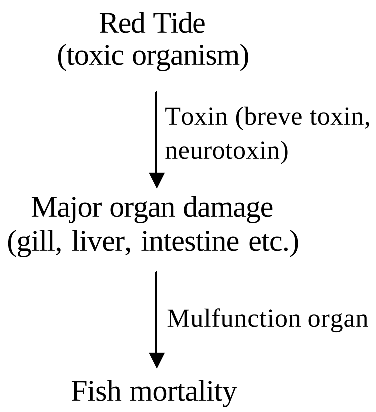

Figure 1. Schematic Effect of Red Tide Toxic Organisms on Fish.

Direct effect of some toxic algae may have devastating effects on fish, both in the wild and in aquacultures. Several species of phytoplankton belonging to very different taxonomic group can produce toxins that may damage fish gill by haemolytic effect. Hallegraeff (1995) and Rensel (1995) pointed out that, some algal species could seriously damage fish gill, either mechanically or through production of haemolytic substances. The impact has resulted in extensive fish kill with major economic losses. While wild fish stocks have the freedom to swim away from problem areas, caged fish appear to be extremely vulnerable to such noxious algal blooms.

As mentioned some type of phytoplankton blooms causes fish mortality through the production of toxin. When the bloom is severe, fish die rapidly because of neurotoxic effects of the red tide, which enter their bloodstream through the gill. Several fish species are perhaps exposed to lower concentration of toxins, but accumulation of these toxins in their body dangerous for consumers because of bio-accumulation. A number of toxin produced by phytoplankton are known to affect fish as well as humans (Richardson, 1997). Some species, such as the dinoflagellate *Alexandrium tamarense* and the diatom *Pseudo-nitzschia australis* produce potent toxins that are liberated when the algae are eaten.

In some cases, there can be mechanical interaction between the phytoplankter and the gills which leads to gill damage and ultimately, suffocation of the fish (Richardson, 1997). Physically damage fish gill is to the point of compromising osmoregulation and/or inhibiting oxygen uptake. The mechanism may include abrasion of the gill epidermis, physical clogging of the gill filaments with excess mucous copiously produce in response to some irritants, or in some cases stripping of the protective mucous layer (Rensel, 1995). Diatoms are often implicated in such even, like *Chaetoceros* species which has spines with serrated edges which can lodge in fish gill tissues, causing irritation, over production of mucous and eventual death (Bell, 1961; Rensel, 1993). Other species which responsible to this phenomenon are dinoflagellate *Gymnodinium mikimotoi*, prymnesiophytes *Chrysochromulina polylepis*, *Prymnesium parvum*, *Prymnesium patelliferum*, radiophytes *Heterosigma carterae*, *Chattonella antiqua* (Hallegraeff, 1995).

There are a number of accidents reported in the literature of animal poisoning/mortalities are associated with liver damage that have been seen in connection with blooms of *Nodularia spumigena* (cyanobacteria/blue-green algae) (Richardson, 1997). Furthermore, he pointed out that *Gymnodinium aureolum* (and some other bloom-forming flagellates) may alter seawater characteristics through the production of extra cellular organic material. This extra cellular material should increase the viscosity of the medium surrounding the fish so that the energy expended in filtering water through the gill exceeds that which can be supported by the oxygen uptake.

Indirect effect. The indirect effect of red tide to the fish is anoxia due to the over-use of oxygen for respiration and decay of dense phytoplankton. Richardson (1995) explained that in aquaculture, hypoxia or anoxia resulting from the respiration and decay of dense phytoplankton can also, on its own, leads to fish or shellfish kills, especially of caged fish that are unable to swim away from the affected area. Subsequently, the limiting oxygen evoke malfunction of major organ such as the brain and heart due to blood hypoxia (Rensel, 1995).

However, in several cases there are large uncertainties regarding the precise kind of chemicals involved and initial mechanism lead-ing to blood-hypoxia and fish death (see **Figure 2**). The major causes of the natural and cultured fish and shellfish deaths of the red tide of *Gonyaulax polygramma* in Uwajima Bay Japan in 1994 seemed to be the anoxic water high sulphide and ammonia concentration from decomposed *G. polygramma* cells (Koizumi *et al.*, 1996).

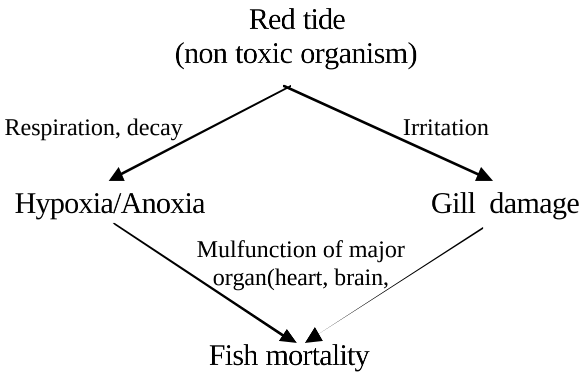

Figure 2. Schematic Effect of Red Tide Non-toxic Organisms on Fish

EFFECT OF RED TIDE ON HUMAN

Once the fish or other filter feeder animals (e.g. clams, mussels) consume these red tide species, the toxin will be accumulated in their tissues. If they are then being consumed by human, the toxin can harm human, in some extends, it causes human death. In Indonesian waters, some fatal evidences caused by human consumption on toxin-infected mussels are recorded in Lewotobi and Lewouran (East Nusa Tenggara), Sebatik Island (East Kalimantan), Makassar waters and Ambon Bay (Widiarti and Pratiwi, 2003).

Some diseases caused by toxic algae are listed in Table 1.

Table 1. Diseases Caused by Toxic Algae (Widiarti and Pratiwi. 2003, GEOHAB, 2001).

Diseases	Causative algae species
Amnesic shellfish poisoning	*Pseudonitzschia* sp.
Ciguatera fish poisoning	*Gambierdiscus* sp.
Diarrhetic shellfish poisoning	*Prorocentrum* sp and *Dinophysis* sp.
Neurotic shellfish poisoning	*Gymnodinium* sp., *Fibrocapsa* sp and *Heterosigma* sp.
Paralytic shellfish poisoning	*Alexandrium tamarense*

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