



Blooms of diatom and dinoflagellate associated with nutrient imbalance driven by cycling of nitrogen and phosphorus in anaerobic sediments in Johor Strait (Malaysia)

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ABSTRACT

Coastal eutrophication is one of the pivotal factors driving occurrence of harmful algal blooms (HABs), whose underlying mechanism remained unclear. To better understand the nutrient regime triggering HABs and their formation process, the phytoplankton composition and its response to varying nitrogen (N) and phosphorus (P), physio-chemical parameters in water and sediment in Johor Strait in March 2019 were analyzed. Surface and sub-surface HABs were observed with the main causative species of *Skeletonema*, *Chaetoceros* and *Karlodinium*. The ecophysiological responses of *Skeletonema* to the low ambient N/P ratio such as secreting alkaline phosphatase, regulating cell morphology (volume; surface area/volume ratio) might play an important role in dominating the community. Anaerobic sediment iron-bound P release and simultaneous N removal by denitrification and anammox, shaped the stoichiometry of N and P in water column. The decrease of N/P ratio might shift the phytoplankton community into the dominance of HABs causative diatoms and dinoflagellates.

1. Introduction

Johor Strait (also known as Terbau Strait) is located between southern Peninsular Malaysia and Singapore. It is an important tropical mariculture industry for both these countries. Until now, there was no clear algal bloom pattern illustrated in tropical area, which involved more species than those in temperate environment (Lim et al., 2012; Leong et al., 2015). Recently, increasing marine microalgal bloom and fish kill events have been reported in the strait (Lim et al., 2014; Suriyanti and Usup, 2015; Kon et al., 2017; Kok and Leong, 2019), which caused huge economic losses and poisoning syndromes. The culprits of these bloom events associated with massive fish kills have been identified as the toxic dinoflagellates. Whereas for diatoms, the abundances of

Skeletonema and *Chaetoceros* were always high in estuaries due to intensive anthropogenic activities (Zhao et al., 2009; Khairy et al., 2014). Johor Strait receives the injection of several rivers, and the estuarine environment should be extremely conducive to the reproduction of *Skeletonema* and *Chaetoceros*. Therefore, the characteristics of algal blooms in the Johor Strait need further study.

Physio-chemical factors, hydrodynamic conditions and nutrition have been reported to influence the pattern of bloom in Johor Strait. Curren et al. (2019) reported that the abundance of phytoplankton in western Johor Strait was significantly higher than that of the east due to the differences in precipitation, salinity and temperature. A hypoxic-anoxia zone forms in inner Johor Strait, accompanied by high biomass diatom blooms (Mohd-Din et al., 2020). The tidal currents may

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