Harmful Algae 40 (2014) 51–62

Contents lists available at ScienceDirect

Harmful Algae

journal homepage: www.elsevier.com/locate/hal

A bloom of *Karlodinium australe* (Gymnodiniales, Dinophyceae) associated with mass mortality of cage-cultured fishes in West Johor Strait, Malaysia

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ARTICLE INFO

Article history:
Received 11 June 2014
Received in revised form 2 October 2014
Accepted 15 October 2014
Available online 30 October 2014

Keywords:
Dinoflagellate
Fish mortality
Harmful algal bloom
Karlodinium australe
Malaysia
West Johor Strait

ABSTRACT

A recent (February 2014) mass mortality of fishes was observed in the cage-farming region of the West Johor Strait of Malaysia, involving over four different species of cultured fishes, numbering ~50,000 fish. A field investigation at six stations along the West Johor Strait collected water samples and examined for the presence of harmful species. Dead fishes were collected for necropsy. The phytoplankton composition was dominated by a species of *Karlodinium*, at a considerably high cell concentration (0.31–2.34 × 10^6 cells l^{-1}), and constituting 68.8–98.6% of the phytoplankton relative abundance at all stations. Detailed morphological assessment by light and scanning electron microscopy revealed that the species was *Karlodinium australe* de Salas, Bolch and Hallegraeff. This was supported by molecular evidence of the nuclear encoded large subunit ribosomal gene (LSU rDNA) and the second internal transcribed spacer (ITS2) via single-cell PCR. The sequences of LSU rDNA yielded 3.6–4.0% divergence when compared to the sister taxon, *K. armiger*; and >6.5% when compared to other *Karlodinium* species. Fish necropsy showed symptoms similar to those affected by karlotoxin ichthyotoxins. This is the first report of a mass mortality of cage-cultured and wild fishes attributed to the unarmored dinoflagellate *K. australe*.

1. Introduction

Many coastline countries in Southeast Asia, including Malaysia, are experiencing a rapid growth in aquaculture/mariculture industries, owing to high demands from domestic and international markets, and the involvement of the government and profit-driven companies (Hishamunda et al., 2009). In Malaysia, the industry has grown by more than 10% annually between 1990 and 2002, with total production of nearly 176,000 tonnes in 2005 (FAO, 2007). While the industry has expanded, it has also suffered huge production losses due to frequent fish kills caused by water quality degradation or the proliferation of harmful marine diatoms and ichthyotoxic dinoflagellates at aquacultures sites.

Several marine microalgal bloom events, some resulting in massive fish kills, have been documented in Malaysia (reviewed in Lim et al., 2012). In 2002, a bloom of *Prorocentrum minimum* (Pavillard) Schiller (at >2 × 10^5 cells l^{-1}) was observed along the Johor Strait, causing massive water discoloration but no fish kills, even near finfish cages (Usup et al., 2003). Subsequent fish-kill events were recorded in the Straits of Malacca, the most important finfish-farming area in the country. In 2005–2006, the most notable protracted algal bloom associated with the mass mortality of caged finfish, with an estimated loss of at least 6 million USD, was encountered in Penang, northern Peninsular Malaysia

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http://dx.doi.org/10.1016/j.hal.2014.10.005
1568-9883/