Harmful Algae 78 (2018) 56–68

Contents lists available at ScienceDirect

Harmful Algae

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

Habitat complexity affects benthic harmful dinoflagellate assemblages in the fringing reef of Rawa Island, Malaysia

Hwa Lin Yong[a], Nurin Izzati Mustapa[a], Li Keat Lee[a], Zhen Fei Lim[a], Toh Hii Tan[a], Gires Usup[b], Haifeng Gu[c], R. Wayne Litaker[d], Patricia A. Tester[e], Po Teen Lim[a,*], Chui Pin Leaw[a,*]

[a] *Institute of Ocean and Earth Sciences, University of Malaya, Bachok 16310 Kelantan, Malaysia*
[b] *Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia*
[c] *Third Institute of Oceanography, Xiamen, 361005, China*
[d] *National Oceanic and Atmospheric Administration, National Ocean Service, National Centers for Coastal Ocean Science, Beaufort Laboratory, 101 Pivers Island Road, Beaufort, NC 28516, USA*
[e] *Ocean Tester LLC, 381 Gillikin Road, Beaufort, NC 28516, USA*

ARTICLE INFO

Keywords:
Artificial substrate
Benthic microhabitat
Ciguatera
Gambierdiscus
Ostreopsis

ABSTRACT

Few studies have investigated the effect of fine-scale habitat differences on the dynamics of benthic harmful dinoflagellate assemblages. To determine how these microhabitat differences affect the distribution and abundance of the major benthic harmful dinoflagellate genera in a tropical coral reef ecosystem, a field study was undertaken between April–September 2015 and January 2016 on the shallow reef flat of the fringing reef of Rawa Island, Terengganu, Malaysia. Sampling of benthic dinoflagellates was carried out using an artificial substrate sampling method (fiberglass screens). Benthic microhabitats surrounding the sampling screens were characterized simultaneously from photographs of a 0.25-m^2 quadrat based on categories of bottom substrate types. Five taxonomic groups of benthic dinoflagellates, *Ostreopsis*, *Gambierdiscus*, *Prorocentrum*, *Amphidinium*, and *Coolia* were identified, and cells were enumerated using a light microscope. The results showed *Gambierdiscus* was less abundant than other genera throughout the study period, with maximum abundance of 1.2×10^3 cells 100 cm^{-2}. While most taxa were present on reefs with high coral cover, higher cell abundances were observed in reefs with high turf algal cover and coral rubble, with the exception of *Ostreopsis*, where the abundance reached a maximum of 3.4×10^4 cells 100 cm^{-2} in habitats with high coral cover. Microhabitat heterogeneity was identified as a key factor governing the benthic harmful dinoflagellate assemblages and may account for much of the observed variability in dominant taxa. This finding has significant implications for the role of variability in the benthic harmful algal bloom (BHAB) outbreaks and the potential in identifying BHAB-related toxin transfer pathways and the key vectors in the food webs.

1. Introduction

Many benthic dinoflagellates species are of interest because some produce biotoxins that cause significant human illnesses. Species of *Gambierdiscus*, for example, produce ciguatoxins (e.g., Yasumoto et al., 1977, 1979; Shimizu et al., 1982; Chinain et al., 1999; Litaker et al., 2017), causing ciguatera fish poisoning (CFP) (Yasumoto et al., 1980; Gatti et al., 2015; Chinain et al., 2016; reviewed in Berdalet et al., 2017); outbreaks of *Ostreopsis* cf. *ovata* produce air-borne palytoxin-like analogues that cause respiratory illness and skin irritation to the beachgoers, negatively affecting beach tourism (Ciminiello et al., 2006, 2008, 2010; Tubaro et al., 2011). Other species in the genera *Prorocentrum*, *Amphidinium* and *Coolia* produce various bioactive compounds (e.g., okadaic acid, Yasumoto et al., 1984; amphidinolide, Kobayashi et al., 1986, 1988; cooliatoxin, Holmes et al., 1995; Wakeman et al., 2015). Some of these compounds are responsible for diarrhetic shellfish poisoning (Yasumoto et al., 1984), palytoxin seafood poisoning (Durando et al., 2007) and clupeotoxicity (Onuma et al., 1999). The diverse array of toxins produced by these organisms and their adverse human health effects have led to a broad commitment to increase studies on benthic harmful microalgae worldwide (reviewed in Berdalet et al., 2017).

Surprisingly, one of the most striking unstudied aspects of the biology of benthic dinoflagellates is how small-scale difference in substrates affects the distribution and abundance of these species, and by inference the local risk of toxicity. Given the cells' intimate association

* Corresponding authors.
E-mail addresses: ptlim@um.edu.my (P.T. Lim), cpleaw@um.edu.my (C.P. Leaw).

https://doi.org/10.1016/j.hal.2018.07.009
Received 17 October 2017; Received in revised form 29 July 2018; Accepted 31 July 2018
1568-9883/