Marine Pollution Bulletin xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

The 2014 summer coral bleaching event in subtropical Hong Kong

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ARTICLE INFO

Article history:
Received 3 October 2016
Received in revised form 27 March 2017
Accepted 29 March 2017
Available online xxxx

Keywords:
Global climate change
Coral bleaching
High temperature
Hypoxia
Porites
Platygyra

ABSTRACT

We reported a coral bleaching event that occurred in August–September 2014 in Hong Kong waters based on video transect surveys conducted at eight sites. The bleaching affected eight species of corals with different growth forms. Bleaching at seven of the eight study sites was minor, affecting only 0.4–5.2% colonies and 0.8–10.0% coral-covered area. Sharp Island East, however, suffered from a moderate level of bleaching, with 13.1% colonies and 30.1% coral-covered area affected. Examination of the government's environmental monitoring data indicated abnormal water quality conditions preceding and during the bleaching event. Follow-up field surveys of tagged colonies showed that 76% of them had fully recovered, 12% partially recovered, and 12% suffered from mortality. These results indicate that the subtropical corals of Hong Kong are not immune to bleaching, and there is a need to study their responses under climate change scenarios.

1. Introduction

Coral bleaching refers to coral tissue whitening due to the loss of endosymbiont zooxanthellae or pigments in these symbiotic algae (Glynn, 1983; Hoegh-Guldberg, 1999). Over the last several decades, large-scale bleaching events have been increasing reported in reefs around the world, especially the 1982–1983 events in the Caribbean (Glynn, 1991), the 1997–1998 events in the Indian Ocean, Caribbean, and tropical Pacific (Wilkinson, 1998), and the 2010 events in the Caribbean (Alemu and Clement, 2014) and tropical Pacific (Doshi et al., 2012; Sutthacheep et al., 2012). Such large-scale bleaching incidences have caused mass coral mortality and large scale degradation of reefs. For instance, the 1997–1998 bleaching events have reduced 16% coral cover around the world, with up to 90% loss in coral cover in some reefs in the Indian Ocean (Wilkinson, 1998).

To date, most coral bleaching events have been reported from tropical reefs. Among the few reports of coral bleaching on subtropical reefs, the affected area was usually small and the impact minor (e.g., Loya et al., 2001; Celliers and Schleyer, 2002; Dalton and Carroll, 2011; Harrison et al., 2011; Abdo et al., 2012). However, such small-scale bleaching events should not be overlooked due to the following reasons: 1, subtropical corals are living under marginal environmental conditions for reef development with slow growth rates and variable recruitment success, therefore their recovery from bleaching disturbance is expected to be slow (Harrison et al., 2011; Hoey et al., 2011; Yang and Goodkin, 2014); 2, many subtropical coral reefs are already under the threats of multiple anthropogenic stressors (e.g., sewage pollution, tourism and sedimentation due to coastal development), therefore bleaching may interact with these stressors to escalate the damage (Ang et al., 2005; Beger et al., 2011); 3, global climate change may result in more frequent extreme weather conditions that can cause bleaching in subtropical corals, therefore the cumulative bleaching effects should be considered (Beger et al., 2014); 4, rising sea temperatures may cause tropical corals to shift their ranges to subtropical regions, and such species invasion can affect the recovery of bleached subtropical corals (Greenstein and Pandolfi, 2008).

Located slightly south to the Tropic of Cancer (22°10′–22°30′N), Hong Kong has a subtropical climate with clear seasonal changes in water temperature. In the wet season (May–October), high temperatures (25–29 °C) satisfy the conditions for coral community development. In the dry season (November–April), however, low temperatures, sometimes down to 14 °C, prevent corals from developing into true reef structures. Nevertheless, compared with many subtropical coral communities, those in Hong Kong are diverse, with 84 species of hard corals (Chan et al., 2005) and 29 species of soft corals (Fabricius and McCorry, 2006; Yeung et al., 2014). In Hong Kong, there have been a few anecdotal reports of coral bleaching since the 1980s,

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http://dx.doi.org/10.1016/j.marpolbul.2017.03.061
0025-326X/

and the damage was usually localized (McCorry, 2002; Ang et al., 2005). The only recorded mass coral bleaching event occurred in 1997, a strong El Niño year (McCorry, 2002). Here we describe a regional-scale coral bleaching event in Hong Kong, analyze some environmental conditions that might have triggered the bleaching, and discuss the consequence of the bleaching event on these subtropical coral communities. Our data could contribute to a better understanding of the resilience of subtropical coral communities to global environmental changes.

2. Materials and methods

2.1. Study area

The marine waters of Hong Kong can be divided into an estuarine zone in the west, a transition zone surrounding Hong Kong Island, and an oceanic zone in the east (Fig. 1). Along the west-east direction there is a strong gradient of salinity and sedimentation due to the influence of freshwater input from the Pearl River, with a mean annual discharge of 1.06×10^4 m^3 s^{-1} that ranks only second to the Yangtze River among all rivers in China (Zhang et al., 2012). Most of the natural coastlines in Hong Kong are lined with igneous rocks that usually extend <10 m below the sea surface. Below the igneous rocks is usually a bottom of silt and clay that can be stirred up easily. These geological and geographical features have limited the distribution of coral communities mainly in the shallow waters of the oceanic and the transitional zones, with those in the oceanic zone being better developed (Hodgson and Yau, 1997; Ang et al., 2005; Chan et al., 2005; Goodkin et al., 2011; Duprey et al., 2016).

2.2. Quantifying substrate composition and coral bleaching

Based on preliminary observations during surveys jointly organized by the Agriculture, Fisheries and Conservation Department, Hong Kong, and Reef Check Foundation that covered 33 sites in the eastern waters, we selected eight sites that had signs of bleaching for more detailed surveys (Fig. 1). The surveys were conducted during day time between 1000 h and 1500 h in August and September 2014. At each site, a rapid underwater inspection was conducted to locate the area with the highest coral cover. Photographs were taken to record the general pattern of coral bleaching. A 100-m transect was laid parallel to the shore on the sea bottom which was 2–5 m below the water surface. A video transect survey was then conducted to quantify the substrate composition and coral bleaching by a diver swimming slowly along the transect at a speed of approximately 10 m per minute. The video was captured at 24 frames per second with a resolution of 1920 × 1080 pixels using a Canon S110 digital camera inside an underwater housing. The camera was held with the lens pointing downward, covering approximately 0.75 m wide on the bottom. Due to the low underwater visibility, it was impossible to cover a wider distance.

In the laboratory, substrate composition of each video was quantified using a point sampling technique that involves stopping the video every 4 s to record the substrate composition overlaid by 5 fixed points on the computer screen (Hill and Wilkinson, 2004). On average, 835 points from 167 frames from each transect were sampled to provide reliable data on the substrate composition. The substrate was classified according to Reef Check's Instruction Manual (http://icran.org/pdf/MARPages/tourism/Docs/RC%20Instruction%20Manual%20(English).pdf) as

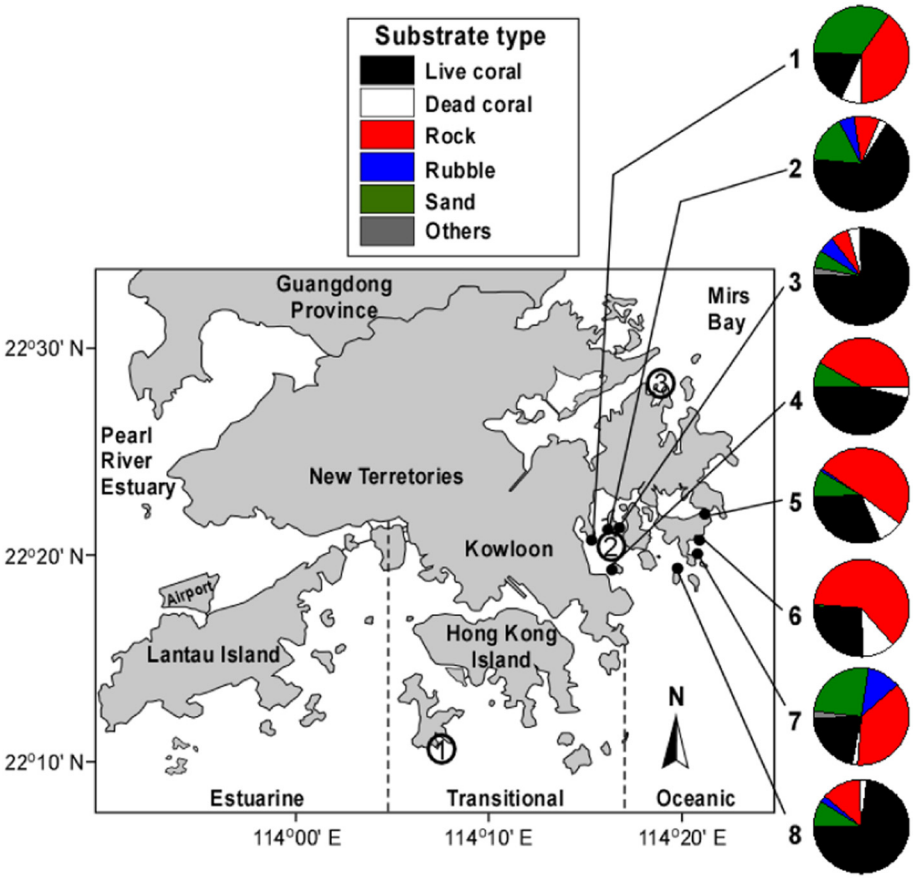

Fig. 1. Map of Hong Kong showing estuarine, transition and oceanic zones, and the benthic substrate composition of the eight study sites in the Port Shelter area (1. Lo Fu Ngam; 2. Sharp Island West; 3. Sharp Island East; 4. Shelter Island; 5. High Island Dam; 6. Pak Lap Tsai; 7. Town Island; 8. Bluff Island). Names of three locations discussed in text are indicated with a circled number: ①, Sham Wan; ②, Sharp Island; ③, Hoi Ha Wan. PM7, an EPD water monitoring site whose data were used to analyze the water quality conditions leading to coral bleaching, is located in the middle of Port Shelter (②).

Please cite this article as: Xie, J.Y., et al., The 2014 summer coral bleaching event in subtropical Hong Kong, Marine Pollution Bulletin (2016), http://dx.doi.org/10.1016/j.marpolbul.2017.03.061