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Changes in octocoral communities and benthic cover along a water quality gradient in the reefs of Hong Kong

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Abstract

Cover of the main reef benthic groups, and abundances and taxonomic richness of octocorals were surveyed in the reefs of Hong Kong, and related to spatial and water quality gradients. Nutrient and particle concentrations are high throughout the area, with concentrations declining from the south towards the north-eastern region. Regression tree analyses showed that hard coral cover was most strongly related to water clarity, that macroalgal cover was highest in areas with high wave action and high water clarity, and that crustose coralline algae were negatively related to sedimentation. Octocoral communities (42 species in 23 genera) were dominated by zooxanthellae-free taxa; those few species with zooxanthellae were restricted to reefs with low wave action and high water clarity in the north-eastern region. The water quality gradient spans from conditions that are marginal for zooxanthellate octocorals while still supporting diverse scleractinian communities, towards an estuarine endpoint where zooxanthellate octocorals cease to exist and hard coral communities are reduced to a few resilient colonies. The data suggest that the types, abundances and richness of zooxanthellate octocorals, and the shift from zooxanthellate to azooxanthellate octocoral communities, may act as useful indicators of water clarity in regions where long-term water quality data are unavailable.

Keywords: Alcyonacea; Soft coral; Gorgonian; Scleractinia; Water clarity; South China Sea

1. Introduction

Hong Kong (latitude 22°N) occupies ~1050 km^2 of marine area, bordered by ~800 km of coastline. The marine environment is marginal for coral reefs, as seawater temperature minima in winter average 17 °C, with occasional brief drops to 14–16 °C in surface waters (Morton, 1982), and freshwater intrusions that can reduce salinity to 28 psu (on rare occasions to <22 psu; Lee and Liu, 1998). Nevertheless, historic data and the presence of centuries-old coral colonies show that temperature and salinity conditions have been suitable to support diverse coral communities especially in the north-eastern region of Hong Kong. Hong Kong's Scleractinian coral communities have been described in several ecological studies (reviewed in Morton, 1982, 1994; Hodgson and Yau, 1997; McCorry, 2000, 2002). While coral accretion has been restricted to some of the north-eastern areas in recent centuries, diverse coral communities are found on the rocky shores of the eastern mainland and many of the numerous islands of Hong Kong (DeVantier and McCorry, unpublished data).

The large Pearl River, situated ~80 km west of Hong Kong, delivers large amounts of sediments, nutrients and freshwater from its South Chinese watershed. The Hong Kong marine environment is therefore characterised by a pronounced south-west to north-east gradient in siltation and freshwater exposure, with river influences being progressively diluted towards the north-east (Morton, 1982). Additionally to this gradient, effluents rich in nutrients and contaminants are delivered locally from the Hong Kong coast with its rapidly expanding population of 7 million people. Intense human use of the marine environment,

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including bottom trawling, sediment dredging and mud deposition for land reclamation, further contribute to high siltation levels (Leung and Morton, 1997). Today, turbidity and concentrations of nutrients and contaminants in both seawater and sediments are high in the marine environment of Hong Kong (Morton, 1994; EPD, 2003).

Coral cover has declined in several areas to low levels (Scott and Cope, 1982; McCorry, 2002), apparently due to impaired coral recruitment and erosion by borers and sea urchins (Morton, 1992; Hodgson and Yau, 1997). Consequently, zooxanthellae-free gorgonians and soft corals are the dominant group of organisms found on otherwise turf algal or silt covered hard substratum in many areas below 5 m depth.

Reef-building hard corals (Scleractinia) contain endosymbiotic dinoflagellates (zooxanthellae) that provide photosynthetically fixed carbon to the corals and hence complement the intake of particulate food. In octocorals, 31 of the 90 genera recorded in shallow tropical to sub-tropical Indo-Pacific waters (from 10 of the 23 families) also contain zooxanthellae (Fabricius and Alderslade, 2001; van Oppen et al., 2005). The other 59 genera are zooxanthellae-free and depend entirely on heterotrophy, i.e., suspension-feeding on small plankton (Fabricius et al., 1995; Ribes et al., 1998). The presence or absence of zooxanthellae therefore explains contrasting requirements for light (i.e., high water clarity) and suspended particulate food for zooxanthellate and azooxanthellate taxa, respectively.

While taxonomic accounts of a number of octocoral species from the zoogeographic region of Hong Kong and the South Chinese Sea are provided by Zou and Scott (1982) and Zou and Chen (1984), ecological information on octocorals from Hong Kong and the South Chinese Sea is presently restricted to one small embayment (Clark, 1997). Here we present water quality data from the southern, eastern and north-eastern marine regions of Hong Kong, and survey results to investigate how coral and algal cover, and abundances of zooxanthellate and azooxanthellate octocorals change along the main spatial and water quality gradients.

2. Methods

2.1. Study reefs and survey methods

Water quality monitoring data, collected monthly between January 1998 and December 2003 from surface, mid-water and bottom layers, were provided by the Hong Kong Environmental Protection Department (the methods are described in detail in EPD, 2003). The data on salinity, temperature, various measures of water clarity, plant pigments and suspended solids, total and inorganic nutrient concentrations, and pH were averaged across the 72 sampling times and depth for each station (a total of 216 samples per station). Water quality monitoring sites were grouped into four regions (Fig. 1): Five water quality stations were available and used to characterize the southern region (S-R: SM1–SM4, and SM19), two stations were from the southern-coastal region (SC-R: JM3 and JM4), three stations from the south-eastern region (SE-R: MP11, MM8 and MM14), and seven stations from the north-eastern region (NE-R: MM15–MM17, and MM3–MM6). The means per station were then established for each of the four regions.

Forty-one benthic surveys were conducted on 19 reefs in four regions along a gradient of decreasing terrestrial and increasing oceanic influences (latitude 22.10–22.33°N, longitude 114.07–114.26°E; Fig. 1). Seven reefs (11 sites) were surveyed in the southern, most river-exposed region (S-R); three reefs (4 sites) in the southern-coastal region (SC-R); five reefs (12 sites) in the south-eastern region (SE-R); and six reefs (14 sites) in the north-eastern region (NE-R). Surveys were conducted in November 1999. Sites were not randomly selected, rather those surveyed were known to support at least some octocorals, precluding some north-eastern sites with high scleractinian coral cover.

Reefs were surveyed using the one-off rapid ecological assessment technique (REA; Done, 1982; Dinesen, 1983; Miller and De'ath, 1996; Devantier et al., 1998; Fabricius and De'ath, 2001b): each site was visually surveyed by one experienced observer (KF) on scuba for 15–20 min, representing typically ~50–300 m^2 of reef area at the prevailing low visibility. Depending on the reef morphology, the communities were surveyed at 1–4 depth zones at predefined depth-ranges: 18–13 m, 13–8 m, 8–3 m, and 3–1 m (labelled as 15, 10, 5, and 2 m). During, and after completion of each survey, the following data were recorded:

(1) Visual estimate of benthic cover of: hard corals, octocorals, macroalgae, coralline algae, turf algae, sponges, tunicates, coral rubble and sand. Cover was estimated in 2.5%-increments from 1% to 10%, in 5%-increments from 10% to 30%, and in 10%-increments for >30% cover. Very low cover was denoted as 0.1%.
(2) Relative abundances of octocoral genera, visually estimated on a rating scale of 0–5: 0 = absent; 1 = one or few colonies; 2 = uncommon; 3 = common; 4 = abundant; and 5 = dominant. However, most taxa were absent, rare or uncommon; from a total of 943 records, no taxon was rated as 'abundant' or 'dominant', and the rating 'common' occurred only twice for *Muricella* and once for *Echinomuricea*. Colonies were identified to genus level in the field (Fabricius and Alderslade, 2001). Species inventories were later compiled based on collected specimens, but this information was not available for all surveys, thus the field survey data were analysed on genus level.
(3) Abiotic variables were estimated at all depth zones:
    (a) Sediment deposit (silt to fine resuspendible sand) on the substratum, rated on a 4-point scale: 0 =