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Note

Abundance and composition of juvenile corals reveals divergent trajectories for coral assemblages across the United Arab Emirates

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ABSTRACT

Marked shifts in the composition of coral assemblages are occurring at many locations, but it is unknown whether these are permanent shifts reinforced by patterns of population replenishment. This study examined the composition of juvenile coral assemblages across the United Arab Emirates (UAE). Densities of juvenile corals varied significantly among locations, but were highest where coral cover was highest. Juvenile coral assemblages within the Persian Gulf were dominated by *Porites*, while no *Acropora* were recorded. We expect therefore, continued declines in *Acropora* abundance, while observed dominance of *Porites* is likely to persist. In the Oman Sea, *Pocillopora* was the dominant juvenile coral, with *Acropora* and *Stylophora* also recorded. This study shows that taxonomic differences in replenishment are reinforcing temporal shifts in coral composition within the southern Persian Gulf, but not in the Oman Sea. Differences in environmental conditions and disturbance regimes likely explain the divergent responses between regions.

1. Introduction

Scleractinian corals are key habitat-forming organisms on tropical reefs (Idjadi and Edmunds, 2006), but the relative contributions of different coral species to habitat structure varies greatly (Coker et al., 2014), mostly in accordance with their morphology. This is a concern because significant and sustained shifts in the structure of coral assemblage could lead to dramatic changes in ecosystem function and dynamics (Pratchett et al., 2011), especially if we see a systematic loss of entire functional groups. Strong directional changes in the composition of coral assemblages are already occurring in many regions (Persian Gulf – Riegl and Purkis (2015); Western Indian Ocean - McClanahan et al. (2007); Southern Japan - Hajime et al. (2002); French Polynesia - Adjeroud et al. (2009); Great Barrier Reef – Graham et al. (2014); Caribbean – Perry et al. (2013)), with climate change likely to exacerbate such changes. However, it is unknown whether these changes are temporary fluctuations in coral composition (e.g., shifts to early successional stages of coral composition that will be restored given sufficient time between major disturbances) or permanent shifts in composition reflective of contemporary environmental conditions and disturbance regimes (Hughes et al. 2012).

Directional shifts in the composition of coral assemblages are a consequence of more frequent and severe disturbances (e.g., climate-induced coral bleaching; Donner et al., 2005), which tend to have disproportionate effects on certain coral taxa (Loya et al., 2001). For example, *Acropora* spp. (especially species with tabular and staghorn morphologies) are among the most susceptible of all scleractinian corals to climate-induced coral bleaching (Marshall and Baird, 2000), and are the first and worst affected by many other major disturbances (Pratchett et al., 2013). However, increasing incidence of disturbances will not necessarily favour those corals that are most resistant to such events. Rather, the long-term persistence of different corals will also depend upon their capacity for recovery (Baker et al., 2008) relative to the incidence of major disturbances. Despite their susceptibility to bleaching, high rates of settlement and rapid growth of *Acropora* spp. can lead to a return to dominance in the aftermath of severe bleaching events (Sheppard et al., 2002).

Coral reefs within the southern Persian Gulf (mainly coastal reefs of the United Arab Emirates) have been subject to frequent and increasing disturbances over the last 20 years, including severe coral bleaching events in 1996, 1998, 2002 and 2012 (Burt et al., 2011; Riegl and Purkis, 2015; Shuail et al., 2016). During this period, there have been sustained declines in the abundance of *Acropora*, and concomitant increases in the abundance of more stress tolerant corals, such as *Porites* (Burt et al., 2011). Moreover, settlement rates of *Acropora* spp. within the southern Persian Gulf (measured using settlement tiles deployed and collected every 3 months from 2009 to 2011) were <50% of those

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of *Porites* (Bauman et al., 2014). Taxonomic differences in rates of population replenishment represent a fundamental feedback mechanisms, which will likely sustain and reinforce shifts in the composition of coral assemblages (Nyström et al., 2008). However, taxonomic differences in settlement rates by scleractinian corals might reflect taxonomic biases in settlement preferences (Babcock et al., 2003). Patterns of coral abundance established at settlement can also be changed by differential early post-settlement mortality (Penin et al., 2010). As such, surveys of juvenile corals on natural substrates provide a more robust measure of recruitment (Adjeroud et al., 2010; Penin et al., 2007).

This study quantified the abundance and taxonomic composition of juvenile corals (<50 mm diameter) on natural reef substrates at sites spanning >2000 km across the southern Persian Gulf and Oman Sea coastlines of the United Arab Emirates (UAE). Surveys of juvenile corals, defined by convention (rather than specific biological thresholds) as colonies <50 mm diameter, are increasingly used, in preference to settlement to artificial substrates, to assess population replenishment of corals (Penin et al., 2007; Adjeroud et al., 2010). Juvenile corals up to 50 mm diameter are likely to be between 2 and 5 years of age (Edmunds, 2007), such that juvenile corals surveys provide an aggregate measure of settlement across several successive years, as well as accounting for early post-settlement mortality (Edmunds, 2000; Penin et al., 2007). Increased taxonomic resolution is also generally possible when surveying juvenile corals as opposed to newly settled corals (Babcock et al., 2003).

2. Materials and methods

2.1. Field sampling

This study was conducted at 5 sites across the UAE (Fig. 1), including three sites within the southern Persian Gulf (Delma, Ras Ghanada and Saadiyat), and two sites in the Oman Sea (Dibba Rock and Al Aqah). Juvenile corals were surveyed at each site in September 2012, which was 1–3 months after the period of peak settlement period for scleractinian corals within this region (Bauman et al., 2014). However, it was not our intention to document spatial variation in the extent of settlement during this most recent settlement event. Rather, the minimum size of juvenile corals recorded on natural substrates (generally > 10 mm diameter) represents corals that recruited at least 12 months prior (Babcock and Mundy, 1996). Densities and taxonomic composition of juvenile corals were recorded within three replicate 1m^2 quadrats positioned randomly along each of three 10 m transects. Transects were arranged radially around a central origin at 7 m depth, with 120 degrees separating each transect, following Shuail et al. (2016). To maximise detection of juvenile corals, quadrats were divided into 10cm^2 squares that were systematically inspected, with all juveniles identified to the highest taxonomic resolution possible and measured (maximum diameter) to the nearest mm. Smaller individuals and certain taxa (e.g., *Porites*) could not be reliably identified to species, and therefore, all juveniles were pooled to genera.

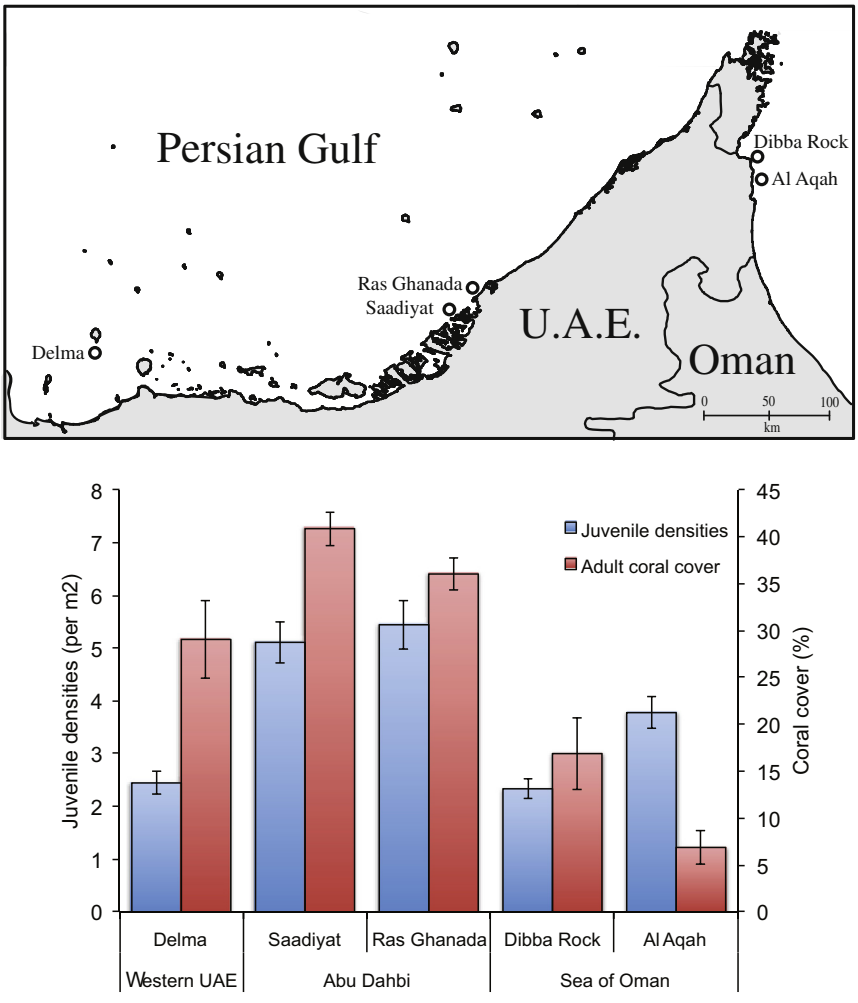

Fig. 1. Map showing sampling locations across the United Arab Emirates, as well as mean (±SE) densities of juvenile corals and mean (±SE) cover of adult corals across sites.

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