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Short communication

Twenty-year changes in coral near Muscat, Oman estimated from manta board tow observations

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ABSTRACT

The coastline of Muscat, Oman, contains some of the most extensive and diverse coral reefs in the northeastern Arabian Peninsula. In the past two decades this region has been impacted by expanding coastal development, the largest cyclone ever recorded in the Arabian Sea, and a large-scale harmful algal bloom which resulted in mass mortality of reefs elsewhere in the Gulf of Oman. In 2012 we estimated live and dead coral using manta tow observations on 370 transects at 13 locations along the coastline and nearshore islands of Muscat Oman. We compared these estimates against observations made on 389 transects at the same 13 locations two decades earlier (1993–94) in order to determine long-term changes in benthos along the Muscat coast. Results were mapped and differences in categorical mean values for transect locations were statistically compared between survey years. Live hard and soft coral decreased over the past two decades at most survey sites, and decreases were significant at three exposed coastline sites and one semi-enclosed embayment. One sheltered embayment site showed a significant increase in live hard coral over the study period. Declines in live hard coral were associated with increases in dead coral framework at 8 of the 13 sites, but these changes were non-significant. We attribute these changes primarily to long-term effects of Cyclone Gonu, which struck the Oman coast in June 2007. The study results suggest that the manta tow method can be an effective way to detect long-term changes in coral and other benthic parameters over large areas, despite limitations on its precision.

1. Introduction

Globally, coral reefs have declined in the past three decades, with much of the degradation due to regionally localized factors such as land-use changes, nutrient enrichment, outbreaks of disease and predation, loss of grazing fish and invertebrates, or impacts from storms (Alvarez-Filip et al., 2011; Bruno and Selig, 2007; De'ath et al., 2012; Schutte et al., 2010). Knowledge of reef declines has often been based on long-term coral reef monitoring programs that have allowed objective assessment of trends in coral reef health through time and among locations (Bruno and Selig, 2007; De'ath et al., 2012; Schutte et al., 2010; , Stokes et al., 2010; Sweatman et al., 2011; Vermeij et al., 2011). There are, however, many understudied regions where long-term monitoring has not been performed but anecdotal evidence is increasingly suggesting that dramatic changes in coral reef viability have likely occurred (Fisher et al., 2011). One such biogeographic region is the Gulf of Oman on the northeastern Arabian Peninsula, an area where research effort has been relatively limited but reefs are considered under threat from a variety of localized anthropogenic stressors, as well as climate change (Fisher et al., 2011).

The corals of Oman were largely unknown until relatively recently, but substantial information on coral species, abundance and environmental factors has accumulated in the last two decades (Al-Jufaili et al., 1999; Claereboudt, 2006; Coles, 1994, 1996, 1997, 2003; Coles and Seapy, 1998; Coles and Wilson, 2001; Green and Keech, 1986; Glynn, 1983, 1993; Salm, 1991, 1993; Sheppard, 1987, 1988; Sheppard and Salm, 1988; Taylor, 2010; Wilson, 2007). Oman's corals exist in a somewhat marginal high latitude environment (Wilson, 2007), with limited hard substratum for settlement, large temperature fluctuations both annually and in the short

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term due to seasonal monsoonal effects (Coles, 1997), relatively high turbidity from high ocean phytoplankton productivity, localized disease outbreaks, oil pollution, physical impacts from fishing activity and periodic massive storms and wave impacts (Coles, 1994, 1996, 2003; Coles and Wilson, 2001). Despite these restrictions, a subset of Indian Ocean coral species thrive in Oman's waters at the intersection of the Red Sea and the Arabian (Persian) Gulf, particularly near Muscat, the Daymaniyat Islands, the Musandam Peninsula and Bar al Hikmann near Masirah Island (Claereboudt, 2006; Coles, 1996; Salm, 1993).

There have been periodic surveys of coral composition and relative abundance through the last forty years on reefs in Oman (Al-Jufaili et al., 1999; Glynn, 1983, 1993: Salm, 1991, 1993), but there have been no published reef re-surveys that could indicate whether positive or negative changes in coral or other benthic components have occurred over the long-term. The waters of the Gulf of Oman and Muscat have been impacted by a number of stressors in the last twenty years that may have affected coral cover and community composition, including expansion of shoreline development and urbanization, increased pressure from fishing activities and anchoring, a major cyclone, and a large-scale harmful algal bloom, to name a few. In order to determine changes on coral communities over the past two decades this study describes and maps the results of surveys of live hard and soft corals and dead coral at 13 locations in the Muscat area in 2012 that duplicated surveys done in 1993–94 by the same observer using the manta tow technique.

2. Material and methods

Manta board tows were used to estimate bottom characteristics and dominant benthic cover at 13 locations along >50 km of coastline and prominent islands near Muscat, Oman (Fig. 1), using the standardized technique described in English et al. (1994) modified with 1 min tows. Manta tows are a rapid assessment technique originally developed to count Crown of Thorns starfish and their impact on large areas of the Great Barrier Reef (Moran and De'ath 1992), but are also used to rapidly estimate coral, algal and other benthic substrata types or cover (De'ath et al., 2012, Miller et al., 2009). An observer towed behind a small boat at a fixed speed records categorical values for ranges of coral cover and other substrata or benthic cover that summarize the conditions observed on the transect. The start and end of the towed transects are recorded by the boat driver. For the present study, GPS start locations and visual landmarks recorded from surveys performed in 1993–94 were used to duplicate transect locations and tow paths in 2012 and observations were made by the same observer (SLC) in both periods. In 2012, 370 transects were surveyed that corresponded to the paths of 389 transects of the total surveyed in 1993–94. The GPS waypoint number for the start and end point of each tow segment in 2012 was recorded by the boat operator (EL) and later plotted using ArcGIS 10© Geographic Information System (GIS) mapping software.

Data and observations along approximate 5 m wide swaths on each transect were recorded by the towed observer (SLC) on a preprinted data sheet, along with the tow segment numbers coinciding with the GPS waypoints recorded by the boat driver. At the end of each site's transect the waypoint numbers were compared between the boat driver and the towed observer and any discrepancies resolved. The site locations, number and depth ranges of the multiple transects done at each location, total distances and mean distances for the transects are shown for both sampling periods in Table 1. Overall tow paths are shown in Fig. 1 and detailed tow paths for specific locations in Supplementary Material Figs. 1–5.

Estimates of categorical values of live hard and soft coral, and dead but intact coral skeleton were made using a modified version of English et al. (1994), i.e. Category 0, bare substratum and rubble, Category 1: 1–5% cover, Category 2: 6–30% cover, Category 3:

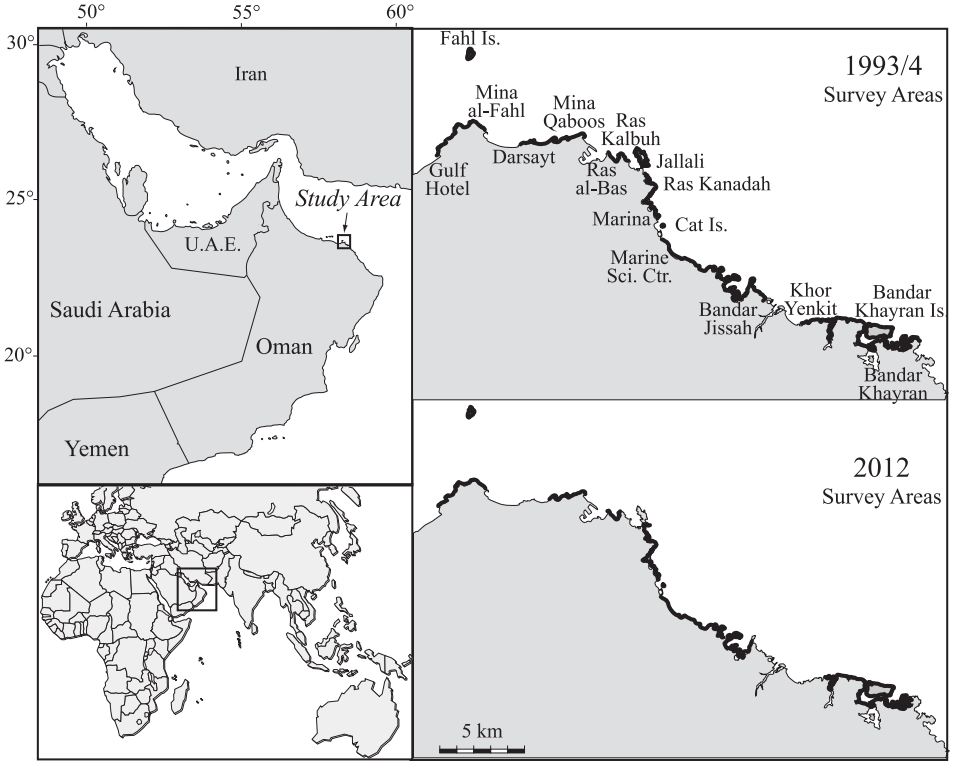

Fig. 1. Map of the Muscat Oman Capital Area coastline showing paths of manta tow surveys in 1993–94 and 2012.