Assessing Bioerosion and Its Effect on Reef Structure Following a Bleaching Event in the Maldives

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INTRODUCTION

The unprecedented coral bleaching in the Maldives in 1998 resulted in extensive mortality of reef invertebrates with symbiotic algae, especially reef building corals. The percentage of living coral cover declined markedly immediately after the bleaching event, from around 30–60% pre-bleaching to 0–5% post-bleaching for shallow reef-flat areas (Allison, 1999). Fast-growing branching corals, particularly *Acropora* spp., were more susceptible to bleaching, and, as a consequence, suffered greater mortality than slow-growing massive corals.

The ultimate consequences of the 1998 bleaching event will not be fully understood for some time, possibly for decades. However, it is clear that reefs will be modified as a result of this bleaching event. In the short term (<5 years), coral reefs that were formerly dominated by branching species will now be dominated by non-living substrate that support a few surviving colonies of massive species. The consequences of bleaching for the reef framework will largely depend on the transport and fate of $CaCO_3$ fragments. Where reef disturbance is severe, boring and grazing organisms may remove $CaCO_3$ faster than primary frame-builders can accrete it. Such biogenic processes will determine whether the structural integrity of the reef will remain intact.

This study was conducted to investigate the processes of reef recovery after the bleaching event in 1998. The primary objectives of this study were to identify the main contributing groups of reef boring organisms and their relative rates of bioerosion.

METHODS

Coral blocks (10 cm x 5 cm x 1 cm) were cut from live colonies of *Porites* collected from a nearby reef. After these blocks were cut, they were soaked in fresh water and oven dried to a consistent weight. At Gulhifalhu reef (atoll outer reef, facing open ocean) and Feydhoofinolhu reef (atoll inner reef, atoll lagoon) in North Male atoll (Fig. 1 on next page), seven blocks were placed at depths of 5 m and 10 m. Each block was attached to a plastic push mount plug drilled to the reef substrate using cable ties via a central hole drilled in each block.

Each coral block was collected after a period of 14 months between February 2001 and April 2002 and was examined visually to record the types of fouling community and their relative densities. Each block was dried and sectioned in both the longitudinal and transverse planes to yield eight cut surfaces per block. The relative area removed by various bioeroding organisms was estimated by placing a plastic sheet printed with small dots evenly spaced over each cut surface of the block and counting the number of points covering the area removed by borers. The intensity of bioerosion was calculated as the percentage of the cross sectional area removed by each type of boring organisms divided by the cross sectional area of each block. Boring organisms were identified as worms, sponges or molluscs by the characteristic cavities they left in the coral blocks. Bioeroding worms were further classified into two size classes, micro worms (<1 mm in diameter) and macro worms (>1 mm in diameter).

Figure 1. Male atoll.

RESULTS

The total area removed by bioeroders was greater at Feydhoofinolhu than at Gulhifalhu (17.3% and 14.3 % for Feydhoofinolhu and Gulhifalhu respectively). Of the four groups of bioeroders idenitified, sponges removed the most of the calcium from the blocks (Feydhoofinolhu, 10.1%) and (Gulhifalhu. 4.8%) followed by clams 2.3% and 4.2% for Feydhoofinolhu and Gulhifalhu respec-

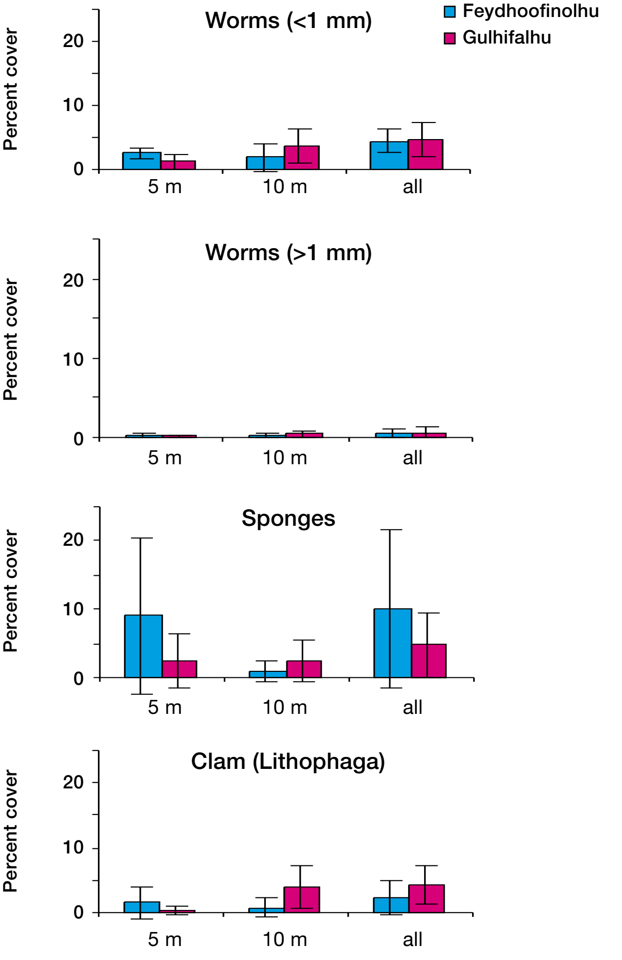

Figure 2. Intensity of boring at the two study locations. Boring intensity is given as the percentage of the area removed by each group from the cross sectional area of the block. (4 separate plots one for each group)

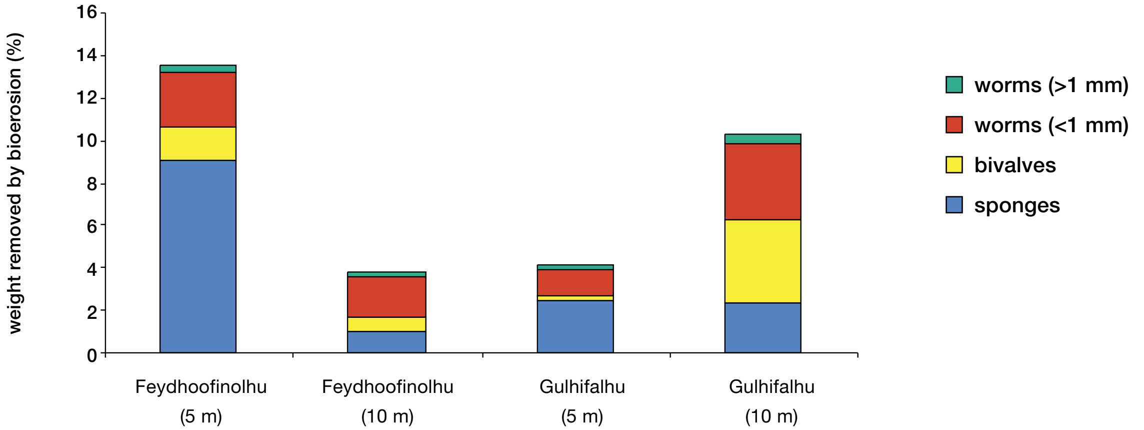

Figure 3. Comparison of the borers at the two study sites Feydhoofinolhu and Gulhifalhu.

tively (Fig. 2). Boring by worms was less at all sites compared to the previous two groups.

There is a significant difference in the intensity of bioerosion between the two depths at each study site. The relative intensity of bioerosion at Feydhoofinolhu at 5 m (13.5%) was higher than at 10 m (3.8%). However, this patterns was reversed at Gulhifalhu where the intensity of bioerosion at 5 m (4.1%) was less than that recorded at 10 m (10.3%) (Fig. 3). Overall, boring by sponges (e.g. *Cliona* sp.) was highest followed by bivalves (mostly *Lithpphaga* sp.) and worms <1 mm group (mostly spirobids).

DISCUSSION

The level of bioerosion at Feydhoofinolhu was significantly higher compared with Gulhifalhu. This difference in the intensity of erosion cannot be attributed to any environmental factor related to these sites because no environmental parameters were recorded for the purpose of this study. Eutrophication has been implicated in causing greater levels of bioerosion (Holmes *et al.*, 2000), but neither study sites have suffered excess nutrient levels.

After the coral blocks were deployed, their entire surface was rapidly colonised by fouling organisms, including filamentous and macro algal groups, calcareous algae, sponges and bryozoans (Fig. 4). Identification of the endolithic borers was carried out using the shape of the boreholes, which were grouped into three major categories (Fig. 5 on next page). Detailed grouping and identification of the organisms will be carried out at the later part of the study.

The intensity of bioerosion at the study sites over the 14-month period ranged between 10–20% and was attributed to three major taxonomic groups. The preliminary finding from this study gives some indication of the rate of biological erosion contributed by the endolithic borers at the sites investigated. Bioerosion has been reported as a key process limiting the rates and patterns of coral reef growth (Hutchings & Bamber, 1985) and, as a

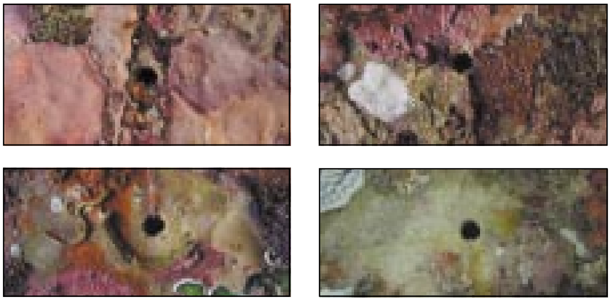

Figure 4. Fouling community succession on settlement tiles. Surfaces were completely covered by coralline algae, sponges, ascidians and bryozoans within four months of deployment.

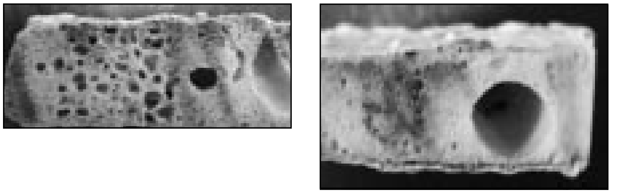

Figure 5. Examples of endolithic borers identified. The large hole is from *Lithophaga* (clam), the very small bores are mainly from worms and the spongy appearance boring with cavities are from boring sponges (e.g. *Cliona*).

consequence, can be viewed as a significant factor affecting reef recovery processes in the Maldives following the mass coral bleaching in 1998. These preliminary findings provide some insight to the intensity of bioerosion by the specific groups of borers identified. It also gave some indication of the important role these organisms play in breaking and restructuring of the reef framework.

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