

## Coral Bleaching and Associated Mortality at Mayotte, Western Indian Ocean

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**Abstract**—Bleaching and associated coral mortality were assessed on fringing and barrier reefs on the north and east coasts of Mayotte from 1-24 May 2010. Major bleaching was encountered; nearly 80% of the corals were bleached or dead (covered with thin algal overgrowth) on fringing reefs along the north coast, and 50% and 35% of the corals were bleached or dead at two sites on the east coast. The observations revealed spatial and temporal heterogeneity in the extent of the bleaching and mortality. The genera that appeared most susceptible to bleaching were *Pocillopora* and tabular *Acropora*, while *Porites* seemed to have suffered the least. Observations on the bleached genera were consistent with those made during the 1997-1998 bleaching event.

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### INTRODUCTION

Bleaching of corals involves stress-related rejection of their symbiotic algae and is a generally accepted consequence of a number of stresses, including warming of the oceans (Brown, 1997). Mass bleaching events may constitute a disturbance that triggers a larger shift in benthic community structure that renders reefs less valuable (Norström *et al.*, 2009), making its prediction and elucidation essential. In mid-February and early March of 2010, warm water masses in the southern western Indian Ocean (WIO) triggered a high alert for coral bleaching in Madagascar and in the Mozambique Channel ([www.cordioea.org](http://www.cordioea.org)). Indeed, these reports showed that extensive bleaching occurred in Madagascar.

The high alert continued throughout April but, by mid-May, the warmer water seemed to have dissipated and the bleaching alert was reduced to low ([www.cordioea.org](http://www.cordioea.org)). The extent of the bleaching in the WIO was not fully known, but, from reports, it appeared that at least moderate bleaching occurred in Madagascar, Kenya, Zanzibar and the Comoros.

Mayotte (12°50'35"S, 45°8'18"E) is located in the Mozambique Channel, between Madagascar and Mozambique (Fig. 1). The island is surrounded by one of the largest coral reef lagoons in the world, covering *c.* 1300 km<sup>2</sup>, with extensive fringing and barrier reefs covering *c.* 150 km<sup>2</sup> (Arnaud *et al.*, 2009). During the 1997-1998 ENSO event, coral colonies in Mayotte suffered severely but recovered from bleaching

and associated mortality during the following years (Quod & Bigot, 2000). Coral bleaching was again noted on some of the Mayotte reefs in February 2010. By then, marine scientists and tourist operators with experience and knowledge of the Mayotte reef systems were describing this as a bleaching event of a magnitude unlike any experienced in Mayotte since 1998 (e.g. Quod & Bigot, 2000; Goreau *et al.*, 2001). In May, extensive areas of bleached and dead coral were recorded, covered with a thin algal overgrowth suggesting recent mortality. This note provides a record of this mass bleaching event in Mayotte and information on the areas affected.

## MATERIALS and METHODS

Fringing and barrier reefs were surveyed using the manta tow method outlined by English *et al.* (2003) at three sites on the coast of Mayotte (Fig. 1) during 1-24 May 2010. Zone A, located at the northern end of Mayotte, is

not protected by a barrier reef and is strongly influenced by the ocean. Manta tows were performed here on fringing reefs and around Choizil and M'Tsamboro Island. The last-mentioned is most exposed to the ocean and has a structurally complex coral reef with high relief. Zone B incorporated fringing reefs around islands in the inner lagoon on the east side of Mayotte and was consequently less influenced by the ocean. This zone included Bouzi (recently made a Marine Protected Area), Hajangua and Bandrele Island and the fringing reef at Sakouli on the mainland. Zone C, also on the east side of Mayotte, incorporated the barrier reefs around Recif du Sable Blanc, Passe Bandrele and Passe en "S", a Marine Protected Area (MPA). The outside reefs were accreted, strongly influenced by the ocean and of varying complexity. The inside reefs comprised coral gardens, some of high complexity, subjected to less wave energy.

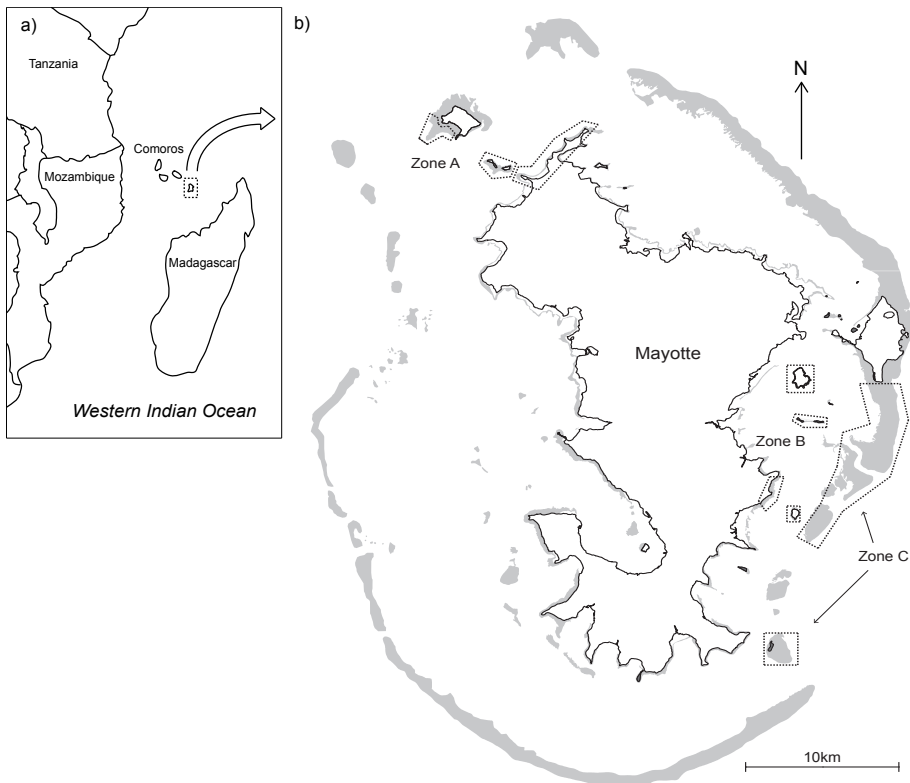


Figure 1. a) Location of Mayotte in the Mozambique Channel. b) Sites of the reef surveys (Zone A, northern fringing reef; Zone B, eastern fringing reef; and Zone C, eastern barrier reef).

The manta tows each covered an area of 300 x 2 m and were conducted at walking speed (c. 2.5 km/h). The distance and speed were measured using a handheld GPS unit. A patchwork of reef habitats was covered, ranging from the reef front of barrier reefs to the reef flat of fringing reefs. The percentage of live, bleached and dead coral was estimated and recorded for the transects. One-way analysis of variance (ANOVA) was performed on the data for each locality (Zone) using R 2.10.0. A description of bleached organisms was also compiled from the observations.

## RESULTS and DISCUSSION

All three survey areas were affected by coral bleaching and mortality (Fig. 2) but the relative cover of each of the coral categories differed significantly (live coral:  $F_{3, 135}=4.50$ ,  $p<0.005$ ; bleached coral:  $F_{3, 135}=25.40$ ,  $p<0.001$ ; dead coral:  $F_{3, 135}=15.69$ ,  $p<0.001$ ). The extent of bleaching and mortality was greatest in Zone A, affecting nearly 80%

(7,437 m<sup>2</sup>) of the corals. In Zone B, the bleaching and mortality were less prevalent around the lagoonal islands and on the fringing reefs, but still affected approximately half of the corals. In contrast to the other two Zones, the barrier reefs in Zone C had less bleached or dead coral (approximately 35 %).

A variety of corals (including soft corals) and anemones were bleached on the Mayotte reefs (Fig. 3). However, the extent of bleaching and mortality varied between the genera (Table 1). For example, *Pocillopora* and tabular *Acropora* were most extensively bleached, with 90-100 % bleaching or mortality recorded in some areas. *Pocillopora* was also the most extensively bleached genus in Madagascar at the time of our survey ([www.cordioea.org](http://www.cordioea.org)) and up to 100 % of the tabulate *Acropora* were killed during the 1997-98 bleaching event in Mayotte (Quod & Bigot, 2000). Our observations of the genera most susceptible to bleaching corroborate those of Obura (2001) in the WIO regional analysis of the 1997-98 warm water anomaly. Similarly, McClanahan

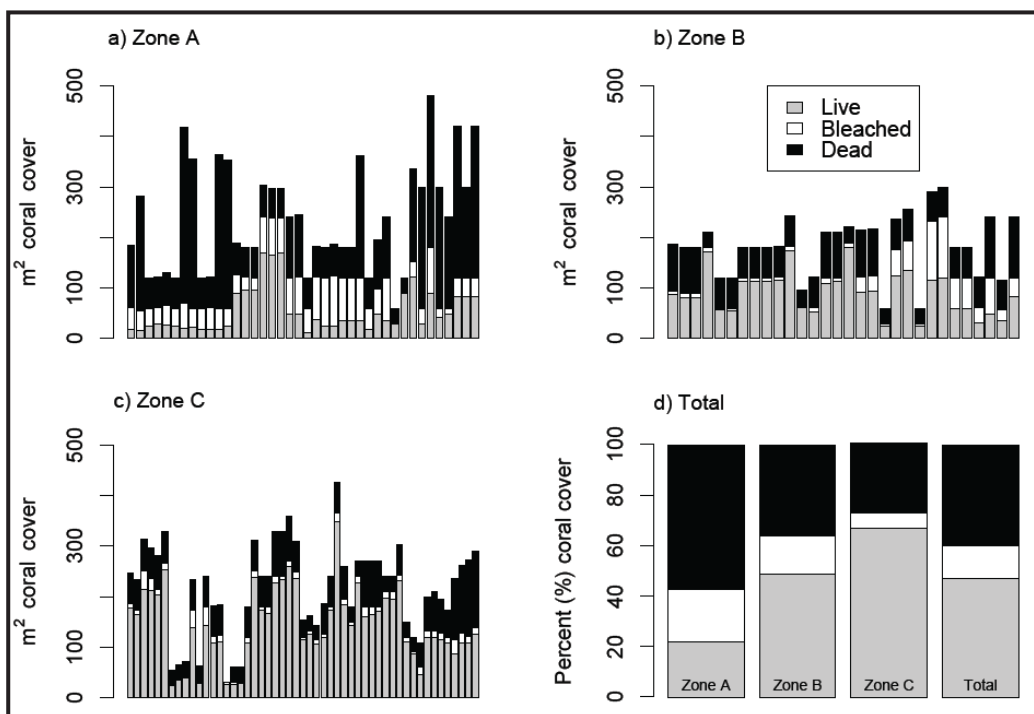


Figure 2. Area of live, bleached and dead coral in 300 x 2 m manta tows in a-c) Zones A, B and C; d) percentage coral cover in each zone and in the total area surveyed at Mayotte.

Table 1. Genera commonly bleached at Mayotte in May 2010, listed in the order of the degree and susceptibility to bleaching.

Genus	Observations
<i>Pocillopora</i>	Very severe bleaching and mortality on both fringing and barrier reefs at depths of 1-15 m. This was the most commonly bleached genus. Bleached stands commonly died and were covered by algae.
<i>Acropora</i> (tabular)	Severe bleaching and mortality on both fringing and barrier reef areas at depths of 1-15 m. Bleached stands commonly died and were covered by algae.
<i>Galaxea</i>	Severe bleaching and mortality on reef front of fringing reefs at depths of 5-15 m. Some bleached stands survived but colonies commonly died and were covered by algae.
<i>Fungia</i>	Severe bleaching and mortality on both fringing and barrier reefs at depths of 1-15 m.
<i>Acropora</i> (branching)	Moderate bleaching and mortality on both fringing and barrier reefs at depths of 1-15 m. Some dead corals with algae were noted, but not to the same extent as the tabular <i>Acropora</i> .
<i>Acropora</i> (digitate)	Moderate bleaching and mortality on both fringing and barrier reef at depths of 1-15 m. Some dead corals with algae were noted, but not to the same extent as the tabular <i>Acropora</i> .
Actinaria	Bleaching on both fringing and barrier reefs but no mortality.
<i>Porites</i>	Some bleaching on fringing and barrier reefs. This genus seemed to be the most resilient to bleaching.

*et al.* (2004) found that *Pocillopora* was the most susceptible genus in both Kenya and in Australia during the same period. From our observations in Mayotte, *Porites* seemed more robust and generally bleached to a lesser extent (~30%), this being consistent with previous observations (Obura, 2001).

The post-bleaching mortality and consequent algal overgrowth on the affected genera seem to vary. For example, bleached tabular *Acropora* generally died and became covered with an algal overgrowth after about 2-4 weeks, whereas some bleached *Galaxea* colonies survived bleaching over this period. This emphasises that the timescale of such a survey (in the present case, three weeks) will affect the level of bleaching and subsequent mortality recorded.

The full extent of bleaching and coral mortality in the region is unknown but the findings of this survey revealed a heterogeneous bleaching pattern at Mayotte, the different areas being affected to a varying extent by bleaching and mortality. In this regard, the results mirrored those recorded in other areas in the WIO. Unfortunately, there are no water temperature data at a sufficiently detailed scale to elucidate the spatial patterns of bleaching encountered at Mayotte. Anecdotal reports indicate that this bleaching event was the most severe in Mayotte since the 1998 ENSO event.

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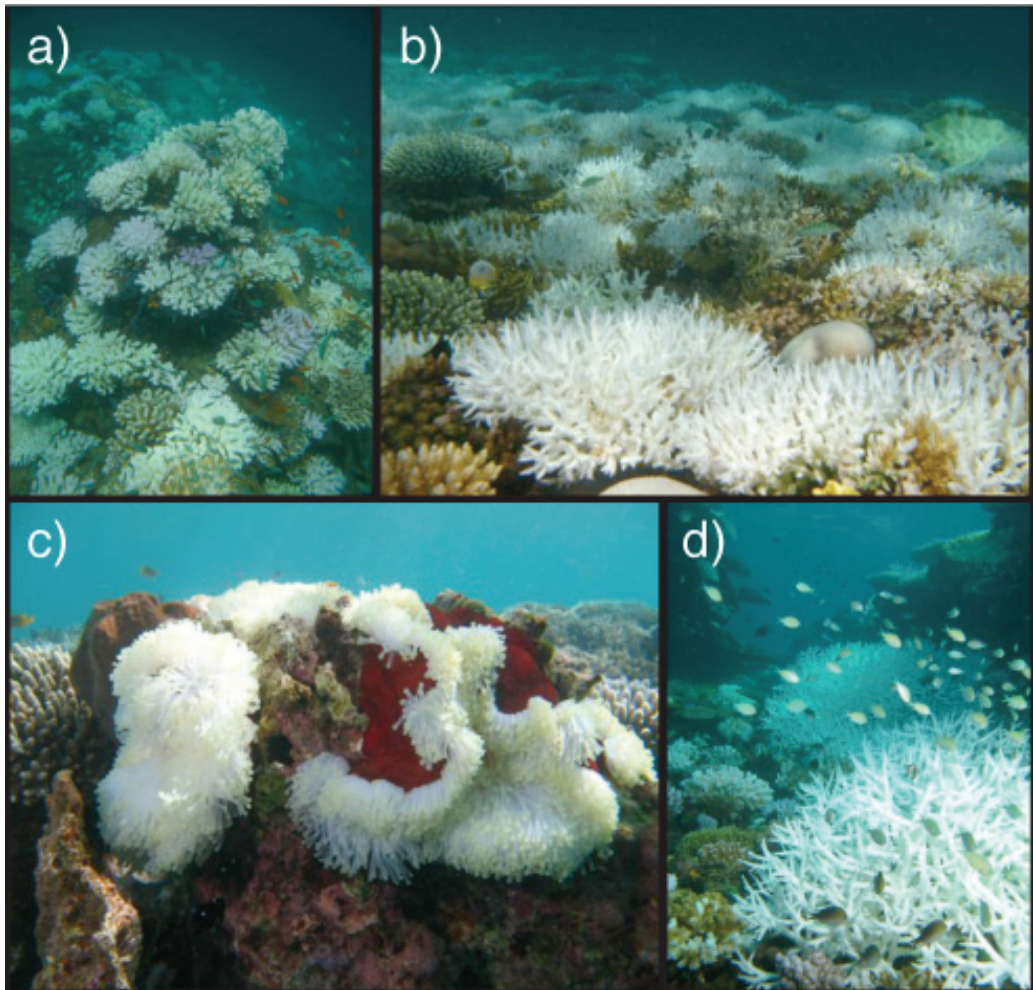


Figure 3. Bleaching and coral mortality at Mayotte in 2010: a) Mainly *Pocillopora* spp. on fringing reef at 10 m depth at Choazil Island (Zone A) in the north; b) mainly *Acropora* spp. on fringing reef at 2 m depth and c) *Heteractis magnifica* at 3 m at Sakouli (Zone B) on the east coast; and d) *Acropora* spp. and *Pocillopora* spp. at 7 m depth on fringing reef at Choazil Island (Zone A).

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