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Reef fish diversity at Aldabra Atoll, Seychelles, during the five years following the 1998 coral bleaching event

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Quantitative surveys of fish-species diversity were undertaken at 10 m and 20 m water depth on the outer reef at Aldabra Atoll, southern Seychelles, between November 1999 and May 2003. No significant changes in total fish-species diversity, numbers of families represented by these species, or numbers of pomacentrid or chaetodontid species were seen, contrary to fish-diversity changes seen on coral bleaching-impacted reefs elsewhere. The lack of additional anthropogenic pressures at remote Aldabara may make this system, and others like it, more tolerant of bleaching-related population changes.

Keywords: coral mortality; habitat complexity; butterflyfish; damselfish; rapid assessment protocol; Western Indian Ocean

1. Introduction

The worldwide demise of coral reefs can largely be attributed to human activity, both direct and indirect (Hoegh-Guldberg 1999). Direct anthropogenic influences include overfishing, coral mining, landfill, siltation and other forms of pollution. Global warming and its consequences are the most prominent example of indirect anthropogenic influence (Hoegh-Guldberg 1999; Wilkinson *et al*. 1999). There remain few coral reefs of significant size that allow the indirect effects to be studied in isolation of direct human pressure. Aldabra Atoll, a UNESCO World Heritage Site in the southern Seychelles, is one exception.

The global coral bleaching in 1997–1998 was the most geographically extensive and severe response to a warm-water event on record (Berkelmans & Oliver 1999; Hoegh-Guldberg 1999; Lindahl *et al*. 2001). In the Central to Northern Indian Ocean mortalities of hard corals reached 80–90% in some areas (Spalding & Jarvis 2002; Spalding *et al*. 2001; Wilkinson *et al*. 1999; Wilkinson 2002), and at Aldabra they approached 40% (Spencer *et al*. 2000). Post-bleaching surveys at Aldabra estimate

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that up to 22% of the live corals in shallow water (10 m) died, but that coral mortality in deeper water (20 m) was negligible in spite of the severity of the event (Stobart *et al*. 2004). Recovery of hard corals has been insignificant.

Early surveys of the outer reef ecosystem at Aldabra found highly diverse fish communities (228 species in 1973 (Polunin 1984)). During the early stages of the bleaching event Spalding counted 244 species in April–May 1998 (M. D. Spalding 1998, unpublished results). This paper examines the changes in fish diversity at Aldabra over the five years following the 1997–1998 bleaching event and the consequent coral-habitat destruction.

2. Methods

Quantitative surveys of the fish species on the outer reef were conducted once during November 1999, February 2001, February 2002 and May 2003 along permanently marked transects on 10 m and 20 m depth contours at seven sites along the northern shore of Aldabra. Surveys used a modification of protocols developed for rapid visual assessments (English *et al*. 1997; Ginsburg *et al*. 1998), details of which can be found in the Aldabra Marine Programme reports at http://www.aldabra.org. Opportunistic checklists were also made of any additional fish species sighted off-transect at each survey site. Regression with analysis of variance (Neter *et al*. 1990) was used to examine changes in fish-species diversity at 10 m and 20 m depths up to 43 months post-bleaching, and to examine changes in the families and species of fish on the outer reef during the 61 months following the bleaching event.

3. Results

Since November 1999 the number of fish species counted at 10 m has ranged from 142 to 156, mean 150, and at 20 m from 133 to 150, mean 142 (table 1). During the 43 months covered by these surveys, there were no significant changes in fish-species diversity at either 10 m ($F_{0.05\,(1),\,1,\,2} = 0.164$, $P = 0.725$) or 20 m ($F_{0.05\,(1),\,1,\,2} = 2.782$, $P = 0.237$).

The opportunistic checklists of fish species conservatively increased the range of total species numbers from 197 to 211, mean 205. The number of families represented by these species ranged from 34 to 38. Although the survey in May 1998, during the early stages of the bleaching event, noted 244 fish species representing 31 families at Aldabra, there were no significant changes in the total fish-species diversity ($F_{0.05\,(1),\,1,\,3} = 4.514$, $P = 0.124$) nor in the number of families represented by these species ($F_{0.05\,(1),\,1,\,3} = 0.683$, $P = 0.469$) during the 61 months following the bleaching event. Over the same period there were also no significant changes in the number of chaetodontid species ($F_{0.05\,(1),\,1,\,3} = 0.335$, $P = 0.604$) or pomacentrid species ($F_{0.05\,(1),\,1,\,3} = 0.043$, $P = 0.849$).

4. Discussion

The abundance and diversity of fishes can be correlated with habitat composition and complexity (Roberts & Ormond 1987; Williams 1991; Lindahl *et al*. 2001; Sebens 1991). Also, reductions in both live coral cover and erect dead coral structures decrease habitat complexity, which alters the diversity and abundance of fishes

Table 1. *The number of fish families and species surveyed at Aldabra: 1998–2003*

year	1998	1999	2001	2002	2003
month	May	November	February	February	May
months since 1998 bleaching event	1	19	34	46	61
survey sites	(Spalding[c])	1–7	1–7	1–7	1–7
survey counts					
species counted in 10 m transects	—	149	152	142	156
species counted in 20 m transects	—	150	147	133	139
total species counted in transects	—	165	183	169	183
families counted in transects	—	30	38	36	31
additional species noted outside transects[a]	—	46	14	41	20
additional families noted outside transects[a]	—	5	—	—	3
total species[b]	244	211	197	210	203
total families[b]	31	35	38	36	34
chaetodontid species	19	20	19	19	19
pomacentrid species[d]	18	18	22	18	17

[a]Opportunistic counts made of fishes not found in transects.
[b]Includes both fishes in transect counts and additional fishes noted outside transects.
[c]Early-bleaching-event surveys (M. D. Spalding 1998, unpublished results).
[d]1998: excludes six species found only at depths shallower than surveyed in 1999–2003.

(Hoegh-Guldberg 1999; Booth & Beretta 2002; Marshall & Baird 2000; Spalding & Jarvis 2002).

Extensive coral bleaching creates a major habitat disturbance that has indirect effects on the associated reef fishes (Booth & Beretta 2002). However, there are few long-term studies on the effects that the loss of live coral habitat due to bleaching has on the associated reef-fish communities (Lindahl *et al*. 2001; Spalding & Jarvis 2002). Coral reefs may continue to support abundant and diverse reef-fish communities after loss of live coral habitat if the dead coral structures retain the habitat complexity of the reef system (Lindahl *et al*. 2001).

In this long-term study, thus far over the five years following the 1997–1998 bleaching there has been negligible recovery of hard corals, and we did not find any significant changes in fish-species diversity regardless of the year or month of the survey or the depth (10 m, impacted area; 20 m, minimally impacted area). Both chaetodontids and pomacentrids have many species that are commonly associated with live coral habitat (see Booth & Beretta 2002). Some chaetodontids are thought to be obligate corallivores (Ohman *et al*. 1998; Cosby & Reese 1996). However, only one of the 19 species of chaetodontids and two of the 18 species of pomacentrids found in

1998 during the early stages of the bleaching event were not found in the 1999–2003 surveys.

These findings do not reflect the changes in fish-species diversity found in studies of systems with both bleaching and anthropogenic impacts. One explanation may be that, without the additional stress of direct human pressure, remote reef systems such as Aldabra may be more tolerant to episodes of coral bleaching. However, fish-species diversity, as measured by the number of species, is only one indicator of the status of the reef systems at Aldabra. Fish numbers, size classes and community structure must also be considered, and will be reported in later papers.

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