

# Status of the coral reefs of Maldives after the bleaching event in 1998

HUSSEIN ZAHIR

*Marine Research Centre, Ministry of Fisheries Agriculture and Marine Resources, Male, Maldives*

## INTRODUCTION

A pilot reef monitoring study was conducted in 1998 to assess the extent of coral bleaching in the Maldives. The aims of this monitoring exercise were:

1. To quantitatively document the post-bleaching status of the shallow-water coral communities on the reefs of the north, central and southern regions of Maldives.
2. To estimate bleaching-induced coral mortality by comparing data yielded by the pilot survey with data from previous surveys, especially those sites for which historical data are available.

## METHODS AND SURVEY LOCATIONS

### Site Selection

The reef area of Maldives is enormous and the resources available for monitoring it are small. Reefs that would provide a description of the current post-bleaching status of the coral communities throughout Maldives were selected. The sampling sites were chosen in the following region (Figure 1):

- *Haa Dhaal* (north and a regional development target)
- *Male* (east central with intensive tourism and other commercial activities)
- *Ari* (east central with intensive existing tourism development)
- *Vaavu* (south central with a community-based integrated island resource management project underway).
- *Addu-Gaaf Alif* (south and a regional development target)

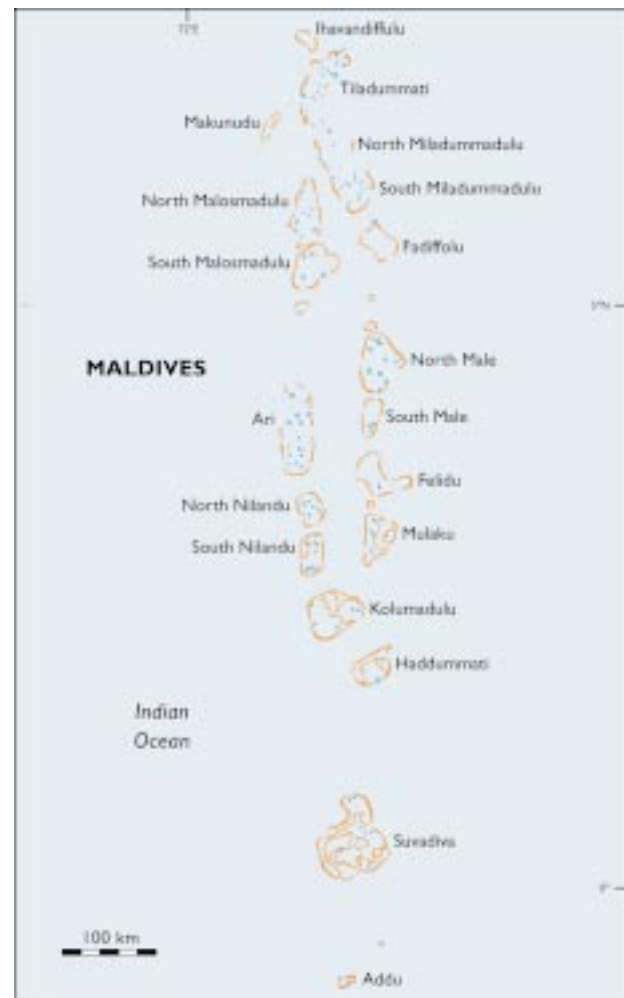


Figure 1. The reef area of Maldives with each survey site illustrated.

In each of these regions three reefs were selected ensuring that reefs that had been surveyed in the recent past were included thus providing baseline data against which data obtained from this study could be compared.

Because virtually all of the previous studies were conducted on the reef top and for logistical efficiency, all of the quantitative surveys conducted in this pilot study were conducted on the reef top also. Surveys were also confined to inner reefs within the atolls because this is where past surveys had been conducted and also because the surge caused by oceanic swells ensures that working in shallow water on outer reefs is usually impossible.

### SURVEY METHOD

On each surveyed reef, data from three line intercept transects of 50 m (English *et al.*, 1997) were recorded in areas near the location of past survey sites and where physical conditions such as wave action permitted. Occasionally, when it was judged efficient to do so, a 50 m long line point insect transect was used. Surveys of the same sites were repeated in 1999 as part of an ongoing monitoring programme to assess the status of the reefs and to compare the results with those of the post bleaching study. It is anticipated that these sites will become permanent monitoring sites and will be surveyed annually to provide an insight to the processes of reef recovery especially after the bleaching in 1998.

### RESULTS

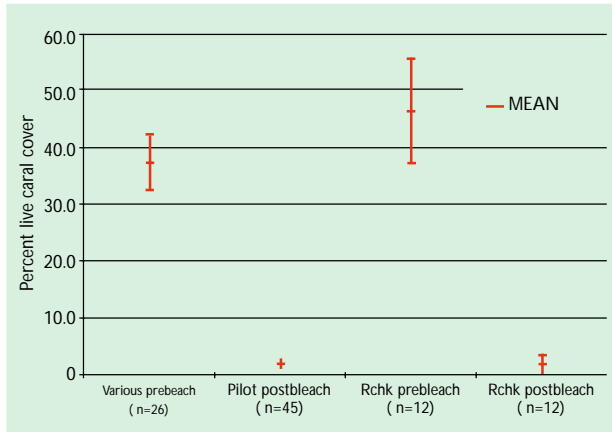
A summary of post-bleaching data shows that the mean cover of live coral was 2.1% and ranged between 1.0% and 3.1% among the different atolls surveyed (Table 1) which is comparable to MRS Reef Check estimates of 1.7% (Table 2). This is in stark contrast with pre-bleaching levels of 46.5% (Table 2) and 37.4% (Table 3) (Figure 2). Although the cover of live coral is uniformly low, there is a suggestion of slight difference among atolls. Members of the family Acroporidae, excluding *Astreopora*, were rarely seen on the reef top, whereas poritids

**Table 1.** Summary data from transects surveyed between August and October, 1998. Estimates for each reef comprises three transect surveys which are pooled to calculate the aggregate estimates.

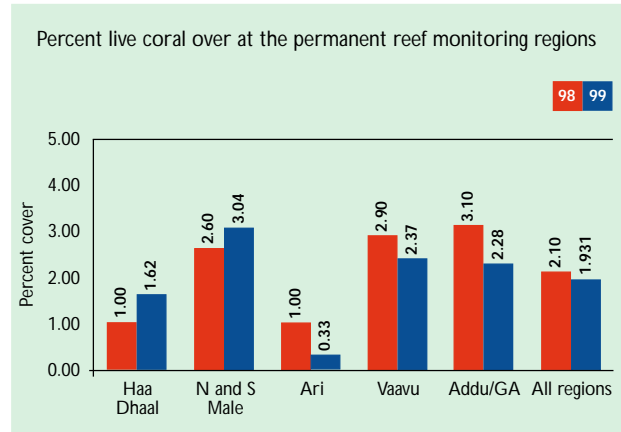
Regions surveyed	Reef Number			Aggregate
	1	2	3	
<b>Vaavu Atoll</b>				
Mean % cover	2.8	1.3	4.7	2.9
Standard deviation	0.92	0.42	1.69	1.82
No. of transects	3	3	3	9
<b>Ari Atoll</b>				
Mean % cover	0.5	2.1	0.2	1.0
Standard deviation	0.38	2.03	0.28	1.36
No. of transects	3	3	3	9
<b>Haa Dhal Atoll</b>				
Mean % cover	0.4	1.6	0.8	1.0
Standard deviation	0.49	0.19	0.94	0.75
No. of transects	3	3	3	9
<b>Addu &amp; Gaaf Atolls</b>				
Mean % cover	3.9	4.3	1.0	3.1
Standard deviation	1.81	2.54	0.24	2.21
No. of transects	3	3	3	9
<b>North &amp; South Male Atolls</b>				
Mean % cover	1.4	5.3	1.0	2.6
Standard deviation	0.82	3.21	1.09	2.71
No. of transects	3	3	3	9
<b>All Transects, All Atolls</b>				
Mean % cover				2.1
Standard deviation				2.06
No. of transects				45
				n=45

and agariciids, despite suffering high mortality, have survived best.

Results from the 1999 surveys show that the mean cover of live coral is 1.9% and ranges between 0.33% and 3.04% among the atolls surveyed (Table 4). These results are compared with those of the post bleaching study and are shown in figure 3.



**Figure 2.** Estimates of live hard coral cover prior to and after the bleaching event plotted as mean bounded by upper and lower 95% confidence intervals. Pilot post-bleaching data from pilot project field work. Various pre-bleaching data from Coral Reef Research Unit, Riyaz *et al.* (1998). Rchk = Reef Check data (Hussein, *et al.*, 1998) from MRC Reef Check surveys in August 1997 (pre-bleaching) and August 1998 (post-bleaching).



**Figure 3.** Comparison of estimates of the cover of live coral obtained immediately following the bleaching event.

**Table 2.** Reef Check data showing 1997 and 1998 coral cover at three permanent transect sites. Source: Marine Research Centre.

Reefs	1997 Transect Estimates						1998 Transect Estimates					
	Ta	Tb	Tc	Td	Mean	SD	Ta	Tb	Tc	Td	Mean	SD
Patch Reef, Vaavu	60.0	57.5	65.0	47.5	57.5	7.36	0.0	0.0	0.0	0.0	0.0	0.0
Thuvuru	22.5	22.5	22.5	45.0	28.1	11.25	0.0	0.0	0.0	0.0	0.0	0.0
Maduvaree	70.0	50.0	50.0	45.0	53.8	11.09	10.0	7.5	0.0	2.5	5.0	4.56
Grand Mean	46.5						1.7					
SD	16.39						3.43					

**Table 3.** Estimates of live hard coral cover prior to bleaching. Source: Marine Research Centre and Naeem *et al.*, 1998.

Reef	Atoll	Date	Transects							
			1	2	3	4	5	6	7	8
Gan	Addu	29/09/97	60.0	45.0	57.5	30.0	35.0	22.5		
Khoodhoo	Gaaf Alifu	15/04/98	22.5	42.5	35.0	50.0	12.5	22.5	22.5	45.0
Bandos	N. Male	05/05/98	28.4	45.1	38.8	36.7				
Udhafushi	N. Male	29/06/98	51.5	26.4						
Kudahaa	N. Male	30/06/98	45.1	30.0						
Rasfari	N. Male	01/07/98	44.5	48.5						
Embudhu Finolhu Far	S. Male	05/07/98	31.0	44.3						
Grand Mean					37.4					
SD					12.05					

**Table 4.** Summary data from transects surveyed from April to June 1999. Estimates for each reef comprise three transect surveys which are aggregated to calculate the aggregate estimates.

Regions Surveyed	Aggregate
<b>Vaavu atoll</b>	
Mean percent cover	2.37
standard deviation	1.29
Number of transects	8
<b>Haadhaal atoll</b>	
Mean percent cover	0.33
standard deviation	0.41
Number of transects	9
<b>Ari atoll</b>	
Mean percent cover	1.62
standard deviation	2.18
Number of transects	9
<b>Addu/Ga. Atoll</b>	
Mean percent cover	2.28
standard deviation	1.92
Number of transects	6
<b>N/S Male atoll</b>	
Mean percent cover	3.04
standard deviation	2.67
Number of transects	9
<b>All Transects (5 regions)</b>	
Mean percent cover	1.931
standard deviation	2.047
Number of transects	41

## DISCUSSION

The post bleaching study data show that only a small amount of live coral cover (~ 2%) remains on the reef tops surveyed. Qualitative observations made by many other people in other parts of the country are consistent with these quantitative surveys and lead to the conclusion that this is the general condition of reef tops throughout Maldives. Surveys conducted before and during the bleaching event indicate that live coral cover was approximately 20 times greater prior to the event. Although quantitative data describing the abundance of

*Acropora* and *Pocillopora* prior to bleaching are unavailable, it is well known that they were common. Indeed, *Acropora* was often the dominant coral on many reefs.

Repeated surveys of the same sites six months later indicated the cover of live coral remained very low at all sites. Indeed, each site surveyed, with the exception of Ari Atoll and North / South Male, possessed less live coral one year after the bleaching event than it did immediately after indicating subsequent mortality of corals and negligible recovery. Furthermore, it is suspected that Ari and Haa Dhaal Atolls were affected more than the other regions surveyed and the low level of coral cover was consistent with consecutive sampling.

Despite the grim picture painted by these data, the survey team has observed new coral recruits at all sites. Re-colonisation of fast growing branching growth forms were observed ten months after the bleaching event, indicating that reef recovery processes were already underway (Clark *et al.*, 1999). Several observations bode well for the recovery of these reefs. For example, many of the new recruits belonged to the genus *Acropora* which was the genus most seriously affected by the bleaching in 1998 (Figure 4-5). In addition, on some reefs encrusting coralline algae are abundant (Figure 6) providing potential areas for coral settlement and recruitment and in some regions (e.g. Haa Dhaal) large



**Figure 4.** Settlement and recruitment of fast growing acroporid species indicates that natural recovery is occurring.



**Figure 5.** *Acropora* was the genus of coral that was perhaps the most severely affected by the bleaching event of 1998.



**Figure 6.** Coralline algae (pink areas) have been implicated as being an important promoter of settlement of coral larvae. The abundance of coralline algae on the reefs of Maldives indicates that settlement and recovery of these reefs will not be hindered by the unavailability of suitable substrate.

*Acropora* tables that were believed to be dead are regenerating live tissue indicating prolonged recovery of some species of coral.

The impacts of the 1998 bleaching event will not be fully understood for some time. However, it is clear that reefs will be modified as a result of this bleaching event. In the short term (< 5 years), reefs formerly dominated by branching species will be dominated by non-living



**Figure 7.** An increase in the size of populations of grazing herbivores brought about by greater abundance of algae following the 1998 bleaching event could increase the rate of erosion of the reef framework.

substrate supporting only a low percentage cover of living corals of which the majority will be massive species. The consequences of bleaching for the reef framework will largely depend on the transport and fate of calcium carbonate ( $\text{CaCO}_3$ ) fragments. Where reef disturbance is severe, boring and grazing organisms may remove  $\text{CaCO}_3$  faster than primary frame-builders can add to it (Figure 7). Such biogenic processes will determine whether the integrity of the reef structure will be compromised.

## REFERENCES

- English, S.; Wilkinson, C. & Baker, V. (eds). 1994. Survey Manual for Tropical Marine Resources. ASEAN-Australian Marine Science Project: Living Coastal Resources. Australian Institute of Marine Science, Townsville. 368 p.
- Clark, S., Akester, S. and Naeem, H. 1999. Status of the coral reef communities in North Malé Atoll, Maldives: Recovery following a severe bleaching event. Report to the Ministry of Home Affairs, Housing and Environment, February 1999, 13 p.
- Naeem, I., Rasheed, A., Zuhair, M & Riyaz, M. 1998. Coral bleaching in the Maldives -1998. Survey carried out in the North and South Malé atolls. 14 p.
- Riyaz, M., Shareef, M. & Elder, D. 1998. Coral bleaching event: Republic of Maldives, May 1998. Ministry of Home Affairs, Housing and the Environment.
- Zahir, H., Naeem, I., Rasheed, A. & Haleem, I. 1998. Reef Check Maldives: Reef Check 1997 and 1998. Marine Research Section, Ministry of Fisheries, Agriculture and Marine Resources, Republic of Maldives.