



1994 Coral Bleaching Event, Society Islands, French Polynesia

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The progression of a temperature-induced bleaching event on the barrier reef at Passe d'Arue, Tahiti, during March–April 1994 was observed at approximately weekly intervals. The event consisted of selective exaggeration of polyp colours (*Montipora verneuilli*, *Pocillopora verrucosa*), fluorescence followed by bleaching (*Acropora* spp.), partial-complete bleaching (*Fungia* spp., *Montastraea curta*, anemones) and commencement of polyp death. *Porites* (massive spp.), *P. (Synarea) rus* and melobesoid algae were almost untouched by the event.

A major bleaching event began in early March 1994 in the Society Islands and by late April appeared to involve all of the reef types (fringing and barrier, atolls and lagoonal patches). Nearly all coral colonies are either partially or totally bleached and appear completely white or of various fluorescent colours (yellow, blue, pink). The classical explanation of bleaching (Brown, 1990) seems applicable to this event, that is, a partial or total expulsion of symbiotic micro-algae (zooxanthellae) from the coral polyps in response to major stress. Fluorescence is thought to be a secondary aspect of bleaching occurring when chromatophoric pigments within polyp tissues are directly irradiated (because the zooxanthellae 'shield' is lost) and light is re-emitted in other wavelengths. The same bleaching–fluorescence phenomenon occurred in the barrier reefs of the Society Islands during April–July 1991 and resulted in a mortality rate of 15–20%.

The casual factor for both the 1991 and 1994 bleaching probably is an abnormal warming of the adjacent ocean which has an excessive thermal content (temperature >29°C). In 1994 excessive temperatures began in February and in both years were related to an ENSO (El Niño Southern Oscillation) anomaly. A second factor is the insolation—UV which may inhibit coral survival (Gleason & Wellington, 1993) during austral summers of high illumination/low rainfall, as during both 1991 and 1994. Another explanation might be the cessation or weakening of the endo-upwelling process if the temperature/density difference between the ocean and reef interstitial water is lost by oceanic warming (Rougerie *et al.*, 1992).

For monitoring the 1994 bleaching event we concentrated our efforts on the west side of Passe d'Arue on the north coast of Tahiti (Fig. 1).

Case Study: Progression of the Bleaching Event on the North Tahiti Barrier Reef

During the 45 days of our observations (12 March–25 April 1994), the effects of the bleaching and the courses that it took were specific in each of the study areas owing to differences in their predominant taxa (Table 1). Bleaching did not occur during the study period in Area A, except for a few widely distributed anemones, *Fungia* sp. and *Pocillopora verrucosa*; all of the dominant taxa were bleach-resistant.

At the time that our observations began, Area B was fully involved in the bleaching event; 60% of the anemones were fully bleached in their upper tentacular crowns, 80% of the *Fungia* sp. were partly bleached and 10% were fully bleached. From these data, we estimate that the event began in Area B about 1 March 1994.

On 12 March each of the dominant species in Area C were undergoing bleaching; among *Montipora verneuilli*, 40% were bleached or had an exaggerated (purple/dark blue) colour, 10% of the *Pocillopora verrucosa* were bleached or with exaggerated colours and 5% of *Acropora* spp. were fluorescent.

The progression of bleaching in Area B was very rapid. For both the anemones and *Fungia* sp. a bleaching 'steady state' was reached by 19 March with 95% of the anemones fully bleached and 90% of *Fungia* were partly bleached and 5% fully bleached. These percentages remained approximately the same to the end of the study period.

TABLE 1

Distribution and relative abundance of taxa undergoing bleaching, Passe d'Arue, north coast, Tahiti, French Polynesia. March–April 1994.

Taxa/Areas	A	B	C	D
<i>Porites</i> spp. (massive)	A	C	r	r
<i>P. (Synarea) rus</i>	A	C-r	r	
Melobesoid (<i>Porolithon onkodes?</i>)	A	C	r	
Anemone	r	A	r	
<i>Fungia</i> sp.	r	A	C-r	
<i>Montastraea curta</i>		C	C-r	
<i>Montipora verneuilli</i>		C-r	A	
<i>Pocillopora verrucosa</i>		r-C	A	
<i>Acropora hyacinthus</i>		C	A	C
<i>A. humilis/nobilis</i> group		r-C	C	A
<i>A. sp.</i> (thin branches)		r	C	A
				C-r
				C-r

A = Abundant; C = Common; r = rare.



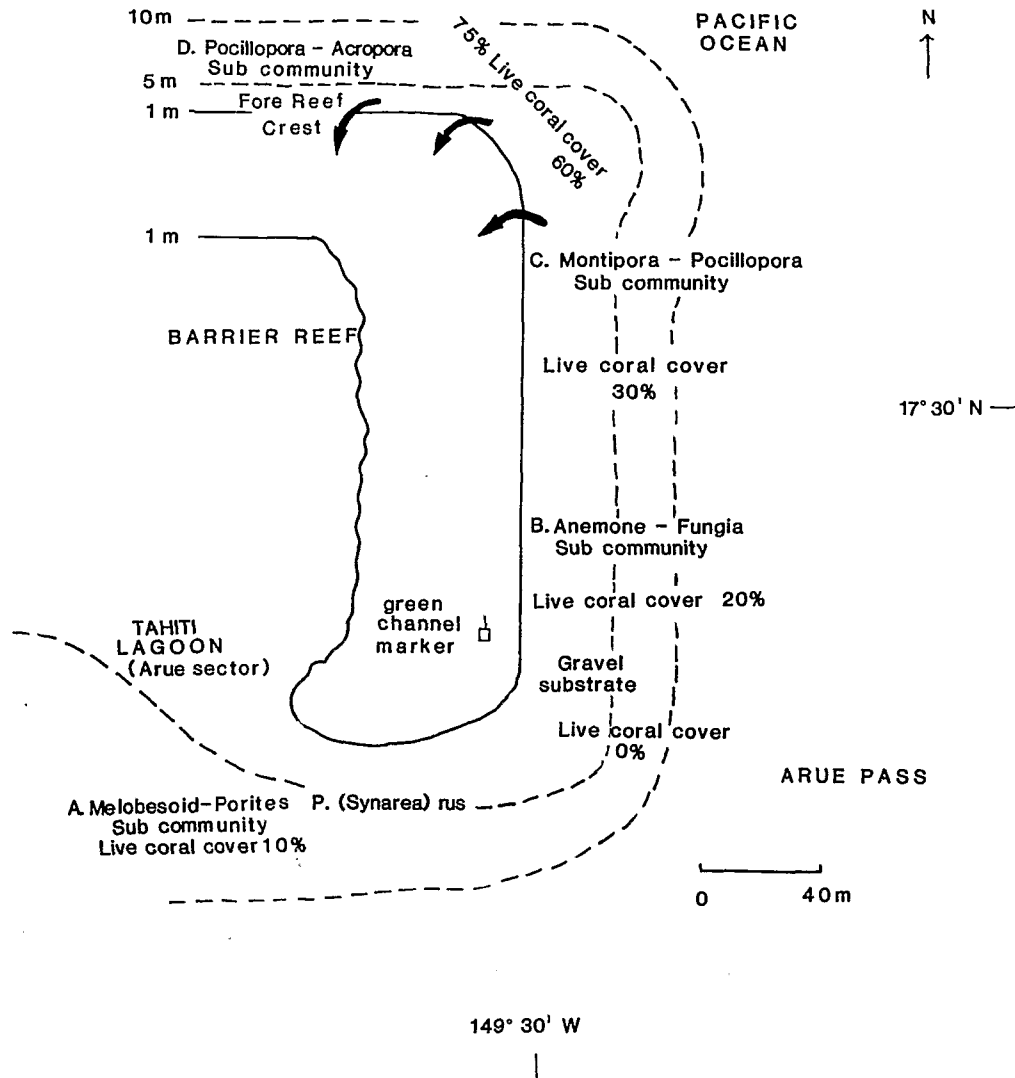


Fig. 1 Schematic map of the passe d'Arue area, north barrier reef of Tahiti showing general locations of four (A-D) reef subcommunities and estimates of % live coral cover. Isobaths (1, 5 and 10 m) in levels below mean sea level; reef crest exposed at low tide between 1 m isobaths. Large arrows indicate location of breaking waves near the pass entrance.

The bleaching progression in Area C was somewhat slower than in Area B, probably a reflection of differences in their dominant taxa. In Area C a bleaching 'steady state' for the two dominants was reached by 28 March. Thus, among *Montipora verneuilli*, 80% were partly bleached and 15% fully bleached and for *Pocillopora verrucosa* 50% of colonies had either exaggerated colours or were fluorescent.

The progression of bleaching for *Acropora* spp. in Area C was from about 15% fluorescent and 35% fully bleached on 28 March to 40% fluorescent and about 40% fully bleached on 18 April. These percentages remained about the same until 25 April when we saw the earliest evidence of death in two or three colonies of *Acropora* spp.

High surf prevented us from observing Area D until 1 April. During the succeeding 18 days colonies of *P. verrucosa* with exaggerated colours or fluorescent branch tips decreased from 45 to 35% but the fully bleached

colonies underwent a compensatory increase from 15 to 20%. During the same period in Area D, changes in *Acropora* spp. were dramatic. Fluorescent colonies increased from 55 to 85% and fully bleached decreased from 25 to 10% compensated by a drop in untouched colonies from 20 to only 5%. By 18 April, Area D had also reached a 'steady state' except for the earliest evidence of *Acropora* spp. death on 25 April.

To evaluate coral mortality from the 1994 bleaching event and its overall effect on the reef ecosystem we must wait until the end of the year. Present indicators suggest that it is a major event and will have short-middle term effects on reef survival in the Society Islands.

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