

Coral bleaching is a particularly difficult issue for an MPA manager as its cause cannot be ‘controlled’. This sheet summarises recent information on bleaching and outlines the various ways that an MPA may be able to assist in mitigation, promotion of the best conditions for recovery, and protection of reefs that are resilient to bleaching.

Coral bleaching is the whitening or paling of coral tissues due to the loss of microscopic symbiotic algae (zooxanthellae) and/or reduction of their photosynthetic pigment concentrations. The zooxanthellae live in the tissues of the host coral and provide it with most of its colour and energy. Bleaching occurs as a result of various harsh environmental conditions including high sea temperatures, abnormal salinity, and bacteriological or viral infection. In most reported incidences high sea temperature (1-2°C above normal maximum) appears to be the main stress. Low wind speed may also be important, as this apparently favours localized heating and a greater penetration of solar (UV) radiation. Prolonged bleaching conditions (for over c. 10 weeks) eventually kill coral polyps and ultimately the colony, but in many cases colonies recover after a certain time.

High sea surface temperatures (SSTs) associated with El Niño and probably climate change have already caused extensive coral bleaching and coral death, particularly in 1998, when the most geographically extensive bleaching event ever recorded took place. The Indian Ocean was the worst affected region, with a SST increase of 3°C for 3-5 months in some places of the WIO. By August 1998, many reefs had experienced some mortality, with up to 100% in some places (e.g. around the Seychelles granitic islands). Recovery has been very variable, but most places now show considerable improvement. To date, the socio-economic impact has not proved to be as serious as feared although potentially bleaching could have long-term impacts on fisheries and tourism.

The Intergovernmental Panel on Climate Change has predicted an increase of 1-2°C in SST over the next 100 years and coral bleaching may become a more regular event.

RESISTANCE AND RESILIENCE

Even with mass bleaching and severe mortality there is never a total loss of all reef-building corals, and scattered colonies, localised communities or whole reef sections will survive. Some reefs can return to their previous state of diversity and abundance more quickly than others through growth and reproduction of surviving colonies and recruitment of new corals.

Corals seem to be more resistant (i.e. colonies do not bleach or do not die if they bleach) if they are near, or affected by: cooler oceanic water and upwellings; strong currents, winds and high wave energy; shallow waters cooled through exposure to air at night; deeper waters less affected by the sun; turbid water which reduces penetration by UV light; cyclone conditions with high cloud cover

and mixing of shallow with deep water; points and narrow channels in the reef; and angled away from the sun.

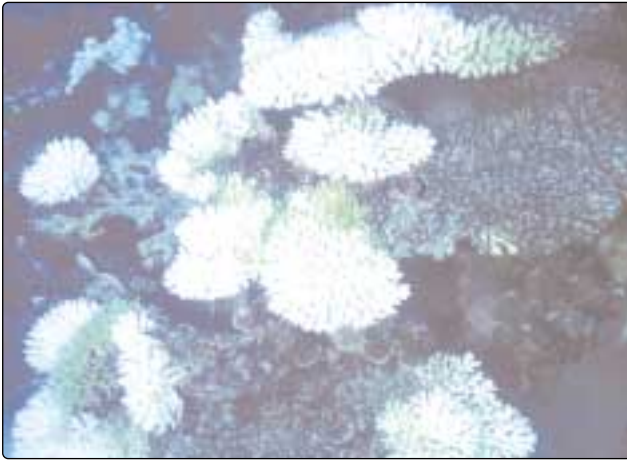
Speed of recovery of a reef from bleaching or its resilience is affected by: connectivity with other reefs through currents; abundance of coral recruits; abundance of species that eat algae and create free substrate for coral larval settlement; and prevalence of bioeroders, corallivores and disease.

MONITORING AND MITIGATION

Even though there is no ‘cure’ for bleaching, MPAs can play an important role in mitigation and aiding recovery, helping to maintain sources of coral larvae that can repopulate damaged areas and using zoning schemes to ensure full protection for corals that consistently resist bleaching and resilient reefs that recover quickly. Determining the start of a bleaching event is important but not always easy. Different categories of ‘paling’ tend to be subjective, but methods are being developed using standard colour charts (e.g. CoralWatch chart – see sources of information) or photographic/computer analysis techniques. Always seek expert advice if it looks as if bleaching may be starting.

KEY POINTS FOR THE MPA

- ❑ Consider developing a bleaching response programme (as has been done by the Great Barrier Reef Marine Park) that includes identifying resistant and resilient reefs through research and monitoring, revising zoning schemes and boundaries to ensure such reefs are fully protected, checking regularly for bleaching as part of monitoring, and monitoring recovery and recruitment after an event.
- ❑ Install temperature monitors (see sheet G5) and monitor SST web sites that give ‘early warning’ alerts for bleaching (see sources) – if the MPA falls into one of these areas, increase monitoring activities in order to record the start date of any bleaching event.
- ❑ Inform MPA users and stakeholders about bleaching so that they can understand why management interventions may have to change.
- ❑ Take all necessary steps to reduce stresses on reefs from human-induced sources (e.g. poor/destructive fishing techniques, pollution, siltation) and encourage conditions that will help corals to resist bleaching and recover quickly (e.g. protecting resistant corals).
- ❑ If the MPA is affected badly by bleaching, rehabilitation may be necessary (see sheet H6) but seek expert advice first; where bleaching is mild, reefs often recover naturally.



Bleached *Acropora* corals off Zanzibar, Tanzania, during the most recent El Niño event, May 1998.

Sources of further information

Marshall, P. & Schuttenberg, H. 2004. *Responding to Global Change: a Reef Managers Guide to Coral Bleaching*. GBRMPA/NOAA.

Obura, D. & Mangubhai, S. 2003. Assessing environmental and ecological factors and their contributions to coral bleaching resistance and resilience of reefs in the Western Indian Ocean. In: Obura, D., Payet, R. & Tamelander, J. (eds.) 2003. *Proceedings of the International Coral Reef Initiative (ICRI) Regional Workshop for the Indian Ocean, 2001*. ICRI/UNEP/ICRAN/CORDIO.

Salm, R.V. & Coles, S.L. (eds.) 2001. Coral Bleaching and Marine Protected Areas. *Proceedings of the Workshop on Mitigating Coral Bleaching Impact through MPA Design*. Bishop Museum, Honolulu, Hawaii, 29-31 May 2001. Asia Pacific Coastal Marine Program Report #0102, The Nature Conservancy, Honolulu, Hawaii, USA. 118pp. www.conserveonline or available from: The Nature Conservancy, Asia Pacific Region, 923 Nu'uuanu Avenue, Honolulu, HI 96817, USA.

The Nature Conservancy *et al.* 2004. *Reef Resilience: Building Resilience into Coral Reef Conservation*. CD-ROM toolkit. www.tnc.org

Schuttenberg, H.Z. (ed.) 2001. *Coral Bleaching: Causes, Consequences and Response*. Coastal Management Report #2230, Coastal Resources Center, University of Rhode Island, South Ferry Road, Narragansett, RI 02882, USA. www.crc.uri.edu

West, J.M. & Salm, R.V. 2003. Resistance and resilience to coral bleaching: implications for coral reef conservation and management. *Conservation Biology* **17**(4): 956-967

Westmacott, S. *et al.* 2000. *Management of Bleached and Severely Damaged Coral Reefs*. IUCN, Gland, Switzerland and Cambridge, UK. 36pp. Also available in Kiswahili, French and Portuguese. www.iucn.org/themes/marine/pdf/coralen.pdf

Australian Institute of Marine Science: www.aims.gov.au/pages/research/coral-bleaching/coral-bleaching.html

CORDIO Coral Reef Degradation in the Indian Ocean www.cordio.org

CoralWatch charts information available on www.CoralWatch.org

Great Barrier Reef Marine Park Authority Coral Bleaching Response Program: www.gbrmpa.gov.au/corp_site/info_services/science/bleaching/response_program.html

NOAA Sea Surface Temperature and Coral Bleaching Hotspots:

http://orbit-net.nesdis.noaa.gov/orad/sub/key_sst_50km_field.html and

http://orbit-net.nesdis.noaa.gov/orad/coral_bleaching_index.html

ReefBase (gives seawater hot spot data): www.reefbase.org

Reefs at Risk: www.wri.org/wri/reefsatrisk

Report on reefs and climate change: www.pewclimate.org/

Information on bleaching in French: <http://www2.univ-reunion.fr/~coraux/blanc/>

CASE STUDY

Rapid response to a bleaching event in Réunion, 2001

Réunion has only about 12 km² of reef, all lying within the Parc Marin de La Réunion, and any major bleaching event could have a devastating impact. Fortunately, less than 10% of the coral communities were affected by the 1998 bleaching event, as a result of a cyclone that caused cloudy conditions at the time. However, in February-March 2001, a warm water spot resulted in localised but intense bleaching, although reefs on neighbouring Mauritius were not affected. Data loggers had been installed and these showed that SST was 0.5-1°C higher than the average for that period.

A rapid response monitoring programme was put in place immediately, starting with a survey of 80 sites by scientists from the organisations ARVAM and ECOMAR, and the MPA 'ecoguards', with financial support from the Ministry of Environment (DIREN). This showed that the La Saline lagoon area was most affected, with 50-90% of corals showing some bleaching. Pockets of resistant corals, with 5-10% mortality or less, were rare. A long-term monitoring programme was then set up to study the recovery, with 14 permanent monitoring stations in seven sites and using GCRMN methods.

The bleaching events, as well as two cyclones in early 2002, resulted in high levels of siltation and freshwater input causing further bleaching and mortality. Despite this, overall reef condition has been relatively stable. This demonstrates that natural recovery can occur quickly (in some cases, bleached areas recovered within 4 months) and also the value of a long-term monitoring programme that includes physical parameters. In this case it showed that bleaching occurred not only in response to elevated SST, but also to siltation and freshwater input, or a combination of these stresses.

Turquet, J. *et al.* 2002. 2001 bleaching on *Acropora* dominated reefs in Réunion. In: Linden, O. *et al.* (eds.) *Coral Reef Degradation in the Indian Ocean*. Status Report 2002. CORDIO, University of Kalmar, Sweden.

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