Vulnerability of Corals to Seawater Warming

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CORAL reefs are the most diverse marine habitat, which support an estimated 1 million species globally. They are highly sensitive to climatic influences and are among the most sensitive of all ecosystems to temperature changes, exhibiting the phenomenon known as coral bleaching when stressed by higher than normal sea temperatures. Reef-building corals are highly dependent on a symbiotic relationship with microscopic algae (type of dinoflagellate known as zooxanthellae), which live within the coral tissues. The corals are dependent on the algae for nutrition and colouration. The bleaching results from the ejection of zooxanthellae by the coral polyps and/or by the loss of chlorophyll by the zooxanthellae themselves. Corals usually recover from bleaching, but die in extreme cases.

In the Indian seas, coral reefs are found in Gulf of Mannar, Gulf of Kachchh, Palk Bay, Andaman seas and Lakshadweep seas. Indian coral reefs have experienced 29 widespread bleaching events since 1989 (www.reefbase.org). Sea surface temperature in the Indian seas has warmed in these years. The relationship between past temperatures and bleaching events can help in understanding the number of future bleaching events in the coral regions in a scenario of further rising of sea surface temperature. Vulnerability of coral reefs to seawater warming in the Indian seas has been assessed here.

METHODOLOGY

To understand the effect of elevated temperatures, the large-scale (50 km) sea surface temperature coral bleaching hotspot anomaly image provided by the United States: National Oceanic and Atmospheric Administration (NOAA), National Environmental Satellite Data and Information Service (NESDIS) was used as a forecasting tool for potential bleaching conditions. These images are based on multi-channel, night-time only satellite AVHRR (Advanced Very High Resolution Radiometer on NOAA Polar Orbiting Environmental Satellites (POES) sea surface temperature data. These images highlight SST anomalies that are greater than 1°C above the maximum monthly mean (MMM) climatological sea surface temperature at each pixel. Degree Heating Week accumulations of these sea surface temperature hotspot anomalies, which usually commence at the 1°C threshold and provide an estimate of the residence time of anomalously warm water in the region, were considered. One Degree Heating Week is equivalent to 1 week of sea surface temperature 1° C above the MMM climatological

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value. Two Degree Heating Weeks are equivalent to two weeks of sea surface temperature 1°C or one week of sea surface temperature 2°C above the maximum monthly mean. Bleaching begins for corals exposed to degree heating week values of 0.5°C or more (Done *et al.*, 2003).

RESULTS AND DISCUSSION

The coral bleaching event in the Gulf of Mannar (GoM, south-east coast of India) in 1998 is given as an example here. In 1998 summer, sea surface temperature increased to 31.3° C on 5 April, peaked at 32.0° C on 3rd May, and remained at around 31.0° C until 14th June (Fig. 22.1), which was 2.0 to 2.5° C above the annual average of 29.3° C. High incidence of coral bleaching affecting 85% of the reefs in the Gulf of Mannar was reported during May 1998 (www.reefbase.org).

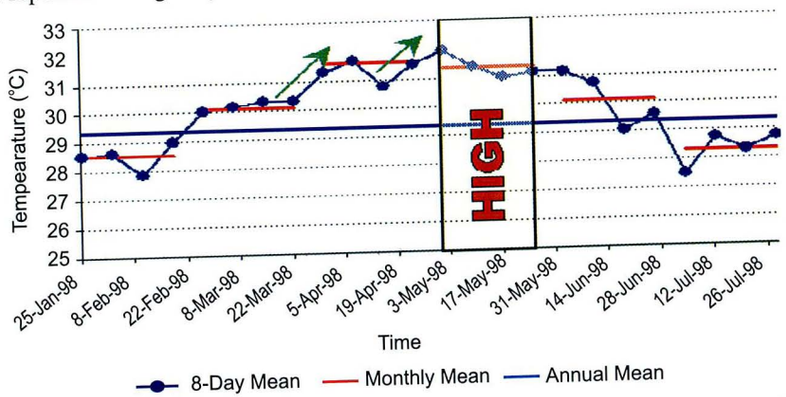

Fig. 22.1 Sea surface temperature profile prior to, during and after the "high" coral bleaching event of 1998 in the Gulf of Mannar (*Source*: AVHRR data)

To understand how reefs will respond to increasing thermal stress in the coming years, the analysis was pursued further by using UKMO HadCM3 model SRES A2 experiment output for the Gulf of Mannar region. For this, monthly sea surface temperature data for 2000-2099 were used and the analysis was carried out based on the following assumptions: (*i*) Though HadCM3 model was pursued, there was a difference between the satellite data and the predicted data. To overcome this problem, a pseudo-threshold limit was calculated for the Gulf of Mannar. Assuming that there was no bleaching incidence from 2000 to 2006 and corals can withstand this temperature, the DHM 0.5 was calculated based on average summer maximum for 2000-2006; (*ii*) Adaptation does not occur at rates fast enough to change thermal tolerances and hence, today's thermal thresholds will be similar for the next 100 years; (*iii*) Bleaching begins for corals exposed to DHM of 0.5 or more. Severe mortality events begin when corals are exposed to DHM equal to or greater than 3.2. This is equivalent to more than 9 weeks at +1°C anomaly above long-term sea temperatures, or 4.5 weeks at +2°C anomaly, and so on (Done *et al.*, 2003).

The analysis suggests that if the projected increase in sea temperature follows the trajectory suggested by the HadCM3 for an SRES A2 scenario, reefs should soon start to decline in terms of coral cover and appearance. The number of decadal low-bleaching

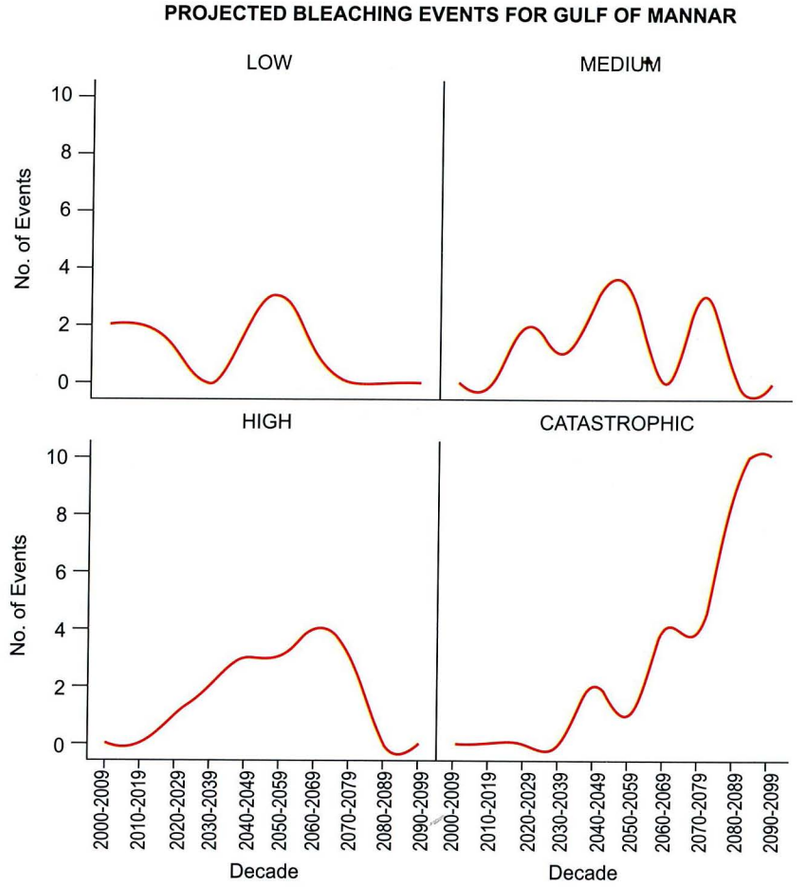

Fig. 22.2 Projected coral bleaching events for Gulf of Mannar for different decades in future

events will remain between 0 and 3 during 2000-2099 (Fig. 22.2), but the number of catastrophic events will increase from 0 during 2000-2009 to 10 during 2090–2099.

On a simple first inspection of the SRES A2 scenario, corals will be soon exposed to regular summer temperatures that will exceed the thermal thresholds observed over the last 20 years. For example, if the summer temperatures exceed 31.5° C for even a few weeks, then bleaching will eventuate in the Gulf of Mannar. If, as suggested by this scenario, these temperatures reach almost every summer from 2025 onwards, annual bleaching will become almost a certainty from 2050 AD in the Indian Seas. Given the implication that reefs will not be able to sustain catastrophic events (> 3.2 DHM) more than 3 times a decade (Done *et al.*, 2003), reef building corals are likely to disappear as dominant organisms on coral reefs between 2030AD and 2040 AD and the reefs are likely to become remnant between 2050 AD and 2060AD in the Gulf of Mannar.

By 2050 AD, catastrophic exposure is the most likely outcome. This scenario would mean a non-coral dominated reef structure by 2030 AD in Lakshadweep region and

2050AD in other reef regions. By 2050AD, the likelihood of a catastrophic exposure is every 10 years.

CONCLUSIONS

Given the implication that reefs will not be able to sustain catastrophic events more than three times a decade, reef building corals are likely to disappear as dominant organisms on coral reefs between 2020AD and 2040AD and the reefs are likely to become remnant between 2030AD and 2040AD in the Lakshadweep region and between 2050AD and 2060AD in the Andaman and Nicobar regions. These projections on coral reef vulnerability have taken into consideration only the warming of seawater. Other factors viz., increasing acidity of seawater would dissolve the calcium carbonate in the exoskeleton of the reefs, and some scientists opined that if the acidification continues as it is now, all the coral reefs in the world oceans would be dead within 50 years.

REFERENCES

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Reefbase. www.reefbase.org