Proceedings of the 11th International Coral Reef Symposium, Ft. Lauderdale, Florida, 7-11 July 2008
Session number 25

Coral reefs of the Gulf of Mannar, Southeastern India - observations on the effect of elevated SST during 2005-2008

J.K.P. Edward[1], G. Mathews[1], K.D.Raj[1], J.Tamelander[2]

1) Suganthi Devadason Marine Research Inst, 44 Beach Road, Tuticorin 628 001, Tamil Nadu, India
2) IUCN Global Marine Programme, P.O. Box 13513, Dar es Salaam, Tanzania

Abstract. The effect of elevated sea surface temperature (SST) on the coral reefs of the Gulf of Mannar, Southeastern India was monitored during 2005-2008 using quadrate and LIT methods. The pattern of effect was almost similar on the reefs every year except the modest fluctuations in the temperature levels. The temperature varied between 31.0^{0}C and 33.5^{0}C during summer (April - June). The major reef areas in the Gulf of Mannar are shallow, between 0.5-3.0 m depth and in general, comparatively high temperature prevailed and the reefs seem to be acclimatized to such situation. The average percentage of bleached corals during 2005, 2006, 2007 and 2008 was 14.6, 15.6, 12.9 and 10.5 respectively. The bleaching of corals was noticed from mid April and high temperature existed for about a month from the end of April. Massive corals especially *Porites* sp. were the first to be affected and the other dominant coral species partially / fully bleached were *Acropora cytherea, A. formosa*, *A. intermedia, A. nobilis, Montipora foliosa*, *M. digitata* and *Pocillopora damicornis*. The incidence of bleaching was not uniform every year, in terms of area and depth, but the pattern was same. Dependent on rainfall and winds, recovery began during June-July and completed in 1-4 months. The branching corals recovered quickly after temperature reduction, but massive corals took longer time. The fastest recovered coral size groups were 40-80 cm and 80-160 cm. There was no coral mortality in 3 years due to elevated SST, but 80% of the bleached recruits dead in 2007.

Key words: Coral reef, climate change, annual bleaching, SST

Introduction

Coral reefs appear to be undergoing worldwide decline (Epstein et al. 2001; 2003). An estimated 20% of coral reefs worldwide have been destroyed, while 24% are in imminent danger and a further 26% are under longer term danger of collapse (Wilkinson 2004). Although much of the coral reefs degradation is directly blamed on human impact, there are natural disturbances causing significant damage to coral reefs.Global warming is undoubtedly important, many instances of bleaching being correlated with increased temperature (Glynn 1991; Glynn 1993; Warner et al. 1999). Increased sea surface temperatures, decreased sea level and increased salinity from altered rainfall can all result from weather patterns such as El Nino (Forrester 1997). Unprecedented anthropogenic pressures on reefs have been exacerbated in the 1980s and 1990s by several strong El Nino Southern Oscillation events, which have been correlated with widespread warm water anomalies and associated bleaching and mortality of corals (Glynn 1984; 1993; Wilkinson et al. 1999).

Reefs in the Gulf of Mannar are developed around the 21 uninhabited islands that lie along the 140 km stretch between Tuticorin and Rameswaram of Tamilnadu, Southeast coast of India (Fig.1).

Figure 1 Map showing Gulf of Mannar

These islands are located between latitude 8º47' N and 9º15'N and longitude 78º12'E and 79º14'E and the average distance of these islands from mainland is about 8 km. The once rich reefs of Gulf of Mannar have been heavily exploited in the past 2-3 decades. Now, due to conservation initiatives, tightening of the enforcement and permanent halt of the coral mining, coral cover is increasing remarkably. However, significant coral bleaching was observed in the Gulf of Mannar in 2005. The present monitoring was initiated to collect baseline information on temperature variation and its impact on corals.

Materials and methods

The temperature was measured monthly in the reef areas of all the islands of the Gulf of Mannar during the period between 2005 and 2008 by digital thermometer. Permanent sites at each islands assessed the bleaching. Percentages bleaching during the summer months and recovery after consequent months were estimated using Line Intercept Transect method (English et al., 1997) and quadrate method.

Results

Temperatures in the Gulf of Mannar are never below 26 ºC. Summer temperatures (April to June) varied between 31.0º C to 33.5ºC. Sea surface temperature peaks during May (overall range 26.5 to 30.5ºC; Fig.2-3).

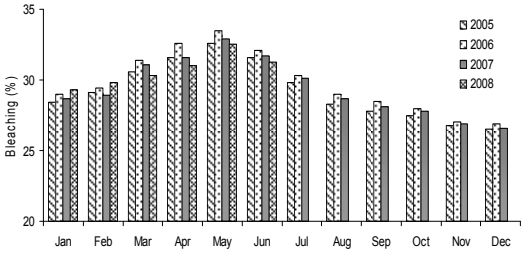

Figure.2: Average monthly SST values in the Gulf of Mannar during 2005 to 2008

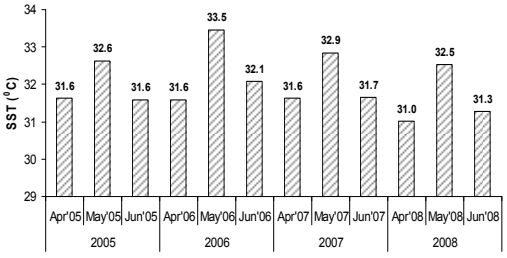

Figure 3: Sea surface temperature (^{0} C) in summer (April, May and June) during 2005 to 2008 in the Gulf of Mannar

Corals bleached every year since 2005 during summer starting from April. Average percentage of bleached corals was 15.6% during 2006, 14.6% in 2005, 12.9% in 2007 and 10.5% in 2008 (Fig.4).

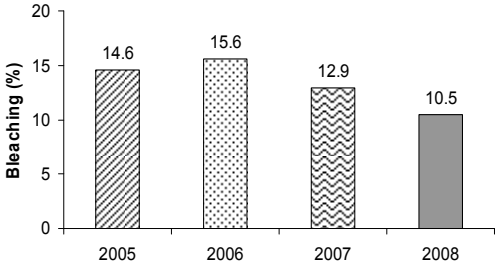

Figure 4: Percent of bleaching in summer (April, May and June) during 2005 to 2008 in the Gulf of Mannar

Massive corals especially *Porites* sp. were the first to be affected and the other dominant coral species partially or fully bleached were *Acropora cytherea*, *A. formosa, A. intermedia, A. nobilis, M. foliosa, M. digitata* and *Pocillopora damicornis*. *A. cytherea* bleached the most (2.91% during 2006) followed by *A. formosa* with 2.55%. In 2005 the most affected species was *A. cytherea* with 2.44% followed by *M. digitata* with 2.12%. In 2007, the highest affected was *Porites* sp. with 2.05% followed by *A. cytherea* and *A. intermedia* and in 2008 it was *Porites* sp. with 1.75% followed by *A. formosa* with 1.66%. The details are given in the Fig.5.

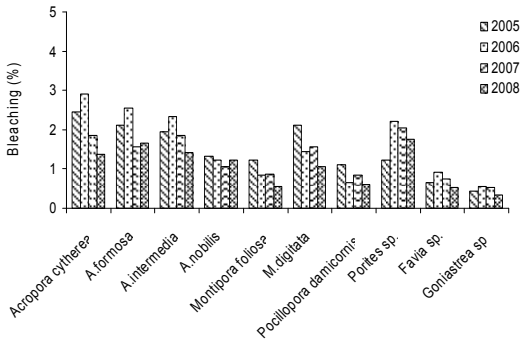

Figure 5: Percent of bleaching in common coral species in the Gulf of Mannar

Incidence of bleaching was not uniform every year in terms of area and depth, but the pattern was comparable. Depending on rainfall and winds, recovery began during June-July and was completed in 1-4 months. The branched corals recovered quickly after temperature reduction, but massive corals recovered slower.

The fastest recovered coral size groups were 40-80 cm and 80-160 cm. There was no coral

mortality in 4 years due to elevated SST, but 80% of the bleached recruits dead in 2007.

Discussion

The projected increases in ocean temperatures are expected to exacerbate the stressors already affecting many coral reefs, resulting in additional coral bleaching and mortality (Pockley 2000; Hughes et al, 2003; Pandolfi et al. 2003). However, the reported annual bleaching in the Gulf of Mannar did not result in any appreciable mortality, maybe because the area has already been severely disturbed. In the Gulf of Mannar, corals tend to bleach when exposed to 2 to 3ºC elevated temperature level in late April every year. Hoegh-Guldberg (1999) predicted that mass bleaching could become an annual occurrence by 2020 in Southeast Asia and the Caribbean, by 2030 on the Great Barrier Reef and by 2040 in the central Pacific. This prediction is already reality in the Gulf of Mannar since the bleaching event happens every year in the same time since 2005.

Corals that are regularly exposed to stressful environmental conditions have, in some cases, been shown to acclimatize and exhibit physiological tolerance to elevated temperatures and UV-radiation that exceed normal thresholds. Reef areas in the Gulf of Mannar are shallow, (0.5-3 m depths), and high temperature around 29ºC prevails throughout the year. Corals seem to be acclimatized but temperature over 31.0ºC causes bleaching and the corals start to recover when the temperature level falls to normal.

Factors influencing resistance of corals to high temperatures include extrinsic (environmental) factors such as strong water currents that reduce the severity of thermal stress (West and Salm 2003; Jokiel 2004), and intrinsic (physiological) factors such as incorporation of heat-resistant zooxanthellae clades (Baker 2004) and the production of heat shock proteins (Brown et al. 2002). Identifying and protecting habitats and colonies that are relatively resistant to high temperatures is important for conserving coral reefs in the face of global warming (West and Sal, 2003). In 2008, the percentage of bleaching was relatively low (10.5%) because of cyclone Nargis and subsequent rainfall and winds which reduced the temperature level by the end of May. There was no coral mortality in 4 years due to elevated SST, but 80% of the bleached recruits died in 2007. Despite this mortality, reefs in the Gulf of Mannar appear surprisingly resilient.

Acknowledgements The authors are thankful to the Coastal Ocean Research and Development in the Indian Ocean (CORDIO) and IUCN for the financial support; and PCCF & Chief Wildlife Warden, Tamil Nadu forest Department and Wildlife Warden, GOMMNP for the research permissions.

Reference

Baker, A.C (2004) Changing by degrees: Algal symbiont communities in reef corals from high temperature environments, latitudinal limits and seasonal extremes. Proc 10th Int Coral Reef Symp, Okinawa, Japan

Brown BE, Downs CA, Dunne RP, Gibb SW (2002) Exploring the basis of thermo tolerance in the reef coral Goniastrea aspera. Mar Ecol Prog Ser 242:119-129

English S, Wilkinson C, Baker V (1997) Survey manual for tropical Marine resources. Australian Institute of Marine Science, Townsville Australia 2:390

Epstein N, Bak RPM, Rinkevich B (2001) Strategies for gardening denuded reef areas: the applicability of using different types of coral material for reef restoration. Rest Ecol **9**:432–442

Forrester A (1997) The Effects of El Niño on Marine Life. Cambridge Scientific Abstracts Web site http://www.csa.com/hottopics/elnino/overview.html

Glynn PW (1993) Coral reef bleaching: ecological perspectives. Coral Reefs 12:1-17

Glynn PW (1984) Widespread coral mortality and the 1982/83 El Ni~no warming event. Environmental Conservation 11:133-146

Glynn PW (1991) Coral reef bleaching in the 1980s and possible connections with global warming. Trends Ecol Vol 6

Hoegh-Guldberg O (1999) Climate change, coral bleaching and the future of the world's coral reefs. Marine and Freshwater Research 50:839-866

Hughes TP, Baird AH, Bellwood DR, Card M, Connolly, Folke C, Grosberg R, Hoegh-Guldberg O, Jackson JBC, Kleypas J, Lough JM, Marshall P, Nystrom M, Palumbi SR, Pandolfi JM, Rosen B, Roughgarden J (2003) Climate Change, Human Impacts, and the Resilience of Coral Reefs. Science 301: 929-933

Jokiel PL (2004) Temperature stress and coral bleaching. In: Rosenberg E, Loya Y (eds.) Coral Health and Disease. Springer-Verlag, Heidelberg 401-425

Pandolfi JM, Bradbury RH, Sala E, Hughes TP, Bjorndal KA., Cooke RG, McArdle, D, McClenachan L, Newman MJH, Paredes G, Warner RR, Jackson JBC (2003) Global Trajectories of the Long-Term Decline of Coral Reef Ecosystems. Science 301: 955-958

Pillai CSG (1971) Composition of the coral fauna of the southeastern coast of India. In: Stoddart DR, Young CM. (eds.), Regional Variation in Indian Ocean Coral Reefs. Symp Zoolo Socit of London 28:301-325

Pockley P (2000) Global warming identified as main threat to coral reefs. Nature 407: 932

Warner ME, Fitt WK, Schmidt GW (1999) Damage to photosystem II in symbiotic dinoflagellates: a determinant of coral bleaching. Proc. Natl. Acad. Sci 96: 8007– 8012

West JM, Salm RV (2003) Resistance and resilience to coral bleaching: Implications for coral reef conservation and management. Conser Biol 17: 956-967

Wilkinson C (ed.) (2004) Status of coral reefs of the world. AIMS: Townsville (Australia) 557

Wilkinson C, Lind_en O, Cesar H, Hodgson G, Rubens J, Strong AE (1999) Ecological and socioeconomic impacts of 1998 coral mortality in the Indian Ocean: an ENSO impact and a warning of future change? Ambio 28:188-196