

Coral bleaching in Andaman Sea – an indicator for climate change in Andaman and Nicobar Islands

Tamal Mondal*, C. Raghunathan & K. Venkataraman¹

Zoological Survey of India, Andaman and Nicobar Regional Centre, National Coral Reef Research Institute, Port Blair-744 102, Andaman and Nicobar Islands, India

¹ Zoological Survey of India, Prani Vigyan Bhavan, M- Block, New Alipore, Kolkata-700 053, India

*[E.Mail: t_genetics@yahoo.com]

Received ; revised

Andaman Sea is one of the highly productive seas in the world. The western boundary of the Andaman Sea is bordering Andaman and Nicobar Islands which harbours more than 400 species of scleractinian coral with the formation of fringing reef along the continental shelf. Scleractinians corals and zooxanthellae (micro algae) are setting up a mutual symbiotic relationship for the survival of each other. A fundamental niche is very much required to maintain the above said relationship. Temperature is one of the curators to make the niche sense. Abrupt rise in Surface Sea Temperature (28°C to 31.7°C) was recorded in April to July 2010 which leads to massive coral bleaching i.e. displacement zooxanthellae from residing scleractinian to the mark of 80±10.5%. On resumption of normal environmental features in due course, recuperation of bleached corals or re-association of zooxanthellae with scleractinian corals was measured up to a maximum of 81.84±3.7% over the period of year. Besides new recruitment of corals (23.15±6.9%) was also noticed in reef areas of Andaman and Nicobar Islands. Coral bleaching is yet another clarion call for Andaman Sea on climate change which needs to be mitigated through effective managerial strategies at regional as well as global scale.

[Key Word: Coral bleaching, Andaman Sea, Climate Change, Andaman and Nicobar Islands]

Introduction

The Andaman and Nicobar Islands are a low mountain chain of islands, which rise from a submerged north-south trending ridge separating the sea from Bay of Bengal between 6°-14° N and 92°-94° E. There are 572 islands in the chain, some of which are volcanic, surrounded by Coco Chanel on North, Great Chanel in extreme South, Andaman Sea in East and Bay of Bengal in West. Apart from that, most of the islands are separated by several channel with insist the flow of water current among islands and maintain the biogenic habitat of underwater life. These islands occupy an area of 8293 km² with a coastline of 1962 km and account for 30% of the Indian Exclusive Zone¹. Coral reefs are most imperative to coastal ecosystems. These massive, calcareous structures are called “underwater rainforests”, which support the most biologically diverse marine ecosystems. Principal producer organisms are microscopic algae called as zooxanthellae that live within the coral tissues. This symbiotic relationship enhances the biological activity of the community in terms of the abundance and the diversity of plants and animals found on the reefs. Coral and zooxanthellae exist in a symbiotic relationship. Coral provides shelter, CO₂, Nitrogen and

Phosphorous for the zooxanthellae and, in return, the zooxanthellae provide energy, O₂ and organic matter through photosynthesis^{2, 3}. Bleaching is a stress response that results when the coral-algae relationship breaks down. The first reported thermal bleaching event was in 1911 at Bird Key Reef in the Florida Keys⁴. Worldwide bleaching of scleractinians was also reported in 1929⁶. In 1999, a report was made by Hoegh-Guldberg that, Climatic changes have great impact on the bleaching of scleractinian corals⁷. Bleaching was also recorded in Jamaica in 1987, 1988, 1990 while in the Indian Ocean, corals in the Andaman Sea bleached in 1991 and again in 1995^{8, 9}. There was a major episode of coral bleaching in 1997 and 1998. Gradually increased global warming produces significant increases in the frequency of high surface sea temperatures^{7, 10}. Scleractinian Coral bleaching is associated with abnormal surface sea temperature (SST) or salinity changes in tropical oceans worldwide¹¹⁻¹⁵. Bleaching in corals could result from a reduction in the content of chlorophyll a^{16, 17} and associated pigments per zooxanthella^{18, 19}, a decline in the population density of zooxanthellae^{20, 21}, or both^{13, 22}. Recent studies have demonstrated that high levels of solar irradiance may exacerbate bleaching

during periods of thermal stress^{23, 7,24} and may cause bleaching at temperatures that would otherwise not elicit bleaching^{9,25}. Most of the islands of Andaman group are surrounded by a massive coral population in fringing pattern showed a great deal of bleaching due to rise of climatic changes or surface sea temperature (SST) during May to August, 2010. The bleached corals also started recovery as well as new recruitments of several scleractinians have been noticed in due course of time. This paper describes the observation on mass bleaching of corals and their recovery in these groups of islands.

Material & Methods

Surveys were conducted during April 2010 to November, 2011 at fifty five sites of Andaman Islands, which were categorized in five main stations to study the scale of bleaching in scleractinian corals and their recovery status (Fig. 1). LIT method²⁶ was applied to carry out the surveys by employing Self –Contained Underwater Breathing Apparatus (SCUBA) diving and snorkeling to estimate the bleaching and live cover. Sony - Cyber shot, Model-T900, marine pack, 12.1 megapixels and underwater video of Sony DCR-TRV330E with marine pack were used for photography and videography respectively. Identification was done *in situ* observation as well as photographs in conjunction with Veron²⁷, Wallace²⁸ and Sheppard²⁹.

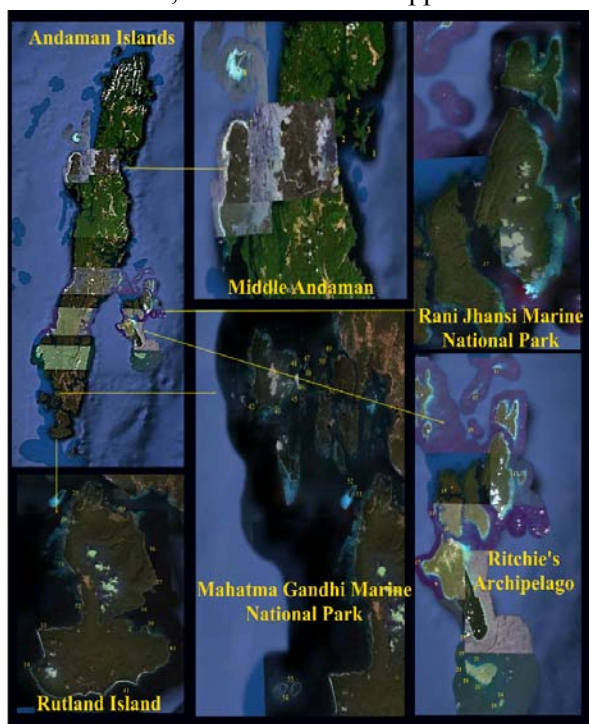


Fig. 1- Study areas of Andaman group of Islands

Results

Temperature is one of the crucial climatic parameter for regulating corals lives. Maximum surface sea temperature of the area surveyed was 28-31.7°C during May to August, 2010. The extent of corals bleaching showed a maximum in Mayabunder (90.43%) where as the minimum was recorded in Rani Jhansi Marine National Park (RJMNP) (69.83%) (Fig. 2). On the basis of extensive surveys more than 400 species of Scleractinian corals were examined as an effective output of coral bleaching in this area studied. The intensity of bleaching was maximum at the depth of 5-15 meter in Rutland Island, Mayabunder and Mahatma Gandhi Marine National Park (MGMNP), and the reefs are healthy beyond 20 m in the study areas. Massive bleaching was recorded in branching, foliose and plate corals. It was quite low in level for the massive corals. Surface Sea Temperature was minimized during the October 2010 onwards at 25-28°C. Due to this favourable habitat, scleractinians corals started to recover. Maximum recovery of bleached corals was observed in Rutland Island (85.1%) where as minimum was recorded at Mayabunder (77.4%) (Fig. 3). New recruitment of several species of scleractinians was also noticed among the study

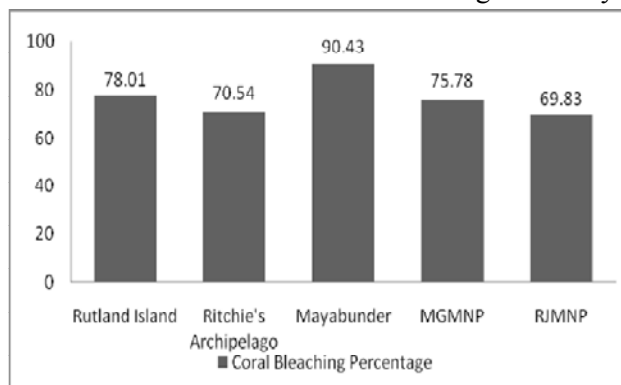


Fig. 2- Percentage of bleaching corals in study areas

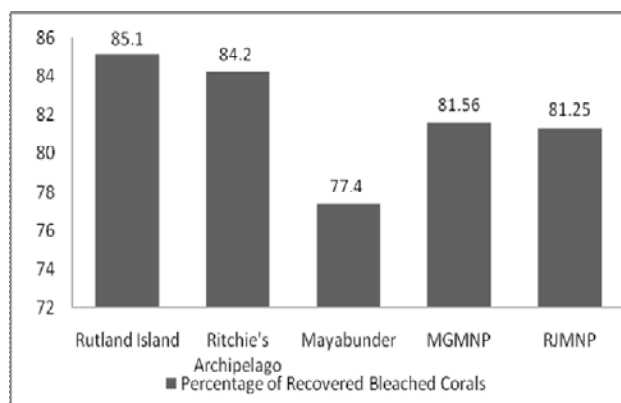


Fig. 3- Percentage of recovery of bleached corals in study areas

areas with maximum of 30.1% at RJMNP and minimum of 16.2% in Mayabunder (Fig. 4).

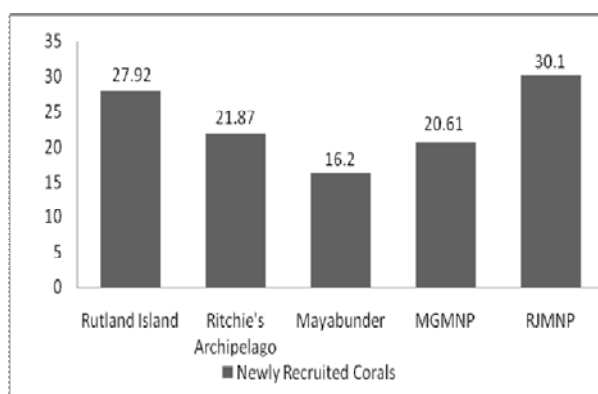


Fig.4- Percentage of newly recruited corals

Discussion

Displacement of zooxanthallae from scleractinian structures is the outcome of coral bleaching. Bleaching events were encountered several times occurred prior to the 1980s. Major global bleaching event was occurred in 1998 where ocean temperatures reached levels of up to 2.8°C above normal and lasted for periods of days to even months^{30,31}. Reef areas in the Gulf of Mannar are shallow (0.5- 3 m depths), and high temperature around 29°C prevails throughout the year. Corals seem to be acclimatized but temperature over 31.0°C causes bleaching and the corals start to recover when the temperature level falls to normal. In 2000, Arthur concluded that coral bleaching in Lakshadweep Sea, Gulf of Mannar and Gulf of Kachchh when abnormal SST had begun to affect Indian reef areas. Between 30% and 40% of coral cover were severely bleached in the Lakshadweep and Gulf of Mannar reefs respectively and more than 20% died in both the areas because of bleaching related stress³². Bleaching was seen more than 90% at Sylph's Hole and Comet's Hole in the lagoon during the summer of 2010³³. Bleaching of mushroom corals was massive up to the depth of 20 m at Koh Tao, Western Gulf of Thailand³⁴. Thai universities and NGOs of Thailand reported that the Sea surface temperatures anomalies of between 30-34°C were recorded during March to June 2010 in the Andaman Sea and the Gulf of Thailand which caused the severe coral bleaching of over 80% at several reef sites³⁵. In this year, the Surface Sea Temperature of Andaman Islands associated areas was 28 to 31.7°C during the day time. NOAA announced detailed bleaching alerts related to sea surface temperatures in 2010 about the thermal stress on corals. Most of the northern Indian

Ocean and Southeast Asia regions have been experiencing intensive thermal stress due to increase in SST. Bleaching was observed in entire reef ecosystem of Andaman and Nicobar Islands. With the quantified data of bleached corals, bleaching was seen 80± 10.5%. Being a climatic factor temperature in reduced normal level (25-28°C) also helped corals for their recovery with a great resilience. Resilience of recovery was documented as 81.84±3.7% from the study areas. Corals are the truly such a parametric bio-indicators, which show a high level of physiological as well as morphological alteration in response of high temperature through the process of bleaching and recovery with the presence of favourable comparative low level of temperature.

Acknowledgement

Authors are grateful to the Ministry of Environment, Forests, Govt. of India for providing financial assistance to undertake the study through the projects of National Coral Reef Research Institute, Zoological Survey of India, Port Blair.

References

- 1 Jeyabaskaran, R. Report on Rapid Assessment of coral reefs of Andaman & Nicobar Islands. GOI/UNDP/GEF Project on Management of Coral Reef Ecosystem of Andaman & Nicobar Islands. Published by Zoological Survey of India, Port Blair (1999) 110p.
- 2 Humann, P. *Reef Coral Identification: Florida, Caribbean, Bahamas*. New World Publications, Inc. Jacksonville, Florida (1993).
- 3 National Oceanic and Atmospheric Administration. Coral Reef Information System. About Coral Reefs. <<http://www.coris.noaa.gov/about/>> (2008).
- 4 Mayer, A.G. *The effects of temperature upon marine animals*. Carn Inst Washington Pub Papers Mar Lab Tortugas **6** (1914) 3–24.
- 5 Yonge, C.M. & Nicholls, A.G. Studies on the physiology of corals. IV. The structure, distribution and physiology of the zooxanthellae. *Sci. Rep. Gt. Barrier Reef Exped.* 1928–1929 **1**(1931) 135–176.
- 6 Shinn, E.A. Coral growth-rate, an environmental indicator. *J. Paleontol.* **40** (1966) 233–241.
- 7 Hoegh-Guldberg, O. Climate change, coral bleaching and the future of the world's coral reefs. *Marine and Freshwater Research* **50** (1999) 839–866.
- 8 Hughes, T.P. Catastrophes, phase shifts, and large-scale degradation of a Caribbean coral reef. *Science* **265** (1994) 1547–1551.
- 9 Brown, B.E., Dunne, R.P., Scoffin, T.P. & Le Tissier, M.D.A. Solar damage in intertidal corals. *Mar. Ecol. Prog. Ser.* **105** (1994) 219–230.
- 10 Crabbe, M.J.C., Walker, E.L.L. & Stephenson, D.B. The impact of weather and climate extremes on coral growth. In: Diaz, H., Murnane, R. (Eds.), *Climate*

- Extremes and Society. Cambridge University Press, Cambridge, UK (2008). pp. 165– 188.
- 11 Brown, B.E. & Suharsono. Damage and recovery of coral Reefs affected by El-Nino related seawater warming in the Thousand Islands, Indonesia. *Coral Reefs* **8**(1990) 63-170.
- 12 Coles, S.J. & Fadlallah, Y.H. Reef coral survival and mortality at low temperatures in the Arabian Gulf: new species-specific low temperature limits. *Coral Reefs* **9**(1990) 231-237.
- 13 Glynn, P.W. & D'Croz, L. Experimental evidence for high temperature stress as the cause of El Nino – coincident coral mortality. *Coral Reefs* **8** (1990) 181-191.
- 14 Williams, M.F. & Bunkley-Williams, L. The world-wide coral Reef bleaching cycle and related sources of coral mortality. *Atoll Res. Bull.* **11**(1990)270-279.
- 15 Fang, L.S., Cheng, Y.W. & Chen, C.S. Feasibility of using ATP as an index for environmental stress on hermatypic coral. *Mar. Ecol. Prog. Ser.* **70** (1991) 257-262.
- 16 Porter, J.W., Fitt, W.K., Spero, H.J. & Roger, C.S. White MW. Bleaching in reef corals: physiological and stable isotope Responses. *Proc. Natl. Acad. Sci. USA* **86** (1989) 9342-9346.
- 17 Szmant, A. & Gassman, N.J. The effects of prolonged “bleaching” on the tissue biomass and reproduction of the reef Coral *Montastrea annularis*. *Coral Reefs*, **8** (1990) 217-224.
- 18 Kleppel, G.S., Dodge, R.E. & Reese, C.J. Changes in pigmentation associated with the bleaching of stony coral. *Limnol. Oceanogr.* **34** (1989) 1331-1335.
- 19 Fang, L.S., Liao, C.W. & Liu, M.C. Pigment composition in Scleratinian coral of different color and during its bleaching process. *Zool. Stud.* **34**(1995) 10-17.
- 20 Fisk, D.A. & Done, T.J. Taxonomic and bathymetric patterns of bleaching in corals, Myrmidorn Reef (Queensland). *Proc. 5th Int. Coral Reef Symp.* **6** (1985) 149-154.
- 21 Hoegh-Guldberg, O. & Smith, G.J. The effect of sudden changes in temperature, light and salinity on the population density and export of zooxanthellae from the reef corals *Stylophora pistillata* Esper and *Seriatopora hystrix* Dana. *J. Bull. Mar. Biol. Ecol.* **129** (1989) 279-303.
- 22 Lesser, M.P., Stochaj, W.R., Tapley, D.W. & Shick, J.M. Bleaching in coral reef anthozoans: effects of irradiance, ultraviolet Radiation, and temperature on the activities of protective Enzymes against active oxygen. *Coral Reefs*, **8** (1990) 225-232.
- 23 Glynn, P.W. Coral reef bleaching: Facts, hypotheses and Implications. *Glob. Change Biol.* **2** (1996) 495–509.
- 24 Mumby, P.J., Chisholm, S.W., Edwards, A.J., Andrefouet, S. & Jaubert, J. Cloudy weather may have saved Society Island reef corals during the 1998 ENSO event. *Mar. Ecol. Prog. Ser.* **222** (2001) 209–216.
- 25 Dunne, R.P., Brown BE. The influence of solar radiation on bleaching of shallow water reef corals in the Andaman Sea, 1993–1998. *Coral Reefs* **20** (2001) 201–210.
- 26 English, S., Wilkinson, C. & Baker, V. *Survey manual for tropical marine resources*. 2nd Edition. Australian Inst. Mar. Sci., (1997) 390 pp.
- 27 Veron, J.E.N. *Corals of the World*. Australian Institute of Marine Science, **1-3** volumes (2000).
- 28 Wallace, C.C. *Staghorn Corals of the World*. CSIRO Publications, Melbourne (1999). pp 421.
- 29 Sheppard, C.R.C. Coral species of the Indian Ocean and adjacent seas:a synonymised compilation and some regional distribution patterns. *Atoll Res. Bull. No.* **307** (1987).
- 30 Goreau T, McClanahan T, Hayes R, Strong A. Conservation of coral reefs after the 1998 global bleaching event. *Conservation Biology* **14** (2000) 5-15.
- 31 Loya, Y., Sakai, K., Yamazato, K., Nakano, Y., Sambali, H. & van Woesik, R. Coral bleaching: the winners and the losers. *Ecology Letters* **4** (2001) 122-131.
- 32 Arthur, R. Coral bleaching and mortality in three Indian reef regions during an El Nino southern oscillation event. *Curr. Sci.* **79** (2000) 1723 -1729.
- 33 Harrison, P.L., Dalton, S.J. & Carroll, A.G. Extensive coral bleaching on the world’s southernmost coral reef at Lord Howe Island, Australia. *Coral Reefs* **30** (2011) 775.
- 34 Hoeksema, B.W., Matthews, J.L. & Yeemin, T. The 2010 coral bleaching event and its impact on the mushroom Coral fauna of Koh Tao, Western Gulf of Thailand. *Phuket mar. biol. Cent.Res.Bull.* **71** (2012) 71–81.
- 35 Yeemin,T., Mantachitra, V., Plathong, S., Nuclear, P., Klinthong, W. & Sutthacheep, M. Impacts of coral bleaching, recovery and management in Thailand. *Proc. 12th Int. Coral Reef Symp., Cairns, Australia* (2012).