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9A Coral Bleaching and Climate change

Bleaching of Corals in Agatti-Lakshadweep, India: A window view

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Abstract. Lakshadweep is an archipelago of coral islands consisting of 12 atolls, 3 reefs and 5 submerged banks scattered in the Arabian Sea (8°-12°3'N latitude and 71°E-74°E longitude) and this region is well known for its coral diversity. In the present study, underwater visual surveys were conducted to document the coral bleaching at the Agatti Island, which covers a reef area of about 17.50 km^2. Under-water surveys were carried out at two stations on north (Station I) and south (Station II) sides of the island during May to June 2010, adopting snorkeling and scuba. The delayed onset of monsoon rains caused sea surface temperatures (SSTs) to rise above than the seasonal average, which triggered widespread bleaching of corals. The mean SSTs were above 31°C and reached a maximum up to 34°C during the study period. The Agatti reefs showed an average of 76.5% bleached corals with 87.5% of the associated organisms like sea anemones and 88% of giant clams also bleached. The level of bleaching varied significantly between the northern and southern part of the lagoon. The ecological and socio-economic implications of this bleaching event are that, this ecosystem supports source of fisheries as well as the collection of ornamental organisms. There is an urgent need for continuous monitoring of coral reefs of the Lakshadweep islands.

Keywords: Lakshadweep, Arabian sea, coral bleaching, sea surface temperature, associated organisms

Introduction

Coral reefs are the most spectacular and diverse marine ecosystems on the planet. Complex and productive, coral reefs boast thousands of species, many of which are currently not described. They are renowned for their extraordinary natural beauty, biological diversity and high productivity (Hoegh-Guldberg 1999). Coral reefs are the major features of the tropical coastal environments between the latitudes 25°S and 25°N and roughly coincide with water temperatures between 18°C and 30°C (Veron 1986). Below 18°C, the number of reef-building coral species decline rapidly and reefs do not form. Coral reefs have a crucial role in shaping the ecosystems that have inhabited our tropical oceans for the last 250 million years.

Reefs represent crucial sources of income and resources through their role in tourism, fishing, building materials, coastal protection and providing new drugs and bio-chemicals (Carte 1996). Coral reefs protect the coastlines from storm damage, erosion and flooding by reducing the wave action. Protection offered by the coral reefs also enables the formation and development of associated ecosystems like seagrass beds and mangroves, which in turn will help to establish essential habitats, fisheries and livelihoods. Globally, the coastal people depend in part or wholly on coral reefs for their livelihood and around 8% of the world's population lives within 100 kilometers of coral reef ecosystems (Pomerance 1999). Therefore, damage and elimination of coral reefs will have dire consequences.

While considering different threats to the coral reef ecosystem, elevated temperature is the cause of mass bleaching events as indicated by the current evidence. Increasing water temperature will rapidly cause zooxanthellae to leave the tissues of reef-building corals and other invertebrates (Hoegh-Guldberg and Smith 1989) resulting in a reduced number of zooxanthellae in the tissues of the corals (Coles and Jokiel 1977, 1978; Hoegh-Guldberg and Smith 1989; Glynn and D'Croz 1990; Lesser et al. 1990). Glynn (1993) also indicated that the increase in sea temperature due to global climate change is likely to push corals beyond their thermal limits. A severe bleaching event in 1998 triggered by elevated temperature affected many reef systems in the Indian Ocean (Vivekanandan et al. 2008).

Sea surface temperatures (SSTs) in tropical regions have increased by almost 1°C over the past 100 years and are currently increasing at the rate of 1°C-2°C per century (Hoegh-Guldberg 1999; Hughes et al. 2003). If this current trend continues, the reefs might disappear entirely within 20-50 years (Hoegh-Guldberg 1999). In India, large scale bleaching and mortality of corals in the Andaman and Nicobar, Lakshadweep Islands, Gulf of Mannar and Gulf of Kachchh has been attributed to SST anomalies

(Vivekanandan et al. 2009). There are also reports about the coral bleaching events during 1987 and 1998 throughout the world, coinciding with El Niño events with increased SST up to 31°C (Vivekanandan et al. 2008). However, there are periodic events of mass coral bleaching occurring at local and regional scales and many of them remain unreported. This paper describes the recent bleaching event that took place at the Agatti Island, Lakshadweep during 2010 and its impacts on associated organisms like sea anemones and giant clams.

Materials and methods

Lakshadweep archipelago consists of several inhabited and uninhabited islands and is well known for its rich floral and faunal diversity. In the present study, surveys were carried out in the lagoon area of Agatti Island, Lakshadweep (Lat. 10º51'N, Long. 72º11'E) during May to June 2010. The total lagoon area of 17.5 km^2 was divided into north (Station I) and south sides (Station II) for convenience (Fig. 1). A total of 5 transects of 100 m length were laid randomly at each site, and 5m × 5m quadrates along the starting, middle and end points of the each transect were surveyed.

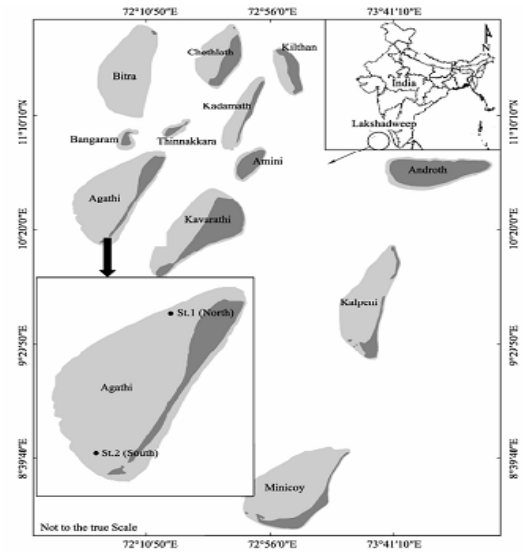

Figure 1: Map showing the study area, Agatti Island, Lakshadweep, India

Visual census was carried out on SCUBA and the number of bleached corals and other associated organisms like giant clams and sea anemones (Fig. 2) were counted within the quadrates. In total, 15 quadrates were studied at each location at a depth ranging from 1.5-4.0m along the lagoon area. Temperature data were collected from the surface waters of both the stations (4 data points/day) in between 12 and 4pm using hand held digital thermometers (Eutech instruments, Singapore) with an accuracy of ±1°C. Observations on bleached corals, sea anemones and giant clams were recorded and expressed as percentage occurrence. Statistical analyses were conducted with Student T-test (Paired two sample or means) to test the variation between two stations (north and south).

Figure 2: Bleached coral *Acropora* sp. (A), giant clam *Tridacna* sp. (B) and sea anemone *Heteractis magnifica* (C)

Results

The bleaching phenomenon in the Agatti Island in 2010 was conspicuous up to a depth of 4m and observed throughout the lagoon area (western side). The rate of coral bleaching was estimated at 68% on the northern side and 85% in the southern side. Bleaching was also observed in other reef-associated organisms such as sea anemones and giant clams with 83% and 85% bleached on the northern side and 92% and 91% on the southern side respectively (Fig. 3).

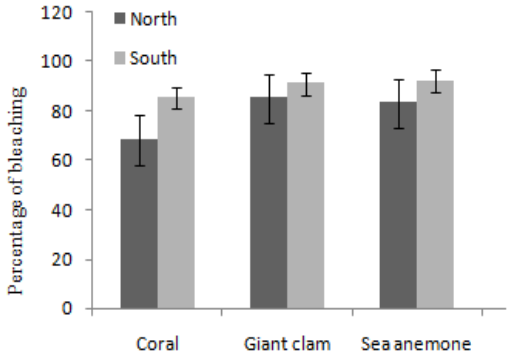

Figure 3: Percentage bleaching of corals, giant clam and sea anemone (±SD)

Student T-test showed significant variation ($t_{(2)}$=2.9199, p=0.0415) between the selected stations. The daily mean SST ranged between 31-34°C during May to June 2010 (Fig. 4). Normal temperature at this time is around 29-31°C.

Discussion

Annual mean sea surface temperature (SST) trend shows that the reef areas of Lakshadweep has warmed from 28.50°C in 1985 to 28.92°C in 2005, at a rate of 0.21°C per decade (Vivekanandan et al. 2008). The annual average maximum SST did not increase, but the annual average minimum temperature increased from 27.2°C to 27.8°C, at a rate of 0.30°C per decade in the Arabian Sea. The effect of El Niño on SST was evident in 1987-1998 when the SST reached 31°C (Vivekanandan et al. 2008). Such temperature rises affect the Indian coral reefs, which have experienced 29 widespread bleaching events in 1989, 1998 and 2002 (Arthur 2000; Rajasuriya 2002; Rajasuriya et al. 2004). Arthur (2000) and Arthur et al. (2005) found that the effects of El Niño corresponded to about 60-90% of coral mortality in the Arabian Sea.

However, the present study recorded a maximum SST of 34°C with daily mean values of 31°C resulting in the bleaching of corals and other reef associated organisms during May and June 2010 (Fig. 4). Similarly, during March-May 2010, an increase in daily average SST of 1°C was observed in the Andaman and Nicobar Islands and a maximum of 32.54°C was recorded on the same period as compared to 31.75°C of the previous year (Mohan et al. 2010). However, influence of this rise on coral reefs in Andaman and Nicobar Islands are comparatively less than that of the Lakshadweep.

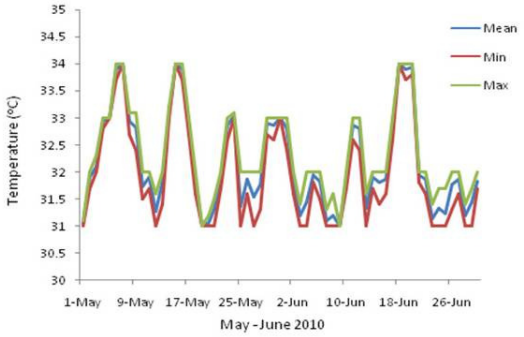

Figure 4: Variation in SST at Agatti Island, Lakshadweep during May and June 2010

During 2005, coral bleaching affected all the coastal south Asian countries, particularly along the Indian coast such as the Gulf of Mannar and Lakshadweep which experienced more or less the same SST (Vivekanandan et al. 2008). In Palk Bay, 50-60% of coral bleaching was recorded at six different sites in association with the increase in SST during the peak summer; however, more than half of the corals recovered during August 2002 (Kumaraguru et al. 2003). A temperature range of 31.0-33.5°C was recorded during the 1998 summer in the coral reef areas of the Gulf of Mannar, which ultimately triggered bleaching of corals in this region (Edward et al. 2008). Past bleaching events and the corresponding SST records of different coral areas of India are summarized in Table 1.

Location, Year	Bleaching (%)	SST of corresponding period (°C)	References
Andaman, 2010	36-69	31-33	Krishnan et al. 2011
Gulf of Mannar, 2008	10.5		
Gulf of Mannar, 2007	12.9		
Gulf of Mannar, 2006	15.6	31-33.5	Edward et al. 2008
Gulf of Mannar, 2005	14.6		
Palk bay, 2002	50-60	32	Kumaraguru et al. 2003
Gulf of Kachchh, 1998	11		
Gulf of Mannar, 1998	82	3 (above the seasonal average)	Arthur 2000
Lakshadweep, 1998	89		

Table 1: Past bleaching events and corresponding SSTs of different coral reefs in India

It was also found that there was a decrease in population of reef-associated fishes like butterfly fishes, parrotfishes, coral groupers and other reef-associated organisms (Vinoth 2012). Furthermore, coral-associated organisms such as giant clams, sea anemones, zoanthids and foraminiferans have been found to suffer due to the increase in SST.

Most coral reef systems are predicted to experience near annual bleaching events that will exceed the extent of the 1998 bleaching event by the year 2040 (Hoegh-Guldberg 1999). Some coral reefs (e.g. Caribbean, Southeast Asian coral reefs) may reach this point by 2020. The expected economic loss due to this bleaching will run into hundreds of billions of dollars per year and it is likely to affect millions of people worldwide (Hoegh-Guldberg 1999).

Conclusion

Mass coral bleaching began to occur in 1980 due to the steady rise in sea temperature that has pushed the reef-building corals closer to their thermal maxima. The present study provides information on the intensity of bleaching during the latest bleaching event in 2010 at Agatti Island, Lakshadweep, India. In this context, it is imperative that continuous monitoring programs to be undertaken in the Lakshadweep coral areas to quantify changes, raise the public profile and assist effective management of these reefs to minimize additional stresses.

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