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CORAL BLEACHING OBSERVATIONS IN THE GULF OF KACHCHH, INDIA – A CLIMATE INDUCED STRESS ON THE SCLERACTINIANS

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Abstract: Climate driven changes have been identified in various ecosystems on earth and they result in either species adaptation or eradication. In order to get insight into such changes, it is necessary to assess their magnitude and rate which will lead to know the gravity of the threats on an ecosystem if any. The Gulf of Kachchh was considered as an area of low to moderate coral bleaching region hence this study was carried out to bring forth the coral health status in terms of coral bleaching. The event of large scale change-*coral bleaching* was observed in the Gulf of Kachchh during May and June, 2010. The incident was evinced by whitening of the coral colonies on the reefs of Narara and Poshitra in the Gulf of Kachchh. The present observations describe the incidents of mass coral bleaching, which affected a total of 19 scleractinian corals in addition to the other zooxanthellate cnidarians. Globally, a number of factors have been identified to induce the phenomenon but for this instance, elevated sea surface temperature is considered to be the responsible factor. The status of coral bleaching at different sites in the Gulf of Kachchh has been discussed.

Key words: Sea surface temperature, Cnidarians, Zooxanthellate

INTRODUCTION

Coral bleaching is the expulsion of dinoflagellate algae zooxanthellae from the coral tissue resulting in white or pale appearance of the coral colony. A number of environmental factors have been identified to induce the dissociation of host and symbiont *i.e.*, extremes of temperature (heat shock and cold shock), high irradiance, prolonged darkness, heavy metals (especially copper and cadmium) and pathogenic microorganisms (Hoegh-Guldberg, 1999; Brown, 2000). However, globally the elevated sea surface temperature is recognized as a major contributor to the considerable coral bleaching events (Stone *et al*., 1999).

The coral bleaching dates back more than a century but after 1980s the events have occurred globally on larger scale with increased frequency and severity (Glynn, 1993; Goreau and Hayes, 1994; Goreau *et al*., 2000). Such an event of coral bleaching that involves entire reef tracts or regions is considered as *mass coral bleaching* (www. reefresilience.org). Hence, mass coral bleaching is believed to be a serious challenge to the health of the global coral reefs. Bleaching may occur at smaller (Egana and DiSalvo, 1982; Goreau, 1964) or larger geographic scales that may affect entire reef systems and geographic realms (Glynn, 1993; Hoegh-Guldberg and Salvat, 1995). It has been observed that globally the coral reefs have come across 60 major coral bleaching events from 1979 to 1990 whereas only nine were recorded from 1969 to 1979 although both the periods are considered as the years of active reef research. (Stone *et al*., 1999).Coral bleaching was also reported during 1983, 1987, 1991 and 1995 from all tropical areas of the Pacific Ocean, Indian Ocean and the Caribbean Sea (Westmacott *et al*., 2000). Majority of the reefs were bleached during the 1998 bleaching event leading to 16% mortality of corals globally (Wilkinson, 2002).

Indian coastline is endowed with four major coral reef formations that have gained focus by the research community especially during major ecological events such as coral bleaching. However, the Gulf of Kachchh reefs have either remained deprived or subordinate to be explored during such episodic events. Moderate to low coral bleaching has been recorded till 2008 from the Gulf of Kachchh (Baker, 2008).

In order to bring forth the coral bleaching event coinciding with the globally reported mass bleaching event of the year 2010, the present study has been carried out in the Gulf of Kachchh in the state of Gujarat.

Study area and methodology

The Gulf of Kachchh is located between 22°15' N and 23°40' N Latitudes and 68°20' E and 70°40' E Longitudes (Fig. 1). It is one of the indentations of Gujarat coast and situated at northern boundary of the Saurashtra Peninsula. Biogeographically, the area falls in $8A_1$ – *Gulf of Kachchh* sub-biotic province (Rodgers and Panwar, 1988). The southern margin of the gulf is fringed by coral reefs, islands and extensive mud flats, which possess a total of 42 islands (Pandey *et al*., 2010), getting partially exposed during low tides. The coral reefs are found on 19 islands, 6 submerged reefs and 5 adjoining areas of the gulf (Pandey *et al.*, 2010). The taxonomic investigations have recorded a total of 59 species of hard corals belonging to 28 genera and 10 families (Pillai, *et al*., 1979, Pillai and Patel, 1988; Singh *et al*., 2004; Venkataraman *et al*., 2003; Sathyanarayana *et al*., 2009). Patchy coral formations are evident on intertidal sandstones in the Gulf of Kachchh. Live corals are found at the edges of the seaward slope of the reef (Bahuguna *et al*., 1992). The present study involves two sites *viz*.,Narara and Poshitra.

Site-I: Narara

Narara is located at the northern boundary of the Jamnagar district. It is situated between 22°25.8' to 22°28.3' N latitude and 69°42.1' to 69°44.7' E longitude by covering an area of 53.34 sq km. It comprises of mangroves, mudflats and coral reefs as the major habitats.

Site-II: Poshitra

Poshitra reef is located near the mouth of the Gulf of Kachchh in the Okhamandal, Dwarka district earlier it was included in Jamnagar district. The region lies between 22°22.0' to 22°22.2' N latitude and 69°11.1' E to 69°12.5' E longitude, comprising of Rocky shores, coral reefs and few mangroves as its major habitat. The reef is characterized by diverse coral species hence it's often referred as *'Crown of the Gulf of Kachchh'* (Parasharya, 2008).

The present study was carried out during the months of May, June, October and November, 2010, covering two distinct seasons *viz.,* summer and post monsoon. The survey was conducted in the intertidal areas of the sites during low tides. The reef area was surveyed by Rapid Ecological Assessment (REA) through ocular observations using 5 belt transect of 50x4 meter (English *et al*., 1997). The coordinates were recorded with E-trex Garmin hand held GPS navigator. The observations include extent of

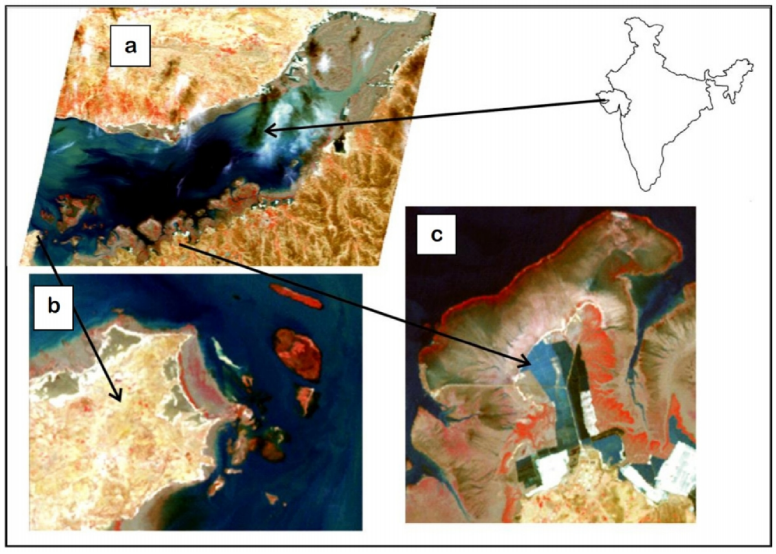

Fig. 1. Map showing the study area - (a) the Gulf of achchh, (b) Poshitra (c) Narara (Source: GEER Foundation GIS Library)

coral bleaching in terms of % bleaching cover in the surveyed area along with the record of affected scleractinian species and other associated invertebrate fauna. The SST data have been derived from the www.oceanmotion.org and www.esrl.noaa.gov for the annual and monthly mean SSTs of the GoK. In order to draw inferences regarding the impact of thermal anomalies on corals, the SST data of last twenty years have been compiled and compared using the Sigma Plot 10.0 technical graphing program.

RESULTS AND DISCUSSIONS

The mass coral bleaching was observed in the surveyed area covering 60-70% of the live coral colonies during the month of May and June, 2010. Occurrence of coral bleaching was evident at both the sites (Fig. 2). The corals showed recovery during the subsequent visits in the month of October, November (1-5% bleached) 2010. All the scleractinian growth forms were observed suffering from moderate to severe bleaching. A total of 19 coral species belonging to 13 genera and 7 families were affected (Table 1). The bleached corals include four near threatened and one vulnerable species (http://www.iucnredlist.org). The extent of bleaching varied among different colonies and even the same species showed difference in bleaching intensity (Fig. 3). Most of the *Porites* colonies were found to be partially recovered in the October, 2010 but showed complete recovery only in the month of November, 2010.The branching coral species are more bleaching prone and fragile than the massive species like *Porites* (Baird and Marshall, 2002) and hence, even after delayed recovery of more than 100 days, *Porites sp.* could survive completely and no mortality was found.

Fig. 2. Large scale Coral bleaching at the GoK reefs - Reef View, June, 2010

The annual mean SST of the GoK ranges between 26.04°C (1985) to 26.10°C (2005) with the annual minimum 23°C and maximum 28.9°C. The annual mean SST of the last two decade from 1990 to 2010 have shown highest thermal anomalies in the GoK during 2010 (Fig. 4). The annual mean SST and annual thermal anomalies of the year 2010 are exceeding even the 1998 SSTs (www.oceanmotion.org). Therefore, the biological consequences of 2010 might be similar or rather worse than 1998 in the GoK which might be reflected in the form of mass coral bleaching. In accordance with this, the Global Coral Reef Alliance (GCRA) predicted 2010 to be, one of the worst coral bleaching years ever (www.globalcoral.org). The thermal threshold for the GoK reefs is estimated to be 30°C (Vivekanandan *et al.,* 2008). The monthly mean SST of the GoK during May and June, 2010 was 30°C and 32°C respectively which is crossing thermal threshold (www.esrl.noaa.gov; Fig. 5). The observations of bleaching recovery in the early winter correspond to the decreased SST of the October and November, 2010 *i.e.,* 28.4°C and 28.1°C respectively.

Mass coral bleaching ranging from 25.8% to 41.3% was recorded from the coral reefs of the Palk bay during the month of April and May, 2010 (Ravindran *et al*., 2012). Other evidences of coral bleaching were recorded at Andaman and Nicobar Islands, which described the occurrence of mass coral bleaching, ranging from 37 to 70% at various sites during the month of April and May 2010. Such an extensive coral bleaching was induced by the elevated sea surface temperature at the respective sites

Table 1. Coral species found bleached during the study

Sr.no	Coral species (Parasharya, 2012)	IUCN status	Bleaching at Narara	Bleaching at Poshitra
Family: Acroporidae				
1.	*Montipora foliosa*	NT		
2.	*Montipora venosa*	NT		
3.	*Montipora explanata*	DD		✓
Family: Siderastreidae				
4.	*Siderastrea savignyana*	LC		✓
5.	*Pseudosiderastrea tayami*	NT	✓	
6.	*Coscinarea monile*	LC		✓
7.	*Coscinarea columna*	LC		✓
Family: Poritidae				
8.	*Goniopora minor*	NT		✓
9.	*Goniopora stutchburyi*	DD		✓
10.	*Porites lutea*	LC	✓	✓
11.	*Porites compressa*	LC		✓
12.	*Porites lichen*	LC		✓
13.	*Porites solida*	LC		
Family: Faviidae				
14.	*Favia speciosa*	LC	✓	✓
15.	*Favia favus*	LC	✓	✓
16.	*Favites bestae*	NT	✓	✓
17.	*Goniastrea pectinata*	LC	✓	✓
18.	*Cyphastrea serailia*	LC		✓
19.	*Leptastrea purpurea*	LC		
20.	*Plesiastrea versipora*	LC		
Family: Merulinidae				
21.	*Hydnophora exesa*	NT		✓
Family: Mussidae				
22.	*Acanthastrea hillae*	NT		
23.	*Symphyllia radians*	LC		✓
24.	*Symphyllia recta*	LC		✓
Family: Dendrophyllidae				
25.	*Turbinaria peltata*	VU		✓
26.	*Turbinaria frondens*	LC		
27.	*Turbinaria reniformis*	VU		
	Total		**6**	**18**

VU -Vulnerable, NT-Near Threatened, LC-Least Concerned, DD-Data deficiency

(Krishnan *et al*., 2011). Evidences of mass coral bleaching were also reported from Lakshadweep during May and June, 2010 which revealed 76.5% bleached corals, 87.5% of sea anemones and 88% of giant clams (Ajithkumar & Balasubramanian, 2012). Other coral reefs located at roughly the same latitude (22°39') as GoK, *i.e*., Persian Gulf (>34°C) and Red Sea also showed coral bleaching of 60-80% (Aug-Sept, 2010) and 14-74% (August, 2010) respectively (Riegl *et al*., 2011; Furby *et al*., 2013).

Arthur (1995) reported 1.2-1.4% of coral bleaching in the Gulf of Kachchh during summer months of Gujarat and concluded it to be a normal summer response of corals towards the summer temperature rise as the coral species of these latitudes are adapted to a wide range of temperature fluctuation at the intertidal regions. But during the summer of year 1998, he recorded an average of 11% coral bleaching in the Gulf of Kachchh resulted after El Nino Southern Oscillation and considered it as a

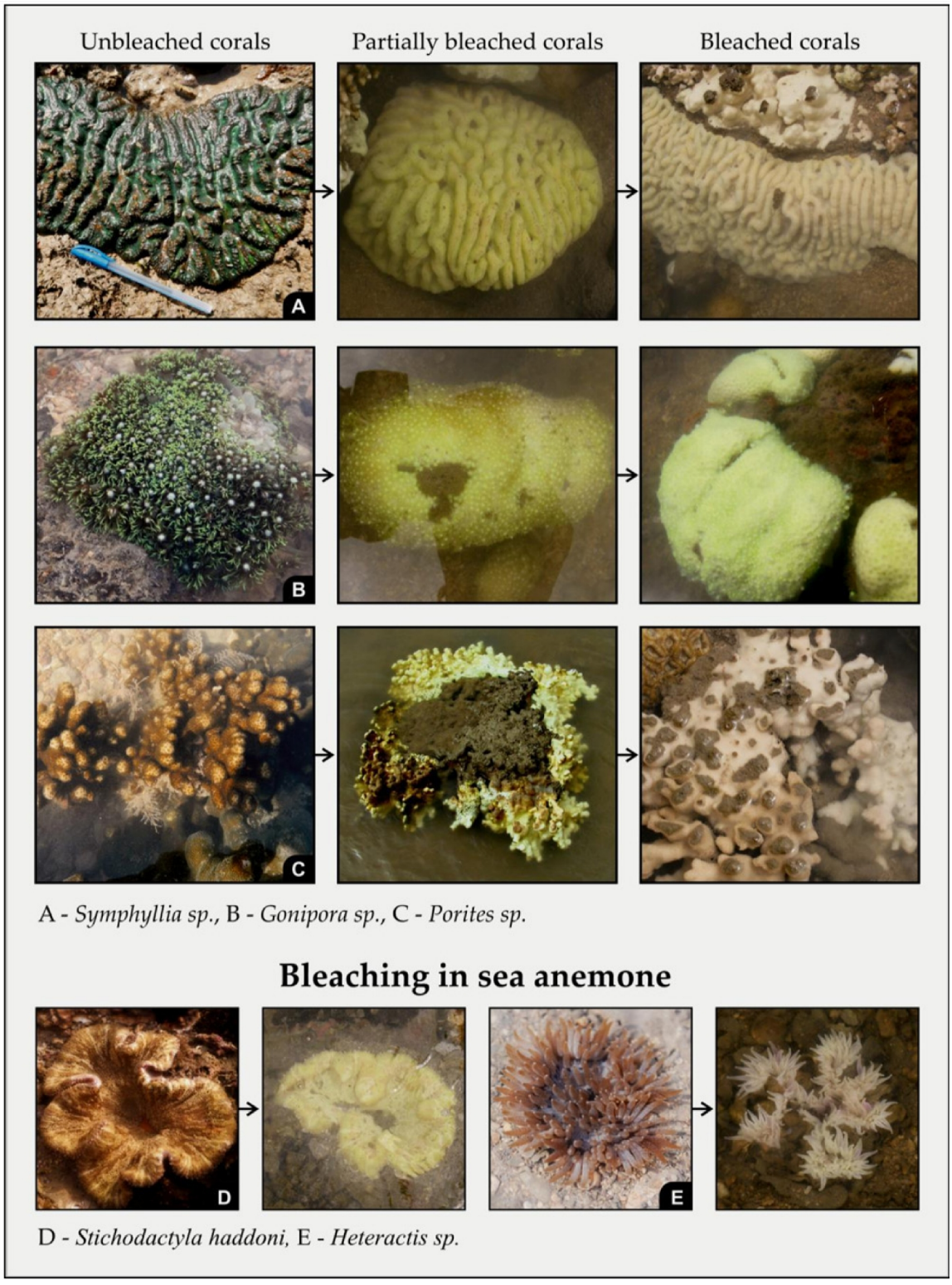

Fig. 3. Bleaching in various coral genera and associates in the GoK reefs, June, 2010

higher level of coral bleaching than a normal summer response. He added that the elevated temperatures even below bleaching threshold can also substantially affect coral health by impairing growth and reproduction (Arthur, 2000). Ecologists of WTI have also recorded coral bleaching at Mithapur in the Gulf of Kachchh during the year 2010(www.wti.org.in).

The large scale coral bleaching following its recovery might be triggered by a common and temporal factor. As well as the occurrence of the coral bleaching at different reef area also coincides with the high SST months of that area suggesting SST to be the major causal factor of the coral bleaching.

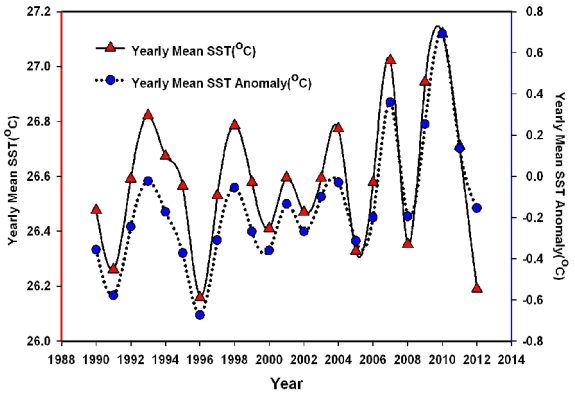

Fig. 4. Annual mean SST and anomaly from 1990-2012

Bleaching weakens the coral colonies against secondary stressors like algal overgrowth, diseases and reef organisms that bore into the skeleton and perforate the structure of the reef. In case of severe bleaching, the resilience of the reef also decreases causing shift in the patterns of coral diversity and resulting in reef community restructuring. In order to detect or trace changes of i) bleached coral reefs, ii) persistence of the changes, iii) magnitude of the changes as well as the iv) status of unbleached corals, a well-planned monitoring can serve as one of the best tool. The data generated from such information can provide us with pre-bleaching and post bleaching scenario of the coral reefs. Such a plan can also integrate the involvement of Policy makers, local organisations, universities and if possible local community. The comparisons of frequently and periodically collected data at the coral reef ecosystem can bring forth the trends of various

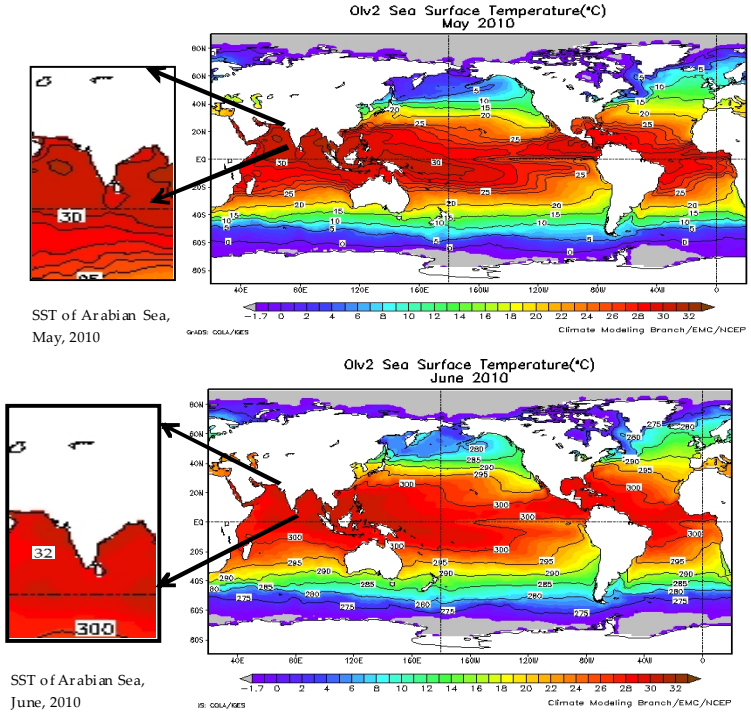

Fig. 5. Map showing the SST during May and June, 2010 (sources: www.esrl.noaa.gov)

consequences of the climate change with the course of time.

CONCLUSIONS

The mass coral bleaching in the GoK from Narara and Poshitra in 2010, its co-occurrence with the global mass coral bleaching events caused by the elevated SST lead to conclude that coral bleaching of 2010 is probably the consequence of the high summer SST at the GoK. However, detailed monitoring on the events of coral bleaching with region specific factors, covering larger area and different seasons is required to be studied which in turn will provide the reef resilience of the GoK.

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