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Research Paper

DELAYED RECOVERY IN *PORITES SPP.* FOLLOWING MASS CORAL BLEACHING: A CASE STUDY FROM THE GULF OF KACHCHH, GUJARAT, INDIA

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Abstract
The resilience of an ecosystem is defined as the ability to resist the changing environmental conditions. It shows the potential of an ecosystem to cope up with the disturbances lasting after adverse changes. In case of corals, such changes are evident by alteration in the patterns of growth, calcification, morphology and reproduction. The focus of the present study is to report the delayed recovery of the *Porites spp.* of Gulf of Kachchh, Arabian Sea, India after the mass bleaching event of 2010 and to derive a probable reasons for such delayed recovery compared to other coral species.
Key words: Coral Bleaching, Calcification, *Proites*, Gulf of Kachchh, Reef resilience.

INTRODUCTION

In coral colonies the changes are evident in the form of colour or integrity of coral tissues that includes coral bleaching, tissue sloughing and patchy tissue necrosis. However, such changes are recorded as a consequence of varied magnitude of environmental stresses and may be followed by quick or delayed mortality [1]. As the breeding in corals occurs at a short period in a year generally spring or early monsoon [2], the impact of stressors on coral fecundity is recognized after long term monitoring which also involves pre stress data as well as taxonomic specification in this regards because breeding seasons and reproduction rate are species specific [3]. Hence, coral bleaching is comparative detectable expression of stress, mostly regardless of taxonomic complications.

Therefore, the coral bleaching is a well-known catastrophe that not only hampers the growth of the coral but also causes mortality to the reef community. Globally, various mass bleaching events have been recorded during the past. 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 [4]. 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 [5]. Majority of the coral reefs were bleached during the 1998 bleaching event leading to 16% mortality of corals globally [6].

India being a tropical country comprises of four major reefs *viz.*, the Andaman and Nicobar Islands, the Gulf of Mannar, Lakshadweep and the Gulf of Kachchh. During the month from April to June, 2010, mass coral bleaching events were recorded from the Indian reefs like Gulf of Mannar - Palk bay, Andaman and Nicobar Islands, and Lakshadweep [7, 8]. Further, the mass coral bleaching event was also observed at the reefs of Gulf of Kachchh [9]. However, none of the studies undertaken during the 2010 mass bleaching event has focused on the species specific recovery rate from the mass coral bleaching event. As mentioned in the previous section, the coral reef resilience is an important phenomenon to overcome the stressed conditions.The present study is an attempt to understand and study the recovery rate of the *Porites* colonies of the Gulf of Kachchh. The *Porites sp.* plays a significant role in the community structuring of coral reefs in the Gulf of Kachchh hence threats to its survival may substantially affect the reef resilience.

STUDY AREA AND METHODOLOGY

The funnel shaped, East–West oriented indentation of Gujarat coast i.e. the Gulf of Kachchh (GoK) is situated between the Kachchh mainland and the Saurashtra peninsula (22°15' N and 23°40' N Latitudes and 68°20' E and 70°40' E Longitudes). Biogeographically, the area falls in $8A_1$ – *Gulf of Kachchh* sub-biotic province [10]. The southern margin of the gulf is fringed by coral reefs, islands and extensive mud flats, which consist of 42 islands [11] that get partially exposed during the low tides. The taxonomic investigations have accrued 59 species of hard corals belonging to 28 genera and 10 families from this region [12, 13 14, 15, 16, 17].The present study focused on two sites *viz.,* Poshitra and Narara due to its accessibility in all seasons (Figure 1).

Poshitra village is situated near the mouth of the GoK and consists of a cluster of islands laying between 22°22.0' to 22°22.2' N latitude and 69°11.1' E to 69°12.5' E longitude. Laku Point (LP) is the coastal location of Poshitra with (nearly 40% coral cover) coral formations spreading over $100m^2$ areas [11]. 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.

A survey was conducted in the intertidal areas during October and November, 2010. The reef area was surveyed using belt transects of 50x4 meter [18]. The coordinates were recorded with E-trex Garmin hand held GPS navigator. The observations include the extent of coral bleaching (% bleaching cover), the affected scleractinian species and other associated invertebrate fauna.

RESULTS AND DISCUSSIONS

The Frequency of occurrence for the *Porites sp.* was estimated to be 36% and 7.27% at Poshitra and Narara respectively. During the study, three species of the genus *Porites* were recorded *Porites lutea, P. compressa* and *P. lichen* distributed at various reef zones viz. reef flat, reef crest, reef slope, tidal pools and lagoons. All the species and growth forms of the *Porites* were recorded suffering from the delayed recovery (Figure 2). Nearly 30% of *Porites* colonies within transects were partially recovered from the mass coral bleaching event (Figure 3). However, other colonies belonging to rest of the genera had recovered completely and got their original pigmentation after the mass coral bleaching event of the year (Table 1). No other Anthozoans were observed in bleached condition.

The slower recovery of this scleractinian *Porites* can be explained by its unusual metabolic pathways. During the healthy state of corals, up to100% of daily metabolic requirements are fulfilled by photo-synthetically fixed carbon from zooxanthellae [19, 20]. Wherein, the excess is stored in the host as lipids at the concentrations of 10–40% of the total biomass[21,22, 23] and represents a significant energy reserve in the corals[24, 25] In bleached corals, decreased zooxanthellae densities or chlorophyll *a* levels result in decreased net photosynthesis[26, 20]. The photo-synthetically fixed carbon translocated to the host decreases that constrain the organism to rely on the stored lipid, carbohydrate or protein reserves to survive and recover.

However, unlike *Porites*, the bleached *Montipora capitata* maintains energy reserves by increasing heterotrophy which is the major difference of metabolism in *Porites* and other species [20]. *Porites* does not increase heterotrophic inputs during stressed condition hence; the mode of nutrition makes it less resilient against bleaching events compare to other species [20].

In addition to this *Porites* shows a different pathway for lipid metabolism, *i.e., Porites* completely, rather than sequentially, metabolizes storage lipids triacylglycerol (TG), wax esters (WE) and phospholipid (PL) affected after bleaching which results in delayed recovery. The bleached *Porites* shows loss of wax esters impairing egg and mucus production. This loss consequently decreases reproductive output and potential of sediment removal from colony. This is not desirable for any reef species to maintain the long term survival of a coral species or a reef.

Table: 1 Bleaching status of various coral species during different seasons

Sr.no	Coral species	Bleaching status during May-June	Bleaching status during October	IUCN status
Family: Acroporidae				
1.	*Montipora foliosa*	Bleached	Recovered	NT
2.	*Montipora venosa*			NT
3.	*Montipora explanata*	Bleached	Recovered	DD
Family: Siderastreidae				
4.	*Siderastrea savignyana*	Bleached	Recovered	LC
5.	*Pseudosidera streatayami*	Bleached	Recovered	NT
6.	*Coscinarea monile*	Bleached	Recovered	LC
7.	*Coscinarea columna*	Bleached	Recovered	LC
Family: Poritidae				
8.	*Goniopora minor*	Bleached	Recovered	NT
9.	*Goniopora stutchburyi*	Bleached	Recovered	DD
10.	*Porites lutea*	Bleached	Partially Bleached	LC
11.	*Porites compressa*	Bleached	Partially Bleached	LC
12.	*Porites lichen*	Bleached	Partially Bleached	LC
13.	*Porites solida*			LC
Family: Faviidae				
14.	*Favia speciosa*	Bleached	Recovered	LC
15.	*Favia favus*	Bleached	Recovered	LC
16.	*Favite sbestae*	Bleached	Recovered	NT
17.	*Goniastrea pectinata*	Bleached	Recovered	LC
18.	*Cyphastrea serailia*	Bleached	Recovered	LC
19.	*Leptastrea purpurea*			LC
20.	*Plesiastrea versipora*			LC
Family: Merulinidae				
21.	*Hydnophora exesa*	Bleached	Recovered	NT
Family: Mussidae				
22.	*Acanthastrea hillae*			NT
23.	*Symphyllia radians*	Bleached	Recovered	LC
24.	*Symphyllia recta*	Bleached	Recovered	LC
Family: Dendrophyllidae				
25.	*Turbinaria peltata*	Bleached	Recovered	VU
26.	*Turbinaria frondens*			LC
27.	*Turbinaria reniformis*			VU
	Total bleached	**20**	**3**	
	Total Recovered	**-**	**17**	

Figure 2: Study area- *the Gulf of Kachchh*: (a) Poshitra, (b) Narara

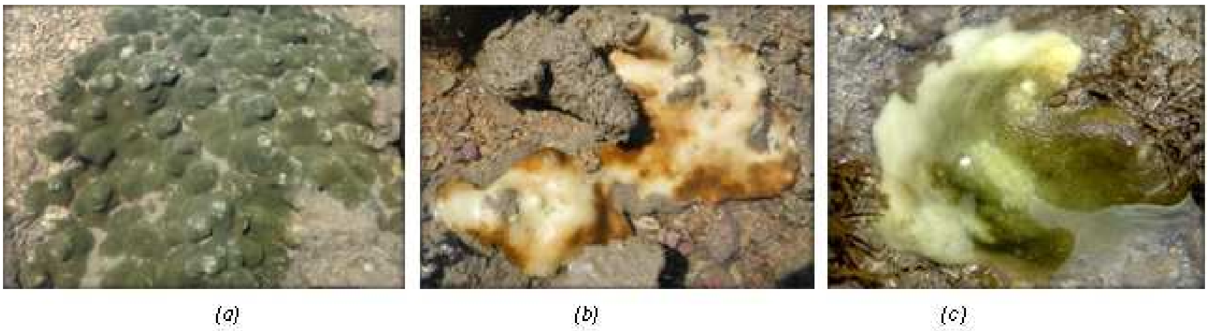

Figure 2: Delayed bleaching recovery in *Porites* spp. (a) original pigmentation, (b) and (c) partially recovered colonies after bleaching

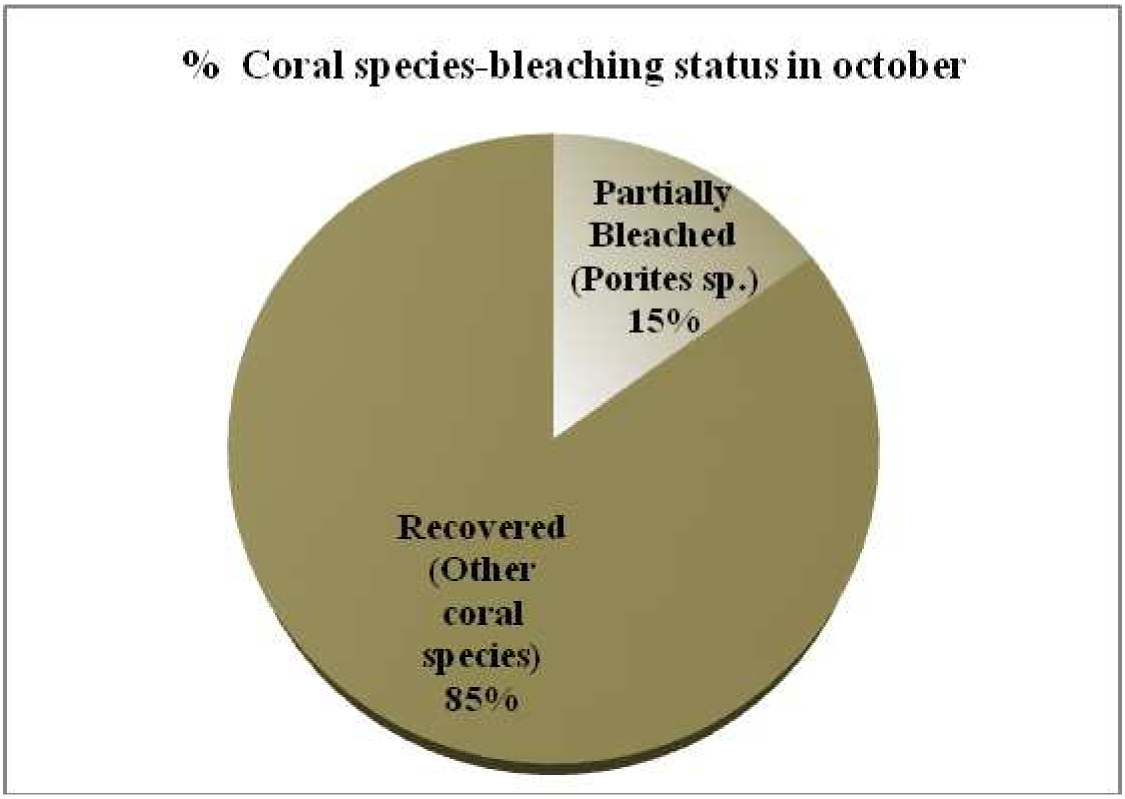

Figure 3: Percentage of coral species bleached and recovered during October, 2010

CONCLUSION

The study shows that a different metabolic pathway and less dependency on heterotrophy during disturbed conditions make the species recover slower than other species. *Porites* is an important reef builder as well as it plays a significant role in the community structuring of the coral reefs of the Gulf of Kachchh. Hence, threats to its crucial biological processes like reproduction and sediment removal will show adverse impacts on the species survival including affects to a number of reef associates.

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REFERENCES

1. Gates, R. 1990. Seawater temperature and sub lethal coral bleaching in Jamaica. Coral Reefs 8: 193-198.
2. Richmond, R., and Hunter, C., 1990, Reproduction and recruitment of corals: comparisons among the Caribbean, the Tropical Pacific, and the Red Sea *Mar. Ecol. Prog. Ser.* Vol. 60: 185-203.
3. Kojis, B. L., & Quinn, N. J., 1981. Reproductive strategies in four species of Porites (Scleractinia). In Proc. 4th int. coral Reef Symp. (Vol. 2, pp. 145-151).
4. Stone, L., Huppert, A., Rajagopalan, B., Bhasin, H., Loya,Y.,1999. Mass coral reef bleaching: a recent outcome of increased El Nino activity? *Ecology Letters.* 2:325–330.
5. Westmacott, S., Teleki, K., Wells, S., and West, J., 2000. *Management of bleached and severely damaged coral reefs* (IUCN, Gland, Switzerland), 36 pp.
6. Wilkinson, C., *2002.Status of Coral Reefs of the World:* Global Coral Reef Monitoring Network and Australian Institute of Marine Science, Townsville, Queensland, Australia, 378 pp.
7. Ravindran, J., Kannapiran, B., Manikandan, R., Murali, M. & Joseph, A. 2012. Bleaching and Secondary threats on the corals of the Palk bay: A survey and Proactive conservation needs. *Indian J. Mar. Sci. 42(1):* 19-26.
8. Krishnan, P., S. Dam Roy, Grinson George, R. C. Srivastava, A. Anand, S. Murugesan, M. Kaliyamoorthy, N. Vikas and R. Soundararajan. 2011. Elevated sea surface temperature during May 2010 induces mass bleaching of corals in the Andaman. *Current Science,* 100(1): 111-117.
9. Joshi, D., MunjparaS., Banerji,U. and Parasharya, D., 2014 *(in press).* Coral Bleaching Observations in the Gulf of Kachchh, India – A Climate Induced Stress on the Scleractinians, *Journal of Aquatic biology and fisheries* **2**:(2) 106-113.
10. Rodgers, W.A. and Panwar, H.S. 1988. Planning wildlife protected area network in India.2 Vols. Wildlife Institute of India, Dehradun, 267. pp.
11. Pandey. C.N., Raval. B. R., Parasharya, D., Munjpara, S., Joshi D., Banerji U., (2010) " Recruitment and Growth Study of Coral Reefs of the Gulf of Kachchh" Gujarat Ecological Education and Research (GEER) Foundation, Gandhinagar. pp 146.
12. Pillai, C. S. G., and Patel M. I. (1988). Sclerectinian corals From the Gulf of Kachchh, *J. Mar. Boil. Ass. India*. 30 (1 & 2): 54-74.
13. Pillai, C. S. G., Rajgopalan, M. S. and Varghese, M. A. 1979. Preliminary report on a reconnaissance survey of the major coastal and marine ecosystems in Gulf of Kachchh. *Mar. infer. Serv. T&E ser.* 14:16-20.
14. Singh, H. S, Pandey, C. N., Yennawar, P., Asari, R. J., Patel, B. H., Tatu, K., Raval, B. R., (2004). The marine national park and sanctuary in the Gulf of Kachchh - A comprehensive study of the biodiversity and management issues. GEER Foundation, Gandhinagar.

15. Venkataraman, K., Satyanarayana, Ch., Alfred, J. R. B., and Wolstenholme, J., (2003). *Handbook on Hard corals of India,* Zoological Survey of India, Kolkata.
16. Sathyanarayana, Ch., and Ramakrisna. (2009)*, Handbook on Hard corals of Gulf of Kachchh,* Zoological Survey of India, Kolkata.
17. Dave, C. S. (2011), Ecological Assessment of Narara reef with special reference to coral community, thesis submitted to Maharaja Sayajirao University of Vadodara, 150 pp.
18. English, S., Wilkinson C. and Baker V. (1997). Survey Manual for Tropical Marine Resources. Townsville, Australia, Australian Institute of Marine Science, Townsville Australia: pp. 378.
19. Muscatine, L., McCloskey, L.R., Marian, R.E., (1981). Estimating the daily contribution of carbon from zooxanthellae to coral animal respiration. Limnol. Oceanogr. 25, 601–611.
20. Grottoli, A. G., Rodrigues, L. J., Palardy, J. E., (2006). Heterotrophic plasticity and resilience in bleached corals. Nature 440, 1186–1189.
21. Stimson, J.S. (1987). Location, quantity and rate of change in quantity of lipids in tissue of Hawaiian hermatypic corals. Bull. Mar. Sci. 41, 889–904.
22. Porter, J. W., Fitt, W. K., Spero, H. J., Rogers, C. S., White, M. W., (1989). Bleaching in reef corals: Physiological and stable isotopic responses. Proc. Natl. Acad. Sci. U.S.A. 86, 9342–9346.
23. Grottoli, A.G., Rodrigues, L. J., Juarez, C., (2004). Lipids and stable carbon isotopes in two species of Hawaiian corals, Montipora verrucosa and Porites compressa, following a bleaching event. Mar. Biol. 145, 621–631.
24. Edmunds, P. J., Davies, P. S., (1986). An energy budget for *Porites porites* (Scleractinia). Mar. Biol. 92, 339–347.
25. Harland, A. D., Navarro, J. C., Davies, P. S., Fixter, L. M., (1993). Lipids of some Caribbean and Red Sea corals: Total lipid, wax esters, triglycerides and fatty acids. Mar. Biol. 117, 113–117.
26. Porter, J. W., Fitt, W. K., Spero, H. J., Rogers, C.S., White, M.W., (1989). Bleaching in reef corals: Physiological and stable isotopic responses. Proc. Natl. Acad. Sci. U.S.A. 86, 9342–9346.