



Coral bleaching in India: Status and prevention

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Abstract

Climate change and ocean warming cause thermal stress on coral reef ecosystems. There are four coral reef ecosystems in India that protect the coastline from erosion. With the rise in Sea Surface Temperature, the symbiotic algae get expelled resulting in coral decolouration which is known as bleaching. The article gives the significance of coral reefs in the India. The coral bleaching events from 1998-2024 are detailed in this review and the coral damage is quantified. The extinction of coral reefs can be attributed to the El Nino events increasing Sea Surface Temperature. Threats to the coral reefs of India are reviewed. Measures taken by the Government of India for their conservation are discussed.

Keywords: Ecosystem, sea surface temperature, government, management

Introduction

Coral reefs, known as the "Rainforests of the Sea", are the regions with the highest biodiversity and highly threatened ecosystems. Coral reefs of India are seen in Tamil Nadu (Gulf of Mannar and Palk Bay), Gujarat (Gulf of Kutch), Lakshadweep, Andaman and Nicobar Islands. Despite covering less than 1% of the ocean floor, reefs host more than one-quarter of all fish species, in addition to many other marine animals. They also act as natural breakwaters protecting our coastlines from erosion caused by waves and storms. Besides ecological benefits, the reefs also support the livelihoods of coastal communities by providing 28 % of the total fish caught in India and contributing to tourism (Raghuraman *et al.* 2013) ^[10]. When the sea surface temperature rises, corals expel the symbiotic algae living in their tissues leading to bleaching wherein they turn white. If this is prolonged for a longer duration a large number of corals vanish. Mass coral bleaching events occurred in the last decade due to the rise in surface temperature of the earth caused by greenhouse gas emissions (Lough, 2008) ^[8].

The information on mass bleaching of corals and studies reporting the health of coral reefs are scanty. The coral bleaching event of 1998 led to the death of 70% of the corals from the Gulf of Kutch, 60-80% from Lakshadweep, 40-60% in the Gulf of Mannar and about 80% of corals in Andaman and Nicobar Islands. However,

coral species recoveries after bleaching in Lakshadweep and Gulf of Mannar were minimal (Venkataraman, 2000) ^[13]. Arthur *et al.* (2005) found that 60% – 90% mortality of corals in Lakshadweep, Gulf of Mannar and Palk Bay corresponds to the El Niño events that occurred during 1998-2008.

The rise in Sea Surface Temperature of tropical oceans in general, the Indian coast in particular and delayed monsoon can induce bleaching of coral reefs. The different coral reefs showed bleaching with the increase in sea surface temperature in summer at an average temperature of 32°C from 1998-2008 (Table 1). The 73% coral bleaching has been observed in Agatti reefs along with bleaching-related mortality of sea anemones and giant clams (Vinoth *et al.* 2011) ^[14]. Krishnan *et al.* (2011) ^[6] working on the effect of SST on corals of Andaman found that the fully bleached corals were maximum at Havelock Island (69.49%) and least in Chidiyatapu (36.54%). Branching corals were highly affected by bleaching whereas massive corals withstood the increased SST. The bleaching events occurred in 2022, 2023 and 2024 in India, the potential bleaching risk of the reef of Mithapur was estimated at 21.9% indicating that the *El Nino* of 2023 elevated the Sea Surface Temperature (Kamboj 2014) ^[5]. During 2020-21, a coral bleaching incident was recorded from the Gulf of Kutch affecting 90% of the reefs in summer months (Muley *et al.* 2000).

Table 1: Bleaching events and corresponding Sea Surface Temperature of different coral reefs in India

Location, Year	Bleaching (%)	Sea Surface Temperature of the corresponding year (°C)
Andaman, 2010	36-69	
Gulf of Mannar, 2008	10.5	31-33
Gulf of Mannar, 2007	12.9	
Gulf of Mannar, 2006	15.6	
Gulf of Mannar, 2005	14.6	31-33.5
Gulf of Mannar, 1998	82	
Lakshadweep, 1998	89	32
Palk Bay, 2002	50-60	
Gulf of Kutch, 1998	11	32

Source: Sahu *et al.*, 2015.

Threats

Uncontrolled global warming (El Nino) and climate changes along with human disturbances pose a threat to coral reef ecosystems (Arthur, 2000) ^[2]. Greenhouse gases in general and CO₂ in particular absorb sunlight, increasing the

temperature in Indian coasts. This rise in temperature causes coral bleaching whereas the sea level increases due to melting of glaciers, and intensified hurricanes can cause floods declining the coral population (Yadav *et al.*, 2024) ^[16].

Various threats to coral reefs are listed in Table 2. Studies show that the recovery of corals bleached during high water temperatures associated with the 1998 El Niño event was poor (Muley *et al.*, 2000). However, natural and human disturbances, *viz.* as the crown-of-thorns starfish, coral mining, destructive and unmanaged coral harvesting, sedimentation and pollution causes much damage to coral and decreases their recovery from bleaching events (Muley *et al.*, 2000; Rajan *et al.*, 2011; Zinke *et al.* 2016) ^[11]. Arasamuthu *et al.*, (2023) ^[1] working on reefs of Gulf of Mannar observed that a red alga *Kappaphycus alvarezii* overgrows on live corals and kills them.

Sand mining is the major activity that leads to the destruction of coral reefs in Andaman and Nicobar Islands (Jeyabaskaran *et al.*, 2007) ^[4]. The exploitation of reef-associated shells namely, *Trochus* and reef fishes by the fisher community would minimise the coral population (Kumaraguru *et al.*,2003) ^[7]. The crown of thorn starfish (*Acanthaster planci*) is known to invade many islands and reefs leading to coral mortality (Kamboj, 2014) ^[5]. White band disease caused by microbes has been reported in the reefs of Andaman and Nicobar Islands and also in other reefs of India. Besides, pink band disease is known to effect scleractinian corals (Raghukumar and Raghukumar, 1991) ^[9].

Other than bleaching, the main causes for the loss of reef biodiversity are dredging of navigational channels, unsustainable fishing practices, coastal development activities, collection of coral-associated resources and other human-induced pressures. The construction of breakwaters on some of the islands is known to damage the coral reefs (Muley *et al.*, 2000; Venkataraman, 2000) ^[13]. Moreover, ocean acidification weakens coral skeletons whereas rising sea levels limit their ability to adapt to changing environmental conditions. These impact assessments would be effective in the formulation of conservation strategies and restoration of coral reefs influenced by changing climatic conditions (Muley *et al.*, 2000).

Ministry of Environment, Forest and Climate Change initiated MISHTI (Mangrove Initiative for Shoreline Habitats & Tangible Incomes) provides financial support to local communities to plant mangroves. Besides, conducts capacity building programmes to create awareness to people about their role in protecting the mangrove wetlands. Sustainable Aquaculture In Mangrove Ecosystem (SAIME) aims at constructing integrated mangrove aquaculture systems for sustainable farming. According to the reports of Sahu *et al.* (2015) a total of 4195.28 ha area of mangroves has been restored South India from 2002 to 2006 (Table 2).

Table 2: Threats to coral reefs

Natural disturbances	Human induced disturbances
Storms including hurricanes, cyclones	Severe pollution, sewage, eutrophication, dredging
Volcanoes	Excessive fishing, Explosion, construction of jetties and breakwaters
El-nino events	Increased industrial runoff and siltation
Chronic wave action and currents	Industrial developments, Thermal power plants, Heavy metals, radioactivity
Sedimentation, Siltation from deforestation	Species introductions
Heavy rainfall, Extreme chilling	Tourism and recreation
Herbivory and predation	Sand and coral mining
Red tides, Ocean acidification	Shell collection

Conservation

Minimising atmospheric carbon concentrations will be beneficial for the survival of corals, thus enabling the successful rescue of damaged reefs. Addressing local pollution and non-destructive fishing practices is important along with stabilised greenhouse gas emissions. Maintaining optimum sea surface temperature for the growth of corals would help in their survival. Funded research needs to focus on the genetic selection of heat-resistant corals that can withstand rising atmospheric temperatures.

Initiatives taken by Indian government for conservation of coral reefs

Taking in to consideration significance of coral reefs and the threats, Government of India has initiated measures for their conservation and management.

- Several regions in the Andaman-Nicobar are declared as new marine protected areas. State-level Steering Committees are constituted to monitor the progress of implementation of conservation action plans to protect coral reefs. Sub-committee on Mangroves and coral reefs research has been constituted to advise the Government. To promote research nodal institutions have been identified in the respective coral reef areas and encouraged to conduct studies on coral reefs (Muley *et al.*, 2000).

- Non-Governmental Organizations (NGOs) together with community participation are reputed to take up the eco-development and awareness activities in the respective coral reef areas. Sustainable livelihood options are identified for the community that is dependent on the coral reef resources to minimise the pressure on this fragile ecosystem (Muley *et al.* 2000). Non-Governmental Organizations (NGOs) are reputed to take up the eco-development and awareness activities in the respective coral reef areas. Wild Life Protection Act (1972) protects certain coral species.
- The Ministry of Environment, Forest and Climate Change conducted training programs at Port Blair in Andaman and Nicobar Islands as well as Kadamat in Lakshadweep Islands (Rajan *et al.*,2011) ^[11]. Policies are developed by Government of India to protect the coral reefs in the country. To regulate the on shore developmental activities the Government of India issued a Coastal Regulation Zone (CRZ) Notification in 1991 and amendments in the subsequent years wherein the collection of corals in live or dead form is prohibited.
- Site-specific Coastal Zone Management Plans (CZMPs) are prepared by state and union territories. Under the Marine Protected Area Network, Ministry of

Environment and Forests has declared the Gulf of Mannar, Great Nicobar Biosphere Reserves, Gulf of Kachchh (Gujarat), Mahatma Gandhi Marine National Park (Andaman) and Rani Jhansi Marine National Park (Andaman) as Marine Protected Areas. These initiatives are proved to be useful strategies for coral reefs protection from the anthropogenic activities.

After the declaration of the Gulf of Kutchchh as a Marine National Park, certain conservation measures for coral reefs have been initiated which are discussed below.

- **Stopping of coral mining:** When the Gulf of Kutchchh Marine National Park was established in 1980-82, the mining lease granted to the cement company was withdrawn and coral reef recovery started.
- The National Institute of Oceanography (NIO) in association with the Forest Department in 2004 carried out the translocation of coral colonies from the jetty corridor and the subsea pipeline near Narara reef of Marine National Park. About 326 live corals in the intertidal pipeline corridor area, 176 live corals in the intertidal jetty corridor and 1,879 live corals in the subtidal pipeline corridor were identified for translocation at three sites at Narara reef during May/December 2004. Survival rate ranged from 70-98% at the translocated sites, and the corals remained healthy throughout the study (Kamboj 2014)^[5].
- The Wildlife Trust of India, Tata Chemicals Ltd. and the Gujarat Forest Department initiated the Mithapur Coral Reef Recovery Project in Gujarat in 2008. The project revealed that only 12% of the reefs were covered with live corals whereas others were bleached. The citizen-science initiative has been followed for coral health monitoring at the reef of Mithapur with the help of TCL employees, volunteers and school students (Kamboj 2014)^[5].
- Gujarat Forest Department initiated a coral rescue program in collaboration with the Wildlife Trust of India (WTI) and Tata Chemicals Ltd (TCL) conducted Coral rescue program (2011-12) at Mithapur reef. The project aimed at rescue corals damaged due to natural and anthropogenic activities. Around 30 upturned and disturbed corals which were rescued during this period and this programme created awareness among the local people about coral reefs.
- **Artificial reef formation (2011 and 2013):** Ten Artificial Reef Sites (ARS) were selected in Mithapur, adjacent to different existing corals, based on different parameters such as bottom topography, current movement, wave action, depth and so on. Limestone boulders were deployed in the selected AR sites with an average depth of about 1-2 meters to make sure they were submerged even at low tide at the the Mithapur reef area. While monitored after a year (2012), coral juveniles (*Favia*, *Favites* and *Montipora* spp.) were observed at four sites. Regular surveys to these sites revealed tentative coral spawning seasons. Subsequently, in 2013, 22 artificial reefs were deployed at Laku Point and the Mithapur reef area. The program intended to rescue corals and Artificial Reef formation. Damaged corals were collected and placed on the artificial reefs, allowing them to regrow. About 110 cubic meters area was restored during the event (Kamboj, 2014)^[5].
- **Transplantation of coral *Acropora humilis* by the Wildlife Trust of India (2012):** Gujarat Forest Department in collaboration with the Wildlife Trust of India (WTI) and Tata Chemicals Limited (TCL) started coral transplantation project in 2012(Kamboj 2014)^[5]. The coral fragments (*Acropora humilis*) were collected from Agatti Island of Lakshadweep and reintroduced in the Mithapur Reef and the Poshitra Reef of Marine National Park in the Gulf of Kachchh. The transplanted coral survived for three months at Laku reef and those of Mithapur survived for six months. Data on water temperature showed that it increased up to 31°C after the transplantation period, which resulted in the bleaching of transplanted coral fragments (Subburaman *et al.*, 2014)^[12].
- **Recruitment of corals on jetties and artificial substrates:** In Gujarat, new recruitments of corals have been observed on jetty pillars and under the boulders approaching the (Dave and Kamboj 2012)^[3]. This infers that with reef protection and providing the required substrates and environment, the corals re-emerge naturally. Hence, this process can be fastened by providing suitable substrates for the recovery of degraded reefs.
- To generate awareness, and impart training about nature, environment education camps were conducted from 1982-83 up to 2013- 14 in Narara Bet, Khijadiya Bird Sanctuary and Poshitra Marine National Park.
- The Forest Department organized many activities under various schemes, many involving local communities through eco-development, the ICZM project protection of mangroves, corals and other coastal resources. A committee has been constructed by Forests and Environment Department, Govt. of Gujarat for monitoring the compliance of conditions related to clearance from environmental, CRZ, FCA, wildlife and pollution-related aspects (Kamboj, 2014)^[5].
- Marine National Park of Gujarat in collaboration with Integrated Coastal Zone Management (ICZM) aims to create awareness about the conservation of corals involving local youths. In this programme, the workshops are conducted to educate the fishermen on the importance of marine biodiversity and its protection, sustainable fisheries, etc. To protect the marine biodiversity, a sewage treatment plant has been established under the ICZM project in Jamnagar city to prevent the flow of sewage into the sea (Kamboj, 2014)^[5].

Conclusion

Global warming poses a major threat to coral reefs, profoundly impacting these fragile ecosystems and associated fauna. The greenhouse gasses that are emitted

trap sunlight leading to an increase in atmospheric temperature. The rise in average global temperatures has triggered many coral bleaching events from 1998-2024. Maximum coral bleaching has been recorded in summer when the SST is 32°C. The government of India has initiated many projects in the Gulf of Kutch Marine National Park, Lakshadweep, Andaman and Nicobar Islands for the protection of coral reefs. Ministry of Environmental Affairs and Non-Governmental Organisations conducted awareness programmes and training for the local people about coral conservation. The artificial substrates and boulders would help in the re-emergence of coral species in the sites of coral bleaching. Reducing greenhouse gas emissions and research to bring about genetically heat-resistant corals would be useful in preventing the decline of coral reefs.

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