

Status survey of the Gulf of Mannar coral reefs following the 1998 bleaching event, with implications for reserve management

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ABSTRACT

The Gulf of Mannar Biosphere Reserve (GoMBR) encompasses 21 coastal islands located between 8°49' to 9° 15' N latitude and 78°11' to 79°15' E longitude on the southeast coast of India. The government of India established these islands as a biosphere reserve in 1989. The Gulf's 3600 species of plants and animals make it biologically one of the richest coastal regions in India. A total of 94 species of corals belonging to 37 genera have been reported from this area and the coral reefs are mostly of fringing type. During 1998-1999, surveys had been conducted to estimate the present status of the coral reefs of this region. Line Intercept Transect surveys were conducted in three different seasons from June 1998 to May 1999 in all the 21 islands divided into three island groups such as Mandapam, Keelakarai and Tuticorin, each group consisting of seven islands. The overall percentage of coral life forms amounted to 24.67% and dead coral, rubble and sand amounted to 75.04%. Among the three groups of islands, Mandapam had a higher percentage of live coral cover (37.03%) than the other two groups (17.29% Keelakarai and 18.69% Tuticorin group). Among the life form categories, massive corals (CM) dominated the GoMBR ($7.67 \pm 2.23\%$). Next to massive corals *Acropora* Branching forms (ACB) dominated in two groups of islands (Keelakarai $6.81 \pm 13.37\%$, $8.5 \pm 13.10\%$ in Mandapam group). The order of dominance of live form in GoMBR is as follows: coral massive (CM) > *Acropora* branching (ACB) > coral sub massive (CS) > coral foliose (CF) > coral encrusting (CE) > coral branching (CB). The reason for the dominance of massive corals over the other groups in GoMBR may be explained by the recent 1998-bleaching event. The fragile and sensitive branching was the most affected life form group as a result of bleaching in this region. The reasons for degradation and deterioration of coral reefs of GoMBR are discussed.

Keywords Status survey, 1998 bleaching, Gulf of Mannar, India

Introduction

The GoMBR comprises of 21 small fringing reefs built on shallow shores of islands arranged in the form of a chain between 8°46' and 9°14' N latitude and 78°9' and 79°14' E longitude from Mandapam in the north to Tuticorin in the south (total distance 170 nautical miles). It covers a total area of 10500 km² on the Indian side (Fig.1). Government of India on February 18, 1989 to conserve its unique biodiversity constituted the GoMBR. This area is remarkable for its faunal and floral wealth, especially the world's most diverse ecosystems, the coral reefs and its associates. The lagoon in these islands is shallow, and can be waded during low tides. The intertidal region of Gulf of Mannar (GOM) islands is sandy and muddy.

The GOM harbors 94 species of coral belonging to 37 genera (Pillai 1986 consolidated this list to 94 species under 37 genera). These coral reefs serve as the spawning grounds for fishes. Sea grass beds and mangroves, which, serve as nursery grounds and shelter respectively, form a unique life-support system both locally and globally. However, the coral reefs and its associates are under severe threat due to natural and human interference in the GOM. GOM is located in the Peninsular India and the Bay of Bengal. The people of this region have traditionally had a close relationship with the sea resulting in strong cultural and economic links with maritime activities such as fishing, pearl diving, shipbuilding and international maritime trading. GoMBR reefs provide habitats for many commercially important fish species. These reefs and some of the associated islands are

becoming increasingly popular sites for recreation and are strategically important for India. The over exploitation of seaweeds, sacred chanks (*Turbinella pyrum*), butterfly chanks, pipe fishes and seahorses by the locals has made them commercially threatened. The pearl oyster pears and gorgonid gardens, which once existed, are disappearing very fast and the unique and endangered fauna including the famous sea cow (*Dugong dugon*) and the balanoglossus (*Ptychodera flauva*) are also becoming locally extinct due to human exploitation.

There has been unprecedented bleaching of hard and soft corals throughout the coral reefs of the world including GoMBR India, from mid 1997 to late 1998 due to a large EI Nino event, followed by a strong La Nina. When corals become stressed, the symbiotic algae are lost from the tissue of the coral polyps, due to the above temperature effect. In GoMBR, some species of coral survived for short periods and most of the reef was rapidly overgrown by algal mat. This has also resulted in drastic changes in the fish and other fauna in the GoMBR ecosystem.

Methods

Depending on the proximity to a major town, all the 21 islands of GoMBR were categorized into three groups namely Mandapam, Keelakarai and Tuticorin, each consisting of seven islands (Fig. 1). The status survey was conducted in three different phases (June 1998 to May 1999). In the first phase, seven islands of Mandapam group starting from Shingle Island in the north to Hare Island in the south were surveyed from 15th to 30th June 1998. In the second phase, another seven islands belonging to Keelakarai group from Mulli Island in the

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north to Anaipar Island in the south were surveyed from 24th October to 8th November 1998. The remaining seven islands belonging to Tuticorin region starting from Nallathani Island in the north to Van Island in the south were surveyed from 8th to 16th May 1999. The expertise of self (the author), Drs. R. Jeyabaskaran and CH. Satyanarayana were used to conduct the Line Intercept Transect (LIT) surveys. The survey started with a Manta tow study of the whole island before laying the 50 m transect as well as to find out the general nature of intertidal region. After confirming the location of the coral reef area a 50 m LIT, (English et al .1997) was laid randomly using a 50 m plastic tape to estimate the life form cover of the coral reef. Depending on the size of the reef two to three transects were laid in all the islands studied and the percentage life form categories were calculated following the method of English et al. (1997).

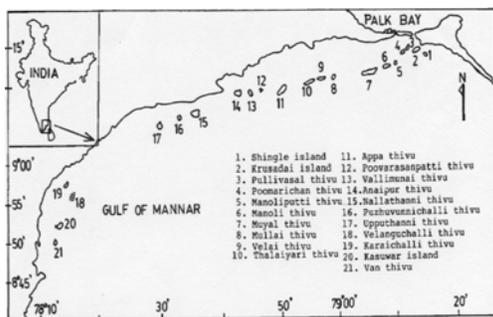


Fig. 1 Map of Gulf of Mannar Biosphere Reserve showing locations of 21 islands.

Results

Marine Biodiversity and Resource Utilization

The mangrove, seaweed and sea grass and coral reef ecosystems are the three important ecosystems in the coastal zone. The GoMBR consists of all these three unique ecosystems and has become significant because of the presence of the coral reefs and its associated fish, sponges, gorgonids, holothurians, pearl pars, chank beds, balanoglossus, sea horse, endangered turtles and the herbivorous marine mammal, *Dugong dugon*.

The floral component comprises of economically viable species of seaweeds such as *Gracilaria*, *Gelidiella*, *Hypnea*, *Sarconema*, *Hydroclathrus*, *Caulerpa*, *Sargassum* and *Turbinaria*. The seagrass communities of this region top the list in India with the highest number of seagrass species providing important feeding grounds for the globally endangered *Dugong dugon*. They also harbour edible *Penaeus semisulcatus* and many *Holothuria* spp., which are harvested for export. There are about thirty-eight fishing villages on the coastal stretch of Ramnad district alone having a population of 12,000 entirely depending on fishery. The entire stretch of GOM coast is inhabited by 47 fishing villages with a total of about 50,000 households and 33 fish landing centres. In the GoMBR area, about 500 mechanised fishing boats (45 to 70 hp diesel engine) operate harvesting the yields from

the sea. Among these boats, some 350 come from Rameswaram and 150 from Mandapam and Pamban. Fishing is mainly done by trawling and by gillnets. Devaraj (1997) reported a four-fold increase of fish catch from 1950 – 1995 in India. The reef fishery is not very important in terms of total landings or earnings when compared to other fishing sectors such as the demersal fishery in the shallow coastal areas or the tuna fishery. The fishermen of GOM either make their living from the pelagic fisheries, the prawn trawl fishery or the small-scale demersal fishery. However, it is expected that the focus of the GOM fisheries are likely to change due to increasing demand from foreign markets for high quality reef fish such as grouper and snapper.

Status of Coral prior to 1998

Although the richness of this area has been documented qualitatively by many studies (CMFRI 1969, James et al. 1969, James 1988, Pillai 1986 and Thomas 1985), quantitative data on fauna and flora of this region, essential for effective management of this unique ecosystem, is lacking. The coral fauna of GOM was found to have 94 species divided among 37 genera (Pillai, 1986). The dominant genera include *Acropora*, *Montipora* and *Pocillopora* among the ramose forms. *Porites*, *Favia*, *Favites*, *Goniastrea*, *Platygyra* and rarely *Symphyllia* represent massive forms. *Cyphastrea* and *Leptastrea* were very common on all reef habitats of this area. The foliaceous forms encountered include *Echinopora lamellosa* and *Montipora foliosa*, which are presently scarce due to siltation and quarrying. Genera such as *Stylophora* and *Seriatopora*, which were common in Andaman and Nicobar Islands and other parts of Central Indian Ocean, were absent in GoMBR. The common hermatypic corals of Lakshadweep and Andamans (*Diplostrea*, *Lobophyllia*, *Euphyllia* and the branching *Porites* spp.) conspicuous elements in reef habitats were absent. The paucity of solitary and colonial fungiids and total absence of the hydrocoral, *Millepora*, and the blue coral, *Heliopora*, were some of the distinguishing characters of the reefs of GOM.

Impacts of the 1998 bleaching

GoMBR reefs have been severely affected by the recent 1998-bleaching event. However, the exact time of bleaching in this region is not known. The studies on Mandapam group were conducted in June 1998 probably immediately after the bleaching event, and the results showed an overall average of 82.49± 19.55% dead coral cover. The average value of live coral cover for life forms in this group of islands was ACB, 5.95%; CB 0.80%; CF 1.35% CM 6.98% CSM 13.93%; CE 1.62 and SC 0.87% and the values for unbleached corals were ACB 3.86%, CM 1.16%, CSM 0.25% and CE 0.43%. During this study, 22 species were found bleached (six branching forms; nine massive coral species; one foliose and six encrusting species) and 15 species (six branching; eight massive and one foliose forms) unbleached. The studies on the other two groups of islands such as Keelakarai and

Tuticorin were conducted during October to November 1998 and May 1999 respectively. The bleaching at Keelakarai has resulted in 60% (DCA+DC+other life form) dead coral and at Tuticorin, 53.31% (DCA+DC+ other life forms). It is presumed that the possible causes for the death of corals may be the 1998 bleaching event as well as other anthropogenic factors not included in this study since there is no pre-bleaching data available for comparison.

Current Status of the Reefs

The results of Line Intercept Transect studies conducted between 1998-1999 for all the 21 islands in the GoMBR show 24.67% live coral cover and the rest dead coral (DC), rubble(R) and sand (S). The percentage occurrence of life form categories of all coral reefs of GoMBR (21 islands) is as follows: ACB $5.30 \pm 4.64\%$, CB $0.38 \pm 0.54\%$, CF $2.90 \pm 2.13\%$, CE $1.31 \pm 1.64\%$, CS $5.78 \pm 8.15\%$ and CM $7.67 \pm 2.23\%$. The order of dominance of live form categories is CM>ACB>CS>CF>CE>CB. It is found that among all the live form categories, massive corals dominate in GoMBR. From the above results, it may be inferred that the worst affected coral species are the branching forms, such as *Acropora* sp. and *Pocillopora* sp. and among the other coral species massive corals (CM) were the dominant live form in all the three groups ($7.30 \pm 7.63\%$ in Mandapam; $5.66 \pm 6.62\%$ in Keelakarai and $7.67 \pm 2.23\%$ in Tuticorin group). ACB was almost absent in Tuticorin group ($0.06 \pm 0.21\%$) with maximum live cover in Mandapam group ($8.5 \pm 13.10\%$) and medium in Keelakarai group ($6.81 \pm 13.37\%$). The percentage of CB in GoMBR was least when compared to other live forms and they were completely absent in Tuticorin group, $0.67 \pm 1.37\%$ in Mandapam and only $0.13 \pm 0.53\%$ in Keelakarai group (Fig. 2).

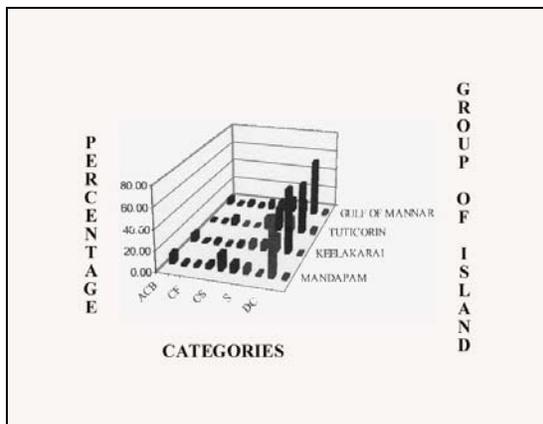


Fig. 2 Percentage occurrence of life form categories of corals three different groups of islands of Gulf of Mannar Biosphere Reserve.

Among the three groups of islands, the Mandapam is found to contain a higher percentage of live coral categories 37.03% than Keelakarai 17.29% and Tuticorin

18.69%. In the Mandapam group sub massive forms dominate ($15.08 \pm 16.64\%$) over other groups such as ACB ($8.5 \pm 13.10\%$), CM ($7.2 \pm 7.63\%$), CE ($3.17 \pm 7.17\%$), CF ($1.42 \pm 4.60\%$) and CB ($0.67 \pm 1.37\%$). In the Keelakarai group ACB dominate ($6.81 \pm 13.37\%$) over the other groups such as CM ($5.66 \pm 6.62\%$), CS ($2.25 \pm 5.95\%$), CF ($1.94 \pm 4.27\%$), CE ($0.5 \pm 0.86\%$) and CB ($0.13 \pm 0.53\%$). Likewise, in Tuticorin group massive corals dominated ($10.06 \pm 14.93\%$) over all other groups such as CF ($5.34 \pm 8.53\%$), CE ($0.23 \pm 0.66\%$) and ACB ($0.06 \pm 0.21\%$).

Discussion

The bleaching in the Mandapam group of GoMBR showed an overall average of $82.49 \pm 19.55\%$ dead coral cover. During this study, 22 species were found bleached and 15 species unbleached. The bleaching at Keelakarai has resulted in 60% (DCA+DC+other life form) dead coral and at Tuticorin 53.31% (DCA+DC+ other life forms). A recent general survey conducted during Feb 2000 showed a large number of species found dead during 1998-99 were reappearing in the GoMBR area (personal observation). During this survey a maximum of 31 species of corals were reappearing in Anaipar Island and a minimum of six species were found in Pullivasal Island. Both in Mandapam and Keelakarai group it was found that an average of 15 coral species were reappearing of which branching *Acropora* species were more in number. From the results, it is clear that some of the islands, which are close to the main land, have a much lower percentage of live coral cover. For example, Pullivasal, Mulli, Valai, Thalaari, Appa, Palliyarmunai, Karaichalli and Kasuwar Islands have very less percentage of live coral cover (Fig. 2). This is probably due to anthropogenic factors such as industrialization, pollution and the discharge of large quantities of sewage into the coastal areas, in addition to the over exploitation of reef resources and illegal mining of corals by the local population.

Threats to coral reefs

Sedimentation

Major problems faced by the coral reefs of GoMBR are sedimentation and bleaching. During the southwest monsoon season (March-September) the wind blows from a northerly direction, creating large waves and resulting in turbid conditions. In the GoMBR area, about 500 mechanised fishing boats (45 to 70 hp diesel engine) operate harvesting the yields from the sea. Among these boats, some 350 come from Rameswaram and 150 from Mandapam and Pamban. Fishing is mainly done by trawling and by gillnets. This trawling operation in the near shore area also adds considerable amount of sedimentation in the reef area. Large amounts of sediment created due to activities in the main land as well as the seaweed collection smother the corals in these islands. Shallow reef flats of the islands are the worst affected due to this sedimentation compared to the reefs present in the deeper regions.

Human Activities

The threats to the GoMBR are through indiscriminate exploitation of natural resources by poachers for commercial purposes. There are about thirty-eight fishing villages on the coastal stretch of Ramnad district with a population of about 12,000 who entirely depending on fishing. Exploitation of fishery resources in the inshore waters has been the sole occupation of hundreds of fishing families along the coast for centuries. Reef exploitation includes reef fishery, chanks and pearl fishery, ornamental shell trade and illegal mining of corals. Villagers around Palk Bay harvest holothurians, seahorses and pipefishes. Other harvesting activities include milk fish fry. Up to 1000 turtles are harvested annually and dugongs are also poached.

The destruction of reefs and reef associated organisms in the GOM and Palk Bay is perhaps unparalleled in the history of environmental damage to nature and natural resources in the recent past (Pillai 1996). The coral reefs of Palk Bay and GOM have been quarried for industrial purposes from the early sixties from Mandapam to Tuticorin. The estimate of coral quarried varies. At Tuticorin the estimate is 80,000 t per year. Pillai (1973) estimated the exploitation of corals for extraction of lime and for manufacture of cement from Mandapam area alone during the sixties and early seventies to the tune of 250 m³ per day. Some of the islands (Vilanguchalli in Tuticorin group and Poovarasampatti Island in Keelakari group) are totally submerged 3-5 m below water level probably due to quarrying. The huge colonies of corals that occupied large areas in the lagoons of many islands are no longer found due to over exploitation of algae and shells for commercial purposes. The corals in GoMBR are fast deteriorating, particularly due to human interference. The boring sponges cause considerable destruction to corals and about 20 species of boring sponges are recorded from this region. Due to sand quarrying, fly ash discharge from thermal power stations and installation of chemical industries in the GOM area are the main cause to destroy the pearl oyster fishing, live corals and the freshwater aquifers. The live export of crabs and lobsters from this area in recent years is also causing damage to live corals. Fish traps (=Koodu) used to collect live crabs for export damage coral reefs in these areas. Other than these disturbances, siltation, agricultural runoff and sewage discharge are major problems in these areas.

Coral Diseases

Three types of coral diseases have been "identified" in GoMBR: white band disease, black band disease, and bacterial/fungal infection. While there is a degree of uncertainty over the causes responsible for each disease, they all appear to be stress-related. Sediment, sewage, pesticides, heavy metals, bleaching and other human impacts stress the corals of GoMBR resulting in tumors, bacterial/fungal attack and parasitic worms. To understand more about this, recently, Ministry of Environment, Government of India has funded some projects to study the coral diseases in GoMBR.

Management of the Biosphere Reserve

The Tamil Nadu State Forest Department manages GoMBR through its wild life wing. A separate office is functioning at Ramanathapuram (district head quarters and major town close to GoMBR) to manage the biosphere reserve through a wild life warden and a range officer. Recently GCRMN Biophysical Monitoring Action Plans have been prepared for effective management of the biosphere reserve. Socio-economic monitoring training by GCRMN is also under way. Since the biosphere reserve does not have any legal status for protection currently, the state of management is not adequate. Actions are being taken to protect the reserve and to reduce the pressure from the coastal population depending on the resources of this reserve by implementing a GOI/UNDP/GEF project. In order to maximise the benefits to the local community, to generate a sense of stewardship in the fishing industry, to achieve effective enforcement, and to minimise habitat damage, it is suggested that trawlers should be excluded from operating in inshore waters of the islands and the traditional fishing communities should be brought into management process. Other gaps in the management of GoMBR area are lack of awareness among the local public, limited scope for reducing the ever-increasing population pressure and lack of trained work force for marine protected area management.

Conclusions and Recommendations for Coral Reef Conservation

Coral reefs in the GOM Islands are under increasing pressure. Factors such as urbanization, population growth, industrial development, international trade, inadequate legislation, lack of trained persons and awareness, leading to habitat degradation, and over exploitation of resources are the known threats to the survival of life support system of the GoMBR. There is no effective management plan to mitigate the threats to the ecosystem, root causes of threat, cost effective interventions to address the root causes, significant threats to the biodiversity of representatives systems of global importance. Networking among the scientific, government and nongovernmental personnel in GoMBR is essential to avoid duplication and what is really needed can be executed. Long-term monitoring of the status of the coral reefs and socioeconomic status of the people depending on the reefs are the need of the hour. The data gathered on the above will form the basis of the management action plan to save the GoMBR from biological desert. Collaboration with international organizations on reef and resource management should be taken up as priority area.

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