

STATUS AND STRATEGIES FOR MARINE BIODIVERSITY OF GOA

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1. INTRODUCTION

Efforts have been made for quite some time to study and use the ocean wealth. The best example of this can be quoted from 'Samudra-Manthan' of Indian mythology. In Ayurveda also there are mentions about the uses of corals, pearls, oysters, shells, etc. In recent years (1960-1965), the International Indian Ocean Expedition - a joint venture of several countries revealed tremendous wealth of living and non-living resources of our seas. Since then, continuous attempts have been made by the Indian oceanographers to explore and exploit these resources. It has been observed that in this vast realm of ocean several forms of life are represented by microscopic unicellular organisms like bacteria, viruses, yeasts, etc. to large gigantic mammals like whales. Scientists have started knowing these resources and their importance. The coastal population is largely dependent on the coastal living resources for their livelihood.

The marine biodiversity can be divided into coastal and oceanic. The coastal regions, because of its easy accessibility and richness of biota, have been studied in greater details for various components. There have been efforts to preserve the endangered germplasm of these valuable resources. Some of the important components of the coastal zones are estuaries and backwaters, mangroves, corals, benthic flora and fauna, the planktonic forms in the euphotic zone and fishery resources.

On the basis of available scientific data, it can be concluded that some of these ecosystems are threatened due to the mismanagement and over-exploitation. Some of the major factors responsible for the degradation of these ecosystems are pollution, deforestation, reclamation and biotic interference. As a result of these man-made

activities, the coastal ecosystems like mangroves and corals have been degraded to the great extent, affecting its biodiversity. Even the remotest islands like Lakshadweep and Andaman-Nicobar group of islands have started showing impact of these factors. It is, therefore, essential to use all the expertise as well as legislative support to control this menace along with the ever-growing population of India. This is of great concern, particularly when the marine living resources from the polluted regions are utilized for human consumption.

As compared to the coastal biodiversity, the oceanic region somehow has not received serious attention so far. Although, scientific efforts have been made to chart the surface water of the ocean for its productivity, the deeper parts of this region, like abyssal has remained totally unexplored. There is a great potential to explore the oceanic biodiversity of the deepest water, because of altogether different environments such as very low temperature (3 to 4°C), very low light intensity (almost dark) and tremendous pressure of the water column. To explore this unique biodiversity of deep region, Indian oceanographer will require special type of equipment such as submersibles and also suitable funding. It is interesting to note that in some of the deep Indian waters, there are hydrothermal vents where temperature rises beyond the boiling point, changing the water chemistry.

Taking into consideration the urgent need for protection of fast decreasing biodiversity from the Goa coast, it is necessary to identify the 'HOT-SPOTS', luxuriant in biodiversity and protect them for posterity. There are several areas like Andaman-Nicobar, Lakshadweep atolls, Sunderban mangrove forests, and deltas along the East Coast, Gulf of Mannar, West Central West Coast of India and the Gulf of Kachchh. In many of these coastal areas, biosphere reserves, wildlife sanctuaries, marine parks and Protected Areas have been declared. Along the Goa coast the estuarine mangrove species have been protected, Chorao Island where 250 ha of mangroves are in luxuriant form have been declared as Dr. Salim Ali Bird Sanctuary. Efforts are being made to preserve the marine flora and fauna of St. George's Island off Marmagao harbour. In addition to this, crocodiles, dolphins, turtles are also protected species (Anonymous, 1992, 93).

For any successful protection programme of the natural living and non-living resources, the conservation and management plans are necessary. India, however, lacks to some extent proper laws for the coastal and marine biodiversity. Although, there have been recently some efforts to modify certain environmental laws like Coastal Regulation Zones (CRZ) for the conservation and management, it has been observed that every time intervention of judiciary becomes essential (Anonymous, 1998, Vanguri, 1994).

Secondly, for effective conservation and management strategies along the Goa coast, so far the participation of local communities has not been effectively used. As a result of this, there have been demonstrations and agitations for the projects of national importance. It is of utmost importance to create scientific temper, public awareness and people's participation in most of the programmes pertaining to the marine biodiversity of Goa. If we can use the traditional knowledge, experience and wisdom, there should not be any problems in future to protect Goa's bio-diversity. This will also become part of our national heritage. It is of urgent need to open a National Register for enumerating the list of coastal and marine biota of Goa and also India. Similarly, the existing Marine Biological Information Centres, Museums and laboratories along the Indian coast can be effectively connected with Goa by the modern communication means like Internet for the quick dissemination of information (Anonymous, 1997).

2. Components of Biodiversity

Goa forms a small coastal state of the Western Ghats and has a coastline of about 105 kms. There are 7 estuaries, sandy beaches and rocky shoreline. The region has the influence of monsoon during June to September, which affects the biodiversity before, and after the season.

Ecologically Goa coast is very important. The tidal amplitude is around 1.5 to 2 M but the intertidal expanse along the coast is limited due to the steep gradient. The climatological conditions are typically coastal and moderate. The region is comparatively pollution free.

Qualitative and quantitative distribution of marine biota along the Goa coast varies during premonsoon, monsoon and postmonsoon. Some of the major components of marine biodiversity are discussed below:

2.1 PHYTOPLANKTON

Phytoplankton population exhibited varied diversity in time and space in the coastal waters of Goa. Phytoplankton of this region is composed of three major groups. Viz. Diatoms (Bacillariophyceae), dinoflagellates (Dinophyceae) and blue-green algae (Cyanophyceae). Another group of organisms encountered is comprised of green algae (Chlorophyceae), the contribution of which is not significant. The environment in question is a diatom-dominated one with a record of more than sixty five species, followed by dinoflagellates with fifteen species, five species of blue-green algae and four species of green algae (Devassy, 1992).

Maximum numerical abundance of phytoplankton was noticed during February-June period and also during September-November months. Diatoms, dinoflagellates and blue greens frequently formed blooms.

The blue-green *Trichodesmium* is the most common bloom-forming organism in this region. Massive blooms of this organism occur every year with a marked periodicity during February-May. This organism has the ability to fix atmospheric nitrogen and on its decay, the nutrient is released to the environment that promotes the growth of many planktonic organisms in succession.

Some of the massive dinoflagellate blooms (Red Tides) affect the fishery of this region and also cause mass mortality of fish and other aquatic animals.

2.2 MARINE ALGAE

The coastline of Goa with the length of 120 kms has been surveyed extensively for marine algae. Altogether 77 species of algae are collected from various places of Goa. A groupwise representation is as follows. Cyanophyceae - 23, Phaeophyceae-22,

Chlorophyceae-23 and Rhodophyceae-29. Habitats like intertidal, estuarine and sub-tidal regions are of algal interest (Agadi and Untawale, 1978).

Intertidal region has been surveyed thoroughly. Species of *Porphyra*, *Gracillaria*, *Gelidium*, *Ulva*, *Sargassum* are the economically important algae occurring along this coast. Various seaweeds are analysed for their biochemical contents and bioactive substances. Calcified algae (articulated corallines and *Padina*) have been studied for taxonomy, distribution, mineral contents, surface morphology, phenology and biological associations. But crustose corallines are remained untouched. Mangrove environment of Goa supports a few algae with low standing crop and the dominant species are *Enteromorpha*, *Caloglossa*, *Gracilaria verrucosa*, *Bostrychia*, etc. Available data on subtidal region is very scanty and is restricted to the depth of 3-6 m. Species of *Padina*, *Stoechospermum*, *Sargassum* and *Amphoroa* are common in this region.

Overall, marine algal flora of Goa is typically 'tropical' type and shows continuity with the West Coast of India and also with the submerged banks. Algal representation is comparatively poor both qualitatively and quantitatively (Dhargalkar, 1982).

2.3 MANGLICOLOROUS FUNGI

The higher marine fungi form four major groups. They are Arnicolous fungi, Manglicolous fungi, and Algicolous fungi and folicolous fungi. There is very little information available about the higher marine fungi of Goa except manglicolous fungi (Fungi growing on the submerged parts of mangrove trees). Total of 62 manglicolous fungi have been reported from Goa. The dominant species are *Halocyphina villosa*, *Massarina vellatospora*, *Verruoulina enalia*, *Lophiostoma mangrovei*, *Lulworthia gradispora* and *Cirrenalia pygmea*. Out of eight species of mangroves *Rhizophora mucronata* (52 species) supported maximum number of species followed by *Rhizophora apiculata* (52 species) *Kandelia candel* (50 species), *Avicennia marina* (48 species), *A. officinalis* (45 species), *Sonneratia alba* (42 species), *Aegiceras corniculatum* (28 species) and *Excoecaria agallocha* (9 species). There are about 15 species of mangroves available in Goa. The investigation of fungi on the remaining mangroves may reveal some more species (Chinnaraj, 1993).

2.4 SEAGRASSES

The seagrass beds form Goa is mostly patchy and confined to the sheltered estuarine swamps. The flora comprised of *Halophila beccarii* and *H. ovalis*. *Halophila beccarii* commonly occurred in association with mangroves in the polyhaline and mesohaline zones (salinity 5-30%). A patch of *Halophila ovalis*, was recorded from euhaline (salinity >30%) zone of Mandovi estuary. The seagrass flora from the Goa coast was observed to be relatively very poor (qualitatively and quantitatively) compared to the other regions of India (Jagtap, 1985).

2.5 MANGROVE FLORA

Goa State along the central West Coast of India covers approximately 2000 ha. of mangroves distributed all along seven estuaries including Kumbarjua canal. The mangrove flora consists of 15 species of 10 genera belonging to 7 families. The dominant mangroves are *Rhizophora mucronata*, *Sonneratia alba* and *Avicennia officinalis*. Major mangroves in Goa are recorded from Mandovi-Cumbajua-Zuari complex with *R. mucronata*, *Kandelia candel* and *S. alba* as dominant species. Chorao Island along Mandovi estuary has denser mangrove vegetation dominated by *A. officinalis* and *R. mucronata* and *S. alba*. Zuari estuary has about 900 ha. of mangrove area with dominant species as *S. alba*, *A. officinalis* and *R. mucronata*. Mangroves are rare in the upstream region, however *S. caseolaris* and *K. candel* continue to be present. Kumbarjua canal has mudflats on either side with quite dense mangrove vegetation of 200 ha. The southern part of Kumbarjua canal has the dominant species like *Avicennia*, *Rhizophora*, *Sonneratia*, etc.

Kandelia candel that is on the verge of extinction appears in abundance along the Mandovi-Zuari complex. *S. caseolaris* which has limited distribution along the Indian coast, is still found growing in the upstream region of Zuari estuary. The species like *Ceriops tagal* and *Lumnitzera racemosa* occurring along northern central West Coast do not occur in Goa. *Xylocarpus* species, which was reported by Cooke (1908), has completely disappeared from the coast. *Bruguiera gymnorhiza* is rarely seen and can be considered as an endangered species from the Goa coast (Jagtap, 1985).

2.6 ZOOPLANKTON POPULATION

The Mandovi-Zuari estuarine system is a highly variable and dynamic environment due to the strong tidal influence. Zooplankton community is dominated by herbivores. The crustacean groups such as copepods, cladocerans, mysids, sergestids, decapod larvae, prawn larvae and juveniles constitute the bulk of zooplankton. The other taxa present are polychaete larvae, ctenophores, veligers, chaetognaths, fish eggs and larvae. Copepod form the single largest taxon represented by 55 species. The temporal and spatial variations of species are determined by prevailing salinity in the estuaries. Maximum and minimum species diversity values are during dry premonsoon and monsoon when salinity is high and low respectively. The zooplankton community structure, diversity and species succession are intimately linked to the salinity cycle in the estuaries (Goswami, 1985).

2.7 SAND DUNE VEGETATION

The 105-km coast of Goa stretches from Querim in North (Pernem Taluka) to Polem in South (Canacona Taluka). Survey along the sandy coastline of Goa indicates the presence of three types of shore. Foreshore, mid shore and backshore. Fore shore is affected by tides regularly, therefore dune formation is not stable and occurs only as embryonic dunes. Mid shore and hind shore has stabilized dunes at many places.

The pioneer sand stabilizing plants along the coastline of Goa are the species of *Spinifex*, *Ipomea*, *Acanthus*, *Clerodendron*, *Vitex*, *Spermacosea*, *Urginea*, *Dioscorea*, *Pandanus*, *Crotolaria*, *Duranta*, *Leucus* and many more. The foreshore is mostly represented by herbaceous plants, the creepers like *Ipomea pes-caprae*, *Cyperus sp.*, *Spinifex littoreus*, etc. The midshore zone comprises little taller shrublike plants i.e. *Duranta* etc., while from the backshore zone mostly the trees are found. This sort of arrangement of herbs, shrubs and trees gives a gentle slope resulting into diversion of the wind towards upward region and preventing sand erosion. Therefore, it is highly essential to protect the coastal dunes alongwith its vegetation. As per the Coastal Zone Regulation, the sand dune vegetation is protected under CRZ – I.

2.8 MACROINVERTEBRATES

Studies on two beaches of Goa revealed the occurrence of 47 species of macroinvertebrates belonging to 32 families. Among these, *Pisionodense indica*, *Nerine cirratulus*, *Glycera alba*, *Doanax faba*, *D. incarnatus*, *Scotollana* sp. and *Dotilla mycteroides*, *Pontharoinia unirostrata*, *Eurydice peratissis* and *Gastrosaccus simulans* were most abundant species. Species diversity was relatively high in low energy estuarine beach at Siridao than the high-energy marine beach at Candolim. Zonation of benthic fauna was discernible with high species diversity in low tide region. Heterogeneity and seasonality of benthic community structure are mainly attributed to interaction of biotic and abiotic factors. Though there are few works on quantitative and qualitative aspects of sand dwelling Benthic fauna in Goa beaches, there are no study on taxonomy of macrofauna and meiofauna. Similarly there is no information on sand dwelling microorganisms (Harkantra and Parulekar, 1986).

2.9 WOOD BORERS

Biodeterioration of marine structures, fishing crafts and living mangrove vegetation is quite severe along the Goa coast. The destruction is caused by atleast 14 species and 1 variety of borers belonging to the molluscan and crustacean families of Teredinidae, Pholadidae and Sphaeromatidae. The species recorded so far: *Dicyathifer manni*, *Lyrodus pedicellatus*, *L. massa*, *Banka rochi*, *B. campanellata*, *B. carinata*, *Nausitora hedlevi*, *N. dunlopei*, *Bactronophrus thoracites*, *Martesia striata*, *M. nairi*, *Lignopholas chengi*, *Sphaeroma terebrans*, *S. annadalei*, *S. annandalei travancorensis*. (Santakumaran, 1985).

These borers, particularly, the molluscs have prodigious fecundity producing enormous number of young ones in one brood. They have unlimited appetite attacking any type of woody materials exposed in the sea. The attacks in heavy intensity and because of their fast rate of growth destroy timber within a short time of few months. All this together with their other highly specialized adaptations make marine wood borers man's number one enemy in the sea (Sawant, 1992).

2.10 MARINE FISH FAUNA

The species composition and taxonomic diversity of marine fish landings in the premonsoon season at 4 important landing centres in Goa comprises of 89 species of marine fishes belonging to 34 different families (Parulekar, 1990; Shastri, 1977).

2.11 OTHER FAUNA

In addition to the above-mentioned faunal composition there are some other groups present in Goa waters. These are as follows:

Under marine mammals, there are dolphins and porpoises found along the Goa coast. Stray reports have been recorded for the stranded whales. Off Marmagao harbour, there is a St. George's Island group where four species of corals are found. Similarly in the coastal waters 4 different species turtles have been reported. The crustacean group includes about 83 pp. of crabs and 4 spp. of prawns (Achuthankutty and Parulekar, 1986).

There are also some groups of marine animals about which there is not much information available. These include marine insects, marine birds and sponges. The macrobenthos of Goa waters comprises about 111 species while the meiofauna is represented by 10 groups like Nematodes, Turbilarians, oligochaets, Harpactoids, Gastrotrichs, Halacarids, Ostracads, Polychaetes, Tanaids, Tardigrades, Tardigrades, Kinorhynchs and isopods (Parulekar et al, 1980). Some of the fauna is rarely observed in Goa waters. These are seahorse, star fish, ornamental fishes, sea anemones, Holothurians, etc.

There is a clear-cut demarcation between the flora and fauna along the open coast and the estuaries. Along the estuaries also the biota changes according to the substratum, salinity and the season. The substratum like rocky shore, sandy or muddy bottom influences the diversity of these organisms.

Seasonal changes particularly the heavy rainfall reduces the salinity and changes the biota. Marine algae are greatly influenced by the salinity and mostly the 'seaweed

season' is from October to May. However, the salinity also triggers the flowering, fruiting and also the germination of mangroves. The tidal amplitude and inundation level is of significant importance in the distribution, zonation and succession of marine biota.

As indicated earlier the marine biodiversity of Goa is comparatively rich. It is, therefore, essential to make the consolidated effort to compile all the scattered marine living wealth, which would give us the indication of endangered and extinct species. At present, there are many gaps in our knowledge about the biodiversity of Goa coast.

For conservation and management of marine biodiversity there are several rules and regulation under Wildlife Protection Act, CRZ and Pollution Control. Mangroves, sand dunes and coral species are the sensitive ecosystems and are protected under CRZ I category (Anonymous, 1998). The marine turtles, dolphins and the crocodiles are protected under the Wildlife Protection Act of India. However, it is surprising to note the rampant violations of these rules.

Goa is one of the major tourist destinations of the national and international level. However, the eco-tourism has not received proper attention, which has high potential. Other important activity in Goa is the large-scale mining of iron and manganese. The mining rejects and overflow in the form of the fine silt adversely affects the bottom dwelling fauna and the benthos. The industrial and the sewage pollution is considerably low and is of sporadic nature as well as site specific.

In conclusion, it can be mentioned that the marine biodiversity of Goa needs systematic study to fix the levels of degradations like extinct, endangered, rare, and indeterminate, out of danger or insufficiently known. In spite of the abundance of marine living wealth and clean waters, some of the factors are responsible for degradation of marine biota. These are population pressure, deforestation, reclamation, pollution and siltation. However, to prevent the degradation and loss of marine biodiversity, some corrective measures like conservation, preservation, restoration, research, education and public awareness are very necessary.

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