

MARINE LIVING RESOURCES AND ECOSYSTEMS ALONG THE WEST COAST OF INDIA

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ABSTRACT

The West coast of India with a wide continental shelf and a long coastline accounts for three fourth of marine fish landings of the country. The estuaries and backwaters receive nutrients from the hinterland, and are most productive area for food but they are also extensively used for disposal of domestic waste, sewage, industrial effluents, and oil wastes and thus face serious threat of pollution and present hazards for public health. In this presentation, backwaters of Cochin and estuaries near Goa are discussed, where mangrove are very common. They add organic matter to the aquatic environment and modify the ecology. These areas have fringing mangroves and mangrove swamps. The fringing mangroves are common in estuaries and mangrove swamps are found in backwaters and low lying areas. The most abundant mangrove swamps are in Gulf of Kutch. These have a special ecosystem which is highly productive and the substratum is rich in organic matter. Around Bombay city a large low lying areas are full of dwarf mangroves and are being reclaimed for urban development at a very high cost. An urgent need has arisen for management of these ecosystems and enhancing food production.

Strong shoreward winds influence the coastal areas in different ways during the monsoon season. In some areas strong coastal upwelling is observed, and in others it may be weak or negligible. Coastal and oceanic islands also influence the environment around them. The combined effect of all these factors lead to creation of separate ecosystem and four major ecosystems can be identified along the West coast of India. They are i) Estuaries and backwaters including mangroves ii) Coastal zone upto 200 m, iii) Open Ocean and iv) Islands and atolls. These systems are adjacent to each other but have their typical physico-chemical characteristics. They differ from each other in food chain and production at different trophic level. Biologically their dominant fauna and flora is also different and each of them have smaller sub ecosystems of their own. Amongst these ecosystems except estuaries and a part of the coastal zone which are intensively utilised for fishing, other ecosystems at present are under exploited. There is, therefore, the need to study these ecosystems for harvesting the exploitable resources at an optimum level.

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INTRODUCTION

The West coast of India and the continental shelf along the Indian coastline are highly productive and accounts for three fourth marine fish landings of the country which is around 1.3 million tons. Along the Indian coastline various changes occur in different areas and these modify the biological processes. Study of these processes shows existence of atleast four major biological ecosystems. Each ecosystem has its special characteristics and their physical, chemical and biological components are different. The production and food chain in marine ecosystems is influenced principally by the geological formation of the area and the physical and chemical processes which occur. These jointly constitute the environment and govern the inter-relationship amongst the organisms and their qualitative and quantitative production. Considerable work on these aspects has been done along the West Coast of India during and after the International Indian Ocean Expedition and sufficient information is available on ecological and biological processes which occur in this area. In this paper an attempt has been made to characterise the ecosystems which are found along the west coast of India.

The west coast presents different environments from south to north. These are the backwaters of Cochin, estuarine areas in Karnataka and Goa States where large but shallow rivers open into the Sea and the shallow region of the Gulf of Kutch with extensive Mangroves. In addition there are a large number of islands in the nearshore and offshore regions. Besides all these, this coast is periodically affected by upwelling in different areas. The available information enables us to delineate four major ecosystems along this coast. These are (i) Estuaries and backwaters including mangroves, (ii) Coastal Zone upto 200 m (iii) open ocean and (iv) Islands and atolls.

1. ESTUARIES AND BACKWATERS

Estuaries and backwaters which form the transitional zone from freshwater to the sea, are very extensive and play an important role through food production, disposal of effluents and sewage, transport etc. The total area of these waters along west coast is about 30.5 lakh acres (Mitra, 1970) and the state-wise break up is given below: (1 lakh acre = 100,000 acres).

State	Backwaters area in lakh acres	Estuaries	Total
Gujarat	9.2	10.0	19.2
Maharashtra	2.0	1.0	3.0
Karnataka	2.0	0.5	2.5
Kerala	5.0	1.0	6.0
Total	18.2	12.5	30.7

It is seen that the estuaries and backwaters are most extensive in Gujarat. This is followed by Kerala, Maharashtra and Karnataka States. In all these areas generally back waters are more important.

Cochin backwaters and the estuaries of Goa have been extensively studied which are discussed here as the representative areas for tropical backwaters and estuaries.

The hydrography of these waters is influenced by the tides and the seasonal changes due to monsoon. Considerable changes occur due to heavy rains and results in lowering the temperature and salinity. The salinity changes during the year range from 0 to 35‰. In Mandovi estuary of Goa, salinity reaches zero in monsoon while in other summer months it is as high as 35‰. These result in strong differences in animal fauna during monsoon and non-monsoon seasons. In Cochin backwaters stratification occurs from June to September when surface and bottom waters are clearly differentiated, (Qasim, 1975, in press). The light penetration is reduced particularly during monsoon months. During the course of a year the euphotic zone varies from 2-6 m. The attenuation coefficient (k) ranges between 0.60 - 3.00 in Cochin backwaters (Qasim, *et al.*, 1968) and 0.48 to 7.5 in Goa estuaries (Bhargava and Dwivedi, in press). No distinct stratification was noticed in Goa estuaries.

The gross and net organic production in Cochin backwaters ranged from 0.5 to 1.50 $gC/m^2/d$ and 0.35 to 0.88 $gC/m^2/d$ respectively (Qasim *et al.*, 1969). C^{14} uptake in surface waters of Mandovi estuary ranges from 134.550 $mg C/m^3/d$ and during high tide 44.122 $mg C/m^3/d$ during low tide.

In Zuari estuary which is more marine in nature, the C^{14} uptake during high tide varies from 580 to 1950 $mg C/m^3/d$ and from 22 to 82 $mg C/m^3/d$ during low tide. In both these estuaries variations occur due to tide and production is higher during high tide.

Recently Bhattathiri *et al.* (In press) have estimated the column production and chlorophylla values during monsoon season from June to September as follows.

Estuary	Organic production ($mgC/m^2/d$)	Chlorophylla mg/m^2
Mandovi	59.04 - 549.38	1.60 - 12.70
Zuari	108.24 - 502.45	1.90-16.78
C.Canal	176.28 - 439.71	2.40 - 12.60

It is seen that the highest values occur in Cumbarjua canal which connects the two estuaries at a distance of about 12 kms from the sea.

The phytoplankton counts in Cochin backwaters were maximum in November and minimum in September and ranged from 22,200 to 299,700 cells/litre (Devassy and Bhattathiri, 1974) with diversity index ranging from 1.59 to 4.50. In Goa estuaries the phytoplankton counts from surface waters during June to September are available which ranged from 3,600 to 430,00 cells/litre.

The secondary production is also high in these waters. The average zooplankton biomass in ml per m^3 in Cochin backwater ranged from 0.09 in July to 0.35 in March (Pillay *et al.*, 1973). The zooplankton biomass in Goa estuaries from a single station was 175 $g/1000 m^3$ in Zuari and 82 $g/1000m^3$ in Mandovi

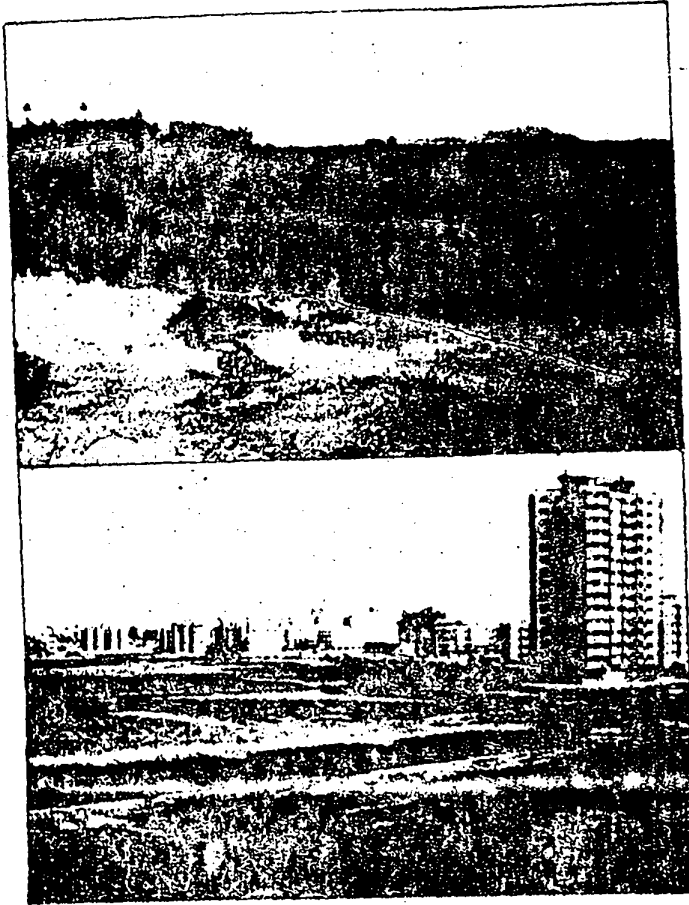


Plate I. Dwarf mangroves around Bombay city. Above - Large mangrove swamp between Andheri and Versova area; below, a part of the same area under reclamation for urban development.

(Goswami et al, 1975). The average zooplankton biomass expressed as wet weight per 1000 m² was found to be 439 gm in Cochin backwater, 61 gm in Mandovi estuary and 149 gm in Zuari estuary. In all these three areas the copepods were the most dominant.

MANGROVES

The mangroves are the tropical ecosystems found in the brackish waters and the estuaries where wave action is negligible and substratum is soft and muddy. They have specialised root systems which help in building up the land mass and harbour variety of benthic life. Along the west coast of India, the fringe mangroves and mangrove swamps are abundant. The southern coast of the Gulf of Kutch is very rich in mangroves, while northern part is devoid of any mangroves. Gulf of Cambay has mangroves in sheltered areas and around islands. Bombay is surrounded by dwarf mangroves (Navalkar, 1940, 42, 48). Navalkar and Bharucha (1948, 49) have studied the various ecological and physiological parameters of this region. At present these mangroves around Bombay city are of no economic value and are being reclaimed at a very heavy cost for urban development & (Plate 1).

South of Bombay from Ratnagiri to Mangalore, along the central west coast, almost all the estuaries have mangroves. Further south in Kerala, Cochin has extensive backwaters with fringing mangroves.

Untawale et al (1973) and Dwivedi et al (1975) have studied favourable and unfavourable environmental parameters for growth of mangroves. In mangrove swamps bacteria break down dead foliage and as a result of biodegradation, the nutrients are regenerated and phosphates and nitrates occur in high concentration. The primary and secondary producers also feed on the organic matter enriched with nutrients. These mangrove swamps act as the nursery grounds for nearshore and estuarine organisms including prawns, shrimps and various fishes like Chanos, Mugil, Anabas and mud skippers. These areas are also subjected to strong variations in the environmental parameters, therefore animal fauna varies from season to season. The most common plants are Rhizophora mucronata, Avicennia officinalis, Sonneratia apetala, Acanthus ilicifolius, Aegiceron con-riculata. These are specially abundant along the central west coast of India. Untawale et al (unpublished) studied the phytoplankton counts, the range was from 50-5000 cells/litre with maximum concentration in May and June while minimum concentration occurs in August and September. The average values of C¹⁴ uptake in these swamps was 37.8 mg C/m³/d (Pant, personal communication).

Based on the available data from Cochin backwaters and Goa estuaries the values are 9.75 mg C/m³/h for organic production and 216 gm/1000m³ for Zooplankton. Thus the estuaries and backwaters along with the mangroves is a highly productive ecosystem and also has a high potential for yield at third trophic level. These areas can be utilized for culture of molluscs, prawns and fishes. However, the present practices of indiscriminate exploitation of the young ones adversely affect production and perhaps this may be the reasons for low yield at the third trophic level inspite of high production at primary and secondary trophic levels. Therefore, these areas should be given high priority for aquaculture.

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The greatest danger to these highly productive areas is from the disposal of domestic sewage and industrial effluents and in recent years the situation has become worse. In order to protect and harness these areas for production, the wastes should be treated before discharge and their disposal should be regulated.

2. COASTAL ZONE UPTO 200 m:

Along the west coast of India fishing is extensively undertaken by non-mechanised boats who follow the traditional fishing methods. There are about 1.06 million fisherman who do not generally go beyond 8-10 kms from the coast. This zone accounts for more than 80% of India's fish landings and has been studied most intensively. Based on these data, the whole coastal zone can be divided in three distinct areas.

- i) South-west coast where upwelling is prevalent.
- ii) Central west-coast where upwelling is negligible and
- iii) Bombay Saurashtra coast with a large continental shelf and mild upwelling.

The organic production along the South West Coast has been measured from Karwar to Cape Comorin (Nair *et al*, 1970). The rate of production upto 50 m depth ranged between 0.18 - 2.45 gmC/m²/day with an average value of about 1.19 gmC/m²/d. However, at the Wadge bank during upwelling months the production is much higher. In the zone starting from 50 m depth to 200 m. the production rate decreases to an average of 0.43 gmC/m²/d on the nearshore waters of Central west coast. Between Goa and Bombay the chlorophyll_a values ranged from 2.4 to 18.8 mg/m³ (Dehadrai and Bhargava, 1972). Higher concentration was seen in November-January and slight upwelling was surmised.

The secondary production through zooplankton has been assessed by many research workers. Based on the data of IIOE, plankton atlases have been published which summarise the total zooplankton biomass. The Zooplankton biomass off Cochin during April-October is of the order of 10 g/m² but gradually decreases to 10 gm/m² towards offshore areas, (Dwivedi, 1973). Off Saurashtra coast a concentration of 1800 ml/1000m³ of zooplankton biomass has recently been recorded, and indicates high potential for pelagic fishery.

The fish yield from these areas is high and mechanised fishing is generally practised upto 100 m depth zone. This is indicated by the trawl catches from three different areas. The figures are 226.0 kg/h off Cochin; 115.35 kg/h off Karwar and 220.5 kg/h off north Bombay and Saurashtra (Dwivedi 1973). These zones also differ in the fish fauna and each of them are dominated by different groups of commercially important fishes. The fishing off South coast is dominated by crustaceans and sardines, the Central zone by mackerals and Laotarius while the northern zone by pomfrets, thread fins, Bombay duck and Pseudociaena Sp.

These areas are still under utilised and the fish production can be further increased. An additional production of 2.27 million metric tons has been estimated from complete Indian continental shelf upto 200 m depth zone. The major share of the yield will come from pelagic resources of the west coast alone. Therefore, this zone has three distinct sub-ecosystems which differ in rates of production and support different combinations of commercially important fishery. Though these ecosystems are adjoining and the physical limits of these systems

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overlap but each of them when examined as larger systems show distinct biological characteristics at primary, secondary and tertiary trophic levels. These differences are also supported by the physical and chemical characteristics. It is necessary to investigate and develop different approach for the optimum utilization of each of these sub-ecosystem. In these areas pollution problem is not serious, however, recently some studies of fishes caught around Bombay Harbour showed the mercury content higher than the permissible limit (Halkar and Tejam, 1974).

In this area Bombay is largest city which has problems of disposal of sewage and industrial effluents, and as a result some bays and creeks have become polluted (Dwivedi and Desai, in press). A detailed study of trawl catches conducted over a five year period aboard R/V Harpodon also show a gradual decrease in fish yield from 1968 to 1973 (Abraham *et al.*, *per.com.*). It thus appears that these areas are used for various purposes which are not compatible for each other and require very careful management policies.

3. OPEN OCEAN

The area beyond 200 m zone is considered here as open ocean. This ecosystem at present is poorly exploited by Indian fishing industry. The most important is Tuna fishery of the Indian Ocean which is exploited principally by Non-Indian Ocean countries. In comparison to estuaries and coastal zone this area is less productive and the average organic production is only $0.18 \text{ gC/m}^2/\text{d}$ while the chlorophyll concentration off Alleppy ranged between $7.6 - 30.35 \text{ mg/m}^2$. Off Cochin it ranged between $2 - 210 \text{ mg/m}^2$. The secondary production in terms of zooplankton biomass has been very well studied during International Indian Ocean Expedition. Indian Ocean Biological Centre, Cochin has published a series of zooplankton atlases on the Zoo-geography of zooplankton in Arabian Seas. Based on this data the estimated average zooplankton biomass is $19 \text{ ml}/200 \text{ m}^3$ for the Arabian Sea and $14 \text{ ml}/200 \text{ m}^3$ for whole of Indian Ocean (Saktivil, personal communication).

The known resources of the open ocean are tuna and Myctophid like fishes. The Indian Ocean central water area and subtropical convergence area (75°E) formed good ground for albacore tuna (Uda and Nakamura, 1973). Panikkar and Jayaraman (1966) pointed out rich fishery for oil sardine and mackerel in upwelling areas of Arabian Sea while Uda and Nakamura (1973) also confirmed upwelling areas a favourable grounds for tuna fishing in the equatorial zone.

This ecosystem may have lesser rates of production but turnover of energy between trophic levels is high. Apart from the fast turnover, large area and a deep euphotic column make this zone important as a source for food potential. The present data suggests over fishing of some tuna species and now it is necessary to concentrate on smaller tunas and tuna like species. Further extensive investigations are also necessary to delineate area of seasonal upwelling where fishing efforts can be concentrated.

4. ISLANDS AND ATOLLS

There are several nearshore and offshore islands in the Arabian Sea along the west coast of India. These areas have not received enough attention from scientific angle. However, they can be classified into 3 major groups;

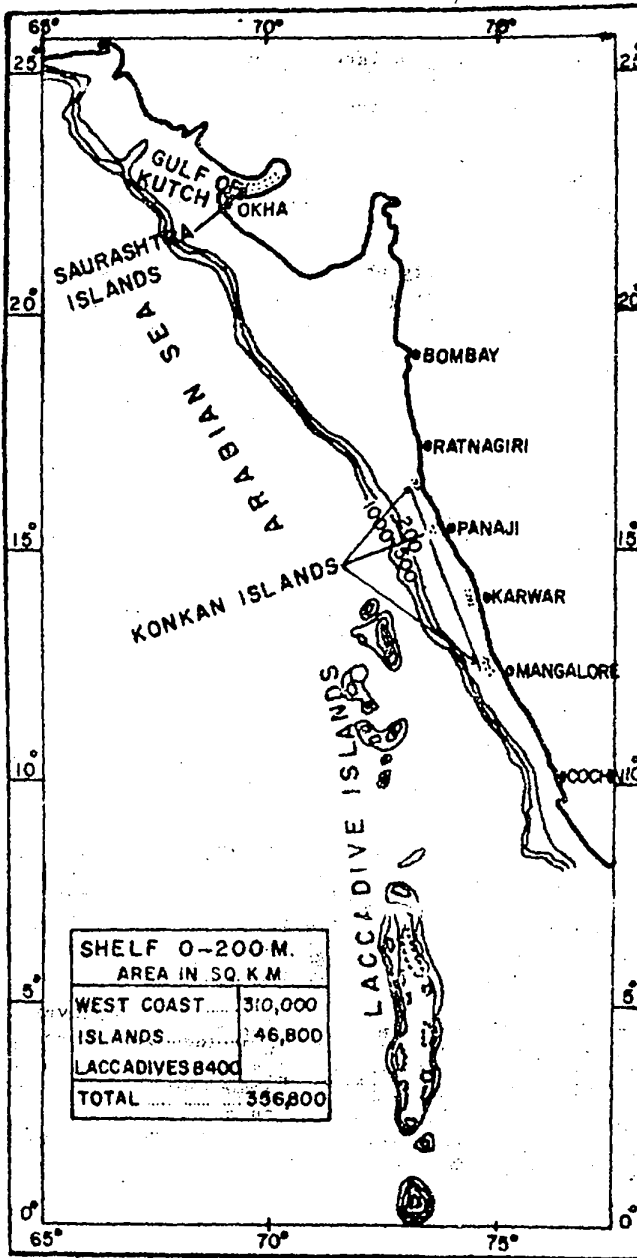


Fig 1. Saurashtra, Konkan and Laccadive group of islands along the west coast of India.

(i) Saurashtra group (ii) Konkan group and (iii) Laccadive and Minicoy group (Panikkar, et al, 1972) (Fig. 1). The Saurashtra group consists of 35 islands in the Gulf of Kutch, and in the Gulf of Cambay. Konkan group also consists of nearly 36 nearshore islands along Central west coast from Bombay to Malpe. Laccadive and Minicoy groups. From its name 'Lakshadwipa' it appears that there were one hundred thousand islands in this region. Today there are approximately 40 islands and several islets. This group of islands is 400 kms away from the mainland. The three groups of islands described above are of two types, the continental islands and oceanic islands.

The Continental islands are Saurashtra and Konkan group and the Oceanic islands are the Laccadive and Minicoy islands. Later are mainly coral atolls in open ocean.

From the preliminary studies of these islands Panikkar et al. (1973) Farulekar (1973), have observed that sea surrounding the islands is more productive. Some of the islands like Laccadives and Minicoy, Karwar group, and others have a rich fishing ground in their vicinity. Important ecosystems develop around the islands which produce a variety of living resources. In this concentration the mangroves around the islands in Gulf of Kutch and tuna fishery around Laccadives are very significant and require special attention.

Very little data is available for these islands. Minicoy group of island have been studied by some authors, Qasim et al. (1972), Qasim and Battathiri (1971), and Goswami (1973). Qasim and Battathiri (1971) studied primary production of grass bed on Kavaratti atoll of the Laccadive Archipelago. These atolls largely consists of turtle grass (*Thalassia hemprichii*) and manatee grass (*Cymodocea isotifolia*) with substratum of Sand coral rocks and debris. The gross production was estimated to be $11.97 \text{ gC/m}^2/\text{d}$ and the net production was $5.81 \text{ gC/m}^2/\text{d}$. In the Kavaratti Lagoon Qasim et al. (1972) recorded gross productions as $4715 \text{ gC/m}^2/\text{year}$, the highest value recorded in such waters except in Hawaiian coral reefs where Gordon and Kelly (1962) reported as $7300 \text{ gC/m}^2/\text{year}$. The lagoon waters have higher values of temperature, salinity and oxygen as compared to the surrounding sea water (Goswami, 1973). The zooplankton biomass was $253 \text{ ml}/1000 \text{ m}^3$. Tranter and George (1969) estimated that zooplankton provide 0.32 gC/m^2 of energy. These ecosystems are highly productive and the sea grass after decay serves as the food for certain animals.

Also around Laccadives, Minicoy and Maldives rich tuna fisheries exist. Thus these islands appear to influence the production around them and modify the food web and distinct ecosystems are created.

The above data supports the presence of four major ecosystems along the west coast of India. Each of these systems have typical food web and differ in their physico-chemical parameters and production at various trophic levels is also different. These eco-systems are inter-continuity with each other and each of them have sub-systems of their own. Therefore for optimum development of food resources, each eco-system should be studied in detail to enable us to plan and formulate marine food resources development and conservation programmes which are suited to each eco-system.

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