CRITICAL HABITAT INFORMATION SYSTEM OF MALVAN (MAHARASHTRA- INDIA)








Government of India
Department of Ocean Development
Integrated Coastal and Marine Area Management
Project Directorate, Chennai
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1. Introduction

The coastal areas of India with a coastline of over 7,500 km, harbours a variety of specialised marine ecosystems like coral reef, seagrass beds, mangroves, algal communities, mud flats and lagoons. Each of these marine ecosystems with its associated habitats supports a wealth of marine resources.

Biodiversity refers to the variety and variability among living organisms. The environment in which they occur and their interaction among each other and with the environment makes these habitats ''unique''. The marine environment is one of the richest ecosystems among all. The developmental activities in the coastal zones coupled with a population increase in these narrow stretches of land, have placed enormous stress on the coastal marine environment, thus affecting the ecological balance of the coastal zones.

Recognising the importance of marine ecosystems and their resources, a new programme entitled "Integrated Coastal and Marine Area Management" (ICMAM), was initiated in 1998 by establishing a Project Directorate at Chennai as a Technical unit of Department of Ocean Development. The concept of ICMAM is being promoted extensively to ensure the sustainable development of the coastal areas, rational utilisation of marine resources and proper management of the marine environment to prevent its degradation from developmental, commercial or other activities. The overall goal of ICMAM is to improve the quality of life of human community who depend on coastal resources, while maintaining the biological diversity and productivity of coastal marine ecosystems.

In this context, with the support of the World Bank, the ICMAM Project Directorate selected 11 critical habitats from East and West Coasts of India to study and develop GIS based information for effective management of these habitats. Malvan (Maharashtra) is one among the 11 critical habitats identified for such a study, on the basis of biodiversity value. The major objective of this study is to create information on the resources of this region using Geographical Information System (GIS) incorporating its components of remote sensing and an external database. This would help the decision makers in effectively monitoring and managing the biological wealth of this area.

2. Malvan – General Description

Sindhudurg district formed in 1981, presently comprises the taluk of Kudal, Malvan, Devgad, Kankavali, Vengurla, Sawantwadi and Vaibhavwadi. The name of the district has been adopted from the famous sea Fort of Sindhudurg built by Shivaji Maharaj in 1967. Malvan is the southernmost part of Maharashtra and located approximately 35 km from the

Mumbai – Goa National Highway No.17. Achara, Jamdul, Juva, Pankhol and Sarjekot are the main villages in the taluk. Many other villages are located within a radious of 5 km from Malvan (Fig.1).

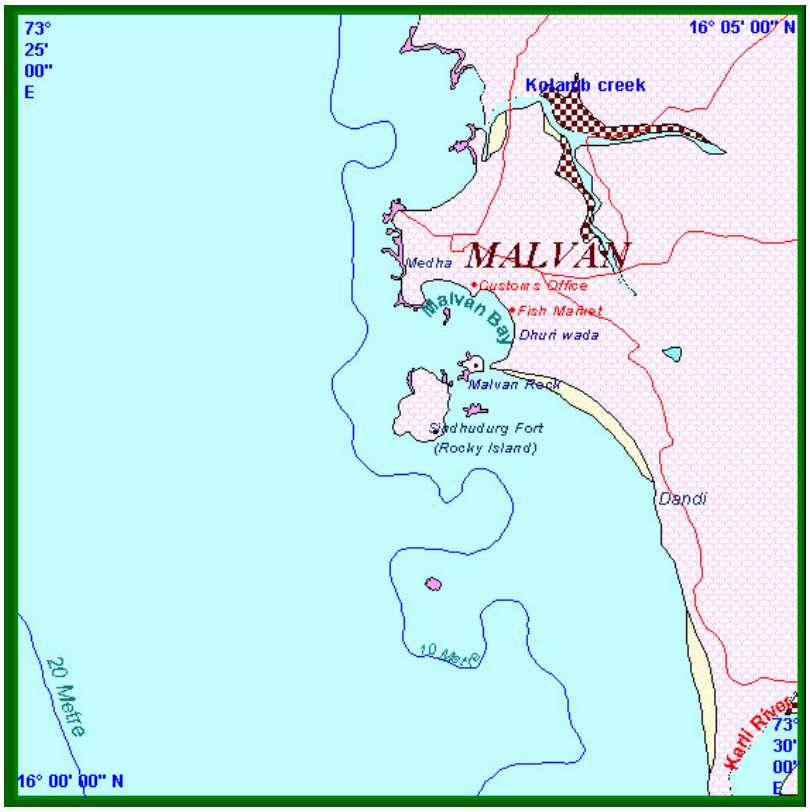

Fig. 1 - Map showing location of Malvan

The Malvan town is bound by 3 small creeks viz., Karli, Kolamb and Kalavali. To the north of Malvan, the most striking feature of the beach is the littoral concrete or beach rock, which continues over long stretches. This littoral concrete occurs as a rocky beach either directly attached to the mainland or separated by sandy or marshy areas. The rock beach gives protection to the coast against strong waves. In some regions, the rocky beach occurs as a rim of banks enclosing marshy islands.

3. Climatology

3.1 Temperature

The average atmospheric temperature ranges from 16.5° C to 33.1° C with minimum and maximum values in January and May, respectively. The average relative humidity varies from 69.4% in April to 98% in July.

3.2 Rainfall

The climate of Malvan is typical of monsoon regions, cool and dry seasons with low intensity of north-eastern winds from the land (November to February) and hot-dry season from March to May followed by rainy season (June to September). The annual average rainfall is 2275 mm. Most of the rainfall occurs during June-October. The average monthly rainfall (1988-97) ranges from 6.5 mm in April to 983 mm in July.

3.3 Currents

The coastal currents are clockwise or shoreward during February to September, while anti-clockwise during November to January and transitional in October.

4. Malvan – Ecological importance

Malvan is an open coastal ecosystem and is dominated by rocky outcrops with intermittent sandy beach. Sindhudurg a Fort constructed by King Shivaji in the 16th century is on an island situated about a kilometre from the mainland. The sea in between and around the Fort has many submerged and exposed rocks that provide an ideal substratum for marine biota and shelter to many organisms. The Malvan coast has six types of habitats viz., rocky shore, sandy shore, rocky island, estuarine, muddy and mangrove habitats.

4.1 Significance of Habitats

The rocky coastline of Malvan is primarily composed of sedimentary rocks. These rocks soft and easily eroded by both wave and wind action, which tends to lead towards animals that prefer a burrowing existence. Many crevices and cracks in the rocks serve as ideal for sheltering, feeding and breeding grounds for many invertebrates and also as an ideal substratum for harbouring marine algae (seaweed).

The inter-tidal zone along the Malvan coast (Fig. 2 & 3) is characterised by the presence of coral species in Rajkot region and mangrove vegetation (Fig.4) in Karil, Kolamb and Kalavali Backwater River.

Fig. 2 - Rocky coast

Fig. 3 - Inter-tidal zone

In Malvan sandy beaches (Fig. 5) are interspersed with rock formation extending over a considerable distance into the sea and forming into small bays. During low tide the exposed areas of the bay have large rocks harbouring a variety of flora and fauna.

Fig. 4 - Mangroves in Kolamb Creek

Fig. 5 - Sandy beaches in Rajkot area

5. Bio-diversity – Review of past literature

Malvan is one of the biologically richest coastal regions in Maharashtra. Earlier reports on the marine flora and fauna of Malvan pertain to sea anemones (Parulekar, 1966, 1969 & 1971 a & b, 1981), molluscs (Joshi, 1969), polychaetes (Parulekar, 1973), pearl oyster (Ranade, 1977), corals (Qasim and Wafar, 1979), seaweed (CMFRI, 1987) and mangroves (Leela J. Bhosale 1989). Marine flora and fauna of the rocky, sandy and muddy shores of Malvan comprise 367 species belonging to 173 genera (97 families, 16 classes and 9 phyla). Forty major animal groups including corals and pearl oysters were identified and also 73 species of seaweed and 18 species of mangroves were recorded between 1971 and 1994 (Table 1).

Table 1 - Marine organisms recorded during different periods

Sl. No.	Groups	No. of species	Sources
1.	Phytoplankton	No Data	-
2.	Zooplankton	No Data	-
3.	Foraminifera	No Data	-
4.	Porifera	2	Parulekar (1981)
5.	Cnidaria	20	Parulekar (1981)
6.	Corals	9	Qasim & Wafar (1979)
7.	Annelida	47	Parulekar (1971B)
8.	Sipunculoidea	1	Parulekar (1981)
9.	Echiuroidea	1	Parulekar (1981)
10.	Arthropoda	47	Parulekar (1981)
11.	Mollusca	70	Parulekar (1981)
12.	Echinodermata	5	Parulekar (1981)
13.	Fishes	74	CMFRI (1994)
14.	Seaweeds	73	CMFRI (1987)
15.	Mangroves and associated species	18	Leela J. Bhosale (1989)
	Total	367	

6. Development of the Resources Information System for Malvan (RISMA)

The major objective of this study is to create an information system on the resources of this region in order to help decision–makers in effectively monitoring and managing the biological wealth of this area.

The Resources Information System for Malvan (RISMA) developed by ICMAM Project Directorate integrates the existing diverse coastal and environmental data sets collected by various organisations on the biodiversity of this region along with data on the land use, Geomorphology and relevant coastal planning and development to facilitate monitoring the health of the Malvan marine sanctuary.

RISMA is built using relational hybrid GIS architecture. RISMA, has the data collected and analysed through various sources including GIS, image processing of remote sensing data, secondary and primary data collected through field surveys and stored in an external relational database.

A number of hybrid structures are available today, which use the power of GIS to portray geometry and topology of spatial objects while utilising the strong capabilities of the commercially available RDBMS such as Oracle, Ingress, Informix etc., to store the voluminous attributes of the spatial data. A hybrid structure was used for the development of the Resources Information System for Malvan. The main advantages of using hybrid structures (geo-relational models) are:

- Attribute data need not be stored with the spatial database and may be kept or developed elsewhere.
- All aspects of the attribute data are stored in specialised file structures and commercial RDBMS ensures that new developments are incorporated as standards.
- Data structures may be defined in standard ways using data dictionaries and data can be queried using general methods such as SQL (Standard Query Language).
- Keeping the attribute data in RDBMS does interfere with the basic principles of layers in GIS.
- Attributes of RDBMS can be linked to spatial units that may be represented in a wide variety of ways.

RISMA was developed using ARC-NODE-RDBMS hybrid structure wherein the full vector arc-node topology was used to describe the spatial data as lines, points or polygons. Each spatial unit is identified by an unique number or code. The attributes of the spatial units are stored in the relational tables handled by Oracle RDBMS.

RISMA incorporates the following:

- Present status of distribution of phytoplankton, zooplankton, benthos and corals.
- Spatial distribution of corals in inter-tidal and sub-tidal zones.
- Information on the previous work done in this area, to give an indication of the changes in biodiversity.

7. Major components of RISMA

7.1 Remote Sensing

Remote sensing is defined as the measurement of object properties on the earth's surface using data acquired from aircraft and satellites. It is, therefore, an attempt to measure objects at a distance rather than *in-situ*. These systems provide repetitive coverage of the earth, which provides periodical monitoring of earth and effects of human/natural activities on it. **IRS ID LISS III Nov. 1998** satellite imagery of Malvan is at Fig. 6.

Fig. 6 - Satellite imagery of Malvan

7.2 Field Survey

It is the primary source of data on the habitat. Methodology varies with respect to parameters studied. Distribution of corals was studied using Line Intercept Transect and GPS was used to fix observation points.

7.3 Relational Database Management Systems (RDBMS)

RDBMS is the acronoym for "Relational Database Management Systems" and is essentially a set of collected data stored in the form of tables and a set of programmes to access it.

7.4 Details of Organisations involved in data collection

Data on phytoplankton, zooplankton and benthos were collected by the National Institute of Oceanography (NIO), Goa during May and September 1998 and March and May 1999. Phytoplankton collection was carried out using standard phytoplankton nets for qualitative and quantitative analysis. Primary productivity was estimated using Light and Dark bottle method. Zooplankton was collected by half-metre mouth diameter bolting nylon net (mesh size 0.33 mm) and the volume of zooplankton was measured by displacement method. The data on benthic organisms were collected by Quadrate methods. The fish catch statistics was collected from the Department of Fisheries, Malvan.

Consequently, all these attribute data collected from the various sources were stored as separate tables in the Oracle database and were linked using a common identifier. Tables were created to hold information on:

- Physio-chemical parameters
- Culturable and non-culturable bacteria
- Flora and Fauna
- Socio-economics

7.5 Geographical Information System (GIS)

Geographical Information System (GIS) is a tool for capturing, storing, checking, manipulating, analysing and displaying data, which are spatially referenced to the earth. GIS is used for wide applications including planning, landuse and geomorphology of land and coastal area.

8. Methodology adopted for development of RISMA

8.1 Mapping of Coral distribution in Malvan

Remote sensing, DGPS, GIS and RDBMS along with field surveys were used in developing the resources information system for this region. Satellite data were selected as primary sources of information and GIS and RDBMS were used to analyse and develop the complete information system.

8.2 Methodology

The rocky island (Sindhudurg), Malvan Bay and Rajkot inter-tidal and sub-tidal regions were surveyed separately and locations of coral points were fixed using GPS. Sampling was done so as to cover the entire region around the study area. These points were later used for generating the thematic map showing the spatial distribution of corals in and around the Malvan bay.

Image processing, GIS and database software were used for the development of RISMA. Digital image processing was carried out using ERDAS – IMAGE 8.4. GIS work was done using ARCINFO 8.0.2 and ARCVIEW 3.2. Tables were created and stored in ORACLE 8.0 database with DEVELOPER 2000 as the front-end. Scripts were written using AVENUE programming language. Finally, RISMA as an information system was presented in ARCVIEW since it is a powerful and easy-to-use tool that has the capabilities to visualize, explore, query and analyze the data spatially.

8. Topography of the coast

Malvan coast extends from 16° 00' 00' N to 16° 05' 00' N Lat and 73° 25' 00' E to 73° 30' 00' E Long. The Coastline is marked by islands (Sindhudurg, Padamaged and Kadebakal), oyster rocks (Mandal and Don Tarra), rocky promonatories (Rajkot and Sargikot), Sandy beaches (Chiwalaychi vel, Kandvel, Malvan Chowpatty and Dandi) and mud flat – mangroves in the environs of Kalavali and Kolamb creek (fig. 7).

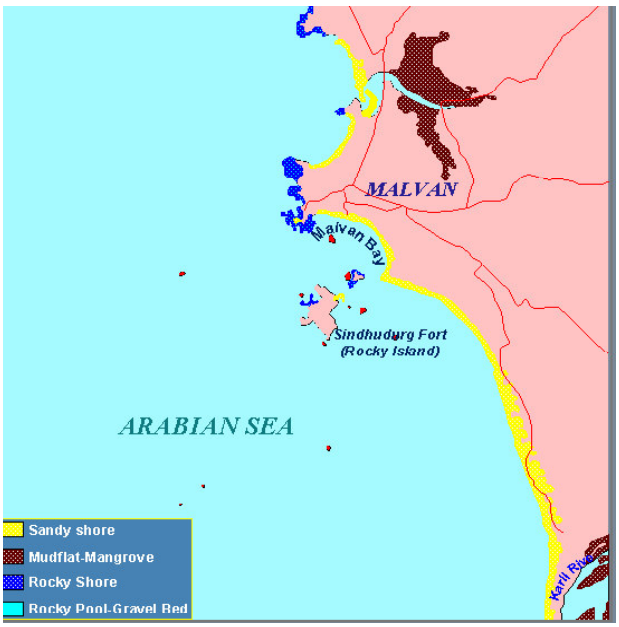

Fig. 7 - Topographical features of Malvan

10. Geomorphology

From Malvan Bay, a chain of submerged and exposed rocky islands, extends towards south up to 16° 00' 00' N - 16° 05' 00' N Lat and 73° 25' 00' E - 73° 30' 00' E Long. In this chain there are several islands including Sindhudurg Fort of Malvan at the northern tip. Other small islets around Sindhudurg Fort are Mandal rock, Malvan rock, etc. There are numerous exposed outcrops in this area.

The coast mainly consists of granites and gneiss and a few gneissic interruptions. The rocks are covered by laterite beds. The coastline near Malvan is interrupted by sandy beaches and rocky cliffs. The most striking feature of the beach is littoral concrete and beach rock, which continues over long stretches. This littoral concrete occurs as a rocky beach either directly attached to the mainland or separated by sandy or marshy areas (Fig. 8). The rocky beach gives protection to the coast against strong waves. In some regions, the rocky beach occurs as a rim on banks enclosing marshy islands.

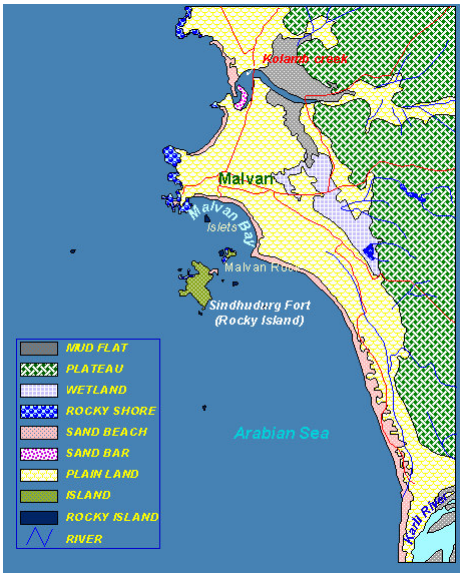

Fig. 8 - Geomorphological features of Malvan Coast

11. Land use/ Land cover

Of the total land area, the human settlement with coconut plantation occupies 32%, upland with/without shrub 26%, forest cover 15%, mangroves 1%, mudflat 4%, agricultural land 8%, rocky islands 1% and the remaining fallow land, irrigation tanks, water bodies, etc (Fig. 9).

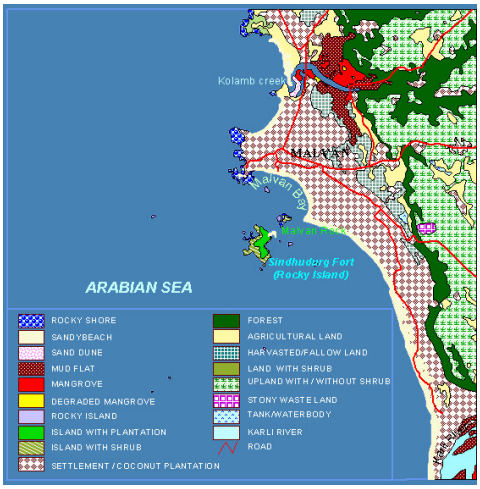

Fig. 9 - Map of landuse/ landcover in Malvan

12. Malvan - Marine Sanctuary

The marine biodiversity in the region has been reported to be relatively rich and hence the Government of Maharashtra has declared port of Malvan coastal waters as Marine Sanctuary in 1987. The total area of Marine Sanctuary is about 29.12 sq. km. (Fig. 10).

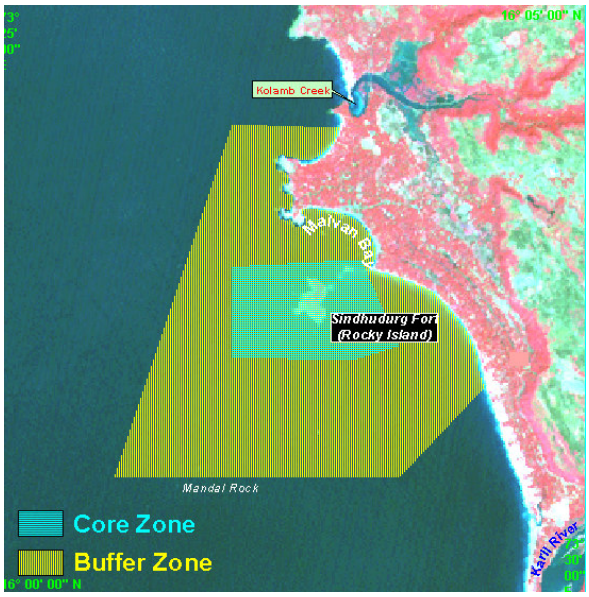

Fig. 10 - Map of Core zone & Buffer zone in Marine Sanctuary

The buffer zone is approximately 25.95 sq. km. The North East border of the buffer zone is about 50 m from the seashore near Malvan Port. In the East, semi-circular sandy beach is about 500 m parallel to the shore at Malvan. In the South, the area covers the buffer zone near "Mandal Rock" of Malvan Port. In the West, the buffer zone area touches the area of Malvan rock.

The core zone covering the area of Sindhudurg Fort, Padamaged Island along submerged exposed rocks extends to about 3.2 sq. km.

13. Hydrological Features

Marine water quality monitoring is required to predict changes in the quality of a particular marine environment, so that curative or prevention measures can be taken to restore and maintain the ecological balance in the habitats. Physico-chemical parameters were studied during 1998-99 (May 1998, September 1998, March 1999 and May 1999) in three locations viz., rocky island (Sindhudurg), Malvan Bay and Mouth of Kolamb creek.

13.1 Surface Water Temperature

The surface water temperature varied from 27^{o} C to 37^{o} C. While low temperatures were recorded in September 1998 (late monsoon), high temperatures were recorded in pre-monsoon season (Summer).

13.2 Salinity

The overall salinity ranged from 23.6 to 37$^{o}/_{oo}$ during 1998-99. Lower salinity values were recorded during monsoon and post-monsoon seasons. June-October is the period of maximum rainfall.

13.3 pH

pH varied from as low as 7.4 in the late monsoon period (September) to as high as 8.25 in summer (March and May).

13.4 Dissolved Oxygen (DO)

DO varied from 3.26 to 5.21 ml/l. The low values are found in May 1998 when temperature is high. Highest values are found in September 1998. Lowest values have been observed near rocky island inter-tidal zone and highest values at 10m depth off rocky island.

13.5 Suspended Particulate Matter

Suspended particulate matter values ranged from 40 to 160 mg/l. During pre-monsoon season, 40-120 mg/l was observed in the Malvan Bay and the mouth of Kolamb creek. The highest value was observed in Sindhudurg region and ranged from 80-160 during post-monsoon period. This value is very high compared to that recorded from other coral reef environments like Gulf of Mannar, where suspended sediment value observed was 20mg/l during 1998.

13.6 Nitrite

The overall Nitrite concentration in Malvan coast ranged from 0.02 to 1.94 μmol/l during 1998-99. The lowest concentration was observed in pre-monsoon and highest in monsoon and post-monsoon periods. The Nitrite values in inter-tidal zone ranged from 0.03 to 1.94 μmol/l, in pre-monsoon season, while during post-monsoon season it was 0.10 μmol/l.

13.7 Nitrate

Nitrate concentration was very high in the inter-tidal zone compared to sub-tidal region. During pre-monsoon period, Nitrate values in the inter-tidal zone ranged from 1.45 to 8.76 μmol/l, while during post-monsoon period it was 2.09 μmol/l. In the sub-tidal zone, the Nitrate values ranged from 0.02 to 3.08 μmol/l in pre-monsoon and 0.23 to 0.79 μmol/l in

post-monsoon seasons. The concentration of nitrate is very high during pre-monsoon when compared to post-monsoon period.

13.8 Phosphate

During pre-monsoon, the phosphate values ranged from 0.09 to 0.48 μmol/l and 0.07 to 0.27 μmol/l during post-monsoon period in sub-tidal zone. In inter-tidal zone, 0.07 to 0.38 μmol/l during pre-monsoon and 0.29 μmol/l during post-monsoon period was observed.

13.9 Silicate

Silicate concentration was very high in pre-monsoon season (3.37 to 25.59 μmol/l in inter-tidal and 1.25 to 16.89 μmol/l in sub-tidal region). During post-monsoon, 0 - 1.99 μmol/l and 3.75 to 12.75 μmol/l were recorded.

13.10 Productivity

The coastal waters from Malvan were observed to be rich in chlorophyll and productivity. Total chlorophyll values were high during pre-monsoon period and the productivity ranged from 0 to 1.77 mg $C/m^{-3}/hr^{-1}$. The near shore waters are generally highly productive due to high levels of nutrients in the coastal waters. The high productivity values during pre-monsoon period may be attributed to higher concentration of chlorophyll and high density of phytoplankton.

14. Marine organisms recorded in Malvan Sanctuary

14.1 Phytoplankton

In the present study (1998-99), 58 species of phytoplankton (Chart-1) were recorded (49 species of Bacillariophyceae, 8 species of Dinophyceae and one species of Cyanophyceae). The seasonal distribution of phytoplankton is given in Table–2. The maximum diversity and density was observed during pre-monsoon season. The density ranged from 5000 to 22,10,000 cells/litre and *Chaetoceros* was the dominant species contributing to 35%. In post-monsoon season, the phytoplankton density ranged from 3,000 to 69,000 cells/lit, dominated by *Asterionella sp*. 15% followed by *Chaetoceros* 11%(Fig-11). Their density and diversity varied seasonally. Chart 1 shows the seasonal and overall distribution of phytoplankton in the Malvan coast.

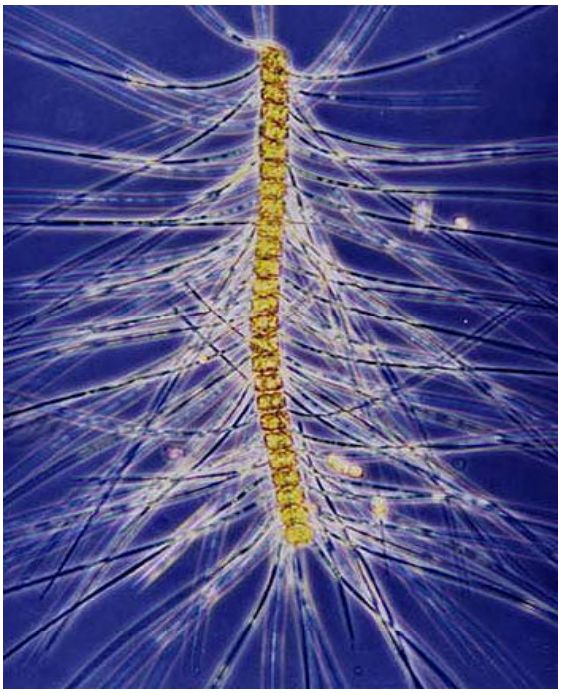

Fig. 11 - Phytoplankton (*Chaetoceros sp*)

Table 2 - Season-wise distribution of Phytoplankton in Malvan

Area	No. of species recorded			
	May '98	Sep. '98	March '99	May '99
Rocky island				
Bacillariophyceae	17	15	13	24
Dinophyceae	1	3	1	4
Cyanophyceae	-	-	1	1
Malvan Bay				
Bacillariophyceae	-	-	-	34
Dinophyceae	-	-	-	3
Cyanophyceae	-	-	-	-
Mouth of Kolamb Creek				
Bacillariophyceae	12	15	8	11
Dinophyceae	-	2	1	-
Cyanophyceae	-	-	1	-

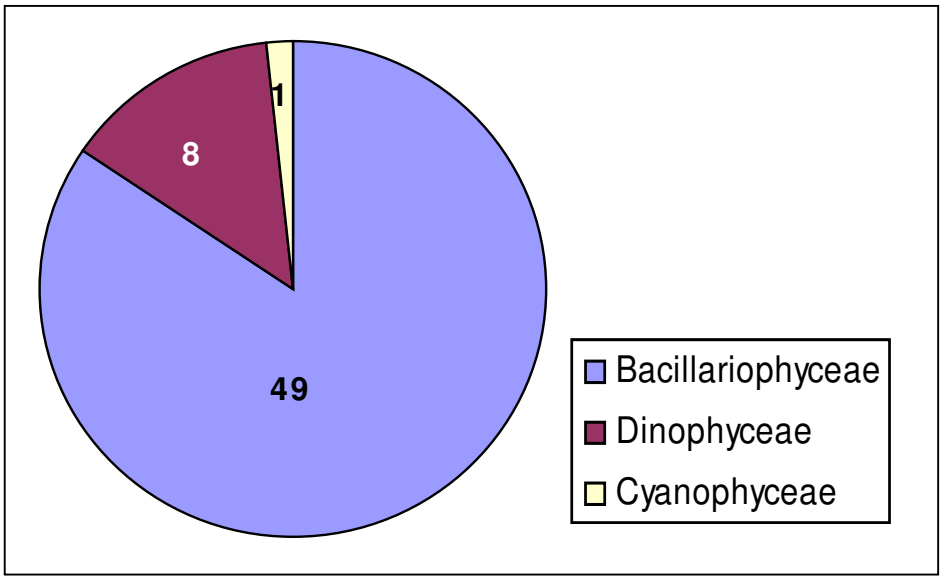

Chart – 1 - Overall distribution of Phytoplankton 1998-99

14.2 Zooplankton

Zooplankton, heterotrophic organisms at secondary level (primary consumer) depend mainly on phytoplankton. It is an important group and indicates the productivity and environmental characteristics of the marine ecosystems. In the current study (1998-1999), 9 groups of zooplankton were recorded.

Fig. 12 - Cyclopoid – Copepod

The copepods constituted one of the most dominant taxa of zooplankton. Totally 34 species were recorded comprising 24 species of Calanoida, 6 species of Cyclopoida (Fig-12), 4 species of Harpacticoida and 2 species of Cladocerans (Chart-2). The seasonal distribution of copepods is given in Table 3.

Table 3 - Seasonal distribution of zooplankton

Area	No. of species recorded			
	May '98	Sep. '98	March '99	May '99
Sindhudurg (Rocky island)				
Calanoida	10	3	14	10
Harpacticoide	-	2	-	-
Cyclopoida	3	2	4	4
Cladocera	1	1	1	1
Malvan Bay				
Calanoida	-	-	-	9
Harpacticoide	-	-	-	-
Cyclopoida	-	-	-	2
Cladocera	-	-	-	-
Mouth of Kolamb Creek				
Calanoida	-	5	14	8
Harpacticoide	-	2	-	-
Cyclopoida	-	3	2	2
Cladocera	-	2	-	-

The biomass of zooplankton ranged from 0.026 to 0.30 ml/m^3 and population density varied from 15 to 2461 nos./m^3 during pre-monsoon season. The copepod, contributed 885 nos. to the total zooplankton population and the biomass of the other groups are fairly diverse and consisted mainly of decapod larvae, cladocerans, ostracods, polychaetes, ctenophore, chaetognaths, lucifer, amphipods, appendicularians and molluscs. Chart 2 shows the overall distribution of zooplankton in the Malvan coast during 1998-99.

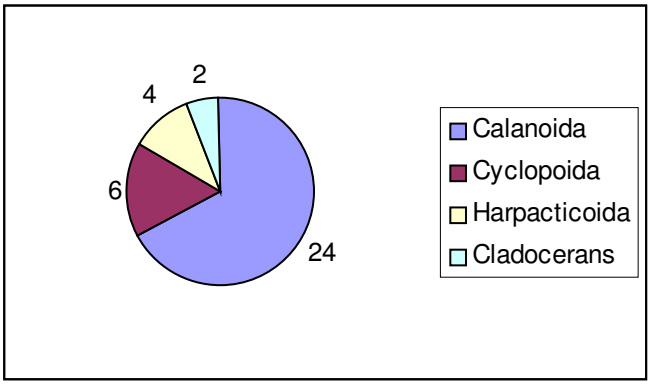

Chart-2 showing the overall distribution zooplankton

On comparison of seasonal data both the biomass and population density were high during pre-monsoon season, which could be attributed to high phytoplankton density.

14.3 Distribution of Foraminifera

In the current study (1998-99), 33 species of Foraminiferans (chart-3) were recorded. The seasonal distribution of foraminiferans is given in Table-4. They were 11 *Quinqueloculina sp*; 6 *Triloculina sp.*; 3 *Ammonia sp*. (Fig-13); 3 species of *Nonion,* two species each of *Amphistegina*, *Cibicides sp.*, *Elphidium sp.*, and *Spiroloculina sp.*; one species each of *Pararotalia* and *Pseudoeponides sp*. The maximum number of species was recorded during September as compared to May.

Fig. 13 - *Quinqueloculina sp.*

Table 4 - Season-wise distribution of Foraminiferans (no. of species)

Species	September 1998	May 1999
Quinqueloculina	11	7
Triloculina	6	4
Ammonia	2	3
Nonion	3	3
Amphistegina	2	1
Cibicides	2	1
Elphidium	2	2
Spiroloculina	2	2
Pararotalia	1	1
Pseudoeponides	1	-

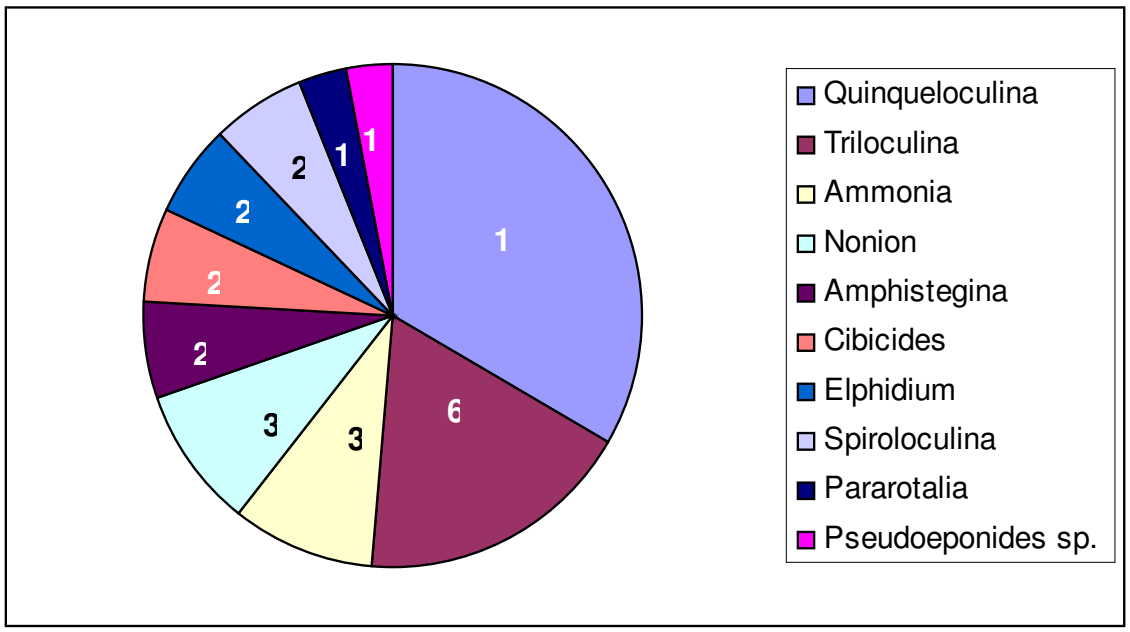

Chart 3 - Overall distribution of Foraminiferans

14.4 Distribution of Corals

Corals are found attached on rocky substratum in inter-tidal and sub-tidal regions. The Coral distribution in Malvan showed in fig-14.

The density was sparse, hardly exceeding 1-2 colonies per sq. m. All the colonies were of encrusting type and the height of the colonies rarely exceeded 5 cm. Only hermotypic corals were found. *Coscinarea sp., Cyphastrea sp.; Favites sp.; Goniastrea sp.; Goniopora sp.; Porites lichen (Fig-15); Porites lutea; Pseudosiderastrea sp.; Synerea sp.; Tubastrea sp.; and Turbinaria sp.* were the coral species recorded. Among them *Turbinaria, Tubastrea, Porites lutea and Porites lichen* were the most dominant.

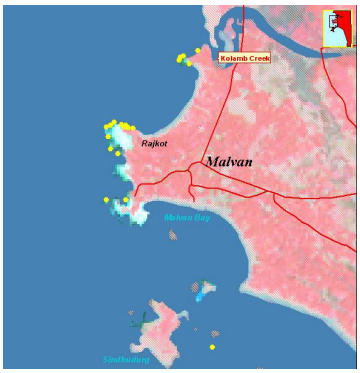

Fig. 14 - Coral distribution in inter-tidal zone

Fig. 15 - Colonies of Coral-*Porites sp.*

14.5 Factors affecting the coral distribution

At all the three locations (namely Sarjikot, Rajkot and mouth of Kolamb creek) where corals were found, the wave action was strong and hence at the low tide the water in the rock pools was fairly turbid. On an average suspended load in the waters was 120 mg/l, which is very high compared to other coral reef locations like Gulf of Mannar where a suspended sediment value of 20 mg/l was observed during 1998.

In the inter-tidal zone, salinity decreases to < 15 ppt for several months in a year due to heavy amount of sediment in these waters. Therefore, the occurrence of hermatypic corals in the inter-tidal zone is interesting because of their ecological adaptations to change in salinity and turbidity.

Recently (2001), a field survey was carried out for the distribution of corals in Malvan. The growth of corals in the inter-tidal region is fairly good. In the low-tide zone, the growth of corals was found to be affected because of desiccation.

14.6 Benthos

In the current study (1998-99), 39 species of benthic organisms were recorded in rocky island (Sindhudurg), Malvan Bay and mouth of Kolamb creek. There were 15 species of polychaetes (fig-16), 12 species of gastropods, 7 species of crustaceans, 4 species of bivalves and one species of stelleroida. Chart 4 shows the overall distribution of benthic organisms in Malvan.

Fig. 16 - Benthos – A Polychaeta

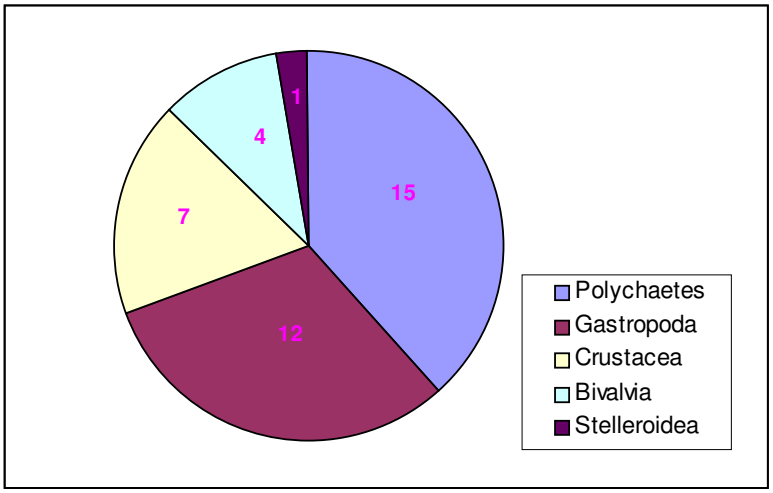

Chart 4 - Overall distribution of Benthos in Malvan during 1998-99

14.7 Meiofauna

Meiofauna from the inter-tidal and sub-tidal regions comprised 15 metazoan groups. Meiofaunal density ranged between 20 and 285 nos./10cm^2. Nematodes were the dominant group contributing over to 64%, harpacticoid copepods 12.4%, turbellarians 12.1%; oligochaets 5.2%; polychaetes 3.2%; nemertinians 1.1% and other faunal groups such as gastrotrichs, ostracods, tardigrades, kinorynchs, foraminiferans and cumaceans were represented in very low density. The maximum density was recorded at the low tide level during the pre-monsoon period and minimum density was observed at high tide level during post-monsoon season.

Considerable fluctuation was observed in the inter-tidal meiofaunal densities due to seasonal variation in sediment texture and environmental parameters.

14.8 Macrofauna

Macrofauna was represented by 10 groups from inter-tidal and 12 groups from sub-tidal areas. Table 5 shows qualitative distribution of benthos during pre-monsoon and post-monsoon. Bivalves formed the most dominant group contributing 38.68%, followed by crustaceans 27.60%; gastropods 16.98% and polychaetes 15.49%. Sipunculids, oligochaetes, nematodes and holothurians were the other groups represented in negligible number.

Table 5 - Qualitative distribution of Benthos during pre-monsoon and post-monsoon

Groups	May '98	Sept. '98	March '99	May '99
Polychaetes	6	3	9	6
Crustaceans	1	3	4	1
Gastropoda	2	7	6	3
Bivalvia	1	2	1	1
Stelleroidea	1	-	-	-

The density of macro fauna in sub-tidal region ranged from 1000 to 22,020 nos./m^3 and 32 to 616 nos./m^3 in inter-tidal region. The high population density of macro fauna was recorded from the sub-tidal region during post-monsoon at 10m depth, compared to the inter-tidal region.

14.9 Seaweeds

In the current study (1998-99) totally 32 species were recorded. There were 12 species of rhodophyceae, 11 species of chlorophyceae and 9 species of phaeophyceae (Chart-5). Table-6 shows the seasonal distribution of seaweeds in Malvan.

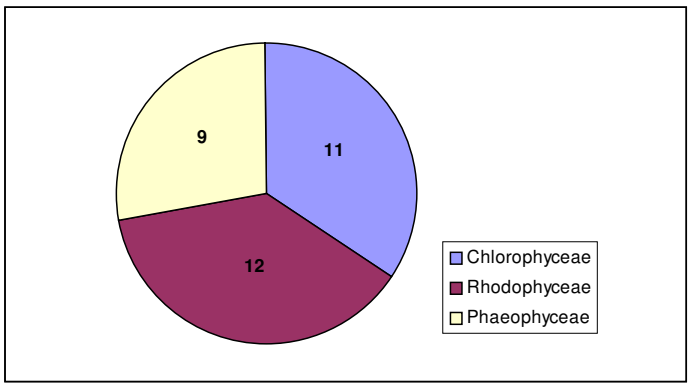

Chart 5 - Overall distribution of Seaweeds

The distribution of seaweeds varied from zone to zone. While *Ulva* and *Chaetomorpha sp.* were observed at upper littoral zone, *Caulerpa, Bryopsis, Hypnea, Padina, Gracilaria* and *Gelidiopsis* were found in mid-littoral zone and *Sargassum* and *Gracilaria* in the lower-littoral zone.

In sub-tidal region, the dominant species were *Caulerpa peltata, Sargassum illicitolium, Amphiroa tragilissima, Padina tetrastomatica, Spatoglossum asperum and Stocheosporum marginatum*.

Table 6 - Seasonal distribution (no. of species) of seaweed

Group	Sep '98	March '99	May '99
Chlorophyceae	5	8	8
Rhodophyceae	5	8	10
Phaeophyceae	4	9	5

14.10 Mangroves

Mangroves are the salt tolerant forest ecosystems mainly found in tropical and sub-tropical inter-tidal regions. The Malvan coast is bound by 3 small creeks namely Karli to the South and Kolamb and Karavali to the North East. A field survey was carried out in Kolamb creek of Malvan for studying the mangrove distribution and species diversity. 18 species of mangroves and associated species were recorded in Kolamb creek regions. They are

Rhizophora mucronta, Sonneratia alba, S. papetala, Avicennia alba, A. marina var., A. officinalis, Ceriops tagal, Lumnitzera racemosa, Aegiceras corniculatum, Excoecria agallocha, Acanthus ilicifolus, Derris heterophylla, Sesuvium portulacastrum, Aleuropus lagopoides, Salvadora persica, Stenophyllus sp., Thesepesia populnea, Clerodendrum inerme. The dominant species were *Avicennia sp., Rhizophora sp., Ceriops sp., Lumnitzera sp., Aegiceras sp.* and *Excoecaria sp*

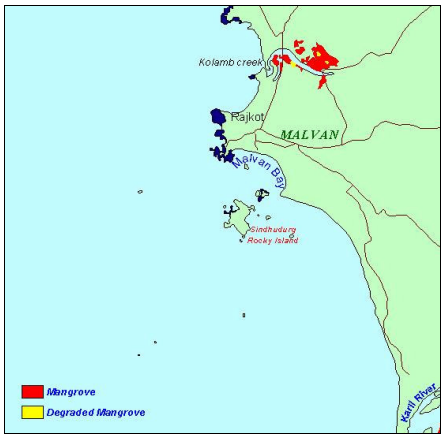

Fig. 17 - Mangrove distribution in in Kolamb creek

Fig. 18 - Mangrove vegetation in Kolamb creek

Estimation using remote sensing data and GIS revealed that mangrove area extended to about 30.4 ha and degraded area to about 1.4 ha in Kolamb creek.

15. Current status of Biodiversity

Earlier reports indicated that 367 species have been recorded in this area. However, in the current study only 279 species are recorded. The change in the number of species does not mean the disappearance or extinction of species in the region. The current study was done only for a period of one year and random sampling methodology was adopted for data collection. If the observations are repeated on an yearly basis for the next ten years, then a clear idea will emerge on the extent of the reduction in number of species off Malvan coast.

Overall status of Marine organisms recorded from the Malvan coast during 1998-99 in given in Table-7.

Table 7 - Marine organisms recorded in 1998-99

Sl. No.	Groups	No. of species recorded
1.	**Phytoplankton**	
	Bacillariophyceae	49
	Dinophyceae	8
	Cyanophyceae	1
2.	**Zooplankton**	
	Calanoida	24
	Cladocera	2
	Cyclopoida	6
	Harpacticoida	4
3.	**Foraminiferans**	
	Quinqueloculina	11
	Triloculina	6
	Ammonia	3
	Nonion	3
	Amphistegina	2
	Cibicides	2
	Elphidium	2
	Spiroloculina	2
	Pararotalia	1
	Pseudoeponides	1
4.	**Corals**	11
5.	**Polychaetes**	15
6.	**Crustaceans**	7
7.	**Molluscs**	16
8.	**Echinodermata**	
	Stelleroide	1
9.	**Seaweeds**	
	Rhodophyceae	12
	Chlorophyceae	11
	Phaeophyceae	9
10.	Mangroves	18
11.	Fishes	52
	Total	**279**

16. Fisheries

Malvan is one of the important fishing centres on the West coast. Mackerel and oil-sardine constitute the major fishery in the West Coast of India. There are four fishing hamlets in the coastal area of Malvan, viz., – Dhuriwada, Medha, Rewatala and Wairi-dandi. There are about 175 mechanised crafts (Fig-19) and 227 country boats, operating in the Malvan coast. The major gears being operated are trawl nets, purse seines, gill nets, dol nets and hook and line. Coastal waters of Malvan support good demersal fishery. It contributes to a sizeable portion of the demersal fish production of the Sindhudurg district. The major fish landed in Malvan comprise, elasmobranchs, clupeids, bombay duck, carangids, sardines, ribbon fish,

Fig. 19 - Trawling operation in Malvan

mackerel, seer fish, pomfret, tunas, penaeid and non-penaeid shrimp, lobsters, crabs and cephalopods. Total fish catch during 1999-2000 was 13,433 tonnes. Table 8 shows the details of fish catch in Malvan from 1978 to 2000.

Table 8 - Group-wise fish catch (1978-79 to 1999-2000) (in tonnes)

Sl. No.	Groups	1978-79	1982-83	1990-91	1994-95	1999-2000
1.	Elasmobranchs	106	653	213	53	73
2.	Eels	4	1	-	13	1
3.	Cat-fishes	432	1538	92	55	80
4.	Wolf-herrings	86	153	25	10	148
5.	Sardines	768	952	496	120	880
6.	Other Sardines	2	48	3	-	-
7.	Anchovies	-	-	-	-	-
8.	Silverbellies	1	418	-	-	-
9.	Clupeides	170	-	87	62	8
10.	Bombay-duck	1	-	-	-	-
11.	Perches	1	1	-	-	-
12.	Red snappers	-	-	-	-	-
13.	Polynemids	2	-	-	-	-
14.	Scianeids	10	-	11	-	-
15.	Ribbon fish	128	776	59	127	57
16.	Otolithus	268	609	389	129	993
17.	Carangids	337	119	-	24	56
18.	Pomfret	35	332	5	65	31
19.	Black pomfret	91	285	50	107	117
20.	Mackerel	1021	133	118	167	5117
21.	Seer fish	1001	119	334	1570	504
22.	Mackerels	190	231	-	113	115
23.	Unicorn cod	-	-	-	-	-
24.	Soles	17	2	3	-	-

Sl. No.	Groups	1978-79	1982-83	1990-91	1994-95	1999-2000
25.	Leiognathus	82	27	1091	13	148
26.	Carangids small	175	159	-	370	4859
27.	Lactarius	42	246	32	8	-
28.	Goat fishes	83	141	-	-	-
29.	Penaeid Prawns	216	930	34	6	41
30.	Non-Penaeid Prawn	-	-	-	-	-
31.	Lobsters	1	-	-	2	-
32.	Cuttle fish	-	42	129	590	138
33.	Miscellaneous	193	394	216	123	67
	Total	**5463**	**8309**	**3387**	**3727**	**13433**

17. Socio-Economic Status

There are four fishing villages along the Malvan Coast. The total fishermen population is 1854, of whom 541 are active fishermen. There are 375 fishermen houses; 175 mechanized crafts; 227 country boats and different types of gears used for fishing.

Gears	Season of operation	Fishes caught
Shore-seine Rampan	Sep. – May	All fishes that come near shore
Drift net Surmai jal Saranga jal Kandali Wawari Dhangad	 March – May & September – December	 Scomberomorous Chirocentrus Pomfrets Smaller pomfrets Scomberomorous Pomfrets Scomberomorous Sciaena Sharks
Gill Net Bangada jal Boat Seine jal Lines wawadi	 March September – October September – May	 Rastrelliger Kanagurta Sciaene – Arius Carcharhindidea Scoliodon Sphyrna Pastinachus Murenerox

The average fish catch per day per boat varies from 50 to 70 kg. The average income of a fisherman has been estimated to be about Rs.85/day. However, the middlemen earn more than the active fishermen.

18. Tourism

Malvan is known for its historical heritage and scenic beauty and hence has a good potential for tourism development. It is famous for the Sindhudurg Fort, standing in open sea constructed by the Maratha King Chatrapati Shivaji in the 16th century. The fort is declared as a national monument and is under the control of the "Archaeological Survey of India". Several tourists visit this place every year.

19. Major threats of Malvan

The entire ecosystem is unique with 279 species of fauna and flora (1998-99) as already reported. Following are the major threats identified, which may impair the species diversity in the Malvan coast.

- ⇒ Intensive trawling operation around the coast.
- ⇒ Rampani fishing activities in core zone areas.
- ⇒ Over exploitation of juveniles (undersized species).
- ⇒ Illicit felling of Mangrove trees.

20. Suggestions for Resource Management

- ❖ Demarcation of core zone and buffer zone for uses and regulations.
- ❖ Strict enforcement of Marine Fishing Regulation Act and its provisions which specify/restrict use of certain gears, net size, etc., for minimizing damage to fishing of brood stock and juvenile.
- ❖ Protect the interest of the artisanal/traditional fishermen by restricting the operation of trawlers, within the zone earmarked for fishing by them. There should be an uniform zonation for fishing by the traditional fishermen and the mechanized fishermen in the adjoining coastal states.
- ❖ Creation of awareness and capacity building through training among the coastal communities to accomplish sustainable utilisation of the marine living resources.

21. Conclusion

A comparison of the present data (279 species) with earlier reports (367 species) from Malvan coast, showed a decrease in floral and faunal diversity. The decrease in faunal density and diversity could be related to increased human activities. Fishing activities in core zone areas seem to have destroyed the breeding and nursery grounds.

The Information System developed by ICMAM-PD on Malvan using GIS especially mapping of corals, geomorphology, boundary of marine sanctuary and the mangroves using remote sensing and GIS has demonstrated that these tools can be effectively used for monitoring and management of coastal zone and health of the resources of the Malvan Marine Sanctuary.

22. References

1. CMFRI (1987). Seaweed Research and Utilisation in India. Published by P.S.B.R. James, CMFRI, Bulletin.41: 100-111.

2. CMFRI, (1994). Commercially important fin and shell fishes. CMFRI bulletin No.134: 4-12.

3. Joshi, M. C. 1969. The marine mollusca of the Konkan Coast. Journal of Shivaji University, 2:47-54.

4. Leela J. Bhosale, 1989. Mangroves of Maharastra – An overview. In wetlands, Mangroves and Biosphere Reserve. Proceeding of the Indo-US Workshop organised by Ministry of Environment & Forests. New Delhi, 4-7 January 1989.

5. Panikkar.N.K, A.H. Parulekar and A. G. Untawale, 1973. Continental shelf islands of the Konkan coast. Journal of Indian Geophysical Union, Special Volume, 10: 141-153.

6. Parulekar, A.H, 1966. Cnidae in the actinians of Maharashtra. Journal of Biological Science, 9: 35-42.

7. Prulekar, A.H. 1969. Neoaiptasia commensali gen et sp. Nov. an actiniarian commensal of hermit crab. Journal of Bombay Natural History Society, 6: 57-62.

8. Parulekar, A.H, 1971 (a). A new sea anemone, Cribrinopsis roberti (Endomyaria: Actiniidae) from Maharashtra and Goa Coast. Journal of Bombay Natural History Society 68: 291-295.

9. Parulekar, A.H., 1971 (b). Polychaetes from Maharashtra and Goa. Journal of Bombay Natural History Society, 68: 726-749.

10. Parulekar, A.H. 1981, Marine Fauna of Malvan, Central West Coast of India, Mahasagar-Bulletin of the National Institute of Oceanography, 14(1), 33-44.

11. Qasim, S.Z and M.V.M. Wafar, 1979. Occurrence of living corals at several places along the West Coast of India. Mahasagar-Bulletin of the National Institute of Oceanography, 12: 53-58.

12. Ranade, M.R., 1977. Occurrence of pearl oysters in Ratnagiri district. Journal of Bombay Natural History Society, 74(3): 553.