STUDIES ON ECOLOGICALLY SENSITIVE COASTAL ECOSYSTEMS ALONG THE CENTRAL WEST COAST OF INDIA

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by

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CERTIFICATE

This is to certify that the thesis entitled '**STUDIES ON ECOLOGICALLY SENSITIVE COASTAL ECOSYSTEMS ALONG THE CENTRAL WEST COAST OF INDIA'** submitted by Nazima Bi Shaikh for the award of the degree of Doctor of Philosophy in Botany is based on original studies carried out by her under my supervision.

The thesis or any part thereof has not been previously submitted for any other degree or diploma in any Universities or Institutions.

AGUntawale

Place: Dona Paula

Date : 26/07/02

Dr.ARVIND G. UNTAWALE

Research Guide

DECLARATION

As required under the Univesity Ordinance 0.19.8 (iv), I hereby state that the present thesis entitled **'STUDIES ON ECOLOGICALLY SENSITIVE COASTAL ECOSYSTEMS ALONG THE CENTRAL WEST COAST OF INDIA'** is my original contribution and the same has not been submitted on any previous occasion. To the best of my knowledge, the present study is the first comprehensive work of its kind from the area mentioned.

The literature related to the problem investigated has been cited. Due acknowledgements have been made wherever facilities and suggestions have been availed of.

Shaikh

NAZIMA BI SHAIKH

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CHAPTER I

GENERAL INTRODUCTION

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GENERAL INTRODUCTION

1.0 Description of coastline

Oceans are the largest ecological regimes, which hold vast resources. Man has turned to the oceans to harness energy, food, medicine, fodder, fertilizer, fuel and many other industrial products. Oceans have an impact on continents through weather, river floods, and climatic irregularities. It is also a medium for shipping, communication and defence. The biome also harbours majority of ecological processes that are critical to the functioning of the ecosystems. These ecosystems are critically important to mankind, as they are most productive. However, the marine ecosystems are complex, ecologically sensitive and exceedingly valuable areas that are under enormous threats. Despite degradation, marine ecosystems have continued to provide invaluable benefits to human beings.

Vegetation growing along the coast such as mangroves, marine algae, seagrass and sand dune plants- between the land and the sea has important ecological roles to play in the maintenance of the coastal zones. In the first instance, the organic matter produced by such vegetation enhances the biological productivity of the coastal ecosystems (Wafar, 1987). For example, the extent of mangrove forests on the coast and the shrimp catch in the coastal waters have shown to be related to each other. In the second instance, these coastal ecosystems serve as conduits for materials of land origin to sea. In the third instance, the structural role of this vegetation is such that they bind the sediments, prevent erosion and protect the shoreline.

1.1 Definition of coastal zone

The coastal zone comprises landward and seaward parts. The question of how far the limits should extend from the coastal line is still the subject of debate. The coastal zone, as defined by various scientific groups, usually covers wide area, which extend from the upper limit of a watershed to the outer limit of the continental shelf. The definition of coastal zone by policy makers, however, rarely coincides with a complete ecological system and is usually less extended. The International Geosphere-Biosphere Programme (IGBP) of the international Council of the Scientific Union (ICSU), includes the area extending from the landward margin affected by salt water to the outer edge of the continental shelf (IGBP, 1993).

A geological definition of the coastal zones in South-East Asia includes the areas from the gently sloping dealtic plain landward influenced by fluvial processes and covered by young fluvial deposits to seaward influenced by marine processes and covered by young marine and brackish deposits (Jelgersma, 1992). To understand the interaction between major components of the ecosystem, coastal zone definition as suggested by the scientific groups shall be followed. However, to manage the coastal areas effectively the existing governmental definitions have to be respected and followed. Efforts should be made to harmonize the different definitions for a specific coastal zone to achieve the most potential benefits. The definition of the coastal zone may, therefore, vary to suit different purposes and situations

The coastal zone in Asia and the Pacific is under severe and increased pressure from rapid urbanization, tourism development, industrialization, pollution and deterioration of the coastal ecosystems. Such pressure is exerted by the continued development in hazard-prone coastal areas and the potential impact of sea level rise associated with climatic change. The awareness of the importance of coastal zone issues is stimulated by the extension of rational jurisdiction from territorial waters to the Exclusive Economic Zone (EEZ) stipulated in the 1982 United Nations Convention on Law of the Seas (UNCLOS) that entered into force on 16 November 1994.

1.2 Major components of the coastal zone and their interaction

Covering its landward and seaward parts from the coastline, the coastal zone is a belt of about one million kilometers in length between land and ocean on our planet. In addition, the coastal zone is also an interface between land and ocean, and the atmosphere. The interactions between the atmosphere, hydrosphere, lithosphere and biosphere make the coastal zone dynamic and the coastal processes complex.

1.3 Coastal systems

Coasts consist of almost equal parts of hard rock and soft sediments. Sedimentary, sandy or muddy coasts are still being shaped and are remarkably younger. The coast may be referred to as a natural system comprising four sub-systems, i.e. fresh water, land, shoreline and coastal water sub-systems. The land and the fresh water sub-systems refer to the landward part of the coastal zone, and the coastal water sub-system to that of the seaward part. The shoreline sub-system is a relatively narrow and dynamic transition area between the landward and seaward parts of the coastal zone, including foreshore, beach area, and coastal protection systems such as dunes and mangrove ecosystems (WCC,1993).

1.4 Ecologically Sensitive Ecosystems or Marine Critical Habitats

The coastal natural ecosystem includes both non-living (abiotic) and living (biotic) components. Therefore, the biological processes should also be considered together with the physical and chemical processes for investigating and understanding of the natural coastal zone system. Ecology is a science that deals with the interactions of living forms (the biota) and their ecological environments (eco-environment). The earth can be seen as a natural ecosystem having biosphere as its living part and all the other non-living parts as its eco-environment.

The concept of ecosphere, as a transition zone between the lithosphere, hydrosphere and atmosphere has been introduced recently while dealing with ecological issues. The coastal ecosystems such as mangroves, marine algae, seagrasses, sand dunes and coral reefs etc are critically important because of their uniqueness, rich biodiversity, productivity and ecological as well as economic importance. In the International arena ' Critical Habitat' is a term used in the endangered species Act referring to the specific areas that contain physical or biological features essential to the conservation of a threatened or endangered species. However, these ecosystems are complex, ecologically sensitive and exceedingly valuable areas that are under enormous threat.

Marine critical habitats which includes both non-living and living components is a fragile balanced pattern easily affected by its neighbouring watershed landward and open or high seas. The coastal ecosystems are disturbed and threatened encountering several problems such as pollution, erosion, storm surges, siltation and anthropogenic pressures. Nearly 60% of the zone exploits the coastal resources (Kathiresan and Rajendran, 1996).

There are constantly increasing human pressure of various kinds to exploit these critical habitats or ecologically sensitive ecosystems and their resources for multiple economic activities. Critical habitats which have been found to be essential for the conservation of the biota and which may require special management consideration or protection. Even though some of the areas are undisturbed, there is urgent need to protect, conserve and manage both the disturbed and undisturbed areas for their sustainable uses. A number of coastal areas along the central west coast of India are rich in biodiversity and have uniqueness with regards to the flora and fauna that needs to be preserved as live natural heritage. These sites can serve as centres for education, research, recreation and eco-tourism. The economically important flora and fauna can be maintained as " germplasm" for conservation purpose. The sensitive ecosystems can be classified based on their naturalness, biological, ecological and socio-economic importance.

In this context, the sedimentary coasts may be divided into ecosystems that include shore lowland (coastal watershed), estuarine area (coastal land and coastal water), offshore water, and open shelf sea. They may be further subdivided into sub-ecosystems such as plains, wetland, estuaries, bays, gulfs, lagoons, coastal barriers, and into even smaller units such as ponds, salt marshes, mangroves, mud-flats, tidal delta, beaches, dunes, coral reefs and seagrass beds.

1.4.1 Mangrove Ecosystem

Mangroves form an important ecosystem of the coastal wetlands in India. Scattered in different geographical and geological zones, experiencing varying climatological conditions, the mangrove ecosystem of India shows rich biodiversity (Table 1.1).

Mangroves support a complex aquatic detrital food web and provide a unique habitat for a variety of animal and plant species. In the tropics, a substantial proportion of the coastlines is occupied by highly productive mangroves (Boto *et al.*, 1984; Por, 1984). The important role played by mangrove ecosystem in supporting the functioning of nearby ecosystems such as terrestrial wetlands, seagrass beds and coral reefs has been well recognized. For centuries, human beings from tropics and sub-tropics have been utilizing mangroves for wood, charcoal food and fertilizers. The coastal inhabitants in particular have been deriving direct benefits from the ecosystem (Hemilton and Snedekar, 1984). The mangrove ecosystem also contributes to the economy of the coastal zone. Timber is one of the biggest resources extracted from mangroves. Other products such as honey, tannins, charcoal, etc. are also extracted from the mangrove forests. The litterfall of mangrove trees amounts to a large quantity of nutrients, which are circulated both within the mangrove forests, and in the adjacent marine ecosystem. Their leaf material is utilized by bacteria and fungi which forms the basis of an aquatic food web (Wafar *et al.,* 1997). The mangrove ecosystem comprises all the biotic components starting from microscopic forms to large size forms (Table 1.1).

Mangroves were looked upon as wastelands and were reclaimed for developmental purposes and human settlements. With rapid industrial development and the increase in human population, mangroves were threatened with reclamation, habitat destruction and over exploitation. These processes exerted tremendous pressure and danger to these ecologically and economically important forests. For instance, reclamation of mangrove forests brought permanent geomorphologic changes. The examples that could be cited are Mumbai in Maharashtra and Vembanad Lake in Cochin backwaters at Kerala, which showed depletion of mangroves. Apart from above man made changes, some natural changes also occurred by earthquakes, sea level rise, floods, siltation and changes in river courses due to tectonic movements etc.

Mangrove forests serve as a link between terrestrial and marine ecosystems (Chapekar, 1994). Import of nutrients from the land to the mangroves and export of matter from the mangroves to the sea is one of the important features of energy flow. The floral elements in mangrove forests responsible for primary productivity are angiosperms; phytoplankton and marine algae while those responsible for secondary and tertiary productivity are zooplankton and benthic animals and fishes respectively. The litterfall of mangrove trees amounts to a large quantity of nutrients.

Table 1.1 Mangrove biodiversity of India

I	FLORA	Genera	Species
1	Algae	30	47
2	Fungi	40	50
3	Seagrasses	1	2
4	Mangrove flora	41	59
5	Lichens	8	14
II	**FAUNA**	**Genera**	**Species**
1.	Crustaceans	46	82
2.	Molluscs	57	88
3.	Wood borers	13	24
4.	Fishes	70	120
5.	Reptiles		
	-Snakes	18	21
	-Lizards	3	4
	-Turtles	5	5
	-Crocodiles	2	2
	-Amphibians	4	8
6.	Birds	53	119
7.	Mammals	29	34

Compiled from various published reports

1.4.2 Coral Reef Ecosystem

Coral ecosystem is known to be diversified and productive ecosystem among all the marine ecosystems of tropical zone (Wells, 1988). Due to their organic and inorganic resources, reefs are of direct economic importance. India has about 19,000 km^2 of major reef area including islands and coastline. Coral reefs are massive limestone structures built up through the constructional cementing processes and depositional activities of the animals of the class Anthozoa (order Scleractinia) and all the other calcium carbonate secreting animals and the calcifying algae. The value of coral reefs, both for the biosphere and human utilization is well known. Reefs are the centers of high biological productivity, sites of carbon dioxide sink, ecosystems of very rich biodiversity helping in shoreline protection, sources of huge deposits of calcium carbonate and centers of scientific research. Additionally, they are providing us with many natural raw materials for deriving pharmacological products especially the life saving drugs (Gopinadha Pillai, 1997).

Coral reefs are diverse and vulnerable ecosystems characterized by a complex interdependence of plants and animals (Devaraj, 1997). Reef resources are traditional sources of food and income to the local coastal people. In India, the coastal people are harvesting most of the biological resources especially algae, reef fishes, holothurians, shrimps, lobsters, crabs, molluscs etc. Significant increase in human population and poverty and also utilization and competition for these reef resources has resulted in indiscriminate harvest of the biodiversity of the coral reefs. The reefs are the most threatened among the coastal and marine habitats. 20% of the Indian reefs have been lost or seriously damaged (World Resources, 1992-93). The flora and fauna associated with this ecosystem is increasingly at risk. due to unplanned, uncoordinated coastal development in most parts of the world has caused lot of destruction of coastal coral reefs and their associated ecosystems.

Indiscriminate overexploitation of corals and reef-associated organisms from our reefs in the last few decades has affected immense damage to this tropical marine ecosystem (Pillai 1975, 1985, 1996; Pillai and Madan Mohan, 1986; Pillai and Jasmine 1996; Salm, 1981; Rashid, 1988; Patel, 1988). Other than the anthropogenic impacts, the natural calamities like, cyclones, sea level variations, current pattern changes, increased nutrient levels etc. also affect the health of the coral reefs directly or indirectly. Sediment deposition over the coral reefs due to erosion of coasts caused by destruction of coastal vegetation has become a major problem in all the coral reef areas. Sedimentation and siltation are not only related to anthropogenic impacts but can also be caused by natural events like current patterns, upwelling etc. the mudflats formed over the reef areas in the Gulf of Kuchchh could be due to the sediment deposits. Man's use of coral reefs is all too often taken to uncontrolled extremes, which represent a threat to the reefs.

Coral reefs are a resource of great value to man now and in the future. There are many measures which can be taken to protect reefs and sustain their ability to support life.

1.4.3 Sand Dune Ecosystems

The sand dune vegetation is totally different plant community, which grows on sandy shores beyond the highest high tide level and is formed by the accumulation of wind blown sand deposited on the shore from the subtidal and intertidal regions. Wind is one of the most important factors in the dune system (Untawale, 1980), which helps in the formation, movement and also distribution of the dunes. Sand dune vegetation helps in the prevention of sand erosion by decreasing wind speed at ground level. Secondly, it functions as a self-supporting community where plants are mutually dependent for protection and nutrient supply. This vegetation also has ability to tolerate a hostile environment of high winds, salt spray, and sandblast, covering by sand, sandy soil and little water (Desai, 1995).

Sand dune vegetation has a significant role to play in the coastal regions. These species not only minimize the erosion, but also stabilize the dune region and increase the organic matter (Barson & Calder, 1981).The over-exploitation of beach sand and indiscriminate cutting of coastal vegetation results in erosion of coastal areas. Dune system is being illegally used for housing, industries and other developmental activities. Therefore, it is necessary to have strict and effective management policies for conservation and protection of sand dune vegetation.

1.4.4 Marine Benthic Algae

Among the marine ecosystems, seaweed ecosystems have been recognized to be important in relation to other organisms of the sea (Fuse, 1962). Their roles in nutrient cycling and fixing energy in the coastal regions are also very important (Littler& Arnold, 1982). Seaweeds are found growing on different substrata, depending on nature of their holdfast.(Hartog Den, 1972). Seaweed's have contributed to human life especially as utility in natural ecosystems, food for man, livestock and as industrial materials. Considering their significant potentials, it is being said that, seaweed's can become our food and energy resources of the 21st century (Leeper, 1976).

Beneficial effects from the use of seaweeds extracts have been obtained on plants, their crop yield, seed germination and their resistance to fungal and insect attack (Dhargalkar and Untawale, 1980). Development of coastline, particularly related to increased population pressure in coastal areas, leads to alienation and fragmentation of habitats available for macroalgae on the coast. Reduction in water quality can lead to a reduction in the depth of the photic zone (Walker and Mc Comb, 1992), and hence to a direct loss of macroalgae habitat.

1.4.5 Seagrass Ecosystem

Seagrass ecosystem is characteristics of marine as well as estuarine environment in the tropical and temperate regions. They generally grow in shallow coastal waters from the intertidal zone to depths up to 10m. These ecosystems are considered to be very productive and serve as nursery and breeding grounds for marine organisms (Dhargalkar and Shaikh, 2000; Qasim and Bhattathiri, 1971; Mc Roy and Mc Millan, 1977, Hudson *et al.,* 1970). Seagrasses also act as sediment stabilizers (Orth, 1977), provide a suitable substratum for epiphytes and a good source of food for marine herbivores, as well as fodder and manure.

Seagrass ecosystem in the Asian regions is being threatened by both natural and human induced disturbances. Natural stresses are mostly due to cyclones, tidal waves, volcanic activity, grazing and competition, shifting sediments, pests and diseases (Fortes, 1988). The extent of their effects on the integrity of the resources, though largely unknown, may be viewed partly in the context of the fisheries resources, which are depleted beyond the level of biological sustainability. Marine fisheries, which provide more than 60% of the animal protein required in coastal diets, partly depend upon seagrass, ecosystem for productivity and maintenance (Kikuchi, 1974, 1980; Pollard, 1984 and Thayer & Phillips, 1977).

Seagrasses play a significant role in the detritus based food chain and stabilization (McRoy and Mcmillan, 1977). Disappearance of the seagrass cover caused erosion of surface substrates and reduction of organic material content in the sediments.

1.5 Biodiversity

Biodiversity is an index to assess the health and product of the critical habitat. Exact definition of biodiversity is, " the variability among the living organisms from all sources including, *inter alia*, terrestrial, coastal and other aquatic ecosystems and ecological complexes of which they are part; this includes diversity within species, between species and of ecosystem. The world's wealth of the biodiversity is found in highly diverse marine and coastal habitat.

Biodiversity is the term used to describe the total variety of living organisms at different levels: genetic, species, ecosystem diversity, which are closely interrelated in a complex way. Most species can only survive if the genetic diversity within their population is maintained at a sufficient level so that their capacity for adaptation to environmental changes is no impaired. Genetic diversity can only be maintained if the population of a species is kept above a minimum critical size. Species diversity is dependent upon the maintenance of the ecosystem diversity, while survival of an ecosystem may rely upon the presence of particular species. There are about 30 million species of living organisms estimated on the earth. The relative abundance of species, the age and structure of populations, the pattern of communities in a region, change in the community composition, ecological processes etc are also important as expressions of biodiversity.

Marine biodiversity is known to be one of the richest among all the living ecosystems. Marine biodiversity can be divided into coastal and oceanic. Of the 33 extant animal phyla, only 11 occur on land while rest are found in the seas. Fifteen of them are exclusively marine and other five make up more than 95% of the marine species. The coastal and marine biotopes host nearly the entire extant diversity of basic animal body plans, and also contains far greater diversity in body size, from whales to plankton, than is found on land. Further, it has shown that filter feeders create extra levels in aquatic food chains that tend to be more complex than terrestrial ones (Margulis & Schwartz, 1988).

1.6 Socio-economic studies

An understanding of the relationship between livelihood and biodiversity is essential in planning conservation strategies, which are socially and ecologically sustainable. This has influenced conventional resource planning in integrated conservation and development projects in favour of major food crops and species of commercial importance. Socio economic study aims at understanding the present utilization pattern of the marine resources and the area by the local people, the nature and magnitude of interdependency. Coastal ecosystems are very rich in natural resources and are highly productive. Most of the world's growing population live in the coastal areas, or within easy reach of them. The human interventions take place mainly in the transitional zone consisting of the areas where the marine areas meet the land masses, where river flow into the sea and where fresh water meets brackish water. This zone is subjected to tremendous environmental, developmental, political, social and economic pressures.

The large scale commercial exploitation of fish by the trawlers, which use high technology fishing practices, inflict serious damage on the marine ecosystem in terms of its carrying capacity and biodiversity. The marine resources are the primary sources of livelihood for the coastal communities, and fish constitutes the most valuable resource amongst them all. In the last few decades, the utilization of these marine resources has created great stress on the marine ecosystem in general and on the livelihood of the traditional and small scale fishing communities in particular.

This crisis of over exploitation of the biological resources points at the necessity of a shift in paradigm towards sustainable development and optimal utilization of resources. For instance, the world's fishing grounds are coming under growing pressure from overexploitation. This brings the risk that their future sustainable yield will be reduced and certain species will be eliminated and that the competition between different types of fishing operators will cause serious economic and social distress to the users apart from having serious ecological repercussions.

The degeneration of other components in the marine ecosystem such as mangrove, is a case of great concern. The destruction of mangroves deprives many fish species of important spawning and nursery areas with consequent knock on effects on fish population and biodiversity in off-shore areas. The increased quantities of silt being washed into the sea as a result of mangrove depletion affects coral reefs and other important coastal habitats such as seaweed, sea grass beds etc.

The situation explained above necessitates the need for immediate action to protect the most valuable resources. The significance of declaring " Marine Protected Areas" or as " Marine Biosphere Reserves" become evident as these serve as replenishment areas for marine resources and should be designed to maintain the genetic diversity of key species. It is necessary to find out the extent of dependency on these resources- for livelihood, fuel, sanitation, etc. to be able to gauge the magnitude of problems that the people will encounter after the declaration of the areas as protected. This entails assessment of the extent and nature of dependency of various classes of people on diverse marine resources. This also underlies the importance of a socio-economic study along with the ecological and technical ones. The interface between the natural and socio-economic system is the realm of coastal zone management.

1.7 Marine Pollution

Many countries experience significant pollution in their coastal waters, especially in enclosed and semi-enclosed bays and estuarine areas embodied by coasts where rapid urbanization and industrialization have taken place. Marine pollution may originate from rivers, or seepage from pipelines or ground water. Pollutants include pathogenic microbes, toxic chemicals, nutrients and suspended solids. Pollution, both industrial and domestic along the coastal regions has created hazards to the marine life. Several studies have been carried out on the effect of sewage on the marine populations (Allen Hancock Foundation, 1965; Hume *et al.*, 1962). As benthic algae represent a major part of the lowest trophic level, anything affecting them may also influence organisms at higher tropic levels. Reduction of numbers of red and brown algae from sewage-polluted areas has been attributed to the toxic effects of the compounds present in the sewage (Nasar and Aleen 1948; Hartog, 1959). Beach contamination by oil spills from tankers has been reported from time to time. Natural hazards such as earthquakes, volcanoes, landslides and subsidence that occur on land also affect the coastal zone.

Coastal farming or aquaculture may cause harmful algal blooms, deteriorate water quality, damage critical habitats as well as nursery grounds, pose serious socio-economic and human health problems if application of bio-active compounds (including pesticides and antibiotics) and discharge of organic wastes are not properly controlled. Increases in nutrients can contribute to blooms of phytoplankton, particularly dinoflagellates and diatoms, and several other groups of photosynthetic micro-organisms. Several algal blooms cause visible coloration of the water, which has led to the common, terms "red tides" (the color may be red, brown, yellow or green). Blooms of certain algal species are associated with toxic effects on fish and shellfish.

1.8 Coastal hazards

1.8.1 Beach erosion

About one-third of the world's coastline consists of beaches, generally made up of sand, gravel or their mixtures. A world -wide study on coastline changes, which has been undertaken by the International Geographical Union's Commission on the Coastal Environment (IGU-CCE) between 1972 AND 1984 has found that in recent decades there has been erosion of more than 70 percent of the world's sandy coastlines, less than 10 percent having prograded, while the remaining 20-30 percent have either remained stable or been subject to alterations with no net changes (Bird, 1985).

Factors affecting coastal erosion include physical agents, human activities and the lithological character of the coastline. Among coastal physical processes, intense storms and sediment budget are the two important factors. Human activities such as building of dams and breakwaters, and quarrying for sand and gravel or for minerals such as ilmenite, tin or gold, cause alterations and imbalances in the sediment budget, coastal processes and relative sea level. In brief, beach erosion is being resulted from either decreased supply of sediment to the beach or increased losses of the sediment from the beach, or combination of both processes.

The socio-economic impact of coastal erosion is negative by jeopardizing the public safety against flood, typhoons, etc. and public life by contamination of drinking water. To protect the beach from erosion, coastal engineering technologies have advanced in recent years. The bio-engineering measures such as plantation of sand dune vegetation, mangroves along the coast are preferably adopted now.

The present work is designed, therefore to assess the physico-chemical and biological state of these ecologically sensitive ecosystems along the central west coast of India, carry out a socio-economic study of the impacts and conduct laboratory studies that would help in our efforts to protect these vegetation and reforest the affected areas. Coastal ecosystems, besides having dynamic oceanographic characteristics are also subjected to the increased human interferences, as it is easily accessible. The monitoring of the theoretical and experimental aspects to determine the ecological status help us to assess and possibly predict the state of coastal ecosystems.

1.9 Conservation and management

There has been a worldwide concern over the damages caused to the coastal areas due to man-made and natural changes. The enormous degree of marine environmental pollution and destruction of mangroves as well as sand dune vegetation has led to the concept of conservation of the important areas. Coastal areas are rich and unique in flora and fauna. These areas are to be conserved with proper management implication.

In any situation a wide range of environmental, social and economic factors, conditions the appropriate management response. The major aspect of the natural environment that can be managed is the human action which can rapidly destroy or degrade the natural environment. With care and planning, human action can maintain the natural environment, so that it can sustain the long term economic, cultural and scientific needs of the society.

1.10 Studies at Malvan (Maharashtra)

Selection of the sites dealt for case studies was done after surveying the sites and were mainly based on the biodiversity status of the area. It was decided to select only one site along the central west coast of India such as Malvan – an Open coast ecosystem (Maharashtra) to be dealt in detail for biodiversity status and also for convenience. In order to understand the changes that had taken place, the detailed studies were carried out. The details of these site is given in separate chapter.

1.11 Importance of the study

The coastal ecosystems in the world such as mangroves, coral reefs, seagrass beds, seaweeds, sand dunes are of global concern. They are important for millions of people around the world as they provide both subsistence and cash-crop fisheries. They have been considered as Marine Critical Habitats (MCHs) because of their uniqueness, rich biodiversity, productivity and ecological as well as economic importance (Untawale *et al.,* 1980). These habitats in India are also categorized under "ecologically sensitive regions" under Coastal Regulation Zone (CRZ-1) Act 1990. In an International arena "Critical Habitat" is a term used in the Endangered species Act referring to the specific areas that contain physical or biological features essential to the conservation of a threatened or endangered species. Critical habitat is defined as specific areas that have been found to be essential to the conservation of a species,and which may require special management considerations or protection (Usha, 1999). Critical habitat determined using the best available scientific and commercial information about the physical and biological needs of the species.

1.12 Need for monitoring of coastal waters at Malvan

Due to human activities, 6.5 millions tons of litter find their way into the oceans each year. Several million tons of top soil with a fertilizer value of over 100 crores of rupees are discharged annually into the sea due to erosion. The sewage, fertilizer use on land and extensive use of detergents have all doubled the rate at which nutrients are added to the coastal zone (Naqvi, 1996).

Over 1,50,000 tons of non-biodegradable plastics find their way into sea and physically endangered the lives of the marine fauna and threatened biological productivity. The plastic hinders transfer of nutrient supply and accelerates the process of anaerobiosis and thus causing mortality. The industrial pollutants entering the oceans are increasing out of proportion. Nearly 15 phyla of filter feeders that are exclusively found in the oceans, are being affected by such a effect (D'Souza, 1996).

If the resources that are available in the coastal zone are to be utilized on a sustainable basis, due attention has to be given to understand the physico-chemical and biological characteristics of coastal waters. This area was studied to be declared as Marine Park due to the high biodiversity status (Untawale 1980).

There are constantly increasing human pressure of various kinds to exploit marine resources for multiple economic benefits. Hence there is urgent need to protect and conserve, particularly Marine Critical Habitats on the sustainable basis.

1.13 Objectives of the present study

The present study was carried out keeping in mind the importance of Marine Critical Habitats in general along the entire west coast of India and along the central west coast of India in particular.

In the recent years, human interferences have caused changes that are too fast for an ecosystem to cope up with. But if the adverse impacts associated with rapid environmental changes can be anticipated and the way the ecosystems might respond, to these can be understood, then it is extremely easy to mitigate these. The main objectives of the study are

- Assessing the status of biodiversity along the central west coast of India.
- Delineating the causes for the changes in biodiversity.
- Assessing the ecologically sensitive ecosystems along the central west coast of India and differentiating them.

- Studies on physico-chemical, biological and socio-economic aspects along Malvan.
- Conservation and management aspects.

CHAPTER II

REVIEW OF LITERATURE

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2.0 INTRODUCTION

Marine ecosystems are known to be highly productive areas among the various ecosystems of the world. In addition, they are also used for fishing vessels, defence and for compelling reasons as channels for disposal of domestic sewage and industrial waste. Increase in population and improper management of their wastes which enters the ocean in unacceptable amount is the prime factor driving coastal pollution (Goldberg, 1995). A list of previous works is presented here. is restricted to the important and related global studies on physico-chemical parameters, phytoplankton, zooplankton, benthic fauna, mangrove ecosystem, corals, marine algae, seagrass and sand dunes.

2.1 Physico-chemical characteristics

2.1.1 pH

The pH of water is an important parameter owing to its relationship with various chemical characteristics and biochemical reactions. High primary productivity, respiration and mineralisation lead to the changes in pH. Increase in pH may also be due to utilization of carbon dioxide from carbonates by algae and higher plants (Reid and Wood, 1976). Absorption of metal increases from nil to near

100% as pH increase (Benjamin *et al.,* 1982). According to Nayak and Bukkari (1992), within tidal reaches, pH seems to be directly related to salinity.

2.1.2 Water temperature

The fluctuations in water temperature are mainly influenced by climatologically conditions rather than by discharge water characteristics. According to Prasad (1956,1954); Marichamy and Siraimeetan, (1979) and Marichamy *et al.,* (1985) minimum values recorded during post monsoon is due to cooler climatic conditions, while higher values were recorded during summer seasons. It is a normal phenomenon observed in many lotic system by Ravinchandran (1985).

2.1.3 Salinity

A negative correlation between salinity and chlorophyll–a recorded indicates that salinity is the predominant factor controlling growth and distribution (Gouda and Panigrahy, 1996). Mc Lusky (1971) states, " the salinity at any point will be dependent on the topography, the state of tide (high or low, spring or neap), the time of the year controlling rainfall etc, and the extent of freshwater flow. Reid (1961) remarks " the momentary salinity may be regarded as a function of the quantity and quality of inflowing and out flowing waters, rainfall and evaporation since these factors may vary with seasons.

2.1.4 Dissolved Oxygen

The dissolved oxygen content of the water is yet another important water quality parameter that indicate the purity of water and also the degree of contamination. Further, oxygen concentration in water is also controlled by various chemical process and is influenced by various chemical processes and is influenced by the time of the day, season, current, velocity, temperature and biological characteristics (Reid and Wood, 1976). It is well known that the solubility of oxygen in seawater is a function of its partial pressure on the one hand and its salinity and temperature on the other. Zingde (1989) showed wide variation of dissolved oxygen, that it is indicative of the aquatic environment under pollution stress.

2.2 Nutrients

2.2.1 Nitrate

Nitrate is the thermodynamically stable and most oxidized form of inorganic nitrogen and plays a significant role in the nitrogen cycle. It is an important nutrient source for phytoplankton. The importance of nitrate lies in its ability to regulate primary production as a new nitrogen source for primary producers (Eppley and Peterson, 1979; Malone *et al.,* 1983; Brodie and Furnas, 1996) reported a maximum of 7.80 m-M of nitrate in Australian Great Barrier Reefs after the cyclone events occurred. Nitrate profiles in coastal marine sediments were studied by Henriksen (1980) and he suggested that the vertical distribution of nitrate depended on the availability of oxygen.

Mann (1981) states that in the coastal waters, the nutrients regenerated from benthic sediments are a major factor influencing primary productivity and suggests that meiofauna and macrofauna are responsible for about 20% of regenerated nutrients. Boynton *et al.*,(1980) observed that nutrient fluxes across the sediment water interface are important in sustaining a high order of production. Dissolved nitrogenous nutrients fluxes are mainly influenced by physical and biological processed (Rendell *et al.*,1997).

2.2.2 Nitrite

Nitrite is known to be an ephemeral nutrient, the concentration of which is therefore determined by the balance between formation and destruction, which depend upon many highly varying factors (Brandhorst, 1959). Its usefulness by virtue of its intermediate position between ammonia and nitrate is highlighted by Rakestraw (1936) and Wattenberg (1937). Nitrite may be taken as an indicator of state of equilibrium between oxidation and reduction processes which make up the nitrogen cycle. Webb *et al.*,(1975) suggested that the autotrophic nitrification occurs in the coral reef areas, the nitrite produced in the coral reef seagrass bed areas might be transformed into nitrite. Ayukai (1993) suggested that the extent of DIN enrichment in the lagoon seems to be dependent on wind conditions, which strongly influences the residence time of water in the lagoon. Sarma *et al.,* (1994) recorded high concentrations (15.889 to 45.73 µM) of nitrite in the continental shelf waters of Bay of Bengal. In coastal waters nitrite concentrations are almost very low and rarely exceed 5% of nitrate levels (Mc Carthy and Kamykowski, 1972).

2.2.3 Phosphate

A critical review of work on phosphate on east and west coasts of India was made by Jayaraman and Sheshappa (1957) who showed that the fluctuations were erratic and that the release of phosphate and its utilization occurred at short intervals of time. Regeneration of phosphate in the shallow mud bottoms was suggested by Cooper (1951). Harvey (1955) suggests release of phosphate in the interstitial sediments in considerable amounts is through autolysis of bacteria. Nair (1972) at Gulf of Mannar recorded the higher concentration of total phosphate during summer season and attributed to the phytoplankton production which contributed to the particulate phosphate and lesser extent due to the detritus. Sczmant and Forrester (1996) and Brodie and Furnas (1996) recorded higher total phosphate in the coral reef waters of USA and Great Barrier Reef, Australia respectively and also reported that in the absence of accidental or point-source pollution inputs, cyclones, floods contribute total phosphate of the water.

2.2.4 Silicate

Silicon is different from nitrogen and phosphate in some ways and in the strictest sense it is not considered as a nutrient but its usefulness in the formation of skeleton of diatoms and radiolarians is very high. Fairly high values were reported in a number of estuaries and coastal bodies of water around India, such as Gautami (Rama Sarma, 1965) and Vasista (Sai Sastry, 1987) of Godavari estuarine system, Cochin backwaters (Joseph, 1974) and Korapuzha estuary (Rao and George, 1959). The work of Cooper (1933a, b) clearly shows that silicon cycle is shorter than that of other nutrients. Bacteria, which play an important role in the recycling of nutrients, are not involved in the silicon cycle. Raghuprasad and Jayaraman (1954) recorded high values of silicates during the June-October period in the shallow waters near Mandapam.

2.3 Phytoplankton

Phytoplankton utilize dissolved inorganic (nitrate, nitrite and ammonium) and dissolved organic (Urea and amino acids) nitrogen for their growth and hence the production of new biomass. Phytoplankton also play an important role in influencing the nutrient pools and it is generally believed that ambient nutrient concentrations are a balance between utilization and supply (Mengesha *et al.,* 1998). Studies by Dugdale *et al.,* (1964), in the Arabian sea and Sargano seas showed that *Trichodesmium* sp. fixed gaseous nitrogen besides utilizing ammonium and or nitrate. Studies along the west coast of India on phytoplankton production are that of Nair *et al.*, (1973); Tiwari and Nair, (1998).

Phytoplankton abundance in estuaries is known to depend on physical and chemical factors such as light (Cloern, 1987), nutrients (Gallegos and Jordan, 1997), stability of the water column (Paerl *et al.*, 1998), turbidity (Cloern, 1987) and temperature (Penmock and Sharp, 1994). Specific nutrient uptake rates vary as a function of the size structure and taxonomic composition of the community (Malone, 1980; Probyn, 1985). Numerous studies have shown that the development of phytoplankton communities are mainly based on nitrate (Wafar *et al.*, 1983, Dauchez *et al.*,1996) while other investigation emphasize a major contribution to ammonium (Probyn and Painting, 1985; L'Helgeum *et al.*,1996).

On the east coast considerable work was done on the various aspects of hydrography in relation to plankton production in the Hooghly-Matlah systems of Ganges (Bose, 1956; Saha, *et al.*,1975). The hydrobiological aspects of Chilka lake (Sewell and Anandale, 1922; Mohanti, 1975; Satyanarayana, 1988) and of Pulicat lake (Kaliyamurthy, 1974; Raman *et al.*,1975; Rao and Rao, 1975) were investigated. Various aspects of hydrography in relation to plankton and benthos were studied in the Vasisita branch of Godavari estuary (Srinivasa Rao, 1978; Sai Sastry, 1987; Rama Jega Rao, 1989). The hydrology and hydrography of Krishna estuary was studied by Ramanadham and Varadarajulu, 1975). Phytoplankton production has been found to vary from 11 to 91 $mgCm^{-3}h^{-1}$ (Untawale *et al.,*1977; Pant *et al.,*1980). Studies conducted by Qasim *et al.,*(1978) revealed high phytoplankton biomass when nitrate concentrations were high.

2.4 Zooplankton

Fish production influence the distribution of zooplankton (Jakobsen and Johnsen, 1987 and Cryer and Townsend, 1988). Studies on zooplankton along the Indian coast and more particularly along the east and west coast of India are that of Arunachalam *et al.,*(1982), Divakaran *et al.,*(1982), Goswami (1982), Balakrishnan Nair *et al.,*(1985), Murty (1987), Goswami and Usha Goswami (1990), Goswami and Devassy (1991), Madhupratap *et al.,*(1991), Ramaiah Neelam (1996).

2.5 Benthic fauna

Peterson (1913) and Hunt (1925) are among those pioneering workers who stressed the need for a quantitative study of benthos. Thorson (1957) through his classical works proved the importance of such a study more vividly. Jones (1950) in his extensive review of marine bottom communities pointed out that among the various factors that affect the distribution of bottom fauna, temperature, salinity and the nature of the bottom deposit are significant. Holme (1964) and Mc Intyre (1969) provide extensive reviews of the work done in the different parts of the world. Ansari and Ingole (1983) recorded high meiofaunal densities on some sandy beaches of Andaman Islands where sand particles ranged from coarse to medium size and the fauna was dominated by nematodes (57%), copepods(13.7%) and polychaetes (12.8%) and on all the beaches they studied the bulk of meiofauna was concentrated in the upper 4 cm. segment. The importance of water as a limiting factor in the distribution of meiofauna was emphasized by De Zio and Grimaldi (1964, 1966). Boaden and Platt(1971) considered the role of chemical and biological factors important in effecting movements of meiobenthic organisms. Gray (1971) showed that strong light inhibits faunal movement.

Patil (1951 a,b, 1952) studied the fauna of the intertidal region along the Karwar coast. The intertidal organisms of the Bombay shores from Cuffe Parade to Mahim was studied by Bhatt (1959). Menon *et al.*, (1962) described some bivalves of the Goa coast.

On the east coast of India, fauna of the Ganges delta was described by Anandale (1907) and Kemp (1917). Hooghly-Mallah estuarine system has been studied by Dutta *et al.*, (1954). Harkantra (1982) and Ansari *et al.*,(1986) showed the dominance of polychaetes, crustaceans and molluscs from various coastal environs, whereas earlier workers that of Ingole(1987), Dekkar(1989) and Harkantra *et al.*, (1990) reported polychaetes to be the dominant forms.

2.6 Grain Size

The importance of grain size in determining the distribution of benthic fauna has been stressed by many workers. The quantity of organic matter lying on and in the sediment is of great importance to deposit feeders. Newell (1965) and Longbottom (1970) obtained a good correlation between organic carbon and organic nitrogen with grain size.

2.7 Biodiversity

Coastal ecosystem is a storehouse of variety of flora and fauna with great ecological and economic significance. Macnae (1968) gave a general account of the fauna of mangroves in the Indo West Pacific region. Das and Siddiqi 1985 compiled the information on wild life species (mammals, reptiles, amphibians and birds) found in Sunderbans. Das and Dev Roy (1989) gave a general account of mangrove fauna of Andaman and Nicobar Islands. The Malaysian probosis monkey is endemic to mangroves of Borneo where it feeds on foliage of

Sonneratia caseolaris and *Nypa fruticans* (FAO, 1982). Crocodiles and alligators are some of the most important reptiles that naturally inhabit the mangrove ecosystem. The salt water crocodile, (*Crocodilus porosus*) is found in almost all large Islands of Andaman and Nicobar which support extensive mangrove swamps and tidal creeks (Tikader and Das, 1985).

Mangrove forests are ideal sanctuaries for avifauna. According to Saenger *et al.*, (1983), the total list of mangrove birds species in each of the main bio-geographical regions includes from 150 to 250 species. All over the world, 65 bird species have been listed as endangered or vulnerable. Das and Dev Roy (1989) have reported 53 species of birds in the mangrove areas of Andaman and Nicobar Islands. Seidensticker and Hai, (1983) have reported over 120 species of fish caught by fishermen in the Sunderbans. Das and Dev Roy (1989) reported important molluscs and crustaceans from Andaman and Nicobar Islands mangroves. Indian mangroves are considered to be rich in floral and faunal biodiversity (Table 1.1). Samant (1986) reported 121 species of birds along the Maharashtra coast.

2.8 Mangroves

Characteristically mangroves are restricted to the tropics, because of their requirements for higher atmospheric and water temperatures, but occasionally some stands of mangroves have been reported as far north as 35°N (Oyama,

1950) and as far south as 37°S (Chapman and Ronaldson, 1958). The total mangrove cover of the world is about 1,81,000 sq.km (Spalding *et al.* 1997), which is comparable to the estimates, prepared by Fisher and Spalding (1993). The most northerly site of the mangrove distribution are the tip of the Red Sea in the Gulf of Aquba (30°N) and in South Japan (32° N), while the most southerly sites for mangrove distribution are Australia (38° S) and Chatham Island east of New Zealand (44° S) (Walter, 1977). The highest concentrations of mangrove species can be, however, found in the Indo-Malaysian region with the key species belonging to families Rhizophoraceae, Avicenniaceae and Sonneratiaceae .Out of the reported 90 species of mangroves in the world, 63 species are found in Asia and Pacific Islands, 16 species have been scattered in Pacific-America, 16 species in Atlantic-America and 11 species in West Africa. Some of the world's geographical areas have uniform mangrove vegetation (Chapman, 1977). Rodin *et al.*, (1975) estimated the World mangrove area to be about 0.47 million km^2. Almost half of this is located in the Asia and Oceania regions. Ajtay *et al.,* (1979) estimated world mangrove area as 0.3 million km^2 while that of Saenger *et al.*, (1983), based on various reports, gives the total mangrove area of the world as 0.16 million km^2.

Pioneering studies on the mangroves of India were carried out by Oureshi (1957), Mathuda (1957), Waheed Khan (1957), Sidhu (1963), Blasco (1977) and Saenger *et al.,* (1983). The extreme limits of these estimates are 7,00,000 ha (Sidhu, 1963), and 3,56,500 ha (Saenger *et al.*, 1983 ; Blasco 1977). This figures shows the changes in mangroves that have occurred due to deforestation, reclamation and other natural changes. The estimates did not include mangrove areas of Konkan coast, Goa, Karnataka and Kerala. The Survey of India ahs estimated mangrove cover of about 6,36,000 ha based on Landsat data of 1987. As per the Forest survey of India (1997), the total mangrove area of India is 4822 sq. km.

Some mangrove species such as *Avicennia marina* var. *resinifera, Sporobolus virginicus* and *Urochondra setulosa* are endemic to west coast of India and species like *Aegialities rotundifolia, Heretiera kanikensis, Myriostachya wightiana and Rhizophora annamalayana* are endemic to east coast of India. *Sonneratia caseolaris* is on the verge of extinction from the Indian coasts (Blatter, 1905). For categorization of the mangrove species found along the Indian coastline based on IUCN criteria, a study was carried out recently (BCCP report, 1998). In all 60 mangrove species (true and associate mangroves), 23 marine benthic algae, 52 marine fishes and 42 invertebrates found in the Indian mangroves were assessed.

Sidhu (1963) highlighted the deltaic mangroves as 4,88,888 ha in Lower Ganga delta/Sundarbans, 12,000 ha at Mahanadi delta/ Bhitarkanika, 5,120 ha at Krishna delta, 13,304 ha at Godavari/Coringa and 2, 640 ha at Cauvery delta. These mangroves spread over an area of about 4,700 km^2, which is about 70 percent of total Indian mangroves. The Sunderbans of West Bengal represent the largest stretch of mangroves in the country, where tree cover was estimated at 2123 sq.km (FSI, 1999). The dense mangroves of Bengal are dominated by *Excoecaria agallocha, Ceriops decandra, Sonneratia apetala, Avicennia* sp., *Bruguiera gymnorrhiza, Xylocarpus granatum, X. moluccensis, Aegiceras corniculatum* and *Rhizophora mucronata.* While species of *R. mucronata, R. apiculata, Ceriops tagal, C. decandra, Bruguiera gymnorhiza, Lumnitzera racemosa, S.apetala, Acanthus ilicifolius, Avicennia officinalis, A. marina, E. agallocha* and *Acrostichum* have a uniform distribution along the east and west coast of India about 20 species of mangroves and their associates occur along the Pichavaram/Cavery delta. Rao and Sastry (1972) along the shallow areas of the east coast of India recorded bigger sizes for *N. fruiticans* under the influence of fresh water.

The mangrove zones in the Andaman & Nicobar Islands are estimated about 18 percent of the Indian total mangroves (Naskar & Guha Bakshi, 1987 and Annonymous, (1992). Jagtap (1985) has reported only 20 mangroves and 2 associates from Andaman group of islands. Jagtap *et al.*, (1993) further reported 27 mangrove flora from Andaman and Nicobar groups of Islands. Mall *et al.*, (1982) reported *Rhizophora stylosa, R. lamarckii* and *Bruguiera sexangula* from the east coast and the Andaman and Nicobar group of islands and these species are totally absent from the west coast of India.

Along the west coast, healthy mangroves are seen along the central west coast i.e. Karnataka, Goa and Southern Maharashtra. Gujarat and Kerala coast also show the presence of mangroves but they are scarce, because of the near total deforestation and reclamation. The estimated area of the mangroves along the west coast of India was 114,000 ha (Sidhu, 1963). The extent of mangroves along the west coast of India has been studied at certain localities (Waheed Khan, 1959; Sidhu, 1963). Mangroves along the central west of India have been studied by Bhosale, 1978. In all 34 species, 25 genera and 21 families have been reported from the west coast of India (Untawale, 1987). Of these, 21 species are from Gujarat, 28 from Maharashtra, 17 from Goa, 18 from Karnataka, 12 from the coast of Kerala and 5 from the Lakshadweep group of islands (Table 2.1). In Gujarat inspite of having the largest mangrove coverage of 37,000 ha it displays a poor assemblage comprising of 12 species. *Avicennia marina, A. alba, A. officinalis, Rhizophora mucronata, Ceriops tagal, Bruguiera gymnorrhiza, Aegiceras corniculatum* and *Sonneratia alba* are some of the species occurring along the Gujarat coast. The most dominant being *A. marina* forming almost pure strand at many places (Singh, 1994). According to FSI, 1997, Gujarat accounts for an area of 991 sq.km, but majority of its mangroves are scrubby and of low height. Area wise, Gujarat stands second after west Bengal, but is considered to be inferior in floristic composition and height. Recent studies have shown that the species of *Xylocarpus* might have become extinct from the west coast of India, where as other species like *Ceriops tagal, Lumnitzera* *racemosa, Sonneratia apetala* and *Kandelia candel* are found only in the certain areas (Untawale, 1987).

Some information is available on the mangrove ecosystems of the Goa region (Dwivedi *et al.*, 1974; Untawale and Parulekar, 1976). The total coastline is approximately 120 km with an mangrove area of about 2000 ha (Jagtap, 1985). The Satellite Imagery report from the Space Application Centre (Anonymous, 1992) has shown the combine mangrove area of Maharashtra-Goa coast together as 148.4 km^2. In these mangrove zones of Goa, about 17 mangroves and mangrove-associated species were reported. The predominant species are *R. mucronata, S. alba, A. marina* and *A. officinalis*. The other species widely distributed are *R. apiculata, S. caseolaris, Kandelia candal, B. gymnorrhiza, B. cylindrica* and *Aegiceras corniculatum*.

Untawale *et al.*, (1980) surveyed and mapped mangrove distribution to the estuarine system of Goa with the help of remote sensing. Naskar & Mandal (1999) reported 17 mangrove species from Goa while Govt. of India report (Anonymous, 1987) and Jagtap *et al.*, (1995) reported 20 mangroves along the Mandovi and Zuari estuaries, though in very degraded manner. Along the Goa coast, mangrove distribution is of fringing in general (Untawale and Parulekar, 1976). Untawale *et al.*,(1982) studied detailed distribution in mangroves of Goa and reported 15 species of mangroves belonging to 10 genera.

Work on mangrove flora, ecology and distribution were studied by Gomes & Mavinkurve (1982), Jagtap (1985a, 1985b & 1986), Jagtap & Untawale (1980 &1981), Matondkar (1980a & 1980b), Murti & Das (1972), Oertel (1988), Parulekar *et al.*, (1980), Querishi (1957), Untawale *et al.*, (1976, 1977, 1981 & 1982), Wagle (1982), Untawale *et al.*, (1977).

Karnataka coast, the mangroves are fringing type in the intertidal zone, covering about 50 km^2 area (Untawale & Wafar, 1986); but based on the through satellite imagery, the sparsely distributed mangroves from the Karnataka coast have been reported at 1.5 km^2 (Anonymous, 1992). According to the Government of India 'Mangrove Status Report' (Anonymous, 1987) the mangrove area in the Karnataka coast is 60 km^2 (Table 2.2). The tidal wetlands of Karnataka coast has been surveyed and classified by Rao *et al.*, (1986, 1987).

Work carried out on mangroves along the Kerala coast by Thomas (1962); Rao& Sastry (1974), showed the presence of different species. Ramchandran, *et al.*, (1986) have reported several mangrove species from Kerala coast on the newly developed mangrove areas, covering 44 ha, near Cochin estuary. According to Chand Basha, (1992) the mangroves have dwindled down to about 1700 ha from 70,000 ha at present. Out of the 12 species reported from the Kerala coast, the most dominant were *Avicennia officinalis, A. marina, Bruguiera cylindrica, B parviflora, B. sexangula, Rhizophora apiculata, R. mucronata, Kandelia candel, Sonneratia caseolaris* etc. (Unni & Jayakumar, 1997). Large areas along this coast are been reclaimed for various purposes such as for urbanization, construction of harbours, ports, prawn farming, coconut plantation etc. Lakshadweep Island is a coral island, but small patches of Bruguiera sp. were reported on the Minicoy Island (Untawale & Jagtap, 1984).

2.9 Coral Reef

Corals formations are found throughout the tropics, though restricted to a few places. Khan (1984) and DOZ, (1997) recorded a total of 66 scleractinian coral species, belonging to 22 genera and 10 families from Narikel Jinjira (Bangladesh). In Bangladesh it was estimated that the weight of coral harvest ranges from 40-100 kg/day/boat or about 20-40 kg/day/person (DOZ, 1997).

Early studies of the reefs and corals of the Maldives were made by the famous naturalist Charles Darwin (1842), and also by Gardiner (1903-1906). Pillai and Scherr (1976) provided a major review of Maldivian stony corals. They described 147 species from their collections, and quoted literature records of a further 94 species, making a total of 241 species. Sheppard (1987) synonymized this list, and suggested that the total number of valid species known from Maldives was 166. Sri Lanka's reefs are located within 40 km from the coast and they contribute significantly to the marine fish production (Rajasuriya and White, 1995).

Clark (1995) reviewed the collection and suggested that the total number of hermatypic corals recorded from Maldives to date is about 200 species, representing over 60 genera. The study of species composition of the coral genus *Acropora* at 12 sites along the Jogian Islands revealed 61 species, making the Jogian Islands one of the most diverse areas known for this genus (Wallace & Woldstenholme 1998). Coral reefs in Indonesia are widely developed particularly along the deeper seas of the eastern portion of the Archipelago (Molengraff 1929).

There are four major fringing coral reef regions on the Indian coast, viz., Gulf of Kuchchh (Gujarat), Lakshadweep, Palk Bay & Gulf of Mannar (Tamil Nadu), and Andaman & Nicobar group of Islands. The mainland coast of India has two widely separated areas containing reefs: The Gulf of Kuchchh in the north west, which has some of the most northerly reefs in the world (Kelleher *et al.*, 1995) and Palk Bay and the Gulf of Mannar (with numerous fringing reefs around small islands) in the south east.

High diversity of corals are found in the Indian Ocean with total 53 genera and 11 endemic genera (Scheer, 1985). Gosliner *et al.,* (1996) have prepared a report on Indo- Pacific coral associated animals exclusive of the vertebrates. Works on the taxonomy of Scleractinian from the Indian waters are those of Alcock (1892), Gardiner (1903-06), Brook (1893) Bernard (1905), Matthai (1914, 1928) and Gravely (1927), wherein corals from the deep waters of India, Rameswaram.

Some of the major studies in the recent past are those of Pillai (1972), Pillai and Jasmine (1996). The absence of reef in the Bay of Bengal is attributed to the immense quantity of freshwater and silt brought by the rivers.

Coral reefs on the Tamil Nadu coast are located in Palk Bay near Rameswaram and in the Gulf of Mannar. Squid breeding grounds occur near Rameshwaram (Vineeta Hoon, 1997). The Gulf of Mannar reefs on the other hand are developed around a chain of 21 Islands that lie along the 140 km stretch between Tuticorin and Rameswaram (Krishnamurthy, 1987; Kumaraguru, 1997). A detailed account of each island is provided by Krishnamurthy (1987) and Deshmukh and Venkatramani (1995). A detailed report on the Gulf of Mannar, their coral fauna, reef associated resources and suggestions for conservation and management was prepared by Krishnamurthy (1987). A comprehensive account of the coral fauna of this region are provided by Pillai (1986). There are about 96 species of corals belonging to 36 genera in the Gulf of Mannar. In a recent study (Ramaiyan V *et al.*, 1995) identified only 94 species of corals. Pillai (1973) estimated that about 250 m^3 of reef was daily removed from Gulf of Mannar during sixties and seventies.

Dorairaj *et al.*,(1987) prepared a detailed report on the corals of Andaman and Nicobar Islands. A total of 135 species divided among 59 genera is known to both Andaman and Nicobar (Pillai 1983). The reefs are rich in soft corals (Pillai, 1996). Reef watch studies indicate that the reefs have been badly damaged in the recent past (Wood, 1991). The destruction of corals in Port Blair is due to toxic wastes released into the coral reef environment (Wafar, 1992).

The west coast of India between Bombay and Goa is reported to have submerged banks with isolated coral formations (Nair and Qasim, 1978). Coral patches have been recorded in the intertidal regions of Ratnagiri, Malvan and Redi, South of Bombay (Qasim and Wafar, 1979) and at the Gaveshini Bank, 100 km west of Mangalore (Nair and Qasim, 1978). Along the Central West Coast of India, Wafar (1986) reported two species (*Pseudosiderastrea tayami* and *Porites lichen*) of hard corals in patches from Mumbai. Good patches of corals were also reported along Mumbai coast by Untawale *et al.*,(1999). Hermatypic corals along the shore are reported from Quilon in the Kerala coast to Enayem in Tamilnadu (Pillai, 1996).The reef area of the Gulf of Kuchchh is 148 sq.km. and the total area occupied by the reef is 315 sq.km (DOD & SAC, 1997). Living coral areas along Gulf of Kuchchh rarely exceed 20 -30 % (GEC, 1997).

A detailed report on Lakshadweep Islands, their coral fauna, reef associated resources and suggestions of conservation and management are set in a detailed report based on an intensive survey of scientists by CMFRI (Bull No 43, 1989) and Rodrigues (1996). The coral fauna of Lakshadweep is known to harbour a total of 105 species divided among 37 genera (Pillai 1996). Rodrigues (1996) has recorded 29 new records for species in Lakshadweep.

Satellite imagery (SAC, 1992) shows scattered patches of corals in the intertidal areas and occasionally at subtidal depths along the west coast of India notably at Ratnagiri, Malvan and Redi port (Venkataraman, 1998). The reports on the status of coral reefs, coral reef research and Government policy towards conservation and management of reefs in India are prepared by Shepard and Wells, (1988), Alan White and Arjan Rajasuriya (1995) and Pillai (1996)

2.10 Sand Dune Ecosystems

Sand dune is one of the important ecosystems of the world.One of the oldest works on coastal Sand Dunes is by Woulter Van Dieren (1934) on how life reacts to stress and how dune plants help to shape the landscape and protect long coasts. Cooper (1958, 1967) and Bird (1976) contributed significantly to the study of Sand Dune vegetation of United States. Other works are that of Larrucea and Tebar (1990) from Menorca Isle, Kutiel *et al.,* (1980) along the coastal plains of Israel; Eig (1939) and Zohary (1962) along the Mediterranean coast, while Hesp *et al.*,(1989) on the African coast, Avis (1985) in the coastline of Africa. Marrel *et al.,* (1985) analyzed the vegetation on the coastal dunes in South West Netherlands, and Babikir (1984) of Qatar, Moreno-Casasola and Espejel (1986) along the Gulf of Carribean Sea of Mexico. Rao and Agarwal (1964, 1971), Rao and Sastry (1972, 1974)and Rao *et al.,* (1974 & 1975) under the Botanical Survey of India have worked extensively on the ecology of coastal and sand dune vegetation along the coasts of Saurashtra and the neighbouring islands. Untawale (1980) gave a report of the sandy coasts of India. Rao and

Agarwal (1971) recognized communities of *Hydrophylax maritima* and *Ipomoea pes-caprae* growing on the Saurashtra coast. Along the Orissa coast Rao *et al.,* (1974) reported the growth of *Canavalia maritima, Cyperus arenarius, Ipomoea pes-caprae, Launea sarmentosa* and *Hydrophylax maritima.* He also reported the growth of *Ipomoea pes-caprae, Cyperus arenarius, Canavalia maritima, Launea sarmentosa, Sporobolus virginicus* and *Zoysia matrella* on the Andhra coast. Along the West Bengal coast, Rao et al (1974) reported the growth of *Synostemon bacciforme, Bordereau articualris, Brachiaria reptens, Elusine indica, Euphorbia thymifolia, Leucas lavandulaetolia, Anrenga porphyrochoma, Rothia indica* and *Trianthema pentandra.*

Sand dune flora of India comprised of 63 species (Untawale and Nair, 1974). However, *Ipomoea pes caprae, Spinifex squarrosus, S. littoreus, Vitex negundo, Launnea pinnatifida, Anacardium occidentale, Pandanus* sp. and *Opuntia* spp. dominate the vegetation. A few plants of branched palm *Hypnae indica* occurred in the backshore regions along the Miramar beach at Goa only. Beaches, bays and estuaries are very commonly subjected to erosion.

Untawale (1994) has listed 67 species of dune plants growing on the sand dunes of Goa, belonging to three different zones. Untawale and Nair (1974) while studying the ecology of sand dune vegetation along the Miramar coast studied the climatological factors like rainfall, humidity, air temperature and wind speed as well as the edaphic factors, i.e. sand texture, pH, humus content, soil temperature and the ground moisture. Desai (1995) studied the structure and function of Sand Dune vegetation along the Goa coast.

2.11 Marine Algae

Marine algae have restricted distribution, i.e. some species may have larger latitudinal distribution, while others are geographically distributed. According to the FAO report (Michanek, 1975) the world seaweed production has increased considerably from 1965 to 1973. Humm (1951) reported *Hypnea musciformis* for the first time about its abundant occurrence along North Carolina, U.S.A. The systematics of various groups of algae from the North-west Pacific have been dealt with by Zinova (1965, 1972) and Petrov (1974).

Selivanova and Zhigadlova (1993) have provided a list of 32 new and rare macrophyte species from Commander Islands. Kussakin and Ivanova (1995) detailed the algal participation in intertidal communities of Medney Island. Floristic investigations on the shelf of the Commander islands by Selivanova and Zhigadlova (1997) revealed 32 species of Phaeophyta, with 6 being recorded for the first time and 87 species of Rhodophyta, with 12 being recorded for the first time. Approximately 442 species of red, green and brown algae are presently known in the flora of Puerto Rico (Almodovar and Ballantine 1983; Ballantine and Norris 1989). Continued collection principally along the deep insular shelf and along the less well-studied north coast of Puerto Rico, has led to the recognition of ten species newly reported in the flora (Ballantine and Aponte, 1997). Harper and Garbary (1997) have listed 242 species from northern Senegal which include 29 species not previously recorded for Senegal and 8 species previously unknown for West Africa. Chevalier (1920) was among the first to publish a substantial list of marine algae that included sites from northern Senegal.The benthic marine algal flora of the Maltese Islands (Mediterranean sea) was studied (Furnari 1984; Ribera *et al.*, 1992; Gallardo *et al.*, 1993). The other studies carried out on these islands were by Piccone, 1883 who listed 12 species.

The macroalgal flora of Lampedusa Island consists of 261 taxa (Seammacca *et al.*, 1993) that of Pantelleria Island of 260 taxa (Giaccone *et al.*, 1973) that of Limosa Island of 315 taxa (Cinelli *et al.*, 1976). Lawson and John (1982) provided a synthesis of the tropical West African flora. Marine algal flora of tropical West Africa and adjacent islands (John *et al.*, 1979, Price *et al.*, 1986, 1988). Past collections in most West African locales have been incomplete and recent studies (Lawson and John, 1982, 1987) have reported many new algal distributions. Lawson (1978) examined Atlantic ocean floras from 87 countries regions and islands with a combined total of over 1500 species. Knowledge of the marine algae of the Pacific coast of North America begins with the 1791-95 expedition of Captain George Vancouver (Anderson, 1960). Florida coast has been surveyed by Harvey (1853, 1858), Farlow (1876, 1881).

In countries like Bangladesh, 165 marine algal species have been reported (Nurul Islam, 1976). Out of these, 38 belong to Chlorophyta, 46 to Phaeophyta and 49 to Rhodophyta. The algal flora of Bangladesh is affected by cyclones, turbidity and silt deposits (Nurul Islam, 1976). Altogether, 260 species have been reported from Sri Lankan coast of which only two (*Gracilaria* spp) are being utilized (Subasinghe and Jayasuriya, 1989).

Maldives, Seychelles and Mauritius are rich in marine algal flora where Maldives flora consists of 163 red, 83 green and 18 brown species (Hacket, 1977), Seychelles islands consists of 79 species (Untawale and Jagtap, 1989), whereas that of Mauritius coast has a total of 122 species, belonging to 34 green, 20 brown and 67 red algal species. Species of *Ulva, Enteromorpha, Cladophora* and *Hypnea* was very common along the Mauritius coast (Jagtap, 1993). From the subtropical region of eastern South Africa, a total of 172 species have been recorded (Jassund, 1976). Along the Tanzanian coast, 291 algal species were found of which species like *Caulerpa pickeringi* was most common (Jassund, 1976). From Kuwait 13 green, 21 brown and 21 red algal species have been recorded (Sheppard *et al.,* 1992). From Saudi Arabia, Basson (1979) reported a total of 89 species.

From Singapore 105 species belonging to 31 Rhodophycean, 54 Chlorophycean and 20 Phaeophycean species were recorded (Wei & Chin, 1983). Caulerpales, Ulvales and Gracilariales were the common species occurring throughout the coast. From Western Australia, altogether 161 taxa have been reported so far (Kendrick *et al.*, (1990).

The total seaweed production of the world is estimated to be about 6500 thousand tonnes wet weight annually, of which less than 5% is being harvested from east and west coast of India (Mickanek, 1989). Out of this, 220,000 tonnes of red algae and 650,000 tonnes of brown algae are actually harvested from both west and East Indian Ocean (Michanek, 1975).

Indian phycologists have conducted extensive research on morphology, taxonomy and distribution of Indian marine algae. According to Untawale *et al.*, (1983), there are about 624 marine algal species of various groups. From station wise distribution of seaweeds for different algal groups it seems that Tamil Nadu coast dominates in number of algal species (302), followed by Gujarat (202), Maharashtra (159), Lakshadweep group of islands (89), Goa (82) etc. the recorded algal species belong to 204 genera, 61 families and 15 orders (Untawale and Dhargalkar 1989) (Table 2.2). Along the Indian coastline, Gulf of Kuchchh and Palk Bay are proven areas for luxuriant seaweed biomass and are being exploited for quite some time. *Sargassum*, *Gelidiella* and *Gracilaria* has been overexploited at these stations. Algal species like *Coelosiera compressa* is recorded only from the Indian coast among all the Indian Ocean regions (Deshmukhe and Untawale, 1986), otherwise this genus is known from the Pacific region only (Abbott and Hollenberg, 1976). Khadilkar, (1986) reported a

Table 2.1 State-wise mangrove cover (Area in Sq.km.)

Sr. No	States	Estimated by States	SAC, Ahmedabad	FSI, Dehradun				
			1992	1991	1993	1995	1997	1999
1	Maharashtra	330	-	113	155	155	124	144
2	Goa	200	6	3	3	3	6	5
3	Karnataka	60	127	-	-	-	2	3

Table 2.2 Seaweed Resources along Central west coast of India

No.	States	Order	Family	Genera	Species
01	Maharashtra	16	40	76	152
02	Goa	13	29	48	75
03	Karnataka	12	19	28	39

Compiled from published reports

total of 38 genera and 50 species from Mumbai coast which is due to the increase in industrial pollution in the coastal regions.

Studies on the ecology of marine algae in India are few and mostly fragmentary (Parija & Parija, 1946; Srinivasan, 1946; Krishnamurthy, 1954; Misra, 1960; Umamaheshwara Rao & Sreeramulu, 1964). Our knowledge of the marine algae of India is mainly based on the work of Boergesen (1930-39). More species have been recorded subsequently by Dixit (1940, 1968), Srinivasan (1965, 1966), Umamaheswara Rao and Sreeramulu (1964), and Krishnamurthy and Joshi (1969). In the checklist prepared by Krishnamurthy and Joshi (1970), he has listed 520 species of marine algae from the Indian coast, excluding the coasts of Pakistan and Ceylon.

Studies on the importance of agaroid yielding red seaweeds such as *Acanthophora* was stressed by Levring *et al.*, (1969), Umamaheshwara Rao (1970) and Chapman (1970). India produces about 110-132 tonnes of dry agar annually utilizing about 880 -1100 tonnes of dry agarophytes, and 360 - 540 tonnes of algin from 3600-5400 tonnes of dry alginophytes (Kaladharan and Kaliaperumal, 1999). India showed the presence of 100 algal species and 5 seagrasses. Among the 100 algal species recorded 20 species belonged to Chlorophyta, 18 species to Phaeophyta, 61 species of Rhodophyta and 1 species of Cyanophyta (Kaliaperumal *et.al.* 1998). The total estimated standing crop (wet. wt.) from 1863 sq. km. sampled area was 75374.5 tonnes consisting of

2750 tonnes of *Sargassum* spp., 962.5 tonnes of *Gracilaria* spp. and 5262.5 tonnes of *Hypnea* spp. Twenty species and two varieties of *Gracilaria* are known so far from Indian waters (Boergesen, 1933, 1934, 1937a, 1937b, 1938; Umamaheswara Rao, 1972. Oza and Tewari (1990) reported the occurrence of *G. eucheumoides* on the Indian coast for the first time. Dwarka, and Krusadi island (Boergesen 1934, 1937); Mahabalipuram (Srinivasan, (1946); Misra, (1966)).

The genus *Porphyra* has a distribution along the west coast from Kanyakumari to Gujarat and on the east coast, at Visakhapatnam. (Umamaheswara Rao & Sreeramulu, 1963). Krishnamurthy and Sundararajan (1986) have given a detailed account of four species of *Galaxaura* viz. *G. marginata, G. lenta, G. lapidescens* and *G. fastigiata*. Barton (1903) enlisted *G. rugosa* from Laccadive and Maldives islands and Jagtap (1985) from the Andamans respectively. Five species of *Padina* have been reported from the Indian coasts namely, *P. boryana, (P. commersonii), P. glabra, P. gymnospora, P. pavonica* and *P. tetrastromatica* (Krishnamurthy & Joshi 1970; Rengasamy, 1986). *P. distromatica* is a new addition to Indian waters (Rengasamy, 1990). Jagtap (1996) reported 56 species of algae, dominated by members of Rhodophyceae, 10 species of diatoms from the southeast coast of India. Srinivasan (1946) studied the marine algal flora of Mahabalipuram near Madras and information on the algae on the Chilka Lake has been published by Parija and Parija (1946). Algal flora of the Krusadai Island have been listed by Chacko *et al.,* (1955)- and the seaweeds growing on the pearl beds of Tuticorin have been studied by Varma (1961). A list of 180 algal species from Mandapam has been prepared by Umamaheswara Rao (1969,1974). And Visakhapatnam coast (Umamaheswara Rao and Sreeramulu; 1964, 1970); Andhra Pradesh (Umamaheswara Rao, 1978). Krishnamurthy (1957, 1960,1966,1977) recorded a few species from South India. Iyengar (1927) published the account on both fresh and marine algal flora of South India. Umamaheshwara Rao, (1978) has surveyed in and around Andhra Pradesh.

The west coast of India has been extensively studied for taxonomical studies, resource evaluation, ecology, distribution, utilization and cultivation (Sreenivasa Rao *et al.*, (1964); Desai (1967), Chauhan and Krishnamurthy (1968) and Chauhan and Mairh (1978); Dixit, 1933; Dhargalkar, 1981; Untawale *et al.*, 1981, 1983). Misra, 1960 has described the zonation places along the Gujarat coast and for Bombay. Barring a few species, all species and all genera found on the west coast are cosmopolitan. Intertidal survey of marine algal resources along the Gujarat coast has revealed great diversity in the Dwarka coast (Chauhan & Krishnamurthy, 1968). The algal biomass along the Dwarka coastline also contributes substantially to the total biomass of Indian coast (Bhandari & Trivedi, 1975). Dhargalkar & Deshmukhe (1996) carried out the subtidal survey of this coast and they reported around 35 marine algal species. Red algal species were dominant (20) followed by green (8) and brown (7). Dwarka subtidal flora is richer and more diversified as compared to that of central west coast of India (Untawale *et al.*, 1989). Blatter (1908) studied the flora of Gulf of Kuchchh. Misra (1960) studied ecology, distribution and seasonal succession of marine algae of India, where he has described the Gulf of Kuchchh region. Chauhan *et al.*, (1978) surveyed the Saurashtra coast and Gulf of Kuchchh for seaweed resources. Recent work along subtidal region of the Central west coast of India (Untawale *et al.*,1988) and on the submerged Angria Bank (42 species) (Untawale *et al.*, 1989) (off Ratnagiri) in the Arabian sea, showed the potential of seaweed resources.

The algal flora of the Maharashtra coast comprises of 94 species belonging to 51 genera and 30 families. Of these, Chlorophyta and Rhodophyta were found to be qualitatively greater in number than the other groups. Boergesen (1935) reported *Ulva reticulata* from Bombay and compared it with the original species of Forsskal. On comparison , it was observed that Indian species of *U. reticulata* has broader reticulate tissue which also agrees with the species under investigation. Thivy and Sharma (1966) reported similar species from Okha, which has narrow ribbons between the lacunae with clear geometric pattern. *Ulva reticulata* showing similar characters have been collected by the authors from Killakkarai (Tamil Nadu).

The algal flora along Karnataka coast is very poor. Agadi (1986) surveyed the Karnataka coast and recorded 61 taxa which belong to 39 genera. Among 61 species recorded, 42 are in common to Central West Coast, 7 to Maharahstra, 6 to Goa and 6 are exclusively restricted to this coast only.

The first contribution of the scientific record on the marine algal vegetation along Goa region was given by Untawale and Dhargalkar (1975). Agadi and Untawale (1978) has recorded 50 marine algal species belonging to different groups from the Goa coast of which 28 species were reported for the first time from Goa. *Ulva reticulata, Wrangelia penicillata, Pocockiella variegata, Martensia fragilis* and *Gastroclonium iyengarii* are some of the rare species occurring along the Goa coast. Jagtap (1986) reported 44 species of algae belonging to 30 genera from mangrove areas of Goa coast. Untawale *et al*., (1980) reported a new species *Dichotomosiphon salina* of family Vaucheriaceae from the brackish waters of Goa.

2.12 Seagrass Ecosystem

Worldwide, seagrass beds constitute one of the most conspicuous and coastal habitat types. Seagrass beds border much of the world's marine shoreline. There are about 50 species of seagrasses belonging to 12 genera and two families throughout the world. Hartog 1970 made the most authoritative account on the distribution of seagrasses (including the ASEAN region). Earlier studies (Santapau and Henry, 1973; Lakshamana and Rajeshwari, 1979; Jagtap and Untawale, 1981; Untawale and Jagtap, 1984; Jagtap, 1985; 1987; Parthasarathy *et al.*, 1988) provide very little information on seagrass ecosystems from other regions of the world (Hartog, 1970, 1977; Jacobs, 1982). Uku *et al.*, (1998) reported 11 species of seagrasses and 33 species of macroalgae in the Mida creek (Kenya). Among these 11 species of seagrasses *Thalassia hemprichii, Halodule wrightii* and *Cymodocea rotundata* were dominating.

In the tropics, seagrass beds are prominent features in the Indo-Pacific and the Caribbean,with the possible exception of the Indo-Pacific seagrass beds of Madagascar and the Seychelles (Kikuchi and Peres, 1973; Taylor and Lewis, 1970). Caribbean seagrass beds are apparently unique for the number and variety of organisms feeding exclusively or nearly exclusively on the grasses and their epiphytes (Kikuchi and Peres, 1973; Ogden, 1976). In Caribbean, the dominant species of seagrass is turtle grass, *Thalassia testudinum* Konig (Phillips, 1960; den Hartog, 1970). Brook 1975 noted a seasonal trend in diversity of invertebrates in a subtropical *Thalassia* bed whereas that of Heck (1977) in Panama. It is estimated that a large percentage of the *Thalassia* blade production enters the detrital food chain (Wood *et al.,* 1969).

The ecology of this temperate seagrass species had been well studied (Giraud, 1979; Bay, 1984; Libes, 1985; Frankignoulle & Bouquegneau, 1987; Meinesz *et al.*, 1988; Velimirov & Walenta-Simon, 1992, 1993; Pergent *et al.*, 1994; Romero *et al.*, 1994), but the role of macro-consumers in the recycling of *P. oceanica* production remains insufficiently investigated (Mazzella *et al.*, 1992).

Halophila decipiens is also reported to penetrate into the heavily polluted northern part of Biscayne Bay, Florida, where the sewage from Miami is discharged (Hartog, 1970). Eelgrass (*Zostera marina* L.) meadows present an ecologically important habitat along the Atlantic coast of North America (Thayer *et al.*, 1984 ; Orth *et al.*,1984), yet, for this region and elsewhere there is a paucity of information on the primary production and decomposition dynamics of this ecosystem. A comparison of ASEAN (Fortes 1989) and Indo-Pacific (Walker & Prince 1987) records shows that the maximum of 16 species have been recorded from Philippines, New Guinea, Torres straits and surrounding areas, with a fewer species in the Pacific.

Though the economic and ecological importance of seagrass meadows has been well documented (Walker & Prince 1987; Price & Coles 1992), published information for the Indian coast is scanty. The earlier studies (den Hartog, 1970; Lakshamanan & Rajeshwari 1979; Jagtap & Untawale 1981; Jagtap 1985,1987, 1991,Parthasarathy *et al.*, 1988; Ramamurthy *et al.*, 1992) document seagrass species of India along Coromandel Coast and Lakshadweep. Fourteen species of seagrasses are known from the Indian coast (Ramamurthy *et al.,* 1992; Jagtap 1992). Eleven species of seagrasses have been recorded from Gulf of Mannar, Andaman and Nicobar islands, Mumbai, Goa, Chilka lake, Nellore, Pondichery and Lakshadweep Islands (Kathiresan 1992).

The seagrass flora of India consists of 14 species and is dominated by *Thalassia hemprichii, Cymodocea serrulata, C. rotundata, Halophila ovalis, H. ovata, Halodule uninervis, H. pinifolia* and *Syringodium isoetifolium* (Jagtap 1991, Ramamurthy *et al.*, 1992). *Halophila beccarii* is exclusively confined to the intertidal swampy regions of the estuaries, while *Enhalus acoroides* has limited distribution in the brackish water regions (Jagtap, 1996).

Along the coastal waters of India 12 species of seagrasses belonging to seven genera have been observed (Jagtap,1991). *Halophila decipiens* Ostenf. is widely in the tropical part of the Indian and the Pacific Ocean as well as the Caribbean area (Parthasarathy *et al.*, 1988). It is the only seagrass of pan tropical distribution (Hartog, 1970). In India, it was earlier recorded only at Malvan, Maharashtra and Colaba in Bombay Island (Hartog, 1970), based on specimens collected by Dixit in 1928 and deposited in Kew Herbarium. Parthasarathy *et al.*, (1987) reported the occurrence of this seagrass in Tuticorin, along the southeastern tip of peninsular India, adjacent to the northwestern tip of Srilanka.

Studies of seagrass meadows from southeast coast of India have mostly dealt with their qualitative and taxonomic aspects (Lakshamanan and Rajeshwari 1985; Ramamurthy *et al.*, 1992). Jagtap 1996 studied seagrass meadows from southeast coast of India and reported *Halodule uninervis* as dominant species in the shallower depth (2-2.5m) while *Cymodocea serrulata* and *Thalassia hemprichii* dominated the deeper (2.5 to 10m) regions. The extensive seagrass beds in India exist in the Gulf of Mannar and Palk Bay, and in the lagoons of a few Lakshadweep islands (Jagtap 1991, Jagtap and Inamadar 1991). The extent of seagrass biomass in the entire Gulf of Mannar and Pak Bay is 10-25 times higher than the other major seagrass beds from India (Jagtap and Inamadar 1991).

India, earlier reported to have seven species (Fortes, 1989), in fact has much higher species richness than was previously realized. With 14 taxa from Gulf of Mannar (Ramamurthy *et al.*, 1992), the country has the second highest number of seagrasses in the Asian region. In India maximum seagrass species (14 spp.) has been reported from the Coromandel coast followed by the Andaman and Nicobar (9 spp.) and Lakshadweep (7spp.). Jagtap 1991, 1992 reported three species of seagrasses from Andaman and seven species from Nicobar Islands.

Seagrasses were found in 10 islands of Lakshadweep and not observed in Kiltan and Bitra (Kaliaperumal *et.al.,* 1989).

CHAPTER III

SOME STUDIES ON BIODIVERISTY

OF

CENTRAL WEST COAST OF INDIA

CHAPTER III
SOME STUDIES ON BIODIVERSITY ALONG THE CENTRAL WEST COAST OF INDIA

3.0 INTRODUCTION

Since the Rio de Janeiro conference in "Biodiversity Convention" the concept of biodiversity has been in the forefront of national priorities. Biodiversity refers to the variety and variability among the organisms, which includes diversity of genes, species and ecosystem corresponding to three fundamental and hierarchically related levels of biological organization (Bharadwaj and Thaker, 1997). Genetic diversity is the variation of genes within the species. This may vary from one population to another, depending upon various ecological conditions. Species diversity refers to the variety of species within the region. Species diversity can be measured as number of species in the region or species richness. Taxonomic diversity or relation of species to each other is more precise method to measure biodiversity. Ecosystem diversity is however, difficult to measure than the previous two because the boundaries of the communities or association of species and ecosystem are not very clear. There are about 30 million species of living organisms estimated on the earth. The relative abundance of species, the age and structure of populations, the pattern of communities in a region, change in the community composition, ecological processes etc are also important as expressions of biodiversity.

Marine biodiversity is known to be one of the richest among all the living ecosystems. There is rich marine biota in different parts of the ocean, from the surface to the deepest part and from the estuarine region to the offshore regions. The developed and developing countries can realize the significance of living organisms, both plants and animals on this planet. Man has been using all sorts of organisms, both plants and animals on this planet for various purposes such as food, feed, fuel, fertilizer, medicine and so on. Coastal population is largely dependent on the coastal living resources for their livelihood.

The world's biodiversity is under tremendous attack by human activities. Estimates suggest that each day, perhaps each hour, we are destroying at least one plant or animal species. Factors, which have contributed to the disruption of living systems on this planet, include ecological ignorance, survival instinct, self-aggrandizement, breakdown of traditional cultures, loss of self-reliance, international aggression and our prevailing global economic systems (Prasad, 1997). As a result of rapid industrialization it has been observed that several economically and ecological important organisms have become extinct or endangered. Some of the important components of the coastal zones are estuaries and backwaters, mangroves, corals, benthic flora and fauna.

According to the World Conservation Monitoring Centre (WCMC, 1992), the total number of species described at the global level so far is 1,604,000. However, WCMC has estimated that at the global level there are likely to be

17,980,000 species, i.e. about 11 times more than the presently known species. The increase is likely to be primarily from the tropics and sub-tropics. However, a more realistic working figure of species at the global level is around 12,250,000 (WCMC, 1992). Of the 126,188 species described from India, Monera (bacteria) comprise 850 species (0.67%), Protista (Protozoa only) 2577 species (2.04%), Fungi 23,000 species (18.23 %), Animalia 74,875 species (59.27%) and Plantae 24,886 species (19.79 %). Nearly 72 % of India's biowealth is constituted by fungi (18.23%), insects (40%) and angiosperms (13.50%) (Khoshoo, 1995) and this tallies generally with the overall trend seen in the tropics and sub-tropics. Furthermore, although India has only 2.4% of the land area of the world as a whole, according to the present estimates. India's contribution to the global biodiversity is around 8 % species (Khoshoo, 1995). Hence the study was carried along the central west coast of India.

3.1 MATERIALS AND METHODS

The present study was concentrated along the central west coast of India. Almost all the coastal areas along the central west coast, starting from Dahanu (North) to Mangalore (South) were surveyed for biodiversity (Lat $12^{0}52$'N to $19^{0}58$'N and Long $74^{0}51$'E to $72^{0}44$'E), The position of the sites is shown in Figs 3.1, 3.2, 3.3, 3.4.

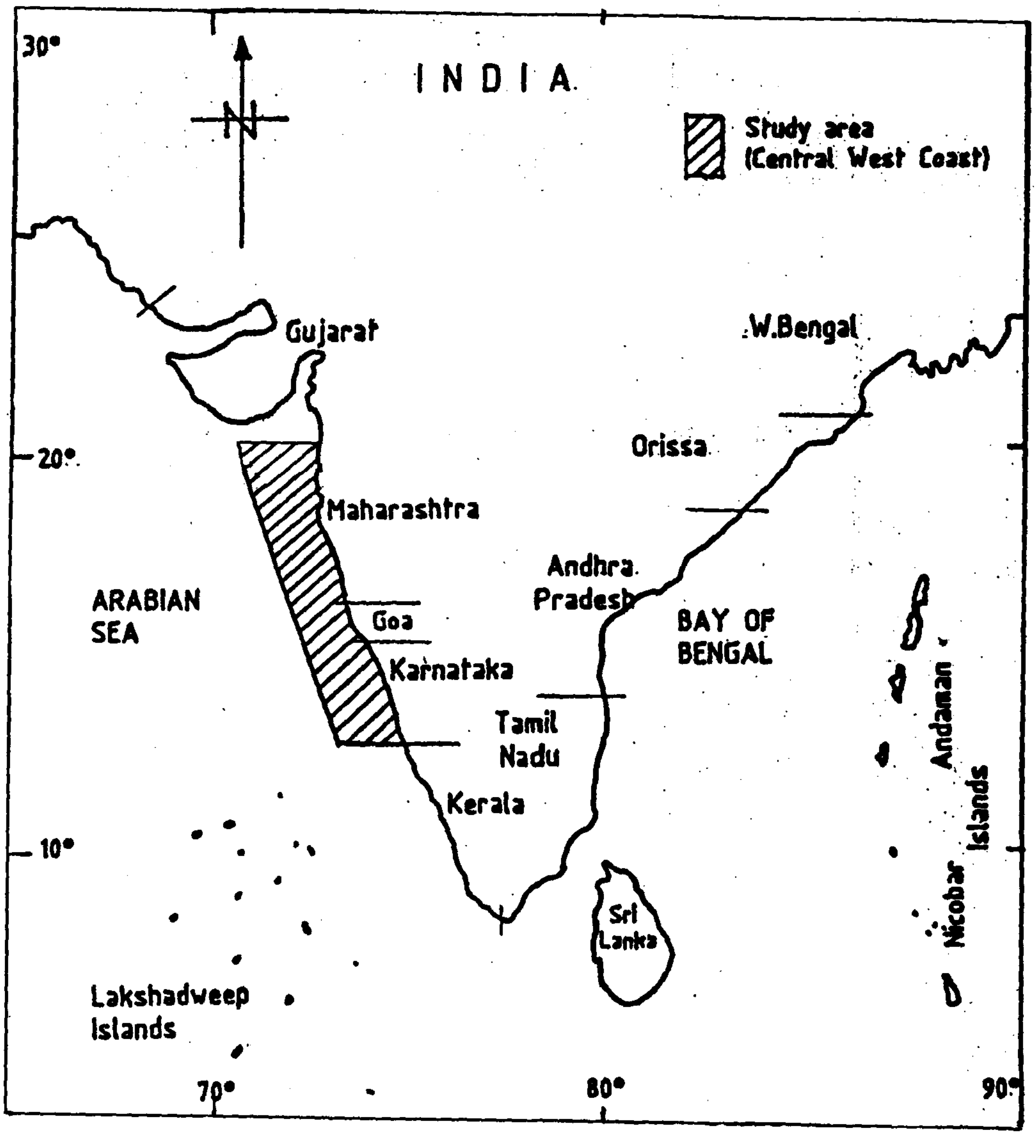


Fig. 3.1 Map of India showing study area

In the preliminary survey along the central west coast of India many localities were surveyed for the presence or absence of coastal vegetation such as mangroves, marine algae, seagrasses, sand dune, corals and their associated flora and fauna. Altogether 37 stations were surveyed along the Maharashtra coast, 26 stations along the Goa coast and 21 stations along the Karnataka coast. The general tidal amplitude along the central west coast of India is given in Table 3.1.

Observations were performed in each station on flora and fauna, the ecosystem and the industries present in that area.

3.5 DESCRIPTION OF THE STUDY AREA

3.2.1 Physiography

On the basis of geological divisions, Indo-Gangetic plains lie between Peninsular and extra-Peninsular region. The Indian peninsula is a stable mass of Archean and pre-Cambrian formations, exposed over more than half the area at present; and the rest is covered by Gondwana and later formations; and by the Deccan Lava flows (Mani, 1974). The peninsula flanked by the Arabian sea on the west and by the Bay of Bengal in the east, abuts into the vast seaboard of the Indian ocean.

Table 3.1 Average tidal amplitude along Central West Coast of India

Stations	Height in meters above Datum				
	MHHW	MLHW	MHLW	MLLW	MSL
MAHARASHTRA					
Mumbai	4.42	3.30	1.9	0.8	2.51
Srivardhan	3.11	2.84	1.46	0.73	2.02
Ratnagiri	2.26	2.13	1.19	0.52	1.52
Vijaydurg	2.13	1.94	1.12	0.36	1.37
Malvan	1.84	1.7	0.95	0.3	1.17
GOA					
Mormugao	2.02	2.20	1.40	0.70	1.60
KARNATAKA					
Karwar	1.74	1.58	0.91	0.30	1.12
Honnavar	1.76	1.55	0.99	0.44	1.19
Malpe	1.55	1.42	0.86	0.30	1.04
Mangalore	1.58	1.37	0.85	0.43	1.01

Compiled from admirality charts

3.2.2 Geology of the Indian coast

Geology of the Indian coast is varied. The coastline is flanked by a narrow coastal strip on the west coast, and by much broader area in the eastern coast. Rocky shores, mud banks, sandy beaches and coral reefs/ coral formations represent the coasts. Central west coast is primarily composed of Deccan traps and rocks of green basalt, which are glossy black and covered by calcareous surfaces. Further south along the west coast up to Cape-Camorin, Archean Gneisses, Schist and crustaceous sediments overlain by tertiary formations. Pure sandy stretches are frequent for greater or lesser distances along the entire east and west coast (Ahmed, 1972). At Lakshadweep there is compact but porous crust of limestone conglomerate, which is underlain by a bed of fine sand. Andaman and Nicobar Islands are fossiliferous consisting mainly of conglomerate, sand stones, limestones and clay.

3.3 Geological features of the Central West Coast of India

Central west coast of India in the present study is divided basically into three coast viz Maharashtra coast, Goa coast and Karnataka coast midway along the west coast of India (Lat $12^0 52'$N to $19^0 58'$N and Long $74^0 51'$E to $72^0 44'$).Each coast is been described separately. Feio (1956), Ahmed (1972), Dessai and

Peshwa (1978), Wagle (1982) studied the coastal features and discussed the various geomorphologic problems of the central west coast of India.

3.3.1 Maharashtra coast

The Maharashtra coast lies between lat. 15° 43' to 20° N and long 72° 49' to 77° 41' E (Fig 3.2). The coastline is about 560 km long and is indented by numerous river mouths, creeks, small bays, headlands, promotories, cliffs, etc. The coast is bordered to the East by the Western Ghat beyond which there is a plateau. The Maharashtra littoral corresponding to the Deccan lava is marked by highly indented coast with numerous inlets and bays alternating with headlands. There are a number of offshore islands. Henery & Kenery, Butcher, Elephanta, and several offshore islands rocky islands along the neighborhood of Bombay. Further, there are a number of rocky islands near Malvan, mostly within 2 km of the shore. Most of the other islands are small rocky projections. The bays and inlets are associated with pocket beaches. The width of the beaches (intertidal expanse) varies from a few meters to 200m. The width of the backshore beaches range from 100-600m. The North of Malvan, the most striking beach feature is the littoral concrete or beach rock. In some region the rocky beach occurs as a rim of banks enclosing marshy islands. Harihareshwar, Ratnagiri, Vijaydurg and Vengurla show the presence of high cliffs. Most of the coastal region is of Deccan lava (Ahmed, 1972) with an exception of the pocket between Vijaydurg and Vengurla, which is of recent region. It is believed that after the eruption of

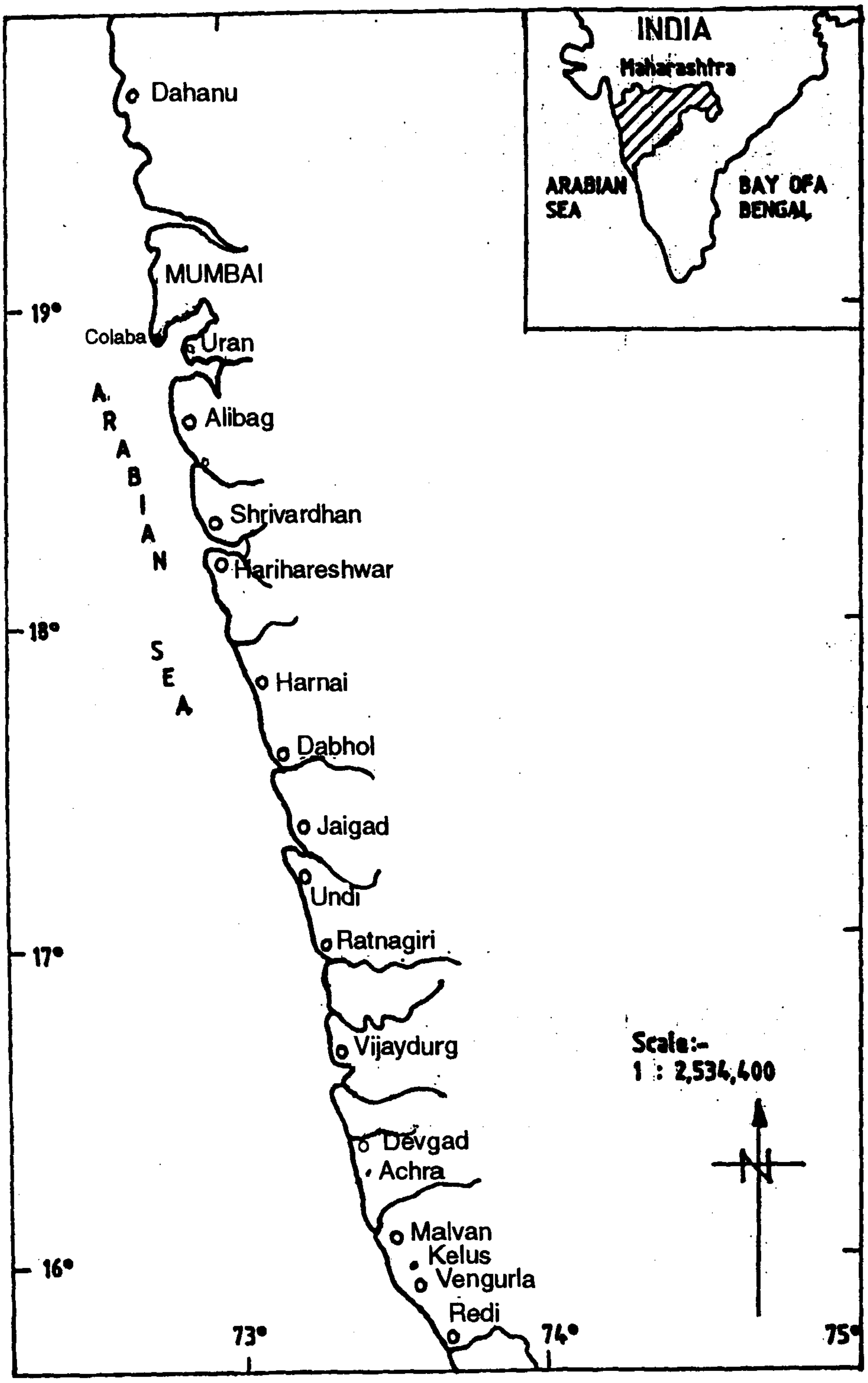


Fig. 3.2 Map of Maharashtra coast, showing the imp. stations

the Deccan volcanoes, the Bay region must have been raised which is otherwise submerged earlier. Tension fractures by failure of the volcanic rupture have formed the creeks like Thana, Mahim and Manori (Subramanyan, 1986). The lateritic beds mainly consist of rolled gravels, and cobbles of laterite with some other rock types cemented by hydrated iron oxides (Wagle,1989).

3.3.2 Goa coast

Goa coast situated along the central west coast of India lies in between latitudes 15° 48' 00" and 14° 43'54"N and longitude 74° 20'13" to 37° 40' 33" E (Fig 3.3), (Anonymous , 1979). The coastline of Goa is segmented as a result of seven rivers like Mandovi, Zuari, Chapora, Sal and others. The coast is approximately 120 km long and 60 km wide strip (in the widest area) between the Western Ghats and the Arabian sea. The coast is segmented due to estuaries, sandy beaches, cliffs, bays and creeks (Ahmed, 1972). The presence of laterite bed at a depth of 27 to 35 m is below the present sea level along the estuaries of Goa (Feio, 1956), indicates the drowned valleys (Wagle, 1982). Geologically the region is occupied by the formations of Pre-Cambrian Dharwar, Cuddapah, Upper Cretaceous to Eocene, Tertiary, sub-recent and recent. Dharwarian and Cuddapah rocks occupy a large area of Goa and the southern part of Maharashtra coast (Upto 16° 30' approx). The, phyllites and slates, quartz-chlorite-biotite schists, granites, gneisses, metabasalts and banded hematite quartizites. These

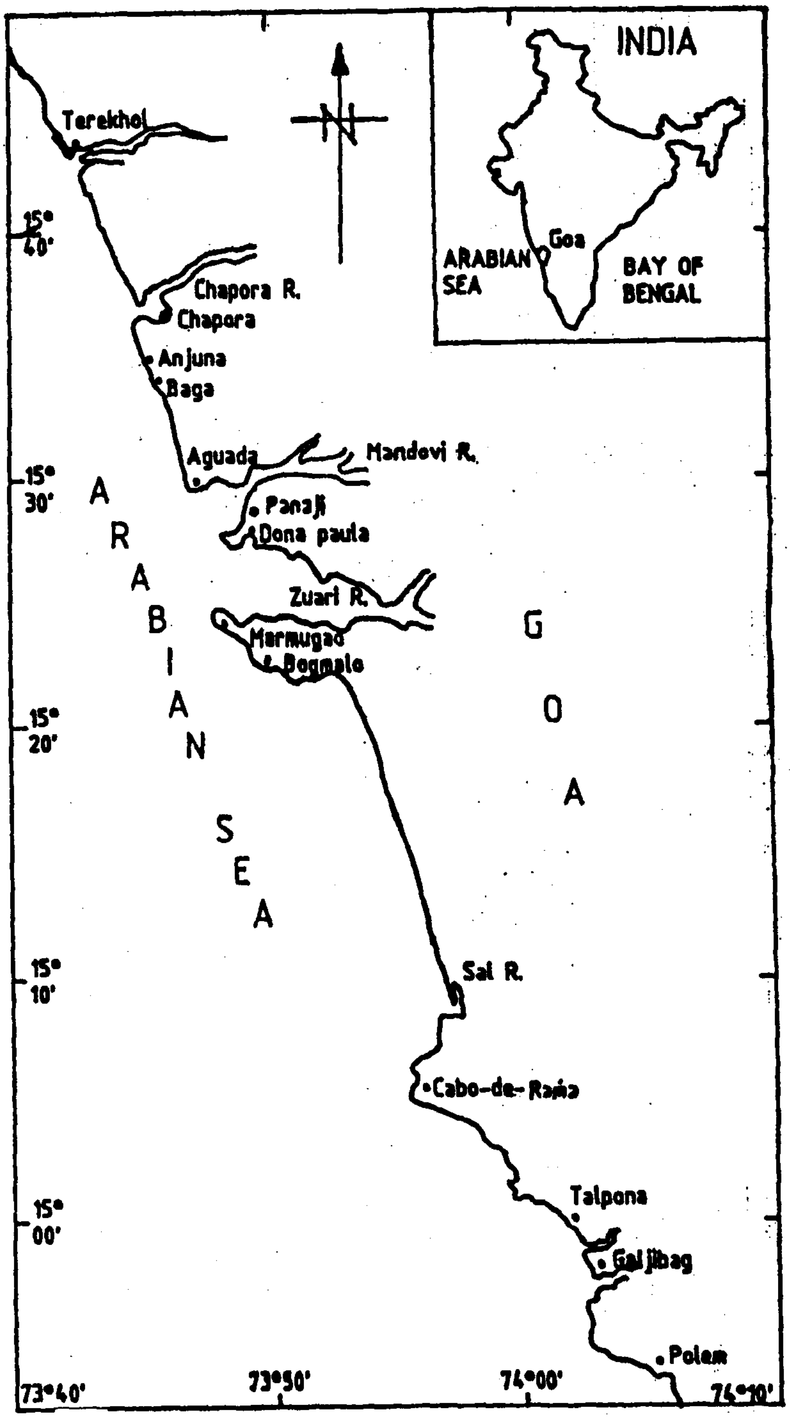


Fig.3.3 Map of Goa coast, showing the imp stations studied

unfossiliferous metasediments are profusely intruded by basic dykes (Ortel 1958).

Laterites of variable thickness (thick along the coast and thin to the interior) which are the products of extensive sub-aerial weathering under tropical conditions are found to occur capping the coastal rocks at different levels from the high plateau of the Sahyadri down up to the sea level. Laterite beds are also reported in the estuaries of Chapora, Mandovi and Zuari at 20, 27 and 34 m below the hydrographic zero (Feio, 1956) and near Ratnagiri coast 14m SSL. Beach sediments consist mainly of quartz along with feldspars and other heavy minerals. Wagle (1982) studied the coastal beaches of Goa along with its geo-morphological aspects. Fresh water runoff during the rainy season causes heavy erosion and sedimentation at the mouth regions.

Soils of the tidal flats consist of silt-sand or silt-clay with abundant organic matter. On either side of the river recent alluvial deposits are observed (Wagle, 1982). Laterite soils of Goa contain very high percentage of iron and manganese.

3.3.3 Karnataka coast

Karnataka state lies between Latitude 112° 12' N to 18° 12' N and longitude 73° 48'E to 78° 18' E (Fig 3.4). It covers a geographical area of about 1,90,4983 sq.km. This coast is about 320 km long and is overshadowed by the Western

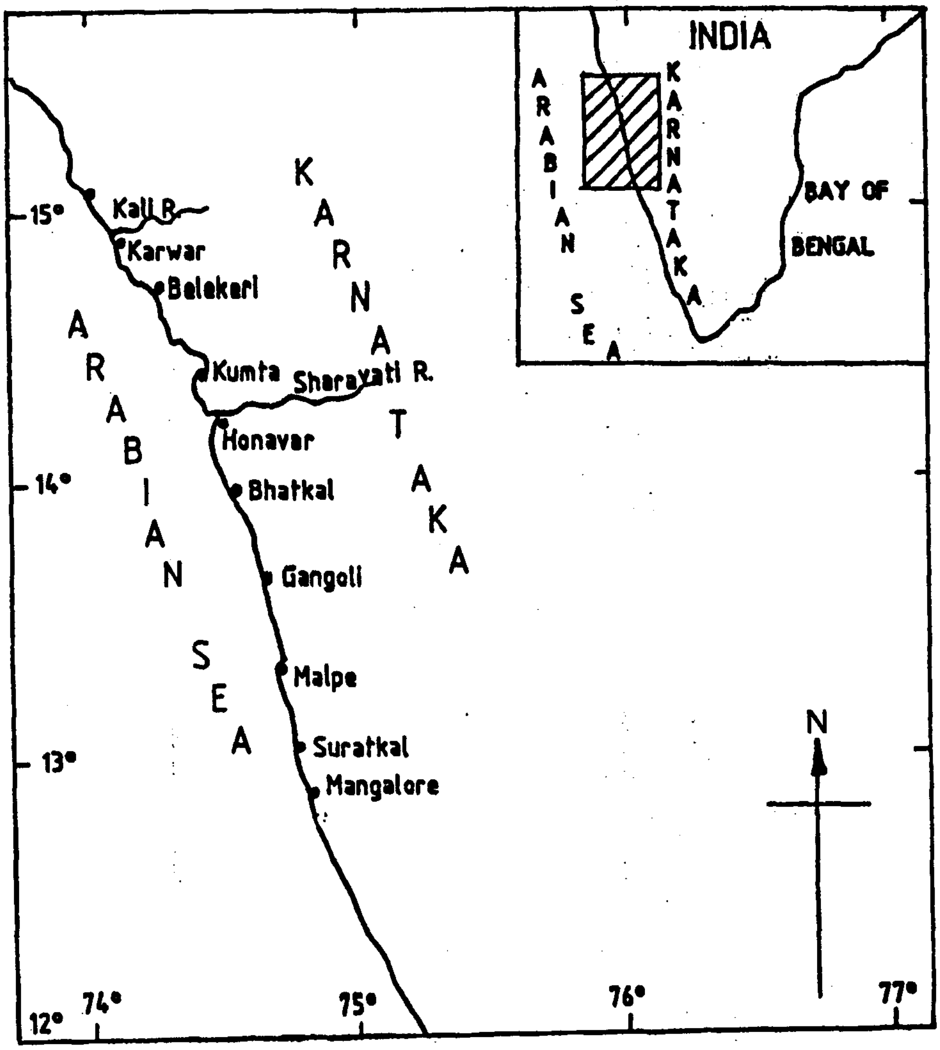


Fig. 3.4 Map of Karnataka coast showing the imp. stations

Ghats mountain range. There is a narrow strip of varying width between the mountain and the Arabian sea, the average width being about 20 km. The major rivers are that of Kali, Sharavati, Gurpur, Kollur and Netravati. The coast is lined with sandy and occasionally rocky shores.

Northern coast (Uttar Kannada) is essentially highland and the real lowland is restricted to pockets, along the lower course of the rivers, that break the ghats (Mani, 1974). The southern side (Dakshin Kannada) is an embayment of lowland. The alluvium is broken by ridges and isolated hills of Archean gneisses and granites (Mani, 1974). Near Karwar, the coastal shelf steepens near the shore, so that 5m contour is occasionally at the shore near promontories and cliffs.

Between Karwar and Mangalore, there are many small rocky islands and submarine banks (Ahmed, 1972), eg. – Pigeon Island near Bhatkal (16 km offshore), St. Mary's Island near Malpe. Many such islands are also off Karwar coast. These tiny islands are rocky and fairly dissected, and some islands are about 70m high. The southern Karnataka coast is of emergent shoreline (Ahmed, 1972) and is mostly with sandy beaches interspersed with some rock and boulders.

3.4 Oceanographic features

Morphologically the Indian ocean is land locked in the northern boundary, and does not exceed to the temperate regions of the northern hemisphere (Wyrtki, 1973).

Tides: Tidal fluctuation occurs along the Indian coast. It is observed that, tide level fluctuations along the east coast of India are lower than that along the west coast (Srinivasan, 1960). The tidal amplitude varies from place to place along the central west coast of India. The tidal range was more along the northern Maharashtra and then lowers gradually towards the southern latitudes. The tidal level for some selected stations are given in Table 3.1.

Climatology: In general the climate shows typical of monsoon region of cool and dry season with low intensity with north-easterly winds from the land (Nov-Feb) and hot dry season from March-May followed by rainy season (June-Sept). The west coast of India receives rains from southwest monsoon. The maximum precipitation is received during July and August.

The relative humidity varies from 70% to 90% throughout the year with its peak during the monsoon months. The mean wind speed remains almost constant between 13-17 km/h, throughout the year except for June to August.

Hydrology: Hydrological parameters such as pH, salinity and water temperature of Malvan, which is dealt, is given in separate chapter in the form of figures. These parameters play very important role as they directly affect the coastal vegetation.

Turbidity: Turbidity in the sea is due to the currents and in some cases due to high biological productivity (resulting in blooms). The water from Dahanu to Mumbai, Alibag, Redi, Chapora, Dona-Paula and Mangalore were observed to be highly turbid. Due to regular dredging activities and navigation in harbour and also due to the flow from the creeks (Thana, Karanja and Amba) the turbidity around Mumbai area was maximum (Agadi, 1986).

Coastal pollution: The estuaries and the coastal areas are threatened due to pollution activities. The industrial effluents, sewage and other human interferences are the major factors that leads to pollution. About 34000 tonnes of pesticides and insecticides, and 110000 tonnes of synthethic detergents are annually, and 25% of these find their way into the marine environment (Sen Gupta, 1978). Studies carried out by Zingde *et al.*, (1979) assessed the waste water discharge along the Mumbai coast. The effluent discharge along Ulhas river, North east of Mumbai area has been monitored by Sahu & Mukherjee, (1983), which shows a combined annual discharge of 100 kg of Cu, $4x10^5$ kg Zn, 7000 kg Hg, and 500 kg Cr from chemical, leather and paper industries, and 35000 kg of suspended solids into the Waldhuni tributary. Besides, Mumbai, there is not much of pollution along the Maharashtra coast except for the domestic wastes discharge along different coastal townships (Plate 1a). Goa and Karnataka coast are almost pollution free, as compared to the Mumbai areas, excepts for some sewage wastes.

Besides the above, moderate effect of oil pollution is also evident along central west coasts. Sen Gupta, (1978) observed a substantial amount of oil spill in the Arabian sea which is mainly due to the transportation of crude oils and shipping activity.

3.5 RESULTS

3.5.1 MAHARASHTRA COAST

Along the Maharashtra coast 37 sites starting from Dahanu upto Vengurla Rock Island were surveyed for the presence and absence of coastal vegetation. The sites surveyed along this coast and their importance is given in Table 3.2. List of coastal vegetation recorded from this coast are given in Tables 3.3, 3.4, 3.5. Based on the study carried out among the 37 sites surveyed only seven sites were studied further (Table 3.6).

Table 3.2 Sites surveyed along the Maharashtra coast and their importance

Sr.No	Name of the sites	Importance of the sites
1	Dahanu	♦ Fishing village ♦ Stunted growth of mangroves ♦ 14 marine algal species recorded
2	Vaitarna	♦ Mangrove forest ♦ Six mangrove species recorded
3	Vasai	♦ 23% area under mangrove coverage ♦ Stunted growth of mangroves
4	Manori	♦ Mangrove forest ♦ Deforestation activities ♦ Entire area threatened for reclamation
5	Colaba	♦ Highly diversified flora and fauna ♦ Total 63 marine algal species recorded including few rare species ♦ Rich biomass ♦ Rich fauna ♦ Presence of corals in the intertidal region
6	Diva	♦ Monospecific mangrove forest (*Sonneratia apetala)* ♦ Sanctuary for terrestrial and avifaunal species
7	Vikroli	♦ Well preserved mangrove forests ♦ Sanctuary for various terrestrial and avifaunal species ♦ Privately owned and conserved ♦ Interpretation centre established ♦ Nursery for afforestation studies
8	Thane	♦ Mangrove forest ♦ Stunted growth of mangrove ♦ Degradation activities ♦ Polluted creek
9	Uran	♦ Open coast ecosystem ♦ Destruction to flora and fauna ♦ Red algae dominating
10	Uran (Dharamtar creek)	♦ 34 marine algal species recorded

		♦ Benthic fauna ♦ Well preserved mangrove forests ♦ Sanctuary for various terrestrial and avifaunal species
11	Thal	♦ 35 algal species recorded ♦ Red algae dominating ♦ Bunding of area by local fishermen
12	Alibag: Versoli-Chalmala creek	♦ Sandy beach with rocky area ♦ Patchy growth of mangroves ♦ Diversified wild life ♦ Sea turtles nesting place
13	Revdanda: Kundalika river	♦ Well preserved mangrove forest ♦ Sanctuary for various terrestrial and avifaunal species ♦ Fishing area
14	Murud: Fort area	♦ Sandy beach ♦ Few algal species recorded
15	Murud: Rajapuri creek	♦ 7 mangrove species recorded with 3 associates ♦ 4 marine algal species recorded
16	Srivardhan creek	♦ 100 ha mangrove area ♦ Rich in clam fishery
17	Srivardhan	♦ 15 algal species recorded ♦ Fishing activities seen
18	Anjarle: Jog river	♦ Well preserved mangrove forest ♦ Traditional fishing common
19	Harne	♦ 34 marine algal species recorded ♦ Rare alga *Martensia* sp. recorded ♦ Intertidal fauna poor
20	Dabhol jetty	♦ 34 marine algal species recorded ♦ Benthic fauna Mangrove Nursery already exist
21	Veldur (Dabhol): Vashisthi river	♦ Sand dune vegetation present ♦ Dense mangroves ♦ Rich bird fauna
22	Nandivada (Jaigadh)	♦ Sand dune vegetation ♦ Marine algal species present
23	Ratnagiri (Shirgaon creek)	♦ Well preserved mangrove forest ♦ 121 bird species present in mangrove area ♦ Sanctuary for various terrestrial

		and avifaunal species ♦ Diversified fauna ♦ Rich fishing area
24	Ratnagiri	♦ 56 marine algal species recorded ♦ Diversified fauna
25	Pawas	♦ Patchy growth of mangroves ♦ Reclaimed for developmental purposes
26	Purangadh	♦ Rich avifauna ♦ Good mangrove cover
27	Jaitapur	♦ Well preserved mangrove forest ♦ Sanctuary for terrestrial and avifaunal species ♦ Sand dune vegetation ♦ Rich wild life
28	Vijaydurg (Vaghotan river)	♦ Well preserved mangrove forest ♦ Sanctuary for terrestrial and avifaunal species
29	Vijaydurg	♦ 20 marine algal species recorded with irregular and patchy ♦ Open shore and estuarine fishery common
30	Deogadh	♦ Well preserved mangrove forest ♦ Sanctuary for terrestrial and avifaunal species
31	Achara	♦ Well preserved mangrove forest ♦ Sanctuary for terrestrial and avifaunal species ♦ Sand dune vegetation ♦ Nursery of mangrove already exists ♦ Minimum destruction to mangrove forest
32	Kolamb	♦ Mangrove area ♦ 2 marine algal species recorded ♦ Destruction of mangroves for firewood
33	Kavdya Dongar	♦ 14 marine algal species recorded ♦ Sea cucumber and Sea Urchin common ♦ Bird nesting area
34	Malvan	♦ Naturally protected site ♦ Total 73 marine algal species are

		found ♦ Rich algal biomass ♦ Rich in marine fauna ♦ Rich in subtidal flora and fauna ♦ Presence of corals and gargoniums ♦ Turtle nesting behind the fort
35	Kelus	♦ Fringing mangroves ♦ Mangrove density poor
36	Vengurla Rocks	♦ Rich subtidal flora and fauna ♦ Good site for ornamental fishes ♦ Site can be used for eco-tourism
37	Vengurla	♦ Mangrove vegetation of moderate growth ♦ Open coast sandy ♦ A rare species *Champia parvula* recorded ♦ Sea anemone common

Table 3.3 Systematic list of mangroves recorded along the central west coast of India

	Maharashtra	Goa	Karnataka
Family : Acanthaceae			
Acanthus ilicifolius L.	+	+	+
Family : Sonneratiaceae			
Sonneratia caseolaris (L.) Engl.	+	+	+
Sonneratia alba J. Smith.	+	+	+
Sonneratia apetala Buch. Ham.	+	-	-
Family : Rhizophoraceae			
Kandelia candel (L.) Druce.	+	+	+
Rhizophora mucronata Lamk.	+	+	+
Rhizophora apiculata BL.	+	+	+
Bruguiera cylindrica (Linn.) Bl.	+	-	-
Bruguiera gymnorhiza Linn.	+	+	+
Ceriops tagal (Perr.) C.E. Robin.	+	+	+
Family : Verbenaceae			
Clerodendrum inerme Gaertn.	+	+	+
Avicennia officinalis Linn.	+	+	+
Avicennia marina (Forsk.) Vierh.	+	+	+
Family : Euphorbiaceae			
Exocoecaria agallocha Linn.	+	+	+
Family : Myrsinaceae			
Aegiceros corniculatum (L.) Blanco.	+	+	+
Family : Fabaceae			
Derris heterophylla Lour.	+	+	-
Derris trifoliata Lour.	-	-	+
Family : Combretaceae			
Lumnitzera racemosa Willd.	+	-	+
Family : Pteridaceae			
Acrostichum aureum L.	+	+	+
Family : Chenopodiaceae			
Sueada maritima	+	-	-
Sesuvium portulacastrum	+		
Salicornia bracheata	+	-	-
Family : Salvadoraceae			
Salvodora persica.L.	+	-	-
Family : Poaceae			
Portresia coarctata	+	+	+

Table 3.4 Systematic list of marine algae recorded along the Central west coast of India

	Maharashtra	Goa	Karnataka
Division : Chlorophyta **Class : Chlorophyceae** **Order : Ulvales** **Family : Ulvaceae**			
Ulva fasciata Delile	+	+	+
Ulva reticulata Forsskal	+	+	+
Ulva lactuca L.	+	+	+
Enteromorpha tubulosa Kuetz.	+	-	-
Enteromorpha flexousa (Wulfen) J.Ag.	+	+	+
Enteromorpha clathrata (Roth.) J.Ag.	+	+	+
Enteromorpha intestinalis (L.) Link.	+	+	+
Monostroma oxyspermum (Kuetz.) Doty.	+	+	+
Order : Cladophorales **Family : Cladophoraceae**			
Chaetomorpha media (C.Ag.) Kutz.	+	+	+
Chaetomorpha linum (Muller) Kutz.	+	+	+
Cladophora fascicularis (Mertens) Kuetz.	+	+	+
Cladophora prolifera (Roth.) Kutz.	-	-	+
Order : Siphonales **Family : Caulerpaceae**			
Caulerpa verticillata J. Ag.	+	+	-
Caulerpa sertularioides (Gmelin.) Howe.	+	+	+
Caulerpa racemosa (Forssk) J.Ag.	+	+	+
Caulerpa scalpelliformis (R.Br.) Web. V. Bose.	+	+	+
Caulerpa peltata Lamour.	+	+	+
Caulerpa sp.		-	-
Family : Protosiphonaceae			
Bryopsis plumosa (Huds.) C. Ag.	+	+	+
Bryopsis hypnoides Lamour.	+	-	-
Family : Codiaceae			
Arainvillea sp.	+	+	+
Codium indicum Dixit.	+	-	-
Family : Valoinaceae			
Valonia aegagropila C. Ag.	+	-	-
Boodlea composita (Harv. Et Hook. F.) Brand.	+	-	-

Microdictyon tenuis (Ag.) Decsne	+	+	-
Struvea anastomosans (Harv.) Piccone	+	+	+
Ernodesmis verticillata (Kutz.) Boergs.	+	-	+
Dascycladaceae			
Acetabularia sp	+	-	-
Division : Phaeophyta **Class : Phaeophyceae** **Order : Ectocarpales** **Family : Ectocarpaceae**			
Ectocarpus conigera Boergs.	+	-	+
Giffordia mitchellae (Harv.) Hamel	+	-	+
Order : Sphacelariales **Family : Sphacelariaceae**			
Sphacelaria furcigera Kuetzing.	+	+	+
Family : Ralfsiaceae			
Ralfsia expansa C.Ag.	+	+	+
Order : Dictyotales **Family : Dictyotaceae**			
Dilophus fasciola	+	-	+
Dictyota dichotoma (Huds.) Lamour	+	+	+
Dictyota bartsyresiana Lamour.	-	+	+
Dictyota atomaria Hauck.	+	-	-
Padina gymnospora (Kutz.) Vickers	+	-	+
Padina tetrastromatica Hauck.	+	+	+
Stoechospermum marginatum (C.Ag.) Kutz.	+	+	+
Spatoglossum asperum J. Ag.	+	+	+
Dictyopteris australis Sonder	+	+	-
Lobophora variegata	+	-	+
Order : Dictyosiphonales **Family : Punctariaceae**	+		
Colpomenia sinuosa (Roth) Derb. et. Sol.	+	+	-
Order : Fucales **Family : Sagassaceae**			
Sargassum swartzii (Turn.) C. Ag.	+	-	-
Sargassum cinereum J.Ag.	+	+	+
Sargassum ilicifolium (Turn.) C. Ag.	+	+	+
Sargassum johnstonii Setchell & Gardner.	+	-	-
Sargassum tenerrimum J. Ag.	+	+	+
Sargassum wightii Greville.	-	-	+
Division : Rhodophyta **Class : Bangiophyceae**			

Order : Erthropelitidales **Family :Erythropelidaceae**			
Erythrocladia sp.	+	+	+
Rhodochorton sp.	+	+	+
Order : Bangiales **Family : Bangiaceae**			
*Porphyra vietnamensis*Tanaka. Et. Ho.	+	+	+
Bangia fuscopurpurea (Dillw.) Lyngbye	+	-	+
Class : Florideophyceae **Order : Nemalionales** **Family : Chaetanginaceae**			
Galaxuara sp.	+	-	-
Scinaia hatei Boergs.	+	-	-
Order : Cryptonemiales **Family : Grateloupiaceae**			
Grateloupia lithophila Boergs.	+	+	+
Grateloupia indica Boergs.	+	-	+
Grateloupia filicina (Wulf.) C. Ag.	-	+	-
Family : Corallinaceae			
Melobesia farinosa Lamour.	+	+	+
Amphiroa fragilissima (L.) Lamour.	+	-	-
Jania adherens Lamour.	+	+	+
Cheilosporum spectabile Harv.	+	+	+
Lithophyllum sp.	+	+	-
Family : Grateloupiaceae			
Halymenia sp.	+	-	+
Order : Gelidiales **Family : Gelidiaceae**			
Gelidium pusillum (Staxk.) Le Jolis.	+	+	+
Gelidium micropterum Kutz.	+	+	+
Order : Gigartinales **Family : Gracilariaceae**			
Gelidiopsis variabilis (Grev.) Schmitz.	+	+	+
Gracilaria corticata J. Ag.	+	+	+
Gracilaria verrucosa (Huds.) Papenf.	+	+	-
Gracilaria prolifera	-	+	-
Gracilaria sp.	+	-	-
Family : Sphaerococeaceae			
Caulocanthus sp.	+	-	-
Family : Solieriaceae			
Sarconema filiformae (Sond.) Kylin.	+	-	-
Soliera robusta (Grev.) Kylin.	+	+	-
Family : Hypneaceae			
Hypnea valentiae (Turn.) Mont.	+	+	+

Hypnea musciformis (Wulf.) Lamour.	+	+	+
Hypnea cervicornis J. Ag.	+	+	+
Ahnfeltia plicata	+	+	+
Family : Rhabdoniaceae			
Catnella repens (Lightfoot) Batters.	+	-	-
Order : Rhodymeniales **Family : Lomentariaceae**			
Champia parvula (C.Ag.) Harv.	+	+	+
Gastroclonium sp.	+		-
Family : Rhodymeniaceae			
Rhodymenia palmata	+	-	+
Order : Ceramiales **Family : Ceramiaceae**			
Ceramium fastigiatum (Roth.) Harv.	+	+	+
Ceramium sp.	+	-	-
Spyridia fusiformis Boergs.	+	-	-
Centroceros clavalatum (C.Ag.) Mont.	+	+	+
Family : Rhodomelaceae			
Laurencia obtusa (Huds.) Lamour.	-	+	+
Laurencia papillosa (Forssk.) Grev.	+	-	+
Laurencia majiscula	+	-	-
Chondria arnata (Kuetz.)	+	+	+
Chondria tenuissima Good et. Wood) C. Ag.	+	-	-
Bostrychia tenella (Vahl.) J. Ag.	+	+	-
Polysiphonia polycarpa	+	+	+
Polysiphonia variegata (Ag.) Zanardini	+	+	+
Acanthophora spicifera (Vahl.) Boergs.	−	+	+
Family : Delesseriaceae			
Martensia fragilis Harvey.	+	-	-
Caloglossa lepureurii (Mont.) J. Ag.	+	+	-
Family : Dasyaceae			
Dasya sp.	+	-	-

+ = Present, - = Absent

Table 3.5 List of sand dune vegetation along the Maharashtra coast

Family	Name of the species
Malvaceae	*Abutilon indicum*
Malvaceae	*Sida acuta*
Malvaceae	*Thespesia populnea*
Meliaceae	*Melia azadarach*
Capparadiaceae	*Cleome viscosa*
Bombacaceae	*Salmalia malabarica*
Convolvulaceae	*Ipomoea pes caprae*
Nyctagenaceae	*Boerhaavia difusa*
Casuarinaceae	*Casuarina equisitifolia*
Fabaceae	*Tephrosia purpurea*
Fabaceae	*Aeschynomene indica*
Fabaceae	*Gliricidia sepium*
Caesalpiniaceae	*Cassia siamea*
Caesalpinaceae	*Delonix regia*
Verbenaceae	*Lantana camara*
Momocaceae	*Acacia auriculiformis*
Rhamnaceae	*Zizyphus jujuba*
Urticaceae	*Trema orientalis*
Euphorbiaceae	*Jaatropa curcas*
Euphorbiaceae	*Ricinus communis*
Moraceae	*Ficus hispida*
Verbenaceae	*Vitex negundo*
Poaceae	*Spinifex littoreus*
Cyperaceae	*Cyperus* sp.

Table 3.6 Stations identified as ecologically sensitive areas for studies

Stations		
Maharashtra	**Goa**	**Karnataka**
Colaba	Terekhol	Kalinadi estuarine complex
Mumbra-Diva	Chapora	Sharavathi estuarine complex
Vikroli	Anjuna-Baga	The Chakra-Haladi-Kollur estuarine complex
Ratnagiri	Mandovi	Malpe islands
Vijaydurg-Deogadh-Achra	Dona-Paula	
Malvan	Cabo-de-Rama	
Vengurla Rock Islands		

3.5.1.1 Colaba

Colaba is towards the southern most tip of Mumbai, lies between Lat. 18°52'50" to 18° 55'00"N and Long. 72° 47'40" to 72° 49'52"E (Fig 3.5). It lies towards the lighthouse more particularly towards the western side. Although, this area is close to the city limit and despite Mumbai coast being one of the most polluted coasts, exhibits a diversified and most luxuriant flora and fauna. The site lies in a restricted area of Naval establishment and Tata Institute of Fundamental Research. The shoreline is a gradual slope with few immerging rocks. The intertidal expanse runs into few kilometers exposing vast area during the low tide. There are several tidal pools with sandy bottom providing ideal environment for marine organisms. Colaba is a sheltered boulder beach, facing NW and lying in a small, shallow bay. It is bordered by a sea-wall parallel to the shore and act as a breakwater and provides considerable shelter from the waves. Colaba reef, present at the entrance also diminishes the wave-action. The rocks extend down only to the level of MLWS, below which the bottom of the bay consists of soft, clay mud. The bay gets exposed during the lowest spring tides.

Totally 64 marine algal species were recorded during this observation (Table 3.13). The most common genus was *Caulerpa* (Plate 2a). Six species belonging to this genus including one rare species *C. verticillata* were recorded. Out of 64 species found, majority belonged to 31 red algae followed by 19 green algae and 15 brown algal species (Table 3.13). In supra littoral zone, blue green alga,

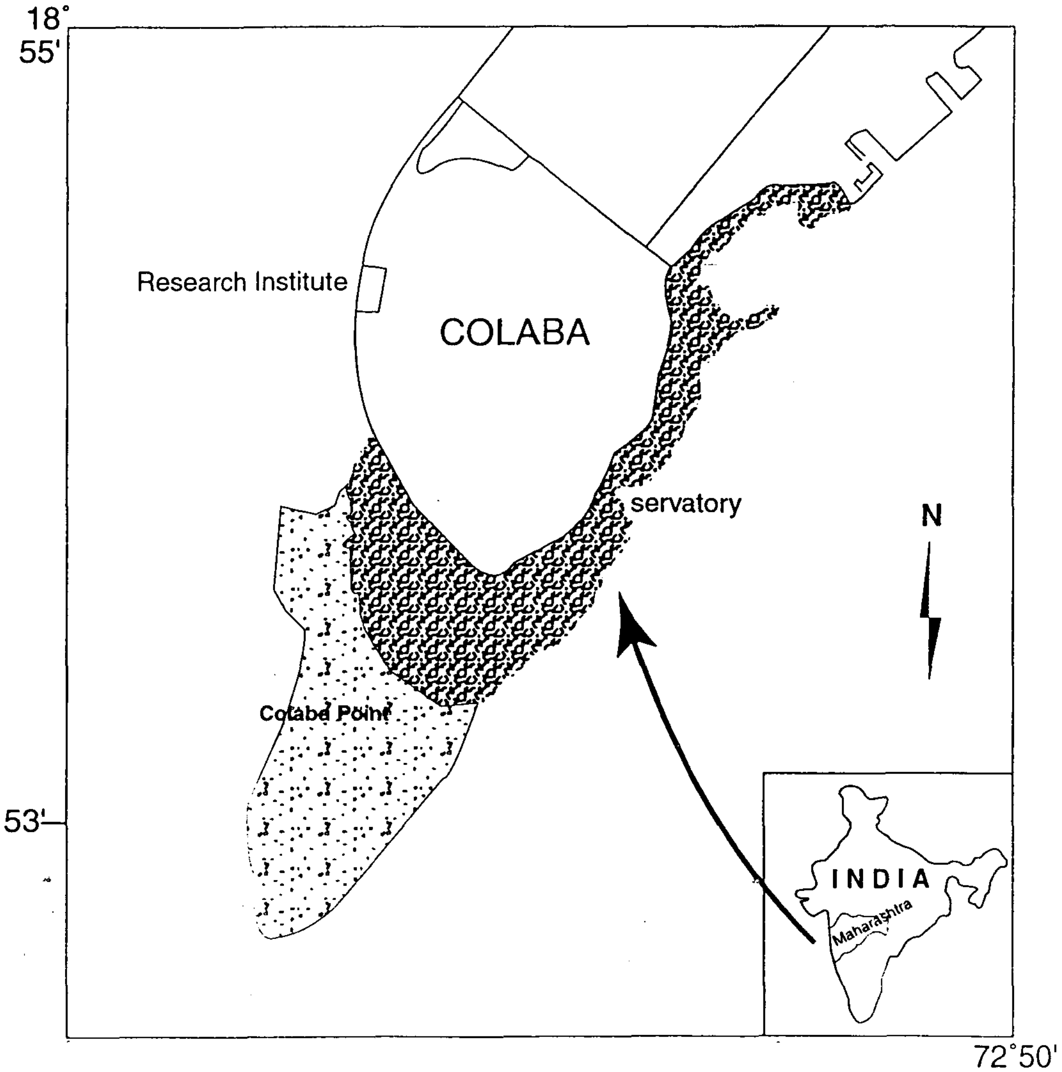


Fig.3.5 Map of Colaba, Mumbai showing rocky area

namely *Microcoleus* was most dominating. Earlier workers (Untawale *et al.*, 1979; Khadilkar, 1988) did not record some species such as *Gastroclonium, Champia etc.* The flora showed more similarities to that of Gujarat (Kuchchh area) coast.

The biomass was also recorded by using 0.25 m^2 quadrant. The average biomass estimated was 0.430 kg m^{-2}. Maximum biomass belonged to *Caulerpa* sp. followed by *Hypnea valentie*. Large numbers of invertebrate species were observed in the intertidal region associated with marine algae (Plate 2b). Most of the boulders and rocks were covered with oysters. Trochids are often found near the base of the boulder. It may be noted that the beach is very irregular and hence the zonation is not always very clear. The proximity of sand and mud and their deposition on the rocks also limits the distribution of many forms. Many forms, which could have otherwise existed at higher or lower levels than at which they are found, are prevented from doing so by the intervening sand or mud and by the absence of suitable substratum at that levels. Despite the nature of the shore, the following four zones can still be recognized at Colaba. They are (1) Littorinid, (2) Balanus Zone, (3) Oyster Zone, and (4) Trochid Zone.

List of the commonly occurring faunal species is presented in Table 3.7. In all four species of corals including soft corals were observed in this area. The Coral polyps were long and healthy (Plate 1b). This area was dominated by a coral species *Goniopora stokesi* that seemed to have developed adaptation mechanism

Plate 1a: Coastal pollution along the Maharashtra coast

Plate 1b: Coral polyps in the intertidal region of Colaba, Mumbai

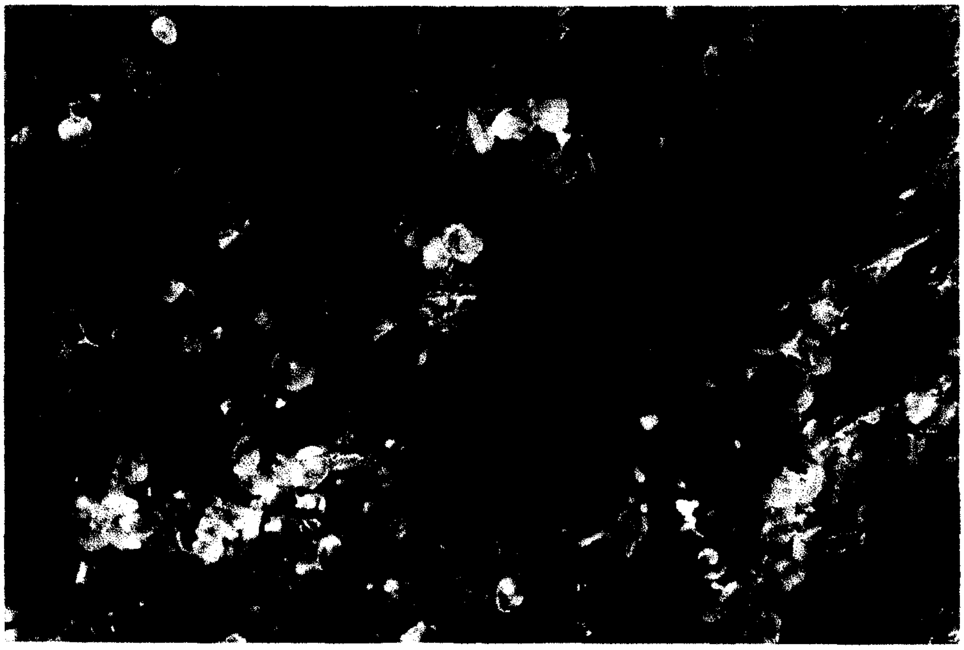


Plate 2a: *Caulerpa racemosa* intertidal region of Colaba, Mumbai

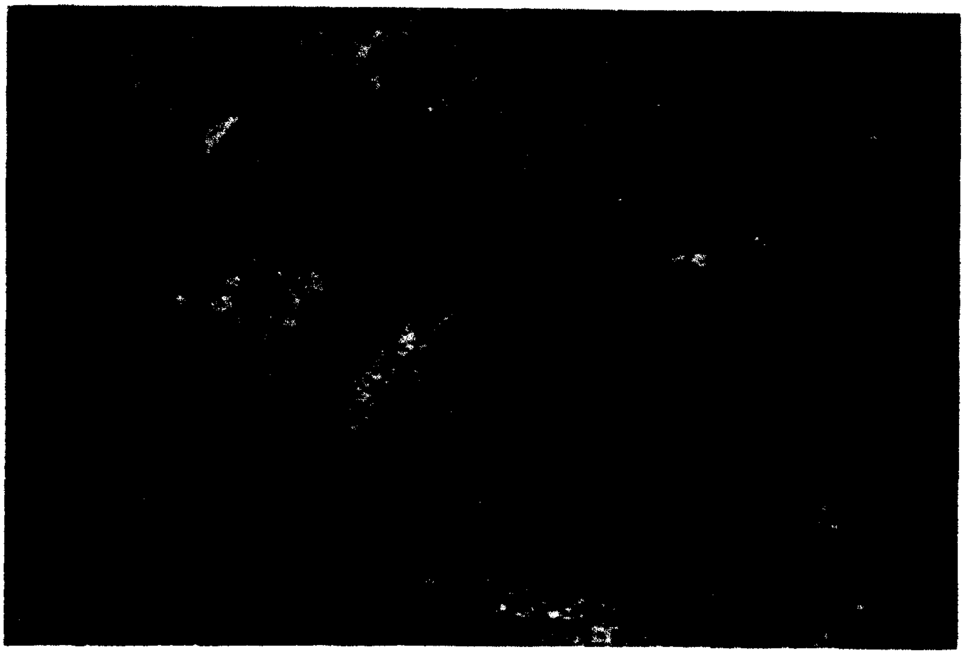


Plate 2b: An association of different marine algal species and the zooxanthallae

Table 3.7 Commonly occurring macrofaunal species in the intertidal zones of Colaba, Mumbai, Maharashtra

Type of Zones			
Litttorinid Zone	**Balanus Zone**	**Oyster Zone**	**Trochid Zone**
Littorina intermedia	*Balanus amphitrite*	*Crassostrea cuculata*	*Calliostoma scobinatum*
Littorina ventricosa	*Crassostrea cuculata*	*Planaxis sulcatus*	*Oncidium verraculatum*
Littorina subgramosa	*Neritina pulchella*	*Aplysia cornigera*	*Cerithium rubus*
Tectarinus malaccanus	*Onuphis* sp.	*Bursa tuberculata*	*Cellana radiata*
Ligia exotica	*Coecolin transversalis*	*Potamides cingulatus*	*Aplysia cornigera*
Balanus amphitrite	*Anthopleura* sp.	*Boleopthgalmus* sp..	*Bursa tuberculata*
Planaxis sulcatus	*Planaxis sulcatus*	*Gelasimus annulipes*	*Pisodonophis bore*
Neritina pulchella		*Gelasimus mariones*	*Ophiactis savignyi*
		Nereid sp.	*Crassostrea cuculata*
		Glycera sp.	*Trochus radiatus*
		Ozius rugulosus	*Clanculus depictus*
		Leptodius crassimanus	*Eluchelus asper*
		Lytocheria angustifrons	*Eluchelus indicus*
		Netograpsus messor	*Eluchelus tricarinatus*
		Trapezium vellicatum	*Gibbula swainsonii*
		Ibla cumingi	*Lithophaga cinnamomea*
		Calliostoma scobinatum	*Tethya lybcurium*
		Oncidium verraculatum	*Seila bandorensis*
		Cerithium rubus	*Scutus unguis*
		Cellana radiata	*Cyprea pallida*
		Pisodonophis bore	*Astrea stellata*
		Ophiactis savignyi	*Pterolisthes boscii*
			Dedrostomum signifer
			Harmothoe ampullifera
			Trapezium vellicatum
			Ibla cumingi

to survive in turbid conditions. Other common faunal species recorded were; sea anemone, sea cucumber, annelid worms, shrimps, amphipods, isopods, brittle stars, zooanthus colonies, etc. This site is with minimum human pressure because of it lies behind Tata Institute of Foundation Research (TIFR) where no one is allowed to enter. The range of physico-chemical parameters is given in Table 3.8.

This is perhaps one of the important site with minimum human pressure.

3.5.1.2 Mumbra-Diva

Towards eastern side of Thane lies Mumbra-Diva site (Lat 19 ° 05'N and Long 72° 59'E) (Fig 3.6). Well-preserved mangrove patch exists in otherwise polluted area. The dominating species is *Sonneratia apetala* with average height of 10-15 m. Other species observed *are A. officinalis, Aegiceras corniculatum, E. agallocha* and *A. ilicifolius* (Table 3.14). This patch supports good mangrove vegetation with high human impact as compared to the other areas of Mumbai. (Fig 3.6). This area is considered to be monospecific.

This creek is polluted due to industrial and domestic pollution. As a result of this high level pollution, the water quality has changed leading to the poor growth of the flora and fauna. There was rapid degradation of mangroves in this creek. There is lot of pressure from the local population for firewood and

Table 3.8 Range of environmental parameters (1997 -98) at Ratnagiri and Colaba (Maharashtra)

Parameters	Ratnagiri	Colaba
Temperature (°C)	23.7-27.8	26.9-27.0
Suspended solids (mg/l)	25.0-23.0	31.0-33.0
pH	7.6-8.4	7.8-8.2
Dissolved oxygen (ml/l)	3.8-4.5	5.8-6.3
Salinity (PSU)	29.96-33.1	30.2-35.2
PO_4-P (µmol/l)	0.24-0.9	3.9-6.8
NO_3-N (µmol/l)	1.0-3.73	1.2-5.7
NO_2-N (µmol/l)	0.1-0.3	0.3-1.9
NH_4-N (µmol/l)	0.8-1.1	0.1-1.61

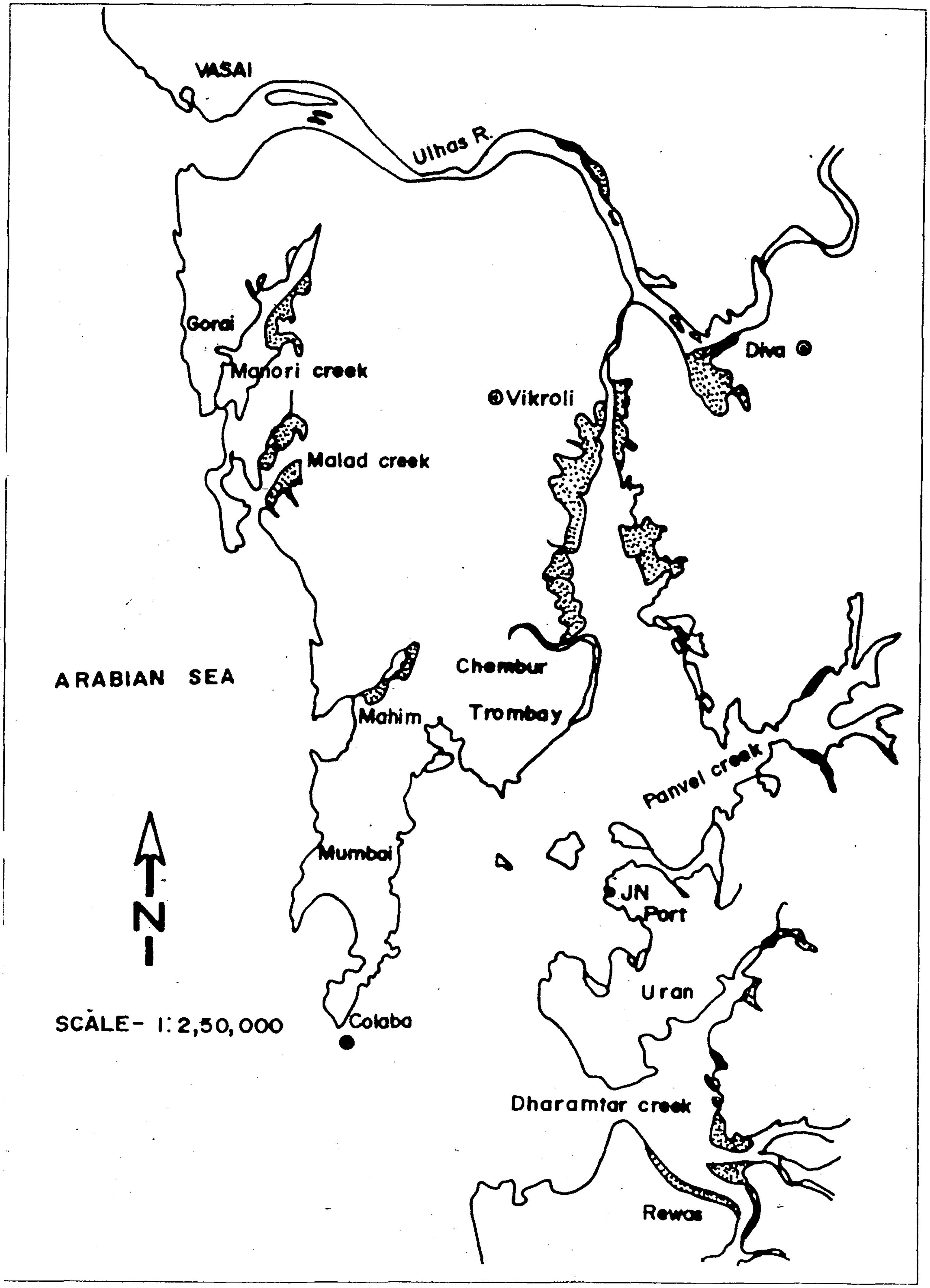


Fig.3.6 Sites along Mumbai

Plate 3a & 3b: Pressure from local population on the coastal vegetation

reclamation (Plate 3a & 3b). Local communities use this area for sand mining and traditional fishing. Deforestation (mainly for firewood) was also observed in this area. This area is taken into consideration because of the monospecific nature of the mangroves.

3.5.1.3 Vikroli

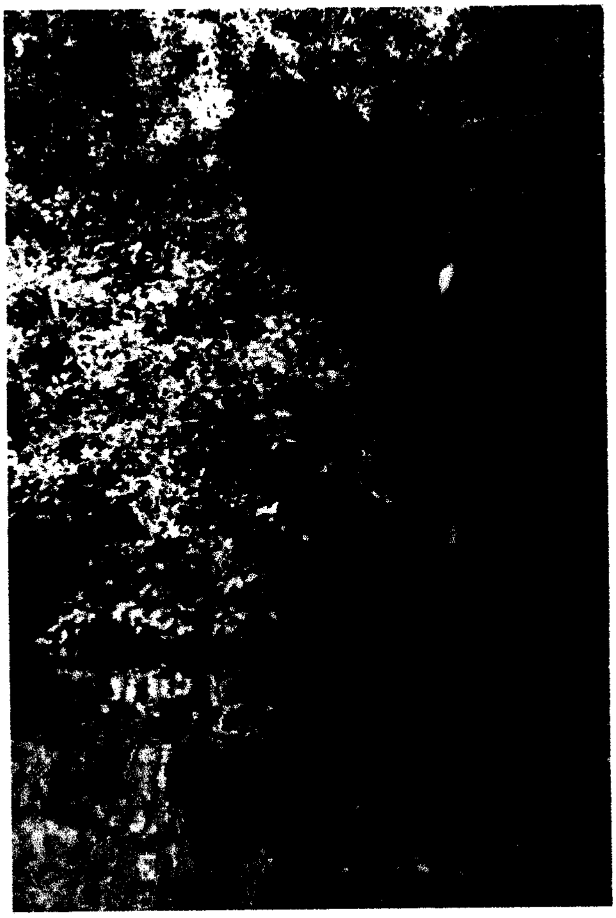
Vikroli lies towards the western bank of Thane creek.(Lat 19° 07'N and Long 72° 48'E) (Fig 3.6). M/s. Godrej Trust Limited considered this area as a special site for conservation and management of the mangrove forest under private ownership*. Vikroli has about 1750 ha of mangrove vegetation owned by M/S Godrej Pvt. Ltd. *Avicennia marina*, is one of the most dominant species along with *R. mucronata*, *S. apetala*, *A. corniculatum* and *A. ilicifolius* (Table 3.14). The average height ranged from 7 to 10 m. The entire expanse of 1700 ha area has natural growth and is protected.

Godrej Company has established an Interpretation Centre to enhance the mangrove awareness for conservation. A nursery is also established for afforestation. Two observation towers have been erected in this area. In general the site although privately owned has been managed in the best possible manner and should be used as a model.

3.5.1.4 Ratnagiri

This is a long creek with healthy patches of mangrove vegetation. Altogether, seven true mangrove species and three associated species were found. (Table 3.14). In some areas, the Social Forestry Department had planted *S. alba* and *R. mucronata* resulting into the dominance of these species. Other species were *Kandelia candel, A. officinalis, and A. ilicifolius.* The average density observed was 20-23 plants in 10 m^2 quadrant. The average height of *S. alba* ranged from 5- 8 m and *R. mucronata* it was 3-5 m. The avifauna as well as the intertidal fauna is quite rich (Plate 4a & 4b). This is also one of the rich fishing area (Table 3.9).

Zooplankton exhibited lower biomass values and high species diversity (Table 3.10). A maximum of 10.96 ml $100m^{-3}$ of biomass was recorded at station B whereas a minimum value of 3.47 ml 100 m^{-3} was observed at Station C. A maximum of 12 faunistic groups were recorded at station C, which is located slightly away from the coast (Fig 3.7). Copepods formed the major component of zooplankton community and comprised more than 60% of total zooplankton catch in all the collections. The occurrence of decapod larvae, fish eggs and larvae in significant quantity revealed that the investigation site falls under highly potential fishing zone (PFZ). Chaetognaths formed an important constituent of zooplankton community and play a major role as indicators of different water masses. Being a sensitive group, their incidence of occurrence



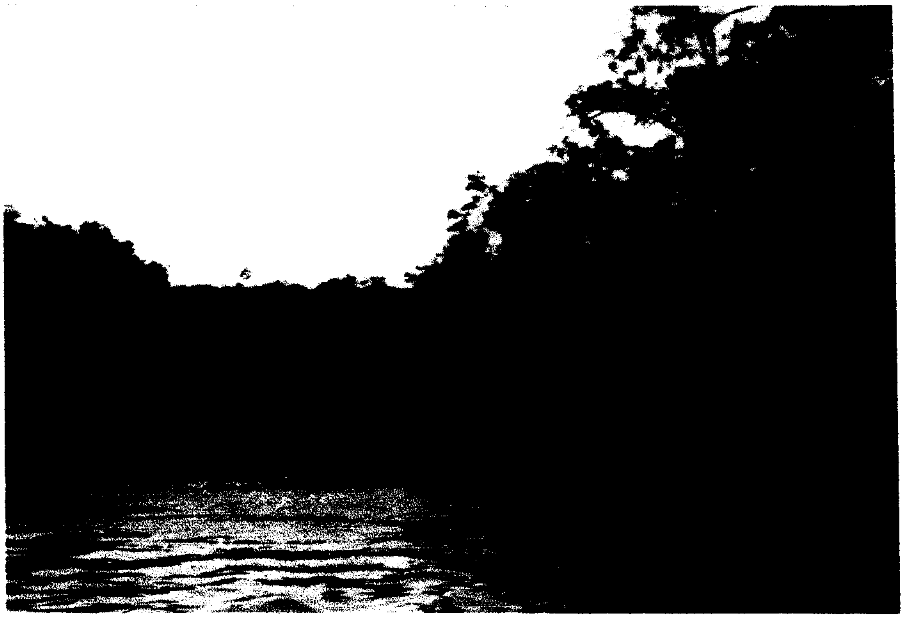


Plate 4a & 4b: Avifauna from the mangrove forests

Table 3.9 Abundance of demersal fish species (mean of three trawling hauls-nos per haul) in the coastal waters off Ratnagiri, Maharashtra

Family	Species	Abundance (mean nos per haul)
Carcharinidae	*Loxodon laticaudus*	2
	Loxodon walbeehmi	1
	Carcharinus limbatus	1
Clupeidae	*Sardinella jussieu*	3
	Sardinella albella	4
	Sardinella longiceps	3
Chirocentridae	*Chirocentrus dorab*	2
Carangidae	*Carangoides malabaricus*	2
	Caranx malampygus	2
Leiognathidae	*Secutor insidator*	2
	Gaza minuta	1
	Leiognathus sp.	3
Sciaenidae	*Otoloithes* sp.	2
Sphyaenidae	*Sphyraena jello*	1
Trichiuridae	*Trichiurus lepturus*	102
	Lepturacanthus savala	14
	Eupleurogrammus muticans	5
Scombridae	*Rostrelliger kanagurta*	4
Scomberomoridae	*Scomberomous guttatus*	3
Stromateidae	*Pampus argenteus*	28
	Pampus chinensis	4
	Parastromus niger	2
Miscellaneous		10
Total Abundance (Nos/haul)		201
Total Biomass (kg/haul)		516

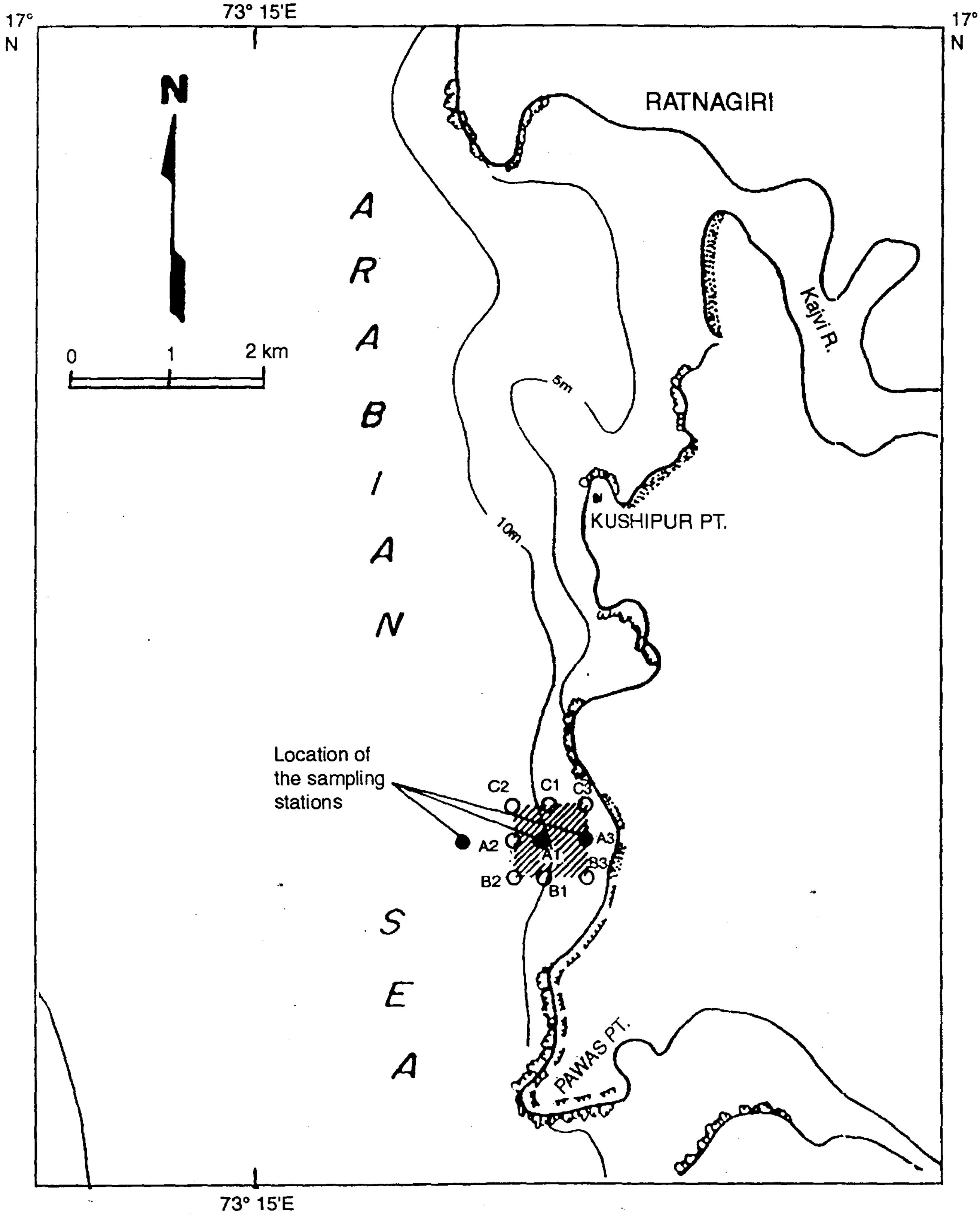


Fig. 3.7 Location of the sampling stations at Ratnagiri

can be considered as an index of the water quality. The representation of this groups with other gelatinous group lesser magnitude or total absence indicated their avoidance of the unfavorable environment. Data on the zooplankton biomass as well as their composition indicated that the area of investigation is low in zooplankton production, which probably may be due to seasonal variations, characteristics of coastal waters as elsewhere. However, frequent occurrence of dolphins in the study area reflects on the high biological productivity. The meiofauna comprised of nine taxonomic groups, and the population density varied between 395 and 2127 numbers in 10 cm^{-2} (mean 826 $\pm$ 615 S.D). The minimum and maximum values were recorded at station C-2 and A, respectively. The fauna was dominated by Nematoda, which comprised 66.5% of the total meiofauna. Oligochaeta was next in the order of abundance (7.9%) followed by crustacean nauplii (7%), harpaticoida (6.3%) and Gastrotricha (5.5%) (Table 3.12).

The macrofauna mainly composed of Polychaeta (91.3%), Amphipoda (2.6%), Bivalvia (2.6%), Brittle star (1.9%), Sipuncula (1.4%) and Sea Urchin (0.4%) (Table 3.11). In general the fauna was rich and varied reflecting on the undisturbed nature of the area and thus the study is comparable to coastal benthic fauna along the Konkan coast.

Compared to meiofauna, the macrofauna were well developed. Inspite of the presence of common faunal communities at all the sampling site, the values for

Table 3.10 Abundance of Zooplankton (numbers $100m^{-3}$) in coastal waters off Ratnagiri, Maharashtra

Faunal Groups	Sampling Stations		
	A	B	C
Siphonophora	103	130	24
Polychaeta	103	65	197
Copepoda	5430	9416	3598
Cirriped larvae	172	260	116
Euphasiids	310	910	104
Decapod (Larvae and adults)	1100	2143	740
Gastropods	138	585	208
Chaetognath	138	585	208
Appendicularia	0	0	70
Fish eggs	344	1818	81
Fish larvae	0	0	104
Total density	**7838**	**15392**	**5277**
Biomass (ml $100m^{-3}$)	**5.37**	**10.96**	**3.47**

Table 3.11 Benthic macrofaunal population density (Nos.m^{-2}) and biomass (gm m^{-2} wet weight) from the sub-tidal waters off Ratnagiri

Fauna	Stations						
	A	A1	B	B1	C	C1	C2
Polychaeta							
Spionidae	400	625	400	400	150	1875	100
Glyceridae	0	250	25	0	0	50	0
Nepthydae	0	0	0	50	0	0	0
Nereidae	0	500	0	100	0	0	0
Lumbriconeridae	0	0	0	50	0	0	0
Other Polycheates	0	125	75	0	0	100	0
Amphipoda	0	125	25	0	0	0	0
Prawn (Juveniles)	0	0	0	50	0	0	0
Bivalvia	25	0	0	0	0	100	25
Echinodermata							
Sea urchin	0	25	0	0	0	0	0
Brittle star	0	0	50	50	0	0	0
Sipuncula	0	75	0	0	0	0	0
Total density	425	1725	575	700	150	2125	125
Total biomass	6.55	13.25	0.9	5.05	10.17	8.47	3.67

Table 3.12 Meiofaunal abundance (numbers) and biomass (mg 10 cm^{-2}) in the sub-tidal waters off Ratnagiri (values in parantheses are biomass)

Taxon	Stations							
	A	A1	B	B1	C	C1	C2	Mean (S.D)
Neamtoda	1512 (756)	551 (276)	471 (237)	221 (111)	586 (292)	252 (126)	252 (126)	549.1±450.6 (247.9±225.2)
Harpacticoida	126 (50)	32 (16)	157 (63)	16 (8)	16 (6)	0 (0)	16 (6)	51.9±62.6 (20.6±25.1)
Turbellaria	32 (16)	32 (16)	16 (8)	32 (16)	32 (16)	0 (0)	0 (0)	20.6±15.2 (10.3±7.6)
Oligocheata	126 (202)	79 (126)	126 (202)	16 (26)	47 (75)	32 (51)	32 (51)	65.4±45.7 (104.7±73.3)
Gastrotrich	142 (71)	16 (8)	32 (16)	47 (24)	32 (16)	32 (16)	0 (0)	45.3±44.0 (22.7±22.0)
Polychaeta	16 (26)	16 (26)	63 (111)	0 (0)	32 (51)	32 (51)	0 (0)	22.7±22.1 (37.9±38.4)
Crustacean nauplii	126 (50)	0 (0)	94 (380)	71 (280)	0 (0)	32 (13)	79 (32)	57.4±48.2 (23.0±19.2)
Kinorhynch	47 (24)	0 (0)	16 (8)	0 (0)	0 (0)	0 (0)	0 (0)	9.0±17.8 (4.6±9.1)
Crustacean larvae	0 (0)	0 (0)	0 (0)	16 (6)	0 (0)	16 (6)	0 (0)	4.6±7.8 (1.7±2.9)
Total	2127 (1195)	726 (465)	977 (683)	419 (217)	742 (456)	396 (263)	395 (223)	826±614.9 (500±349.4)

Figures in parentheses are biomass.

meiofaunal standing stock ranged widely and showed significant variation among the sampling sites ($P<0.005$). The chief cause of fluctuations in animal numbers within the relatively small (1 sq.km), was the sediment characteristics. In general, the meiofauna of the subtidal water off Ratnagiri was rich and diverse. Abundance of nematodes, harpacticoid copepods and polychaete larvae clearly showed that the environment was conducive for the prolific production of benthic biota, which in turn forms the food for prawns, crabs, lobsters and finfishes.

The high abundance of crustacean nauplii in benthic fauna indicate the breeding activity of crustaceans in the area. The reportedly rich lobster fishery off Ratnagiri cost also support the above findings, and suggest that the backwaters of Bhatty and Pawas creeks might be serving as nursery grounds for economically important crustacean groups like prawns, crabs and lobsters. Therefore, the coastal the coastal water between Pawas and Bhatty are very important for local lobster and crab fishery. Since the industrial development is very fast along the Ratnagiri coast a long term marine environment monitoring of the coastal waters of Ratnagiri is necessary to predict the probable effects of industrial development on marine environment and biota, therein. The result will therefore help in devising and implementing a conservation plan.

The coastal waters off Ratnagiri are traditionally known for its rich fishing grounds for prawns and finfish fishery. Ratnagiri has a long sandy beach with rocky outcrop towards north. The average intertidal expanse in the open coast was around 30 m. The narrow expanse was due to the high cliffs. Barnacles, oysters, *Ulva fasciata* and *Enteromorpha* sp. covers the supralittoral zone. The mid-littoral zone was usually covered with Dictyotaceae members like *Dictyota, Padina, Stoechospermum, Spatoglossum* etc and red algae like *Gracilaria* and *Grateloupia.* The maximum seaweed growth was found in this zone. The lower littoral zone was dominated by *Sargassum* sp. List of marine algal species recorded are given in Table 3.13.

Pawas estuary is close to Ratnagiri (south). Although a small estuary, good patchy growth of mangroves were seen towards mouth region. Insignificant mangrove growth was recorded from upstream region. The mangrove forest here is mostly reclaimed for developmental purposes. The estuarine and intertidal fauna like fiddler crabs, gobid fishes etc. were found to be scanty excepting crabs and oysters.

3.5.1.5 Vijaydurg-Deogadh-Achara

Vijaydurg is a heritage site with an ancient fort of 12th century. It has irregular shoreline with rocky cliffs, thus having a narrow intertidal expanse. The observations were done adjacent to fort area were pollution level was comparatively low. List of mangrove species recorded are given in Table 3.14 and Fig 3.8.

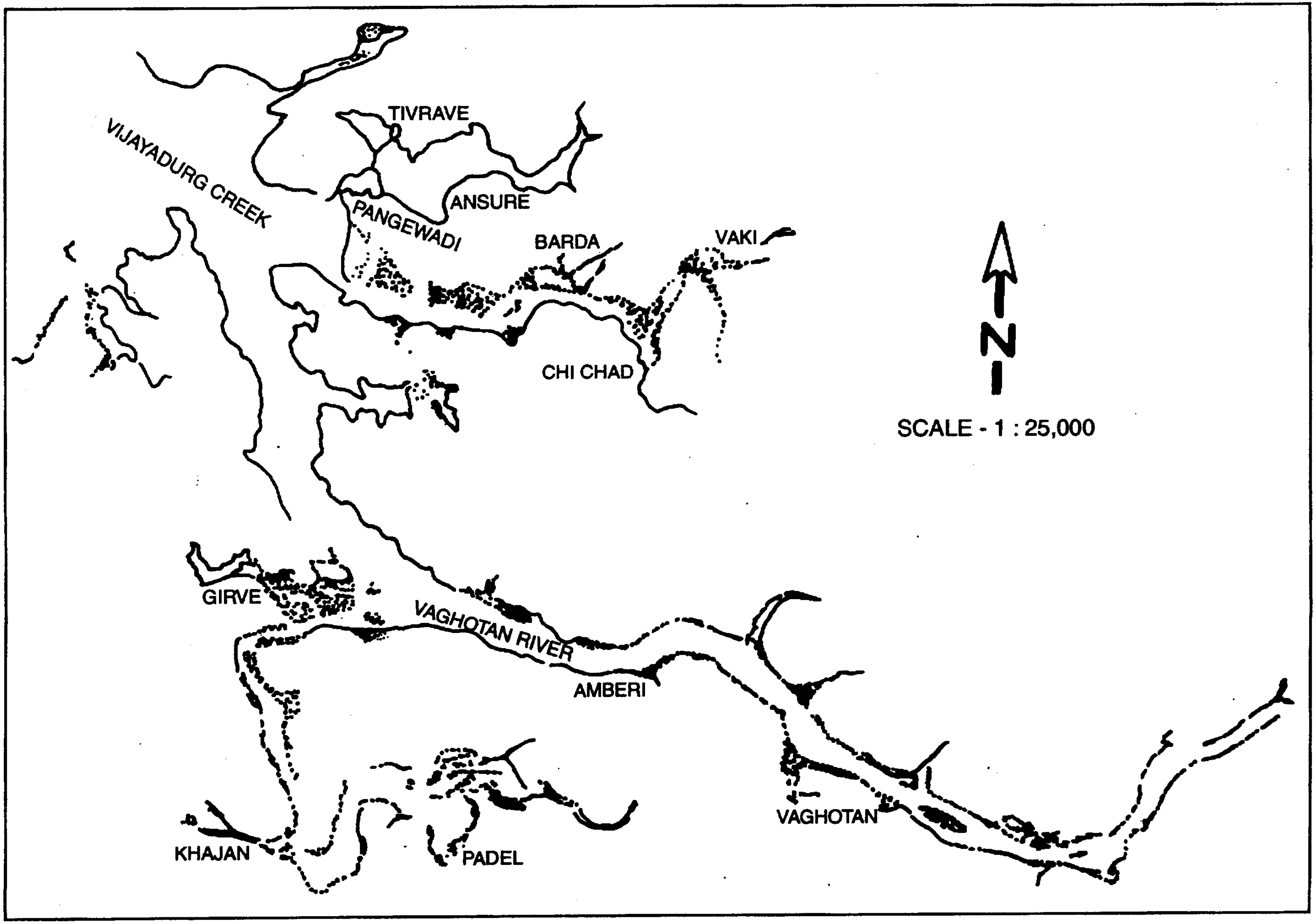


Fig.3.8 Map of Vaghotan creek showing mangrove distribution

The substratum was of laterite rocks. Distinct zonations could not be marked out as the intertidal zone was very narrow. About 20 species of marine algae belonging to all major groups were recorded (Table 3.13).

The distribution pattern was irregular and found in patches. In the surf zone few species of *Ulva* and *Chaetomorpha* were observed. This is also a very good fishing centre where the open shore and estuarine fishery is quite common. Fish population is considerably high and is a major source of income for local people (Plate 5a).

Devgarh creek, situated towards north of Achra, is 16.5 km long with estuarine area of 1900 ha (Fig 3.9). The approximate area under mangrove cover was 300 ha. Altogether 8 mangrove species with two associated floral species have been reported from this estuary (Table 3.14). *Avicennia marina, Rhizophora mucronata, Excoecaria agallocha* and *Sonneratia alba* are the most common species found (Plate 5b). The fauna was represented by polychaeta, mollusca and echinodermata groups.

The Achra river (16^0 12'- 16^0 14'N. and 73^0 25' -73^0 30'E) runs about 20 km in length, tracing the boundary between Sindhudurg and Ratnagiri districts of Maharashtra (Fig 3.10). Tall hills encompass the river in the north and south, while the east has flat plains covered almost entirely with paddy fields.

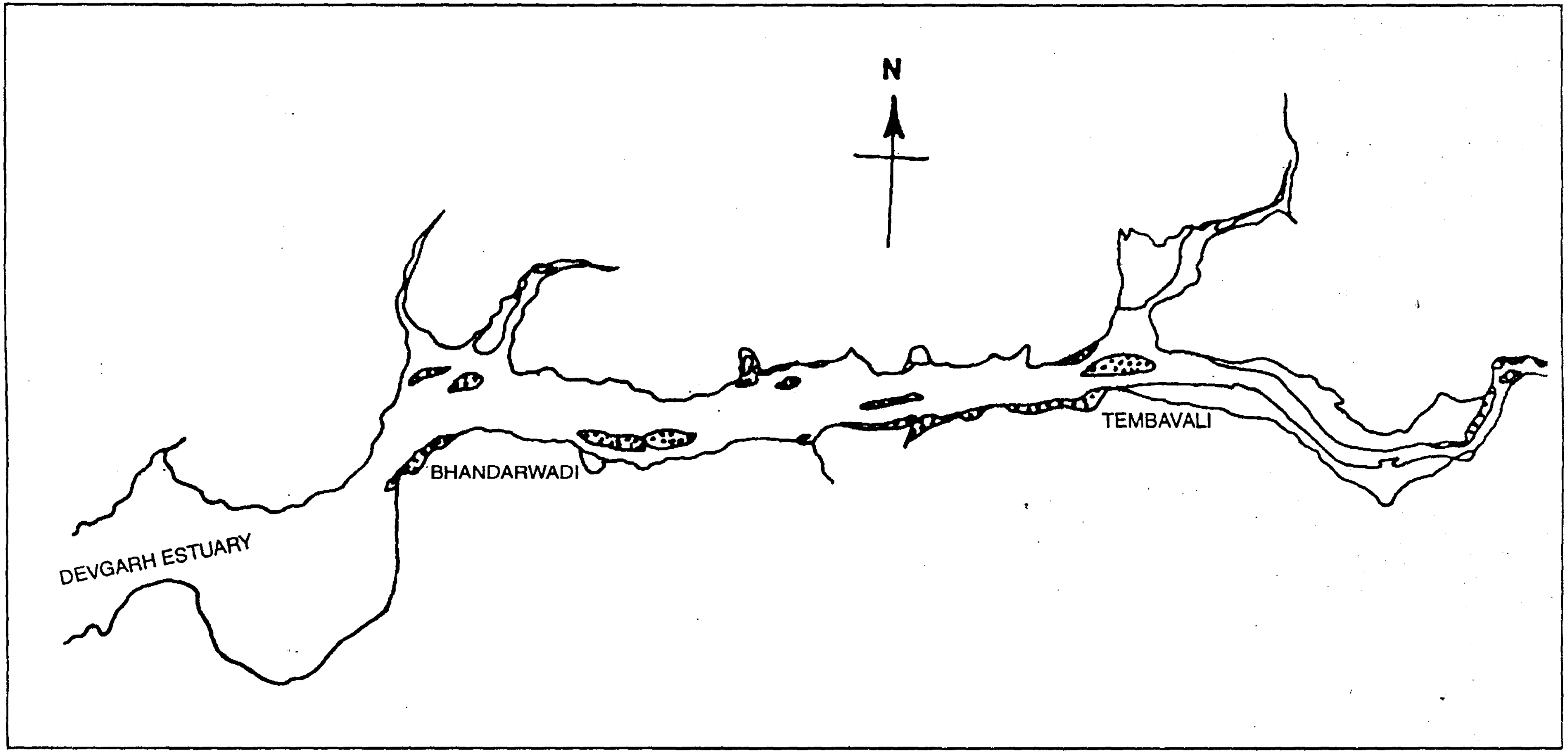


Fig. 3.9 Map of Devgarh estuary showing mangrove distribution

Plate 5a: Shrimp catch along the Maharashtra coast

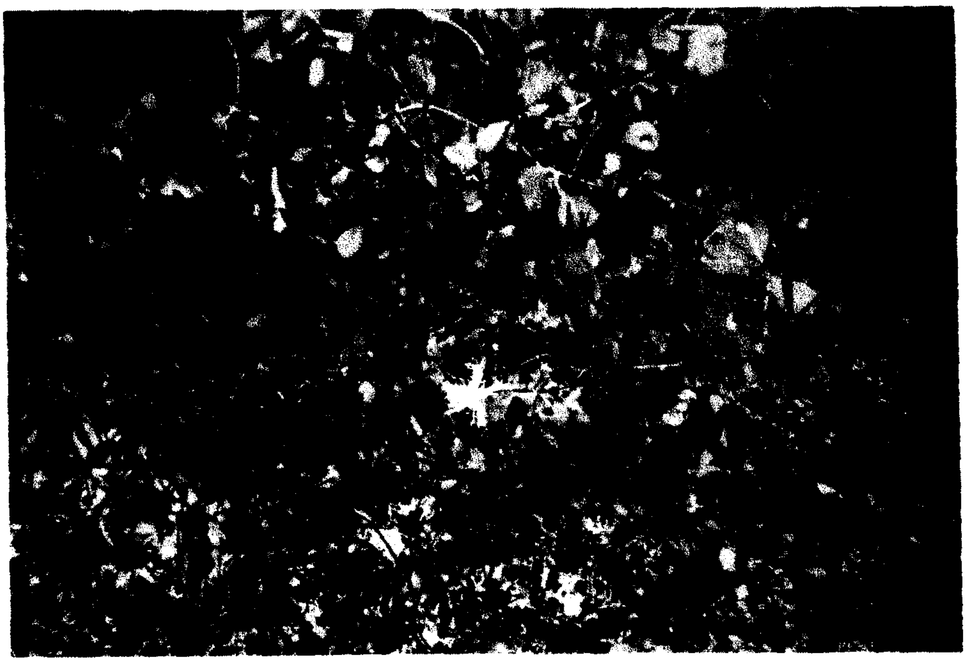


Plate 5b: Flowering of *Sonneratia alba*

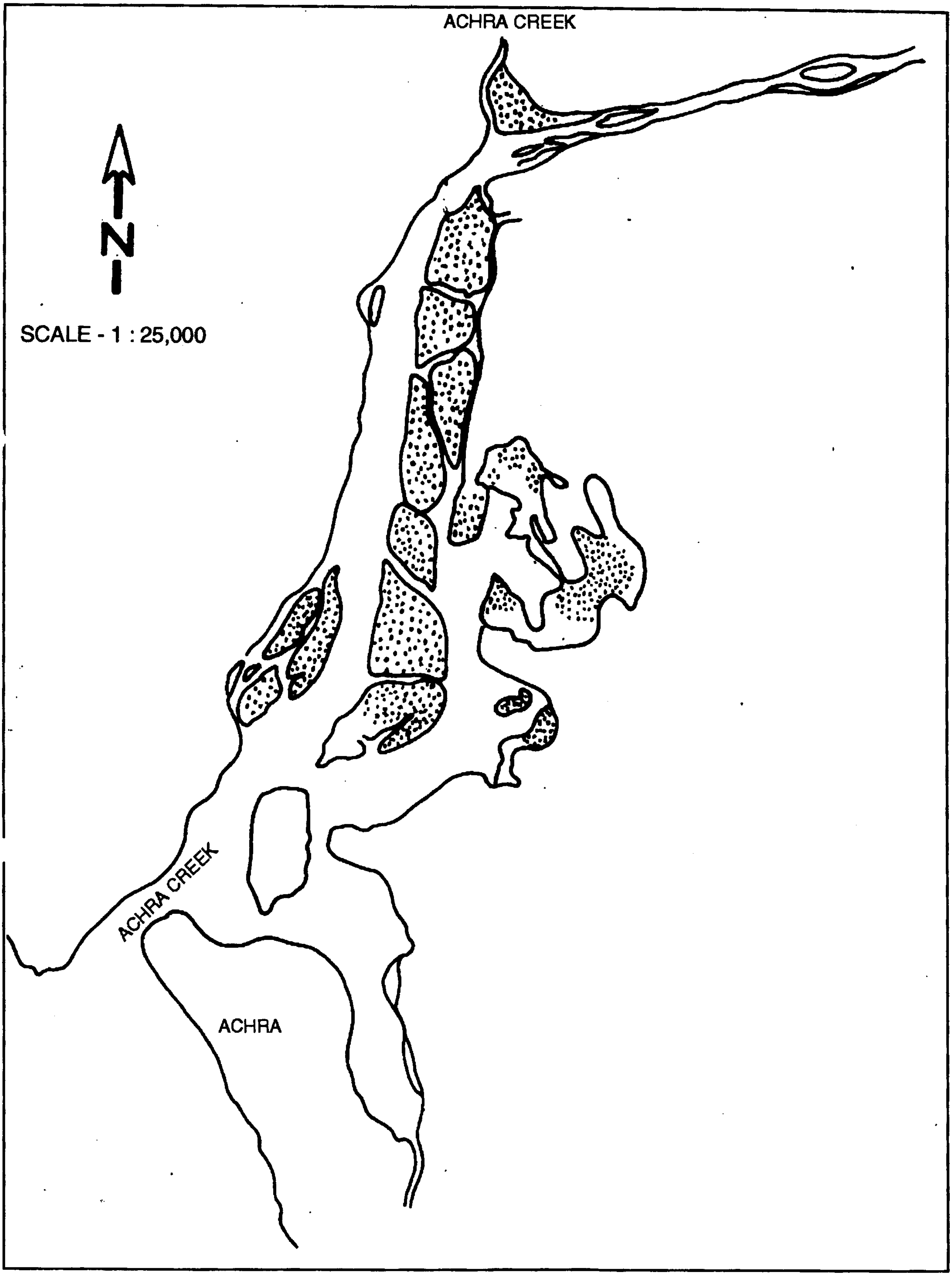


Fig. 3.10 Map of Achra creek showing mangrove distribution

The estuarine region where mangroves were seen extends to a distance of 5 km from the mouth of the river. This region has an estimated area of 400 ha. Eleven mangrove species were distributed along the stretch of the estuary, viz. *Rhizophora mucronata, Avicennia officinalis, Avicennia marina, Sonneratia alba, Sonneratia caseolaris, Excoecaria agallocha, Bruguiera gymnorrhiza, Acanthus ilicifolius, Aegiceros corniculatum, Derris heterophylla* and *Clerodendrum inerme* (Table 3.14). *Rhizophora mucronata* and *Avicennia officinalis* were found to occur in all parts of the estuary while the remaining species had a restricted distribution. *S. alba* and *S. caseolaris* were observed only in the midstream region of the estuary. *E. agallocha, A. corniculatum, C. inerme* and *D. heterophylla* were seen in the upper reaches of the estuary. Species like *B. gymnorhiza* and *A. marina* were noticed only in a few islands. The *Rhizophora* zone was dominated by *R. mucronata* with height ranging from 6 to 10 m approximately.

The mangroves cover an area of approximate 273 ha extending almost continuously over a distance of 3 km along the western and northern bank of the river. The zone had an assortment of species having dominance for none. Zonation on the basis of abundance is observed in this zone.

The Achra mangrove forest is presently a well-protected ecosystem. The management of a temple situated less than a kilometer from the forest has been looking after this specialized ecosystem. This sacred grove has minimum felling of trees and is practically free of any sort of pollutants, excepting perhaps sewage from the nearby villages of Achra. Mangrove afforestation programme have been undertaken in this area by the Forest Department (Plate 6a).

Two marine algal species i.e. *Monostroma oxyspermum* and *Enteromorpha clathrata* were dominant in the mangrove area. Other species such as *Gracilaria verrucosa, Colpomenia sinusa, Padina tetrastromatica* were found in patches. Species like *Caloglossa* and *Catnella* were common on the pneumatophores and lower stem portion of the mangrove trees that gets submerged during high tide.

3.5.1.6 Malvan

Malvan is an open coast ecosystem, and is dominated by rocky outcrops with intermittent sandy beaches. This area is dealt in detail in Chapter IV & V.

3.5.1.7 Vengurla Rock islands

Vengurla rocks consist of a group of rocky islets and extend up to the Malvan Rock forming a chain of exposed and submerged rocks. The Vengurla Rock is 41 m high and the highest islet of the group is situated about a kilometer north northeastward of Tapti rock. There is a lighthouse on one of the islets. The periphery of the islets is steep, where the intertidal expanse ranges from 0.5-1.5 m. There are number of submerged rocks in the surrounding region. The marine fauna is mainly corals, jellyfishes and gorgonians. The major seaweed species are *Sargassum, Ulva, Gracilaria*, etc. (Table 3.13). This island group is very good site for ornamental fish, with high productivity and diversity. The adjacent regions around these islands are common fishing grounds for the fishermen from Vengurla, Neuti and other nearby coastal areas. The transparency of water is very good and hence excellent site for diving. Thus these islands can be used for eco-tourism.

Vengurla displayed different types of ecosystem. There is a small river called Mandovi, which flows along the sandy coast. The open coastline is sandy, with gradual slope. Towards the north, the coast is rocky. The rocky shore, however, has steep slope, exposing a narrow intertidal belt of about 5-10 m during the low tide. The substratum was muddy and sandy in estuarine zone while made up of laterite cover in the rocky area.

Among the mangrove flora, only four to five true mangrove species were recorded, dominated by *Avicennia marina* and *A. officinalis*. The status of mangrove vegetation at this area can be described as moderate growth. The average height of the mangrove trees ranges from 2-3 m and density was poor. Among algal species, some Cyanophyceae and Chlorophyceae members like

Table 3.13 List of marine algae recorded at few stations along the Maharashtra coast and their ecological status

Sr.No	Name of the species	Ecological status			
		Colaba	Ratnagiri	Vijaydurg	Vengurla
	CHLOROPHYCEAE				
1	*Monostroma oxyspermum*	-	C	-	-
2	*Ulva fasciata*	C	C	C	C
3	*Ulva lactuca*	R	-	R	-
4	*Ulva reticulata*	-	R	-	-
5	*Enteromorpha tubulosa*	C	-	C	-
6	*Enteromorpha flexousa*	C	-	-	-
7	*Enteromorpha intestinalis*	C	-	-	-
8	*Enteromorpha clathrata*	-	C	C	C
9	*Chaetomorpha media*	C	C	C	-
10	*Chaetomorpha linum*	C	C	-	-
11	*Cladophora fascicularis*	C	C	C	-
12	*Caulerpa verticillata*	R	-	-	-
13	*Caulerpa sertularioides*	C	C	-	-
14	*Caulerpa racemosa*	C	C	-	-
15	*Caulerpa peltata*	R	R	-	-
16	*Caulerpa* sp.	R	-	-	-
17	*Bryopsis plumosa*	R	R	-	-
18	*Bryopsis hypnoides*	R	-	-	-
19	*Ernodesmis verticillata*	R	-	-	-
20	*Avurenvillea* sp.	R	-	-	-
21	*Struvea anastomosans*	R	-	-	-
22	*Microdictyon tenuis*	-	R	-	-
	PHAEOPHYCEAE				
23	*Ectocarpus conigera*	C	C	-	C
24	*Giffordia mitchelli*	C	C	-	C
25	*Sphacelaria furcigera*	C	C	C	C
26	*Dilophus fasciola*	-	R	-	R
27	*Dictyota dichotoma*	C	C	-	C
28	*Dictyota atomaria*	-	C	-	-
29	*Dictyopteris australis*	C	-	-	C
30	*Lobophora variegata*	R	R	-	R
31	*Padina gymnospora*	R	R	R	R
32	*Padina tetrastromatica*	C	C	C	C
33	*Ralfsia expansa*	R	-	R	-
34	*Stoechospermum marginatum*	C	C	C	C
35	*Spatoglossum asperum*	C	C	C	C
36	*Colpomenia sinusa*	C	C	-	-

37	*Sargassum swartzii*	C	C	C	C
38	*Sargassum cinerum*	C	C	-	-
39	*Sargassum ilicifolium*	C	C	-	-
40	*Sargassum johnstonii*	-	C	-	-
	RHODOPHYCEAE				
41	*Porphyra vietnamensis*	C	C	-	-
42	*Scinaia hetai*	C	C	-	-
43	*Gratelopia lithophila*	C	C	-	-
44	*Gratelopia indica*	C	-	-	-
45	*Melobesia farinosa*	R	R	-	-
46	*Amphiroa fragilissima*	C	C	-	C
47	*Jania adherens*	C	C	-	C
48	*Cheilosporum spectabile*	C	C	-	C
49	*Lithophyllum* sp.	R	-	-	-
50	*Gelidium pusillum*	C	C	C	C
51	*Gelidiopsis variabilis*	C	-	-	-
52	*Sarconema filiformae*	R	-	-	-
53	*Soliera robusta*	R	-	-	-
54	*Caulocanthus* sp.	-	C	-	R
55	*Gracilaria corticata*	C	C	C	C
56	*Gracilaria verrucosa*	R	-	-	R
57	*Hypnea valentie*	C	-	-	C
58	*Hypnea cervicornis*	C	-	-	-
59	*Hypnea musciformis*	-	C	-	-
60	*Ahnfeltia plicata*	-	R	-	-
61	*Champia parvula*	R	-	-	R
62	*Gastroclonium* sp.	R	-	-	-
63	*Ceramium fastigiatum*	C	C	C	C
64	*Acanthophora spiciphera*	-	C	-	-
65	*Spyridea fusiformis*	R	-	-	-
66	*Laurencia obtusa*	R	-	-	-
67	*Laurencia papillosa*	C	-	-	-
68	*Chondria armata*	R	-	-	-
69	*Chondria tenuissima*	R	-	-	-
70	*Rhodymenia palmata*	R	-	-	-
71	*Polysiphonia polycarpa*	C	-	-	-
72	*Polysiphonia variagata*	C	-	-	-
73	*Centroceras clavulatum*	C	C	C	C
74	*Martensia* sp.	-	C	-	-
75	*Catnella repens*	-	C	C	C
76	*Dasya* sp.	R	-	-	-
77	*Caloglossa lepureuii*	C	C	C	C
78	*Bostrychia tenella*	-	-	R	-

C : Common, R : Rare

Table 3.14 List of mangroves recorded at few stations along the Maharashtra coast and their ecological status

Sr. No	Name of the Species	Ecological status					
		Mumbra -Diva	Vikroli	Ratn- agiri	Vijay- durg	Achra	Devgarh
1	*Acanthus illicifolius*	C	C	C	C	C	-
2	*Aegiceras corniculatum*	R	C	-	-	C	C
3	*Avicennia officinalis*	-	-	C	C	D	-
4	*Avicennia marina*	C	C	C	C	D	C
5	*Brugueira gymnorrhiza*	-	-	-	R	-	R
6	*Ceriops tagal*	-	-	E	-	-	R
7	*Derris heterophylla*	-	-	-	-	-	C
8	*Exoecaria agallocha*	-	-	-	C	C	C
9	*Portresia coarctata*	-	-	-	-	C	-
10	*Kandelia candel*	-	-	E	-	-	C
11	*Rhizophora apiculata·*	-	-	-	-	C	C
12	*Rhizophora mucronata*	C	R	C	C	C	C
13	*Sonneratia alba*	-	-	C	C	D	C
14	*Sonneratia caseolaris*	-	-	-	-	C	-
15	*Sonneratia apetala*	D	C	-	-	-	-
16	*Salvodora persica*	C	-	-	-	-	-
17	*Salicornia bracheata*	C	-	-	-	-	-

C: Common, E: Endangered, R: Rare, D: Dominant

Enteromorpha clathrata were recorded from this area. The benthic faunal group Polychaeta was dominant in the estuary.

The open coast was sandy. *Sargassum* sp. dominated the intertidal zone. Altogether 10 species were recorded. A rare species *Champia parvula* was also recorded from this area. Among the sand-dune vegetation, *Ipomoea pescaprae* dominated the other species (Table 3.5). The invertebrate faunal species of sea anemone was common.

3.5.2 GOA COAST

Along the Goa coast 24 sites were surveyed for the presence or absence of flora and fauna (Table 3.15). List of marine algae, sand dune vegetation, mangroves, corals recorded along the coast are given in tables 3.3, 3.4, 3.16. Among the 24 sites surveyed 6 sites were selected for further studies (Table 3.6)

3.5.2.1 Terekhol

The Terekhol river is about 26 km in length showing the presence of rocky as well as the mangrove area (Fig 3.11). The northernmost part of the river shows the presence of vast intertidal expanse. The intertidal area is a mixture of rocky area (made up of laterite) and sandy beaches. The expanse is shallow with less wave action.

Table 3.15 Sites surveyed along the Goa coast and their importance

Sr.No	Name of the sites	Importance of the sites
1	Terekhol	♦ Mangrove vegetation ♦ 30 algal species recorded
2	Keri	♦ Sandy coast ♦ *Casuarina equisetifolia* plantation
3	Harmal beach	♦ Sandy coast ♦ Human disturbance ♦ Erosion
4	Mandre	♦ Sand dune vegetation ♦ Luxuriant growth of *Pandanus* sp.
5	Morjim	♦ Sand dune vegetation ♦ *Casuarina equisetifolia* plantation
6	Chapora river	♦ Mangrove vegetation ♦ 12 algal species recorded
7	Anjuna	♦ 30 algal species recorded ♦ Tourism activities
8	Baga	♦ Fishing activity ♦ 45 marine algal species ♦ Few prominent dunes
9	Aguada head	♦ 14 algal species recorded ♦ Patchy algal growth
10	Mandovi estuary	♦ Mangrove forest ♦ Rich flora and fauna
11	Chorao island	♦ Mangrove forest ♦ Rich flora and fauna ♦ Afforestation activities ♦ Bird sanctuary
12	Old Goa	♦ Mangrove forest
13	Marlim jetty and Betim	♦ Mangrove plants ♦ Human disturbance ♦ Afforestation activities ♦ Marine algal species recorded
14	Opposite Goa Medical College	♦ Discharge point ♦ Algal biomass high ♦ Sand dune vegetation ♦ Conservation activities
15	Miramar	♦ Sand dune vegetation

		♦ *Casuarina* plantation
16	Dona-Paula	♦ 48 algal species recorded ♦ *Sargassum* spp dominant
17	Marvel beach	♦ 46 algal species recorded ♦ Species of *Arainvillea* and *Ralfsia* recorded
18	Mormugao	♦ 24 algal species recorded ♦ Sewage discharge point
19	Bogmalo	♦ 19 algal species recorded ♦ Sewage disposal point present
20	Zuari estuary	♦ Rare occurrence of *Kandelia candel* ♦ Patchy growth of mangroves
21	Cumbarjua canal	♦ Fringing mangroves ♦ *Bruguiera gymnorhiza* and *Bruguiera parviflora* in degraded condition
22	Cabo-De-Rama	♦ 39 algal species recorded ♦ Good algal representation
23	Sal	♦ Mangrove forest ♦ Natural regeneration of *Avicennia officinalis* and *Sonneratia alba*
24	Talpona	♦ Mangrove forest ♦ 13 algal species recorded
25	Galgibag	♦ Mangrove species present ♦ *Casuarina equisetifolia* plantation on the foreshore region
26	Polem	♦ Moderate fishing activity ♦ 15 algal species recorded ♦ Poor sand dune vegetation

Table 3.16 List of sand dune vegetation recorded along the Goa coast

Family	Name of the species
Malvaceae	*Sida cordifolia*
Vitaceae	*Leea sambucina*
Mimosae	*Mimosa pudica*
Tiliaceae	*Triumfetta rhomboidea*
Anacardiaceae	*Anacardium occidentale*
Aizoaceae	*Sesuvium portulacastrum*
Rubiaceae	*Spermacoce stricta*
Asteraceae	*Lactuca remotiflora*
Asteraceae	*Launaea nudicaulis*
Asteraceae	*Ageratum conyzoides*
Asteraceae	*Adenoon indicum*
Caesalpiniaceae	*Cassia tora*
Fabaceae	*Crotalaria verrucosa*
Fabaceae	*Crotalaria retusa*
Fabaceae	*Abrus precatorius*
Fabaceae	*Canavalia gladiata*
Fabaceae	*Desmodium polycarpum*
Fabaceae	*Tephrosia purpurea*
Fabaceae	*Zornia diphylla*
Convolvulaceae	*Ipomoea pes-caprae*
Asclepidiaceae	*Calotropis gigantea*
Solanaceae	*Physalis minima*
Pedaliacea	*Pedalium murex*
Verbenaceae	*Vitex negundo*
Verbenaceae	*Lantana camara*
Verbenaceae	*Clerodendrum inerme*
Verbenaceae	*Duranta plumieri*
Labiatae	*Leucas aspera*
Labiatae	*Ocimum gratissimum*
Casuarinaceae	*Casuarina equisetifolia*
Chenopodiaceae	*Portulaca nudiflora*
Euphorbiaceae	*Phyllanthus reticulatus*
Pandanaceae	*Pandanus tectorius*
Liliaceae	*Urginea indica*
Cyperaceae	*Cyperus arenarius*
Cyperaceae	*Fimbristylis miliacea*
Poaceae	*Spinifex littoreus*
	Eragrostis uniloides
	Saccharum apontaneum

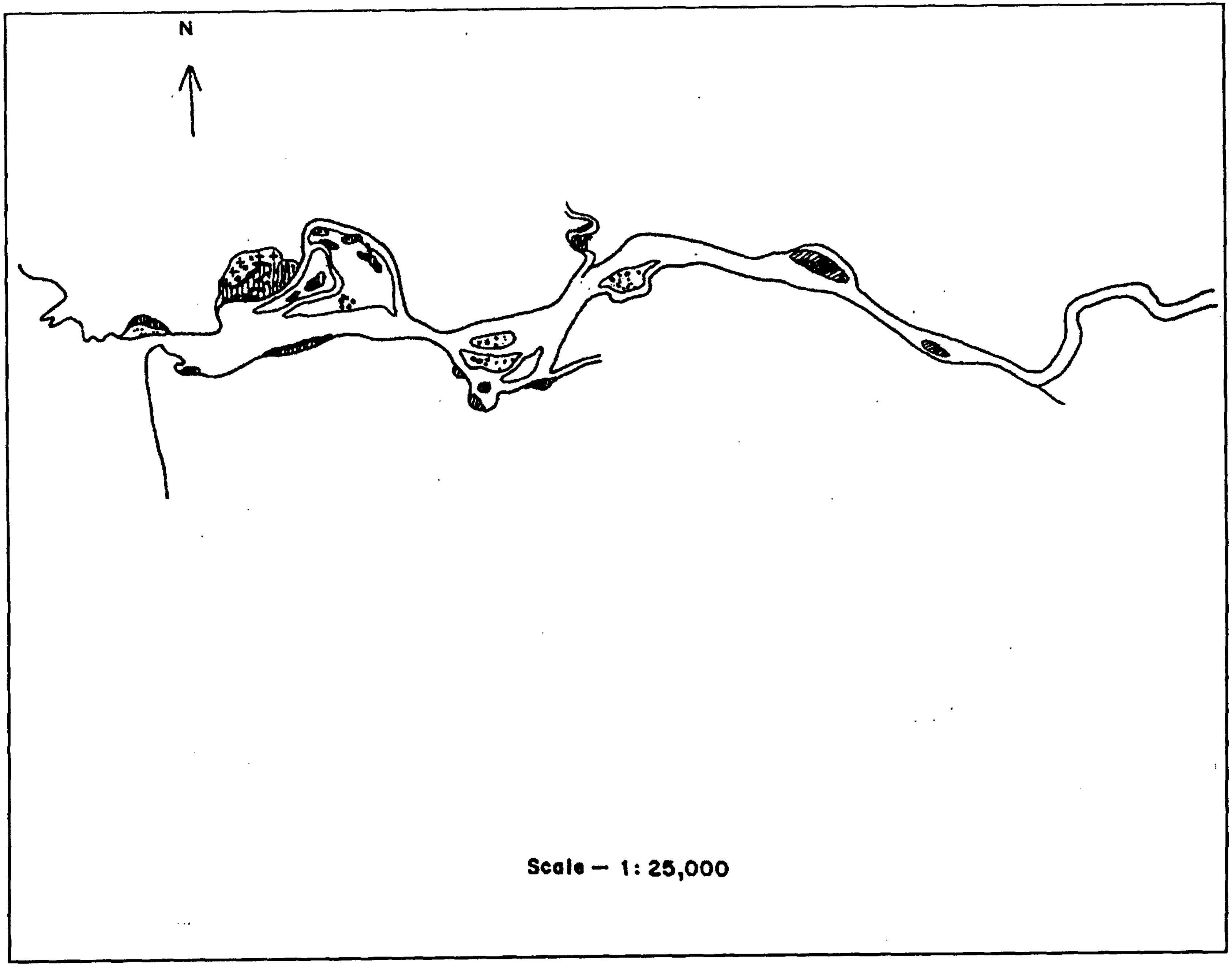


Fig. 3.11 Map of Terekhol estuary showing distribution of mangroves

The mangrove vegetation is present in the bay region where the plants are dwarf in nature (Table 3.23). Very few tall plants of *Avicennia* and *Rhizophora* were seen along the northern bank of the estuary. *Rhizophora mucronata* was one of the most dominant vegetation present along the mouth region with lot of new germinating seedlings. The mouth region also shows the presence of *Avicennia*, but in a degraded state due to deforestation activity. The composition of mangroves varies from the mouth region to the interior part. The species present along the estuary were *Rhizophora mucronata, Avicennia officinalis, A. marina, Sonneratia alba, Exoecaria agallocha, Acanthus illicifolius, Aegiceros corniculatum, Kandelia candel* (Table 3.23). One of the fern species, *Acrostichum aureum* was noticed only in the upstream region where the salinity was low. Jagtap (1985) and Naskar & Mandal (1999) also reported *Ceriops tagal* as rare along Terekhol estuary and absent along all other estuaries of Goa. The dwarf and thin mangrove vegetation along the estuaries was due to constant indiscriminate cutting and grazing (Jagtap, 1985).

About 31 algal species were recorded from this station (Table 3.22). Distinct zonation could not be observed where the distribution was found in patches. Chlorophyta members dominated the supralittoral zone consisting of *Ulva fasciata, Enteromorpha clathrata* and *Caetomorpha media*, and at times by Rhodophyta species such as *Caloglossa leprieurii* and *Gelidium pusillum*. The characteristic mid-littoral species were *Padina tetrastromatica, Stoechospermum* *marginatum, Spatoglossum asperum, Caloglossa leprieurii* and *Acanthophora spicifera, Hypnea musciformis*. Lower littoral region is dominated by species of *Sargassum* and *Gracilaria corticata*. Rock pools in the lower littoral zone were also observed harbouring various algal species of *Sargassum* sp., *Stoechospermum marginatum, Gracilaria corticata, G. verrucosa, Acanthophora spicifera* and *Hypnea musciformis. Porphyra vietnamensis* intermingled with *Ulva fasicata* and *Chaetomorpha media* dominated supralittoral region and the upper littoral region during the monsoon season.

In the sandy substratum along this estuary species like *Ulva reticulata* and *Gracilaria verrucosa* were observed. *Enteromorpha clathrata* and *Chaetomorpha media* were also seen in patches.

Quantitatively members belonging to Phaeophyta dominated this station during the pre-monsoon months, but during the monsoon months *Porphyra vietnamensis* was found to be dominating. The average biomass (wet wt.) calculated from this station was 1.2 kg/m^2. *Sargassum* sp. showed maximum biomass, while that in case of Rhodophyta members, *Gracilaria corticata* showed 1.52 kg/m^2 biomass.

3.5.2.2 Chapora river

This station was estuarine in nature, where Chapora estuary opens into the Arabian sea (Fig 3.12). The substratum at this station is sandy along the Chapora bay and rocky around the Chapora fort. The length of the river is approximately 30 km. Fishing was one of the most evident activity seen in this area. Chapora bay is an extensive shallow area, which gets emerged during low tides. Substratum was muddy. The rocky outcrops showed the presence of many shelled organisms.

The bay area did not show the presence of mangrove vegetation. Very few plants of *Avicennia* is seen growing mostly near the edge of the bay. Polychaetes, mussels, oysters, gastropods and crustaceans are some of the animal species observed on this soft substratum. The mangroves here have occupied around 100 ha. *Avicennia officinalis* was dominating towards the mouth region (Table 3.23). Most of the trees were observed to be dwarf in nature, while few species of *Avicennia* were found to be tall i.e. about 7-8 m. Few species of dwarf *Sonneratia alba* was found to be associated with *A.officinalis. E. agallocha.*. The dominant species found were *A.officinalis* and *A.illicifolius*. The freshwater influence is greater beyond Colvale village, where the vegetation is represented by *Derris heterophylla, Acrostrichum aureum, Avicennia officinalis* was dominating followed by *S. alba* and *E.agallocha.*

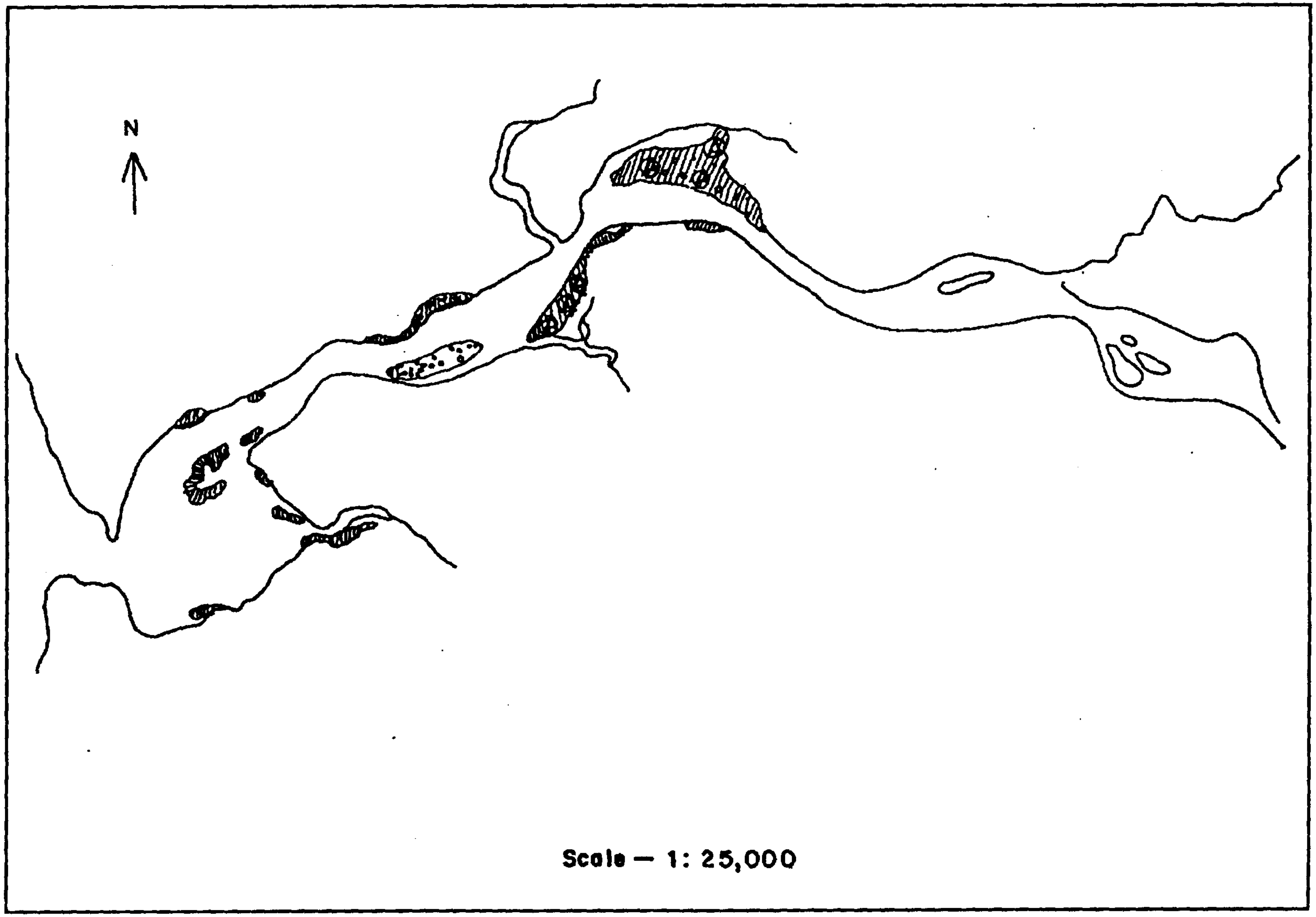


Fig. 3.12 Map of Chapora estuary showing distribution of mangroves

Almost around 19 species of algae have been recorded from this area (Table 3.22). The substratum was sandy with *Ulva reticulata* as the dominant species. The midlittoral region was extensively covered with *Ulva reticulata*. The other species present along this region includes *Giffordia* sp. *Ulva reticulata, Enteromorpha clathratha, Chaetomorpha media, Padina tetrastromatica, Gracilaria verrucosa* etc. While *E. clathrata, P. tetrastromatica, G. verrucosa* and *C. media* showed patchy occurrence. The estuarine influence was high at this station. The Rhodophyta member *Porphyra vietnamensis* was seen growing along with *Enteromorpha clathrata* and *Chaetomorpha media* on the rocky substratum near the fort during the monsoon season. Mean algal biomass recorded at this station was 0.95 kg/m^2. As the substratum was muddy the major representation was of green alga *Ulva reticulata*, which was the major contributor for the biomass. Species diversity was also less due to the muddy substratum. *Ulva reticulata* was found attached to polychaete tubes and gastropods. Except *Ulva reticulata*, abundance of other green algae was poor.

The sandy shores were also seen along this station with few prominent dunes as this region shows the presence of rivers and cliffs. This area starting from Chapora–Baga-Calangute-Sinquerim has beautiful sandy shores, but the area is disturbed due to development of tourism. Lot of hotels and restaurants have been constructed in this area. At certain spots away from the popular beach sites some green cover is still observed but no dune system as such presently exists. The dominant species recorded were *Ipomoea pescaprae* and *Spinifex littoreus*.

3.5.2.3 Anjuna-Baga

This is on of the most important tourist spot of Goa, which is a pure marine area. It has a sandy stretch covering 2.5 km and rocky boulders covering 1.4 km. Intertidal expanse at this station is quite wide with moderate wave action. At few places fishing activity by the local people was seen. Baga is situated further south of Anjuna beach and north of Calangute beach. There is a small creek, which opens into the sea. This creek rivulet shows the presence of few mangrove species. On the southern side of this area (7km) lies Calangute beach, which is sandy; while on the northern side the area shows the presence of rocky boulders. The rocky substratum shows the presence of tide pools, which in turn shows the presence of algal species. Local fishing activity is seen in this area.

A small patch of mangroves was found at Baga. Dominant species were that *Avicennia marina, A. officinalis* and *Rhizophora mucronata.* The mangroves were in a degraded form

About 30 species of seaweeds have been recorded from this station (Table 3.22). Rhodophyta members dominate this station. *E. intestinalis, C. media, U. fasciata* and *Giffordia* sp. were present in the supralittoral region. The dominant species of the rock pools of midlittoral region were *Hypnea musciformis, Gracilaria corticata* and *Sargassum* sp. Other prominent community associations were seen in between *Padina-Caulerpa-Hypnea, Spatoglossum-Stoechospermum,* *Dictyota-Sphacelaria* and *Gracilaria-Grateloupia.* At the infra-littoral zone species of *Sargassum* showed luxuriant growth in association with *Gracilaria corticata* and *Hypnea musciformis. Sargassum, Hypnea* and *Gracilaria* were dominant quantitatively while *Ulva fasciata, P. tetrastromatica* and *Spatoglossum asperum* were also present, but the biomass was quite less. *Gelidium pusillum* was found growing on the outer shells of barnacles. During the monsoon months *Porphyra vietnamensis* was found growing along with *Enteromorpha flexuosa, Ulva fasciata* and *Chaetomorpha media*, but the biomass of *Porphyra vietnamensis* was quite less as compared to the other stations. The growth of *Ulva* and *Enteromorpha* was found to be patchy. *Acanthophora spicifera* was found growing in huge clumps.The average biomass value recorded from this station was 1.52 kg/m^2.Agarophytes and alginophytes can be harvested from this station in fairly good amount.

From Baga around 45 species of marine algae have been reported (Table 3.22). This is one of the most important area along the Goa coast where there is good distribution, abundance and biomass of the species. The algae were seen in association of 2 or 3 species. The most dominant species present were *Ulva fasciata, Chetomorpha media, Enteromorpha clathrata, Padina tetrastromatica, Hypnea misciformis, Acanthophora spicifera* etc. Rock pools were found on all the tide levels. Luxuriant growth of algae was seen in the littoral rock pools. Dominant species of the mid-littoral region were *Caulerpa scalpeliformis, Bryopsis* sp., *Hypnea musciformis, Padina tetrastromatica, Acanthophora* *spicifera, Grateloupia* sp., *Laurencia papillosa, Spatoglossum asperum, Stoechopermum marginatum, Ulva fasciata, Chaetomorpha media* etc. During the monsoon month's species such as *Porphyra vietnamensis, Caloglossa* and few species of Chlorophyta such as *Ulva fasciata, Chaetomorpha media* were also seen. Mean algal biomass of this station was 1.61 kg m^{-2}. Major contributors to biomass were species of *Sargassum, Padina, Ulva, Stoechospermum, Spatoglossum* etc.

Sandy shores along this region show the presence of few prominent dunes. These dunes, which are present, are with hardly any vegetation, as the area is been reclaimed for construction of hotels and restaurants. These areas are one of the major tourist areas. Patchy growth of *Spinifex littoreus*, along with few plants were seen. Coconut plantation was seen mostly in the backshore region.

3.5.2.4 Mandovi estuary

The Mandovi estuary of Goa (Lat 14° 54' and 15° 48' N and Long. 73° and 74° 20'E) forms an integral part of the Mandovi-Zuari- Cumbarjua canal system on the west coast of India and it mixes with the Arabian Sea. (Fig 3.13). This estuary is about 3 km wide at the mouth and 0.5 km in width towards upstream (Jagtap, 1985). The total estuarine system is about 137 km in length. The mouth region is devoid of any mangroves as a result of rocky substratum, strong wave action and currents, but these areas showed the growth of algal species.

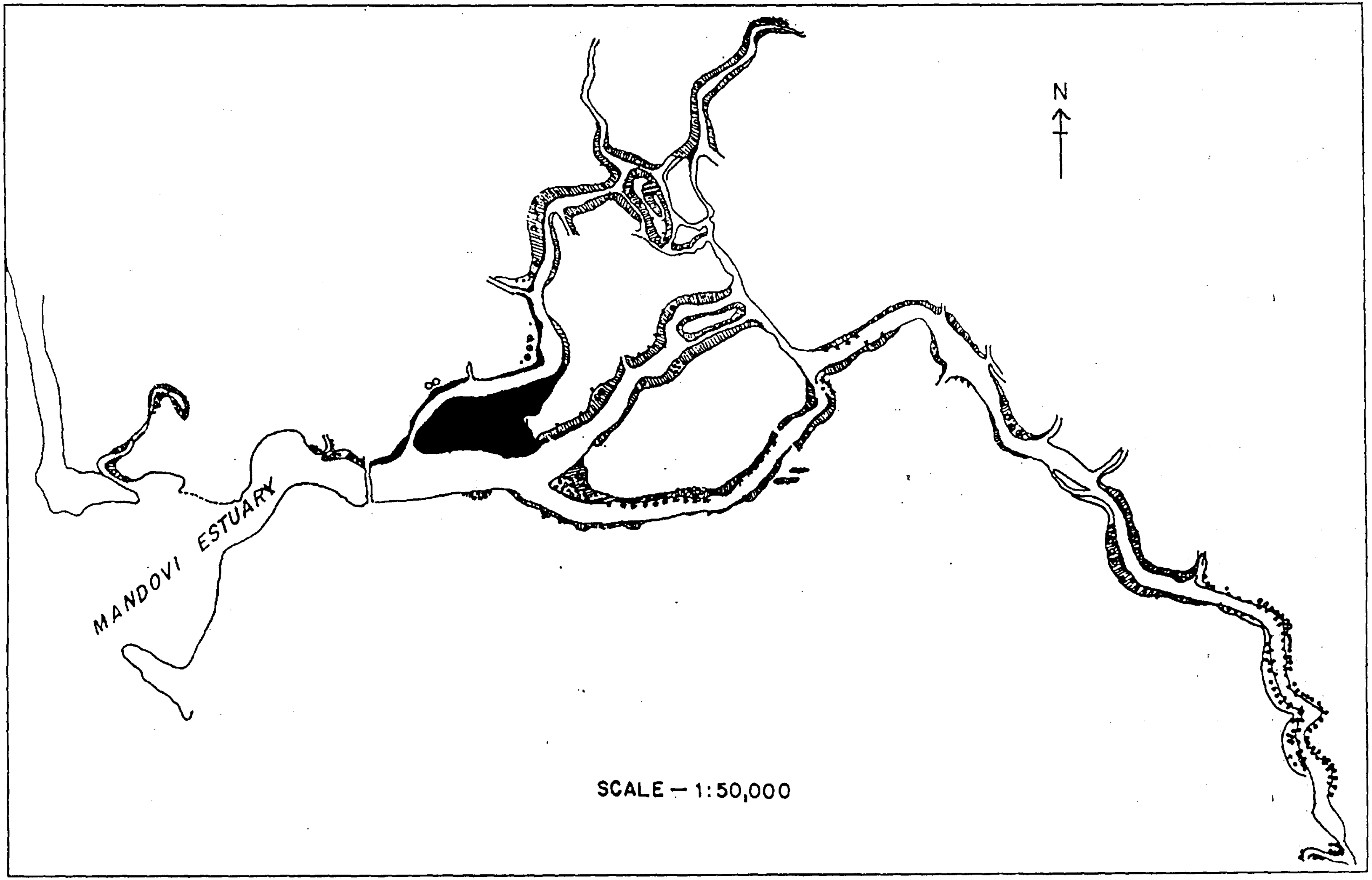


Fig. 3.13 Map of Mandovi estuary showing distribution of mangroves

The first appearance of mangroves was seen with the occurrence of *Sonneratia alba* species in the creek of Mandovi estuary near Betim. *Avicennia* seedlings were seen in between the rocky area were the substratum was muddy. Good growth of mangroves started from Orda, where the creek showed the presence of mixed type of vegetation with *Avicennia officinalis* as the dominant species. The species present were *R. mucronata,, E.agallocha* and *A. illicifolius. Rhizophora* was seen growing below the Mandovi Bridge and continued dominance along the northern bank (Table 3.23). Denser vegetation was seen in Chorao.

Mandovi estuary at Goa, in its middle reaches, branches off into river Mapusa on the northern side and river Mandovi on the southern side, forming an island in the middle called as Chorao Island (Fig 3.14). The total area of the Chorao Island is 423.75 hectares, and the mangrove cover of the Island is about 250 ha (Wafar 1988).

Chorao Island shows a very good growth of mangroves, which serves as a site for tourist, education centre for students etc. Mangrove nurseries are developed at this site. A observation tower present in the middle of the mangrove forest (Plate 6b). Altogether 16 number of species of mangroves and its associates were reported with the dominance of *Rhizophora apiculata, R. mucronata, Sonneratia alba, Avicennia marina A. officinalis* etc (Table 3.23) (Plate 7a). A total of 17 marine algae were reported from these sites. The list of marine algae present and its ecological status is given in Table 3.17.

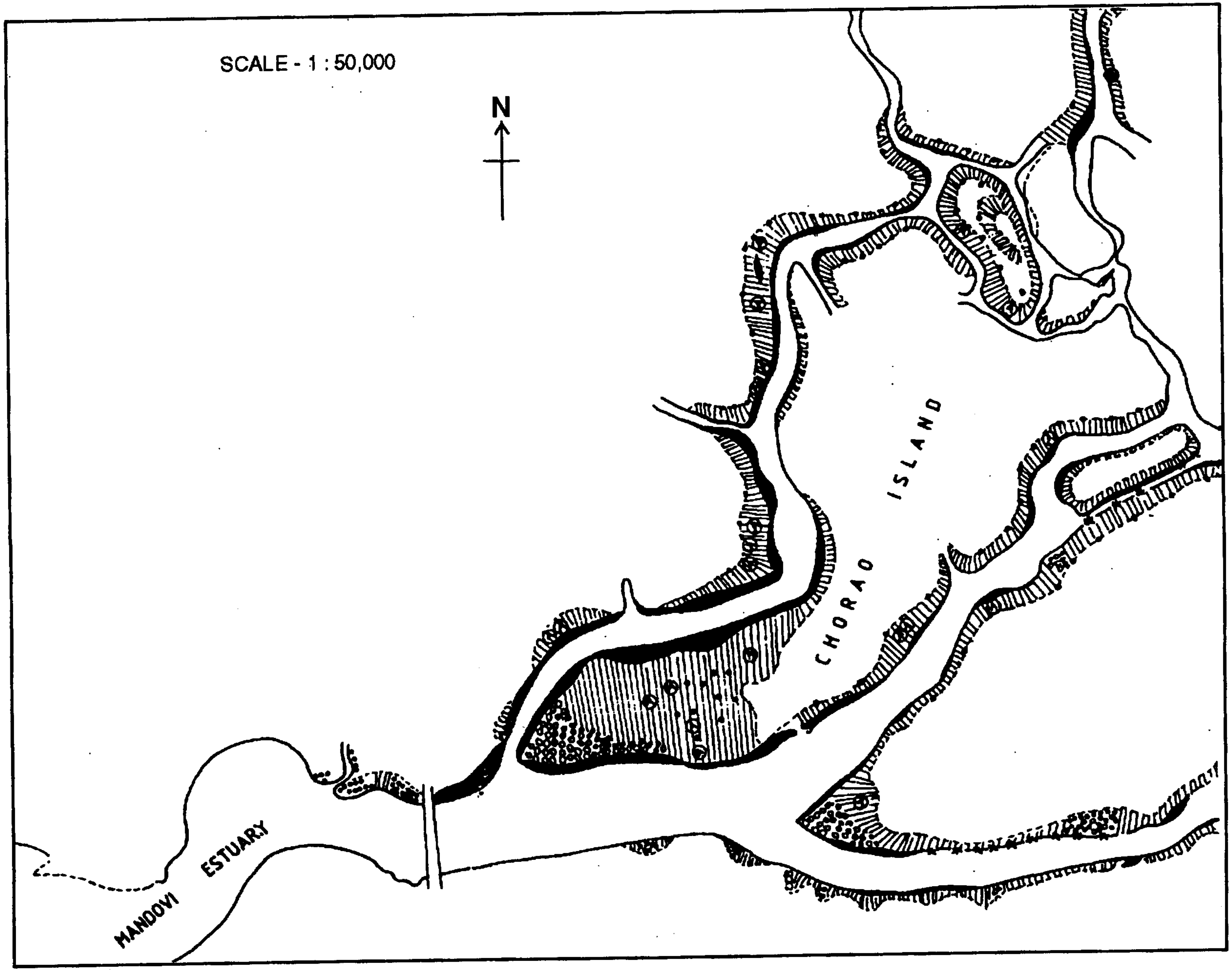


Fig.3.14 Map of Chorao Island showing distribution of mangrove

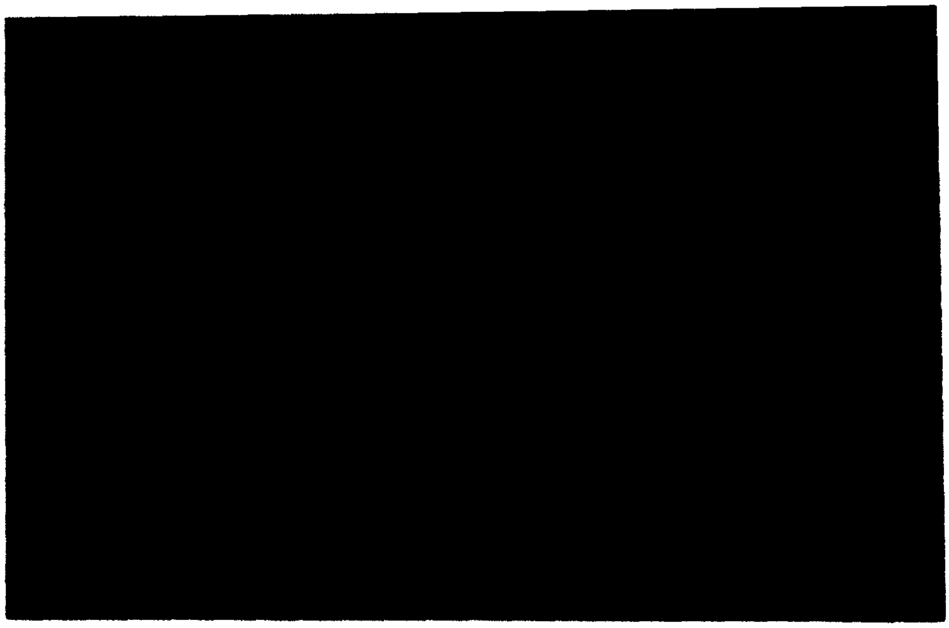


Plate 6a: Afforestation of mangroves along the Maharashtra coast

Plate 6b: Observation tower in the mangrove forest of Chorao, Goa

Table 3.17 List of marine benthic algae recorded and their ecological status at Chorao island, Goa

S.No	Species Name	Ecological status
1	*Enteromorpha clathrata* (Roth) J.Agardh	C
2	*Enteromorpha intestinalis* Linnaes	C
3	*Enteromorpha flexuosa* (Wulfen) J. Agardh	R
4	*Ulva fasciata* Delile	C
5	*Chaetomorpha linum* (Muell) Kuetz.	C
6	*Padina tetrastromatica Hauck*	OC
7	*Colpomenia sinuosa* Derbes et Solier	OC
8	*Catenella repens*(Lightf.) Batt.	AB
9	*Gracilaria verrucosa* (Huds) Papenfuss	C
10	*Caloglossa leprieurii* (Mont.) C. Ag.	C
11	*Bostrychia tenella* (Vahl.) J. Ag.	OC
12	*Polysiphonia macrocarpa* Greville	C
13	*Oscillatoria* sp.	C
14	*Phormidium fragile.*	C
15	*Phormidim* sp.	C
16	*Schizothrix* sp.	C
17	*Chlorococcus turgidus*	C
18	*Anabaena* sp.	C

C: Common, R: Rare, OC: Ocassional, AB: Abundant

This site serves as a bird sanctuary and is named as Dr. Salim Ali Bird sanctuary. A total of 46 birds were reported of which 33 were resident bird species and 13 of them migratory. (Table 3.18). Chinnaraj (1993). Reported 65 species of marine fungi of which 49 belongs to Ascomycetes, 1 to basidiomycetes and 15 species to deuteromycetes (Table 3.19). Other fauna reported includes 13 species of fishes 12 species of crustaceans and 5 species of gastropods were also found. (Table 3.20, 3.21).Afforestation of mangroves have been undertaken by the Forest Department (Plate 7b).

Zonation along the Mandovi estuary of the mangroves was found to be distinct, where it is mostly dependent on the salinity gradient. In the polyhaline zone (18 to 30 %), mangrove species like *R. mucronata, Avicennia officinalis, A. marina, S. alba* were seen, while in the mesohaline zone (5 to 18%) *Kandelia candel, R. apiculata, Avicennia officinalis, B. cylindrica* were observed. The oligohaline zone (0.5 to 5%) region was characterized by the presence of *S. caseolaris, Kandelia candel, Excocaeria agallocha, Acanthus ilicifolius, Derris heterophylla, Acrostichum aureum.* The average height of the major mangrove species varied from 5 to 12 m.

Along the northern bank of Mandovi estuary, near Reis Magos Fort, intertidal rocks were covered with number of seaweed species. In this Rhodophyta was represented by number of species while, the Phaeophyta member, *Padina tetrastromatica* dominated in biomass occupying entire rock surface in varying

Table 3.18 List of Avifauna recorded with common names from Chorao island, Goa

S.No	Scientific name	Common name
	Resident Bird species	
1	*Ardeola grayil* Sykes	Pond heron
2	*Bubulous ibis* Linne	Cattle erget
3	Elanus caeruleus	Blackwinged kite
4	*Haliastur indus* Boddaert	Brahminy kite
5	Milvus migrans Buddaeri	Pariah kite
6	*Alcedo atthis Linne*	Small blue kingfisher
7	*Alcedo meninting*	Blue eared Kingfisher
8	Ceryle rudis Linne	Lesser pied kingfisher
9	*Halcyon smyrenensis Linne*	White breasted Kingfisher
10	*Coracias benghalensis Linnaeus*	Roller or Blue Jay
11	*Upupa epops*	Hoopoe
12	*Micropternus brachyurus Vieillot*	(Rufous Woodpecker)
13	*Dinopium benghalense*	Goldenbacked Woodpecker
14	*Oriolus trailii*	Vigors Maroon Oriole
15	*Dicrurus leucophaeus Vieillot*	Grey or Ashy Drongo
16	*Sturnus malabaricus Gmelin*	Greyheaded Myna
17	*Dendrocitta vagabunda Latham*	Tree pie
18	*Tephrodornis virgatus Temminck*	Largewood shrike
19	*Vanellus indicus Boddaert*	Redwattled Lapwing
20	*Ardea cinerea Linne*	Grey Heron
21	*Ardea alba* Linne	Lesser Egret
22	*Tringa hypoleucos Linne*	Common sandpiper
23	*Triga totanus*	Redshank
24	*Numenius arquata* Linne	Curfew
25	*Hydrophasianus chirurgus* Scopoli	Pheasant tailed Jacana
26	*Nectarinia asiatica Latham*	Purple Sunbird
27	*Himantopus himantopus* Linne	Stilts
28	*Melops orientalis* Latham	Green bee eater
29	*Copsychus saularis* Linne	Magpie Robin
30	*Orthotomus sutorius*	Tailor Bird
31	*Hirundo rustica* Linne	Common swallow
32	*Mycteria leucocephala*	Storks
	Migratory bird species	
1	*Anus acuta* Linne	Pintailed Ducks
2	*Fulica atra*	Coots
3	*Porphyrio porphyrio*	Purple moorthen
4	*Phalacrocorax carbo* Linne	Cormorant
5	*Anhinga rufa*	Darter

6	*Anas clypeata* Linne	Shoyeller
7	*Anus crecca* Linne	Teal
8	*Anas platyrhynchos* Linne	Duck chicks
9	*Sarkidiornis melanotos* Pennat	Nekta Duck
10	*Sterna hirundo* Linne	Common Tern
11	*Larus* sp	Sea Gull
12	*Anastomus oscitans* Boddaert	Openbill storks
13	*Ephippiorhynchus asiaticus* Latham	Black necked storks

Table 3.19 List of marine fungi and it ecological status from Chorao island, Goa

S.No	Species Name	Ecological status
	Ascomycetes	
1	*Acrocordiopsis patilii* Borse et Hyde	OC
2	*Aigialus grandis* Kohlm. Et Schatz	OC
3	*A. mangrovei* Borse	OC
4	*A. parvus* Schatz et Kohlm	R
5	*Aniptodera chesapeakensis* Shearer et Miller	OC
6	*Aniptodera* sp.	R
7	*A. mangrovei* Hyde in Hyde	R
8	*Ascocratera manglicola* Kohlm	C
9	*Biatriospora marina* Hyde *et* Borse	OC
10	*Dactylospora haliotrepha* (Kohlm *et* Kohlm) Hafellner	OC
11	*Halosarpheia abonnis* Kohlm	R
12	*H. marina* (Cribb *et* Cribb) Kohlm	R
13	*H. ratnagiriensis* Patil *et* Borse	OC
14	*H.minuta* Leong in Leong	R
15	*H. retorquens* Shear *et* Crane	R
16	*Halosphaeria quadricornuta* Cribb *et* Cribb	OC
17	*Helicascus kanaloanus* Kohlm	OC
18	*Hydronectria tethys* Kohlm *et* Kohlm	R
19	*Hypoxylon oceanicum* Schtz	C
20	*Leptosphaeria australiensis* (Cribb *et* Cribb) Hughes	OC
21	*Leptosphaeria tax* sp.	R
22	*Leptosphaeria longirostris* Cribb *et* Cribb Kohlm	OC
23	*Lophiostoma mangovei* Kohlm *et* Vittal	C
24	*Lulworthia grandispora* Meyers	C
25	*Lulworthia* sp.	OC
26	*Marinosphaera mangrovei* Hyde	OC
27	*Massarina velatospora* Hyde *et* Borse	OC
28	*Massarina thalassiae* Kohlm *et* Volkm Kohlm	R
29	*Massarina ramunculicola* Hyde	R
30	*Nais* sp.	OC
31	*Passeriniella savoryellopsis* Hyde *et* Jones	OC
32	*Savoryella lingnicola* Jones *et* Eaton	OC
33	*Savoryella paucispora* Cribb *et* Cribb Koch	R
34	*Verruculina enalia* (Kohlm) Kohlm *et* Volkm Kohlm	C
35	*Saccardoella marinospora* Hyde *et* Mouzouras	R

36	*Payosphaeria minuta* Leong in Leong	OC
37	*Quintaria lingnatilis* (Kohlm) Kohlm *et* Volkm	R
38	*Rhizophilla marina* Hyde	OC
39	*Saccardoella rhizophorae* Hyde	R
40	*Capillataspora corticola* Hyde	R
41	*Julella avicenniae* (Borse) Hyde	R
42	*Belizeana tuberculata* Kohlm *et* Volkm Kohlm	R
43	*Lineolata rhizophorae* Kohlm *et* Kohlm	R
44	*Zopfiella marina* Furuya *et* Udagawa	R
45	*Torpedospora radiata* Meyers	R
46	*Coronopapilla mangrovei* (Hyde) Kohlm *et* Volk	R
47	*Leptosphaeria tax* sp.	R
48	*Philophorophoma litoralis* Linder in Barghoorn	R
49	*Halonectrian tax* sp.	R
	Basidiomycetes	
50	*Halocyphina villosa* Kohlm *et* Kohlm.	C
	Deuteromycetes	
51	*Cirrenalia basiminuta* Raghukumar *et* Zainal	R
52	*Cirrenalia pseudomacrocephala* Kohlm	R
53	*Cirrenalia pygmea* Kohlm	C
54	*Cirrenalia tropicalis* Kohlm	R
55	*Cytospora rhizophorae* Kohlm *et* Kohlm	R
56	*Humicola alopallonella* Meyers *et* Moore	R
57	*Monodictys pelagica* (Johnson) Jones	R
58	*Periconia prolifica* Anasta	C
59	*Phoma* sp.	OC
60	*Trichocladium achrasporum* Meyers *et* Moore	OC
61	*Zalerion varium* Anasta	OC
62	*Etheirophora blepharospora* Kohlm *et* Kohlm	R
63	*Cladosporium* sp.	R
64	*Calathella mabgrovei* Jones et Agerer	R
65	*Clavatospora bulbosa*(Anasta) Nakagiri *et* Tubaki	R

Source Chinnaraj (1993) R: Rare; OC: Ocassional; C: Common

Table 3.20 List of other faunal species and their ecological status from Chorao island, Goa and their ecological status

S.No	Name of the species	Ecological status
	Crustaceans	
1	*Penaeus monodon*	C
2	*Penaeus indicus*	C
3	*Panaeus merguiensis*	C
4	*Metapenaeus dobsoni*	C
5	*Metapenaeus affines*	C
6	*Macrobrachium* sp.	C
7	*Alpheus* sp.	C
8	*Scylla serrata*	C
9	*Macroplalmus* sp.	C
10	*Uca annulipes*	C
11	*Diogenes cusias*	C
12	*Clibanarius padavensis*	C
	Mollusca	
13	*Gelonia erosa*	C
14	*Saccostrea cucullata*	C
15	*Crassostrea madrasensis*	C
16	*Perna viridis*	OC
17	*Meritrix* sp.	OC
	Gastropods	
18	*Telescopium telescopia*	C
19	*Cerithium morum*	C
20	*Cerithidea flaviatilis*	C
21	*Littorina scabra*	C
22	*Drupa acuta*	C
	Reptiles	
23	*Crocodilus palustris*	OC
24	*Snakes*	C
25	*Phython*	C
	Mammals	
26	Canis aureus (Jackal)	OC
27	*Pteropus giganteus* (Indian flying fox)	R
28	*Delphinus delphis* (common Indian dolphin)	R
29	Otters	C
30	Bats	C

( ) : Common names, OC : Ocassional, C- Common, R: Rare, EN : Endangered, A: Abundant

Table 3.21 List of Fishes with common name and their ecological status from Chorao island

S.No	Scientific name	Common name	Ecological status
1	*Mugil cephalus*	Mullets	C
2	*Mugil tada*	-	OC
3	*Boliopthalmus dussumieri*	Mud skippers	C
4	*Trypauchen vagina*	Mud skippers	OC
5	*Lutjanus* sp.	Tamboso	C
6	*Etroplus suratensis*	Kalundra	C
7	*Gerres setifer*	Kharchane	C
8	*Arius* sp.	Catfish	C
9	*Pseudorhombus rhombi*	Flat fish	OC
10	*Ambassia gymnocephalus*	Buriyato	C
11	*Therapon jarbua*	Indian baracuda	C
12	*Therapon puta*	-	C
13	*Chanos chanos*	Ghodsi	C

C: Common, OC: Ocassional

Plate 7a: Association of different species of mangroves

Plate 7b: Afforestation of mangroves along the Goa coast

degree of concentration. The average biomass recorded for this species was 215 g/m^2 (wet wt.).

Towards the downstream portion near the mouth of the estuary along the northern bank at Reis Magos, rocks harboured number of algal species. At this site Rhodophyta dominated the algal composition. *Acanthophora spicifera* grew abundantly on the rock surface. This species showed luxurious growth with maximum frond length of 11 to 12 cm., with an average biomass of 419 g/m^2 (wet wt). Other dominant algal species were *G. corticata* and *Ahnfeltia plicata. Ahnfeltia plicata* was seen growing in the rock crevices and in the sunken surfaces of the rocks. Overall the growth of the algal species at the study sites was healthy.

In the vicinity of **Marlim jetty** and **Betim**, a small patch of mangrove comprising of *R. mucronata, S.alba, A.marina, A.officinalis* were seen. The average height of the trees in this area was about 4m. The growth was found to be stunted. Most of the plants were cut by the local people to use as firewood. Although the substratum consisted of silty-clay which is ideal for settling of the mangrove seedlings and their growth, very few such plants could be observed in this area. Human disturbances arising out of the activities of fisheries jetty could have been responsible for preventing the growth of new plants resulting in the low crop in the area.

A seaweed species, *Enteromorpha clathrata* was found growing abundantly in the muddy area, which were attached to the pebbles and dead molluscan shells. The fronds of this species grow to a length of about 50 to 60 cm. The average biomass recorded for this species was 930 g/m^2.

Some seedlings of *Avicennia marina* were also found growing in the Reis Magos rocky area. The seedlings must have been washed ashore from the upstream region of the mangrove area and trapped in the rock crevices where they grew further.

Along the southern bank of the Mandovi estuary near the Mandovi bridge, mangrove plantation was carried out by the Forest Department, Govt. of Goa. *Rhizophora mucronata* seedlings were raised in the nursery and then transplanted at this site. The seedlings have shown healthy growth and are 2-.5 m in height.

The area opposite Goa medical college which receives the sewage discharge is a estuarine flat which get exposed during the low tide. The substratum is sandy-clay and showed the presence of *Ulva reticulata, Gracilaria verrucosa* and *Enteromorpha clathrata*. The most dominant species of this site was *U. reticulata* with an average biomass estimated to be 134 g/m^2 (Wet weight). *G. verrucosa* a Rhodophyta member was second dominant species of this site. *G. verrucosa* intermingled with *C. linum* and the former showed comparatively high biomass than *U. reticulata* (Table 3.22). The presence of these algal species indicated that this area is still under the influence of sewage pollution.

A small patch of sand dune was observed near the Children Park, Campal. Although, the sand dune area is small, it harbours characteristic dune vegetation. The dominant species of the dune vegetation was *Ipomoea pes- capre* covering 78 % of the dune area . This creeper showed healthy growth all along with profussed branches measuring 3 to 4 m long. The average biomass of this dune species was 765 g / m ^{2}.

Spinifex littoreus, showed patchy distribution. The average length of the stolon was 4.5 m having an inter-node at 13 cm. Nodes produce long roots, which initially run vertically and then obliquely below the sand. The biomass recorded for this species was 538 g / m ^{2}. Other species recorded from this area were *Cyperus arenarius, Pandanus tectorius and Clerodendrum inerme.* At the backshore zone of the dunes *Casuarina equisetifolia* plantation has been undertaken to minimize the wind effect.

On the southern bank of the Mandovi estuary i.e. near the Sports Complex, where the treated sewage discharge point was located, green alga, *Chaetomorpha linum* was dominant. The filaments of this species grew up to 60 to 70 cm in length. Although, the substratum was sandy, this species grew on the dead molluscan shells and debris trapped in the sand. The average biomass of *C. linum* was 478 g/m^2 (Wet weight).

At Miramar the sandy shore is broad and is about 90-100 m in length and is one of the famous tourist spot. These area does not show the presence of any rocky area, hence no seaweeds. The backshore region shows the presence of *Casuarina* sp. plantation. In the mid-shore region Forest Dept of Goa has undertaken plantation of *Cocos nucifera*. While at the foreshore region *Ipomoea pes-caprae, Boerhvia diffusa* , *Crotolaria retusa* , *Leucas aspera* was seen. At some places on Caranzalem side the fore dune has thick carpet of *Ipomoea pes-caprae* in association with *Spinifex littoreus, Amaranthus spinosa, Boerhavia diffusa, Crotalaria retusa* and *Zornia diphyla*, while on the Panaji side the fore dune vegetation is destroyed by plantation of *Casuarina*. List of sand dune species recorded along the Goa coast is given in Table 3.16. This plantation would have been successful in maintaining the fore and mid dune system if the plantation was taken up at the backshore. But the back-dune is totally absent due to Urbanization.

3.5.2.5 Dona – Paula

It is just at the mouth of Zuari River, opposite to Marmugao harbour. The coastline is characterized by rocky outcrops, which encloses small sandy beaches and the Dona Paula bay. Substratum is of laterite boulders, cliffs, abruptly merging with the sea. Mouth region of the estuary is full of rocky outcrops that emerge only during low tides. Because of harbour activities, Dona-Paula area gets affected mainly by turbid waters. Observations were also taken at Marvel beach. The Marvel beach is a small semi - circular beach of about 150 m in length. On the either side of the beach there are laterite boulders, which extend into the sea.

Algal zonation was normal like other stations. Qualitatively algal flora is rich with 40 taxa. Upper-littoral was generally dominant of herbivorous animals and oysters. Upper littoral was inhabited by species of *Porphyra, Ulva, Enteromorpha* and *Chaetomorpha* which all form an association. Other minor algae such as *Caloglossa leprieurii* and *Gelidium pusillum* were also observed that extend downwards also. A delicate Phaeophytan alga *Dictyota bartayresiana* forms a mat like growth on rocks in mid-littoral zone. The zonation of *Grateloupia filicina* and *Acanthophora spicifera* in mid-littoral is like earlier station-Terekhol. *Sargassum* spp. was dominant from mid to lower, and at lower-littoral, and at lower-littoral chlorophyta alga *Codium* spp. and Rhodophyta algae- *Scinaia hatei* and *Palmaria palmata* was present. Some rare occurrence of algae were those of *Arainvillea* sp. and *Ralfsia* sp., which generally grow in standing water (pools), on mud covered rocks and thalli also were encrusted with thin layer of silt (Plate 8a). *Caulerpa verticillata, Martensia fragilis* grow as patches on vertical faces of rocks mostly in sheltered areas

(Table 3.22). *Sargassum* species was found growing to the maximum height of 1-2 m and were profusely branched.

Some tide and rock pools were present in the intertidal area, inhabited with species of *Arainvillea, Padina, Sargassum, Stoechospermum, Acanthophora, Gelidiopsis* etc. Some seaweeds drift ashore, mainly due to disturbances (turbulence) and the major among them were - *Dictyota* spp., *Padina tetrastromatica, Sargassum* spp. and *Ulva fasciata. P. vietnamensis* was found growing luxuriantly during the monsoon months with an maximum biomass of 1.2 kg/m^2 in mid August. These are do no have significant dunes.

Marvel beach, many rock pools are present at upper littoral and lower littoral levels which harbours many algal species. Algal representation at this station, both qualitatively and quantitatively is high. In all about 46 algal species have been recorded from this area.

The algal demarcation can be seen very clearly at this locality. *Ulva, Enteromorpha*, *Chaetomorpha* and *Cladophora* represented the supra-littoral region. Most of places these species were seen associated with each other.

The mid-littoral region is represented by many algal species. Species of *Arainvillea* and *Ralfsia* are found only at this locality along the Goa coast. *Spatoglossum, Stoechospermum* and *Padina* dominated this region and their growth observed till the end of May. *C. verticillata* was found growing separately in the rock pools, while species of *Ralfsia* and *Gelidiopsis* were seen growing together. Many shallow rock pools have been observed with only *Acanthophora* growing in them. Species of *Arainvillea* was found growing in shallow rock pools with *Padina*. At the lower mid littoral rock pools species of *Sargassum* and *Spatoglossum* sp. were seen. The infra littoral region is dominated by species of *Sargassum* which grows abundantly at this station. In the month of December *Sargassum* was found growing luxuriantly with an average length of about 0.75m. *Spatoglossum asperum* and *Stoechospermum* marginatum was also found growing abundantly at this region. The average algal biomass was 1.63 kg/m^2.

Large numbers of species belonging to Phaeophyta were found drifted on the shore due to turbulent conditions. The dominant species were *Dictyota, Padina* and *Sargassum* with few drifted fronds of *Dasya* and *Laurencia*. From this station alginophytes like *Sargassum* can be harvested in large amounts.

3.5.2.6 Cabo-De-Rama

This station is situated towards the southernmost part of Goa, which showed a mixed coastline covering sandy beaches and rocky coasts. The sandy beach is situated towards the northern side while the rocky area is on the southern side. The cliff has an irregular shoreline with many rocky boulders projecting into the sea. Intertidal expanse at this station is quite wide. Large laterite boulders were present in the supra-littoral region. This rocky substratum harbours innumerable rock pools of various sizes. Rock pools harbour majority of the algal flora. Fishing activity is negligible at this station.

Algal representation was very high at this station with about 40 species belonging to different groups (Table 3.22). *Enteromorpha* sp. of 15 cm in length was found growing in the supra-littoral region. This alga covers entire exposed surface of the rock. The mid-littoral region is represented by many algal species. In the upper mid-littoral region species of *Ulva* and *Chaetomorpha* form a mat on the rocky surface. Below these species of *Padina, Stoechospermum, Gracilaria* and *Hypnea* grow profusely. *Acanthophora spicifera* was found to prefer mid-littoral zone with few patches of *Grateloupia filicina.* From the mid-littoral zone to lower littoral zone *Sargassum* sp. was prominent. Various large littoral rock pools have been observed which are qualitatively and quantitatively rich in algal production. Because of these rock pools, the algal production at this locality is considerable. *Sargassum* sp. was dominating the lower littoral region and is represented with other species such as *Gracilaria corticata, Stoechospermum marginatum, Spatoglossum asperum.* The average algal biomass recorded was 1.54 kg/m^2 (wet wt.).This station is very rich in agarophytes like *Gracilaria* sp. and *Hypnea* sp. and alginophytes like *Sargassum* sp. As at other stations, the monsoonal presence of *P. vietnamensis* along with the species of *Enteromorpha* sp.and *Chaetomorpha* sp. was observed.

Table 3.22 List of marine algal species recorded at few stations along the Goa and their ecological status

Sr. No.	Name of the species	Ecological status					
		Tere-khol	Cha pora	Anjun a-Baga	Man-dovi	Dona Paula	Cobo-de-Rama
	CHLOROPHYCEAE						
1	*Enteromorpha clathrata*	D	C	D	R	C	D
2	*Enteromorpha flexousa*	C		C	R	R	-
3	*Enteromorpha compressa*	R	-	-	-	-	C
4	*Enteromorpha intestinalis*	-	R	C	R	-	C
5	*Ulva fasciata*	D	C	D	C	C	D
6	*Ulva lactuca*	-	-	R	-	-	-
7	*Ulva reticulata*	R	D	-	D	R	-
8	*Chaetomorpha media*	C	C	D	R	C	D
9	*Chaetomorpha linum*	-	R	C	D	-	-
10	*Cladophora prolifera*	R	-	R	R	-	C
11	*Cladophora saracenica*	R	-	C	R	R	C
12	*Bryopsis hypnoides*	-	-	R	-	-	-
13	*Bryopsis plumosa*	-	-	R	R	-	C
14	*Caulerpa scalpelliformis*	-	-	R	-	-	C
15	*Caulerpa peltata*	-	-	C	-	-	C
16	*Caulerpa verticillata*	-	-	-	C	C	-
17	*Caulerpa racemosa*	-	-	R	-	-	C
18	*Caulerpa sertularioides*	-	-	R	R	R	C
19	*Codium elongatum*	-	-	-	-	R	D
20	*Microdictyon* sp.	-	-	R	-	-	R
21	*Arainvillea* sp.	-	-	-	R	C	-
	PHAEOPHYHCEAE	-		-			
22	*Ectocarpus* sp.	-	R	R	R	-	C
23	*Giffordia* sp.	-	C	C	-	C	-
24	*Ralfsia* sp.	-	-	R	R	C	-
25	*Sphacelaria furcigera*	C	-	D	R	D	C
26	*Dictyota dichotoma*	R	-	C	C	C	C
27	*Dictyota bartayresiana*	C	-	C	R	C	C
28	*Dictyopteris australis*	-	-	C	R	C	C
29	*Padina tetrastromatica*	D	C	D	C	D	D
30	*Stoechospermum marginatum*	D	-	D	C	D	C
31	*Spatoglossum asperum*	D	-	D	C	D	D
32	*Colpomenia sinuosa*	-	-	R	R	R	-
33	*Sargassum cinereum*	D	-	D	-	-	-

34	*Sargassum wightii*	R	-	D	-	D	-
35	*Sargassum ilicifolium*	D	C	D	D	D	D
36	*Sargassum tenerrimum*	-	-	D	D	-	D
	RHODOPHYCEAE				-	-	
37	*Porphyra vietnamensis*	C	C	D	D	D	D
38	*Scinaia hatei*	-	-	-	R	-	-
39	*Asparagopsis taxiformis*	R	-	C	R	C	-
40	*Gelidium pusillum*	D	C	C	C	C	C
41	*Grateloupia filicina*	D	-	C	C	R	C
42	*Grateloupia lithophila*	-	-	C	-	-	-
43	*Gracilaria corticata*	D	C	D	C	C	D
44	*Gracilaria verrucosa*	D	D	-	R	R	-
45	*Gelidiopsis variabilis*	C	-	C	C	C	R
46	*Melobesia farinosa*	-	-	-	C	-	-
47	*Amphiroa fragilissima*	-	-	-	R	D	R
48	*Jania adherens*	-	-	-	R	-	-
49	*Cheilosporum spectabile*	-	-	C	R	-	-
50	*Hypnea musciformis*	D	C	D	C	-	C
51	*Hypnea cervicornis*	C	C	C	C	C	R
52	*Palmaria palmata*	-	-	-	R	R	R
53	*Champia* sp.	R	-	R	R	R	-
54	*Ceramium fastigiatum*	C	C	C	C	C	C
55	*Centroceras clavulatum*	C	C	C	R	C	D
56	*Caloglossa lepureurii*	D	C	C	R	C	R
57	*Acanthophora spicifera*	D	-	D	C	D	C
58	*Martensia fragilis*	-	-	-	R	R	C
59	*Catnella repens*	-	-	R	-	-	-
60	*Chondria tenuissima*	-	-	R	-	-	-
61	*Laurencia papillosa*	-	-	C	R	R	C
62	*Polysiphonia macrocarpa*	-	-	R	R	C	C
63	*Polysiphonia variegata*	-	-	R	R	-	-

C: Common; R: Rare

Table 3.23 List of mangrove species recorded at few stations along Goa coast and their ecological status

Sr. No	Name of the species	Ecological status			
		Terekhol	Chapora	Mandovi	Chorao
1	*Rhizophora mucronata*	C	R	D	C
2	*Rhizophora apiculata*	-	-	C	C
3	*Avicennia officinalis*	C	D	D	C
4	*Avicennia marina*	R	R	R	C
5	*Avicennia alba*	-	-	R	-
6	*Sonneratia alba*	C	D	D	C
7	*Sonneratia caseolaris*	R	D	D	-
8	*Kandelia candel*	R	D	D	C
9	*Bruguiera gymnorhiza*	-	-	R	R
10	*Bruguiera cylindrical*	-	-	R	C
11	*Exoecaria agallocha*	C	D	C	C
12	*Ceriops tagal*	E	-	-	-
13	*Aegiceras corniculatum*	R	-	R	R
14	*Acanthus ilicifolius*	C	C	D	C
15	*Derris heterophylla*	C	C	D	C
16	*Acrostichum aureum*	C	C	R	C
17	*Porteresia coarctata*	-	-	C	C
18	*Cleredendron inerme*	-	-	C	C

C: Common, R: Rare, E: Endangered, - = Absent

3.5.3 KARNATAKA COAST

Along these coast 21 sites were surveyed along the Karnataka coast (Fig 3.4, Table 3.24). List of coastal vegetation recorded along this coast is given in Table 3.3, 3.4, 3.25). Among the sites surveyed 4 sites were selected for biodiversity studies, which are as follows (Table 3.6).

3.5.3.1 Kalinadi estuarine complex

These estuarine complex lies towards the north of Karnataka coast (Fig 3.15). The mangroves along this estuary were mostly fringing type, and were recorded at Sunkeri, Kadvad, Sidda, Madhevada, Vilas Bandar, Kanasgiri, Sadashivgarh and Ramanathagudda. *Sonneratia alba* was one of the most dominating species found at Sunkeri and Kadvad. The other species present at Sunkeri are *Excoecaria agallocha, Avicennia alba, Avicennia officinalis, Acanthus ilicifolius, Rhizophora mucronata, Kandelia candel, Derris scandens* etc (Table 3.27). The waterlogged area of Madhevada is totally dominated by dense formations of *Rhizophora mucronata.* Kali estuary is also influenced by the tides with limited expanse and lesser algal growth. Two chlorophyta members, *Ulva reticulata* and *Monostroma* sp. were recorded from the estuarine area (Mavinhole creek). Growth of *Ulva reticulata* was less and the size of the thallus was comparatively small as compared to Chapora and Panaji stations.

Table 3.24 Sites surveyed along the Karnataka coast and their importance

Sr.No	Name of the sites	Importance of the sites
1	Kalinadi estuarine complex	♦ Mangrove forest ♦ *Sonneratia alba* dominating ♦ Two chlorophyta members recorded
2	Karwar	♦ Algal species recorded ♦ Rhodophyta members dominating
3	Gangavali Estuarine complex	♦ Mangrove area
4	Kumta	♦ 26 algal species recorded
5	Sharavathi Estuarine complex	♦ Mangrove vegetation
6	Honavar	♦ 35 algal species recorded ♦ Rhodophyta memebrs dominating ♦ Rare algae *Champia parvula* and *Bostrychia* sp. recorded
7	Bhatkal	Sandy and rocky coast ♦ Algal flora less
8	Shiroor	♦ Rocky and sandy substratum ♦ Sand dune vegetation ♦ Mangrove vegetation
9	Gangoli	♦ Sand dune vegetation ♦ Plantation of *Casuarina* sp. and *Cocos nucifera* Human disturbance
10	Marvathe	♦ Intermixed association of vegetation ♦ Sand dune vegetation ♦ Human disturbance
11	Beejady	♦ Sand dune vegetation
12	Koteshwar	♦ Sand dune vegetation ♦ Human disturbance
13	Chakra, Haladi and Kollur estuarine complex	♦ Mangrove forest ♦ Plantation of *Rhizophora mucronata*

		♦ Human interference
14	Malpe	♦ 5 islands ♦ 51 algal species recorded ♦ Sand dune vegetation
15	Suratkhal	♦ Sandy beaches ♦ Chlorophyta members dominating
16	Mulki and Pavanje Estuarine complex	♦ Mangrove plants
17	Udiyavara Hole	♦ Mangrove area
18	Swarna, Sita and Kodi estuarine complex	♦ Dense formation of mangroves
19	Kodi hole	♦ Good patch of mangroves ♦ Coconut plantation observed
20	Mangalore	♦ Sandy beaches and rocky area ♦ Algal species recorded ♦ Fishing activities noticed
21	Netravathi and Gurupur estuarine complex	♦ Mangrove vegetation ♦ No regeneration

Table 3. 25 List of sand dune species recorded from Karnataka coast

Sr.No	Family	Name of the species
1	**Convulvulaceae**	*Ipomoea pes-caprae*
2	**Asteraceae**	*Launaea pinitifida*
3	**Asteraceae**	*Vernonia cinerea*
4	**Labiatae**	*Leucas aspera*
5	**Asclepidiaceae**	*Calotropis gigantia*
6	**Nyctaginaceae**	*Boerhavia diffusa*
7	**Papilionaceae**	*Alysicarpus monilifer*
8	**Poaceae**	*Cynadon dactylon*
9	**Poaceae**	*Paspalum vaginatum*
10	**Poaceae**	*Spinifex littoreus*
11	**Poaceae**	*Zoysia matrella*
12	**Amaranthaceae**	*Achyranthes aspera*
13	**Vitaceae**	*Ceratopteria thalictroides*
14	**Palmae**	*Cocos nucifera*
15	**Pandanceae**	*Pandanus tectorius*
16	**Casuarinaceae**	*Casuarina euisitifolia*
17	**Verbenaceae**	*Clerodendron inerme*
18	**Cyperaceae**	*Cyperus arenarius*
19	**Rubiaceae**	*Borreria articularis*
20	**Fabaceae**	*Crotolaria striata*
21	**Fabaceae**	*Tephrosia purpurea*
22	**Fabaceae**	*Crotolaria verrucosa*
23	**Tiliaceae**	*Triumfetta rhomboidea*
24	**Pteridaceae**	*Adiantum lunulatum*
25	**Pteridaceae**	*Cheilanthus tenuifolia*
26	**Pteridaceae**	*Lygodium flexuosum*
27	**Moraceae**	*Ficus benghalensis*
28	**Lythraceae**	*Ammania baccifera*
29	**Elatinaceae**	*Bergia ammonoides*
30	**Rubiaceae**	*Hydrophylax maritima*
31	**Rubiaceae**	*Mollugo oppositifolis*

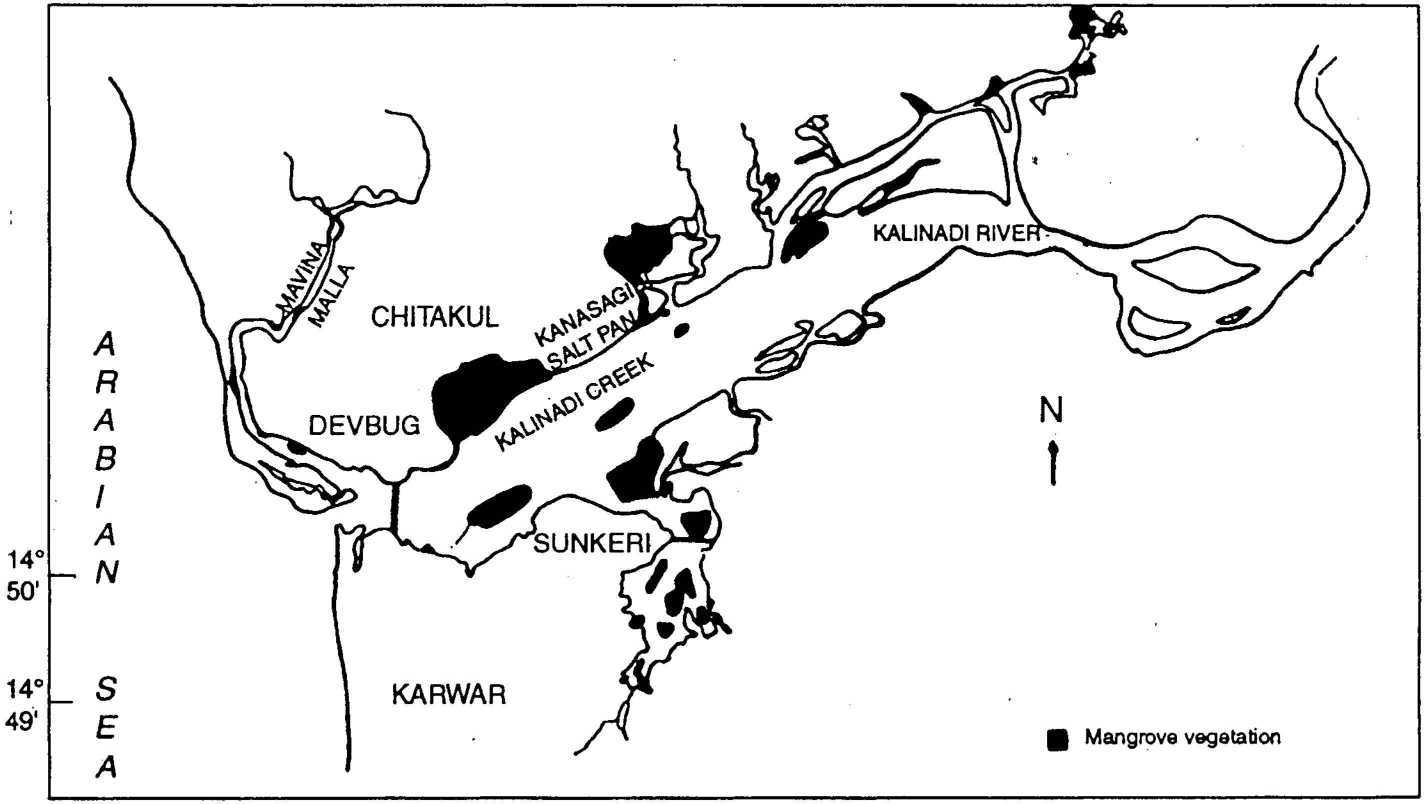


Fig. 3.15 Map of Kalinadi creek along Karnataka coast indicating mangrove formations

Karwar coast has both rocky and sandy belts. Kali river opens into sea near this station. Substrata consist mainly of granite boulders with few laterite rocks. Impact of wave action is tremendous due the presence of steep slope. Sandy beaches are present in between the rock promotories. Intertidal expanse is less. Qualitatively, members belonging to Rhodophyta (13) were dominating followed by Chlorophyta (12) and then by Phaeophyta (9) (Table 3.26). Supralittoral region was occupied with animals like- clams, barnacles, snails etc. Species like *Enteromorpha, Porphyra, Chaetomorpha* and *Ulva* were the typical of the upper- littoral region. Zonation at mid-littoral and lower- littoral is almost similar to the stations like - Ratnagiri, Malvan etc. A red alga *Grateloupia filicina* was found in the upper-littoral zone, and withstands heavy wave-action. *Sargassum* sp. occupied the mid-littoral to lower littoral zone. Dominant algae were - *Sargassum* sp., *Ulva fasciata, Padina tetrastromatica* and lesser ones were - *Stoechospermum marginatum*, *Porphyra vietnamensis, Gracilaria corticata* etc. The association of species was not clearly evident.

3.5.3.2 Sharavathi Estuarine complex

The Shravathi river has its origin at Ambutirtha in Tirthahalli taluka of Shimoga district (Fig 3.16). The mangroves along this area are in very poor condition, with only Honavar showing few mangrove species (Table 3.27). The mangrove flora was represented by *Rhizophora mucronata* followed by *Sonneratia caseolaris, Avicennia alba, Excoecaria agallocha, Acrostichum aureum,*

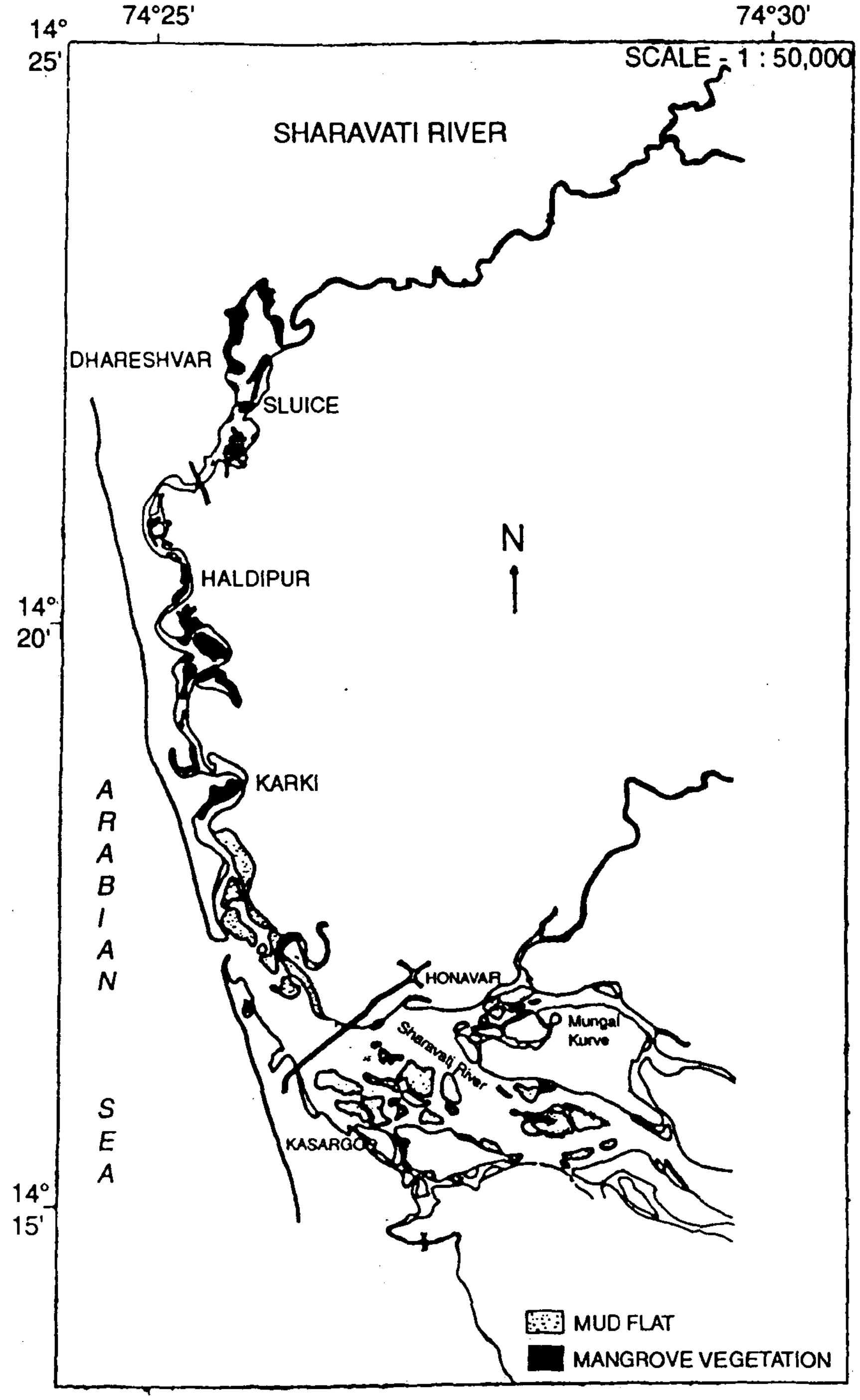


Fig.3.16 Map of Sharavati - Dhareshvar creek along Karnataka coast showing mangrove distribution

Portresia coractata and ocassionally by *Kandelia candel* with *Clerodendrum inerme.*The main reason for the reduction of mangroves habitats in these area are due to construction and use of mangroves for fuel. Most of the vegetation in this area is been destroyed. Honnavar coast, with wide intertidal expanse, and poor wave action. Substrate is of laterite rocks. Even though the beach is unevenly indented the beach profile is uniform with many sheltered areas. Altogether 32 species were recorded, with Rhodophyta and Chlorophyta dominating the collection. Zonation can be clearly demarcated here. *Caulerpa peltata, Gracilaria corticata* was found growing in the sheltered area of the upper littoral zone while *Caulerpa scalpelliformis* growing in the sheltered area of lower littoral zone. *Sargassum ilicifolium* was dominant alga followed by *Ulva fasciata, Padina tetrastromatica.*

3.5.3.3 The Chakra, Haladi and Kollur estuarine complex

This river is formed by several smaller creeks that meet and form a broad estuary to the north of Coondapur town, and meet the sea at Gangolli (Fig 3.17). Dense formations of mangroves are observed in many regions along these rivers such as Kodi, Vadera hobli, Jalady, Uppinakudru, Hemmadi, Kannada Kudru and Gujjady. In Kodi, the estuarine banks are over washed with each high tide nearer to the sea where as the banks away from the shore line are subjected to rise and fall of tidal water to a great extent. *Rhizophora mucronata* is exclusively dominant at several low lying places of the estuarine bank.

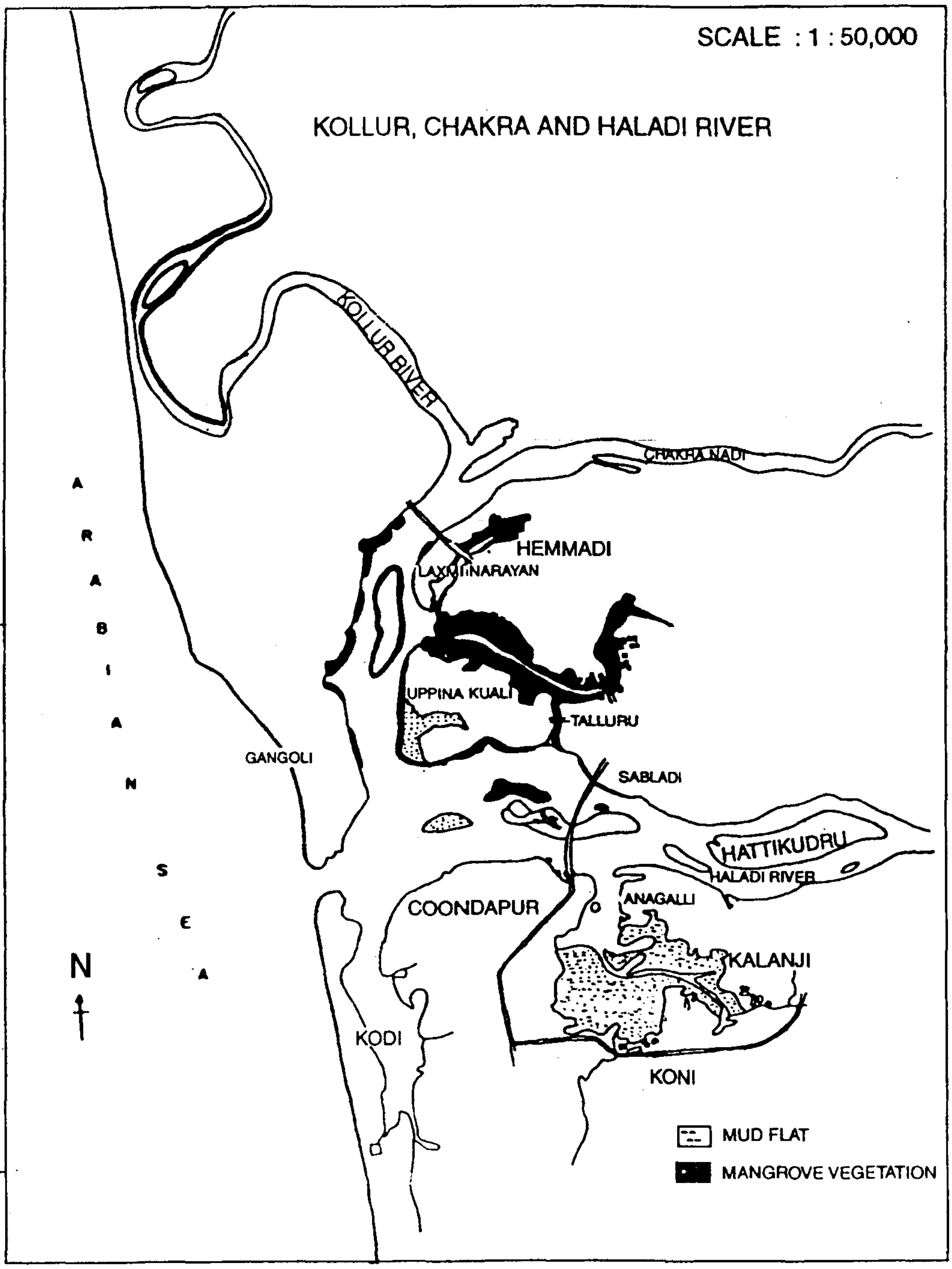


Fig. 3.17 Map of Kollur, Chakra and Haladi river along Karnataka coast showing mangroves distribution

Sonneratia alba occupy the higher levels of the estuarine banks often interspresed with *Acanthus ilicifolius*. The flat estuarine banks of this area are being covered with pure formations of *Avicennia alba* or *Sonneratia alba*. The trees of *Rhizophora mucronata* reach upto a height of about 4 m, as this area being a lagoon. It is highly subjected to the tidal influence. The regeneration is very much restricted due the narrow width of the niche. The area around Vadera hobli, is dominated by *Acanthus ilicifolius* and the tree forms of *Rhizophora mucronata, Kandelia candel* and *Avicennia alba.* A few trees of *Sonneratia caseolaris* and *Lumnitzera racemosa* are seen in all small estuarine islands in the midstream. A small island by name Kamastara Kudru is totally dominated by the trees of *Rhizophora mucronata* and *Lumnitzera racemosa*. Here, most of the trees have been destroyed only for fuel wood. At many spots, however *Rhizophora mucronata* is planted to protect the inland areas covered with coconut plantations and agriculture fields.

At Jalady a pure and dense formation of old mangrove were recorded. This area is dominated by *Rhizophora mucronata* and *Kandelia candel* and the other sparsely distributed taxa are *Avicennia alba, Aegiceras corniculatum, Bruguiera gymnorrhiza* and *Sonneratia caseolaris* (Table 3.27). Uppina Kudru a riverine bank on the backwaters of the river Haladi is completely under the tidal influx, and is dominated by *Rhizophora mucronata*. Several mangrove patches were seen covering an area of about 1 to 4 acres. Other species present were *Sonneratia caseolaris, Acanthus ilicifolius, Kandelia candel, Avicennia alba,* *Aegiceras cornicualtum* and *Bruguiera gymnorrhiza,* but all these species were scattered. *Sonneratia alba* and *Avicennia alba* trees were in degraded stage. This area is under destruction due to human interference. At the riverine bank on the backwaters of the river Chakra and river Kollur the area Hemmadi showed the presence of good mangrove formations. *Rhizophora mucronata* dominates whereas the other mangroves *Sonneratia alba, Aegiceras corniculatum, Avicennia alba, Bruguiera gymnorrhiza* and very rarely *Excoecaria agallocha* are sparsely distributed. The landward margin of the riverine banks is represented by *Acanthus ilicifolius.*

An island, Kannada Kudru in the backwaters of the river Kollur and the river Chakra is about 13 acres and is completely under the tidal influence. Inside the island paddy, coconut, groundnut and green gram are being cultivated. Here the mangroves are confined to the periphery. The trees have been preserved to check the erosion and to protect the inland coconut plantations. In Gujjady along the estuarine banks *Rhizophora mucronata*, a few trees of *Kandelia candel* and *Avicennia alba* have been noticed whereas landward margins are being covered with *Acanthus ilicifolius.* At Arati the area is covered with fringe mangroves. Trashi and Hadavu, *Kandelia candel* is followed by other tree forms of *Aegiceras corniculatum, Bruguiera gymnorhiza, Rhizophora mucronata* and *Avicennia alba,* while *Sonneratia alba* and *Acanthus ilicifolius* are sparsely distributed. The areas were the mangroves are under severe destruction are been occupied by *Acrostichum aureum* bushes.

Towards, north west about 13 kms of Coondapur town. is Marvanthe beach. This beach possesses a intermixed association of vegetation, with varied taxa, distributed irregularly, occupying different places on the beach (Plate 8b). The dominance of any taxon is not consistent throughout. The beach shows a steep gradient from the high water level and receded towards the inland, with consistence strand flora on the backshore. The beach shows a narrow foreshore and a wide backshore. Some places the backshore is barren but towards the inland it shows the presence of *Ipomoea pes-caprae, Launaea pinitifida, Leucas aspera, Calotropis gigantia, Boerhavia diffusa, Alysicarpus monilifer, Vernonia cinerea, Hydrophylax maritima. Spinifex littoreus* is seen continuing from the pioneer zone. *Ipomoea pes-caprae* and *Hydrophylax maritima* was found mixed up with species such as *Spinifex littoreus, Launaea pinitifida, Cyperus arenarius, Achyranthes aspera, Boerhavia diffusa, Vernonia cinerea, Alysicarpus monilifer* etc with scarce distribution (Table 3.25).

A lengthy sea wall is built along the backshore in order to prevent erosion of the sea. Some part of the backshore is also been are owned by private owners, who have built resorts and a number of small scale industry such as sardine liver oil extracting huts, thus the distribution of the vegetation is not consistent, due to various allogenic causes. Sea erosion has eroded most part of the beach and at two sites the river is separated from the sea by a narrow stretch of sand. The backshore area of the beach has been converted to residential area and small industries, which has restricted the strand vegetation to narrow widths. Sand mining and also bio-mining is also a threat along the eroding area and its vicinity.

Tekkatte, Kumbashi, Beejady and Koteshwar are some of the beaches that are present towards the south of Coondapur taluka. The Tekkatte beach is mostly sandy with the presence of vegetation towards the backshore region. The distribution of vegetation was sparse. The pioneer species present were *Ipmoea pes-caprae* and *Sesuvium portulacastrum*. Further north a perfect association of *Ipomoea pes-caprae* and *Spinifex littoreus* is seen with *Zoysia matrella* and *Launaea pinnitifida*. Other species present further were *Boerhavia diffusa, Leucas aspera* etc. *Ipomoea pes-caprae* dominated this station. The backshore region shows the presence of *Cocos nucifera, Pandanus tectorius* , *Casuarina equisitifolia Clerodendrun inerme, Calotropis gigantia* etc. This beach is under stress due to human interferences.

South of Tekkatte lies Kumbashi beach. The backshore region of the beach shows the presence of strand vegetation. The general trend of distribution of vegetation is sparsely towards the seaward side, to sufficient density towards the inland. *Ipomoea pes-caprae* forms a mat with the association of *Sesuvium portulacastrum* in patches, and grasses like *Paspalum vaginatum* and *Zoysia matrella*. *Sesuvium portulacastrum* was found growing in the supratidal level. The other species present were *Leucas aspera, Cyperus arenarius, Boerhavia diffusa, Spinifex littoreus, Achyranthes aspera, Borreria articularis*. The beach is bordered towards the inland by trees, viz., *Casuarina equisetifolia, Pandanus tectorius, Clerodendrun inerme* and *Cocos nucifera.*

Beejady lies after Kumbhashi, where the beach platform showed the presence of marked gradient towards inland. The general trend of distribution of strand vegetation shows low density of vegetation towards the seaward and high density away from it. *Ipomoea pes-caprae* was dominating with association of few the herbaceous species such as *Boerhavia diffusa, Crotolaria striata, Achyranthes aspera, Triumfetta rhomboidea, Crotolaria verrucosa* etc. Plants belonging to Poaceae family were very few with patchy distribution of *Zoysia matrella, Spinifex littoreu*s etc. *Cyperus arenarius* was also recorded. This beach was found to be rich in vegetation cover as compared to all other stations studied in Coondapur taluka.

Koteshwar is a station towards the south of Beejady. The vegetation showed the presence of creepers like *Ipomoea pes-caprae, Launaea pinitifida, Cyperus arenarius, Spinifex littoreus, Crotolaria verrucosa* . The dominance of vegetation was shown by the species, *Spinifex littoreus.* The pioneer zone is completely devoid of any vegetation and is reflected by the barren beach area. This area is a highly disturbed area with lot of human disturbance on the shore. The backshore area is completely occupied for construction purpose. The offshore region is highly polluted to certain extent as all the effluents of the industries are directed to the sea.

3.5.3.4 Malpe

St. Mary's Islands: These are the strings of islands lying at the entrance of the Udiyavara river at a distance of 1.5 kms from the coast and is situated in north-south direction. A five fathoms line passes beyond the islands, which are also known as St. Mary Isles. They are comprised of four major islands and a number of exposed and submerged rocks. These islands are South Island, Daryabadurgad Island, North Island, Coconut Island.

South Island is the southernmost island and is completely rocky in nature. Locally it is also known as Malati Island which is 14.3m high and situated 2.5 kms from the mouth of the Udiyavara river. The Island is almost barren and is surrounded by rocky cliffs and boulders. This island is 187.5 m in width and 250 m in length. South island show very poor vegetation. As the island is mainly of granite rock, a few plants which can survive through the extreme conditions are found. The flora is represented by only 5 species, 5 genera belonging to 4 families. In the rock crevices, bushes of *Z. xylocarpus* are found on which occurs a species of *M. prurita*. At some places, *Vitex* sp. and *Clerodendrun inerme* are found.

Daryabadurgad Island is 1.5 kms from the mouth of the river and lies in between the South and the North Island. It is almost rocky having a small sandy beach facing east which is the only landing place. The island is covered with several herbaceous and shrubby species along with many climbers and creepers. This Island is comparatively denser in distribution of plants. Here, 35 species covering 33 genera and 20 families have been recorded. The vegetation is composed mostly of herbs and shrubs. Only a few trees like *Erythrina indica, Ficus benghalensis* and stray plants of *Avicennia officinalis* and *Rhizophora* sp grow on this island. The most common climber was *M. prurita.* The pteridophytic flora is represented by *Adiantum lunulatum, Ceratopteria thalictroides, Cheilanthus tenuifolia* and *Lygodium flexuosum*.

North Island is situated about one cable north-west of Daryabahadurgad island. On the top of southeastern end of this island Malpe lighthouse is situated hence it is also known as 'Lighthouse Island'. The island is surrounded by rocky cliffs except a small sandy beach towards eastern side. The island is 625 m in length.

The landward side of North Island does not have much vegetation except *Tephrosia purpurea* associated with few grasses. Occasionally, *Z. jujuba* and *F. benghalensis* also grow. However, the westward portion of the island is denser than the eastern part. A large and thick patch of *Pandanus tectorius* grows here.

Coconut Island: The Island lies north-west from the entrance of Udiyavara river which is 800 meters in length and 342 m in width. As the name suggests, coconut trees are common. It is fringed with rocky shore on all sides intercepted by long sandy beaches. The Island stands on a reef, which extends about two cables south-eastward from the island.

Coconut Island is mostly covered by *Cocos nucifera* and hence the name of the island. General distribution of flora on this island covers 27 species, 26 genera of 20 families. Common fern of this island is *A. lunalatum, C. tenuifolia* and *L. flexuosum* which grow in the rock crevices, while *C. thalictroides* grows in the moist and shady places. Common trees species are *Ficus, Bombax, Tamarindus, Zizyphus, Anacardium* and *Caryota*. The ground flora is composed of herbaceous species which include *Bergia ammanoides, Mollugo oppositifolia, Ammania baccifera, Plumbago zeylanica, Rungia parviflora, Achyranthes aspera, Eragrostis unioloides, Dactylostenium aegypticum* and *Cynadon dactylon.*

All the four islands are characterized with steep slope of the rocky cliffs resulting into minimum intertidal expanse. Therefore, the seaweeds are represented poorly. Some of the rocky ridges where the seaweeds are growing get exposed only during lowest low tide. The intertidal regions of the sandy beaches also do not harbour any seaweeds as a result of constant erosion and acression. The common species found in the vicinity of these islands are *Sargassum tenneririum* , *Caulerpa peltata, C. racemosa, C. scalpeliformis, Acanthophora* sp., *Cheilosporum spectabile, Colpomenia sinuosa, Dictyota pinnatifida, Dictyopteris woodwardii, Bryopsis* sp., *Padina tetrastromatica,*

Table 3.26 List of marine algae recorded at few stations along the Karnataka coast and their ecological status

No.	Name of the species	Ecological status	
		Karwar	Honnavar
	CHLOROPHYCEAE		
1	*Enteromorpha flexuosa*	R	R
2	*Enteromorpha intestinalis*	R	R
3	*Ulva fasciata*	C	C
4	*Ulva lactuca*	R	R
5	*Ulva reticulata*	C	-
6	*Monostroma oxyspermum*	R	-
7	*Chaetomorpha media*	R	R
8	*Chaetomorpha linum*	-	R
9	*Cladophora prolifera*	R	R
10	*Caulerpa peltata*	R	R
11	*Caulerpa taxifolia*	-	R
12	*Caulerpa sertularioides*	R	-
13	*Caulerpa scalpelliformis*	R	R
14	*Ernodesmis verticillata*	R	-
15	*Avrainvillea* sp.		R
	PHAEOPHYHCEAE		
16	*Ectocarpus* sp.	-	R
17	*Ralfsia* sp.	-	R
18	*Sphacelaria furcigera*	R	R
19	*Dictyota dichotoma*	R	R
20	*Dictyota bartayresiana*	R	-
21	*Padina tetrastromatica*	R	C
22	*Padina gymnospora*	-	R
23	*Stoechospermum marginatum*	R	C
24	*Spatoglossum asperum*	C	R
25	*Dictyopteris australis*	C	-
26	*Sargassum ilicifolium*	D	C
27	*Sargassum tenerrimum*	C	R
	RHODOPHYCEAE		
28	*Porphyra vietnamensis*	R	R
29	*Gelidium pusillum*	R	R
30	*Gelidium micropterum*	R	R
31	*Amphiroa fragilissima*	R	R
32	*Cheilosporum spectabile*	R	R
33	*Grateloupia filicina*	C	R
34	*Grateloupia indica*	R	-
35	*Gracilaria corticata*	R	R

36	*Gracilaria verrucosa*	-	R
37	*Gelidiopsis variabilis*	R	R
38	*Hypnea musciformis*	R	-
39	*Hypnea cervicornis*	R	R
40	*Hypnea valentiae*	R	R
41	*Centroceras clavulatum*	R	-
42	*Ceramium fastigiatum*	-	R
43	*Acanthophora spicifera*	-	C
44	*Bostrychia* sp.	-	R
45	*Champia parvula*	-	R

R: Rare, C: Common

Table 3. 27 List of mangroves recorded at few stations along the Karnataka coast and their ecological status

Sr.No	Species Name	Ecological status		
		Kalinadi estuarine complex	**Sharavati estuarine complex**	**Chakra-Haladi-Kollur estuarine complex**
1	*Avicennia alba*	C	C	C
2	*Avicennia marina*	R	-	-
3	*Avicennia officinalis*	C	-	-
4	*Sonneratia alba*	D	C	D
5	*Sonneratia caseolaris*	-	C	R
6	*Acanthus ilicifolius*	R	D	C
7	*Rhizophora mucronata*	D	C	D
8	*Rhizophora apiculata*	-	-	-
9	*Exoecaria agallocha*	R	C	C
10	*Derris scandens*	C	-	-
11	*Acrostichum aureum*	C	C	-
12	*Porteresia coaractata*	-	C	-
13	*Kandelia candel*	R	R	D
14	*Clerodendrum inerme*	R	C	-
15	*Aegiceras corniculatum*	-	-	R
16	*Bruguiera gymnorrhiza*	-	-	R
17	*Lumnitzera racemosa*	-	-	R

C: Common; R: Rare

Ulva fasciata,, *Enteromorpha* sp., *Bryopsis* sp., *Polysiphonia* sp. and *Corallina* sp.

On the upper reaches of the sandy beaches of this Island, *Gardinia gummifera* is more common. *Ipomoea pes-caprae* also sometimes seen creeping in the backshore region of the beach. In the low lying areas where the soil moisture is retained for a long time, plants like *Ammania baccifera, Bergia ammonoides, Mollugo oppositifolia, Cynadon dactylon* make their appearance. *Mucuna prurita* is a common species, which is seen growing on any support. The only fern belonging to Polypodiaceae i.e. *Adiantum lunulatum* is found here.

St. Mary's Islands are not very rich in the growth of marine algae. The most common species found in the vicinity of these Islands are *Sargassum tenerrium, Caulerpa peltata, C. racemosa, C. scalpeliformis, Acanthophora spicifera, Cheliospermum spectabile, Colpomenia sinuosa, Dictyota pinnatifida, Dictyopteris woodwardii, Bryopsis* sp., *Polysiphonia* sp., and *Corallina* sp.

3.6 DISCUSSION

During the present investigation (September, 1997 to May, 1998) 37 different locations were visited covering the entire Maharashtra coast), 26 along the Goa coast and 21 along the Karnataka coast. The intertidal habitat zone along the Central west coast of India is characterized by different type of ecological habitats such as islands, estuaries, mangrove habitats, rocky shores and open sandy beaches. The coast is a long sandy beach with rocky outcrops in patches. Rocky cliffs and shores are mostly with narrow intertidal expanse (south) to vast expanse of more than a kilometer (north – Dahanu).

Data on the most dominant species observed during the study period is depicted in the Tables. Among the sites surveyed along the Maharashtra coast 7 sites were finally selected , 6 along Goa coast and 4 along the Karantaka coast. Different sensitive ecosystems were assessed.

3.6.1 Coastal vegetation along the Central West Coast of India

3.6.1.1 Mangrove Vegetation

The mangrove forests of Maharashtra comprises of 17 species along with some associated land plant species (Table 3.3). Among 37 stations visited along the Maharashtra coast, 25 stations harboured mangrove flora. Good patches of mangroves were observed along Achra, Deogadh, Vijaydurg (Sindhudurg district), Purangadh, Ratnagiri (Ratnagiri district), Kundalika (Raigadh district), Vikroli and Mumbra-Diva (Mumbai area). *Avicennia marina* was most common species. High density of mangroves was observed at above-mentioned stations. Due to good forest cover, these areas also give shelter to variety of wild animals such as foxes, wild bore, snakes, etc. Aquatic animals such as Otters are also found in these estuarine regions. The mangrove forest is also known to be a sanctuary for various local or migratory birds. *Crocodilus palustris* a crocodile species is also found in Goa.

The mangrove forests along Achra (sacred grove), Deogadh and Vijaydurg estuaries are well preserved forest. Nursery for mangrove plantation already exists at Achra. As mentioned earlier, mangrove forest provides sanctuary for various terrestrial and bird species. Similar observations were made at Ratnagiri and Kundalika region and Ratnagiri exhibited high biodiversity and luxuriant flora and fauna along the open coast also. Vikroli is mentioned here as a well-preserved mangrove forest managed by private management, which should be encouraged. Ecological status of mangroves and marine algae of different important sites along the Maharashtra, Goa and Karnataka coast are given.

Unique features were observed along the Mumbai coast. Two areas Mumbra-Diva and Colaba were selected from Mumbai. The former site had a good growth of a single mangrove species: *Sonneratia apetala*. The average height of the trees was 10-15 m and the population was also highly dense. This needs immediate protection.

Distribution of mangroves in Goa is mainly influenced by salinity. Along many estuaries of Goa topography seemed to be favorable for mangrove establishment and growth. According to Naskar & Mandal (1999), the mangroves along the coastal zones of Goa are relatively poor for the anthropogenic causes. Untawale

(1982), estimated 2000 ha of mangrove area along the different estuaries of Goa coast. The coastal mangrove zones of Mahrashtra, Gujarat and Karnataka was reported to be 622 sq.kms (Sidhu, 1963) and 200 sq.kms (Blasco, 1975; 1977). The satellite imagery report from the Space Application Centre (Anonymous, 1992) reported the combined area of Maharashtra and Goa as 148.4 sq.kms.

Mangroves along the Goa coast are fringing type (Untawale & Parulekar, 1976). In the present study 16 mangrove species along with its associates have been reported from the Goa coast, which is reported by Untawale *et al.*, (1982); Naskar and Mandal (1999). Though in degraded state, Govt of India Report (Anonymous, 1987) and Jagtap *et al.*, (1995) reported 20 species of mangroves along with associates along the Goa coast. The reported dominant species were *Rhizophora mucronata, Sonneratia alba* and *Avicennia officinalis.* Other species were *Rhizophora apiculata, Sonneratia caseolaris, Kandelia candel, Bruguiera gymnorrhiza, Aegiceras corniculatum, Excoecaria agallocha, Acanthus ilicifolius* etc. The mangrove vegetation along the estuaries of Goa coast like Terekhol, Chapora were very poor. Indiscrimate cutting and grazing by animals are the main reasons for the destruction of mangroves along the estuaries of Goa as also reported by Jagtap, (1985), (Plate 9a).

Rhizophora mucronata though found along all the estuaries of Goa was rare along the Chapora estuary. Jagtap (1985) reported the occurrence of *Rhizophora mucronata* as a dominant species along Mandovi and Zuari estuary. Natural regenration was very poor. *Rhizophora apiculata* was found growing along the Mandovi estuary with good natural regeneration but it was absent along the other estuaries like Terekhol and Chapora. *Avicennia officinalis* was the dominant species along all the estuaries of Goa. Untawale *et al.,* (1982) reported *Avicennia marina* as rare along Mandovi, Zuari estuaries, Cumbarjua canal and absent alogn all other remaining estuaries. Jagtap (1985) reported the dominance of *Sonneratia alba* along the estuaries of Goa with good natural regeneration which is also true with the present study. The other species such as Species of *Bruguiera gymnorrhiza* was dominant along Zuari and Talpona estuaries, while *Bruguiera cylindrica* dominant along the Cumbarjua canal and *Kandelia candel* was dominant along Chapora, Mandovi and Zuari estuaries. Jagtap (1985) reported *Excoecaria agallocha* as very common mangrove in Goa. In the present study *Ceriops tagal* occurred dominantly along Terekhol estaury, which was vice versa as that reported by Jagtap (1985) and Naskar and Mandal (1999). *Aegiceras corniculatum* was dominant along Talpona estuary while, *Acanthus ilicifolius* and *Derris heterophylla* showed its dominance along mandovi, Zuari estuaries and Cumbarjua canal. Untawale *et al.,* (1982) reported *Acrostichum aureum* to be present in the upper stretches along all the estuaries of Goa , was found to common along Terekhol, Chapora, Zuari and Sal estuaries. Chorao island along the Mandovi estuary is one of the important area for mangrove flora and fauna. The flora and fauna of the Chorao Island is given in Table 3.17 to 3.21.

Mangroves along the Karnataka coast are fringing type, found in the intertidal regions along the estuaries, backwater, islands etc. About 14 species of mangroves belonging to nine genera under seven families have been reported along the estuaries of Karnataka coast (Untawale and Wafar, 1985). The dominant species are that of *Acanthus ilicifolius, Avicennia officinalis, Avicennia marina, Rhizophora mucronata* etc. In coastal Karnataka, mangroves are found growing along the rivers like Kalinadi, Gangavali, Sharavati etc. A good vegetation of mangroves is present at Coondapur particularly in the confluence zone of the three rivers namely Chakra, Kollur and Haladi. In Karnataka mangrove trees are used for variety of purposes like food, feed, fertilizer, tannin, paper and pulp, timber, fuel and alcohol. The estuaries at Karnataka with fringing mangroves are good source of fisheries of commercial importance. Many fish farms and prawn farms are located in this area (Plate 8c). The mangrove forests at Coondapur area have been reclaimed for agriculture and the remnants of past mangroves are still seen surviving here. According to local enquires the mangroves in Karnataka are been reclaimed by private sector.

Fringing mangrove formation is the dominant stable type along the estuaries of Karnataka. They are poor in species and often found in pure and mixed associations in response to soil gradients of salts. The Karnataka coast is non-deltaic and supports mangroves only on estuarine border lands. The succession of mangroves is less dense, woody and far taller.

Plate 8a: *Ralfsia* sp. in the intertidal region

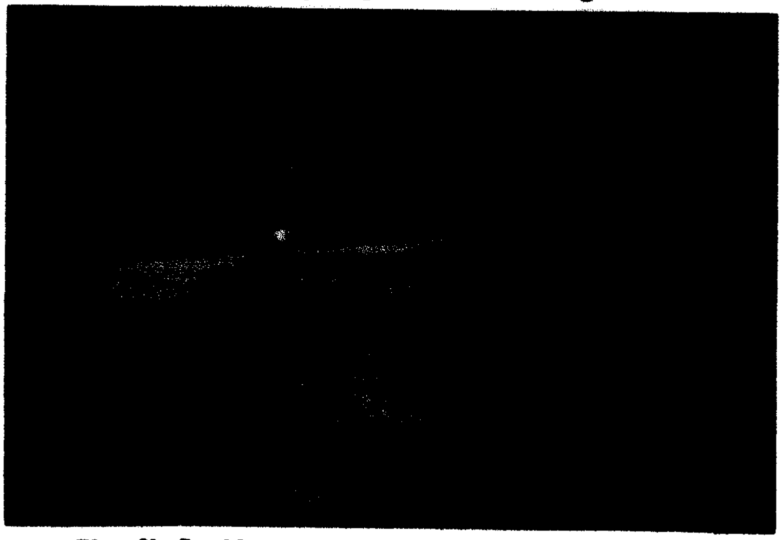


Plate 8b: Sanddune vegetation along the Karnataka coast

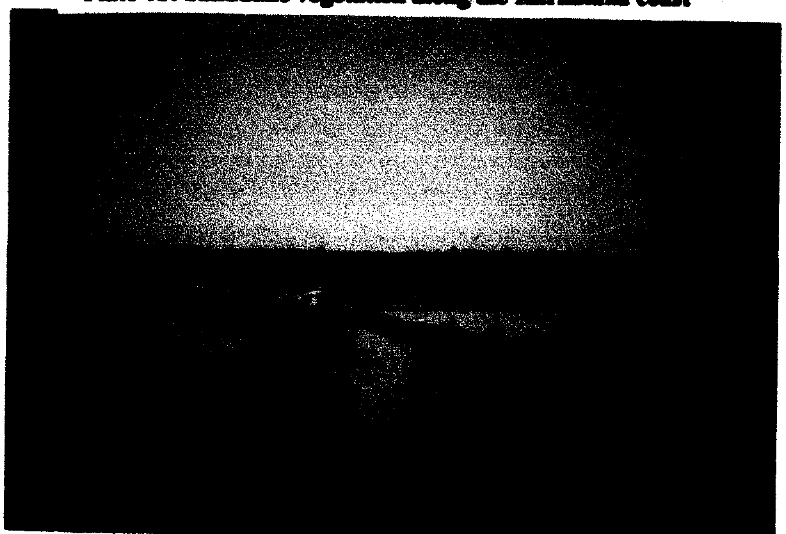


Plate 8c: Conversion of mangrove area into aquaculture farms along the Karnataka Coast

The Coondapur mangrove area has good assemblage of mangroves despite heavy anthropogenic pressure. The studies along this area indicate conservation potential of these areas. The mangrove formation of Coondapur are estuarine oriented and are very much influenced by the tidal backwater creeks. The mangrove trees at these areas show luxuriant growth but regeneration is very much restricted due to narrow width of the niche.At many spots, however *Rhizophora mucronata* is planted to protect the inland areas covered with coconut plantation and agriculture fields.On the whole there is a good patch of *Rhizophora mucronata* as a main component among the mangroves. At Shiroor Hole (Coondapur taluka), if the area is properly protected the area becomes suitable for the regeneration of mangroves. However, most of the mangrove habitats are totally destroyed with a view to have prawn farms.

Fringe mangroves were recorded at few places along the Kalinadi estuarine complex of Karwar taluka. The mangrove formation confined mostly the riverine banks. If these area is properly protected it can become a good habitat for *Sonneratia alba* trees. The factors inhibiting the development of mangroves are mainly due to construction of embankments to protect the inland settlements and coconut plantations, which are, situated Adjacent to the riverine banks. Most of the mangrove trees have been destroyed for fuel purposes and collection of fencing poles. The deposition of silt and mud by the tidal river is very less due to the high force of the tides. On the banks of tidal rivers near the sea where clay soil is dominant , *Avicennia marina* is found in abundance. They do not seem to attain a good tree height at the estuarine complex of the Karnataka coast. It is evident that the fringing mangrove type is dominant and stable type along the estuarine banks of the Karnataka coast and their discontinuity is due to large-scale woodcutting or reclamation for agriculture purposes

Dense formation of mangroves were observed along the Chakra, Haladi and Kollur estuarine complex. The trees showed luxuriant growth but regeneration is very much restricted due to narrow width of the niche. A few trees of *Sonneratia caseolaris* and *Lumnitzera racemosa* are seen in all small estuarine islands in the midstream.

Dense mangrove formations were also recorded along the Sharavathi estuarine complex and are represented by *Rhizophora mucronata* followed by *Sonneratia caseolaris, Avicennia alba, Excoecaria agallocha, Acrostichum aureum, Portresia coractata* and occasionally by K*andelia candel* and *Clerodendrum inerme.*

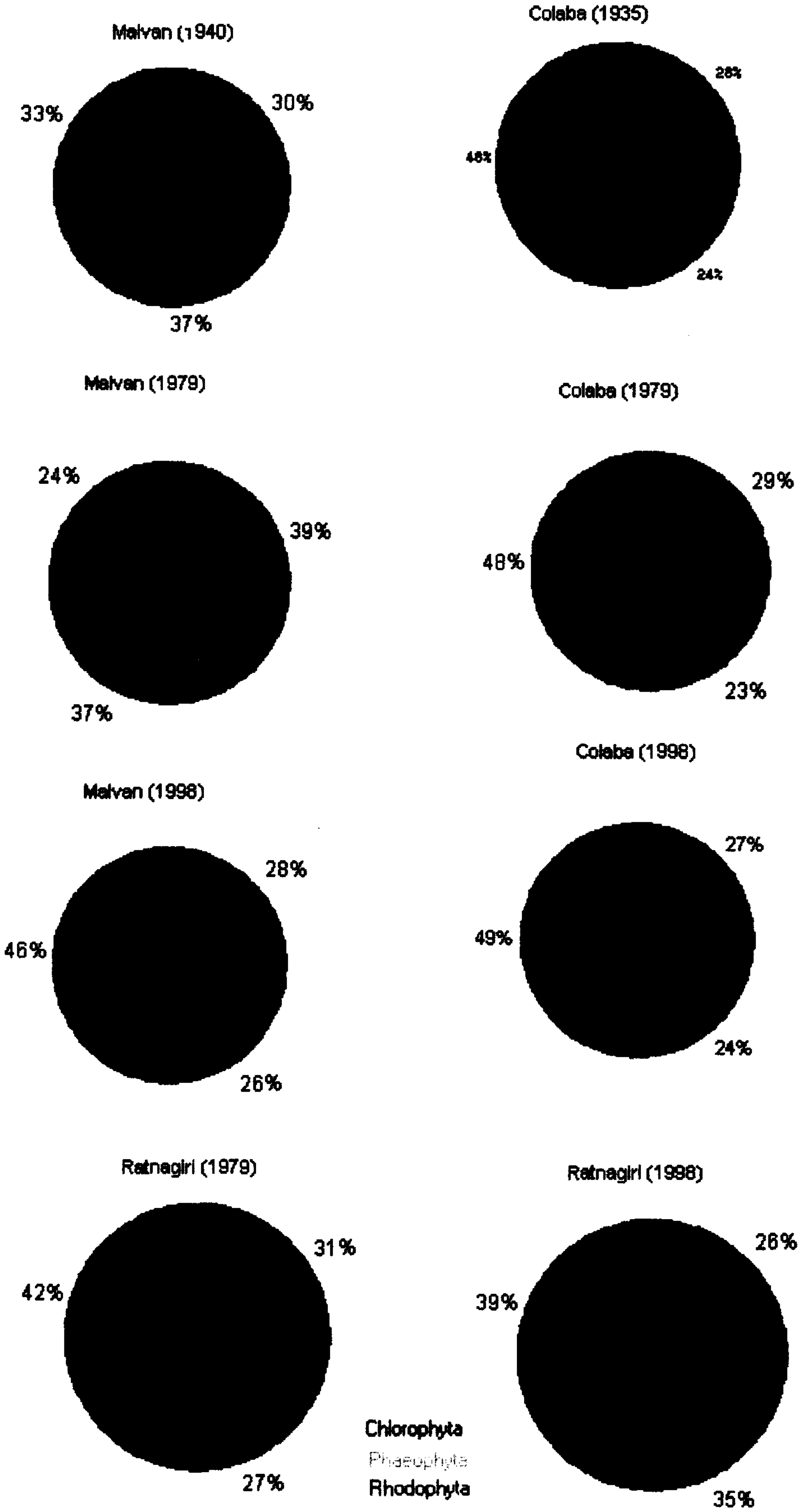
Mangroves were dominated along the Maharashtra coast as compared to the Goa and Karnataka coast.

3.6.1.2 Marine Algae

The marine algae were more in numbers along rocky shores and they preferred gradual intertidal expanses. Apart from climatic and environmental conditions, the wave action and substratum also play an important role. Comparison were made to assess the changes that have occurred on distribution, abundance, composition, standing crop biomass and diversity of marine algae along the Central West Coast of India (Boergesen, 1932; Dixit, 1940; Untawale, 1979; Agadi, 1986; Khadilkar, 1986; Untawale *et al.,* 1989). Altogether 91 marine algal species were found along the Maharashtra coast. Malvan displayed maximum number of marine algal species (69) followed by Colaba, Mumbai (64) and Ratnagiri (51). Species belonging to genera such as *Monostroma, Gelidium, Gracilaria, Sargassum*, etc. are economically important and hence exploited for their commercial values. Some species, e.g. *Acetabularia sp., Caulerpa verticillata* are rare and required to conserve by modern techniques such as germplasm preservation and cryopreservation, etc. Maximum biomass estimation at Malvan indicates that environmental conditions at this station are more suitable for the marine algal growth. Although along the central west coast of India the quantity estimated along the Gujarat coast was maximum followed by Maharashtra, Goa and Karnataka. The major part of the algal biomass comprised of *Ulva, Gracilaria* and *Sargassum.* At Malvan due to high transparency and rocky as well as sandy substratum luxuriant growth was observed. Colaba on the other hand, despite being in the megacity area, where the seacoast is highly polluted, had diversified marine flora and fauna including corals. 64 marine algal species were recorded from this area (Table 3.13). The dominant group was Rhodophyta followed by Chlorophyta and Phaeophyta.Percentage-wise there was not much change since 1935 to 1998, however, over a period a considerable variation n species composition was noticed (Fig 3.18). *Goniopora stokesi* a coral species was found in association with algae. High degree of symbiotic relationship may be beneficial to both the algae as well as the coral for their growth and survival in the stress environment.

The average biomass recorded at Colaba was 1.33 kgm^{-2} with Rhodophyta contributing to the highest followed by Phaeophyta and Chlorophyta. Species such as *Gastroclonium iyengarii, Champia compressa, Solieria robusta* which were not reported earlier ((Khadilkar, 1986) were found growing luxuriantly during the present investigation.Comparison of algal species from that of Malvan and Colaba revealed that large number of species i.e. 64.50% were common to both the coasts while 18 % were found only at Colaba and 17.48% at Malvan. Overall, growth of these algal species was found to be luxuriant at Colaba than Malvan, which could be attributed to high nutrient, levels presumably resulted from treated sewage effluent outfall at Colaba. At Colaba, regular discharge of treated sewage did not show any adverse effects on the macroalgal growth. Perhaps, tidal flushing dilutes sewage effluent considerably with marginal effect keeping th e water quality relatively healthy (Zingde *et al.*, 1998). At Colaba sediment load was high (Table 3.9) and it was observed that

Fig 3.18 Comparison of percentages of different groups of marine algae (1935-1998) along Malvan, Ratnagiri and Colaba, Mahrashtra.



majority of the species were in healthy condition. At Ratnagiri also good algal diversity was seen. Earlier (Chaugule *et al.,* 1989) had reported *Acetabularia moebii* from Malvan, but during the present study this species was not reported. The comparison of the earlier data with the present study revealed that there is a decreasing trend in number of algal species from 1979 to 1998 (Untawale *et al.,*1979; Agadi, 1986).

The marine algae of the central west of India showed peculiar type of zonation, although it was not similar to that described by Stephenson and Stephenson (1949). At Honavar (Karnataka), Anjuna (Goa) the rock pool communities were observed to have more number of species. Increase in the number of species in different algae from October to January tallied with the increase in temperature and salinity. At Karnataka, the beaches are sandy and they are exposed to high wave action, which results in harbouring less number of algae. At Karwar, due to sandy or muddy substratum the number of algal species were reduced. St. Mary's Island at Malpe is represented by 51 species. The algal species along the central west coast of India is almost similar to other Indian flora (Srinivasan, 1960). This flora also includes some species, which are common to Antarctic and sub-Antarctic marine alge (Papenfuss, 1964). Karnataka algal flora showed an increase, which may be due to the changes in oceanographic conditions, and human activities. Long term algal population declines have been attributed to stress from pollution (Bellamy *et al.,*1967; Widdowson, 1971). Wilkinson and

Tittley (1979) suggested that comparison of different floras for a set area is misleading mainly due to different nomenclatures and taxonomic interpretations.

Along Central west coast of India the flora varied. Almost all the species belonging to Chlorophyta are common to all the three coasts except species such as Monostroma *oxyspermum* and *Ernodesmis verticillata* are found along the Maharashtra, Goa and Karnataka coast as also reported by Agadi (1986). *Cladophora prolifera* was found only along the Karnataka coast whereas *Valonia aegagropila* and *Acetabularia* sp. recorded only along the Maharashtra coast. Phaeophyta members showed dominance along the Maharashtra coast followed by Karnataka and Goa. Among the different stations studied along the central west coast of India, numerical abundance also varied. Agadi (1986) recorded few species along the Colaba coast but during the present study 64 species were recorded along the station at Colaba. The substratum was rocky which represented good flora and fauna. The lesser number at Chapora is due to estuarine habitat as also reported by Agadi (1986). The influence of mining activity along the shores also affects the flora by causing turbidity and silt accumulations at intertidal zones. The seaweed community structure along the Central west coast generally varies according to different climatic periodicities. Algal flora was not uniform throughout the year and it showed a heterogeneous rather than homogenous composition. Other studies also concluded that seasonality and standing crop in tropics are due to monsoons (SW and NE) and the combination of ecological factors during different seasons of the year (Trono & Azanza-Corrales, 1981).

Along the central west coast of India it was generally observed that soft and rough textured rocky areas (laterite) supported more algae of diverse taxa and also in abundance presence of rocky coast was not uniform along the central west of India. Good growth of marine algae was observed at stations like Colaba, Ratnagiri, Malvan, Anjuna-Baga, Honavar etc. Since species diversity was more, algal zonation was clearly demarcated. Krishnamurthy, (1967a),and Krishnamurthy & Subbaramaiah, (1972), concluded that algae of rocky coasts is entirely subtidal which is not correct. Misra (1967) reported that the topography determines the type and composition of the algal vegetation. *Porphyra vietnamensis*, a red algae was recorded along the central west coast during monsoon season is not the same for the east cost (Umamaheswara Rao & Sreeramulu, 1963) , where it is found during the summer conditions. Another species of *Porphyra, Porphyra indica* was reported from Karwar, Karnataka (Krishnamurthy & Baluswami, 1984), was not collected during the present study. The growth of *Grateloupia lithophila* at Ratnagiri may be a genetic or ecological response to certain local conditions like thermal or organic pollution, promoting enhanced growth . Although this algae was present along central west coast it was not reported from Okha shores (Murthy *et.al.,* 1978; Ohno & Mairh, 1982). It has been proved that the oil pollution decreases the species number and species abundance, towards the exposure extremes (Dalby, 1980). As compared to the zonation patterns of other shore, Central west coast is almost similar to the upper-littoral zones of other Indian coast.(Srinivasan, 1960; Maheshwari *et.al.,*1965). At uneven coast, particularly where cliffs and steep boulders are dominant (Vijaydurg, Karwar, Kumta, Mangalore), the algal habitation was poor, and obscure zonation was due to lack of vertical expanse, and not because of strong wave action. Inspite of the adverse conditions, few species like *Enteromorpha, Ulva, Gracilaria, Gelidium, Hypnea* etc, occur throughout the year, which is indicative of their sensitivity or adaptability to climatic changes particularly to water temperature, solar radiation and monsoon effects.

Along estuarine areas of Goa coast- at Chapora and Mandovi estuary algae belonging to chlorophyta such as *Ulva reticulata* and *Chaetomorpha linum* and a rhodophyta alga *Gracilaria verrucosa* were recorded.These algae were not recorded from the adjacent rocky shores may be they are true estuarine taxa (Simons 1975). Another species of alga *Monostroma oxyspermum* was found to occur only in the mangrove habitat of Ratnagiri, Achra and Karwar. Non colonization of these species in the other estuaries may be due to fluctuating salinity and heavy sediment load, that are probably important factors in algal distribution in an estuary (Wilkinson, 1980). However these alga was reported to occur from marine rocky shores of Okha (Ohno & Mairh, 1982). It is documented the number of taxa and their abundance decreases from the marine shores to estuarine waters (Zechman & Mathieson, 1985). *Ulva reticulata* was found to grow mostly attached to polychaete tubes , stones etc. The rapid growth of these alga may be due to availability of nutrients, and also ammonia released to water by polychaetes (UNESCO, 1984). Sewage pollution leads to absence of Phaeophyta members (Wilkinson, 1980). *Ulva reticulata* member as is found mostly at the sewage influenced habitats, can be considered as a indicator species of sewage polluted conditions (Bellamy *et al.*,1968). Low salinity during monsoon months affect the growth of this species and when marine conditions prevail, alga starts growing. Photosynthetic activity of this alga increases the dissolved oxygen and pH values (Dhargalkar,1978).Along the central west coast of India, heavy rainfall causes gross fluctuation in the salinity during monsoon months (Singbal, 1973, 1976; Untawale *et al.*, 1979), probably might be one of the reasons to have poor algal crop during monsoon months.

Dhargalkar (1981) estimated the standing crop of Goa coast to be 2,000 tonnes/year (wet. wt.), which was much lower than the estimated crop for Maharashtra crop by Untawale *et al.*, (1979). In the present study, phaeophyta constituted the major portion of biomass followed by rhodophyta and chlorophyta as also reported by Dhargalkar (1981) for Goa coast ,Untawale *et al.*,(1979) for Maharashtra coast and Chauhan and Mairh (1978) for Gujarat coast. Harvesting of algae for industrial application is going on along all the coast. If marine algae are harvested using improper techniques as suggested by Untawale *et al.*, (1979) then the standing crop of the area may not be adversely affected.

Along the Karnataka coast, marine algae are found in littoral and sublittoral belts, on rocky substratum. From this coast 63 algal species belonging to 19 of chlorophyta, 17 of Phaeophyta and 28 of Rhodophyta have been recorded. Rhodophyta group dominated followed by Chlorophyta and Phaeophyta. The trend was similar to that of recorded by Untawale and Wafar (1985) but the number of species varied. Monsoon months *Porphyra vietnamensis* was dominating. Maximum number of species were recorded along the Karwar coast (38) followed by Honnavar coast (36) The dominant species found along the Karnataka coast are that of *Enteromorpha, Ulva, Sargassum, Gracilaria* etc as also reported by Untawale and Wafar (1985).

As a result of favourable conditions along the central west coast of India, marine algae are found growing at several places. But due to various pressures like pollution from various sources, human disturbances etc the quantity is insufficient. Hence it is advisable to carry out cultivation of seaweeds.

3.6.1.3 Corals

Perhaps one of the ecologically important faunal groups recorded at few locations (such as Vengurla- Malvan, Ratnagiri, and Mumbai) is coral. Among the above two sites, the corals are most abundant at Malvan. Nine species of corals are reported from Malvan waters (Qasim and Wafar 1978, Parulekar 1981). List of corals recorded at Malvan are given in Table 4.22. The peculiar characteristic of the corals at Colaba, Mumbai was their survival in the polluted and turbid area and the long polyps (Untawale *et a.,* 1999). Rodrigues *et al.,* 1998 reported three species of reef building corals, *Porites lutea, Favites peniagona* and *Turbinaria mesenterina* near Grandi island off Marmugao, Goa. The coral patch was observed at a depth of 3m.

3.6.1.4 Sand dune Vegetation

Dune vegetation are characteristics with a strong, firm and deep penetrating root system which goes down to the water table below as the top soil cover is composed of sand Along the Central West Coast of India dunes are present along many places. 22 species were recorded along the Maharashtra coast, 42 species along the Goa coast and 31 along the Karnataka coast. Sand binders like *Ipomoea pes-caprae, Cyperus* sp. *Spinifex littoreus* etc are some of the dominant species recorded along the Maharashtra coast. *Casuarina equisetifolia* act as wind barrier. *Casuarina equisetifolia* plantation was found on every bar formation near the river mouths, which helps to prevent the sand blocking by binding it to some extent. Some of the dominant species recorded were that of *Vitex negundo, Lantana camara, Carrissa caranda, Zizyphus jujuba, Calotropis* etc. Extensive dunes were encounterd at Arvali (near Redi) Ubhadanda, Mithmumbri, Garambi (near Murud), Tarkarali and Achra (Gole, 1997). Towards South, Malvan, *Annacardium occidentale* was very common. In most cases, *Ipomoea-Spinifex* association was common where *Ipomoea* usually dominated.

Sand dunes are located along various places of Goa like Terekhol, Keri, Harmal, Mandre, Chapora, Vagator, Anjuna, Baga, Calangute, Campal, Miramar, Caranzalem Cabo-de-Rama, Galgibag, Pollem etc. *Ipomoea pes-caprae, Spinifex littoreus* are the dominant species along the coast as also reported by Desai, (1995). *Casuarina equisetifolia* plantation was seen at many places like Morjim,Miramar, Keri, Galjibag etc.

Along the Karnataka coast along the sandy beaches, 31species of sand dune species were recorded. The dominant species were growing towards the foreshore region and consist of *Ipomoea pes-caprae, Spinifex littoreus, Leucas aspera, Cyperus arenarius* etc. Along many beaches large scale plantation of *Casuarina equisetifolia* was recorded. Untawale and Wafar (1985) recorded 99 species of sand dune plants along the Karnataka. This variation may be due to certain changes or may also be due to no proper collection during the present study. Along many beaches of Karnataka, coastal erosion has been observed, which may be due to the extraction of sand from these areas and indiscriminate cutting of the coastal areas. It is necessary to have a strict and effective management policies for conservation and protection of sand dune vegetation as well as the sand. In a badly eroded areas such an attempts should be made to grow more sand dune plants.

3.6.1.5 Seagrass Vegetation

Along the mangrove swamps of Chapora, Terekhol and Mandovi estuaries of Goa, *Halophila beccarri* was observed. Small beds of *Halophila ovalis* were observed in the mangrove influenced swamps towards the mouth region of Mandovi (Jagtap, 1977) but was not reported during the present study.

3.6.1.6 Other Fauna

The open sandy beaches generally have fine to medium sand and thus provide ideal pore space for the development of rich and diverse interstitial fauna. In general, the benthic macrofauna was dominated by polychaetes both in term of density and diversity (till this date > 72 species are reported from the area). Molluscan fauna was represented by many important species of bivalves and gastropods such as *Perna virides, Crassostrea cuculata, Pinctada sp., Meretrix casta, M. meretrix, Paphia sp. Donax incarnatus, Solan sp. Gafrarium sp.,* and *Bullia sp.*Crustacea was the other faunal group represented by many economically and ecologically important groups such as prawns, crabs, lobsters, isopods, amphipods. Some other faunal species such as sea anemone, zooanthus, brittle stars etc. were also observed at Colaba, Mumbai. Benthic macrofauna of the Mangalore coast includes bivalves, polychaetes, gastropods, scaphopods, polychaetes and echinoderms. Bivalves were found dominant group in this region (Goplakrishnan and Chandrasekharan, 1998). Parulekar *et al.,* (1973) has reported six faunal assembalges from Mandovi, Cumbarjua and Zuari estauries. Dwivedi *et al.,* (1974) studied the macrofauna of mangrove swamps of Goa and reported that macrofaunal population density varies from 60 to $2100/m^2$ and standing stock vary from 1.5 to 379 g/m^2 . List of flora and fauna from Chorao Island is given in Tables 3.17 to 3.21.

Coastal zone plays an important role as breeding, feeding and nursery grounds for large numbers of birds. Avifaunal studies along the coastline are one of the unattended subjects. Very scanty information regarding the marine birds of coastal areas is available. Total 121 bird species were recorded from mangroves of Ratnagiri and adjacent areas (Samant ,1986). Out of 121 species, 66 species were resident and local migrants, 24 true migrants, 28 resident with migratory population and only 3 are vagrant or occasional stray (Table 3.28). Along the Goa coast information on the birds is very scarce, however, a list of seabirds inhabiting mangrove region of Chorao Island has been published by Forest Department, Govt. of Goa. List contains 33 residents' birds and 14 migratory birds from Salim Ali bird Sanctuary at Chorao (Table 3.18). Fisheries potential of Goa coast is also high. Comparison of marine fish landing to that of inland fish landing showed the high density of marine fishes along the Goa coast.

Table 3.28 List of birds found along the Maharashtra coast

No.	Scientific name	Local name
01	*Oceanites oceanicus*	Wilsons Storm Petrel
02	*Phalacrocorax carbo*	Cormorant
03	*P. fuscicollis*	Indian Shag
04	*Ardea cinerea*	Grey Heron
05	A. purpurea	Purple Heron
06	*A. alba*	Large Egret
07	*Ardeola striatus*	Little Green Heron
08	*A. grayii*	Pond Heron
09	*Bubulcus ibis*	Cattle Egret
10	*Egretta intermedia*	Smaller Egret
11	*E. garzetta*	Little Egret
12	*E. gularis*	Indian Reef Heron
13	*Nycticorax nycticorax*	Night Heron
14	*Ixobrychus cinnamomeus*	Chestnut Bittern
15	*Ixobrychus sinensis*	Yellow Bittern
16	*Ephippiorhynchus asiaticus*	Black Necked Stork
17	*Plegadis falcinellus*	Glossy Ibis
18	*Anas acuta*	Pintail
19	*Anas querquedula*	Garganey
20	*Milvus migrans*	Black Kite
21	*Haliastur indus*	Brahminy Kite
22	*Accipiter badius*	Shikra
23	*A. nisus*	Sparrow Hawk
24	*A. virgatus*	Basra Sparrow Hawk
25	*Buteo buteo*	Buzzard
26	*Haliaeetus leucogaster*	Whitebellied Sea Eagle
27	*Gyps indicus*	Indian Longbilled Vulture
28	*G. bengalensis*	Indian Whitebacked Vulture
29	*Circus pygargus*	Montagu's Harrier
30	*C. aeruginosus*	Marsh Harrier
31	*Pandion haliaetus*	Osprey
32	*Microhierax melanoleucos*	Whitelegged Falconet
33	*Rallus striatus*	Bluebreasted Banded Rail
34	*Porzana porzana*	Spotted Crake
35	*P. fusca*	Ruddy Crake
36	*Amaurornis phoenicurus*	Whitebreasted Waterhen
37	*Fulica atra*	Coot
38	*Metopidius indicus*	Brozenwinged Jacana
39	*Haematopus ostralegus*	Oystercatcher
40	*Rostratula benghalensis*	Painted Snips

41	*Himantopus himantopus*	Blackwinged Stilt
42	*Recurvirostra avosetta*	Avocet
43	*Dromas ardeola Paykul*	Crab Plover
44	*Esacus magnirostris*	Great Stone Plover
45	*Glareola pratincola*	Collared Pranticole
46	*G. hkactea*	Small Indian Pranticole
47	*Vanellus indicus*	Redwattled Lapwing
48	*Pluvialis squatarola*	Greg Plover
49	*Charadrius leschenaultii*	Large Sand Plover
50	*C. dubius*	Little Ringed Plover
51	*C. alexandrinus*	Kentish Plover
52	*C. mongolus*	Lesser Sand Plover
53	*Numenius phacopus*	Whimbrel
54	*Limosa limosa*	Blacktailed Godwit
55	*L. lapponica*	Bartailed Godwit
56	*Tringa totanus*	Common Redshank
57	*T. nebularia*	Greenshank
58	*T. ochropus*	Green Sandpiper
59	*T. guttifer*	Spotted Greenshank
60	*Gallinago solitaria*	Solitary Snipe
61	*Calidris minuta*	Little Stint
62	*C. temminckii*	Temminck's Stint
63	*Limicola falcinellus*	Broadbilled Sandpiper
64	*Larus brunnicephalus*	Brownheaded Gull
65	*L. ridibundus*	Blackheaded Gull
66	*Chlidonia hybrida*	Whiskered Tern
67	*Gelochelidon nilotica*	Gullbilled Tern
68	*Sterna anaethetus*	Brownwinged Tern
69	*S. albifrons*	Little Tern
70	*Eudynamys scolopacea*	Koel
71	*Bubo zeylonensis*	Brown Fishowl
72	*Glaucidium radiatum*	Jungle Owlet
73	*Athene brama*	Spotted Owlet
74	*Apus pacificus*	Large Whiterumped Swift
75	*A.affinis*	House Swift
76	*Cyspirus parvus*	Palm Swift
77	*Ceryle rudis*	Lesser Pied Kingfisher
78	*Alcedo atthis*	Common Kingfisher
79	*Pelargopsis capensis*	Storkbilled Kingfisher
80	*Halcyon smyrnansis*	Whitebreated Kingfisher
81	*H. chloris*	Whitecollared Kingfisher
82	*Merops orientalis*	Green Bee-eater
83	*Tockus birostris*	Common Grey Hornbill

84	*Anthracoceros coronatus*	Malabar Pied Hornbill
85	*Megalaima virens*	Great Hill Barbet
86	*M. zeylanica*	Green Barbet
87	*M. rubricapilla*	Crimsonthroated Barbet
88	*Calandrella cinerea*	Short-toed Lark
89	*C. raytal*	Sand Lark
90	*Hirundo tahitica*	House Swallow
91	*Lanius schach*	Rufousbacked Shrike
92	*Dicrurus adsimilis*	Black Drongo
93	*Acridotheres tristis*	Common Myna
94	*Corvus splendens*	House Crow
95	*C. macrorhynchos*	Jungle Crow
96	*Coracina melanoptera*	Blackheaded Cuckoo Shrike
97	*Aegthina tiphia*	Common Iora
98	*Pycnonotus jocosus*	Redwhiskered Bulbul
99	*P. cafer*	Redvented Bulbul
100	*Pellorneun ruficeps*	Spotted Babler
101	*Pomatorhinus horsfieldii*	Slatyheaded Scimitar Babler
102	*Chrysomma sinense*	Yelloweyed Babler
103	*Turdoides caudatus*	Common Babler
104	*Alcippe poioicphala*	Quaker Babler
105	*Muscicapa tickelliae*	Tickell's Flycatcher
106	*Cisticola juncidis*	Streaked Fantail Warbler
107	*Prinia hodgsonii*	Franklin's Wren-Warbler
108	*P. socialis*	Ashy Wren-Warbler
109	*P. sylvatica*	Jaungle Wren-Warbler
110	*Orthotomus sutorius*	Taylor Bird
111	*Phylloscopus affinis*	Tickell's Leaf-Warbler
112	*Copsychus saularis*	Magpie Robin
113	*Saxicoloides fulicata*	Indian Robin
114	*Parus major*	Grey Tit
115	*Anthus novaeseelandiae*	Paddyfield Pipit
116	*A. spinoletta*	Water Pipit
117	*Motacilla citreola*	Yellowheaded Wagtail
118	*M. cinerea*	Grey Wagtail
119	*M. maderaspatensis*	Large Pied Wagtail
120	*Dicaeum erythrorhynchos*	Tickell's Flowerpecker
121	*Zosterops palpebrosa*	White-eye

3.7 CONCLUSION

On the basis of available 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 the biodiversity. Even the 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.

For 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.

Secondly for effective conservation and management strategies along the Indian 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. If we can use the traditional knowledge, experience and wisdom, there should not be any problems in future to protect our coastal biodiversity and Intellectual Property Right (IPR) from the invasion of the foreigners. 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 India. Similarly the modern gadgets like Internets for the quick dissemination of information can effectively connect the existing Marine Biological Information Centres, Museums and laboratories along the Indian coast.

CHAPTER IV

SENSITIVE COASTAL ECOSYSTEMS OF MALVAN

:A SPECIAL CASE STUDY

CHAPTER IV

SENSITIVE COASTAL ECOSYSTEMS OF MALVAN: A SPECIAL CASE STUDY

4.0 DESCRIPTION OF THE STUDY AREA

4.1 Location and brief history

Malvan is a small coastal town (16°02' to 16° 40'N lat and 73° 27' to 73° 29'E long) situated in the Sindhudurg district of Maharashtra. The history of Sindhudurg can be traced back to the 2nd Century AD when it was ruled by the Mauryas. This was followed by the Chalukyan rule and the conquest of the region by the Portuguese in the 16th century. Subsequently, between 1675 and 1817, the region was under the control of the Marathas and when finally the struggle between the British and Peshwas came to an end, the whole of Konkan was transferred to the British in 1817. After independence, with the re-organisation of the States in 1956, the district (then part of Ratnagiri district) was included in the Bombay (now Mumbai) state and since 1960 it formed part of Maharashtra. Sindhudurg district was formed in 1981 and now comprises the tehsils of Kudal, Malvan, Devgad, Kankavali, Vengurla, Sawantwadi and Vaibhavwadi. The name of the district has been adopted from the famous sea fort of Malvan i.e. Sindhudurg built by Shivaji Maharaja in 1667. The fort was constructed on low fortified Island on the coastal reef joined to the mainland by a sand bar, which gets exposed during low tide. Stations for the present study were identified after the preliminary survey. Station I was very close to the Sindhudurg Fort where the disturbance was less and Station II was towards the Arshe Mahal side where there was disturbance (Fig 4.1).

4.2 Physiography

4.2.1 Physical features

The Malvan coast is a open coastal ecosystem, dominated by rocky outcrops with intermittent stretches of sandy beaches (Ahmed, 1972). The coastline is about 6.5 sq.km. From Malvan Bay a chain of submerged and exposed rocky islands extend to the south upto 15 ° 53'N lat and 63 ° 27'E long. Malvan coast forms a part of the Western ghat where Sahyadri ranges gradually meet the Arabian Sea. From Vengurla point, the coast trends towards north for about 22 kms. To the north of Malvan the most striking beach feature is the littoral concrete or beach rock often continuous over long stretches. This littoral concrete occurs as a rocky beach either directly connected to the mainland or separated by sandy or marshy areas. The rocky beach gives protection to the coast against strong waves. In some regions the rocky beach occurs as a rim of banks enclosing marshy islands.

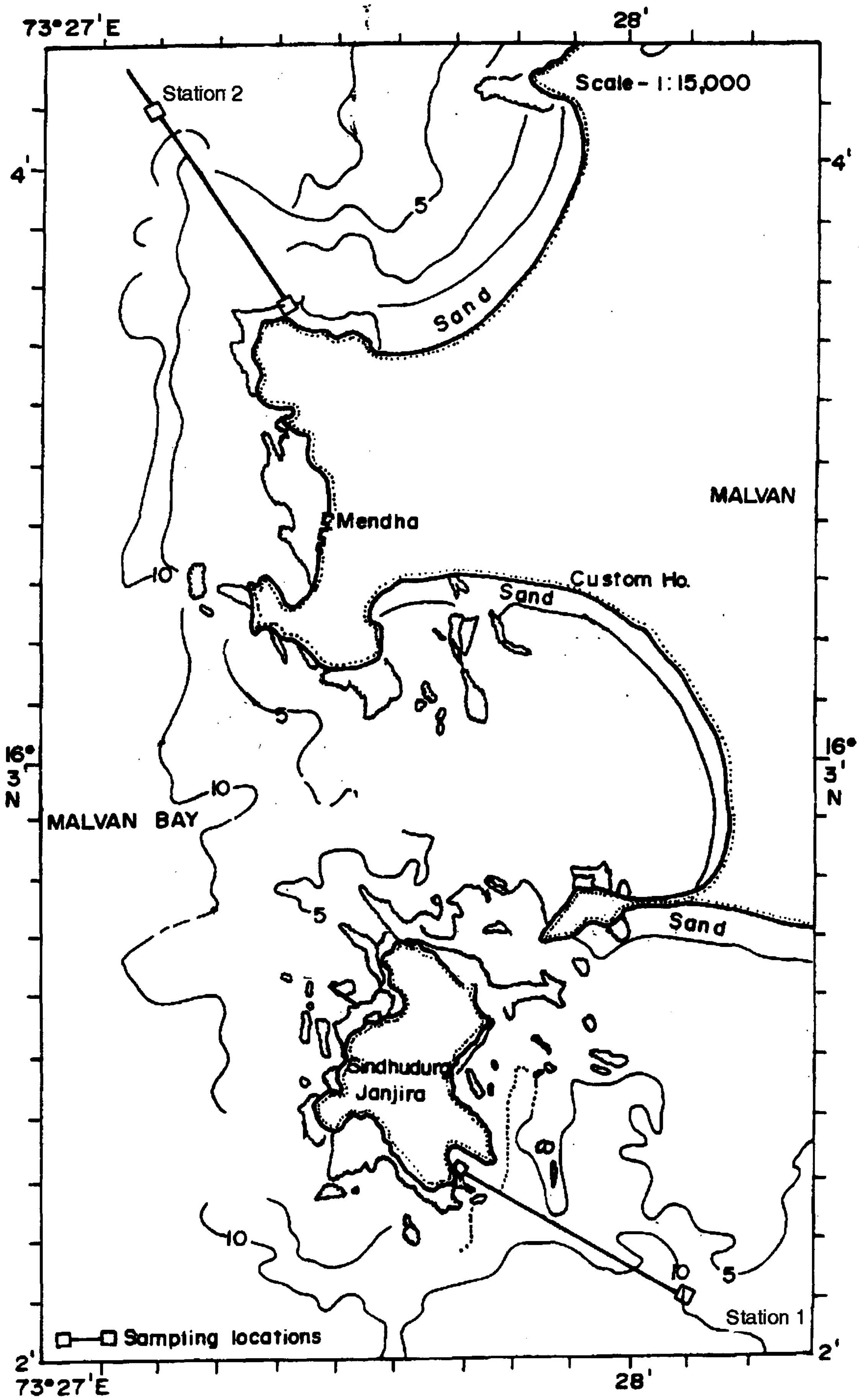


Fig.4.1 Map of Malvan showing geographical locations of stn. 1 & stn. 2 at Malvan

4.2.2 Geo-climatic features

4.2.2.1 Soils

Malvan shows the presence of three types of soils viz., laterite soil, salty soil and coastal alluvium. These soils are found in two main grades- rice soil and varkas soil which are low in fertility. Paddy is the main crop grown in these soils. The other crops include Ragi, Vari and Nagali. The lateritic slopy soil is ideal for cash crops such as mango, cashewnut, kokam, arecanut and jackfruit. Salty soil, locally known as Khar or Khajan is found in these area. Coastal strips have a deep sandy loams where coconut and arecanut gardens thrive on these soils.

4.2.3 Topography

Malvan is an open coastal ecosystem, the prominent features of this coastline are rocky,dissected mainland with projecting headlands stacks and erosion platforms, rocky shoals, submerged reefs and boulders. The shoreline is very irregular, indented and hence is known as 'Crenulate' shoreline. Malvan waters have always been good fishing grounds. The lowlands along the Karli and Kolamb creeks are influenced by salt water resulting into Khar/Khajan lands. The sea in between and around the Sindhudurg fort has many submerged and exposed rocks that provide ideal substratum and shelter for marine biota including corals and other organisms. Gradual slope occurs between mainland

and the fort, which is exposed during low tide (about 300-500m). Towards northwest, cliffs are present with narrow (10-20m) intertidal expanse.

4.3 MATERIALS AND METHODS

4.3.1 Environmental parameters

Data for atmospheric temperature and rainfall were obtained from the Indian Meteorological Department, Colaba, Mumbai for the year 1997-1999.

4.3.2 Hydrographical parameters

4.3.2.1 Sampling procedure (Water)

Surface water samples for general analyses were collected using a clean polyethylene bucket while a Niskin sampler with a closing mechanism at a desired depth was used for obtaining sub-surface and bottom water samples.

4.3.2.2 Method of analysis

Majority of the hydrographical parameters was analyzed in the field laboratory. The surface water temperature (Celsius thermometer), pH (Labinda pH analyzer), Salinity (Mohr-Knudsen method : Strickland and Parson, (1972), Dissolved Oxygen (Wrinkler's method: Strickland and Parson, (1972) and nutrients such as Nitrate (NO_3-N), Nitrite (NO_2-N), Phosphate (PO_4 –P) and silicate (SiO_4) were determined by following Strickland and Parson (1972).

4.3.2.3 Sampling procedure (Sediment)

Sediment samples were collected by the Van Veen grab of (0.04 m^2) area and hand held acrylic core (4cm diameter). The samples after retrieval were transferred to polyethylene bags and were preserved for further analysis.

4.3.2.4 Method of analysis

To find out the soil characteristics such as soil texture and organic matter the samples were concentrated in the present study. Soil texture was determined using standard method (Folk, 1968). Organic carbon was anlaysed (Walky and Ripley 1957) and then changed to organic matter by multiplying with a factor value (1.72).

4.3.3 Biological parameters

4.3.3.1 Phytoplankton and its abundance

For the enumeration and identification of phytoplankton cells, surface water sample was collected with the help of pre-cleaned plastic bucket. A 250 ml of water sample (in duplicate) was then immediately transferred to a plastic bottle and fixed with 1% Lugol's solution. The samples were stored in dark at room temperature until enumeration within a period of one month after collections. For the quantitative analysis, the settling and siphoning procedure was followed to obtain 20-25 ml concentrate. 1 ml of this concentrated sample was transferred to a Sedgwick Rafter Plankton Counting Chamber and observed under a stereoscopic binocular microscope (magnification 100X) for enumeration and identification of phytoplankton of sizes > 5μm. Species identification was done according to Subrahmanyan (1959), Wimpenny (1966), Desikachary (1959, 1987), Steidinger and Williams (1970), Taylor (1976), Anand *et al.,*(1986). Phytoplankton not identified to species was collectively placed under generic listings.

The phytoplankton observed during the present study was grouped into Bacillariophyceae, Dinophyceae, Cyanophyceae and Chlorophyceae for convenience and easy enumeration.

Species diversity index (H') was calculated using the Shannon and Weaver's (1949) formula.

$$H = -\sum_{i=1}^{s} pi \log2 PI$$

Where H' = species diversity in bits of information per individual and pi = proportion of the samples belonging to the i^{th} species.

pecies richness (SR) was calculated as described by Gleason (1922).

$$SR = \frac{S - 1}{\text{LogeN}}$$

Where, S = the number of species of a particular sample and N= the natural logarithm of the total number of individuals of all the species in the sample.

Evenness index (j') (equitability) was calculated using the formula of Pileou (1966).

$$J = \frac{H'}{\text{Log}_2 S}$$

Where H' = species diversity in bits of information per individuals and S = number of species.

Dominance index (δ) was calculated using the formula of Mc Naughton (1967) as described by Ignatiades and Mimicos (1977).

$$\delta = 100 \frac{(n1 + n2)}{N}$$

Where δ = dominance index, equal to the percentage of total standing crop contributed by the two most important species, n1 and n2 = percentage of total population contributed by the two most abundant species in the sample and n = average concentration of total phytoplankton standing crop in the same series of sample.

Data obtained were treated statistically for drawing a simple correlation (r) between different parameters.

4.3.3.2 Zooplankton

Zooplankton samples were collected using a Heron Tranter net (mouth area 0.25 m2, mesh size 200 μm). The net towed horizontally at approximately 1 m depth below the surface for 5 minutes for a distance of about 50m. A calibrated flow meter (General Oceanics, USA) was attached to the mouth of the net to record the volume of seawater filtered through the net during the tow. The sample was divided using Folsom Plankton Splitter, either to 25 or to 6.25 % to determine the concentration and composition of zooplankton. All zooplankton samples were analyzed for numerical counts of different groups and common species. The species were identified using the descriptions of Scott (1909), Wilson (1932), Dakin and Colefax (1940), Davis (1955), Kasthurirangan (1963) and Wickstead (1965).

Statistical analysis was done as the same way as mentioned for phytoplankton.

4.3.3.3 Macrobenthos

Sediment samples were collected with a Van Veen grab, covering an area of 0.04 m^2 with the help of quadrant (625 cm^2 area). Triplicate samples for macrobenthos were washed through a 0.5 mm mesh stainless steel sieve and the remaining samples were preserved in 10% seawater formaldehyde solution containing rose Bengal. The samples were again washed through 0.5 mm mesh sieve in running water in the laboratory to clear adhering sediments. All stained animals were picked and preserved in 90% alcohol. Later organisms were sorted and counted group-wise and identified under a stereoscope zoom binocular microscope.

4.3.3.4 Marine algae

The intertidal zones along the open rocky coast were surveyed for marine algae at low tides. Marine algal samples were collected at random and the common species were recorded. Separately samples were also recorded along the stations marked. Samples collected from the quadrant were washed with seawater to remove sand particles and adhering debris. The samples were again washed with fresh water in the laboratory and each species was sorted out. The seaweed species preserved in the form of herbarium sheets or in 5% formalin for further clarification and identification and deposited in the Museum of National Institute of Oceanography, Goa.

The distribution and zonation of the algae was studied following the universal scheme proposed by Stephenson and Stephenson (1949).

4.3.3.5 Corals

Stations along the study area were also observed for the presence or absence of corals. This study was carried out by surveying the intertidal area during the low tide Subtidal area was surveyed by Scuba diving, with the help of trained diver scientists.

4.3.3.6 Mangroves

Mangrove flora were surveyed during low tides and the species recorded were identified.

4.4 RESULTS

4.4.1 Environmental parameters

The environmental parameters such as temperature and rainfall were recorded in the present study from January 1997 to June 1999 in Malvan as follows.

4.4.1.1 Atmospheric temperature

The minimum temperature of 14.7 (Feb) and 24.8 °C (July); 16.7 (Dec) and 26.7 °C (May); and 15.1 (Jan) and 24.7 (May) and the maximum temperature of 29.7 (Aug) and 33.1 (May); 29.9 (Sept) and 34.0 (May), and 29.7 (June) and 32.7 (Feb) were recorded respectively during 1997-1999 (Fig 4.2)

4.4.1.2 Rainfall

The total rainfall recorded (mm) recorded as 2934.4 (1997), 3138.4 (1998) and 1780.4 (1999). The minimum rainfall of 11.2 (Jan), 52.0 (May) and 267.2 mm (May) and the maximum rainfall of 984.6 (July), 1014.2 (June) and 1513.2 mm (June) were recorded during 1997-99 (Fig 4.3).

4.4.2 Hydrographical parameters

4.4.2.1 Surface water temperature

At station I, the surface water temperature ranged from 28 (May 99) to 30.3 °C (May 98), while it varied from 27.7 (May 99) to 32.7 °C (May 98) in Station II (Fig 4.4). ANOVA (Two way) showed significance between stations and not between seasons (Table 4.1).

Fig 4.2 Monthly average atmospheric temperature recorded at Malvan

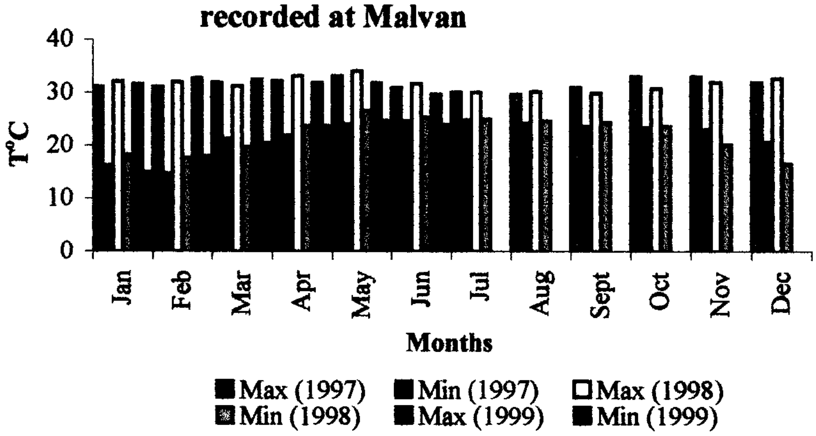


Fig 4.3 Monthly average rainfall (mm) recorded at Malvan

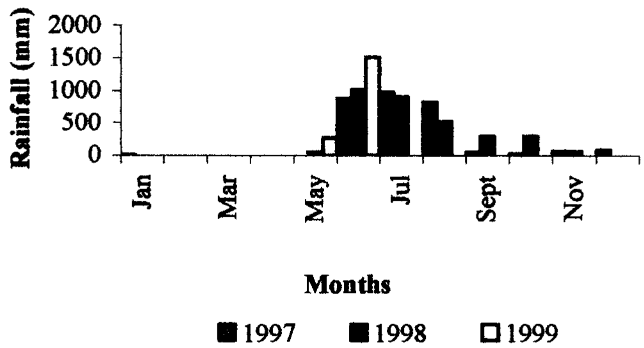
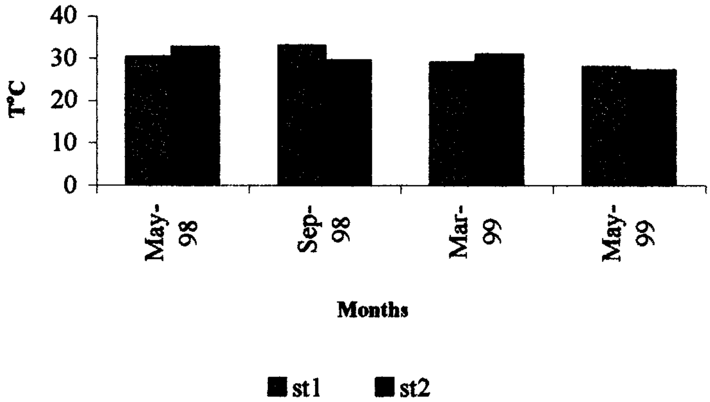


Fig 4.4 Average temperature recorded at Malvan during the study period



4.4.2.2 Salinity

At Station I, the seawater salinity varied between 29.06 PSU (Sept 98) and 35 (May 98). It fluctuated from 27.52 (Sept 98) to 35.83 PSU (May 98) at station II (Fig 4.5). ANOVA (Two way) for salinity exhibited significance between stations and not between seasons (Table 4.2).

4.4.2.3 pH of water

At station I, pH ranged from 7.11 (May 98) to 7.85 (May 99), whereas it varied between 7.09 (May 98) and 8.22 (Mar 99) at station II (Fig 4.6). ANOVA (Two way) showed significance between seasons and not between stations (Table 4.3).

4.4.2.4 Dissolved Oxygen

The maximum values for dissolved oxygen of water was found to be between 5.44 and 3.44 ml/l (May 99) and the minimum of 3.82 to 3.16 ml/l (May 98) in the stations I and II respectively (Fig 4.7). ANOVA (Two way) for dissolved oxygen showed remarkably significance between seasons and stations (Table 4.4)

Table 4.1 ANOVA (Two way) for the difference in temperature between the stations I and II

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.651225	3	0.550408	0.687278	0.582147	3.862539
Columns	25.17868	3	8.392892	10.47994	P<0.005	3.862539
Error	7.207675	9	0.800853			
Total	34.03758	15				

Table 4.2 ANOVA (Two way) for the differences in salinity between the stations I and II

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.2116	3	0.070533	0.216493	0.882517	3.862539
Columns	146.1333	3	48.7111	149.5123	P<0.005	3.862539
Error	2.9322	9	0.3258			
Total	149.2771	15				

Table 4.3 ANOVA (Two way) for the differences in pH between the stations I and II

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	5.640625	3	1.880208	14.52428	P<0.005	3.862539
Columns	1.965275	3	0.655092	5.060468	P<0.05	3.862539
Error	1.165075	9	0.129453			
Total	8.770975	15				

Fig 4.5 Salinity recorded at Malvan during the study period

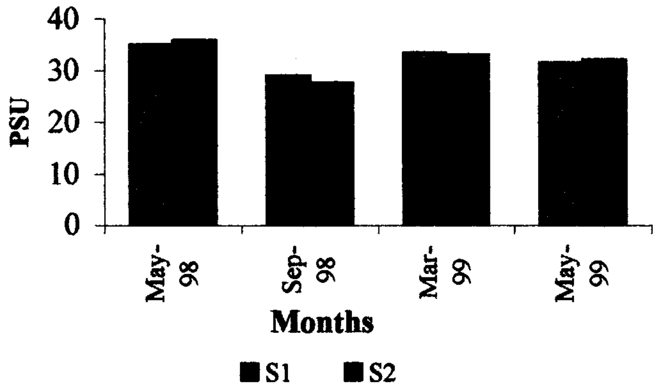


Fig 4.6 pH recorded at Malvan during the study period

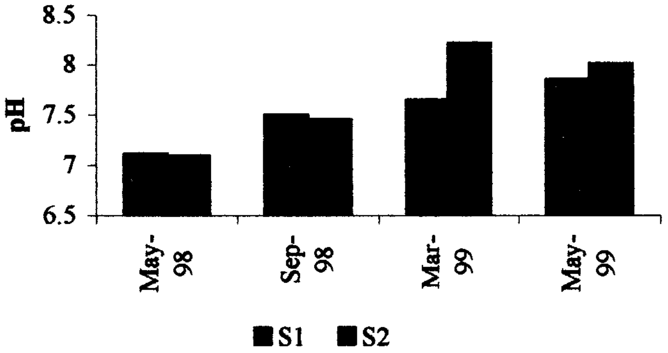
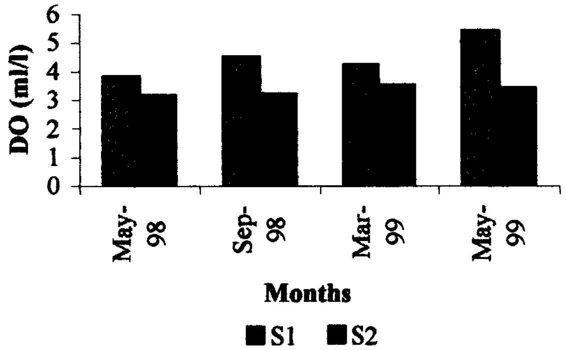


Fig 4.7 Dissolved oxygen recorded at Malvan during the study period



4.4.2.5 Biological Oxygen Demand (BOD)

The maximum value of BOD was found to range between 2.98 and 2.4 ml/l (Sept 98) and the minimum between 1.45 and 1.17 ml/l (Mar 99) respectively in stations I and II (Fig 4.8). ANOVA for BOD showed significance between stations and between seasons (Table 4.5).

4.4.3 Nutrients

4.4.3.1 Nitrate

At station I, the nitrate concentration varied from 1.67 (May 98) to 5.08 (May99), while it ranged between 0.49 µmol/l (Mar 99) and 3.31 (May 99) in station II (Fig 4.9). ANOVA for nitrate showed remarkable significance between seasons and stations (Table 4.6).

4.4.3.2 Nitrite (NO_2)

At station I, the nitrite concentration ranged between 0.03 (Mar 99) to 1.17 (May 99) µmol/l and it varied from 0.09 (Sept 98) to 0.49 (May 98) in Station II (Fig 4.10). ANOVA (Two way) showed significant between stations and not between seasons (Table 4.7).

Table 4.4 ANOVA (Two way) for the differences in dissolved oxygen between the stations I and II

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.3969	3	0.1323	7.647399	P<0.01	3.862539
Columns	4.2921	3	1.4307	82.69942	P<0.005	3.862539
Error	0.1557	9	0.0173			
Total	4.8447	15				

Table 4.5 ANOVA (Two way) for the differences in BOD between the stations I and II

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.065025	3	0.021675	0.26056	0.852069	3.862539
Columns	1.182275	3	0.394092	4.73747	P<0.05	3.862539
Error	0.748675	9	0.083186			
Total	1.995975	15				

Table 4.6 ANOVA (Two way) for the differences in nitrate between the stations I and II

Sources of variation	SS	df	MS	F	P-value	F crit
Rowa	12.14523	3	4.048408	15.60498	P<0.005	3.862539
Columns	20.56828	3	6.856092	26.42746	P<0.005	3.862539
Error	2.334875	9	0.259431			
Total	35.04838	15				

Fig 4.8 Biological oxygen demand recorded at Malvan during the study period

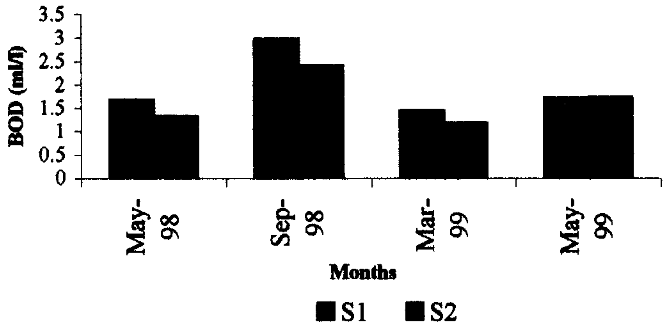


Fig 4.9 Nitrate recorded at Malvan during the study period

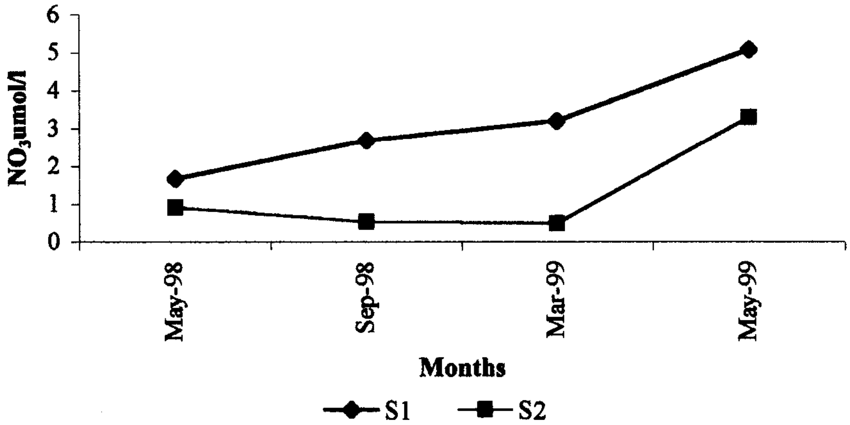
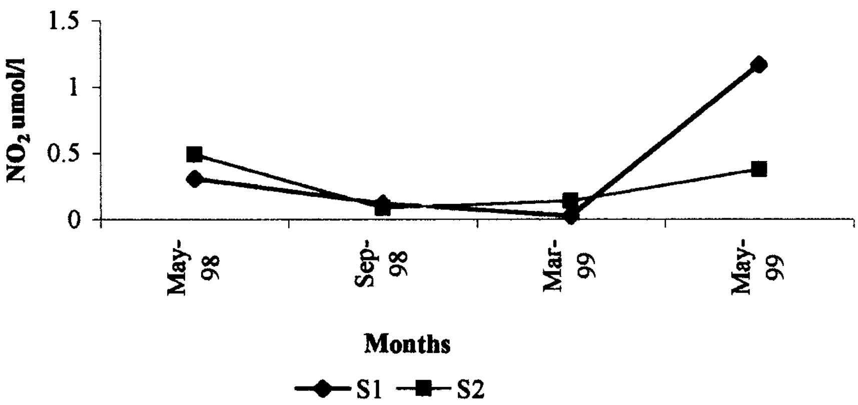


Fig 4.10 Nitrite recorded at Malvan during the study period



4.4.3.3 Phosphate (PO_4)

At station I, the phosphate concentration varied from 0.25 (Mar 99) to 0.57 µmol/l (May 98), whereas it ranged between 0.45 (May 99) and 1.57 (May 98) µmol/l in station II (Fig 4.11). ANOVA showed no significant difference between seasons and stations (Table 4.8).

4.4.3.4 Silicate (SiO_4)

The maximum silicate concentration of 23.27 and 15.89 µmol/l (May 99) and the minimum of 3.42 (Sept 98) and 3.79 (Mar 99) µmol/l were recorded at station I and II respectively (Fig 4.12). ANOVA showed no significant difference between seasons and stations (Table 4.9).

4.4.4 Sediment

4.4.4.1 Organic matter

At station I, the organic matter values varied between 0.11 (May 98) and 1.79 % (Mar 99), while it ranged from 0.61 (Mar 99) to 1.67 % (May 99) at station II (Fig 4.13). ANOVA for organic matter exhibited no significant difference between seasons and stations (Table 4.10).

Table 4.7 **ANOVA (Two way) for the differences in nitrite between the stations I and II**

Source of variation	SS	df	MS	F	P-value	F crit
Rows	0.065025	3	0.021675	0.26056	0.852069	3.862539
Columns	1.182275	3	0.394092	4.73747	$P<0.05$	3.862539
Error	0.748675	9	0.083186			
Total	1.995975	15				

Table 4.8 **ANOVA (Two way) for the differences in phosphate between the stations I and II**

Sources of Variation	SS	df	MS	F	P-value	F crit
Rows	4.7524	3	1.584133	0.219676	0.880331	3.862539
Columns	662.6317	3	220.8772	30.62965	$P<0.005$	3.862539
Error	64.901	9	7.211222			
Total	732.2851	15				

Table 4.9 **ANOVA (Two way) for the differences in silicate between the stations I and II**

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.2809	3	0.093633	0.289677	0.831863	3.862539
Columns	2.116	3	0.705333	2.182118	0.159872	3.862539
Error	2.9091	9	0.323233			
Total	5.306	15				

Table 4.10 **ANOVA (Two way) for the differences in organic matter between the station I and II**

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.2809	3	0.093633	0.289677	0.831863	3.862539
Columns	2.116	3	0.705333	2.182118	0.159872	3.862539
Error	2.9091	9	0.323233			
Total	5.306	15				

Fig 4.11 Phosphate recorded at Malvan during thestudy period

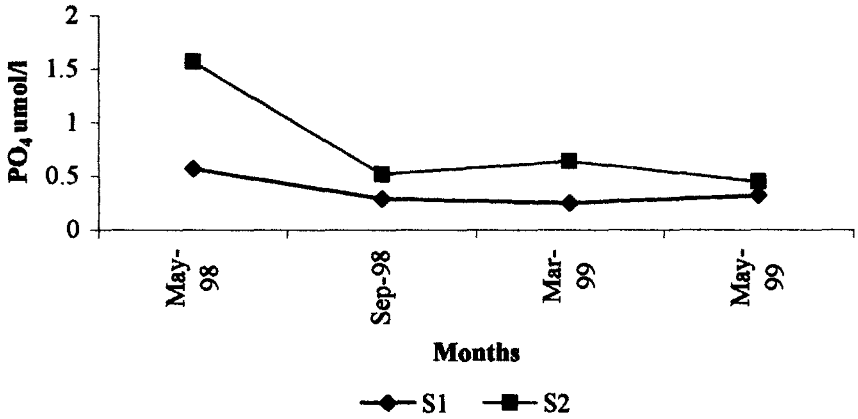


Fig 4.12 Silicate recorded at Malvan during the study period

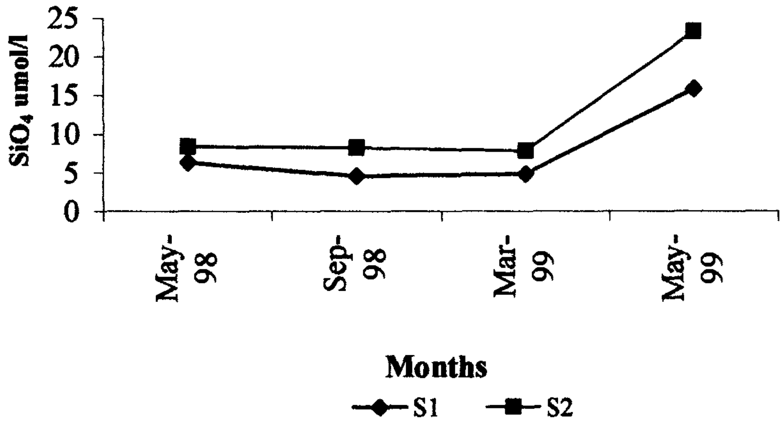
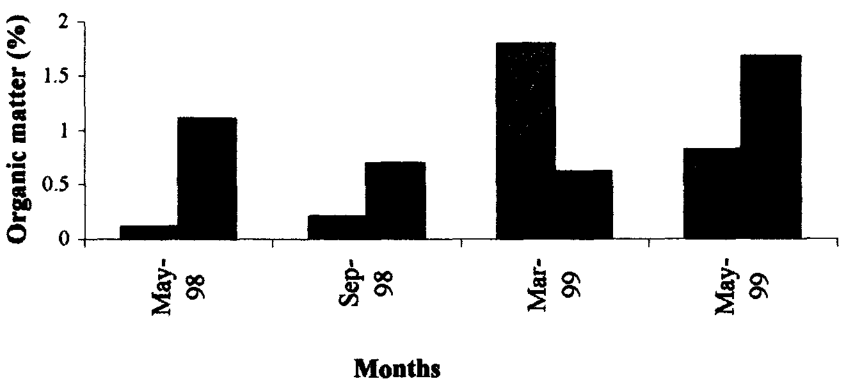


Fig 4.13 Organic matter recorded Malvan during the study period



4.4.4.2 Soil texture

Soil texture was analyzed in both the stations I and II. In station I, the sand composition ranged between 55.6 (May 99) and 84.1 % (Mar 99); silt composition of 1.7 (Sept 98) and 43.2% (May 99); and clay composition of 1.3 (Mar 99) and 24.5 % (May 98) (Fig 4.14).

At station II, the sand composition of 59.5 (May 98) and 66.95 (May 99); silt composition of 22.1 (May 98) and 33.0 (May 99); and clay composition of 0.1 (May 99) and 18.4 % (May 98) were recorded (Fig 4.15).

Based on the observation of the present study, at the stations the nature of soil was sandy.

4.4.5 Phytoplankton

4.4.5.1 Species composition

57 species of phytoplankton were totally recorded from both the stations, in which Bacillariophyceae members were found to be predominant at both the stations.

Among 36 number of species recorded at station I, the group Bacillariophyceae was found to be dominant (34) followed by Dinophyceae (1) and

Fig 4.14 Soil texture (%) composition at Station I

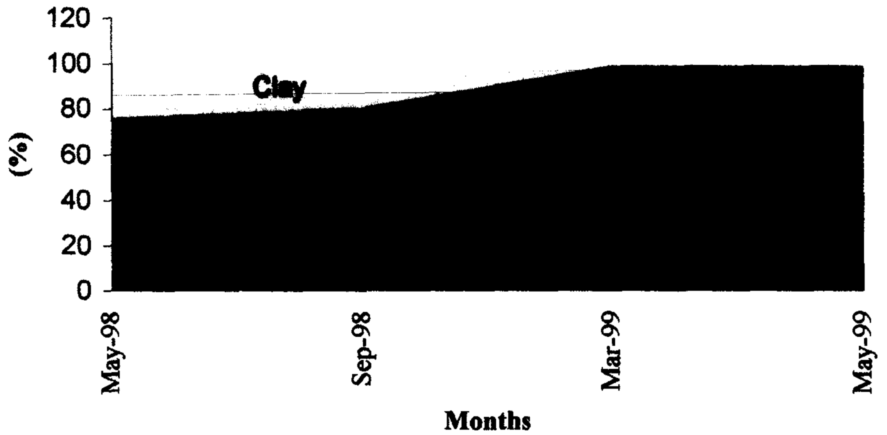
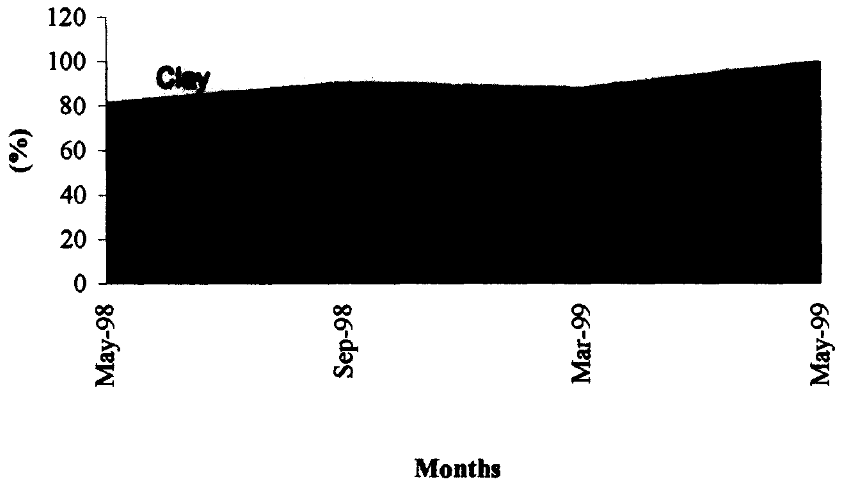


Fig 4.15 Soil texture(%) composition at Station II



Cyanophyceae(1). At station II, totally 29 species were recorded, among those Bacillariophyceae (25) dominated followed by Dinophyceae (3) and cyanophyceae (1). The group Bacillariophyceae was found to be present throughout the study period whereas Cyanophyceae was recorded only during March 99. Among various species recorded *Chaetoceros debilis, C. affinis, C. constrictus, C. curvisetus, Thallassionema nitzschioides, Asterionella japonica, Skeletonema costatum, Prorocentrum gracilis* and *Trichodesmium* sp were found to be predominant in the present study (Table 4.11).

4.4.5.2 Percentage Composition

The percentage composition of the phytoplankton was recorded at both the stations. At both the station similar trend was noticed as Bacillariophyceae (98.8%), Dinophyceae (0.4 %) and Cyanophyceae (08%) (Fig 4.16 & 4.17).

4.4.5.3 Population density

The population density of a minimum of 60,000 Nos/l (Mar 99) and 43,000 Nos/l (Mar 99) and the maximum density of 31,90,000 Nos/l (May 98) and 160,0000 Nos/l (May 98) were recorded at Station I and II respectively during the study period (Fig 4.18).

Table 4.11 Qualitative data for phytoplankton at Station I and II at Malvan

Name of the Species	Station I				Station II			
	May 98	Sept 98	Mar 99	May 99	May 98	Sept 98	Mar 99	May 99
BACILLARIOPHYCEAE								
Acanthes longipes	-	-	-	+	-	-	-	-
Asterionella japonica	-	+	-	+	-	+	-	+
Bacteriastrum varians	-	-	+	-	-	-	-	-
Biddulphia favus	-	-	-	+	-	-	-	-
Biddulphia mobiliensis	-	-	-	+	-	-	-	+
Biddulphia sinensis	-	-	-	-	-	-	-	-
Chaetoceros affinis	+	-	-	-	+	+	-	-
Chaetoceros coarctatus	-	-	-	-	-	+	-	-
Chaetoceros constrictus	+	-	-	-	+	-	-	-
Chaetoceros curvisetus	-	+	-	-	+	-	-	-
Chaetoceros debilis	+	-	-	-	+	-	-	+
Chaetoceros decipeince	-	-	-	-	-	+	-	-
Chaetoceros laciniosus	-	+	-	-	-	-	-	-
Climacosphemia moniligera	-	-	-	+	-	-	-	-
Coscinodiscus sp	-	-	+	+	+	-	+	+
Diploneis sp	-	-	-	-	-	-	+	-
Ditylum brightwelli	-	-	-	+	-	-	-	-
Eucampia zoodiaars	-	-	-	-	-	-	-	-
Fragilaria oceanica	-	+	-	-	-	-	-	-
Grammatophora sp	-	-	+	+	-	-	+	-
Hyalodiscus stelligies	-	-	-	+	-	-	-	-
Leptocylindrus danicus	+	-	+	-	-	+	-	+
Melosira moniligera	-	-	-	-	-	-	-	+
Nitzschia bilobata	-	-	-	+	-	-	-	-
Nitzschia closterium	+	+	-	+	+	+	-	+
Nitzschia delicalissima	+	+	-	-	+	+	-	-
Nitzschia longissima	-	+	-	-	-	-	-	-
Nitzschia panduriformis	+	+	-	+	-	+	-	-
Nitzschia seriata	+	-	-	+	-	-	-	-
Nitzschia sigma	-	-	-	-	-	-	-	-
Pinnularia sp	-	-	-	-	+	+	+	-
Planktoniella normanis	-	-	-	-	-	-	-	-
Planktoniella sol	-	-	-	-	-	-	-	-
Pleurosigma angulatum	+	-	+	+	+	-	+	-
Pleurosigma carinatum	-	-	-	-	-	-	-	-
Pleurosigma directum	-	-	-	-	-	-	-	-

Pleurosigma elongatum	-	-	+	+	+	-	-	-
Pleurosigma galapagense	-	-	-	-	-	-	-	-
Pleurosigma normanii	-	-	-	-	-	-	-	-
Rhizosolenia alatu	+	-	-	-	-	-	-	-
Rhizosolenia seligera	-	-	-	-	-	+	-	-
Rhizosolenia sholterfothii	-	-	+	-	-	+	-	-
Sceletonema costatum	-	-	-	+	-	-	-	+
Stouroneis sp	-	-	-	+	-	-	-	-
Striatella unipunctata	+	-	-	-	+	-	-	-
Thalassiosira condensates	-	-	-	+	-	-	-	-
Thalassiothrix frauenfuldpii	-	-	-	+	-	-	-	-
Thallasionema condensates	-	-	-	+	-	+	-	-
Thallasionema nitzschioides	+	+	+	+	-	+	-	+
Thallassionema condersortei	+	-	-	-	-	-	-	-
Triceratium sp	-	-	-	-	-	-	-	-
DINOFLAGELLATES								
Ceratium furca	-	-	-	-	-	-	-	-
Ceratium sp	-	-	-	-	-	-	-	-
Dinophysis caudata	-	-	-	-	-	-	-	-
Disophysis sp	-	-	-	-	-	-	-	-
Prorocentrum gracile	-	+	+	+	-	-	+	-
Prorocentrum micans	+	-	-	-	-	+	-	-
Prorocentrum sp	-	-	-	-	-	-	-	-
Protoperidinium pallucidum	-	-	-	-	-	+	-	-
CYANOPHYCEAE				-		-		
Trichodesmium sp	-	-	+	-	-	-	-	-

Fig 4.16 Percentage composition of phytoplankton at Station I

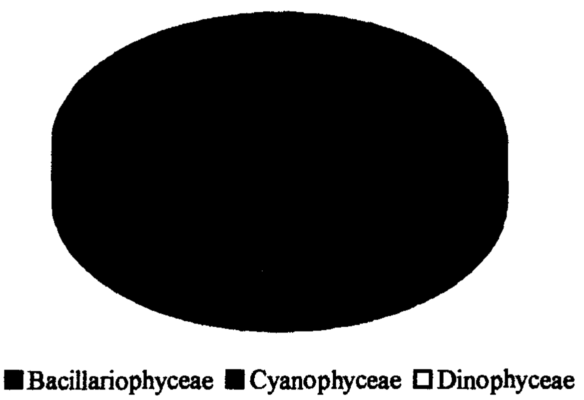


Fig 4.17 Percentage composition of phytoplankton at Station II

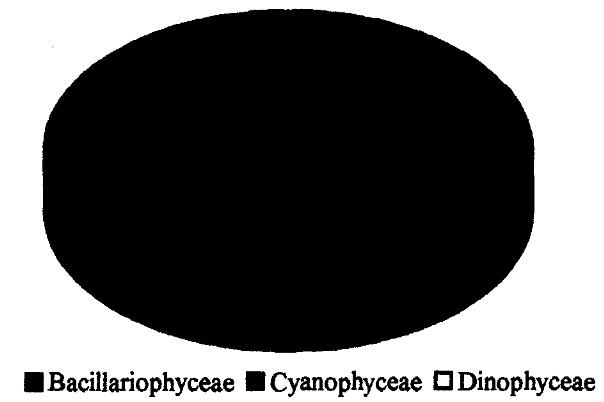
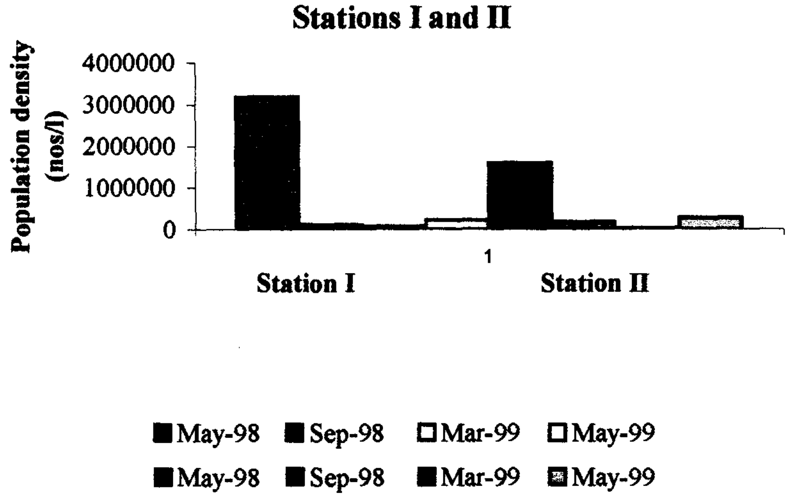


Fig 4.18 Population density of phytoplankton at Stations I and II



4.4.5.4 Species diversity

At station I, the species diversity ranged from 2.1241 (Mar 99) to 3.5060 bits/individuals (May 99), while it varied between 2,4339 (May 98) and 3.6235 bits/individuals (Sept 98) at station II (Table 4.15).

4.4.5.5 Species evenness

In the present study, the species evenness varied from 0.6250 (May98) to 0.8789 (Sept 98), while it ranged from 0.7036 (May 98) to 0.9464 (May 98) at stations I and II respectively (Table 4.15)

4.4.5.6 Species richness

At station I, the species richness differed from 0.7852 (Sept 98) to 1.7019 (May 99) and it ranged from 0.6614 (May 99) to 1.1967 (Sept 98) at station II (Table 4.15).

4.4.5.7 Dominance index

In the present study, the dominance index showed a range of 0.1211 (Sept 98) and 0.3750 (May 98); 0.0536 (Mar 99) and 0.2964 (May 98) at station I and II respectively (Table 4.15).

The correlation coefficient (r) values between phytoplankton and other hydrological parameters for the station I and II are given in Tables 4.17 and 4.18. At station I, the phytoplankton composition showed significant positive correlation with pH, dissolved oxygen, nitrate and phosphate and significant negative correlation with temperature, salinity, biological oxygen demand, silicate and organic matter. At station II, it had significant positive correlation with temperature, pH, dissolved oxygen, nitrite and phosphate and significant negative correlation with salinity, biological oxygen demand, silicate and organic matter.

4.4.6 Zooplankton

4.4.6.1 Zooplankton composition

Zooplankton composition constituted of Copepods, Cladocera, Ostracods, Amphipods, Lucifers, Siphanophora, Mollusca, Chaetognatha, Decapod larvae , Appendicularia, Invertebrate eggs and Fish larvae.

Among the above mentioned ones, Copepods dominated with 74.17 (Sept 98) to 95.1 % (May 98); 46.03 (Sept 98) to 93.04 % (Mar 99) at station I and II respectively. Next to Copepods, Cladocera (4.97 Sept 98 to 36.51 % Sept 98) Decapods larvae, Lucifers, Molluscs, Polychaetes. Ostracodes, Chaetognatha, Appendicularia, Amphipoda, Invertebrate eggs were found dominant in the same order. The percentage composition of zooplankton are presented in Table 4.12.

Owing to the high percentage of copepods, special efforts was made to go up to genus or species level.

33 species of copepods were totally recorded at both the stations. Among these, *Centropages calaninus, Acartia ambionensis, Paracalanus sp. Calanopia elliptica and Centropages sp.*were found to be dominant during the study period.The qualitative analysis of Zooplankton and Copepods are presented in Tables 3.13 and 3.14 respectively.

4.4.6.2 Species diversity

The species diversity values of zooplankton ranged from 0.4022 (May 98) to 1.4404 bits/individuals (Mar 99); 0.6902 (Mar 99) to 2.3404 bits/individuals (May 99) at station I and II respectively (Table 4.16)

4.4.6.3 Evenness

At station I, the evenness was found to vary between 0.1122 (May 98) and 0.4939 (Sept 98) whereas it ranged from 0.2242 (May 98) to 0.7383 (May 99) at station II (Table 4.16)

Table 4.12 Percentage composition of zooplankton of Station I and II at Malvan.

Groups	May 98		Sept 98		Mar 99		May 99	
	StI	StII	StI	StII	StI	StII	StI	StII
Siphonophora	0.1	0.59	-	-	-	-	-	-
Polychaeta	0.04	0.89	-	-	-	1.49	0.62	3.12
Mollusca	0.3	2.69	-	-	1.61	-	-	-
Cladocera	0.6	1.49	4.97	36.51	1.61	4.84	4.66	12.6
Ostracodes	0.3	1.89	0.33	-	1.61	-	0.31	3.12
Copepods	95.08	89.8	74.17	46.03	77.42	93.04	87.28	62.5
Decpods larvae	1.1	1.19	7.38	7.93	9.68	-	4.03	6.35
Chaetognatha	0.05	0.29	0.66	1.59	-	-	0.31	-
Appendicularia	0.1	0.59	-	-	-	-	-	-
Invertebrate eggs	0.1	-	-	-	1.61	-	0.62	-
Fish eggs	0.04	0.29	5.63	6.35	4.94	-	0.62	6.25
Lucifers	2.2	0.29	6.95	1.59	-	0.72	1.24	3.12
Amphipoda	-	-	-	-	1.61	-	0.31	3.12

St: Station

Table 4.13 Qualitative data of Zooplankton of Station I and II at Malvan

Name of the Group	Station I				Station II			
	May 98	Sept 98	Mar 99	May 99	May 98	Sept 98	Mar 99	May 99
Siphonophora	+	-	-	-	+	-	-	-
Polychaeta	+	-	+	+	+	-	+	+
Mollusca	+	-	-	-	+	-	-	-
Cladocera	+	+	+	+	+	+	+	+
Ostracods	+	+	+	+	+	+	+	+
Amphipoda	-	-	+	+	-	-	-	+
Copepods	+	+	+	+	+	+	+	+
Decapod larvae	+	+	+	+	+	+	+	+
Chaetognatha	+	+	-	+	+	+	+	-
Appendicularia	+	-	-	-	+	-	-	-
Invertebrate eggs	+	-	+	+	+	-	-	-
Fish eggs	+	+	+	+	+	+	+	+
Lucifers	+	+	+	+	+	+	+	+
Pteropoda	-	-	-	-				+
Nauplius	-	-	-	-				+

+ = present, - = absent

Table 4.14 Qualitative data for copepod species recorded of Station I and II at Malvan

Name of the species	Station I				Station II			
	May 98	Sept 98	Mar 99	May 99	May 98	Sept 98	Mar 99	May 99
COPEPODA								
Centropages calaninus	+	-	-	-	+	-	-	-
Centropages tenuiremis	-	-	+	+	-	-	-	+
Centropages sp	-	+	-	-	-	+	-	-
Eucalanus sp	+	+	+	+	+	-	-	-
Corycaeus sp	+	-	+	+	+	+	-	+
Oithona similis	-	+	-	-	-	+	-	-
Oithona sp	+	-	+	+	+	-	+	+
Acartia amboinensis	+	-	-	-	+	-	-	-
Acartia bowmani	-	-	-	-	-	-	+	-
Acartia erythraea	-	-	+	-	-	-	+	-
Acartia negligens	-	-	+	+	-	+	+	+
Acartia spinicauda	+	-	-	-	+	-	-	-
Paracalanus sp	+	-	+	+	+	+	-	+
Bomolochus sp	-	+	-	-	-	-	-	-
Copilia vitrea	-	-	+	+	-	+	-	-
Labidocera sp	-	-	-	+	-	+	+	+
Macrosetella sp	-	+	+	-	-	+	-	-
Clytemnestra scutella	-	-	-	-	-	+	-	-
Clytemnestra sp	-	-	-	+	-	-	-	-
Pseudodiaptamus serricaudatus	+	-	+	+	+	-	+	-
Canthocalanus pauper	+	-	+	-	+	-	-	+
Acrocalanus sp	+	-	-	+	+	-	+	-
Calanopia elliptica	+	-	-	-	+	-	-	-
Calanopio sp	-	-	+	-	-	-	+	-
Undinula vulgaris	-	-	+	-	-	-	-	-
Calocalanus pavo	-	-	+	+	-	-	-	-
Cosmocalanus darwini	-	-	-	+	-	-	-	-
Temora turbinata	+	-	+	+	+	-	+	-
Temora sp	-	-	-	-	-	+	-	-
Euterpina sp	+	-	-	-	+	-	-	-
Oncaea sp	+	-	+	-	+	-	+	-
Pontella sp	-	-	-	-	-	-	+	+
CLADOCERA								
Penilia avirostris	-	+	-	-	-	+	-	-
Evadne tergestina	-	+	-	-	-	+	-	-

+ = Present; – = Absent

4.4.6.4 Species richness

The species richness of te zooplankton varied from 1.0507 (Sept 98) to 1.7299 (May 99); 1.047 (Mar 99) to 2.0778 (May 99) at both stations I and II respectively.

4.4.6.5 Dominance index

The dominance index of zooplankton in the present study showed a variation between 0.5061 (Sept 98) and 0.8878 (May 98) in station I, while it was between 0.2617 (May 99) and 0.7758 (May 98) in station II (Table 4.16).

4.4.7 Copepod species

4.4.7.1 Species diversity

The species diversity of the copepod species in the present study showed a range of 1.9476 (Sept 98) and 3.7401 (May 99) bits /individuals; 2.7559 (Sept 98) and 3.5969 (May 98) bits/individuals in station I and II respectively (Table 4.20).

4.4.7.2 Evenness

At station I, the evenness the copepods was between 0.6492 (Sept 98) and 0.9573 (May 99) while it varied from 0.7687 (Sept 98) to 0.9462 (May 99) in station II (Table 4.20).

Table 4.15 Biodiversity index of phytoplankton species recorded at station I and II

	Station I				Station II			
	May 98	**Sept 98**	**Mar 99**	**May 99**	**May 98**	**Sept 98**	**Mar 99**	**May 99**
Species diversity	2.3126	2.9196	2.1241	3.506	2.4339	3.6235	2.4464	2.7727
Evenness	0.625	0.8789	0.9464	0.7982	0.7036	0.9275	0.9464	0.8747
Species richness	0.8617	0.7852	0.5429	1.7019	0.7503	1.1967	0.5429	0.6614
Dominance index	0.375	0.1211	0.0536	0.2018	0.2964	0.0725	0.0536	0.1253

Table 4.16 Biodiversity index of zooplankton groups recorded at station I and II

	Station I				Station II			
	May 98	**Sept 98**	**Mar 99**	**May 99**	**May 98**	**Sept 98**	**Mar 99**	**May 99**
Species diversity	0.4022	1.3865	1.4404	0.9063	0.7758	1.7783	0.6902	2.3404
Evenness	0.1122	0.4939	0.4544	0.262	0.2242	0.688	0.2301	0.7383
Species richness	1.458	1.0507	1.6309	1.7299	1.7208	1.2068	1.047	2.0778
Dominance index	0.8878	0.5061	0.5456	0.738	0.7758	0.312	0.7699	0.2617

4.4.7.3 Species richness

The species richness of the present study showed a variation between 1.252 (Sept 98) and 2.8049 (Mar 99); 1.7346 (May 98) and 2.7091 (Sept 98) in stations I and II respectively (Table 4.20).

4.4.7.4 Dominance index

The dominance index in station I was fluctuated from 0.0746 (Mar 99) and 0.3508 (Sept 98) whereas it was between 0.0538 (May 99) and 0.2313 (Sept 98) in station II.

The correlation coefficient (r) values between zooplankton and other hydrological parameters for the stations I and II are presented in Tables 4.17 and 4.18.

At station I, zooplankton showed significant positive correlation with temperature, nitrite and silicate and significant negative correlation with salinity, pH, dissolved oxygen, biological oxygen demand, nitrate, phosphate and organic matter.

At station II, it exhibited a significnat positive correlation with pH, dissolved oxygen and biological oxygen demand and a significant negative correlation with temperature, salinity, nitrite, nitrate, phosphate, silicate and organic matter.

4.4.8 Macrobenthos

4.4.8.1 Species composition

At both the stations I and II, totally 52 species of marobenthos were recorded. Of which, polychaetes (17), Gastropods (13), Crustacea (12), Pelecypoda (6), Oligochaeta (1), Ophiuroidea (1), Sipunculida (1) and Nematoda (1) were observed during the study period.

At station I, 38 species were totally recorded. Polychaetes dominated with 13 species followed by Gastropoda (10), Crustacea (8), Pelecypoda (5), Oligochaeta (1), Ophiuroidea (1) and Sipunculida (1) while in station II, totally 48 species were observed. Among them, Polychetes (17) were found to be dominant followed by Gastropoda (10), Pelecypoda (6) and Oligochaeta (1), Sipunculida (1) and Nematoda (1).

The qualitative analysis of species composition of macrobenthos are presented in Table 4.19.

Table 4.19 Qualitative data of macrobenthos recorded of Station I and II at Malvan

Name of the species	Station I				Station II			
	May 98	Sept 98	Mar 99	May 99	May 98	Sept 98	Mar 99	May 99
POLYCHAETA								
Streblospio sp	-	-	-	-	+	-	-	-
Glycera alba	-	-	-	-	+	-	-	-
Nereis costae	-	-	-	-	+	-	-	-
Maldanids	-	-	-	-	-	+	-	-
Cosura sp	-	+	-	-	+	+	-	-
Nereis sp	-	+	+	-	-	-	+	-
Lumbriconereis sp	-	-	+	+	-	-	+	+
Prionospio pinnata	-	+	-	-	-	+	-	-
Onuphis sp	-	-	-	+	-	-	+	-
Cirralutus sp	-	-	+	-	-	-	+	-
Glycera sp	-	-	+	+	-	-	+	+
Gonaida sp	-	-	+	+	-	-	+	-
Glycinde sp	-	-	-	+	-	-	+	-
Scoloplos sp	-	-	+	-	-	-	+	-
Polydora sp	-	-	+	-	-	-	+	-
Syllis sp	-	-	-	+	-	-	-	+
OLIGOCHAETA	-	+	+	-	+	+	+	-
GASTROPODA								
Cerithium morus	+	+	-	+	+	+	-	+
Umbonium vestiarium	-	+	+	+	+	+	+	+
Babylonia spirata	-	+	-	-	-	-	-	-
Turbo intercostalis	-	+	-	-	-	-	-	-
Bursa sp	-	+	-	-	-	+	-	-
Cerithium fluviatilis	-	+	-	-	-	+	-	+
Turitella sp	-	-	-	-	-	+	-	-
Cerithium sp	-	+	-	-	-	-	+	-
Cerithidea sp	-	-	+	-	-	-	+	-
Buccinum sp	-	-	+	-	-	-	+	-
Pyrene sp	-	-	-	-	-	-	+	-
Vexillum sp	-	-	-	-	-	-	+	-
CRUSTACEA								
Gammarus sp	+	+	+	-	-	+	+	-
Nannastacids	-	-	-	-	-	-	-	-
Mysidopsis sp	-	+	-	-	-	+	-	-

Eurydice sp	-	+	-	-	-	+	-	-
Emerita holthuisi	-	+	-	-	-	+	-	-
Philyra globosa	-	+	+	-	-	-	+	-
Clibanarius padavensis	-	+	+	-	-	-	+	-
Cirolanids	-	-	-	-	-	+	-	-
Euphausids	-	-	+	-	-	+	-	-
Tanaids	-	-	-	-	-	-	+	-
Isopods	-	-	+	-	-	-	-	+
Matuta sp	-	-	-	-	-	-	+	-
Flabellifers	-	-	-	-	-	-	-	+
OPHIUROIDEA								
Ophiactis sp	+	-	-	-	-	-	-	-
PELECYPODA								
Donax scortum	-	+	-	-	-	-	-	-
Meretrix sp	-	+	-	-	-	+	-	-
Cardium sp	-	+	-	-	-	+	-	-
Venerids	-	-	+	-	-	-	+	-
Donax sp	-	-	+	+	-	-	-	+
SIPUNCULIDA	-	+	-	-	-	+	-	-
NEMATODA	-	+	-	-	-	-	-	-

+ = Present ; – = Absent

4.4.8.2 Percentage composition

The percentage composition of marcobenthos for both the stations I and II are presented in Figs 4.19 and 4.20.

At station I, Pelecypoda dominated with 74.64% followd by Crustacea (17.49%), Polychaeta (4.22%), Gastropoda (3.14%), Sipunculida (0.37%), Oligochaeta (0.08%) and Ophiuroides (0.06%). It was on the contrary that the Polychaetes dominated with 41.05 %, followed by Crustacea (37.33%), Gastropoda (9.38%), Pelecypoda (5.79%), Sipunculida (3.91%), Oligochaeta (1.72%) and Nematoda (0.82%).

The percentage composition of macrobenthos can be arranged in ascending order as follows

Station I:

Pelecypoda >Crustacea>Polychaeta>Gastropoda>Sipunculida>Oligochaeta

Station II:

Polychaeta>Crustacea>Gastropoda>Pelecypoda>Sipunculida>Oligochaeta>Ne matoda.

Fig 4.19 Percentage composition of macrobenthos at Station I

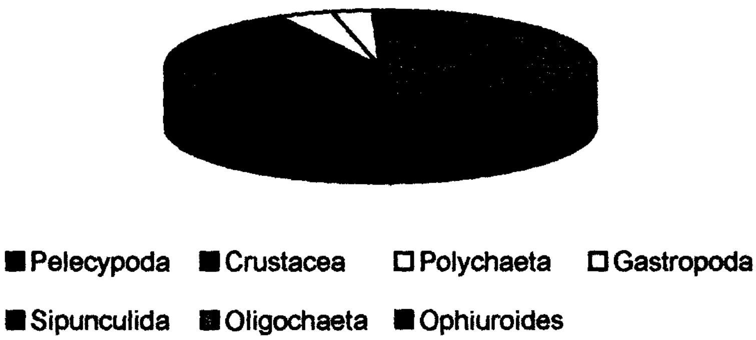
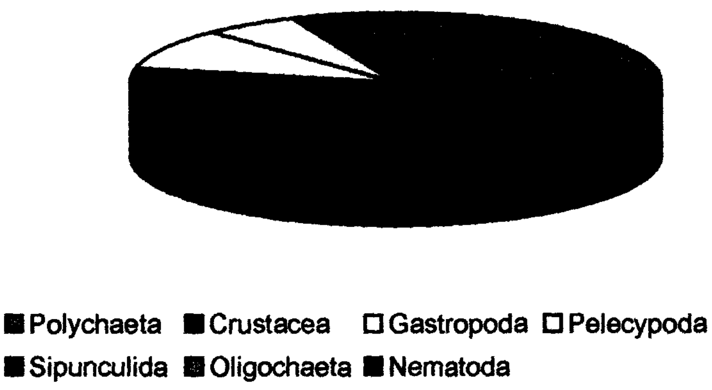


Fig 4.20 Percentage composition of macrobenthos at Station II



4.4.8.3 Species diversity

Macrobenthos species diversity was varied from 0.578 (May 98) to 3.269 bits/individuals (mar 99); 2.416 (May 98) to 4.178 bits/individuals in stations I and II respectively (Table 4.21).

4.4.8.4 Evenness

In the present study, the evenness of the macrobenthos was between 0.249 (May 98) and 0.984 (May 99) at station I and it was between 0.762 (may 98) and 0.966 (May 99) in station II (Table 4.21).

4.4.8.5 Species richness

The species richness showed a range from 1.71 (May 99) to 2.299 (Mar 99); 1.171 (May 98) 3.263 (Mar 99) at stations I and II respectively (Table 4.21).

4.4.8.6 Dominance index

At station I, it ranged between 0.016 (may 99) and 0.751 (May 98) whereas it varied from 0.034 (May 99) to 0.238 (May 98) at station II.

Table 4.20 Biodiversity index of copepod species recorded at station I and II

	Station I				Station II			
	May 98	Sept 98	Mar 99	May 99	May 98	Sept 98	Mar 99	May 99
Species diversity	3.5969	1.9476	3.5235	3.7401	3.5969	2.7559	3.3745	2.8385
Evenness	0.9447	0.6492	0.9254	0.9573	0.9447	0.7687	0.9119	0.9462
Species richness	1.7346	1.252	2.8049	2.4877	1.7346	2.7091	1.8382	2.2325
Dominance index	0.0553	0.3508	0.0746	0.0427	0.0553	0.2313	0.0881	0.0538

Table 4.21 Biodiversity index of macrobenthos recorded at station I and II

	Station I				Station II			
	May 98	Sept 98	Mar 99	May 99	May 98	Sept 98	Mar 99	May 99
Species diversity	0.578	1.189	2.029	3.269	2.416	3.481	4.178	3.208
Evenness	0.249	0.267	0.487	0.984	0.762	0.805	0.937	0.966
Species richness	0.545	2.062	2.299	1.71	1.171	2.565	3.263	1.619
Dominance index	0.751	0.733	0.513	0.016	0.238	0.195	0.063	0.034

The correlation coefficient (r) values between macrobenthos and other hydrological parameters for the stations I and II are given in tables 4.17 and 4.18.

At station I, macrobenthos exhibited a significant positive correlation with salinity and biological oxygen demand and a significant negative correlation with temperature, pH, dissolved oxygen, nitrite, nitrate, phosphate, silicate and organic matter.

At station II, it showed a significant positive correlation with temperature, pH, nitrate, silicate and organic matter and a significant negative correlation with salinity, dissolved oxygen, biological oxygen demand, nitrite and phosphate.

4.4.9 Distribution of Corals

The qualitative distribution of corals at Malvan (stations I and II) and their status are presented in Table 4.22.

Totally 9 species of corals were recorded in the study area during the study period. At station I, *Turbinaria* sp was recorded as dominant species and the *Coscinaria* sp was recorded as rare. At station II, the abundance of dominant species includes *Goniastrea* sp and *Porites lutea* and the common species were

Table 4.17 Simple correlation coefficient(r) values between hydrographical variables and phytoplankton, zooplankton and macrobenthos in station I

	Phyto plankton	Zoo plankton	Macro benthos	Temp	Salinity	pH	DO	BOD	Nitrite	Nitrate	Phosphate	Silicate	Organic matter
Phytoplankton	1												
Zooplankton	0.4659	1											
Macrobenthos	-0.4065	-0.7361^{b}	1										
Temp	0.4165	-0.6021^{a}	0.4746	1									
Salinity	0.3863	0.2284	-0.8106^{c}	-0.0088	1								
pH	-0.8518^{c}	0.0525	-0.0543	-0.8285^{c}	-0.1824	1							
DO	-0.7982^{b}	0.1433	0.0686	-0.8361^{c}	-0.4185	0.9557^{c}	1						
BOD	-0.2477	-0.4041	0.9163^{c}	0.3097	-0.9535^{c}	-0.0725	0.1484	1					
Nitrite	-0.139	0.8044^{c}	-0.4656	-0.9252^{c}	-0.1159	0.6009^{a}	0.7023^{b}	-0.1712	1				
Nitrate	-0.6831^{b}	0.3269	-0.2015	-0.946^{c}	-0.1847	0.9575^{c}	0.9632^{c}	-0.1076	0.8057^{c}	1			
Phosphate	0.8562^{c}	-0.0571	-0.0554	0.8152^{c}	0.3377	-0.986^{c}	-0.9893^{c}	-0.0788	-0.6299^{a}	-0.9589^{c}	1		
Silicate	-0.2354	0.7492^{b}	-0.4706	-0.9648^{c}	-0.0835	0.6869^{b}	0.7607^{b}	-0.2131	0.9924^{c}	0.8664^{c}	-0.7036^{b}	1	
Organic matter	-0.5481	-0.2696	-0.3301	-0.3231	0.5575^{a}	0.5666^{a}	0.2991	-0.6219^{a}	-0.045	0.3983	-0.429	0.0718	1

a= P<0.05; b= P<0.01; c=P<0.001

Table 4.18 Simple correlation coefficient (r) values between water quality variables and phytoplankton, zooplankton and macrobenthos in station II

	Phyto plankton	Zoo plankton	Macro benthos	Temp	Salinity	pH	DO	BOD	Nitrite	Nitrate	Phosphate	Silicate	Organic matter
Phytoplankton	1												
Zooplankton	-0.4731	1											
Macrobenthos	0.4198	-0.2389	1										
Temp	0.7605^{c}	0.1293	0.5991^{a}	1									
Salinity	0.4381	0.4522	-0.3017	0.5810^{a}	1								
pH	-0.7912^{c}	0.7006^{c}	-0.7902^{c}	-0.5600^{a}	0.1729	1							
DO	-0.7712^{c}	0.9145^{d}	-0.4669	-0.2828	0.1921	0.9028^{d}	1						
BOD	-0.2949	-0.6189^{a}	0.2917	-0.5624^{a}	-0.9800^{d}	-0.2874	-0.3621	1					
Nitrite	0.8969^{d}	-0.5254	-0.0055	0.4745	0.5197	-0.5442	-0.7093^{c}	-0.3429	1				
Nitrate	-0.0526	-0.4375	-0.7682^{c}	-0.6175^{a}	0.007	0.2607	-0.1795	0.1149	0.3759	1			
Phosphate	0.9421^{d}	-0.1709	0.4925	0.9310^{d}	0.5851^{a}	-0.6896^{c}	-0.5475	-0.4954	0.7567^{c}	-0.3176	1		
Silicate	-0.264	-0.4959	-0.6758^{b}	-0.8135^{d}	-0.3146	0.2685	-0.1528	0.4106	0.1259	0.9435^{d}	-0.5490	1	
Organic matter	0.1654	-0.5353	-0.6671^{b}	-0.4447	0.1017	0.0852	-0.3452	0.0499	0.5661^{a}	0.9762^{d}	-0.1090	0.8746^{d}	1

a= P<0.05; b= P<0.02; c=P<0.01; d=P<0.001

Table 4.22 The qualitative distribution of corals and their status in station I and II

Sr.No	Name of the species	Station I	Station II	Status
1	*Coscinaraea sp*	+	-	Rare
2	*Turbinaria* sp.	+	-	Dominant
3	*Pseudosiderastrea* sp	-	+	Common
4	*Favites* sp	-	+	Rare
5	*Cyphastrea* sp	-	+	Rare
6	*Goniastrea* sp	-	+	Dominant
7	*Porites lichen*	-	+	Common
8	*Porites lutea*	-	+	Dominant
9	*Synerea* sp.	-	+	Rare

Pseudosiderastrea sp. and *Porites lichen*, while *Favites* sp, *Cyphastrea* sp and *Synerea* sp were rare species.

4.4.10 Distribution of Algae

Qualitative distribution of algae were concentrated during the study period (March 1999 and May 1999) at stations I and II and also along the entire coast of Malvan.

32 species of algae were totally recorded during the study period. At station I, 12 species (May 99) and 14 species (Mar 99) were found while 18 species were recorded during March 99 and 20 species in May 99 along the stations identified. All along the surveyed coast a total of about 69 marine algae were recorded (Table 4.24). The average biomass recorded was 0.69 kg/m^2 and mainly contributed by members of Phaeophyta (55%) and Rhodophyta (32%).

Along the stations, the division Rhodophyta dominated with 37.5% followed by Chlorophyta (34.4%) and Phaeophyta (28.1%). The number of species recorded in stations I and II are represented in percentage contribution (Fig 4.21 and 4.22). The qualitative data of algae recorded along the Malvan coast at the stations I and II are presented in Table 4.23.

Fig 4.21 Percentage composition of marine algae recorded at Station I

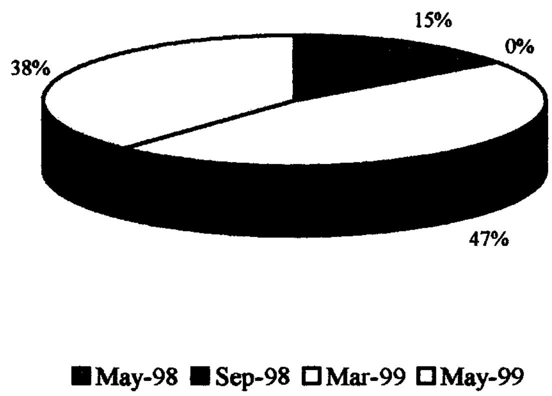


Fig 4.22 Percentage composition of marine algae at Station II

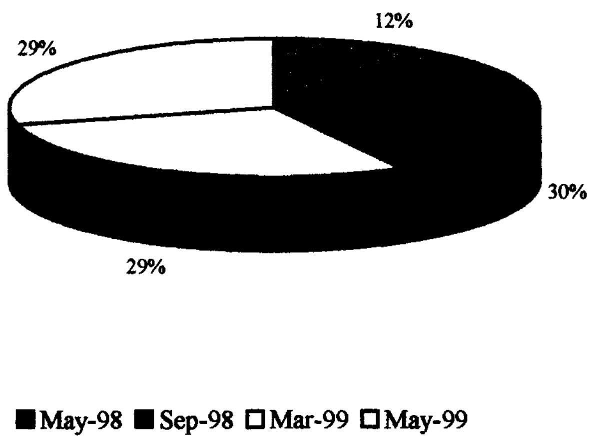


Table 4.23 Systematic list of marine algae recorded at Station I and II

Name of the species	Station I				Station II			
	May 98	Sept 98	Mar 99	May 99	May 98	Sept 98	Mar 99	May 99
CHLOROPHYCEAE								
Boodlea composita (Harv.et. Hook.f.) Brand.	-	-	+	+	-	-	-	-
Bryopsis plumosa (Huds.) C. Ag.	+	-	+	+	-	-	-	-
Caulerpa peltata Lamour.	-	-	+	+	-	-	+	+
Caulerpa scalpelliformis (R.Br.) Weber. V.Bose	-	-	-	-	-	+	-	-
Caulerpa sertularioides (Gmelin.) Howe.	-	-	+	+	-	+	+	+
Caulerpa verticillata J.Ag.	-	-	+	-	-	-	+	-
Chaetomorpha media (C.Ag.) Kutz.	-	-	-	-	+	+	+	+
Enteromorpha clathrata (Roth.) J. Ag.	-	-	-	-	-	+	-	-
Enteromorpha flexuosa (Wulfen.) J.Ag.	-	-	-	-	-	-	-	-
Ernodesmis verticillata (Kutz.) Boergs.	+	-	+	+	-	-	-	-
Ulva fasciata Delile.	-	-	-	-	+	+	-	+
Ulva lactuca L.	-	-	-	-	-	-	+	+
PHAEOPHYCEAE								
Colpomenia sinuosa (Roth.) Derb.et.Sol.	-	-	+	-	-	-	-	-
Dictyopteris australis Sonder.	-	-	-	-	-	-	-	-
Dictyota bartrsyasiania Lamour.	-	-	+	+	-	-	+	+
Dictyota dichotoma (Huds.) Lamour.	-	-	+	-	+	-	+	+
Padina tetrastromatica Hauck.	+	-	+	+	+	+	+	+
Sargassum illicifolium (Turn.) C.Ag.	-	-	+	-	-	+	+	+
Sargassum swartzii (Turn.) C.Ag.	+	-	+	-	+	+	+	+
Sargassum tenerrimum J.Ag.	+	-	-	-	+	-	-	-

Spatoglossum asperum J.Ag.	-	-	-	-	-	+	-	-
Sphacelaria furcigera Kuetzing.	-	-	-	-	+	-	-	-
Stoechospermum marginatum (C.Ag.) Kutz.	+	-	-	-	-	-	-	-
RHODOPHYCEAE								
Acanthophora spicifera (Vahl.) Boergs.	-	-	+	-	-	-	+	+
Amphiroa fragilissima *(L.) Lamour.*	+	-	-	+	+	+	+	+
Ceramium fastigiatum (Roth.) Harv.	+	-	-	+	+	+	+	+
Cheilosporum spectabile Harv.	-	-	-	+	-	-	+	+
Gelidium pusillum (Stasek.) Le. Jolis.	-	-	-	-	+	-	-	+
Geliodiopsis variabilis (Grev.) Schmitz.	-	-	-	-	+	-	-	-
Gracillaria corticata J.Ag.	+	-	-	-	+	+	+	+
Grateloupia filicina (Wulf.) C.Ag.	-	-	-	-	-	-	-	+
Grateloupia indica Boergs.	-	-	-	-	+	-	-	-
Hypnea cervicornis J.Ag.	-	-	-	-	-	-	+	+
Hypnea muciformis (Wulf.) Lamour.	+	-	-	-	+	+	-	-
Hypnea valentiae (Turn.) Mont.	+	-	-	-	+	+	-	-
Jania adherens Lamour.	-	-	+	+	-	-	+	+
Melobesia farinosa Lamour.	+	-	-	-	+	-	-	-
Melobesia sp	-	-	+	+	-	-	+	+

+ = Present ; − = Absent

Table 4. 24 List of marine algae recorded along the Malvan coast, Maharashtra and their ecological status

No.	Name of the species	Ecological status
	CHLOROPHYCEAE	
1	*Ulva fasciata*	C
2	*Ulva reticulata*	R
3	*Ulva lactuca*	R
4	*Enteromorpha rigida*	R
5	*Enteromorpha flexuosa*	C
6	*Enteromorpha clathrata*	C
7	*Enteromorpha intestinalis*	C
8	*Chaetomorpha media*	C
9	*Chaetomorpha linum*	C
10	*Cladophora fascicularis*	C
11	*Cladophora prolifera*	R
12	*Caulerpa verticillata*	R
13	*Caulerpa sertularioides*	C
14	*Caulerpa racemosa*	C
15	*Caulerpa scalpelliformis*	C
16	*Caulerpa peltata*	R
17	*Bryopsis plumosa*	R
18	*Ernodesmis verticillata*	R
19	*Microdictyon tenuis*	R
20	*Averenvillea* sp.	R
21	*Acetabularia moebii*	E
22	*Boodlea composita*	R
	PHAEOPHYHCEAE	
22	*Ectocarpus conigera*	C
23	*Giffordia mitchellae*	C
24	*Sphacelaria furcigera*	C
25	*Dilophus fasciola*	R
26	*Dictyota dichotoma*	C
27	*Dictyota atomaria*	C
28	*Dictyopteris australis*	C
29	*Lobophora veriagata*	R
30	*Padina gymnospora*	R
31	*Padina tetrastromatica*	C
32	*Ralfsia expansa*	R
33	*Stoechospermum marginatum*	C
34	*Spatoglossum asperum*	C
35	*Sargassum swartzii*	C

36	*Sargassum cinereum*	C
37	*Sargassum ilicifolium*	C
38	*Sargassum tenerrimum*	C
	RHODOPHYCEAE	
39	*Rhodochorton* sp.	R
40	*Erythrocladia* sp.	R
41	*Bangia fuscopurpurea*	E
42	*Porphyra vietnamensis*	C
43	*Galaxaura* sp.	C
44	*Scinaia hatei*	C
45	*Grateloupia. indica*	C
46	*Melobasia farinosa*	R
47	*Amphiroa fragilissima*	C
48	*Jania adherens*	C
49	*Cheilosporum spectabile*	C
50	*Lithophyllum* sp.	R
51	*Gelidium pusillum*	C
52	*Gelidium micropterum*	C
53	*Gelidiopsis variabilis*	C
54	*Gracilaria corticata.*	C
55	*Hypnea valentiae*	C
56	*Hypnea musciformis*	C
57	*Hypnea cervicornis*	C
58	*Halymenia porphyrioides*	R
59	*Soliera robusta*	R
60	*Ahnfeltia plicata*	R
61	*Rhodymenia australis*	R
62	*Ceramium fastigatum*	C
63	*Ceramium rubrum*	C
64	*Callithamnion byssoides*	R
65	*Martensia fragilis*	R
66	*Spyridea fusiformis*	R
67	*Chondria arnata*	R
68	*Chondria tenuissima*	R
69	*Laurencia papillosa*	C
70	*Polysiphonia macrocarpa*	R
71	*Acanthophora spicifera*	C
72	*Centroceros clavulatum*	C

C: Common ; R: Rare ; E: Endangered

Kavdya dongar is a small islet situated towards north of Malvan coast about 1 km away from the main land. The island is about 3 acre in area with small intertidal expanse of about 30-40 m. The substratum is of basalt rock. Altogether 14 marine algal species were recorded from this coast. Most dominant species belong to Dictyotales followed by *Sargassum* sp. In small tidal pools species of *Gracilaria corticata* and *Gelidium pusillum* were common. IV Among the faunal species, Sea cucumber and sea urchins were most common. The sea cucumbers were found in the intertidal zone along with Dictyotacean species. Sea anemones and sea urchins were found in the crevices of rocky intertidal pool. Numbers of annelid worms, crustaceans were seen in the intertidal zone. The supralittoral zone was dominated by oyster shells, which are exploited by the local fishermen. Some species of marine algae are being collected, dried and used as manure by the local people.

Another peculiar thing observed on this islet was a skeleton perhaps of a baleen whale washed ashore and trapped in the rock crevice. Based on the size of the bones, the whale was approximately 7 to 8 m in length. The islet is known for the nesting of a bird (locally known as Kavdya). Subtidal flora was also found to quite high around the Sindhudurg fort (Plate 10a). Species such as *Lobophora variegata, Melobesia* sp. were recorded. (Plate 10b).

4.4.11 Mangroves

Mangroves play a crucial role in sustaining and nurturing our life supporting ecosystem. A small patch of mangroves is present in the Sindhudurg fort area (Plate 9b). These are the mangroves, which were dominated with the species like *Avicennia marina* and *Avicennia officinalis.* Almost all the sample villages have access to mangrove forests.

Kolamb estuary lies adjacent to Malvan (Fig.4.23). *Sonneratia alba* and *Rhizophora mucronata* were dominant species followed by *Avicennia marina.* Mangrove species are 1-3 m in height. A lot of destruction of mangroves for firewood was observed. Only two marine algal species namely *Monostroma oxyspermum* and *Enteromorpha clathrata* were recorded.

4.4.12 Fishery resources

Sindhudurg is one of the important maritime districts in Maharashtra and therefore, marine fishery is an important economic activity of the district. Fishing is done all along the coast in the sea generally up to 65 kilometers from the coast. Malvan is one of the important fisheries centers in the district. Fishery activity is carried out during nine months from September to May. The average marine fish catch for the last three years is estimated to be 41.147 metric tonnes.

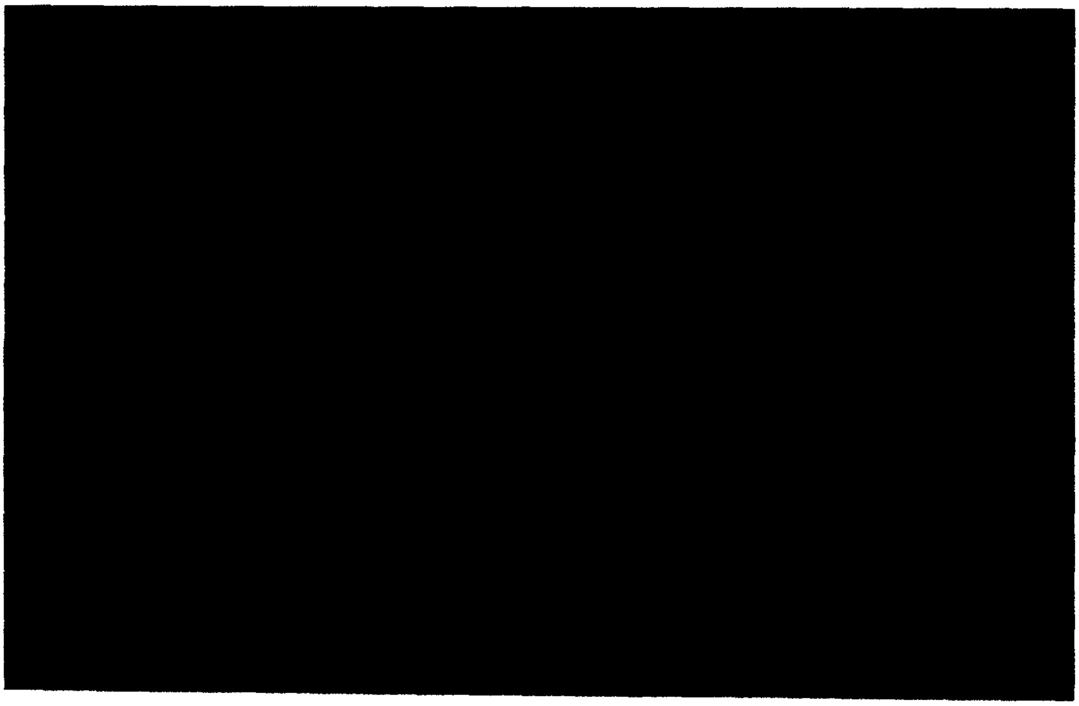


Plate 9a: Mangrove trees used by cattle's for grazing

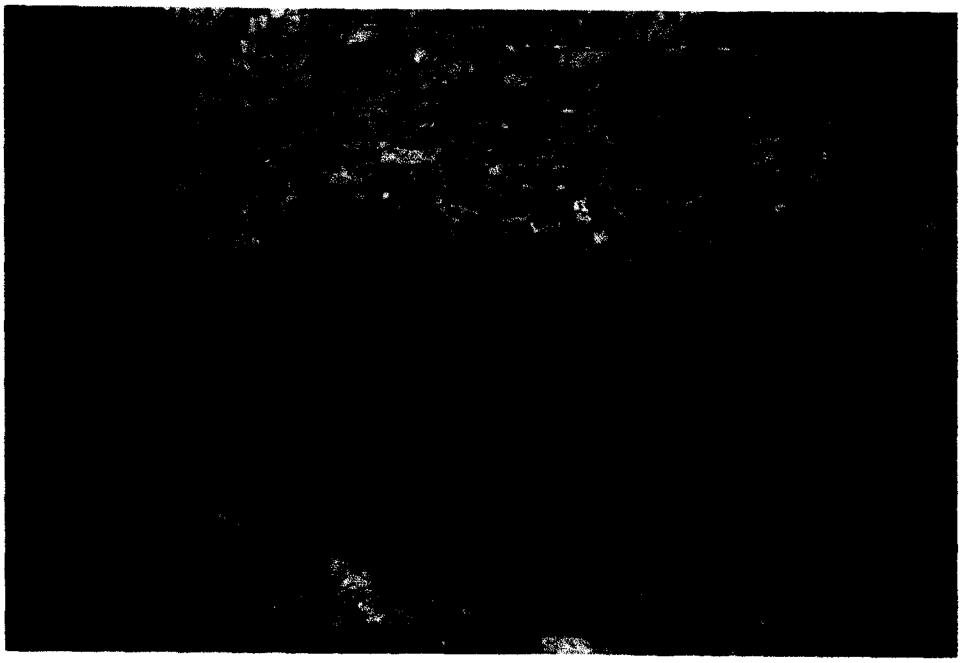


Plate 9b: A small patch of mangrove area inside the Sindhudurg fort area

Plate 10a: Subtidal flora around Sindhudurg Fort at Malvan

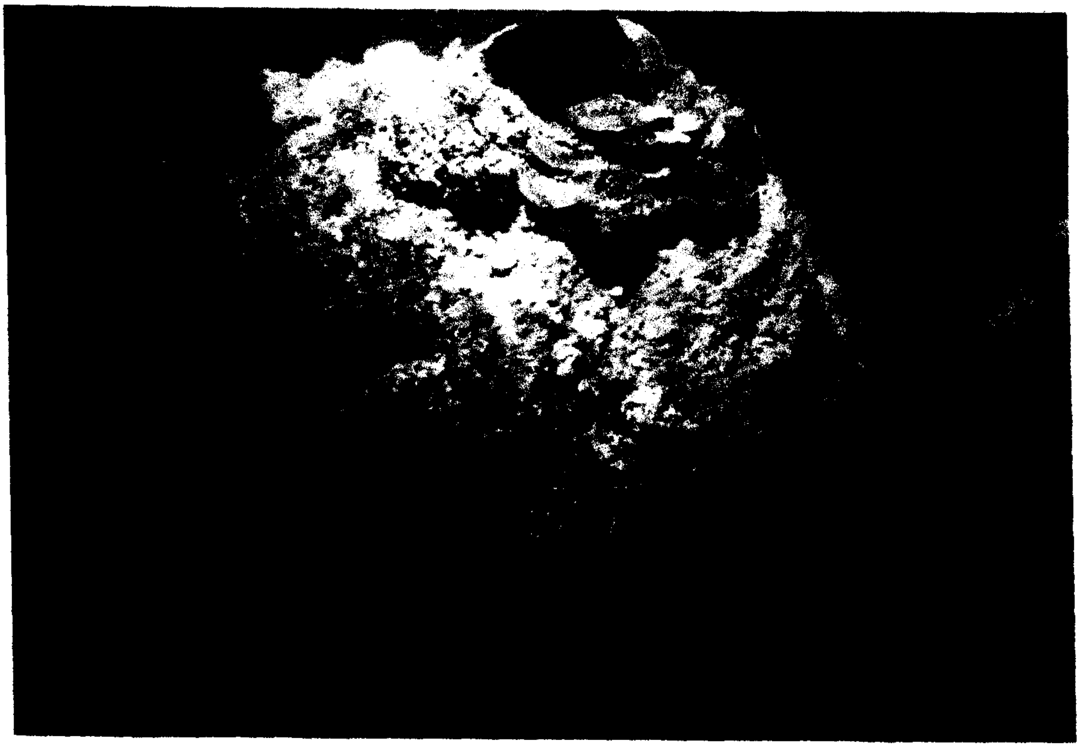


Plate 10b: *Lobophora variegata* and *Melobesia* sp. at 8m depth at Malvan

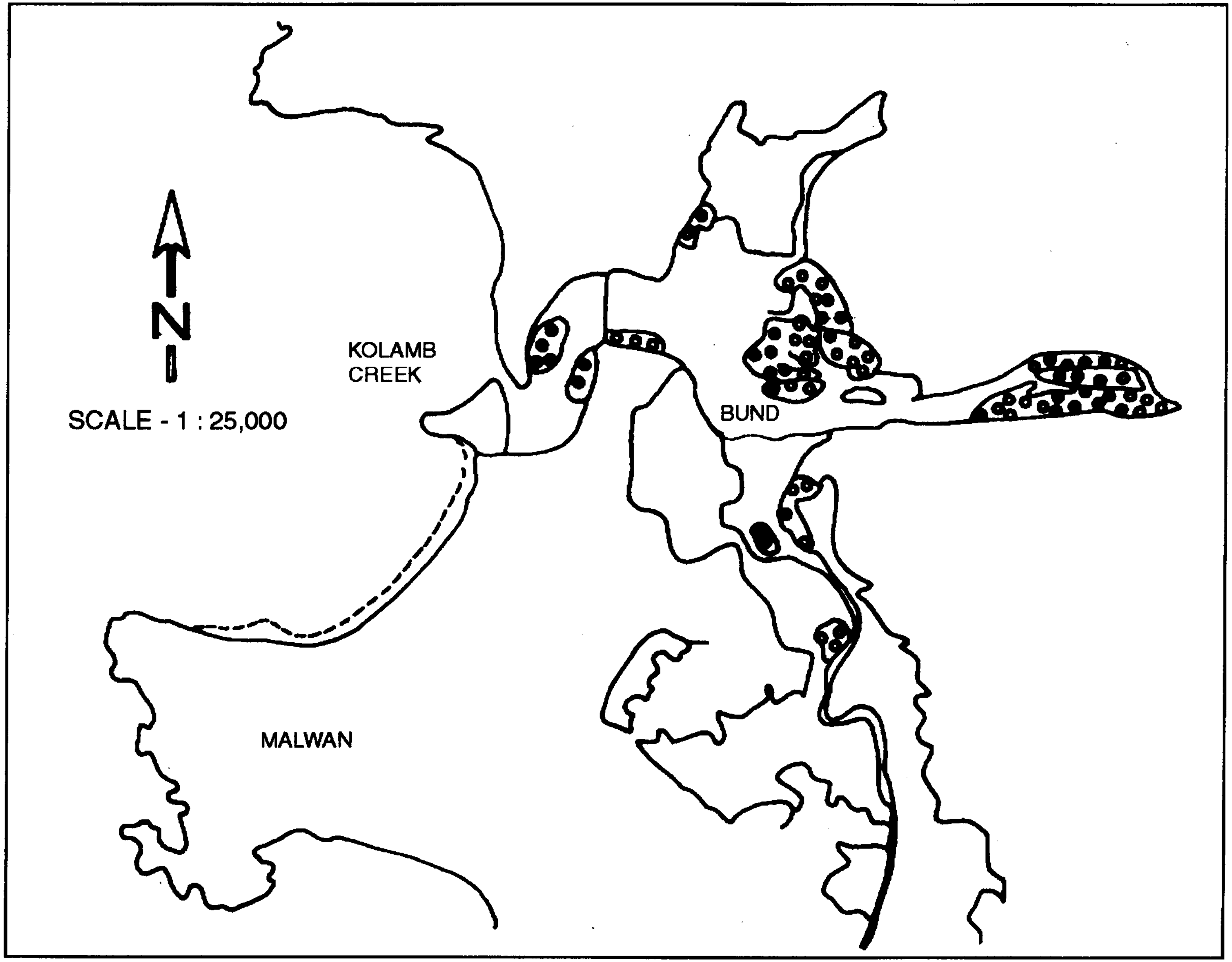


Fig. **4.23** Map of Kolamb creek showing mangrove distribution

The commercially important variety of fish are Mackeral, Sardines, Prawns, Kingfish, Pedva, Mulshi, Shingada, Pomfret, Halwa, Gedar, Dhoma, Ghol and Karli (these are common names of fishes). Besides, Clam and Oysters are also available along the entire coastal line, mainly in the creeks and backwaters. The local people get most of their protein requirements from the fish which is the cheapest source of animal protein. The primary household level survey shows that the per capita daily consumption of fish among the fishermen families is 185 grams, which is higher than the recommended standards. The fisheries detail is given in Chapter V.

4.5 DISCUSSION

Malvan coast forms a part of western Ghats where Sahyadri ranges gradually meet the Arabian sea. From Vengurla point, the coast trends towards north about 22 kms. The coast is flanked on the north by Kalavatii and Kolamb rivers while Karli river towards south. Malvan town is a small coastal town in the Sindhudurg district of the Maharashtra state. It is connected to Ratnagiri, Sawantwadi, Mumbai and Panaji by road and recently by train also.

The sandy shores and the nearby estuaries like Kolamb, Kalavati and Karli shows the presence of several species of mangroves, seagrasses and sand dune vegetation. The marine flora of this coast is luxuriant and unique consisting of around 73 species of marine algae. The faunal composition represents sponges, seapens, seafans, soft corals, sea anemones, hard corals, stomatopods, isopods, crabs, prawns, barnacles, insects, mollusks, sea cucumber, sea urchins, brittles star, star fishes and other different types of fishes

Nowadays, the coastal bodies are heavily polluted due to different type of discharges such as agriculture, municipal wastes and domestic sewage wastes. These discharges directly or indirectly affect the abundance of planktons, benthic fauna as well as the physicochemical characteristics of the environment. The understanding of the physico-chemical and biological dynamics of the marine ecosystem is most important for protecting, planning and effective implementation of coastal management strategies. Malvan is one of the cleanest areas along the central west of India where the flora and fauna are still living undisturbed in their conditions. This is considered as ecologically important areas because it serves as one of the most important biodiversity rich area. Studies on the physico-chemical characteristics, population density and faunal assemblages in this biota are scanty. Hence the present work was carried out to find out the variations in physico-chemical parameters, their influence on the diversity of plankton, benthic macrofauna in Malvan waters around the Sindhudurg fort.

4.5.1 Physico-chemical parameters

Maximum air temperature recorded could be attributed to the solar radiation with clear sky and the minimum recorded values may be due to the monsoonal rains and cold weather with cloudy sky. Arunchalam *et al.,* (1982); Antony Fernando (1983); Nair *et al.*, (1985); Balakrishnan Nair *et al.,* 1987; Kannan (1992); Saraswathi (1993); Silas Ebanezar and Parameshwaran Pillai (1993) made similar observations.

Rainfall influences the cyclic phenomenon in tropical countries and imparts important changes in the hydrography (Qasim and Gopinathan, 1969). In the present study the highest rainfall observed was 1014.2 mm (June 1999).

In general, the surface water temperature is influenced by sunshine, evaporation, cooled freshwater influx and admixture of ebb flow from the adjoining neritic waters. The maximum and minimum surface water temperature were recorded during the summer and the monsoon seasons respectively as observed earlier by Sai Sastry and Chandramohan (1990); Anilkumari and Abdul Azis (1992); Kannan (1992), Saraswathi (1993); Ananthan (1995) in the various marine environments of India. Station I showed slightly lower temperature than station II.

Other most important factor in the marine environment is salinity. The fluctuations in salinity affect the biological characteristics of the environment. McLusky (1971) stated that the salinity at any point in an estuary will be dependent on the topography of the estuary, the state of tide (high or low, and spring or neap), the time of the year controlling rainfall etc, and the extent of freshwater flow.

The high salinity values during the present study may be due to the higher rate of evaporation and lack of fresh water flow from upstream waters. The minimum value was due to heavy rainfall and freshwater inflow as reported by Claridge *et al.*, (1986). Salinity showed an inverse relation with freshwater discharge as observed in various marine environs such as Mahanadi estuary (Upadhyay, 1988), Rushikulya estuary (Rajashree Goudaand Panigrahy, 1992), Mandapam salt water lagoon (Silas Ebanezar and Parameswaran Pillai, 1992); Dharamtar creek, Bombay (Tiwari, 1990) and Godavari estuary (Rao, 1995).

pH at both the stations was found to be alkaline. The increase in pH levels may be due to the uptake of CO_2 by the photosysnthetic organisms especially phytoplankton from the water. The low values in pH may be due to the fresh water influx and decomposition of organic matter as suggested by (Zingde *et al.*, 1987 and Upadhayay, 1988).

The solubility of oxygen in sea water is a function of its partial pressure on one hand and salinity and temperature on the other. Maximum value may be due to higher solubility of oxygen in colder less saline water. The minimum dissolved oxygen concentration might be due to the lack of fresh water inflow, increased salinity and absence of strong winds. The maximum values could be due to the heavy rainfall and resultant heavy input of fresh water into the system (Jagadeesan, 1986; Murugan and Ayyakkannu, 1991).The low values reported may be due to the utilization of dissolved oxygen by the organisms. The higher values observed may be due to the production of oxygen by the coral zooxanthallae during daytime (Yonge *et al.,*1932) and photosynthesis by plankton, seagrasses and algae etc. (Smith and Key, 1975).

Sai Sastri (1990) also stated that a general decline in the levels of dissolved oxygen in summer months could be due to the increasing temperature and salinity of water. Chandran (1982); Antony Fernando *et al.,* (1983); Murugan and Ayyakkannu (1991); Silas Ebaneszar and Pillai (1993); Mishra (1993) and Ananthan (1995) have also made similar observations along the east coast of India.

One of the most important parameters in the marine environment are nutrients. The distribution of which is mainly based on the seasons, tidal conditions and river flow.

Higher nitrate concentration may be due to the rainfall, land discharge and agriculture discharge. Upadhayay (1988) suggested that the addition of nitrogeneous nutrients mainly through freshwater and terrestrial run-off during the monsoon definitely increased the levels of nitrate. According to Rao (1995), low nitrate concentration may be attributed to the utilization by the benthic algae and phytoplankton. Ramalakshmi and Chauhan (1990) have experimentally proved the utilization of nitrate by phytoplankton.

Nitrite is an important nutrient. The concentration of nitrite is determined by the balance between formation and destruction, which depend upon many highly varying factors (Brandhorst, 1959). Rakestraw (1936) and Wattenberg (1937) have highlighted the intermediate position between ammonia and nitrate. Nitrite concentration was found to be much lower that that of nitrate as reported by many authors earlier. According to Ambazhagan, (1988) the excretion of phytoplankton, reduction of nitrate and oxidation of ammonia combined together or individually contribute to the concentration of nitrite in the environment.

Lesser amount of freshwater input and high saline condition in the environment may led to low nitrite level as also reported by Shoba (1987); Verlencar (1987); Sarala Devi (1991); Mishra and Panigrahy (1993); Tiwari (1990) and Ananthan (1995) in various marine environs.

More concentration of phosphate may be due to rainfall, input of domestic sewage and fertilizers from the adjacent agriculture lands. Possibilities of intrusion of upwelled sea water into the backwater also results in increased level of phosphate (Nair *et al.*, 1983 and 1984). The regeneration of total phosphorus in bottom muds and subsequent release of te same in to the water column by turbulence and mixing of heavy winds also attribute to the higher values (Murugan, 1989). The diminished river discharge and utilization for biological productivity also cause low phosphate level in the environment (Nair *et.al.* 1984). Similar observations were made by Tiwari (1990) in Dharamtar creek of Maharashtra state.

Silicate plays an important role in the formation of skeleton of diatom and radiolarians. The concentration of silicate was found to be much higher than other nutrients. Higher values of silicate observed was attributed to the heavy freshwater influx, while that of low concentration could be due to higher salinity, through more influence of neritic waters, cessation of freshwater inflow and also due to the removal by biological processes. Gouda and Panigrahy (1992) reported that the uptake of phytoplankton and other processes like absorption and co-precipitation of soluble silicon might also govern the distribution of dissolved silicate in the marine environment.

Senguptha *et al.,* (1981) reported that the silicate was lower in the Bay of Bengal as a whole, than in the Arabian sea. The evaporation rate was reported to influence the silicate concentration and the decreased levels associated with decreased wind speed (Ayukai, 1993).

4.5.2 Organic matter

The results of present study showed that maximum values were recorded in station II than station I except during March 1999. Higher values of organic carbon are attributed to a lot of allochotonous material carried by the inflowing rainwaters into the study area. The detrital particles brought down by the rivers are largely responsible for increasing the organic load in the environment (Sreepada *et al.,* 1993). According to Sarala Devi (1989) the higher values of organic carbon in the monsoon months especially during flood conditions, due to the increased turbidity of water. The findings of present study also supports this earlier observations

4.5.3 Phytoplankton

Planktons are the main biotic components of an ecosystem, which forms a principal food item of many aquatic organisms. Therefore, knowledge of their abundance, composition and seasonal variations is an essential pre-requisite for any successful management. Plankton community structure may be used as an indicator of the trophic phase of water body (Verma and Munshi, 1987). Davis

(1955) pointed out that several physico-chemical and biological factors act simultaneously to influence the plankton fluctuation.

In the present study, 57 species of phytoplankton were totally recorded. In which Bacillariophyceae were found to be predominant in both the stations, by the presence of *Chaetoceros debilis, Chaetoceros affinis, Chaetoceros constrictus, Chaetoceros curvisetus, Thallassionema nitzschioides, Astrionella japonica, Skeletonema costatum;* Dinophyceae with the dominance of *Prorocentrum gracilis* and Cynophyceae with the dominance of *Trichodesmium sp* during the study period. Santhanam *et al.*, (1994) studied the impact of *Trichodesmium theibauttii* bloom on the phytoplankton and productivity in the Tuticorin Bay and found that this bloom inhibits not only other phytoplankton but also microzooplankton. This may be due to the superiority of the bloom former in competing with other phytoplankton species for nutrients and for the metabolic products of the bloom, former may inhibit the growth of other phytoplankton and also microzooplankton. However, Devassy (1987) observed that *Trichodesmium* bloom has no harmful effect on fish and fisheries of the Arabian sea.

The population was dominated by diatoms at both the stations during the entire study period. The abundance of this group (Bacillariophyceae) was 98.8%. The maximum density of 31,90000-160,0000 were recorded at stations I and II respectively during summer season in the study areas. Similar observations were made by Subrahmanyan and Sarma (1967), Qasim (1982), Sawant and Madhupratap (1996).

Sawant and Madhupratap (1996) noted the role of phytoplankton in rapid carbon export and this may also indicate that during productive periods (summer and winter), mesozooplankton grazing does not effectively control the production in the Arabian sea (Banse *et al.,* 1996).

The range (2.1241 to 3.6235 bits/ individuals) of species diversity noted in the present study is comparable with earlier studies (Verma and Munshi, 1987). Minimum species diversity coincided with low salinity and higher turbidity conditions arising out of heavy freshwater inflow in the lagoon. McCormic and Quinn (1975) reported low species diversity in highly turbid water column.

High population density and species richness in stable environmental conditions resulted in peak diversity during summer season. During the present study the number of species increased when diversity increased. Species richness also showed variation between stations I and II. Maximum richness values were recorded during May 99 at station I and during Sept 98 at station II and minimum was during Sept 98 at station I and May 99 at station II. Higher values of species richness were recorded in higher salinities. Evenness at both the stations varied similarly.

4.5.4 Zooplanktons

Zooplanktons are the secondary producers and are considered as the major index of utilization of aquatic biotope because of their intermediary role between phytoplanktons and fishes. They are considered as the chief index of utilization of aquatic biotype at the secondary trophic level (Goswami and Padmavati, 1996). Zooplankton occupy a strategic position in the pelagic food web. Being a principal phytoplankton grazers in aquatic ecosystem, they play a leading role in converting the plant tissues stored in phytoplankton to animal tissue. Hence the fate of energy transfer from producer to higher trophic levels is primarily dependent upon them. The abundance and diversity in the present study were found to fluctuate widely because pf unstable physico-chemical conditions.

13 groups of zooplanktons were identified in both the stations. Copepods were the dominant group followed by Cladocera, Decapod larvae, Lucifers, Molluscs, Polychaetes, Ostracodes, Chaetognatha, Appendicularia, Amphipoda, Invertebrate eggs etc. Copepods were dominant with a total record of around 33 species. Among theses *Centropages calanunis, Acartia ambionensis, Paracalanus sp, calanopia elliptica and Centropages sp* were dominant. *Acartia bowmani, Clytemnestra scutella, temora sp, Pontella sp.* were reported at station II but not at station I.

Among the Cladocerans, *Evadne tergestina* and *Penilia avirostris* were found to be restricted at stations I and II. At both the stations copepods were the dominant group of zooplankton throughout the period of observation. Grindley (1981) reported that although most of the taxonomic groups were present in the holoplankton of neritic seas and estuaries, the copepods were the dominant forms in most of the estuaries in the world. Similar observations on the dominance of copepods were made by Jagadeesan (1986) in Coleroon estuary, Sarawathi (1993) in Arasalar and Cauvery estuaries and Ramaiah-Neelam (!996) in Burhabalkanga estuary. Nandan and Azis (1994) suggested that the distribution of copepods was controlled by rainfall, river discharge and salinity as evidenced in the present study.

The high population density may be due to the stable environmental conditions and minimum density may be due to the unstable conditions such as heavy rainfall and consequent decrease in salinity and higher turbidity. Arunabhamitra *et al.,* (1990) reported high population density as well as more copepod species when the salinity was high and relatively stable. Murugan (1989) also suggestd that heavy moonsoonal rain reduce the population density of zooplankton. Fish predation also influence the distribution of zooplankton (Jakobsen and Johnsen, 1987 & Cyber and Townsend, 1988).

At station I, zooplankton showed significant positive correlation with temperature, nitrite and silicate and negative correlation with salinity, pH, dissolved oxygen, biological oxygen demand, nitrate, phosphate and organic matter. Whereas station II positive correlation was shown with pH, dissolved oxygen and biological oxygen demand and negative correlation with temperature, salinity, nitrite, nitrate, phosphate, silicate and organic matter.

Species diversity, richness and evenness values were found to vary between stations I and II for the zooplankton groups, whereas for that of the copepod species in particular they were found to have resemblance. The high values may be due to the stable environment and high population density.

In general among both the stations, station II exhibited high species diversity, richness and evenness than station I.

4.5.5 Benthic macrofauna

Benthic production plays an important role in the biological productivity of an area. This community is characterized by temporal and spatial changes in the population.

A total of 52 species of macrobenthos were recorded. Species composition of the benthic macrofauna in the present investigation showed the dominance of Polychaetes, Gastropods, Crustaceae, Pelecypoda. Similar observations were made earlier by Harkantra (1982) and Ansari *et al*., (1986) from various coastal environs.

The high population density might be due to higher temperature, salinity, low turbidity and stable environment. Evidently Wiktor (1960) and Raveenthiranaath Nehru (1990) reported that the high temperature and salinity played a crucial role for the higher benthic macrofaunal density in Szczecin lagoon, Poland and Coleroon estuary, India respectively. The significant correlation coefficient between station I and Station II varied.

The effect of heavy rainfall was fairly seen on the macrofauna in certain regions of the Kakinada Bay (Radhakrishna, 1964). The minimum density of the benthic macrofauna during the monsoon seasons is attributed to higher amount of freshwater input, high turbidity, predation of shore birds and unstable environments. The observations coincide with the previous findings of Parulekar *et al*., (1985). They reported that increased water turbidity control the distribution pattern of benthic macrofauna. Davis (1978) and Casper (1981) reported that the decline in the macrofaunal density in all the habitats during monsoon seasons could be attributed to the predation of shore birds and other birds.

At both the stations, polychaetes were the dominant forms. Similar observations were made by earlier workers, Ansari (1982); Chatnanthawes and Bussarawit

(1987); Ingole (1987); Dekkar (1989) and Harkantra *et al.*, (1990) in various coastal environments.

Crustaceans formed the second dominant group followed by polychaetes. Similar reports were made by Bloom *et al.*, (1972) and Chatnanthaer and Bussarawit (1987).

High diversity of the benthic macrofauna was associated with high population density and high salinity as observed by Jagadeesan (1986). The lower values of diversity are attributed to higher freshwater influx, higher turbidity and low population density.

Evidently Boesch (1977) suggested that the salinity had been well documented as the major environmental factor controlling the number of species and community structure of estuarine faunal community

4.5.6 Marine algae

Totally 72 marine algal species were reported from the Malvan coast. The average biomass recorded at this site was 0.69 kg/m^2 and mainly contributed by members of Phaeophyta (55%) and Rhodophyta (32%). Along the stations marked during the present study only 38 species were recorded of which

Rhodophyta (37.5%) group dominated followed by Chlorophyta (34.4 %) and Phaeophyta (28.1%).

Dixit (1940) reported 9 chlorophyta, 11 Phaeophyta and 10 Rhodophyta species along the Malvan coast. Untawale *et.al.,* (1980) and Untawale and Agadi (1981) reported *Monostroma oxyspermum* (Kuetz.) Doty and *Ernodesmis verticillata* (Kuetz) Boergs were reported for the first time from Malvan coast. The comparison of the macroalgal groups with the earlier studies showed that the percentage of Rhodophyta decreased from 33% in 1940 to 24% in 1979 and later increased to 46% in 1998. in other two groups, Phaeophyta showed 39% increase in 1979, whereas, Chlorophyta showed similar percentage composition i.e. 37% in 1940 and 1979 and thereafter it decreased to 26% in 1998 (Fig 3.18).

4.6 CONCLUSION

On the basis of representation of several marine floral and faunal members along the Sindhudurg Fort of Malvan, it is strongly recommended to further support the concept of Malvan Marine Park, which was proposed earlier (Untawale, 1980). The environmental conditions like climatological, edaphic and oceanographic factors are ideally suitable. The level of marine pollution is minimum and can be further reduced after taking preventive measures.

CHAPTER V

SOCIO-ECONOMIC STUDIES AND SUSTAINABLE UTILIZATION OF MARINE RESOURCES

CHAPTER V
SOCIO-ECONOMIC STUDIES AND SUSTAINABLE UTILIZATION OF MARINE RESOURCES

5.0 INTRODUCTION

Coastal ecosystems are unique and highly productive. For this reason, most of the Worlds growing population live in coastal areas, or within easy reach of them. The human interventions take place mainly in the transitional zone containing important biodiversity and diversified habitats such as mangroves, salt marshes, mudflats, seagrass, seaweeds and coral reefs.

The marine resources are the primary sources of livelihood for the coastal communities, and fish constitutes the most valuable amongst them all. In the last few decades, the utilization of this marine resource has created great stress on the marine ecosystem in general and on the livelihood of the traditional and small fishing communities in particular. When the rate of utilization exceeds the nature's capacity for regeneration and self-stabilization exploitation ensues. Whether a resource is utilized or exploited depends upon the carrying capacity of the resource. The carrying capacity of the resource in turn depends upon the stock and extent of its regeneration. The overexploitation of aquatic resources is already occurring in some heavily fished areas and has become an increasing problem. Fish stocks are being depleted due to inappropriate fishing techniques and inshore pollution (Winpenny 1993). Even though the modern techniques of fishing have certainly generated greater income and revenue to the big business and to the government respectively, they have inflicted irreparable damage to the biodiversity of the marine ecosystem.

This crisis of overexploitation of the biological resources points at the necessity of a shift in paradigm towards sustainable development and optimal utilization of resources. The worlds fishing grounds are coming under growing pressure from overexploitation. This bring the risk that their future sustainable yield will be reduced and certain species will be eliminated and that the competition between different types of fishing operators will cause serious economic and social distress to the users apart from having serious ecological repercussions.

The degeneration of other components in the marine ecosystem such as mangroves is a cause of great concern. The destruction of mangroves deprives many fish species of important spawning and nursery areas with consequent effects on fish populations and biodiversity in off-shore areas. The increased quantities of silt being washed into the sea as a result of mangrove depletion also affects coral reefs and other important coastal habitats such as seagrass beds. This is a chain reaction

According to the Food and Agricultural Organisation (FAO), more than 70 percent of the worlds fish are either exploited, depleted or under drastic conditions limits to allow a recovery (Charanji, 1995). The global fish catch increased five fold between 1950 and 1989, rising from around 20 million tonnes to just over 100 million tonnes due to mainly increase in fishing vessels. Subsequently the catch began to fall and finally plateaued at around 101 million tonnes in 1993. If this trend continues, the quantity and quality of the fish catch is expected to deteriorate to an unsustainable level in the coming few years.

This situation explained above necessitates the need for immediate action to protect the most valuable marine resources. This can be done by declaring certain areas as Protected areas, Marine parks, Sanctuaries, Biosphere reserves etc. These protected areas serves as replenishment areas for marine resources and should be designed to maintain the genetic diversity of key species.

Protection of these marine resources have greater ramifications as it affects the basic livelihood support systems of the coastal communities. It is, therefore essential to find out the extent of dependency on these resources- for livelihood, fuel, sanitation, etc. to be able to gauge the magnitude of problems that the people will encounter after the declaration of the area as protected. This entails assessment of the extent and nature of dependency of various classes of people on diverse marine resources. This underlies the importance of a socio-economic study along with the ecological and technical ones.

5.1 MATERIALS AND METHODS

The socio-economic aspects of Malvan coast and Chorao were concentrated to gather information, which was classified as household and village levels. The questionnaire were prepared. Both the schedules are given in Appendix 1.

The purpose of the study necessitated the selection of households who are mainly dependent on the marine resources for their livelihood. They are basically the fishing community with varied asset holdings. Care was taken to get a fairly good representation of the marginal, small and large scale operators among the fishing community.

Primary data were collected at the household level by administering the household level interviews and informal discussions about the dynamics of the fisheries sector. Secondary data was collected from various sources such as (a) District Census Handbook; (b) Gram Panchayats; (c) Government Functionaries (such as Fisheries Department, Forest Department etc); (d) Fishing Co-operative Societies; and (e) Banks and other Financial institutions. Households level interviews were conducted in detail only for Malvan village and not for Chorao as here there were no fishing community in particular who were fully dependent on marine resources. The study was carried out keeping in mind the following objectives:

- To understand the livelihood of the people of the selected sites with special reference to their dependency on marine resources.

- To assess the extent of utilisation/exploitation of the marine resources by different classes of fishing operators.
- To identify the existing stresses and issues and those that could arise due to the initiatives to protect marine areas.
- To suggest action areas to redress the stresses and to resolve the issues.

5.2 DESCRIPTION OF THE STUDY AREA

An in depth socio-economic study was carried out in six selected coastal villages from Malvan, Sindhudurg district, Maharashtra and Chorao site from Tiswadi taluka, Goa. The villages studied from Malvan are Achra, Jamdul, Pirawadi, Juva Pankhol, Sarjekot and Sidhudurg fort settlement. The details of the study area for Malvan is as given in Chapter IV .Study area of Chorao, Goa is as follows.

5.2.1 Location and Brief History

Chorao Island is a small village in the Tiswadi taluka of North Goa district. Goa forms a small coastal territory on the western ghats and has a coastline of about 120 kms. North Goa District as the name suggests covers the entire northern part of Goa state and is bounded by the Arabian sea on its west; Terekhol river in the north which separates Goa state from Sindhudurg of Maharashtra; by Belgaum district of Karnataka state in north-east and by the district of South Goa in the South. The district of North Goa is situated between the lat 15° 47'59"N and 15 ° 16' 22"N and the Long 73 ° 40' 54"E and 74 ° 16' 89"E. The earliest known historical record of Goa belongs to the 3rd Century A.D. The history of Goa state can be traced back to 3rd Century A.D when it was ruled by the Bhojas from Aparant or Konkan referred to in the rock cut edicts of the Emperor Ashoka. The Satavahanas of Kolhapur followed this in the first Century of the Christian era. Goa was conquest by the Portuguese in the 16th Century. In 1469 Goa passed under the Bahamani's Sultan of Gulbarga when Mahmud Gawan, a general of Muhammed III (1463-1482) conquered the Konkan area. The historic event which marked the end of about 450 years of Portuguese took place on 19 December 1961 and Goa became free and a part and parcel of India on that day. Several tributaries of Mandovi estuary (Mapusa river, Narora river and Goa river) have formed islands such as Chorao (Chodan) and Diwar. Chorao island is only 5 kms from Panaji city, near Ribandar ferry wharf. The details of Malvan is given in Chapter IV.

5.2.2 Physiography

Chorao Island is an estuarine ecosystem, dominated by muddy substratum. The total area of the Chorao island is 423.75 hectares, and the mangrove cover of the island is about 250 hectares. This district where Chorao lies has a hilly terrain especially on its eastern side where lies the southern ends of the Sahyadri range. The details of Malvan is given in Chapter IV.

5.2.3 Fishing Resources of Chorao

Goa is endured with rich marine and inland fishing potential. Fishing like agriculture is one of the oldest occupations of the Goan people and an important means of livelihood particularly of those living in the coastal areas. Goa is the first state in India where diversified fishing methods were introduced as early as 1964. Fishing is restricted to 16 kms. of the coastline. Here also the fishing activity are carried out for nine months from September to May. The annual fish catch at some of the villages situated along the bank of river Mandovi during 1997 and 1998 is given in Table 5.1. Fish catch in Goa has increased from 17,000 tonnes in 1960 to 55,000 tonnes in 1991.Almost 80% of the total catch comprises pelagic resources like mackerels, sardine etc. and the remaining 20% from inland and demersal resources in sea. Prawns constitutes 8 to 10 per cent of the total catch. Fish is the major source of protein for the local people .

5.2.4 Mangroves of the study area

Mangroves play a crucial role in sustaining and nurturing the life supporting eco-system. They serve as filters between land and water, anchoring nutrients and trapping pollutants, thereby reducing the eutrophication and pollution of coastal

Table 5.1 **Annual fish catch at some of the villages situated along the bank of river Mandovi during 1997 and 1998**

Village	Fish catch (tonnes)	
	1997	**1998**
Aldona	87	124
Pomburpa	125	124
Brittona	94	68
Nerul	35	29
Verem	16	36
Candolim	6	5
St. Estevem	160	149
Cumbarjua	115	94
Diwar	176	149
Chorao	152	185
Mandur	64	65
Goa-velha	42	60
Verna	68	91

Source: Fisheries Department, Goa

waters; control and prevent erosion; provide coastal storm protection; enable important reproduction, nursery, and feeding areas for numerous aquatic species; and ensure a conducive environment and resources for subsistence farming and fishing (Thomson and O'Riordan 1995).

The details of mangrove vegetation and its associated flora and fauna for Chorao is given in Chapter III whereas for Malvan it is given in Chapter IV.

5.3 RESULTS

5.3.1 Demographic features

5.3.1.1 Decadal Population Growth

The decadal growth of population of Sindhudurg district during the 1981-1991 period was 6.56 percent which is strikingly low as compared with the corresponding growth rate of Maharashtra (25.73 per cent),While that of Tiswadi taluka of North Goa district where Chorao lies , it was 10.99 percent which is also low as compared to the growth rate of Goa state (16.08 percent). In the study area decadal rate of growth of population shows that there is a trend of negative or very low rate of growth of population. The village wise distribution of population and the decadal growth rates per year is given in the Table 5.2.

The primary data shows that there has been a tremendous migration from these villages to other cities in India and to the Gulf countries. This is mainly due to the lower level of development of the district economy to provide adequate employment opportunities for the local people.

5.3.1.2 Age - Sex Structure

The age-sex structure of the study area is presented here in order to illustrate the sex ratio; to assess the percentage of people in the economically productive age and to find out the dependent population (Table 5.3)

Age -sex structure of the sample household was found in Malvan village. The sex ratio in Malvan area is 859 females per 1000 male population which is lower than the State average (934 females per 1000 males). In fact, the sex ratio in the district is higher (1137 females per 1000 males) testifying the migration pattern (Table 5.3). It was noted that in Malvan and nearby villages there was mass out-migration to Mumbai and other cities nearby. Migration in the fishermen community seems to be much less than the general trend. It has, however, been noticed that out of the households surveyed one person has out-migrated from 53% of the households.

In Chorao according to ration card data from the Panchayat the population is 7105 (above 5 years) while 378 (below 5) and the number of households are

1372. But according to the 1991 census data the population is 5577 and 1107 households.

5.3.2 Social characteristics

5.3.2.1 Health

The disease profile of the study area indicates the incidences of a variety of diseases which are seasonal in nature, such as fever, cough and cold, waterborne diseases such as diarrhoea and dysentery and a few stray cases of tuberculosis, cataract and malaria. No clear cases of any health hazards are reported.

The people have fairly good accessibility to the health facilities. Wherever the health facilities are not present within the village, they are available at a maximum travel distance of 5 to 10 kilometres. The most preferred type of health facility is the private doctors followed by the Primary Health Centres. The table 5.4 shows the availability/accessibility of various health facilities in the study area.

5.3.2.2 Literacy and Education

The literacy rate along Malvan villages and Chorao (Goa) was found to be quite high. Various factors have contributed to the high literacy level in the study area. Prominent among them are the locational and attitudinal factors. Every village

Table 5.2 Decadal Changes in the distribution of Population in the study area.

Villages/sites	Population		
	1981	1991	Growth rate/year
Achra	718	1447	10.15
Jamdul	240	234	-0.25
Pirawadi	695	655	-0.57
Juva Pankhol	208	186	-1.05
Sarjekot	903	922	0.21
Malvan*	17,328	17,986	0.38
Chorao	-	5577	-

Source: Maharashtra Census Directorate, 1981and 1991
Goa Census Directorate, 1981 and 1991

* Sindhudurg fort settlement, one of the study village is a part of Malvan town.

Table 5.3 Age-sex structure of the sample households at Malvan

Age Groups	Sex		
	Male	Female	Total
0-5	5	3	8
6-14	12	11	23
15-60	52	50	102
60 and above	9	4	13
Total	78	68	146

Table 5.4 Availability/Accessibility of Health Facilities in the Study area

Sr. No.	Villages/Sites	Health Facilities Available
1	Achra	1 FPC, PD
2	Jamdul	Within a distance of 5 kms
3	Pirawadi	1 CHW
4	Juva Pankhol	Within a distance of 5 kms
5	Sarjekot	Within a distance of 5 kms
6	Sindhudurg fort	Within a distance of 5 kilometers (by boat)
7	Chorao	1 PHS, 1RMD, 1FPC3, 1 TB, 2 PD

Source: Maharashtra Census Directorate, 1991& Goa Census Directorate, 1991
FPC-Family Planning Centre, PD-Private Doctor, CHW-Community Health Worker
PHS-Primary Health Sub-centre, RMD-Rural Medical Dispensary, FPC-Family Planing Centre, TB- T. B. clinic,

has access to primary middle and high schools, if not available in the village, are located at fairly good accessible distance, at the nearest urban centers. The people's attitude to literacy and education was also observed to be very positive. Accessibility to educational institutions for the study area is given in Table 5.5.

It is seen from the Table 5.5 that almost every village has a primary school; >70% of the villages have middle schools and 60 percent of the village have high schools within the village. Higher education institutions are located within a distance of 10-30 kilometers distance from any village. In Chorao even has one higher secondary school.

5.3.2.3 Shelter Quality

It was observed that the people of the study area in general are very conscious about the environmental hygiene and this is reflected in the way they have maintained their homesteads and houses. In the study villages, it has been noticed that more than 50 percent have pucca houses (Good houses) and the remaining are kucha houses (without proper roofing etc). The analysis of primary data shows that there is a positive correlation between the ownership of pucca houses and the level of income. This means that as the income increase, the people invest in improving the quality of their shelter. Consider the Table 5.6 for the sample households in Malvan villages

Table 5.5 Literacy and education in the study area

Name of the Village/Site	Educational Facilities Available
Achra	1PS; 1MS
Jamdul	1PS
Pirawadi	1PS; 1MS; 1HS
Juva Pankhol	1PS
Sarjekot	1PS; 1MS; 1AEC
Sindhudurg fort	Within a distance of 5 kilometres (by boat)
Chorao	11PS; 3MS; 2HS;1HIS

Source: The Maharashtra Census Directorate,1991
The Goa Census Directorate,1991

Note: PS: Primary School; MS: Middle School; HS: High School; AEC: Adult Education Centre; HIS: Higher Secondary School

Table 5.6 The shelter quality in Malvan villages

Levels of Subsistency (Rupees)	Number of mud houses	%	Number of good Houses	%	Total	%
Up to 207	2	7.14	-	-	2	7.14
207-413	5	17.86	3	10.71	8	28.57
413-620	3	10.71	4	14.29	7	25.00
620-827	2	7.14	4	14.29	6	21.43
827 and above	1	3.57	4	14.29	5	17.86
Total	**13**	**46.42**	**15**	**53.58**	**28**	**100.00**

It may be noted here that the expenditure estimates of the study households are given as a proxy for income estimates for income estimates as responded by the households, as usual, is underestimated. Expenditure estimates supported by estimates of asset holding are better indicators of the level of well being. The households therefore are classified according to the levels of subsistence. One time subsistence is Rs. 413 per capita and this means that this amount is just sufficient for the household to meet the expenses on food and fuel to obtain 2,400 kilo calories per capita per month.

In the above analysis shelter quality is classified as pucca and kucha. Pucca houses are constructed with longer lasting building materials such as bricks, concrete and tiles. Kucha houses are made of low quality building materials which do not last long. It has been found that 53.58 per cent of the households have pucca houses and 46.42 per cent have kucha houses for the sample household surveyed. There is a clear relationship between the level of well being and the quality of shelter.

5.3.3 Land utilisation pattern

5.3.3.1 Land Use Pattern

The land use pattern refers to the distribution of the total geographical area of the village for various purposes. They are classified under five land uses; viz., forest, irrigated land, un-irrigated land, culturable waste and the area not available for cultivation. The culturable waste here also includes the groves sand gouchar lands. The Table 5.7 gives the land utilisation pattern of the study area.

One of the striking features of the land utilisation pattern is the absence of any land under forest cover. The coastal forests are apparently not included in the forest area given in the table. Coastal forests, especially the mangroves are included in the culturable waste land consisting of orchards and gouchar land. According to the respondents in the primary survey, the mangroves in and around the villages are getting depleted over a period of time. The land under irrigation is negligible except in the cases of Achra (23.39 %) and Chorao (1.11 %). In the irrigated areas, the chief source of irrigation is wells and in the un-irrigated areas, the cultivation is mainly dependent on monsoons.

5.3.4 Coastal area

Any initiative to protect the coastal area from human activities has to take into account its present utilization pattern. It has been observed that the coastal land has been used for sanitary purposes, disposal of garbage and drying fish (Table 5.8).

In the villages of Malvan, it was noticed that on an average around 62 per cent of the households in the primary survey use the beach front land for the purpose of sanitation mainly because of the lack of sanitation facilities at the household or

Table 5.7 Land Use Pattern in the study area

Villages/Sites	Area (in hectares)	Irrigated Land	Un-irrigated Land	Culturable waste	Not available for cultivation
Achra	156.90 (100)	36.71 (23.40)	65.65 (41.84)	15.20 (9.69)	39.34 (25.07)
Jamdul	56.45 (100)	-	10.95 (19.40)	-	45.50 (80.60)
Pirawadi	59.46 (100)	-	45.36 (76.29)	-	14.10 (23.71)
Juva Pankhol	61.54 (100)	-	29.40 (47.78)	-	32.14 (53.22)
Sarjekot	66.70 (100)	-	48.27 (72.37)	0.16 (0.24)	18.27 (27.39)
Chorao	1983.21 (100)	22.08 (1.11)	912.11 (45.99)	137.84 (6.95)	911.18 (45.95)

Source: The Maharashtra Census Directorate, 1991.
The Goa Census Directorate, 1991.
Figures in parentheses are percentages

Table 5.8 Percentage Dependency of the sample Households on the coast for sanitation and Garbage disposal

Villages/Sites	Purposes	
	Sanitation(%)	Garbage Disposal (%)
Achra	66	66
Jamdul	100	100
Pira wadi	57	14
Sarjekot	50	10
Sindhudurg Fort	50	-
Chorao	20	50
Average for Study Area	57.17	48

community level. While on an average most of the household in Chorao village have toilets or more than 150 toilets are been constructed by the government free of cost along this village.. A small number of people (13 per cent) use this area for the disposal of household garbage.

5.3.5 Economic Engagements

5.3.5.1 Employment Pattern

This study defines work as participation in any economically productive activities. Main workers are those who have been economically engaged in productive work for at least six months (183 days) or more for a given year. Marginal workers are the ones those have worked for less than six months. All those who have not worked are categorized as non-workers. Persons engaged in household duties, students, retired persons, rentiers and dependants are some of the groups included in the category of non-workers.

The Table 5.9 indicates that the percentage of people engaged as marginal workers is low (3.69%), while only 29.39 % are main workers, and a substantial percentage (66.96) as non-workers. As far as participation of male and female separately is concerned in economic activities, in the category of main workers, 24.53 % are females and 75.44 % are males. However, in the category of marginal workers, 63.46 % are females and 36.54 are males. A large number of females (62.11 %) are non-workers amongst the category of non-workers. Here ,

Table 5. 9 Employment Pattern in the Study Area

Villages/Sites	I to IX		I		II		III		IV		Va		Vb	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Achra	314	109	138	57	46	26	1	-	-	-	-	-	36	4
Jamdul	40	37	16	1	10	27	8	2	-	-	-	-	-	4
Pirawadi	140	91	-	-	-	-	103	22	-	-	-	-	4	1
Juva Pankhol	52	36	48	34	4	2	-	-	-	-	-	-	-	-
Sarjekot	200	64	7	9	1	-	129	1	-	-	-	-	16	3
Malvan	4004	1172	164	51	95	30	854	784	10	6	29	14	484	277
Chorao	1238	438	388	164	94	91	17	7	9	-	18	4	133	24
Total	5988	1947	761	316	566	176	1112	816	19	6	47	18	673	313

Villages/Sites	VI		VII		VIII		IX		MW		NW		Total		
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	T
Achra	14	-	29	4	10	-	40	18	12	162	341	509	667	780	1447
Jamdul	-	-	5	1	-	-	1	2	2	6	62	87	104	130	234
Pirawadi	3	-	10	58	5	8	15	2	3	2	158	261	301	354	655
Juva Pankhol	-	-	-	-	-	-	-	-	-	1	27	70	79	107	186
Sarjekot	2	-	16	35	13	-	16	16	7	30	238	383	445	477	922
Malvan	214	25	868	272	494	62	862	365	318	386	4539	7567	8861	9125	17986
Chorao	98	35	152	29	104	5	225	79	19	40	1487	2355	2744	2833	5577
Total	331	60	1080	399	626	75	1159	482	361	627	6852	11232	13201	13806	27007

Source: the Mahrashtra Census Directorate, 1991

I to IX : Categories of Main workers.

I: Cultivators; II = agricultural labourers; III= Livestock, forestry, fishing, hunting, plantation and orchards and allied activities; IV = Mining and Quarrying; Va = Manufacturing, processing, servicing and repairs in household industries; Vb = Manufacturing, processing, servicing and repairs in other than household industries; VI = Constructions; VII = Trade and Commerce; VIII = Transport, storage and communications; IX = Other services; MW = Marginal workers; NW - Non-workers (those who have not participated in any economically productive activity).

the females who are engaged in household work are put in the category of non-workers. The employment pattern in Malvan town and Chorao village is almost similar.

5.3.5.2 Women's participation in the Economy

In Malvan it was observed that the womenfolk in the fishermen families are engaged in economically productive activities such as retailing fish in the local markets, salting and drying the fish. They are also engaged in selling homestead based horticultural products such as coconut's which was also seen in case of Chorao womenfolk. They are rarely included as workers (main or marginal) even though they are productively engaged in economic activities. They, however, do not go out into the sea for fishing along with the men as fishing is considered to be a strenuous labour. It may be pointed out here that the Census does not consider the contribution of housewives as economically productive.

5.3.5.3 Dependency ratio

Dependency ratio is an important demographic indicator showing the number of dependents (i.e. non-earners) supported by the earners. The Table 5.10 gives the dependency ratios in the study villages and sites.

The average dependency ratio for the study area is 202.62 percent implying that 1 Worker supports 2.02 persons. Dependency ratios is very low in Juva Pankhol (108.99) and was quite high in Sarjekot (206.31), Malvan (205.88) and Chorao (221.19)

5.3.5.4 Sources of Livelihood

In the villages of Malvan the primary source of livelihood for majority of the fishing community is the fisheries sector. Fisheries sector provides around eight to nine months of productive employment. During the remaining three to four months they are engaged in a variety of off-season employment such as net repairing, net weaving, boat repairing, agriculture/horticulture, lumbering, construction labour, fishing in rivers and backwaters, and cattle grazing. In Chorao the primary sources of livelihood was mostly trade and commerce. Fishing along with agriculture, construction labour etc were secondary activity. Most of the people from this village are employed somewhere in private or government firms. Survey conducted for Malvan villages for the various sources of livelihood and the percentage income derived from them is given in Table 5.11.

It was noted from the primary survey that in Malvan villages, for the lower expenditure classes, the average income from fishing ranges from 66.64 to 100 per cent and the main supplementary sources of income are fishing labour,

Table 5.10 Dependency ratio in the study area

Villages/sites	Non-workers	Workers	Dependency ratio (%)
Achra	850 (58.74)	597 (41.26)	142.38
Jamdul	149 (63.68)	85 (38.32)	175.29
Pirawadi	419 (63.97)	236 (36.03)	177.54
Juva Pankhol	97 (52.15)	89 (47.85)	108.99
Sarjekot	621 (67.35)	301 (32.65)	206.31
Malvan	12106 (67.30)	5880 (32.7)	205.88
Chorao	3842 (68.87)	1737 (31.14)	221.19
Study Area	18084 (66.96)	8925 (33.05)	202.62

Source: The Maharashtra Census Directorate, 1981 and 1991
The Goa Census Directorate, 1991
Note: The Dependency ratio is the percentage ratio of non-workers to workers
Figures in parentheses are percentages.

Table 5.11 Various sources of livelihood and the percentage income derived from them (Malvan villages)

Subsistency Classes (Rs.)	No. of house-holds	Sources of Livelihood (%)					
		Fishing	Fishing Labour	Agri./ Horti.	Remitt -ances	Others	Home Consump-tion
Up to 207	2	66.64 (2)	34.70 (1)	32.70 (1)	-	-	-
207 - 413	8	71.42 (5)	8.06 (1)	29.62 (2)	-	33.05 (5)	5.60 (5)
413 - 620	7	100.00 (7)	-	30.43 (4)	-	23.07 (1)	10 (3)
620 - 827	6	99.01 (4)	-	67.41 (3)	22.47 (1)	-	5.1 (2)
827 - above	5	42.45 (3)	22.93 (1)	39.00 (4)	60.52 (1)	68.80 (1)	31.19 (3)

Figures in parentheses indicate the number of households.
Other sources of income includes shops and off-season employment such as construction labour, boat repairing, net repairing, weaving and lumbering.
Home consumption refers to consumption of eggs, fish and coconuts produced/gathered at household level.

construction labour and agriculture/horticulture. However, the lowest class does not have any supplementary sources of items of home consumption.

All the respondents in the middle income category depend primarily on fishing as the source of livelihood. They also have supplementary sources such as horticulture /agriculture and remittances from the family members who have migrated to other cities in India and abroad. The situation is very similar to the next expenditure class wherein 75 percent of the households derive 99.01 per cent of the income from fishing. They too have supplementary sources such as agriculture/horticulture, remittances and home consumption. The highest income category, notable, has more income sources. Their dependency on fishing as primary source of livelihood is not considerable - 60 per cent of households belonging to this class derive only 42.45 percent of their income from fishing. The income is equally supplemented by other sources. The value of home consumption is the highest in this class (31.19 percent) because of the availability of surplus fish and coconut. For them the two income sources, i.e., fishing (42.45 percent) and agriculture/horticulture (39.00 percent) are complementary to each other.

5.3.6 Poverty Estimates

5.3.6.1 Consumption Expenditure Pattern

The consumption expenditure pattern of the sample population is carried out mainly for the purpose if assessing the levels well being. It has been noticed that consumption expenditure of a household supported by the asset holdings give a more realistic picture of the income levels of the people because the respondents are always reluctant to reveal their income. Therefore, expenditure classes are considered as proxy for the income classes. These estimates are closer to the reality.

A detailed analysis was done in order to estimate a locally relevant poverty line from the prevailing consumption pattern. The FAO-WHO standard of 2400 kilo calories per capita per day was taken as the subsistence level and the money value for obtaining this amount of calories was calculated at the rates prevalent in the study area. It was found that the cost of obtaining 2400 kilo calories per capita per day for a month is a Rs. 413 and this is considered as the subsistence level of income in Sindhudurg district while that of Goa a household where the monthly income is below Rs.1700/- is considered to be below poverty line. The per capita expenditure of the people are then classified into multiples of subsistence. The income levels of the people according to these estimates are given in the Table 5.12 & 5.13.

It was noted that at Malvan 35.71 % of the people live below the subsistence level . As mentioned earlier Rs. 413 per month is just sufficient for a person to obtain the required standard calories in Sindhudurg district. If other essential expenses such as on medicines, clothes and education are considered , it will be

Table 5.12 Income distribution of the sample households at Malvan villages

Subsistence Class	Expenditure per capita (Rs.)	Number of households	%
0.5 time	Up to 207	2	7.14
1.0 time	207 - 413	8	28.57
1.5 time	413 - 620	7	25.00
2.0 time	620 - 827	6	21.43
Above 2.0 time	827 and above	5	17.86
Total		**28**	**100.00**

Table 5.13 Average per capita monthly expenditure of sample households of Malvan

Expenditure classes	Food & Fuel (%)	Clothing (%)	Shelter (%)	Health (%)	Education (%)	Festivals (%)	Conspicuous consumption (%)	Others including travel (%)
Up to 207	75.67	9.27	0.38	2.06	10.02	1.41	-	1.23
207 - 413	88.36	3.26	0.88	1.25	2.94	3.59	1.62	1.53
413 - 620	51.2	8.08	0.04	3.22	4.03	21.62	0.53	1.38
620 - 827	57.27	5.87	0.99	1.94	4.23	41.72	8.38	4.68
827 and above	43.78	3.53	0.73	5.11	1.53	37.07	3.37	3.79

Source: Survey 1998.

The expenditure figures will not add up to 100 for they are median values of percentage expenditure of the number of people belonging to the concerned expenditure class.

The average family size of these study area (Malvan villages) is 4.86.

60.71 per cent of the people live below the poverty line. The people at 2 time subsistence and more may be considered as better off sections in the fishing community

Data collected for Malvan on household level on the pattern of expenditure of various income classes. It was noticed that the lower income group spend a substantial portion of their income (75 to 88 %) on food and fuel and proportionately less percentage (1.25 to 2.06 %) on health care as they depend mostly on the government health care facilities and occasionally on private medical practitioners. However they spend a substantial amount (2.94 to 10.02 %) on education, and this is reflected on the high literacy rates prevalent in the district in general and in the study area in particular. Even though the Konkan people are highly tradition bound, the expenses of the lower income classes on festivals are comparatively low as they have lower disposable income.

As the income increases a distinct pattern of expenditure emerges. It was seen that as the income increases, the expenditure on food and fuel decreases while the expenditure on festivals and conspicuous consumption items increases. The expenditure pattern has deeper implications as it shows the household priorities of the people of the study area. Typically, most of the lower income class of people live in kuccha houses and fishing is their primary source of income. Some of them work as fishing labourers. Any intervention to protect the marine resources will have to address the livelihood issues of the dependent people.

5.3.6.2 Ultra poor and depth of poverty

Further analysis into the poverty situation shows that there is a distinct class of poor people who can be termed as ultra poor. Ultra poverty is said to occur when a household cannot meet 80 % of FAO-WHO minimum calorie requirements (i.e., 2,400 kilo calories), even after spending 80 % of their income on food and fuel. Of the surveyed households, 21.43 per cent can be categorized as ultra poor. In the above analysis , they typically live below subsistence level of income (their average monthly income is Rs.316.04 per capita) (Table 5.13).
In order to assess the depth of poverty the measure of poverty gap is calculated. The average per capita monthly income of the people below the poverty line needs to be augmented to the tune of more than Rs.227.11 bring them above poverty line in Maharashtra while in Goa it is said that the household which has a monthly income below Rs.1700/- come s below poverty line.

5.3.7 Productive Asset Holdings

The value of assets owned is a clear indicator of the status of livelihood and the well being of an individual. The primary survey along Malvan reveals a distinct income-linked asset holding pattern. Since the respondents in this study area belong to the fishing community the assets listed are mainly fishing equipment. Other assets include agricultural land and household belongings (Table 5.14).

It was observed that in Malvan the poorer sections do not possess any substantial fishing equipments except fishing nets which are mostly cotton nets that require frequent maintenance. The owners of fishing nets are involved in group fishing. A few of them have non- mechanised boats (hodi) used for fishing purposes. In Chorao very few people were involved in fishing. Around 15 non-mechanised boats are owned by these people, when they go for fishing which is a rare phenomenon.

The higher income classes in Malvan possess mechanised boats and trawlers (28.57 to 57.14 %). Owners of these boats do not go out for fishing; they employ labourers who go in the sea for fishing. These types of boats and trawlers use expensive nylon fishing nets (costing up to Rs. 40,000/-) which can sweep in a large quantity of fish.

5.3.8 Fisheries

Malvan is one among the Sindhudurg district where the primary occupation of the people is fishing. In these area the employment provided by fishing in considerable production is also significant in quantitative terms. While Chorao which is small village situated in the north district along the Mandovi river , fishing is considered as the secondary activity. Among all the villages situated along this river Chorao ranks first in the fish catch in 1998 .

Table 5.14 The expenditure classes and the assests listing of the fishing community at Malvan

Expenditure Classes	Assets					
	Non-Mechanised Boats	Mechanised Boats	Traw-lers	Fishing nets	Movable Assets (Rs.)	Agricul-ture Land (Ha.)
Up to 207	-	-	-	5	3,200	0.4
207 - 413	1	-	1	12	3,847	0.16
413 - 620	3	2	2	43	6,947	0.78
620 - 827	1	-	2	28	10,770	0.14
827 and above	1	1	4	4	8,500	0.27

In the study area (Malvan), prior to the advent of mechanised fishing techniques, Rampans were widely used with surface gill nets, mid-water gill nets, and bottom water gill nets. Small fishermen still use this method (about 50% of the fish production is derived from the traditional method) as is evident from the number of non-mechanised vessels. Mechanised trawlers have substantially increased the fish production bringing in its wake a host of other problems. In Chorao only non mechanised boats were used for fishing activity.

5.3.8.1 Equipments used for fishing

The survey revealed that in Chorao only non-mechanised boats were used while in case of Malvan two main types of boats were used . They are mechanised boats - trawlers and gill netters; and non-mechanised boats - sailing boats, Rampan and Tonny. Trawlers are of two types - with 2 cylinder engine and 6 cylinder engines.

Non mechanised traditional boats are permitted to fish up to a distance of 10 kilometres at a depth of 30 metres. The mechanised boats can fish between10-15 kilometres with depth being 30-50 metres; while the large vessels can go beyond 15 kilometres where the depth is more than 50 metres. However, during the survey the respondents stated that it was a common practice for the trawlers in Malvan to fish at 20 fathoms. A variety of nets ranging from ordinary cotton to modern synthetic nets were used. In Goa at present fishing is restricted to 16 kms. of the coastline. Local fishermen in Goa have started using vessels of larger length around 38' to 52' which enable them to go for fishing beyond 16 kms.

5.3.8.2 Investment on fishing

A rough estimate with the enquiry from the study area (Malvan) reveals that an investment on trawlers vary from three lakhs to twelve lakhs rupees . Another major item of investment is in the nets. The nets cost from Rs. 1,300 to Rs. 13,200. The sample households had invested a sum total of Rs. 93,35,300 in fishing equipment and this amounts to an average of Rs. 3,33,403 per household. From this it can be inferred that this occupation requires a substantial initial investment. Besides this capital investment, the fishermen have to incur every year a significant amount of recurring costs for operations, maintenance, repairs and replacements.

5.3.8.3 Techniques of fishing

The entire technique of fishing differs with the type of vessels employed for fishing. Non-mechanised, traditional boats generally are engaged in 'One shift fishing'. They can stay out at sea for 12 hours at a stretch. They fish either throughout the day or night. Depending on the size of the boat a maximum of 4 fishermen form a group per boat. Ordinary cotton nets are used by these fishermen. These nets last only for one fishing season of 9 months (September to

May). The mechanised boats (with out-board engines) and trawlers are equipped to go for fishing for a continuous period of 3-7 days. Some of the trawlers are fitted with the latest equipments such as the eco-sounder, fish detectors and wireless sets. Since this vessels have a capacity to trawl for longer periods their rate of extraction is very high.

5.3.8.4 Fish Production

It is necessary to know the profitability of this industry in terms of total fish catch, the extent of fish dried , development of by-products and the resources base that it can offer to other medium - sized or small scale industries. The fish production for Sindhudurg (1994-1997) and Goa (1991 - 1998) is given in Table 5.15 and Table 5.16 respectively.

A persual of the above data shows that the marine fish production is far greater than that of the brackish water and inland fish production. There has been a steady rise in the fish production in all the 3 categories in Sindhudurg district while that of Goa the marine fish production has decreased .The increase in production in Sindhudurg may be attributed to various factors such as the government incentives to the fisheries sector, the state of the art, fishing techniques employed by trawlers etc.

Table 5.15 Fish production for the Period (1994 to 1997) for Sindhudurg District

Year	Source		
	Marine (metric tonnes)	Brackish water (metric tonnes)	Inland water (metric tonnes)
1994-1995	28,258	13.59	10
1995-1996	41,147	24.84	11
1996-1997	51,674	35.10	18

Table 5.16 Estimated annual inland & marine fish catch (in tonnes) for Goa State from 1991 to 1998.

Year	Quantity (metric tonnes)	
	Inland	Marine
1991	2506	75623
1992	2714	96333
1993	3053	100922
1994	3429	95840
1995	3562	81856
1996	3302	92737
1997	3270	91277
1998	3474	67236

The fish correlates to the type of fishing equipment used. In Sindhudurg the breakeven point for the traditional non-mechanised boats is the fish catch worth Rs. 500/- day. The daily catch varies (according to the size and power of the boat) between 40 to 80 kg. in fishing season with the approximate turnover being between Rs. 880/- to 1600/-.

The mechanised boats and trawlers are capable of a greater output. The breakeven point of these trawlers is Rs. 5,000/- per day. These trawlers can stay upto seven days in the sea. The daily catch varies between 0.5 and 1 tonne, and the approximate turnover is Rs. 10,000/-.

Group fishing is prevalent in some area. The boats may be traditional, non-mechanised boats or mechanised boats fitted with outboard engine. These boats are jointly owned by the fishermen. The size of the group and the vessel size is directly related (e.g., at Pirawadi village 35 fishermen were grouped together and owned a mechanised vessel). The catch is shared equally amongst the owners. Different types of fishes are found in the sudy area during the season (Table 5.19). The composition of inland and marine fish landings and their percentage of occurrence of different groups for Goa state (1997,1998) varied. The details of which are as given in Table 5.17 & 5.18.

Besides these, many varieties of fishes are also found in these areas. Along with the fish catch a number of tiny fishes such as Khatvi (common name) come in

Table 5.17 Composition of inland fish landings (tonnes) and percentage occurrence of groups for Goa state (1997 & 1998)

Groups	1997	%	1998	%
Prawns - big	59	1.83	36	1.04
Medium	268	8.32	172	4.95
Small	876	27.20	691	19.89
Lady fish	57	1.77	106	3.05
Mullets	94	2.92	164	4.72
Gerres	25	0.78	22	0.63
Lutanus	24	0.75	13	0.37
Catfish	195	6.06	300	8.64
Anchovy	59	1.83	25	0.72
Pearl spot	26	0.81	42	1.21
Betki	6	0.19	4	0.12
Megalops	1	0.03	3	0.09
Milk fish	1	0.03	-	0
Scatophagus	5	0.16	21	0.60
Ambasis	44	1.37	92	2.65
Crabs	99	3.07	154	4.43
Black water clam	190	5.90	219	6.30
False clam	69	2.14	322	9.27
Oyster	2	0.06	1	0.03
Palo	8	0.25	-	0
Lepo	1	0.03	1	0.03
Bali red	4	0.12	17	0.49
Palu	-	0.00	4	0.12
Miscellaneous	1107	34.38	1065	30.66
Total	3220	100	3474	100

Table 5.18 Composition of marine fish landing (tonnes) and percentage occurrence of groups for Goa state (1997 &1998).

Groups	1997	%	1998	%
Mackerel	21721	23.80	19663	29.24
Oil sardine	5640	6.18	9508	14.14
Other sardine	11480	12.58	9022	13.42
Prawns-big	143	0.16	255	0.38
Medium	1930	2.11	1083	1.61
Small	2101	2.30	1313	1.95
Seer fish	1143	1.25	1272	1.89
Shark	964	1.06	583	0.87
Skates	0	0	30	0.04
Rays	23	0.03	37	0.06
Kovala koval	1341	1.47	639	0.95
Golden anchovi	8	0.01	18	0.03
Catfish	684	0.75	650	0.97
Sciaenid	4150	4.55	3529	5.25
Butterfish	793	0.87	651	0.97
Indian salmon	86	0.09	17	0.03
Silver belly	4558	4.99	1232	1.83
Lobsters	6	0.01	2	0
Soles	2838	3.11	1813	2.70
Silver bar	328	0.36	372	0.55
Pomfret	1191	1.30	524	0.78
Lady fish	10	0.01	55	0.08
Mullets	7	0.01	18	0.03
Caranx	1	0	16	0.02
Bombay duck	0	0	1	0
Cuttle fish	5159	5.65	2162	3.22
Perches	963	1.06	502	0.75
Crabs	578	0.63	799	1.19
Ambasis	4	0.00	2	0
Ribbon fish	3720	4.08	2583	3.84
Thread fin	4648	5.09	864	1.29
Leather jacket	106	0.12	22	0.03
Thread fish	2374	2.60	1096	1.63
Shelga	720	0.79	747	1.11
Horse mackerel	331	0.36	156	0.23
Shell fish	105	0.12	4	0.01
Palu	54	0.06	-	0

Tamoso	78	0.09	-	0
Khadye	22	0.02	-	0
Others	582	0.64	-	0
Misc.	10687	11.71	5996	8.92
Total	91277	100	67236	100

the net. These are dried and sold as chicken feed and manure at the rate of Rs. 2 per kg.

5.3.8.5 Marketing

Fish is a perishable commodity and therefore marketing is a crucial activity with time constraint. Inadequate storage and transport facilities leads to the price differentials at various centres.

Three types of marketing patterns are prevalent in the study areas at Malvan. First, most of the respondents sell their produce to the agents. These agents give an advance, which enables the fishermen to cover their operating costs thus binding them to a particular agent. The other marketing outlets are the various fishing co-operatives, who offer better rates and payment against delivery. The smaller fishermen sell directly in the local market or in some cases engage in door-to-door selling. The type of fish and their market price found at Malvan is given in Table 5.19.

5.3.8.6 Fish Curing

Fish is cured with salt and then sun dried. Large quantities of fish are being sun dried on beaches in the study area. Cured fish is always in good demand in the local market and also is been send outside.

Table 5.19 Type of Fish and their market price at Malvan

Type of Fish	Rate
White Pomfret	Rs. 60- 100 per kg.
Bangada	Rs. 200 per 100 fishes
Pedwa	Rs. 30 per 100 fishes
Black Pomfret	Rs. 60.00 per kg.
Bala	Rs. 25.00 per kg.
Dyna	Rs. 3.00 per kg.
Arkuti	Rs. 3.00 per kg.
Kharbi	Rs. 3.00 per kg.
Dhodi	Rs. 7.50 per kg.
Shwada	Rs. 250 per kg.
White Prawns	Rs. 200 per kg.
Brown Prawns	Rs. 100 per kg.
Tiny Prawns	Rs. 30 per kg.

5.3.8.7 Regulatory measures

Several laws have been enacted to regulate and facilitate the fishing operations in India (Diwan and Diwan 1997). Some of the relevant ones are as follows:

- The Territorial water, Continental shelf, Exclusive Economic Zone and other Maritime Zone Act, 1976 provides under section 5(4)(6) that the central government can take measures in contiguous zone with respect to sanitation. Section 6(3) of this Act provides that the Union has in the continental shelf "exclusive jurisdiction to preserve and protect marine environment and to prevent and control marine pollution".
- According to this Act, the Central Government may make provisions with respect to the protection of the marine environment of a designated area. In the Exclusive Economic Zone, the Union has exclusive to preserve and control the marine environment and to prevent and control marine pollution. The Central Executive has the power to make rules for preservation and protection of the marine environment and prevention and protection of marine pollution.
- The Indian Parliament enacted *The Coast Guard Act,* 1978. It is an Act for the constitution and regulation of an Armed Force of the Union for ensuring the security of the maritime zones of India, with a view to protect the maritime and other national interests in such zones and for matters connected therewith.

- Government of Maharashtra enacted *The Maharashtra Marine Fishing Regulation Act,* 1981 to provide for the regulation of fishing vessels in the sea along the Maharashtra coastline. This Act aims at protecting the interests of different sections of persons engaged in fishing, particularly those engaged in fishing using traditional fishing craft. It regulates the fishing activities of different types of fishing vessels within specified areas. Registration and licensing of fishing vessels is mandatory under this Act.
- In India, adequate legislative measures have been taken to control marine pollution. The government passed *The Water (Prevention and Control of Pollution) Act* 1994, in order to prevent and control water pollution.

In the Study area it was observed that all fishing vessels possessed a fishing license to operate within a specified area. The respondents in Malvan (which has 300 trawlers) stated that insurance was compulsory for getting a license. The respondents were aware that any crossing of specified limits for fishing entailed punishment from the Port Trust. It can be stated in general that the respondents in the study area were aware of the regulatory measures involved in the fishing trade.

5.3.8.8 Support from Institution for fishing activity

Institutional support is essential to facilitate the development of any sector of the economy. Institutional facilities, financial assistance for technology up gradation, marketing facilities etc. are vital to promote marine fisheries. In an attempt to improve the productivity and profitability of fishing operations, various schemes are introduced by different institutions. The schemes generally are aimed at : a) modernizing fishing craft; b) providing cold storage and ice plants; c) Upgrading fishing harbours and fish landings; and d) ensuring a steady marketing outlet. Various initiatives are taken both by the government and private sectors to assist fishermen community.

5.3.8.9 Fishing Co-operatives

The rationale behind any co-operative is joint ownership and equitable distribution of benefits, keeping in view the principles of social justice. With this philosophy, the fishing co-operatives have been established to provide benefits to the fishermen who, without this assistance, would find it difficult to operate in their trade. The main purpose of the fishing co-operatives are

- to provide diesel, kerosene and ice at reasonable rate
- to purchase daily catch of fish
- to help in transporting fish to market areas
- to extend short term loans and

- to help in procuring loans from other sources like National Co-operative Development Corporation (NCDC) loan scheme.

The respondents in the study area expressed various problems encountered in their daily fishing operations. The distress areas were ultimately procurement of diesel and kerosene to run the fishing vessel, and adequate ice for preservation of fish. Other stress areas are procedural delays for getting the loans sanctioned for the purchase of fishing equipment and uncertain market conditions. All these shortcomings are being addressed to by the fishing co-operatives.

5.3.8.10 Banks

Development of an economy needs a corresponding expansion and support for financing economic initiatives and infrastructural facilities. This has to be timely, adequate, easily accessible and economical. The banking sector in the district plays a supportive role for development of the fisheries sector.

5.3.8.10.1 Loans: Banks have been administering loans to the fisheries sector for the following purposes:

- purchase of boats/trawlers
- purchase of machines
- purchase of nets
- loans to storage units

- loans to ice factories and
- loans to processing units (e.g., fish drying).

The rate of interest is in conformity with the Reserve Bank of India guidelines of 16% per annum. The collateral is mandatory in the form of property or the item for which the loan has been sanctioned.

According to the Saraswat Co-operative Bank, Malvan, there is 60 per cent default rate for loans against trawlers. The following advances were made to the fisheries sector in Sindhudurg district from 1st April 1997 to 31st December 1997.

The Table 5.20 and 5.21 gives the details of the loans availed by the surveyed households for the purchase of capital equipment for fishing purposes.Banks charge a fixed rate of interest of 26 % per annum on loans. Among the sample households, there is only one case of borrowing from a co-operative society and one from a broker. In both cases the rates of interest differ, it is only 5 % in the case of co-operatives , and the broker charges interest in kind (fish).

Table 5.20 Item-wise distribution of loans for fisheries equipment

Items	Number	Amount (Rs.)
Mechanised boats	38	39,34,000
Non-mechanised boats	15	5,81,000
Miscellaneous fishing equipment	69	22,76,000

Table 5.21 Details of Fishing related loans taken by the sample households (Malvan villages)

Expenditure classes	Loans				
	No. of households	Source	Amount (Rs.)	Rate of Interest (%)	Purpose
Up to 207	-	-	-	-	-
207 - 413	2	BOM Coop.Soc.	50,000.00 3,000.00	16 5	Purchase of boat. Purchase of nets.
413 - 620	1	BOM	75,000.00	16	Purchase of outboard engine.
620 - 827	2	Saraswat Bank, BOM	3,00,000.00 5,000.00	16 16	Purchase of trawler. Purchase of nets.
827 and above	4	BOM, BOM, Brokers Syndicate Bank	9,000.00 6,000.00 50,000.00 65,000.00	16 16 in kind (fish) 16	Purchase of boats. Purchase of nets. Purchase of nets, to cover off season expenses. Purchase of launch.

BOM = Bank of Maharashtra.

5.3.8.11 Government schemes for fisheries development

Marine fishery is an important economic activity, employing people in the fishing trade. Inadequate facilities at the landing centres such as approach roads, supply of ice, diesel and drying platforms are problems that need to be addressed. Lack o appropriate marketing facilities for the sale of fish is a complex problem especially because fish is a highly perishable commodity. Large chunk of the fish catch is marketed as fresh. There are limited facilities for cold storage, deep freezing, drying and processing. The government has designed various schemes to address these problems with the aim of increasing fish production by promoting the marine fishery, creek fishery and inland fishery.

5.3.8.11.1 Marine fishery: For promotion of mechanisation of country boats the Government has sponsored the following steps

i) Grants on Out-board engines : The grants on out-board engines amount to 50 % of the cost of engine (with a ceiling of Rs. 10,000) shared equally by the state and central governments. The balance 50 % of the purchase cost is to be borne by the beneficiary.

In the 7th Five Year Plan there were 104 beneficiaries, 79 in the 8th Five Year Plan and in the 9th Five Year Plan grants have been earmarked for 100 outboard engines.

ii) Subsidy on purchase of Internal Engines : 50 percent subsidy (with a ceiling of Rs. 12,000/-) is offered on the purchase of internal engines for traditional non-mechanised boats.

iii) Building of mechanised boats under employment and self-employment scheme : Loans are granted upto 25 percent of the cost of mechanised boats with a ceiling of Rs. 30,000/- and the balance 75 percent has to be mobilised by the beneficiary.

iv) Loan for purchase of fishing equipment : For boats with a capacity of over 3 tonnes, grants for purchase of upto 100 kg nylon monofilament threads are given. For boats with a capacity below 3 tonnes, grants for purchase of 50 kg nylon non monofilament thread is permissible. This grant in the form of 15% loan on the purchase price.

v) Grants for electrical equipments used in fishing vessels: Under the scheme fishermen get loans for the purchase of walkie-talkies, fish detectors, GPS telephones, eco sounders etc.

vi) National cooperative development corporation (NCDC) Loan scheme: This scheme was started by the fisheries department in 1978 for menbers of fishing cooperatives. A loan is given for the entire cost for the construction of mechanised fishing vessels.

vii) Storage, transport and marketing: Storage, preservation, transport and marketing of fish will involve production of ice, construction of cold storage units, purchase of vehicles, supply of diesel for marketing of fish. In Malvan

NCDC has proposed to grant loan for the construction of ice factory of 25 tonnes capacity and cold storage units with a capacity of 50 tonnes.

viii) Tax concession on high speed diesel: The government had started this scheme in 1990- 91 to provide diesel at a reasonable rate to fishing cooperatives. A concession of 35 paise per litre is given for vessels less than 20 meters in length.

ix) Improvement in infrastructure facilities: The improvements at the landing centres include providing fish drying platforms, construction of jetties and other minor works such as providing guide lights, approach roads, etc. There are 40 landing centres in the district, out of these 10 landing centres have been provided with some of these facilities. The government has plans to develop some new ports for fish landing. They are at: Tarkarli, Achare, Talashit, Dandi, Malvan and Mobara (Malvan Tehsil) Taramumbri, Matthbaon and Chambharwada (Devgad Tehsil) and Nwati, Kochara, Dabhoswada, Navabaag, Muth, Shiroda, Khavane (Vengurla Thesil)

x) Development of fishing harbours: It has been proposed to develop harbours at Anandwadi (Devgad Tehsil) and Sarjekot (Malvan Tehsil), as the off - loading facilities at these places are inadequate.

xi) Requisites for fishing operations and welfare schemes: Requisites for fishing operations like nylon twine and nets, gear material, high speed diesel, construction material for non-mechanised boats etc. need to be provided to the fishermen. The financial assistance is mainly provided through co-operatives.

xii) Concession of electricity charges to fishermen co-operatives: Ice factories that supply ice to the fishing co-operatives get a concession of 40 % per unit of electricity.

xiii) Insurance scheme for fishermen: Under this scheme, fishermen are covered against accident for Rs. 25,000/- between 1994-97.

xiv) Konkan development Programme: Under this scheme, initiated by the Government of Maharashtra, Raigad, Ratnagiri and Sindhudurga districts have been declared as fishing zones. Rs. 36.3 crores have been allocated for this project. The government plans to make the following provisions under this scheme:

- construction of fish landing ports;
- construction of the factories and cold storage plants;
- supply of refrigerated trucks, tempos to fishing co-operatives;
- loan upto Rs. 60,000 for cultivation of fish in non-ocean water;
- construction of medium size vessels with 150 to 200 horse power engines to fishing co-operatives; and
- prawn cultivation centres in river waters.

xv) Housing facility for fishermen out of National welfare fund: Under this scheme, houses of 350 sq.ft. have been planned to be built at an estimated cost of Rs. 35,000 per house. The areas to be covered are Devgad Tehsil (Kunkeshwar and Tambaldig), Vengurla tehsil (Kochra and Tak), and Malvan tehsil (Talashir).

xvi) Construction of artificial reefs on the sea coast: In an attempt to protect the interests of the smaller traditional fishermen, the Central Government has initiated a novel scheme of the construction of artificial reefs. The main purpose is to protect traditional fishermen from big mechanised vessels and to make more fish available for them near the shore.

In 1997-98, 20 such reefs of 10 metres width were built in Malvan. The total expenditure was Rs. 10 lakhs.

5.3.8.11.2 Creek fishery

Creek fishery is a relatively new field and detailed site specific study to identify prospective locations for this purpose. At present, there are many constraints in undertaking creek fishery on a large scale such as inadequate capital, limited technical know-how of feeds and seed production. However the government has initiated some schemes to encourage non- oceanic fishery.

i) Non-oceanic fishery development scheme: Due to high export demand for prawns and the need for foreign exchange, prawn fishing is promoted by the government. Artificial cultivation of prawns are also encouraged.

ii) Non-oceanic prawn cultivation centres: The government has made plans to build a prawn cultivation centre in Malvan. The expenditure is to be shared equally by the Central and State governments. However, this project is yet to be implemented.

iii) Prawn fertilisation centre in each district:

iv) Government's scheme for preservation and growth of prawns in non-oceanic water under the employment and self-employment scheme: This scheme was formulated in 1997 and aims at providing employment to the educated unemployed youth.

5.3.8.11.3 Inland fishery

For increasing fish production from inland fishery, two aspects are very important: (a) seed production by artificial means; and (b) providing financial assistance to individuals for constructing ponds. Keeping this in view, the government has given certain incentives for inland fishery.

There are 23 ponds in the district with a total area of 486.25 hectares. 42 ponds are under the control of the Zilla Parishad with a total area of 72.87 hectares.
In the 7th Five Year Plan seeds worth Rs.2.97 lakhs were distributed. Ponds have been leased to individuals and fishing co-operatives. In the current year seeds worth Rs.8.30 lakhs have been distributed and 10 members of fishing co-operatives have recieved training in the latest techniques of fish cultivation.

5.3.8.12 Fisheries Training Centre

A fisheries training centre was started in Malvan in 1983 by the Maharashtra

Government. The main aim was to train young fishermen in the state of the art fishing techniques to augment fish production.

The course is divided into two terms of six months duration each and has a capacity of 22 trainees who are given a stipend of Rs. 300/- per month. The course covers two areas (a) fishery and navigation; and (b) marine diesel engine. The centre has its own mechanised fishing vessels to train students. Till now 614 fishermen has been trained.

5.4 DISCUSSION

Protection of the fragile marine ecosystem and marine resources has become a global necessity. However, the initiatives to protect marine resources clash with the prevailing policies and programmes of the government. The increase in fish production by modernising the fishing sector by promoting mechanized boats and trawlers has affected the marine ecosystem. The protective initiative will have to restrict trawling as the trawler fishing has serious adverse impacts on the marine ecosystems. The trawlers use high technology nets which have the capacity not only to over fish the fish stocks but also to sweep in other fragile marine resources. In the sites surveyed the fish catch year after year was getting depleted. The over fishing by trawlers seems to account for this increase in annual fish production and is comparatively recent phenomenon especially after the advent of high technology trawlers (1981). Reports from various part of the world also do testify the relationship between depleting marine resources and the capital-intensive 'catch all' fishing technology.

The trawlers have not only caused considerable damage to the marine ecosystems but have created major threats to the livelihood of the small fishermen. Inspite of the statutory limits of fishing grounds, they always cross over the areas of fishing by small fishermen. . Secondly , in the process if encroachment by the trawlers, the fishing equipment of the small fishermen get damaged.

Promotion of tourism is an economically productive activity. However, this has to be done with extreme care as tourism gives rise to a lot of social issues. The influx of large number of tourists will pressurize the capacity and threshold limit of the existing infrastructure such as drinking water, transportation, solid waste disposal and management, and health care facilities. Marine based tourism, which includes diving, bird watching, sailing, snorkeling, swimming and even exploring affects the ecosystems if over exploited.

Certain crucial factors are normally overlooked in current impact assessment practices of tourism projects. The most important of them is the participation of the local community in the assessment procedures. Normally it so happens that the local residents incur more of the cost and enjoy less of the benefits than the visitors, immigrant workers or commercial intermediaries. The current skill levels and employment patterns of the local residents will have to undergo substantial changes as some of them will become redundant. New skills will have to be inculcated to take advantage of the new avenues of employment that might open up. However, the local residents will have to face competition from the immigrant workers. The experience from around the world shows that along with creation of more employment opportunities, the cost of living in general gets inflated. It is very important the local community is taken into confidence about these impacts (and appropriately prepared to face the impacts) of tourism development, before actually initiating the project.

There is a dichotomy in the nature and extent of stakes of different classes of people who presently utilise marine resources. Firstly, there is a class of people who have high stakes in terms of capital invested in fishing operation - for instance, for the purchase of trawlers and other high technology fishing equipment. They have got very high profit margins but do not exclusively depend on fishing for a livelihood. This is not to gainsay the fact that there is a section among trawler owners who have invested all their resources and are solely dependent on fishing for livelihood. This is not to gainsay the fact that there is a section among trawler owners who have invested all their resources and are solely dependent on fishing for livelihood. They are the increasing number of small fishermen who have formed groups and pooled their resources (often by taking loans) to buy trawlers. They depend exclusively on fishing for a livelihood.

The second class of stakeholders is the traditional and small fishermen. Fishing is the primary source of livelihood for most of them and other sources of supplementary income are negligible. For them, stake in terms of absolute financial capital invested may be less than that of the individual trawler owners (who usually have substantial alternative and supplementary sources of income), but they derive more than 90 per cent of their income from fishing. This comparatively increases the value of their stakes.

Both these classes of stakeholders will strongly resist any initiative to protect the marine environment, if it denies their access to fishing. Hence it is important that marine protection should be carried out selectively considering the livelihood requirements of the people and the maximum sustainable yield (MSY) of fish on the one hand and the economic optimum fishing level in the concerned zone on the other. A note of caution: in cases of free access to fishing and deteriorating fish catches, it is quite possible that the fishermen go in for upgrading their fishing equipment to increase their share of the shrinking catch. This will exceed the MSY and will in turn be harmful to the marine ecosystem.

5.5 CONCLUSION AND RECOMENDATIONS

The foregoing analyses of the context and the livelihood systems of the fishermen community in the study area, along with the identified stress areas and issues, presents some useful insights into the interdependency of the people and the marine ecosystems and the socio-economic and political implications involved in any initiative to protect the marine resources from potential degradation due to human interventions.

A management plan to protect the marine resources should address to the needs of livelihood security of the marine dependent people on the one hand and to the regenerative capacity of the marine ecosystem on the other. This should also redress the existing stresses, resolve the conflicting issues and work towards achieving the goal of sustainable livelihood security with protection of marine ecosystem. In order to achieve this goal, the following action areas have been identified.

- Adoption of appropriate and sustainable fishing practices.
- Stringent enforcement of the law for controlling and regulating fishing:

Marine resources are common properties due to free access. This lead to exploitation and degradation/depletion as each user tries to maximise his/her share. Thus, regulation is required when the equilibrium of utilisation is disturbed. Self regulated common properly management is a rarity and specially so in this case because of lack of visible or enforceable boundaries, due to numerous fishermen, the vastness of the area, and the lack of cohesion among fishermen. Hence government legislation should regulate: (a) the fish catches or access to the sea by seasons and area (considering e.g.,fish breeding); (b) the technology used for fishing; and (c) the number of fishing vessels to be given access to the sea (considering the extractability and regenerative capacity of the fishing zones) by licensing and other appropriate regulatory measures.

The Maharashtra Marine Fishing Regulation Act 981 does address these areas of concern. However, instances prevail, where trawlers transgress the specified limits thereby affecting the catch of the smaller fishing vessels and increasing the rate of extraction. Certain inappropriate ' catch all' and 'sweeping' techniques used by trawlers need to banned. The existing laws need to incorporate the maximum sustainable yield of marine resources and its strict enforcement will ensure sustainable fishing practices which strike a balance between the income generation and regenerative capacity of the marine ecosystem.

- **Detailed research on**

➢ the impact of trawler fishing on the marine ecosystem; and

➢ the maximum sustainable yield of the marine resources: It has been observed that not much detailed study has so far been conducted on the impact of trawler fishing on marine eco-system either in India or elsewhere. However, it is quite evident that the trawler fishing has adverse impacts on the sustainability of marine resources, as over fishing by trawlers exceeds the rates of regeneration. A detailed study in these areas will bring out the maximum sustainable yield (MSY) of fish and the appropriate technology needed.

- **Education programmes on marine ecosystem**

Natural resources form the basic component of any activity. Conflicts arise due to the multiplicity of users and the uses to which these scarce resources can be put to. Natural resource management, then, should bring about economically productive, socially equitable and environmentally sustainable utilisation of these resources. Awareness programmes should promote the need and appropriate practices for the judicious utilisation of natural resources, and marine resources in this context.

- **Awareness among local people**

Submergence of the coastal land due to advancement of the sea is a recent phenomenon which has been observed in the Blue Belt. Over the last four to five years, the sea has been gradually advancing on to the coastal land, endangering the human settlements. Taking protective measures such as construction of barriers on the one hand and rehabilitation of endangered settlements on the other demand immediate attention.

The primary survey reveals low levels of income and fewer supplementary and off-season employment opportunities, especially, for the lower income groups. Declaration of marine protected areas will adversely affect the current income sources for many. At the same time promotion of tourism in the area will open up new employment opportunities, which will require new skills. This changing scenario needs to be addressed to by designing appropriate income generation programmes and by identifying alternative employment avenues. Four areas need to be attended to in this regard. (a) Augmentation of the income levels of the artisanal fishermen whose primary occupation is fishing; (b) generation of supplementary off-season employment; (c) alternative productive employment for the displaced fishermen; and (d) skill development of the local people to take advantage of the new employment opportunities from tourism development.

- **Sanitation facilities**

Presently the coastal areas are used b a large number of people for sanitation purposes. This is an environmentally unhealthy practice and therefore, provision of community toilets on beaches and promotion of private toilets at the household level need to be given high priority. Appropriate technologies and practices for safe disposal of household garbage need to be promoted.

- **Development of fisheries sector support system.**

For enhancement and regularity of incomes in the fisheries sector the necessary support systems need to be developed and made accessible to the fishermen. The areas of improvement are in marketing, storage (deep freezing), transport (refrigerated vans), training (in modern and sustainable methods of fishing), and emergency relief facilities. The availability of basic inputs such as diesel and ice needs to be ensured on a regular basis.

- **Medical facilities**

During the monsoon season, the islands settlements in the study area (e.g., Sindhudurg Fort and the island settlements across Sarjekot) are cut off from the mainland. Arrangements are to be made for the provision of emergency medical facilities in these areas.

- **Ecotourism**

Special purpose tourism is an economically and environmentally rewarding activity. But this should be done with extreme care because controlling the nature of tourism is extremely difficult. Uncontrolled mass tourism will adversely affect the fragile marine ecosystem. The major areas of concern in the normal practice of tourism: (a) social pathologies such as prostitution, child sex abuse; drug abuse etc.; (b) crimes such as land grabbing, forced eviction, harassment of the tourists by the anti-social elements etc.; (c) inadequacy of supporting infrastructural facilities such as sanitation, solid waste disposal and management, medical and health care facilities; emergency relief facilities etc.; (d) changes in the prevailing employment patterns; and (e) changes in the land use and prices of real estates and general inflation. Impact assessment procedures are another area of concern, the impact assessment should take cognizance of the legitimate interest of the stakeholders involved and their early participation in the entire process is called for. All these have to be done in a well-planned way and managed professionally with participation of local community.

CHAPTER VI

CONSERVATION AND MANAGEMENT

OF

ECOLOGICALLY SENSITIVE

COASTAL ECOSYSTEMS

CHAPTER VI
CONSERVATION AND MANAGEMENT OF ECOLOGICALLY SENSITIVE COASTAL ECOSYSTEMS

6.0 INTRODUCTION

Over the past two decades there has been increased competition for, and conflicts over, the use of coastal zone resources. The coastal regions in India are facing serious problems of stress from human pressures and interference similar to those on land. Rapid industrialization, human settlements, man-made engineering works, intense fishing activities in coastal and estuarine areas, dumping of wastes, reclamation of coastal wetlands, deforestation of mangroves and unplanned tourism development are but a few serious threats.

The widely increasing pollution problems, extensive destruction and modification of marine habitats in the name of economic development and the prodigious overexploitation of renewable resources are definite indications of out heading towards a point of no return in many areas of our country, without concern for the future. Rapid mechanization in the exploitation of marine living and non-living resources with increasing industrial involvement has added to the difficulties. Because of the conflict of uses in the coastal zone, coast related island systems and surrounding habitats, many facets of the marine ecosystem and habitats are being increasingly tampered with activities such as commercial fishing, navigation, energy exploitation, national defense, recreation and quarrying for industrial needs.

In the recent years the conservation of marine resources and habitats has assumed great significance in developing countries in the context of the role of conservation in socio-economic development and the recognition of its functional role. The other values attached to this are aesthetic and cultural. The enormous range of marine environmental problems poses a serious challenge which has evoked biocentrism and anthropogenic arguments in favor of biospheres, natural reserves, parks, sanctuaries, core areas and buffer zones, being established to rehabilitate, rejuvenate and retain the ecologically important natural resources.

Shelving the " Silent valley Project" from alteration in natural habitats in Kerala because of the efforts of conservationists, is a standing proof of concern of the Union Government in the preservation of wildlife habitats and the bio-geographic pride of the nation. In this context, establishment of National Marine Parks in India is not only a means of preserving the endangered marine species and some of the critical habitats, but also a flexible device for enabling the use of marine fisheries on a sustainable basis.

The management of the coastal ecosystems and the people living on the coastline has to be regulated in order to conserve the significant biological wealth of the coastal area. The people living on the coastline have traditionally enjoyed unrestricted rights of fishing, collection of species of the marine environment, mining of corals etc. The status and management of the coastline has a strong impact on the quality of the marine environment. Pollution from domestic wastes, sewage, industrial effluents, siltation down the river systems and shifting sands are all very important and have deleterious effects on the marine flora and fauna. In order to mitigate and control unplanned activities on the coastline by the people, Government agencies and private entrepreneurs, a coordinated management system involving all concerned has to be evolved. The People, Government departments, private entrepreneurs and NGO's have to be motivated and made aware of the deleterious effects of their actions and prescription of restrictions for sustainable management of the resources needs to be emphasized.

6.1 Conservation efforts

6.1.1 Mangroves

Mangroves are usually considered as one of the highly productive areas. Apart from their productivity, these areas also generate nutritionally important detritus, which is ultimately transported, distributed and consumed as food by various detritivorous organisms. According to Saenger *et.al* 1983 and FAO Report 1982, there are several direct as well as indirect economic gains of this ecosystem. Both the natural and man-made threats are equally responsible for the destruction of mangrove environment. Increasing population pressure, rapid industrialization as well as rural and urban development has been responsible for the reclamation of roughly 200,000 ha of the total mangrove area along the Indian Coast (Untawale, 1987). Deforestation and overexploitation of mangroves had resulted in the degraded or open marshy land of approximately 100,000 ha. Mangroves along the west coast of India are considered as the highly degraded areas (Blasco, 1975; Blasco, 1977). Although mangrove forest have been used, however, conservation of mangrove forests and its environment has not received much attention till recently. *Crocodylus porosus*, the estuarine crocodile which in reported in the mangrove area of Goa (Jagtap, 1985) has been protected in India by the Wildlife Protection Act. Along the central west coast of India, some of the areas, people are aware if the importance of the mangrove and they are taking initiative for the protection of mangroves. At Achra (Maharashtra) mangrove area is under the control of temple authorities. In areas at Karnataka also plantation of mangroves along the bunds is been carried out by the local people. In Goa, afforestation has been attempted in collaboration with Forest Dept and National Institute of Oceanography.

The mangroves of Karnataka are feared to have decreased considerably mainly due to expansion of cultivation, deforestation and encroachment activities in the mangrove niche. Artificial regeneration of mangroves have been carried out in these areas. Along the Karnataka coast the Chakra-Haladi-Kollur estuarine complex of Coondapur have beentaken up for afforestaion (Anand Rao and Suresh, 2000).

6.1.2 Corals

Coral reefs, among the most productive areas in the marine ecosystems, are deteriorating all over the world due to human interference, particularly, elicit removal of corals. Destructive fishing practices have been responsible for the destruction of coral reefs throughout the world. These activities have been brought down by the Forest Department after taking over these areas. Legal measures should also be taken to prevent further loss of live corals. Malvan along the Mahrashtra coast though does not have good growth of corals, whatever is present should be preserved. Along the Colaba coast, Mumbai, though in the polluted area, long polyps of corals were seen which are to be monitored regularly.

6.1.3 Sand Dune vegetation

Sand dune vegetation is vital to its stability. The vegetation anchors sand in the dune and traps sand blown from the beach aiding dune build up. Damage or destruction of dune vegetation results in wind erosion and lowering the dune. When this happens the dune is less effective barrier against wave attack. Damage to the dune vegetation is due to various factors. To prevent damage to dune vegetation and to give the damaged dune areas a chance to recover it is often necessary to follow some conservation measures and to undergo some management plans.

6.1.4 Marine Algae

Marine algae are important ecologically as well as economically. Increasing demand of marine algae as raw material for phycocolloid industries, food, feed, etc, has created the necessity to start large scale cultivation programme in order to augment the natural resources and produce the required quantity of desired quality. Some of the marine algal species are on the verge of extinction due to over-exploitation and other kinds of human interferences. Conservation and management is an important step to have a continuous uninterrupted flow of raw material to the industry. It also ensures minimum ecological impact.

6.1.5 Sea grass

The sea grass beds provide a habitat for many different organisms such as worms, crustaceans, mollusks, fishes and mammals. Sea grass have an extensive root system that reaches up to 1.5m deep and their ability to spread laterally helps them to dominate eventually the area where they grow. The primary aim of conserving sea grasses is to conserve the natural habitat of endangered aquatic mammal, protected under the Indian Wildlife Protection Act (1972).

6.2 Conservation efforts organized with legal protection

6.2.1 Biosphere Reserve

UNESCO launched the concept of Biosphere Reserve in 1975 as a part of Man and Biosphere Project and over the years it has attained greater recognition world wide. It is in this context that the Man and Biosphere Programme (MAB) Committee in India started functioning under the direct patronage of the Government of India and as much as 13 important areas have been brought under the category of biosphere reserves so far. The approach is based on synergestic linkages between biodiversity conservation and sustainable development and it gives weightage to social linkages. Biosphere reserve will have following salient features:

- They serve three functions namely conservation, logistics (including research, monitoring of environmental parameters, training and environmental education) and the development of regions immediately adjacent to the reserve. They are designed to be sites where a well informed management elaborates the logistic function in order to demonstrate the links between conservation of Biological diversity and the sustainable socio-economic development of surrounding regions.
- Each Biosphere reserve consists of core, buffer and transition zones. The core comprises an example of a minimally disturbed ecosystem which is legally protected. A clearly delineated buffer zone surrounding the core also has legal protection but is managed to accommodate a greater

variety of resource use strategies than is permitted within the core. Management strategies for the buffer zone are designed with the long term goal of minimizing the resource dependency of local people on the core zone. The transition zone which is the outer most part of the biosphere reserve, is an area of active co-operation between reserve management and the local people for promoting sustainable socio-economic development. Thus the biosphere reserve approach attempts to mesh biodiversity conservation with the people's aspirations for sustainable socio-economic development.

- Further the biosphere reserve need not necessarily be a single large unit but could be a conglomerate or cluster of many small units geographically separated from each other. The Maharashtra Government has notified in the gazette its intention to develop a marine wild life sanctuary at Malvan and also indicated its boundary. The presence of corals and other marine biodiversity in the areas as well as the presence of the historical Sindhudurg fort give added significance to the area. In addition to above Achra estuary from its mouth upto its head i.e. origins should also form part of the Malvan Marine Wild Life Sanctuary. So also the Kundalika estuary should also be a part of the proposed Malvan Marine Sanctuary. On the estuarine banks the sanctuary boundary limits should be presently coterminous with outer boundary of coastal regulation zone 3, as defined in the environment protection act 1986.

- Since the wild life sanctuaries (marine, coastal and well as estuarine), as well as the areas covered and managed under the coastal biosphere reserve are basically conservation measures, wherever the environment protection act clearance to carry out such activities on the coast would need to be obtained from the Government of India, Ministry of Environment and Forests.
- Additionally the State Government could also make rules under the wild life protection act for better functioning of the coastal biosphere reserve, which give them legal standing and protection.
- It is suggested that a special working group be set up for this purpose with the object of coming up with a set of regulations for operational management of coastal biosphere reserve as well as closed areas designated under the wild life act.

6.2.2 Marine National Park

The IUCN Commission on National Parks and Protected Areas (CNPPA) compiles the United Nations list of Protected Areas, with the assistance of UNEP, UNESCO and WWF. The ten categories for conservation management identified in 1982, are divided into three groups as follows:

- Group A- Areas of particular interest to CNPPA: For these categories the CNPPA has taken responsibility to monitor the status and provide technical advice. They are (a) Scientific Reserves/ Strict Nature Reserves, (b) National

Parks/ Provincial Parks, (c) National Monuments/ Natural Landmarks, (d) Nature Conservation Reserves/Managed Nature Reserves/ Wildlife Sanctuaries and (e) Protected landscapes.

- Group B- Areas of interest to IUCN in general: These are of particular importance to IUCN as a whole and generally found in most nations, but would not be considered exclusively within the scope of CNPPA. However, CNPPA may wish to monitor and provide expertise on those areas, which are of particular importance to nature conservation. These include: (a) Resources Reserves, (b) Anthropological Reserves and (c) Multiple Use Management Areas/ Managed Resources Areas.
- Group C – Internationally recognized/ affiliated designations: These categories form part of international programmes and have specific relevance to nature conservation. Many areas in such cases have received protection under the previous category. CNPPA may be called upon to monitor these categories and to provide special attention in co-operation with other institutions with which IUCN has consultative status. These include (a) biosphere reserves and (b) world heritage sites.

6.3 MANAGEMENT

Coasts were perhaps the earliest habitats for the primitive man (Ranwell, 1972). Management holds a promising success, since it balances the need for total preservation and the benefits of economic uses of coastal ecosystems.

Management processes identify and analyze management issues and develop the necessary policy and management options. It consists of integrated planning, implementation, monitoring and evaluation. The management issues embrace the conflicts resulting from resource exploitation (e.g. over-fishing, tourism potential, destruction of habitats coral mining) and use (habitat loss, pollution, coastal erosion). Management actions constitute the most important dimension of coastal management programme and include direct public investment (e.g. restocking, fisheries enhancement, education and public awareness): incentives and regulation, which might change behavior (e.g. permits, quotas, legislations, taxes) and institutional and organizational arrangements (e.g. clarification of legal rights, monitoring and enforcement). There are different management plans for different ecosystems. Jagtap (1985) has dealt with detail of the various management options and their applicability to Goan mangroves. Only with the co-operation of the local inhabitants management policy will be successful.

The essential elements of coastal management are integration and co-ordination. Any policy and management action which has been designed to address coastal development conflicts must be founded on a sound understanding of natural processes and ways in which these may be disturbed, on political socio-cultural and economic conditions; on present and future demands, as well as social costs involved. The management of coastal resource system consists of three dimensions such processes, issues and actions.

6.3.1 Management strategy and approach

The objectives of management of the sensitive coastal ecosystems could be as follows:

- To accord complete protection to the breeding and feeding grounds of the endangered and vulnerable fauna and flora and to eliminate gradually the disruptive and destructive factors, affecting the system.
- To develop the protected coastal habitat as gene pool reserve for marine aquatic species.
- To restore and protect natural vegetation and to stabilize the areas by promoting natural regeneration and by restoring to artificial regeneration.
- To create awareness on the need for conservation and management of the marine ecosystem on scientific lines for proper socio-economic development of the region.
- To promote a judicious and optimal utilization of the landscape in the coastal areas and the sea waters within the Protected Zone, for research, educational and recreation purposes, consistent with the ecological principles of habitat management.

6.3.2 Steps to be taken for management

The transport of pollutants would have an adverse impact on the survival of the existing flora and fauna along the Central West Coast Of India. It is therefore proposed to develop a continuous monitoring plan for the selected sites along the central west coast of India

- The factors causing irreparable damage to a variety of habitats such as coral reefs, seagrass beds, mangroves, marine algae, sand dune vegetation should be found out. It is important to plan strategies for restoring these habitats.
- Special attention is needed for the management of the species, especially the endangered and vulnerable once.
- Proper control of the surrounding areas is absolutely essential to avoid conflicts in utilization of resource open entry systems, escalation of unauthorized activities and creation of ecological imbalances which may result in siltation, pollution and other man-made changes. There should be a close monitoring of the activities of the surrounding areas to advise on developments, which may impair conditions in the coastal areas where legislative action should be taken.
- Socio-economic problems are the major problem which has to be solved before taking any steps. It is necessary to identify alternative avocations or the enhancement of similar activities in the surrounding areas.
- A Functional Geographical Information System if developed would help in better understanding of the dynamics of the ecosystem.
- Special emphasis should be given to activities relating to social welfare of the local people. Socio-economic survey at regular intervals to monitor the effects of various activities should be taken up. Involving people in income-

generating activities should be ensured. Providing certain community services such as recreation centers, community halls, health care and educative centers. Drinking water supply and other welfare measures should be undertaken. All these will have to be done after ascertaining the views and needs oft the local people and this will be an activity, which will earn the goodwill and voluntary co-operation of the local community, in the protection of the ecosystem.

- Soil and water conservation work, coupled with planting activities in the coastal zone, help to minimize the deleterious effects on the ecosystem should be taken up.
- Activities emphasizing ecologically appropriate and compatible technologies should be supported such as integrated aquaculture, aquaculture of marine ornamental fishes, demonstration for developing valued-added products.
- Adequate training should be given to the personal involved in the management and the development of the coastal areas. They should acquire scientific knowledge about the flora and fauna.
- Creating awareness would encourage participation of the people in the management programmes.
- Interpretation centers should be set up.
- Tourism and recreational activities have to be identified, planned and regulated without creating harm to the natural ecosystem.
- Local co-ordination committees should be formed with local field staff, members of NGO's and the locally influential persons to have dialogue with

he fishermen and enforce control in the exploitation of the resources and help in conservation of the ecosystem.

6.4 Recommendations for different ecosystems along the Central West Coast of India

6.4.1 Mangroves

- Control shrimp ponds, timber use etc. by regulation and law (which is under practice).
- Maintain the topography and character of the forest substrate and water channels.
- Maintain the natural, temporal and spatial patterns of surface and groundwater salinity.
- Perpetuate the natural pattern and cycles of tidal activity and freshwater runoff.
- Maintain the natural equilibrium between accretion, erosion, and sedimentation.
- Involvement of local people.

6.4.2 Coral Reef

- Seek alternative sources of construction aggregate and calcium carbonate (for ,lime and cement) to relieve pressures on coral reef.
- Do not undertake dredging or other activities that disturb the sediments and create silty water near or upstream from coral reefs. If possible, sediment containment (pipes, settling ponds, curtains) should be applied to take sediment away from reef.
- Initiate monitoring program to regulate mining activities to acceptable water-quality standards.
- Avoid introduction of pollutants and excessive nutrients into the reef environment. Proper setting of industries including sewage outfalls, storm outfalls, storm water drain away from influence of coral reef areas. Possible mitigation measures include treatment settling and cooling ponds, and disposal in areas around seaward of the reef.
- Stop the use of explosives and poisons to harvest reef fish.
- Set maximum limits on the annual harvesting of reef materials and associated fish and shellfish species to maximum sustainable yield.
- Promote and control tourism on the basis that coral reefs are valuable national assets. Control anchoring places and collection of souvenirs.
- Avoid alteration of the natural salinity. Control disposal or brine waste and drainage of salt pond/excess fresh water discharge.

- Avoid alteration of water temperatures such as by heated discharge water from industrial plants. Use cooling ponds.
- The badly damaged or dead reefs areas can be used for coral mining by small scale operators.
- Enforcement by means if strict laws and regulation.
- Proclaim any significant coral reef area to be a marine national park.

6.4.3 Sand dunes

- Site specific studies may be required at many locations to assure wise planning decisions
- Develop a setback line before construction begins. Restrict construction to areas behind the dune line.
- Provide technical assistance and a convenient source of beach grass plantings to property owners.
- Where a major obstruction to long-shore sand transport is built, allow for an adequate sand- bypassing system.
- Use soft solution rather than hard solution to solve beach erosion problems i.e. nature-synchronous techniques.
- Maintain a prominent fore dune ridge.
- If storm alters the beach, let the normal beach cycle return the sand.
- Strict enforcement of legal provisions of the notification through proper publicity and due punishment if the rules are not rightly followed.

- Afforestation of species such as *Ipomoea* and *Spinifex* on area between 200 and 500 metres (CRZ) to be undertaken..
- Government agencies to be involved in plantation programme.
- Development of nurseries.

6.4.4 Marine algae

- Areas with natural luxuriant growth, both qualitatively and quantitatively should be declared as Marine Protected Area (MPA) and Marine Parks such as the ones given in Table 3.6.
- Economically important and endangered marine algal species should be maintained in a culture condition to provide the seeds or germplasm for large scale cultivation and reforestation of areas where seaweeds are over-exploited.
- Facility to preserve the marine algal biodiversity in the form of gene bank should be maintained.
- Commercial harvesting techniques that have low level of ecological impact.
- Adequate facilities for harvest processing.
- Establishment of government organization to monitor the seaweed harvest and tò obtain agreeable harvesting, buying and processing units that comprehenses resource management.

6.4.5 Seagrass

- Dredging should be away from seagrass bed to ensure that siltation does not spoil the area, silt barrier and circulation of tidal currents should be emphasized and studied.
- Engineering works should be designed to minimize either erosion or deposition on nearby seagrass beds.
- Prevent the wastes from industrial effluents, high-temperature, water discharge etc.
- Dumping of dredge spoil on tidal flats should be prohibited.
- Bottom trawling should be prohibited along Malvan and Vijaydurg, Maharashtra.
- Shipping routes should be located away from seagrass beds.
- Diversion of upstream water inland should ensure that the amount of flushing water is sufficient to sustain the coastal, salinity regime.
- Creating awareness about the importance of seagrasses to the locals.
- Regulation on coastal aquaculture.
- Regulation of human settlement on the coast.
- Transplantation of seagrasses.
- Legislation/regulation and sustainable resource use.

6.5 Law and regulation for management of ecologically sensitive coastal ecosystems along the Central West Coast of India.

In order to protect the Coastal Zone the Central Government of India brought out a Notification in 1991 " The Coastal Regulation Zone Notification", by which the Coastal Zone is divided into CRZ I, II, III and IV. These zones have to be protected according tot he specific regulations. There are many laws and regulations related to coastal resources and their development. They are as follows:

6.5.1 Nature Conservation Acts

This group of Acts consists of the Wild Animals Reservation and Protection Act of 1960, the National Park Act of 1961 and the National Forest Reserves Act of 1964.

6.5.2 Natural Resources Exploitation Acts

This group of Acts consists of the Forest Act of 1941, the Fisheries Act of 1947, the Minerals Act of 1967, the Petroleum Act of 1971 and the Tourism Act of 1979.

6.5.3 Environmental Protection Act

This is the Enhancement and Conservation of National Environmental Quality Act of 1975, which covers the control of quality and standards for the environment.

6.6 National policies and programmes

Forest legislation in India dates back to 1865, when the Indian Forest Act was enacted for the first time. In 1927, a more comprehensive Indian Forest Act was adopted, which continues to date. The National Forest Policy was announced in 1952 following Independence.

Considering the importance of mangroves, sea grasses and coral reefs, marine algae and sand dunes which together form an integral part of the coastal ecosystems, the Department of Environment, Government of India, in 1979, constituted the National Mangrove Committee which defined the flowing objectives for research, development and management of the coastal environment.

- Nation-wide mapping of the coastal areas, preferably by remote sensing techniques coupled with land surveys, to make an assessment of the rate of degradation of the ecosystem.

- Quantitative assessment of mangrove forests for area, climatic regime, rate of growth of forest trees and seasonal variations of environmental parameters.
- Research and development activities such as ecology, resources inventory, associated flora and fauna, hydrology, energy flow, qualitative and quantitative studies for organic production, biochemistry of organic matter and sediments, afforestation of degraded mangrove areas and management of mangrove forests.
- Assessment of suitable sites for declaration as " Reserve Forests" to take up intensive conservation programmes.
- To develop plan to manage key species of economic and ecological importance for sustainable utilization.
- Exploitation of the resources from the sensitive sites to be regulated or stopped depending on the level of genetic diversity of the site.
- It would be important to monitor the environment on regular basis.
- Advisory committee representing various Stat Govt. Department, NGO's, Scientific Institutes, local stackholders may be constituted for effective policy decisions.
- Linkages with research and educational Institutions should be maintained (Table 6.1)

The committee was also entrusted with responsibilities such as (a) advising the Government in appropriate policies for conservation of mangroves had related

Table 6.1 Linkages of Socio-economic aspects and conservation plan with the Institutes/Organisations/Govt. Departments

Sr.No	Socio-economic aspects	Conservation and Management	Linkage Inst./Govt Dept/NGO's	Measures to be taken
1	Fisheries ♦ Capture ♦ Culture	Identification of fishing ports and infrastructural facilities	♦ Fisheries Dept. ♦ Educational Inst. ♦ Fishery Co-operatives ♦ Fishery Societies	♦ No restriction on small scale traditional fishery ♦ Encourage traditional fish farm without disturbing the coastal ecosystems
2	Fuel and firewood	Afforestaion of high density energy plantation	♦ Forest Dept. ♦ NGO's ♦ Local communities ♦ Research laboratories	♦ Large scale afforestation programme ♦ Joint forestry management pratices
3	Khar land development	Transfer the sites by bunding the sluice gate to upper limit of estuary	♦ Kharland development ♦ Forest Dept. ♦ Revenue Dept. ♦ Agriculture Dept. ♦ River Navigation Dept.	♦ To assess the damage incurred earlier and prepare eco-friendly plans
4	Ecotourism	Preparation of management plan for Eco and Adventure tourism in sensitive sites	♦ Tourism Dept. ♦ Forest Dept. ♦ Fisheries Dept. ♦ Captain of Ports ♦ Coast Guards ♦ Revenue Dept. ♦ Custom Dept. ♦ NGO's	♦ To prepare detailed maps of each sites amd to prepare affective managemetnplan for tourism without disturbing the environment. ♦ Development should be withing CRZ regulations.
5	Biodiversity of the sensitive sites	Monitoring of the health of sensitive sites Evaluation of living resources Periodic biodiversity assessment Establish biodiversity information network for local and national assessment	♦ National laboratories ♦ Coastal Universities ♦ Forest Dept. ♦ Other Academic Institutions	♦ Strict implementation of conservation policies ♦ For protection of germ plasm ♦ Sustainable utilization of living resources ♦ Awareness about IPR (Intellactual Property Rights ♦ Increase awareness and values of biodiversity in locals

ecosystems in the coastal areas. (b) Advising in research and training on mangrove and related ecosystems, (c) suggesting selective mangrove areas for conservation, (d) helping the Government of India in the development of collaborative projects with UNDP/UNESCO and other inter-governmental bodies in the field of coastal ecosystems and (e) suggesting suitable action programme for conservation of mangroves and coral reefs.

6.7 CONCLUSION

The coastal vegetation like mangroves, seagrasses, corals, sand dune and seaweeds form a very important ecological complex in the littoral region. If these systems are managed properly, they can be of great economic and ecological value. The use of these resources for various programmes like tourism, education, research, recreation and also conservation should be planned in a proper way so that there is no harm caused to them.

The coastal area along the central west of India especially the sensitive ecosystems that are getting degraded due to various reasons need to be conserved and protected due to its ecological significance by also for its economical importance. The economic values of the coastal habitats is not taken into account that provides direct and indirect benefits to mankind. There are many important ecological benefits that are provided by coastal habitats. This require critical economic appraisal. Diversity of the deep-sea benthic communities and fishes in the water column is largely unknown and these communities offer rich sources of genetic diversity.

It is necessary to maintain population of various communities at optimal level for genetic exchange and that the varieties of breeding populations are maintained to sustain natural genetic diversity. Participation of the local people in the biodiversity conservation is very important. It is important to create awareness amongst the coastal inhabitants about the sustainable biodiversity in day-to-day life.

Based on the studies carried out the following sites are recommended for conservation and management along the central west coast of India

- **Maharashtra Coast**

  Malvan
  Ratnagiri
  Achra
  Colaba
  Mumbra-Diva

- **Goa Coast**

  Chorao
  Terekhol
  Cabo De Rama

- **Karnataka Coast**

  Kalinadi estuarine complex
  Chakra-Haladi-Kollur estuarine complex

CHAPTER VII

SUMMARY

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SUMMARY

Coastal ecosystems such as mangroves, seaweeds, seagrasses, sanddunes, coral reefs etc are critically important because of their uniqueness, rich biodiversity, productivity and ecological as well as economic importance. In the International arena" Critical Habitat" is a term used in the Endangered species Act referring to the specific areas that contain physical or biological features essential to the conservation of a threatened or endangered species. However, these ecosystems are complex, ecologically sensitive and exceedingly valuable areas that are under enormous threats.

Marine critical habitats, which include both non-living and living components, is a fragile balanced pattern easily affected by its neighbouring watershed landward and open or high sea, seaward. The coastal marine ecosystems are disturbed and threatened encountering several problems like pollution, erosion, storm surges, siltation and anthropogenic pressures.

There are constantly increasing human pressure of various kinds to exploit these critical habitats/ ecologically sensitive ecosystems and their resources for multiple economic activities. Critical habitats which have been found to be essential for the conservation of the biota and which may require special management consideration or protection. Even though some of the areas are undisturbed, hence there is urgent need to protect, conserve and manage both the disturbed and undisturbed areas for their sustainable uses. A number of coastal areas along the central west coast of India are rich in biodiversity and have uniqueness with regards to the flora and fauna that needs to be preserved as live natural heritage. These sites can serve as centers for education and research, recreation, eco-tourism etc. The economically important flora and fauna can be maintained as " germplasm" for conservation purpose. The sensitive ecosystems were classified in the present study based on the following criteria:

- Naturalness
- Biological importance
- Ecological importance
- Socio-Economic importance

Altogehter 37 stations were surveyed along the Maharashtra coast, 26 along the Goa coast and 21 along the Karnataka coast for the presence of absence of coastal ecosystems.

The results obtained and inferences drawn on the study carried out forms the major theme of this thesis and are addressed in different chapters as follows.

The **Chapter I** of the thesis is introductory in nature. It describes the ecosystems such as mangroves, corals, sanddunes, marine algae, seagrasses etc and their interaction It further gives the description on biodiversity, socio-economic studies, Conservation and management. The scientific rationale and the major objective behind the study are highlighted at the end of the chapter.

Due to various ecological and economic pressures on the coastal resources some of the disturbed as well as undisturbed areas have become ecologically sensitive. Hence there is urgent need for protecting and conserving these sensitive ecosystems through proper management.

The **Chapter II** of the thesis discusses the review of literature for the present study. It gives the account of physico-chemical parameters such as pH, water temperature, salinity, dissolved oxygen, Nutrients (nitrate, nitrite, phosphate, silicate), biological parameters such as phytoplankton, zooplanktons, benthic fauna etc, grain size. Further it gives the review on Biodiversity and different coastal ecosystems such as mangroves, corals, marine algae, sand dune and seagrass.

The **Chapter III** of the thesis deals with the general description, methodology and the results of the surveyed areas along the Maharashtra, Goa and Karnataka coast. In order to achieve the objectives, a total of 37 sites were surveyed along Maharashtra coast, 26 sites along Goa coast and 21 sites along the Karnataka coast. Out of these sites 7 sites were selected from Maharashtra coast, 6 sites along the Goa coast and 4 sites along the Karnataka coast were further studied for their ecological sensitivity.

The mangrove forests of Maharashtra coast comprises of 17 species along with some associated land plant species. Good patches of mangroves were observed along Achra, Deogadh, Vijaydurg, Ratnagiri, Kundalika, Vikroli and Mumbra-Diva. *Avicennia marina* was most common species. The mangrove forest is also known to be a sanctuary for various local or migratory birds. Vikroli is mentioned, as a well-preserved mangrove forest managed by private management should be encouraged. Ecological status of different important sites along the Maharashtra, Goa and Karnataka coast are given in the form of tables. Different selected sites are described here along these three coasts for the flora and fauna. Along the Goa coast 16 mangrove species were reported. The dominant species recorded were *Rhizophora mucronata, Sonneratia alba* and *Avicennia officinalis.*The mangrove vegetation along the estuaries of Goa coast like Terekhol, Chapora were very poor. Chorao Island along the Mandovi estuary is one of the important areas for mangrove flora and fauna. Coondapur mangrove areas along the Karnataka coast have good assemblage of mangrove despite heavy anthropogenic pressure. Mangroves were dominated along the Maharashtra cost as compared to the Goa and Karnataka coast.

It further discusses the algal distribution along the above three coasts. Altogether 91 species were recorded from Maharashtra coast, 61 along Goa coast and 63 along Karnataka coast. The changes that took place in species composition of marine algae along some sites from 1935-1998 are recorded. Along all the three coasts Rhodophyta members were dominating. Due to various pressures like pollution from various sources, human disturbances etc the algal growth is reducing. Hence it is advisable to carry out cultivation of marine algae. Along the sites studied along the central west cost of India corals were found in Malvan, Vengurla and Colaba. The list of corals reported from Malvan is given in Chapter IV. Sand dune vegetation reported along the study area is discussed further followed by the seagrass vegetation. There was no report of seagrass species during the present study. It further highlights the distribution of other fauna present.

In general Mumbra and Diva along Maharashtra coast can go preservation aspects as it is monospecific. Malvan displayed a maximum number of species. Benthic fauna was dominated by polychaeta. Corals were recorded at few stations only.

The **Chapter IV** of the thesis presents the case study at Malvan. In general it described the area, its location, brief history, physical features, topography. It further described the materials and methods used for the analysis in this chapter. Results include data for physical-chemical and biological parameters. Statistical analysis such as ANOVA (Two way) and correlation coefficient was carried out. The data is presented in the form of figures and tables in the thesis.

Among the hydrological parameters, salinity was found to fluctuate widely showing its maximum during summer and minimum during monsoon.

Significant correlation observed between dissolved oxygen and salinity. No significant fluctuation in pH could be observed. During monsoon, nutrients, organic carbon showed maximum variation. Subsequently during post-monsoon, phytoplankton and zooplankton population was high. Benthic macrofauna was found to be more in summer and less during monsoon.

In **Chapter V** of the thesis describes the socio-economic and sustainable utilization of the resources. It gives a general introduction followed by methodology used. The analysis of the context and the livelihood systems of the fishermen community in the study area present some useful insights into the interdependency of the people on the marine ecosystems. A management plan to protect the marine resources should address to the needs of livelihood security of the marine dependent people on the one hand and to the regenerative capacity of the marine ecosystems on the other.

An understanding of the relationship between livelihood and biodiversity is essential in planning conservation strategies, which are socially and ecologically sustainable. The socio-economic study will entail assessment of the extent and nature of dependency of various classes of people on diverse marine resources and will help to assess carrying capacity of the study area.

Chapter V is on the preservation, conservation and management aspects of the ecologically sensitive coastal ecosystems which is of worldwide concern. Good resource planning decisions often require present status information at all levels. In any situation a wide range of environmental, social and economic factors, conditions the appropriate management response. Need for conservation and management is strongly felt primarily due to increasing human population. Conservation of sensitive ecosystems is needed for maintaining healthy environment. This chapter deals with the conservation efforts for different ecosystems, discussion on biosphere reserve and Marine National Park. It further deals with the management aspects such as management strategy and approach, steps to be taken for management, recommendations for management of different ecosystems along Central west coast of India, law and regulations for management of coastal ecosystems.

In preservation, absolute protection is provided to the area and do not interfere at all with the natural problems. Conservation ensures maintenance, restoration, development and sustainable utilization of the identified sensitive ecosystems.

The coastal ecosystem if managed properly, they can be of great economic and ecological values. It is necessary to maintain population of various communities at optimal level for genetic exchange and that the varieties of breeding populations are maintained to sustain the genetic diversity. Participation of the local people in the biodiversity conservation is very important. It is important to create awareness amongst the coastal inhabitants about the sustainable biodiversity in day-to-day life.

APPENDIX I

APPENDIX 1
QUESTIONAIRE FOR SOCIO-ECONOMIC STUDY

VILLAGE LEVEL SCHEDULE

Taluka	District	VN	PN	NW	WD	Population							FBPL
						NH	TP	M	F	R	C	D	

NH: No of households, TP: Total population, M: Male, F: Female, C: Childrens, D: Density/sq.km, FBPL: Families below poverty line, WD: Wadies name, NW: No. of wards

Details of Nearby Villages/Towns/Cities

Sr.No	Name	Distance (Km)	Mode of Transport	Fare

Cropping pattern and Production

Name of crops	Yield per crop	Period		Total area per crop
		From	To	

Livestocks details

Livestocks	No.	Quantum of dairy production
Buffaloes		
Cows		
Goats:		
Poultry birds		

Land Information

VC	AUF	EA	MA	AUC	IR	UIR	CW	ANC	FLA	PLA	G

VC: Village coastline (km), AUF: Area under forest, EA: Estuarine Area, MA: Mangrove Area, AUC: Area under cultivation, IR: Irrigated, UIR: Un-irrigated, CW: Cultivable waste, ANC: Area not under cultivation, FLA: Fallow land area, PLA: Pasture land area, G: Gaothan.

Forest information

Total forest area	Government	Private	Plantation (Type)	Communidad

- Mangrove Forest Area
- Type of medicinal plants and Herbs
- Flora and fauna of the forest
- Annual income of the Panchayat from the forest
- Mangrove
- Others
- No. of training held to create awareness about mangrove forest
- No. of firewood depot
- No. of Solar cookers used
- Solar energy
- LPG gas centres

Information about Wildlife

- Whether people go for hunting
- No. of people having license

Economic activities

Occupation	**Primary**	**Secondary**
Fishing		
Dry Fishing		
Agriculture		
Handicraft/Cottage industries		
Manufacturing, processing		
Household activities		
Trade and Commerce		
Construction		
Transport		
Storage(marine Products)		
Tourism		
Mining and Quarrying		
Marginal workers		
Non workers		
Labour		
Other services		
Boat Building		
Boat Repair		

Basic services and facilities

Sources of water			Number	Ownership	Scarcity	Availability
DP	CN	AP				

DP: Drinking purpose, CN: Cattle needs, AP: Agriculture purpose

Village sanitation		Type of drainage		
Public toilets	Private toilets	Open gutter	Closed gutter	Kitchen garden

Electricity

Year	No. of wadies electrified	No. of households electrified	Street light

Transport and Communication

Type	Kacha road	Tar/Pacca road	Footpath
Length in Km			
From			
To			

Modes of Transport

Public	Private

Postal Services

Post and telegraph offices	No. of telephones

Financial institutions

Private money lenders	Nationalised banks	Co-operative banks

Health services

Nearest PHC	Nearest private doctor	Nearest private hospital	No. of maternity homes	Nearest medical store	Veterinary services	Common diseases

Educational Services

	Total	Total Strength		Dropout rates	Teachers	Distance
		Male	Female			
Primary Schools						
Secondary schools						
Colleges						
Vocational training Institutes						
Balwadis						

Ownership of land adjoining the sea shore

Private	Gram-Panchayat	Government

Industries and effects of industrialisation

No. of industries	Type of industries	Solid waste	Garbage disposal	Effluent discharge

- What are the associated problems with the coast/sea?
- Does anyone use explosives for fishing? If yes , how many
- Do you collect any seaweeds, medicinal herbs, mangroves, other items from the bed of the sea? If yes, details:
- For the fishing activities which benefits are avaliable __________
- Has there been any change in the fishing or marine activities over a period of time? (fish catch, quality, quantity).
- Do you use fish or other sea products as fertilizers for trees or in the garden? Details
- No. of hath Bhattis in the village?

Credit facilities

Insurance	Fisheries department	Loans

Marketing facilities

Fisheries detail

Type of fish	Season	Quantity per catch	Rate per Kg.	Distance of availability

- List of fishes available in the area.
- On an average how much fishing is carried out in the area?
- Per month Annual
- Are there any trawlers fishing in this area? If yes…….
- How many?
- Owned by?
- Number of fishing boats in the village?
- Traditional-----------------------(total)
- Mechanised ------------------(total)
- No. of Dams, barrages across the river:
- Seasonal Distribution of fishing activity
- Is there any protected area
- Any marine aquarium

➢ **Tourist activities carried out in the area**
No. of tourist per year
Peak Season
Facilities for tourists in the village
Scuba diving availability

➢ **Fishing co-operatives in the village**
Number
Year of establishment
Name of the Society
No. of members
Activities

➢ **List of equipment used for fishing**

Type of fish	**Season**	**Quantity**		**Rate**
		Market	**Individual**	

➢ **Comment on the other information**

HOUSEHOLD LEVEL SCHEDULE

Sr.No	Date	Name of the village	Wadi	Name of the respondent	Religion	Caste

Family details

Sr.No	Name of the Family Member	Age	Sex	Education	Occupation		Annual income in Rs.	
					Primary	Secondary	Primary	Secondary

Migration

Name or Number	From	To	Place	Remittances

Household structure

Type		No. of rooms	Cattle shed	
Kaccha	Pacca		Yes	No

Health

Facility	Purpose	Reason
Home remedies		
Superstitious		
Pvt. Doctors		
PHSC		
PHC		

Common diseases and problems among the children and adults

Name of Disease		Frequency		Reason/Cause/Source	
Childrens	adults	Childrens	adults	Childrens	adults

Maternity cases

Home	Local Dai	Hospital	Nurse/Midwives	Others

OCCUPATIONAL INFORMATION

- Is fishing your primary/secondary activity?
- What is the net income from fishing or marine related activites?
- Where do you go for fishing? Sea/Creek/River/Pond
- How far do you go into the sea?
- How many times you go for fishing in a day?

Frequency per day	Season	Catch

- How many months you go for fishing in a year?
- Which are they?
- What are the activities carried out when there is no fishing activity?
- What are the equipment you use for fishing?

Type (local name)	Season	Quantity		Rate

- How many members from the family are into fishing activity?
- Do you collect anything else from the sea/coast/ If yes, specify
- What are the other activities carried out on coast/sea?
- What do you do when there is excess/surplus of fish catch?
- Marine algal use
  Species
  Quality & Quantity

Type of fish	Season	Quantity	What is done

- Where do you sell the fish /other products from marine ecosystem?
- Is anyone from the family a part of the co-operative fishing group? If, yes
  details
- Do you go for combined/group fishing? If yes
  details
- Do you practise fish processing or dry fishing? If,yes
  details
- Do you /your family members use the coast/sea for
- Sanitation If yes
  details
- Garbage disposal If yes
  details
- Fish disposal (excess) If yes
  details
- Dumping any other unwanted waste, If yes
  details

- Do you collect sea shells? If yes details
- Do you own any of the land on the beach front? If yes details
- Do you collect firewood from the mangrove forest? If yes details
- What are the other sources of income?
- Do you kill Dolphin or turtles and sell the meat or eggs

Occupation

Type of occupation	Place	Income	Duration
Agriculture			
Labour			
Service			
Assistance in Fishing			
Trade and Commerce			
Net Weaving			
Boat Repair/ Maintenance			
Boat Building			
Tourism activity			
Transport (Road/Boat)			
Handicraft			
Construction			
Any other			

Livestock

Livestock	No.	Yield		Income	No. of members involved
		Home	Market		
Cows					
Buffalo					
Sheep					
Goats					
Bullocks					
Hens					

Family Belongings

Item	Number	Type	Value in Rs.
Land			
Fishing boat/Boat			
Fishing nets			
Other equipments			
Trees			
Radio			
Bicycle			
Two wheeler			
Cassette player			
Chulla			
Stove			
Gober gas			
Wall clock			
Wrist watches			
Fans			
Utensils(All types)			
Table			
Chair			
Cots			
Bedding/Mattresses			
Cupboards			
Grain storage(Kangi)			
T.V.			
Sewing machine			
Bulbs			
Electric tubes			

Consumption and expenditure pattern

Item/Material	For in-house only	Quantity in Gms./Kg's			Yearly
		Daily	Weekly	Monthly	
Rice					
Wheat					
Nachani					
Kulit					
Oil/Ghee					
Fruits					
Sugar					
Jaggary (Gud)					
Eggs					

Chicken					
Mutton					
Fish					
Alcohol					
Pulses					
Fuel - Kerosene wood					
Travelling					
Health					
Entertainment					
Religious ceremony					
Education					
Community activity					
Marriages					
Guests					
Deaths					
Clothing					
Consumer goods					
Furniture					
Maintenance- House, Land,Cattle					
Tax					
Festivals					
Cosmetics					
Toys					
Newspaper					
Miscellaneous					

Loans

Amount	**Source**	**Rate of interest**	**Purpose**

Savings

Amount	**Place**	**Rate of interest**	**Year**

- Fishing methods
- Cost of fishing equipment
- Maintenance of fishing equipment

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