

Prioritization of Potential Sites for Marine Biodiversity Conservation in India

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Introduction

There are about 30 million species of living organisms estimated on earth. Marine Biodiversity is known to be one of the richest among all the living ecosystems. There is a rich marine biota in different parts of the oceans, from the surface to the deepest part and from the estuarine region to the offshore regimes. Ocean waters can support life from the microscopic bacteria to the gigantic whale. As compared to the information available on terrestrial biodiversity, much less information is available on the marine biota.

Tropical marine ecosystems of the Indian subcontinent harbour a large number of species belonging to various habitats that include mangrove swamps, estuaries, lagoons, muddy, sandy/rocky shores, and oceanic islands. In India, although the marine biological research has been going on for a long time, there are several groups of living, or endangered (some extinct!) organisms, about which there is no proper scientific information available.

(There is a definite food chain present in the oceanic system. The famous "Trophic Prism" indicates the intimate and intricate relationships among the primary, secondary and tertiary levels. At the same time, different ecosystems are mostly interdependent but self-sufficient.) Various biological, biochemical and reproductive processes of a complex nature support numerous life forms in the ocean. The value of biodiversity lies in the functioning of these components supported by the interactions of organisms, populations and communities.

There are various ecosystems and species that are threatened as a result of several developmental activities like over-exploitation, pollution, reclamation, etc. These include coral reefs, mangroves, marine algae and seagrasses, conventional fishery resources, the rare groups of faunal elements and various micro-organisms responsible for different activities.

(Rapid industrialization has resulted in the destruction of habitats and the consequent extinction of several marine organisms.) On the advent of the industrial revolution, the coastal regions have become threatened by industrial pollution, and by habitat destruction because of dredging,

sand mining, reclamation and rapid urbanization. Only a fraction of these species affected are known to science. The IUCN has categorized this biota into extinct, endangered, vulnerable, rare indeterminate, out of danger and insufficiently known. It would be premature to decide the specific priorities based on the scattered and inadequate data available.

Various marine ecosystems such as the estuaries and islands, along with mangroves, seaweeds, seagrasses, corals, fisheries and sand dunes including associated flora and fauna, are ecologically as well as economically important to mankind. Human beings are utilizing the riches of the ocean since time immemorial for food, feed, chemicals, minerals and energy.

Though data on marine species and ecosystems is still sparse, on the basis of available data it is possible to identify the undisturbed areas along the coast where biodiversity is rich. There are, fortunately, already some Biosphere Reserves, Sanctuaries, National Parks declared along the Indian coast. Similarly, detailed inventories can be prepared separately for the marine flora and the fauna in order to identify priority areas for conservation.

Status of Marine Biodiversity in India

The real impetus to the study of marine biology came out of the International Indian Ocean Expedition, during 1964. Several countries participated in this program and, as a result, lot of marine biological samples were collected along with very valuable data on their qualitative and quantitative resource evaluation. Different atlases have been prepared to show their distribution and biomass. Taxonomical information has also been recorded.

Although some data on the distribution, abundance and other ecological functions of marine biota are available, much of this information is on individual groups, various other ecological and environmental parameters. The biodiversity concept is recent and, for this purpose, it is necessary to compile all the available data pertaining to various groups of marine biota.

Microorganisms

These include microscopic forms such as bacteria, actinomycetes, fungi, yeasts, viruses, flagellates, ciliates, diatoms and other planktonic forms. The numbers and kind of microbes occurring in the marine world are influenced by environmental conditions and the presence of higher organisms. Microbial habitats in the marine environment are broadly divided into six categories, i.e. (1) Nearshore habitats (air-sea interface), (2) Planktonic (free floating), (3) Fecal sestonic (organic debris), (4) Epibiotic (attached to surface), (5) Endobiotic (symbiotic/pathogenic), (6) Benthic (seafloor).

So far 96 species and 66 genera of marine fungi have been reported from the Indian coast. Among the yeasts, 24 yeast species were reported from EEZ of west coast and 9 from EEZ of east coast (Ranu Gupta and Prabhakaran, 1990).

Phytoplankton

These are microscopic, planktonic unicellular plants drifting along the sea surface. These are the main primary producers in marine ecosystems and are placed at the bottom of the Trophic Prism. Phytoplanktons are classified on the basis of their cell size as Microplanktons (2 - 200 μm), Nanoplanktons (2-2 μm) and Picoplanktons (0.2-2 μm). Majority of them belong to unicellular Chlorophyceae (green algae), Bacillariophyceae (diatoms), Vouchariaceae and Xanthophyceae (golden algae) and Dinophyceae.

Zooplanktons

These organisms are known as secondary producers and occupy the second lower level of the prism. They are considered as the major index of utilization of aquatic biotope because of their intermediary role between phytoplanktons and fishes. Zooplanktons are characterized by their faunal diversity and include organisms varying in size. No single system of classification has been adopted universally. These are being classified on the basis of size as follows:

Ultraplankton <5 μm ; Nannoplankton 5-60 μm ; Microplankton 1-500 μm ; Mesoplankton 0.5 - 1.0 mm; Macroplankton 1 - 10 mm and Hegaplankton >10 mm.

The physico-chemical boundaries play an important role in zooplankton distribution.

Macro-Algae

Marine macro-algae, commonly known as seaweeds, are benthic forms of the lower plant group. They are classified into four major groups based on their pigmentation and

stored food. These are as follows: Chlorophyceae, Phaeophyceae, Rhodophyceae and Cyanophyceae.

A total 624 marine algae are reported from the Indian coast and classified into 64 families, 215 genera (Table 1). Their distribution along the Indian coast is given in Table 2, (Untawale *et al.*, 1983).

Seagrasses

Seagrasses are marine flowering plants and are highly productive in the sea or in the estuary. Twelve species belonging to seven genera are reported from Indian waters. The seagrasses are mostly found in lagoons or in the intertidal regions. Two species of *Halophila*, *H. beccarrii* found mainly in intertidal mangrove mudflats and *H. ovalis* is associated with mangroves.

Sand-Dune Vegetation

The strand or sand dune vegetation which are also termed as Psammophytes, are generally observed growing on the sandy areas beyond the supra-littoral zone. These are angiosperm species, belonging to different families with an ability for sand binding, which results in control over the movement of sand. There are about 148 species representing 115 genera and 49 families, reported from the east and west coast of India (Untawale, 1980). The west coast has been observed to have more diverse species than the east coast.

The dominant species representing strand flora are *Spinifex littoreus*, *Hydrophyllax meristima*, *Ipomea pes-caprae*, *Asparagus dumosus*, *Cyperus conglomeratus*, *Halophyrum mucronatum* and *Sporobolus trimulus*.

The supra-littoral region with sandy substratum has been divided into three zones, i.e. Pioneer zone, Midshore zone and Backshore zone. These three zones show varying type of environmental conditions and also different floral elements such as herbaceous, shrubaceous and trees. The natural arrangement of these three groups gives a gradual slope of vegetation which diverts the wind blow coming from the seaward side and thus minimizing the sand erosion.

Marine Fauna

Marine fauna comprises of several phyla, orders, classes, families, genera and species. There are innumerable species in the coastal as well as offshore environment. It is practically difficult at this stage to enlist various species family wise. These faunal complex elements, therefore are indicated as separate groups like zooplankton, benthos, corals, fishes, amphibians, reptiles, birds, mammals, etc.

According to the scientific data available, there are 23 groups of faunal elements which have been reported from the Indian coast line. Due to lack of space, it will be difficult to deal with all the marine faunal groups here. However, some important ecosystems are being described separately for their biodiversity.

Coastal Biodiversity

Marine biodiversity has been classified into two sectors, i.e., coastal and offshore, for convenience. The coastal areas are shallow and cover ecosystems like estuaries, nearshore intertidal areas where strand flora and mangroves are available. The intertidal and subtidal regions also harbour the biota like marine algae, seagrasses, corals and the associated flora and fauna.

Mangrove Ecosystem

Mangrove is an assemblage of different flowering plants that can grow in the saline or brackish water along the estuaries, on deltas, back waters, creeks, etc. In India, mangroves occur in various habitats such as delta, estuarine, backwater and sheltered-insular bay types. Deltas are found along the east coast. The great rivers deltas, such as those of the Ganga, Brahmaputra (Sundarbans, West Bengal), Mahanadi and Bhitarkanika (Orissa), Godavari and Krishna (Andhra Pradesh), Pichavaram and Gulf of Mannar (Tamil Nadu coast) are mangrove formations along the east coast. On the west coast however, the estuaries display fringing growth.

Mangrove forests serve as a link between terrestrial and marine ecosystems. The energy flow through the nutrients, from land to the sea, and enrichment due to the detritus formation, makes mangrove ecosystem rich in relation to the primary and secondary production. The swamps also serve as nursery grounds for variety of fishes and prawns. 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 mangrove ecosystem comprises all the biotic components starting from microscopic forms to large size forms. Table 3 displays the number of species belonging to various biotic components of the mangrove ecosystem.

Phytoplankton

As mentioned earlier, the phytoplanktons are the primary producers. The mangrove or estuarine ecosystem is well mixed, weakly or strongly stratified. About 20% of primary production (PP) is contributed by phytoplanktons of 20 µm

in size (Qasim, 1973). Species belonging to genera such as *Skeletonema*, *Nitzschia*, *Coscinodiscus* and *Navicula* contribute to the phytoplankton abundance. Mandovi-Zuari estuarine system of Goa is a tide dominated estuary. About 80 species of phytoplanktons have been recorded from Goa. Out of this, 63 species were diatoms, 14 dinoflagellates and 3 blue green algae (Devassy and Goes, 1988).

Zooplankton

Zooplankton population of the mangroves comprises of epibenthic forms and organisms living in the water column. Zooplanktons of the mangrove region have received very little attention, as most of the research pertained to the flora. Along the mangroves of Goa coast, Goswami (1992) described the seasonal variability in the zooplankton standing structure and eco-physiological adaptation. Crustaceans, fish larvae tintinnids, rotifer are the common groups reported from central west coast. Copepods (83.5 to 84.1%), mysids, decapods, polychaetes, chaetognaths, cladocerans, coelenterates, fish eggs and fish larvae are abundant in this region. In the Sundarban mangrove region, Sarkar *et al.* (1986) reported that copepods are the most dominant group, followed by meroplankters and chaetognaths.

Algae and Seagrasses

Marine algae in the mangrove environment are either floating or attached to the sea floor and mangrove bark or pneumatophores. Little is known about the algae associated with mangrove regions. There are a few reports on the distribution of algae in mangrove (Jagtap, 1986). A total of 48 species belonging to 30 genera are reported from the central west coast of India.

Caloglossa lepieurii, *Catnella impudica*, *Ulva reticulata* and *Enteromorpha clathrata* are characteristic algal species that occur throughout the year. Economically important algae such as *Monostroma oxyspermum* (edible) and *Gracilaria verrucosa* (agarophyte) also grow in mangrove areas with high salinity. *Dichotomosiphon salina* - a Vauchariaceae member, has been reported only from the Goa mangroves (Untawale *et al.*, 1980). Mangrove environment is distinguished with unstable soils and wide fluctuations in salinity, temperature, turbidity and nutrients, resulting in poor distribution of marine algae in mangrove areas. The maximum number of algal species occur during October to April, when generally a high salinity level is recorded. Blue green or cyanophycean species dominate during monsoon season.

Seagrasses: The polyhaline and mesohaline zones of mangrove areas are generally associated with *Halophila*

(Hydrocharitaceae). *Halophila beccarii* is an exclusively mangrove related seagrass, whereas *H. ovalis* also occurs in the sheltered euhaline regions (salinity > 30%) of west coast during March-June and throughout along the east coast.

Yeast, Bacteria and Fungi

Microbial flora consisting of yeasts, bacteria and fungi, play a significant role in the decomposition of mangrove litter resulting into the protein rich detritus. About 50 bacterial strains are reported from the mangrove area, mostly gram positive. *Micrococcus*, *Brevibacterium* and *Kurthia* are reported as predominant. Bacterial species such as *Lactobacillus*, *Corynebacterium*, *Listeria*, *Bacillus* and *Clostridium* are also found in this area. Bhaumic *et al.* (1986) reported 24 bacterial strains abundant in Sunderban mangroves. The most dominant strains belonged to genera *Brevibacterium*, *Clostridium*, *Kurthia*, *Lactobacillus*, *Micrococcus* and *Pseudomonas*. Cellulose sulphate reducing bacteria have been reported. Although only a few bacterial species have been recorded, there is a great potential for their population, distribution and diversity in the mangrove ecosystem.

There are 184 species of terrestrial fungi reported, while 76 species are known to be manglicolous fungi of great commercial value. Most of them belonged to Ascomycetes, Basidiomycetes and Deuteromycetes (Chinnaraj, 1993). Two lichen species are also reported from the mangroves of west coast of India.

Mangrove and Associated Flora

Mangroves are defined as characteristic littoral plants found in the tropical and subtropical coasts (SCOR/COE, 1981). They are a diversified group of trees and shrubs. There are 59 mangrove species belonging to 41 genera and 29 families present along the Indian coast. The west coast harbours 34 species, whereas 46 species are present along the east coast. The total mangrove area cover in India is approximately 700,000 hectares (Sidhu, 1963). The east coast, including Andaman-Nicobar Islands, contributes about 82%, while west coast about 18% of mangroves. East coast mangroves give a slightly better picture than the west coast mangroves, in species composition and area covered.

Geomorphology, environmental and hydrological conditions are mainly responsible for the distribution for mangroves. Apart from physical conditions such as soil type, rainfall, tidal inundations, and fluctuations, salinity gradients, and biotic factors are also important. Polyhaline and mesohaline zones (salinity 5-30 %) shelter many mangrove species. The oligohaline zone (salinity 0.05-5

%) supports limited species such as *Kandelia candal*, *Sonneretia caseolaris* and *Acrostichum aureum*.

Among the west coast states, Maharashtra has the most diversified mangrove flora composed of 19 species, followed by Goa and Karnataka. Gujarat, despite having largest mangrove coverage of 37,000 ha., displays a poor assemblage of 9 species. *Avicennia alba*, *A. marina*, *A. officinalis*, *Rhizophora mucronata*, *R. apiculata*, *Acanthus ilicifolius*, *Sonneretia alba* and *S. apetala* are some of the dominant species along west coast. Shrubby vegetation including *A. ilicifolius*, *A. marina*, *Salicornia brachiata* and *Sueda* sp. occurs above the high tide mark. Due to the deforestation as well as development activities and domestic exploitation, species of *Nypa* and *Xylocarpus* have become extinct from the west coast, whereas other species like *Ceriops tagal*, *Lumnitzera racemosa*, *Sonneretia apetala* are found only in certain areas (Untawale, 1987). A very distinct discontinuous, distribution of mangrove plants has been observed along both the coasts of India due to various factors.

The east coast mangrove vegetation is comprised of 47 species with almost 70% of the total mangrove cover of India. The maximum number of 27 species has been reported from the Mahanadi delta. Mangrove species like *Avicennia* spp. and *Aegiceras majus* are dominant along the Godavari, Krishna and Cauvery deltas, whereas *Ceriops decandra* and *S. apetala* are dominant in the Mahanadi delta. The dominant flora of Gangetic Sundarbans delta comprises of species like *Exoecaria agallocha*, *Heritiera fomes* and *Xylocarpus moluccensis*. Mangrove species like *Nypa*, *Xylocarpus*, *Heritiera* and *Acanthus ebracteatus*, etc. are confined to east coast only.

The associated flora are the plant species that can sustain various levels of salinity in the elevated regions above the spring tide mark. About 30 terrestrial species are known to grow in these areas. The most common mangrove associates are *Clerodendron inerme*, *Thespesia populnea*, *Pongamia pinnata*, *Sesuvium portulacastrum*, *Myriostachya wightiana*, *Hibiscus tiliaceus*, *Fimbristylis ferruginea*, *Aeluropus lagopoides*, *Cressa cretica*, etc.

Benthic Fauna

Benthic fauna can be divided into two major groups: macrofauna and meiofauna. Dominant macrofaunal species recorded from the Goa mangroves were *Modiolus metcalfei*, *Perna viridis*, *Diopatra neapolitina*, *Meretrix casta*, *Paphia malabaricus*, *Cerithidea fluviatilis*, *Diogenes* *custus* and *Glycera alba*. While polychaetes are dominant macrofauna, meiofaunal species belonging to family Chromadocidae and Desmodoridae, followed by copepods, are also quite abundant. The upper 2 cm layer of the mangrove sediment harbours 60% of the total meiofauna.

From the east coast, Mandal and Misra (1986) reported 78 macrobenthic faunal species from the mudflats of Lower Bengal. The most dominant group was Crustacea (27 species) followed by Molluscs (25) and Coelenterata (17). Kasinathan and Shanmugam (1986) studied molluscan fauna of Pichavaram mangroves. They reported 14 molluscan species. Subba Rao and Mukharjee (1975) reported 22 species from Mahanadi estuary.

Wood borers of India are represented by about 26 species belonging to class Crustacea and Mollusca (Turner and Santhakumaran, 1989). Biodeterioration of mangrove wood is severe along the Indian coast. Species such as *Dicyathifer manni*, *Lyrodus pedicellatus*, *Banka rochi*, *B. campanellata*, *Nausitora hedlevi*, *N. dunlopei*, *Bactrosophorus* sp., *Martesia* spp., *Lignopholus chengi* cause sever damage to the woods.

Fishery Potential

The mangrove environment of India harbours 105 species of Fishes, 20 species of shell fishes and over 225 species of crustaceans. Commercially important species such as *Meretrix* sp., *Crassostrea* sp., *Penaeus* sp., *Scylla serrata* and *Mugil cephalus* are important. Finfish resources are abundant in mangrove creeks and estuaries. The milk fish *Chanos chanos*, mullets (*Mugil cephalus*), *Atroplus* sp. are suitable for culture in mangrove areas. Both the captive and culture fisheries are quite common in the mangrove forests.

Avifauna

Mangrove forests provides good shelter, food and breeding ground for the resident and migratory birds. About 177 species of birds are found in the mangrove forests of India (Mukharjee, 1975; Samant, 1986). Kingfishers, herons, storks, sea eagles, kites, etc. are the dominant and common birds observed. Mangrove region of the Gulf of Kuchchh harbours about 119 bird species. Extensive mudflats in the Gujarat coasts attract birds like pelicans. There are several bird sanctuaries in Sundarbans, Andaman and Nicobar Islands, and several other mangrove forests.

Mammals and Reptiles

A diversified mammalian and reptilian fauna is observed from mangroves. The Royal Bengal Tiger is one of the endangered species that lives in the Sundarbans area. This is the only locality in the world where the tiger shares aquatic and terrestrial food web. Some of the common animals found in mangrove swamps are the monitor lizard (*Varanus* sp.), estuarine crocodile (*Crocodylus porosus*), Pacific Ridley turtle *Lipidochalys olivacea*, various species of monkeys, otters, deers, foxes, wild pigs and fishing cats.

Along the west coast, the crocodile (*Crocodylus palustris*) is found only in the Goa mangroves. Among the reptiles, 21 snake, 4 lizard, 5 turtles and 1 crocodile species are recorded (Deshmukh, 1994) from the Maharashtra coast.

Coral Ecosystem

Coral reefs are known to be the most diversified and productive ecosystem among all the marine ecosystems of tropical zone (Wells, 1988). Many corals are very beautiful, colourful and attractive to human being (Wafar, 1988). India has about 19,000 km² of major reef area including islands and coasts. Coral reefs are of direct economic importance due to their organic and inorganic resources. Corals are also source of income through tourism, and play an important role in protecting the shoreline. Coral reefs are often exploited for calcium carbonate - a raw material for many lime based industries such as lime, cement and calcium carbide. The fishery's resources of the reefs are extremely rich and diversified. The reefs are also exploited for their beautiful associated fauna such as molluscs and gastropods. *Trochus niloticus* and *Turbo marmoratus* are costly gastropods found in Andamans. Many species of cowries fished from this area are used in making gift articles such as lamp-shades, mirrors, dolls, etc. The giant clam *Tridacna* sp. is common in the Andaman-Nicobar and Lakshadweep.

Indian coral reefs consist of atolls, fringing reefs, patch reefs, elevated banks and submerged banks (Pillai, 1971). Table 4 presents the summary of Indian coral reefs, and the species distribution along the major reefs.

Coral Atolls

Lakshadweep archipelago consists of atolls with several low-lying islands in the east, a broad well-developed reef in the west, with a lagoon in between, connected to the open ocean by several channels. In addition, three more reefs and five submerged islands also harbour living corals. The number of coral species known is 103, belonging to 37 genera (Pillai and Jasmine, 1989). *Acropora* spp., *Pocillopora* spp., *Porites* spp. and massive encrusting faviids are common coral species of the Lakshadweep. *Psammocora* is common in the northern islands. Other common species are *Helipora coerulea* (blue coral) and *Millepora* spp. Genera like *Montipora* and *Echinopora* are recorded from the northern islands but are absent in Minicoy.

The Andaman-Nicobar Island: Coral reefs here are the fringing type surrounding the islands. There are about 500 islands, believed to be part of an emergent mountain chain. There are 516 villages with tribal inhabitants including Andamanis, Onges, Nicobaris, Jarawas and the

hostile Sentinels (Jain, 1984; Banerjee, 1985, Tikader and Das, 1985). The islands are covered with thick forests and mangroves are common trees. The complete biodiversity resources of this region is yet to be evaluated, due to non-accessibility to the region.

Pillai (1983) reported 135 species of Scleractinia, 110 species and 45 genera are hermatypic. Most of the reefs occur at depths of 5 to 7 m. Inshore waters are turbid with scarce coral growth < 100m from shore. Most dominant species in the reef flats are massive *Porites* and *Faviidae*. *Acropora*, *Pocillopora*, *Seriatopora*, *Stylophora*, etc. are the common arborescent genera commonly found. Major reef inhabitants include sand and shingle of the upper intertidal zone, dominated by *Donax*, *Hippa*, *Crassostrea*, *Nerita*, *Thais*, *Drupa* and *Cerithium* (Pillai 1983); subtidal dead shingle with *Arca*, *Tridacna* and many diversified species. The reef flats are dominated by *Drupa*, *Pyrene*, *Cerithium*, *Arca*, *Lithophaga*, *Pinactada* and variety of hard corals including a stinging coral *Millepora platyphylla*. The stony corals include genera *Porites*, *Favia*, *Acropora*, *Pocillopora*, *Helipora*, *Tubipora* and *Montipora*.

Fringing Reefs

The coastal reefs of India, can broadly be divided into a) minor coastal coral reefs along the west coast and Visakhapatnam on the east coast and b) major coastal coral reefs along southeast India including Palk Bay and the Gulf of Mannar. Corals, though rare in occurrence, are reported throughout the west coast. On the east coast, however, due to delta formation, heavy siltation takes place hindering coral growth.

Among the Coastal Coral Reefs, Gulf of Kutch region in Gujarat has the most luxuriant coral growth along the west coast of India. There are about 44 species of scleractinian corals and 12 soft coral species (Patel, 1988). The submerged reefs of this area harbour 18 stony coral species and has 45 percent coverage. The common genera are *Acropora*, *Porites*, *Pseudosiderastrea*, and *Favia*. One soft coral *Juncella juncea* is also very common. Corals from this region are largely destroyed by limestone industries and siltation. Along the central west coast, Wafar (1986) reported two species (*Pseudosiderastrea tayami* and *Porites lichen*) of hard corals in patches from Mumbai. Recently, Untawale *et al.* (Pers. Observation) cited large well-developed hard coral colonies at Colaba, near south Mumbai. The area under coral coverage is about 60 to 70 percent. One soft coral species is also found in this area. The fringing corals then extend up to Kerala. Malvan (discussed further) is considered to have the richest marine biodiversity along the central west coast. Parulekar (1981) reported *Porites*, a stony coral, as most common in Malvan

waters. He reported nine species, including a rare red coral species, belonging to genera *Coscinarea*, *Favites*, *Goniastrea*, *Syneraraea* and *Pseudosiderastrea*, *Cyphastrea*, *Turbinaria*. All coral species reported are non-branching. Angria bank - a submerged reef situated off Ratnagiri has stony corals. Five coral species are reported from Gaveshani bank, off Malpe along Karnataka coast. *Pocillopora eydouxi* is recently reported from Visakhapatnam, on the east coast (Bakus, 1994).

The major coastal coral reefs, along the east coast is a series of fringing reefs. Ninety-six species belonging to 36 genera of scleractinian corals and seven species of ahermatypic are reported from this region. The Gulf of Mannar is known to have more diversified and abundant coral species (Pillai, 1986). *Montipora* and *Acropora* represent 40 percent of the species (Pillai, 1971) in Palk Bay. Manauli and Crusadai islands near Mandapam, in the Gulf of Mannar, are known for their rich diversified fauna. Thirty species of stony corals were reported from Manauli reef of which the dominant corals were *Acropora*, *Porites*, *Goniastrea*, *Favia*, *Pocillopora* and *Montipora*. Krusadai Island demonstrates a well-developed coral reef. The "Mannar Barrier" consists of 20 small islands (Lal Mohan, 1986). Pillai (1977) reported 96 species belonging to 26 genera of hermatypic and 10 species of ahermatypic corals. *Acropora*, *Pocillopora*, *Poritidae* and *Favia* are the dominant corals from the north region. Due to natural calamities and over-exploitation by industries, students and local dwellers for ornamental value, many large colonies of coral species such as foliaceous forms *Montipora foliosa* and *Echinopora lamellosa* are about to become extinct.

Associated Algae and Seagrasses

The coral ecosystem provides a good shelter for marine algal growth and diversified seaweed flora is often observed in coral areas. Some of the algae, though in minor scale, are responsible for reef building. There are certain algae that have calcium carbonate deposition and are known as coralline algae. The role of calcareous algae is however, less significant in the Indian Ocean than in the Pacific Ocean. Jagtap (1987) reported 20 m wide algal ridge on the seaward side of Kavaratti and Agathi Islands, of Lakshadweep.

The maximum marine algal biodiversity of more than 180 species and 99 genera is reported from Gulf of Mannar and Palk Bay (Umamaheshwara Rao, 1972). *Halimeda opuntia* contributed to 20 percent of total sampling. Altogether 82 marine algal species are recorded from the Lakshadweep lagoons with an estimated annual yield of 3645-7598 m tons of fresh weight per year (Subbaramaiah *et al.*, 1979). Rhodophycean species were maximum in

numbers (39) followed by 33 green and 10 brown algal species. From Andaman and Nicobar Islands, 64 species and 40 genera were reported, including 27 Rhodophyceae, 21 Chlorophyceae and 15 Phaeophyceae species (Gopinathan and Panigrahi, 1983; Jagtap, 1986). Kalimuthu *et al.* (1990) reported 77,000 wet tons of seaweed biomass for the Indian coast and approximately 19,345 tonnes from Lakshadweep groups of Islands.

Palk Bay and the Gulf of Mannar have extensive seagrass beds. Jagtap (1996) reported 12 species and seven genera of seagrasses from this area. Five species of seagrasses are reported from the Minicoy lagoon by Untawale and Jagtap (1984). The common genera were *Thalassia*, *Halophila* and *Cymodocea*. Kavaratti lagoon had luxuriant seagrass growth of *Thalassia* and *Cymodocea*.

Fisheries and Ornamental Fishes

The lagoons of the coral islands harboured about 600 marine fishes (Jones and Kumaran, 1980; Bakus, 1994) and the estimated fish production from the reef environments varies from 6 to 9 million tonnes per year (Munro, 1982). Fin fishes are one of the major fish resources from Lakshadweep and the Andaman-Nicobar Islands. There are 9 fin fish species and 12 prawn species, which are exploited from the lagoons (Lal Mohan, 1983; Silas *et al.*, 1983). Alagarwamy (1983) reported abundance of sharks at >10 m depths of the Andaman-Nicobar Sea. Lakshadweep waters also harbour a good amount of sharks. Five species of Lobster *Panulirus* spp. are reported to occur from the innermost barrier reef to the outermost reef of the Indo-West Pacific coral reefs (George, 1974). Eight species of spiny lobster (*Panulirus*) and five species of slipper lobster (*Scyllarids*) occur along the Indian coast. Eight species of edible crabs are reported from Andaman-Nicobar Islands (Kathirvel, 1983). Apart from this, snail species *Trochus niloticus*, and *Turbo* spp. were exploited for their commercial value. Four edible oyster species are also reported. The pearl oyster *Pinctada margaritifera* and few other species such as *Pteria pengion* occur on coralline reef flats at depths of 0 to 10 m (Alagarwamy, 1983). Seven species of holothurians along with sea urchin *Tripneustes gratilla* are known to be potential food species in the Andaman and Nicobar Islands (James, 1973). Some of the holothurian species from Lakshadweep are being over-exploited for export.

Ornamental Fish from the coral reef are in great demand as aquarium samples. There is a vast resource available and fishes such as surgeon fish, parrot fish, damselfish, soldierfish and cardinalfish are most popular. In Lakshadweep and the Andaman-Nicobar Islands, fishes of the group clupids and apogonids along with

pomacentrids are captured. Gopakumar *et al.* (1994) located a large resource of *Spratelliodes delicatulus* in the marine park of Wandoor.

Five species of **Marine Turtles** are found all along the Indian coast and in Lakshadweep and the Andaman-Nicobar Islands (Rajgopalan, 1996). Hawksbill turtle *Ertmochelys imbricata* *Chelonia mydas* (green turtle), *Caretta caretta* (loggerhead) *Lepidochelys olivacea* and *Dermochelys coriacea* are the most common. Visit of the Gaharimatha coast along Orissa by millions of marine turtles is a matter of great interest. There have been large scale mortalities also recently. The population of the horseshoe crab are reported from the West Bengal coast. There are two different species and they are of great economical - medicinal value.

Ocean Biodiversity

The oceans cover 71 % of the earth's surface and provide the major global environment for the evolution of life. A variety of organisms inhabit different areas in the ocean, starting from the intertidal areas to the depths of the ocean. Biodiversity increases from the polar region towards the equator and reaches to the maximum in the tropical zone. As compared to coastal biodiversity, the ocean shows the presence of lesser, but altogether different, forms of life. There are also certain areas in the offshore region which are known as 'deserts', where no life exists. The oceanic waters can be grouped into two categories, i. e. - surface and deep seas.

Surface

The ocean surface is a very dynamic zone where air-sea interaction, influence of radiation and heavy precipitation are seen. Because of the presence of planktonic organisms, the surface waters normally show high biological productivity due to the qualitative and quantitative presence of phytoplankton and zooplankton.

Plankton - Phytoplankton and Zooplankton

Due to the availability of essential environmental conditions and nutrients, the planktonic species show the phenomenon of 'eutrophication'. The best example of this is observed along the west coast, during pre-monsoon, in the blooms of *Trichodesmium erythraeum* - a blue green alga. The euphotic zone of the 250 m water column shows the presence of several phytoplanktonic species which are unicellular in nature.

The zooplankton species responsible for the secondary production normally graze on the phytoplankton species. There are several species of zooplankton belonging to

different groups. These planktons migrate horizontally and vertically and are considered as an important food source for the tertiary animals.

Phytoplankton: There is sufficient information available on the productivity of phytoplankton in the Arabian Sea (Radhakrishna *et al.*, 1978; Qasim, 1982; Bhatathiri, 1992). Goes *et al.* (1992) studied the distribution and production of phytoplanktons by using satellite imageries for chlorophyll images along the west coast of India. The intense cooling in the Gulf of Kutch, with high phytoplankton biomass, is an interesting phenomenon.

The most dominant phytoplankton group is diatoms (86%) followed by cyanobacteria (7%) and dinoflagellates (6%). Sawant and Madhupratap (1996) reported a total of 36 phytoplankton species. The most common were *Nitzschia* species such as *N. seriata*, *N. closterium* and *N. pungens* comprising 25% of the total population. *Navicula* was common (22%) at only one station (15°N 64°E), followed by *Rhizosolenia* spp (10%) and *Chaetoceros* (9%). *Ceratium* sp. and *Peridinium* sp. were the dinoflagellates constituting 4% of the population.

There is no systematic list of phytoplankton species available and most of the work carried out is site-specific. It is necessary to document all available phytoplankton species systematically, along with the important environmental parameters.

Zooplankton: Zooplanktons are placed at the second lowest level of the trophic prism, feeding on the phytoplanktons. High zooplankton mass is observed when phytoplankton count is less and nutrition depletion is observed (Madhupratap *et al.*, 1992). Along the central and eastern Arabian sea, the composition of microzooplanktons in the upper 200 m was dominated by protozoans (ciliates - loricates and aloricates), flagellates and sarcodines, ranging from 55% to 91% (Gauns *et al.*, 1996). Tintinnids were represented by 30 genera, and 11 genera (*Tintinnopsis*, *Eutintinnus*, *Favella*, *Parundella*, *Amphoroides*, *Codonella*, *Tintinnus* and *Xystonellopsis*) were present throughout the year. They further reported that among metazoans, nauplii and copepodite stages were common. The upper 100 m water column showed high microzooplankton abundance in all the seasons. The intermonsoon season showed the highest value of zooplankton, at 700 ml l⁻¹, followed by summer (300 ml l⁻¹) and winter (130 ml l⁻¹). Copepod fauna sampled from southeast and southwest coast of India was composed of Paracalanidae forming 27.6% to 76.7% of the total. In the upper stratum, Pencilostomatoids (Oncaeidae and Corycaeidae) along with cyclopod Oithonidae constituted 16.6% to 43.5% (Stephen, 1992). Among the twenty species of calanoids, *Pteromamma indica* was the most dominant species in 0-500 m water column. Based on

zooplankton data collected from 1864 samples in the duration of 12 years (1976-1988), the zooplankton biomass values vary between 0.1 to 12 ml m⁻³, 0.1 to 8.0 ml m⁻³, 0.1 to 1.6 ml m⁻³, and 0.02 to 0.37 ml m⁻³ in the Arabian Sea, the Bay of Bengal, Lakshadweep Sea and the Andaman Sea respectively (Goswami *et al.*, 1992). The numbers of zooplanktons species recorded from various parts of the Indian coastline are given in Table 5.

Fishery

India's marine capture fish production was 1.10 million tonnes in 1970. With the mechanization it reached 2.27 million tonnes in 1995-96 and has been showing signs of leveling off immediately thereafter, with the annual growth rates oscillating between ± 5%. The potential fishery yield estimate from India's EEZ is 3.9 million tonnes, with hopes of increasing production from the outer continental shelf. However, fish production is correlated to zooplankton production (Prasad *et al.*, 1970).

The shelf waters indicate a dense congregation of a number of coastal species. The neritic waters in the depth range of 150-398m were promising for deep sea forms like *Pseneopsis* spp., *Chlorophthalmus* spp., *Priacanthus* sp., etc. (Table 6).

Based on the FORV Sagar Sampada data, a check list of the fishes found in the exclusive economic zone (EEZ) of India was prepared by Balachandran and Nizar (1990). In all 87 families and 242 species including both conventional and non-conventional fish fauna, along with zoogeographical and vital biological information, have been collected to assess the stock potential and exploitation. Information on non-conventional resources of the pelagic, mesopelagic, bathy pelagic and benthic fishes of the outer shelf and beyond is essential to strengthen coastal fishery.

Deep Sea Life

Human interest in deep sea life has increased globally in the past few decades. Deep sea productivity is more chemosynthetic in nature (with the presence of hot springs and hydrothermal vents) than photosynthetic primary production (Grassle, 1986; Tunnicliffe, 1991).

Micro-Organisms

Microbes are of great importance in the deep sea due to their active role in the biogeochemical cycles (Chandramohan, 1992). Chandramohan *et al.* (1987) isolated bacteria attached to ferromanganese (polymetallic) nodules from the Indian Ocean. These nodules were collected at 5400 m depth in the Indian Ocean. Two types of psychrotrophic bacteria Mn (II) oxidizing and MnO₂ reducing were

reported. They belonged to members of *Vibro*, members of Enterobacteriaceae, *Bacillus*, *Micrococcus*, *Staphylococcus*, *Arthrobacter* and Coryneforms.

Deep sea fungi were isolated from the calcareous shells at 100 to 860 m depth in the Bay of Bengal. All the species isolated had terrestrial origin and *Aspergillus rusticus* was the most common species (Raghukumar *et al.*, 1992).

Benthic and Fishery Resources

Qualitative investigations on deep sea benthos of the Indian Ocean in the depth ranges of 1580 to 6000 m (latitude 21° N - 21° S and 51° - 94° E) revealed rich biota having relatively low species biodiversity (Parulekar *et al.*, 1992). Six meiofaunal and 12 macrofaunal taxa with nematodes comprising 53.3 % of the total meiofaunal species were recorded (Table 7). Foraminifera (17.6%) and harpacticoids (16.8 %) were the other important taxa. Polychaeta was the most dominant group among the macrofaunal taxa and accounted for 63.4%. Both macro and meiobenthos decreased in abundance with increasing water depths. In the <2000 m depth, the benthic biomass was uniformly high (0.11 - 12.75 g m⁻²) and was lowest (0.12 g m⁻²) at 7550 m depth.

Lack of adequate information on the availability and extent of commercially exploitable resources beyond the conventional fishing grounds has been a major constraint for the development of deep sea fishing in India. Deep sea fishing, being a capital intensive industry, depends largely on the exploitable varieties of resources that could earn foreign revenue. Crustaceans, mainly prawns, are much sought after due to their export value.

The exploitable stocks of crustaceans in the shelf water of India have been reported by George *et al.* (1963), Rao (1973), Sekharan *et al.* (1975) and Muthu *et al.* (1975). Occurrence of crustaceans in appreciable quantities beyond the continental shelf has also been reported (Kurian, 1965; Silas, 1969; Suseelan, 1974; 1985; and James, 1989) from the southwest coast and the Gulf of Mannar. On the west coast, the coastal prawns *Parapenaeopsis styliifera* (Karaiikudi) has been encountered in various densities, up to 53 m depth, during the south west monsoon almost as a continuous belt in the off shore waters between Quilon and Marmagoa. The upper continental slope provides an entirely different faunistic composition in which members of all deep sea penaeidean families (Solanoceridae, Aristeidae and Penaeidae) and Caridean prawns of family Pandalidae are represented. In a 200 - 300 m depth, the important species were *Plesionika spinipes* (60.5%), *Penaeopsis jerryi* (26.3%), *Solanocera hextie* (5.6%), *Metapenaeopsis andamanensis* (3.7%) and *Heterocarpus woodmasoni* and *H. gibbosus*.

The deep sea spiny lobster *Puerulus sewelli* is found in the appreciable quantities in the 200 to 400 m depths, mainly between Kanyakumari and Alleppey. The highest catch per haul was recorded at 200 to 300 m depth off Thiruvanthpuram. The size of these lobsters ranged from 71 to 200 mm in total length. This species is known to occur off Lakshadweep Islands between 660 and 840 m depth (Holthuis, 1984). An abundance of sand lobster *Thanus orientalis* at 40 to 70 m depth off Veraval to Dwarka and Kanyakumari to Alleppey has also been reported (Suseelan *et al.*, 1990). The swarming crab *Charybdis (Goniohellenus) smithii* ranging from 42 to 72 mm in carapace width is potentially an important constituent catch in the offshore waters. The highest catch was recorded at 200 to 400 m depths between Thiruvanthpuram and Alleppey.

The neritic squids of the family Loliginidae and the oceanic squid of Omnastrephidae account for 70 % of the world's cephalopod catch. The purpleblack flying squid *Symplectoteuthis oualaniensis* (Lesson) belonging to Omnastrephidae family, comprises the economically important species of oceanic squid of the world. Other species that occur in stray quantities are *Onychoteuthis banksi* (Leach), *Thysanoteuthis rhombus* (Troschel) and members of the family Enoplateuthidae.

The literature review on the Indian Ocean shows that there are few efforts to study the deep sea biota. Therefore, there is much to be learnt about the biodiversity of this silent and dark zone of the deep sea.

Case Studies - Maharashtra Coast

A number of coastal areas along the Maharashtra coast are rich in marine biodiversity and have unique flora and fauna that needs to be preserved. These localities can serve as centers for ecotourism, recreation, education and research. The flora and fauna can be maintained as 'Germ plasm preservation centres'. Efforts were made to identify the areas with high biodiversity and uniqueness of flora, fauna and other environment as 'Marine Protected Areas' taking into consideration the ecological, biological and other environmental factors.

Detailed observations were carried out at each station on the flora, the fauna, the environment, etc. and information regarding local industries in that area was also collected. Changes in the marine biodiversity during the past 10 year were also determined by making comparisons with the earlier data, in order to indicate the trend. The intertidal zones along the open rocky coast were surveyed at low tide, for marine algae and benthic meiofauna. Marine algal samples were collected at random and the common species were recorded. Biomass of dominant algae was calculated by placing 0.25 m² quadrants randomly in 2-3

transacts. Species were preserved in the form of herbarium sheets and deposited at the National Institute of Oceanography, Goa. Benthic faunal samples were taken by placing a core size of 4 cm diameter randomly. Samples were immediately preserved in 5% formalin for further identification. In some cases, such as Colaba, Mumbai, the density of corals, and sea anemones was measured by photographing the area without disturbing the organisms.

The estuarine stations were surveyed for mangroves. The reproductive phenology was recorded and branches were collected to make herbariums. The density of mangrove trees was recorded by placing 10 m² quadrants at random. The core samples were taken for meiofauna. Algal species were collected, whenever observed. Avifauna was recorded photographically and bird species were identified with the help of field guides (Ali and Ripley 1983a, 1983b). The availability and abundance of wild life was also recorded through discussions with the local people.

Marine Protected Areas

The Maharashtra coast lies between lat. 15° 43' to 20° N and long. 72° 49' to 77° 41' E. The coastline is 560 km long and is indented by numerous river mouths, creeks, small bays, headlands, promontories, cliffs, etc. There are about 18 major estuaries along the Maharashtra coast, harbouring many mangrove floral and faunal species in varying density.

The mangrove forests of Maharashtra comprise of 17 species along with 17 associated plant species. Among 37 stations visited, 25 stations harboured mangrove flora. Good patches were observed along Achra, Deogadh, Vijaydurg (Sindhudurg district), Purangadh, Ratnagiri (Ratnagiri district), Kundalika (Raigadh district) and Mumbra-Diva. *Avicennia marina* was the most common species. A high density of mangroves was observed at the above mentioned stations. Due to a good forest cover, these areas also give shelter to a variety of wild animals such as the fox, wild boar, snakes, etc. The mangrove forest is also known to be a sanctuary for various local and migratory birds.

Marine algae are more in number along rocky shores and prefer gradual slopes in the intertidal expanses. Altogether, 91 marine algal species were found along the Maharashtra coast. Malvan displayed a maximum number of marine algal species (73) followed by Colaba, Mumbai (64) and Ratnagiri (56). Species belonging to genera such as *Monostroma*, *Gelidium*, *Gracilaria*, *Sargassum*, etc. are economically important and hence exploited for their commercial value. Some species, e.g. *Acetabularia* sp. and *Caulerpa verticillata* are rare and require to be conserved by modern techniques such as germ plasm preservation, cryopreservation, and tissue culture.

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 is dominated by polychaetes, both in term of density and diversity (till this date > 72 species are reported from the area). The mollusc group is represented by many important species of bivalves and gastropods such as *Perna virides*, *Crassostrea cucullata*, *Pinctada* sp., *Meretrix casta*, *M. meretrix*, *Paphia* sp., *Donax incarnatus*, *Solan* sp., *Gafrarium* sp., and *Bullia* sp. Crustacea is the other fauna group represented by many economically and ecologically important groups such as prawns, crabs, lobsters, isopods, amphipods. One of the ecologically important faunal group recorded at only a few locations (such as Vengurla-Rock Islands, Malvan, Ratnagiri, and Mumbai) is coral. From the above sites, corals are most abundant at Malvan. Nine species of corals are reported from Malvan waters (Qasim and Wafar, 1978; Parulekar, 1981). However, the highest density of corals have been recorded at Colaba.

The coastal zone plays an important role as a breeding and feeding ground for a large number of birds. However, avifaunal studies of the coastline are not many. Very scanty information regarding the birds of the coastal areas is available. A total of 121 bird species were recorded from mangroves and adjacent areas (Ali and Ripley, 1983a, 1983b; Samant, 1986). Out of these, 66 species are resident and local migrants, 24 true migrants, 28 resident with migratory populations and only 3 are vagrant or occasional strays.

The coasts of Maharashtra have marine turtles, porpoises, and dolphins. Occasionally, drifted and stranded whales are also reported from this region.

Selection of sites suitable as Marine Protected Areas (MPA) was mainly based upon the biodiversity of that particular area. In Table 8, merits of each area are described. Malvan was considered as one of the priority areas, as it has a naturally protected coast, and the Sindhudurg fort. The diversity of flora and fauna is also high. Due to the geomorphology of this area, subtidal biodiversity is also rich. Endangered species such as corals and gorgonians are found in this area.

Altogether 37 stations were surveyed for the floral and faunal biodiversity and to identify the probable sites for Marine Protected Areas, taking into consideration their general environmental conditions.

After assessing the merits of each station, primarily 10 sites were selected for further detailed observation. In the last phase, out of these 10 sites, only 5 sites are recommended as Marine Protected Areas (Table 8). These areas are as follows:

Malvan is an open coast ecosystem, and is dominated by rocky outcrops with intermittent sandy beaches.

'Sindhudurg', a fort constructed by Maratha King Shivaji in the 16th century is on an island situated at a kilometer distance from the main land. The sea in between and around the fort has many submerged and exposed rocks that provide ideal substratum for marine biota and shelter many organisms. There is a gradual slope between main land and the fort, which is exposed during low tide (about 300 to 500 m). Towards northwest, cliffs are present with 10 to 20 m intertidal expanses. The recorded flora and fauna is highly diversified and present in large number. The Government of Maharashtra has notified its intention to make this area into a National Park. In general, the Malvan coast has sandy, rocky and muddy substratum. The rainfall is heavy and water transparency is quite good. Marine life, in comparison with other sites along the Maharashtra coast, is richer, both qualitatively and quantitatively.

Altogether 73 marine algal species are recorded from Malvan. Among these, 23 were Chlorophyceae, 17 Phaeophyceae and 33 Rhodophyceae members. The average biomass was 1.12 kg m⁻². The estimated standing algal crop of the Malvan coast varied from 450 to 600 tonnes annually. Brown algal species such as *Sargassum* spp. and the Dictyotales formed the major portion of the biomass.

Marine benthic fauna of the Malvan coast (sandy, rocky and marshy area) comprised of 208 species belonging to 172 genera (Parulekar, 1981). The faunal species displayed diversified composition of several groups including 9 corals, 2 sponges, 2 seapens, 18 sea anemones, 49 polychaete worms, 5 stomatopods, 5 isopods, 2 crab species, 5 prawns, 5 barnacles, 1 insect, 4 limpets, 10 top shell, 8 whelk, 11 spire shells, 3 sea hare, 3 mussels, 3 edible oyster, one pearl oyster, 11 clams, 3 echinoderms and 2 mud skipper species. There is also a chain of rocky islets towards the south extending up to Vengurla Rock Islands, which harbour a very good biota up to 15-20 m depth.

Achra - Devgad - Vijaydurg

Vaghotan, Deogad and Achra complex shows good mangrove formations and rich in biodiversity.

Achra is an estuarine station with good mangrove patches. This region has an estimated area of 273 ha. Eleven mangrove species are distributed along the stretch of the estuary, viz. *Rhizophora mucronata*, *Avicennia officinalis*, *A. marina*, *Sonneratia alba*, *S. caseolaris*, *Exoecaria agallocha*, *Bruguiera gymnorhiza*, *Acanthus ilicifolius*, *Aegiceros corniculatum*, *Derris heterophylla* and *Clerodendron inerme*. *R. mucronata* and *A. officinalis* were found to occur in all parts of the estuary while the remaining species had a restricted distribution. *Sonneratia alba* and *S. caseolaris* were observed only in the midstream region of the estuary. *Exoecaria 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.

Achra mangroves are considered as 'sacred' since this land belongs to the local deity of Shri Rameshwar. Vijaydurg and Devgad have very good mangrove cover and these are also 'heritage' sites. Perhaps this tri-estuarine complex can be considered as a transition zone for the north and south west coast.

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

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 is due to the high cliffs. Barnacles, Oysters, *Ulva fasciata* and *Enteromorpha* spp. always cover the supralittoral zone. The mid-littoral zone is usually covered with Dictyotaceae members like *Dictyota*, *Padina*, *Stoechospermum*, *Spatoglossum* etc. and red algae like *Gracilaria* sp. and *Grateloupia* sp. The maximum seaweed growth was found in this zone. The lower midlittoral zone is dominated by *Sargassum* spp. Sea anemones, zooanthus, hydroids, crustaceans, etc. represent the faunal group. Zooanthus is mostly associated with marine algae and occupies a large area.

The Shirgao creek in Ratnagiri is quite long with healthy mangrove trees. Altogether, seven mangrove species and three associated species are found. In some areas, the Social Forestry Department had planted *S. alba* and *R. mucronata* during 1986 resulting in 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 m² quadrant. The average height of *S. alba* was 6m and *R. mucronata* 4m. 117 bird species were recorded from Ratnagiri mangroves. This is also one of the rich fishing areas with luxurious intertidal fauna.

Colaba, a highly populated area of southern Mumbai, is a tip protruding into the Arabian Sea. This area, though within the city limits and despite the fact that the Mumbai coast is one of the most polluted coasts, exhibits a diversified and most luxuriant flora and fauna. The shoreline is a gradual slope with few immersing rocks. There are various tidal pools, with sandy bottom, providing an ideal environment for marine organisms.

A total of 64 marine algal species were recorded from here. The most dominant species were *Caulerpa* spp. Six

species belonging to genus *Caulerpa*, including one rare species *C. verticillata*, were recorded. Out of the 64 species found, majority (31) were red algae, followed by 19 green algae and 14 brown algal species. In supra-littoral zone, blue green alga, namely *Microcoleus* sp. was most dominant. Earlier workers (Untawale *et al.*, 1979; Khadilkar, 1988) did not record some species, such as *Gastroclonium*, *Champia*, etc. The flora here showed a marked similarity to that of the Gujarat (Kuchchh area) coast. The average biomass estimated was 0.25 m² quadrants. The average biomass estimated was 0.430 kg m⁻². The maximum biomass belonged to *Caulerpa* sp. followed by *Hypnea valentiae*.

Fishing with gill net and rampon has been very common here. At many places, fisherfolk build stone walls to trap the fish during low tide. The local people collect oysters and clams. A large numbers of invertebrate species were observed in the intertidal region associated with marine algae. This area is dominated by the coral species *Goniopora stokesi*. There are two other coral species also growing in the intertidal zone. The corals seemed to have developed an ecological adaptation to survive in turbid as well as polluted conditions. Other common faunal species recorded were; sea anemone, sea cucumber, annelid worms, shrimps, amphipods, isopods, brittle stars, zooanthus colonies, etc.

Vikroli lies towards the western banks of the Thane creek. This area is important as a case for the conservation and management of mangrove forests in private ownership. Vikroli has about 1750 ha of mangrove vegetation owned and preserved by M/S Godrej Trust Pvt. Ltd. *Avicennia marina*, is one of the most dominant species along with *R. mucronata*, *S. apetala*, *A. corniculatum* and *A. illicifolius*. The average height ranges from 7 to 10 m. The other forms that enrich the biodiversity of Vikroli include 185 bird species, 8 prawn species, 15 crab species and 30 reptile species (Deshmukh, 1994; Kulkarni, Pers. Comm.).

The Godrej Trust has established an Interpretation centre to enhance the awareness about mangroves and the need to conserve them. A nursery has also been developed for providing saplings for afforestation. Two observation towers have been erected in this area. This is one of the best managed mangrove areas along the coast.

There are several islands present off Maharashtra coast such as Vengurla - rock islands, off Malvan, Kanderi-Underi, off Thal, etc. These islands support rich marine biodiversity as there is little pollution on these islands. Being remotely placed, less human interference has been observed. These islands are free from siltation occurring in the nearshore regions and have a less turbid and more transparent environment. All these conditions are ideal for the rich and healthy growth of intertidal and subtidal flora and fauna. These islands are also ideal for research,

education and adventure tourism. Some submerged banks with rich biota are also present along the Maharashtra coast.

Unique features were observed along the Mumbai coast. The Mumbra-Diva site had a good growth of mangrove species, *Sonneratia apetala*. The average height of the trees was 13m and the population was also highly dense. These need immediate protection.

Other Hot Spots Along the Indian Coast

Activities such as deforestation of mangrove forests, dredging of the coral reefs, and uncontrolled harvests of rare organisms by over-enthusiastic communities are the main reasons for degradation of the marine biodiversity (Dhargalkar and Untawale, 1991). Despite the over-exploitation and ever increasing pressures, some coastal areas have still retained their rich biodiversity. These sites are being identified and recommended for urgent preservation, conservation and sustainable utilization.

West Coast of India

Apart from the sites already described, Pirotan Island (Gulf of Kuchchh), is another priority coastal site.

The **Gulf of Kuchchh** lies between 22° 45' - 23° 55' N latitude and 70° 10' - 71° 58' E longitude. Apart from being a coral reserve, it is also known as the breeding ground for the Lesser Flamingo, a nesting place for Great Indian bustard, *Choriotis nigriceps* and a wintering area for waders, pelicans and ducks. The Pirotan Islands and submerged reefs display corals, giant sea anemones, sea cucumbers, gorgonians, etc. The Gulf of Kuchchh is also very rich in marine algal biodiversity and biomass. There are several commercially important seaweed species such as *Sargassum* spp., *Gracilaria* spp. etc. Some of the rare and endangered genera such as *Acetabularia*, *Neomeris*, *Halimeda* have also been reported from this region. Table 9a describes the biodiversity values of the Gulf of Kuchchh.

In Tables 9b, 9c and 9d the biodiversity and socio-economical values of other hotspots from west coast of India, namely Colab-Mumbra-Vikroli, Malvan-Achra-Deogad and Coondapur, are described.

East Coast of India

The east coast of India with the large delta formations supports large mangrove forests. The Gulf of Mannar is particularly known for its rich marine biota. Because of its high biodiversity value, the Indian National Man and Biosphere Reserves Committee declared Sundarbans and Gulf of Mannar as marine biosphere reserves in 1974 (Dhargalkar and Untawale, 1991).

Sunderbans is in the Ganga and Brahmaputra Delta (21° 30' - 22° 45' N latitude and 88° 60' - 89° 5 E longitude), an area of 9630 km² with 4264 km² under mangroves. The mangrove forest of Sunderbans is a habitat for the tiger. This is the only place in the world where the tiger shares both an aquatic and a terrestrial food web. There are 64 mangrove species and they are home for many wild, endangered and globally threatened plant and animal species. The Royal Bengal tiger, estuarine crocodiles, monitor lizard and gray water monitor (*Varanus flabescens*) are some of the wild animals found in this area. It is also a nesting place for marine turtles and marine mammals such as the Gangetic dolphin, the black finless porpoise, and the horse-shoe crab (a living fossil) are also found here.

Bhittarkanika is situated north of Mahanadi delta with mangrove forests covering the tidal islands. The largest living reptile - an estuarine crocodile *Crocodilus porosus*, which grown to be upto 5 m long, resides in this sanctuary. The most significant characteristic of this area is that Gaharimatha is a nesting site for the Pacific Ridley turtle *Lepidochelys olivacea*, which is the largest turtle in the world. This area is unique for its biodiversity values. (Dhargalkar and Untawale, 1991).

Gulf of Mannar is a shallow protected area between India and Sri Lanka (8°49' - 9° 15 N latitude and 78° 11' - 79° 15' E longitude) and is rich in marine biodiversity. About 106 coral species have been reported from this area, including branching corals *Acropora* spp. and *Montipora* spp., along with largely exploited molluscan species such as *Conus* and *Murex*. Economically important seaweed genera like *Gracilaria*, *Gelidiella*, *Sargassum* and *Turbinaria* are collected in large quantities for the phycocolloid extraction. The extensive seagrass beds are the feeding grounds for endangered species like the dugong and various turtles. The sandy beaches are nesting sites for the marine turtles.

Islands

Both the Lakshadweep archipelago and the Andaman-Nicobar group of islands are important marine areas. The Lakshadweep group of islands is formed of typical coral atolls and harbours a significant number of coral species, associated fauna and ornamental fishes. The rich biodiversity of this region includes 105 coral species, along with 78 seaweed species, 6 seagrasses, 91 sponges and 18 boring sponges (Bakus, 1994).

The Andaman and Nicobar Islands are considered to be one of the hot-spots of marine biota. These islands support both mangrove and coral ecosystems. The thick mangrove forests harbour 20 mangrove species and other rare and endangered animal species such as the estuarine

crocodile, marine frog, and turtles. Other endangered species are Andaman wild Pig (*Sus scrofa andamanensis*), crab-eating macaque (*Macaca fascicularis umbrosa*), and various species of birds. (Tikadar and Das, 1985). Most important areas are Vandoor and Narcondam.

There are about 2,900 marine animal species recorded from this group of islands (Subba Rao, 1984). Avifauna is composed of 50 species. Some of the species highlighting the rich biodiversity of the fringing corals of Andaman-Nicobar include 135 hard coral species, 251 species (22 endemic to Andaman-Nicobar) of echinoderms, 19 penaeid prawns, 4 crabs, and 6 lobster species. There are about 70 sponges, > 110 coelenterates, and 31 sea anemones (Bakus, 1994).

In Table 9e, 9f, 9g, 9h and 9i, the biodiversity and socioeconomic values of the hotspots of the east coast of India, namely Sunderbans, Bhitarkanika, Gulf of Mannar, Lakshadweep Island, and Andaman -Nicobar Islands, are described.

Conclusion and Recommendations

1. The coastal areas have greater variety of habitats than the open ocean and are subjected to greater developmental pressures and exploitation. Therefore, the conservation of the coastal habitats should have the highest priority.
2. The economic value of the coastal habitats is usually not taken into account while assessing their value. Coastal regions provides direct and indirect benefits to humankind. There are many ecological benefits, that coastal habitats provide, that need to be economically evaluated.
3. Diversity of the deep sea benthic communities and fishes in the water column is largely unknown. However, it is clear that they are a rich sources of genetic diversity.
4. It is necessary to maintain the population of various communities at an optimal level in order to sustain genetic exchange and ensure that the varieties of breeding populations are maintained to sustain natural genetic diversity.
5. In most of the developing countries the focus is on food production and on economic growth rather than on the conservation of biodiversity. Therefore, there is a need to explore the economic value and other practical benefits of conservation of biodiversity, so that policy decisions are made keeping in view the benefits biodiversity conservation offers.
6. Participation of the local people in the conservation of biodiversity is the need of the hour. It is essential to create awareness amongst coastal inhabitants about the need for the sustainable use of biodiversity.

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Table 1: Marine algal diversity of the Indian Coast

	<i>Chlorophyta</i>	<i>Pheophyta</i>	<i>Rhodophyta</i>	<i>Cyanophyta</i>	<i>Total</i>
Order	4	5	6	2	17
Families	15	12	31	6	64
Genera	45	39	120	11	215
Species	159	141	307	17	624

Table 2: Seaweed Resources available along the Indian Coast

<i>No.</i>	<i>Coastal States</i>	<i>Order</i>	<i>Family</i>	<i>Genera</i>	<i>Species</i>	<i>Production (Ton/year)</i>
01	Gujarat	15	42	105	202	100,000
02	Maharashtra	16	40	76	152	20,000
03	Goa	13	29	48	75	2,000
04	Karnataka	12	19	28	39	~100
05	Kerala	8	10	14	20	?
06	Lakshadweep Islands	13	29	51	82	70,000
07	Tamilnadu	15	45	428	302	90,000
08	Andra Pradesh	14	29	51	79	?
09	Orissa*	1	2	3	6	?
10	West Bengal	3	4	5	6	?
11	Andaman and Nicobar Islands	8	25	40	64	?

*Information available on Chilka Lake only.

Table 3: Mangrove biodiversity of India

<i>I</i>	<i>FLORA</i>	<i>Genera</i>	<i>Species</i>
1	Algae	30	47
2	Fungi	40	50
3	Seagrasses	1	2
4	Mangrove flora	41	59
5	Lichens	8	14
<i>II</i>	<i>FAUNA</i>		
1.	Crustaceans	46	82
2.	Molluscs	57	88
3.	Woodborers	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.

Table 4: Diversity of coral species along the Indian coast

<i>Area</i>	<i>Type</i>	<i>Hermatypes</i>		<i>Ahermatypes</i>	
		<i>Gen</i>	<i>Spp.</i>	<i>Gen</i>	<i>Spp.</i>
Palk Bay and Gulf of Mannar	Fringing	26	96	9	10
Gulf of Kuchchh	Fringing				
	Patchy	20	34	4	3
Andaman and Nicobar Is.	Fringing	47	100	12	35
Lakshadweep Is.	Atolls	27	69	4	9
Submerged Banks	Patchy	5	5	-	-
Central West Coast	Patchy	8	8	-	-
Indian Reefs	-	51	156	21	44

Total Genera : 71, Total Species : 200

Compiled from published reports.

Table 5: Zooplankton species distribution along the Indian coast

<i>Locality</i>	<i>Family</i>	<i>Genus</i>	<i>Species</i>
Shelf & slope waters of cochin	-	14	51
Goa estuaries	28	36	76
Godavari estuary	-	-	60
Vengurla & Karwar	23	33	90
Vengurla & Malpe	23	34	92
Goa (Coastal waters)	-	31	93
Lakshadweep	-	35	51
Bay of Bengal	-	19	28
Arabian sea	-	13	30

Compiled from published reports.

Table 6: Percentage composition of various groups of coastal and deep sea demersal fishery resources along west and east coasts of India

<i>Area: Effort (hrs/min): Composition</i>	<i>West coast 212 hrs/15 min %</i>	<i>East coast 118 hrs %</i>	<i>Andaman & Nicobar Archipelago 12hrs/40 min %</i>
Shark	0.80	1.81	2.46
Skates	0.17	1.01	0.06
Rays	0.66	2.17	9.22
Carangids	2.89	8.39	17.20
Nemipterids	28.43	26.71	1.56
Saurida spp.	3.12	0.96	2.22
Upeneus spp.	0.97	1.97	1.88
Sphyræna spp.	1.28	8.85	0.68
Priacanthus spp.	6.98	7.55	0.39
Epinephelus spp.	0.73	2.25	3.24
Lethrinus spp.	0.78	1.44	7.21
Lutjanus spp.	1.25	0.28	5.90
Lutianus spp.	0.14	0.74	-
Other perches	0.45	0.66	-
Scieanids	0.84	1.26	-
Silverbellies	0.004	1.42	29.65

Contd. ...

<i>Area: Effort (hrs/min): Composition</i>	<i>West coast 212 hrs/15 min %</i>	<i>East coast 118 hrs %</i>	<i>Andaman & Nicobar Archipelago 12hrs/40 min %</i>
Mackerel	0.23	9.38	0.47
Cat fish	2.01	1.47	-
Flat fish	0.63	0.11	-
Trichiurus spp	6.17	0.53	1.01
T. auriga	1.56	1.00	-
Chlorophthalmus spp.	10.37	-	-
Cubiceps spp.	2.14	-	-
Neopinnula spp.	1.29	-	-
Pseneopsis	10.89	0.46	-
Psenes indicus	0.21	4.96	3.04
Psenes spp.	0.12	-	-
Pipe fish	2.31	-	-
Deep sea fish	0.96	2.26	-
Other fishes	6.74	9.16	12.72
Crustaceans & cephalopods	4.39	4.25	1.08

Compiled from published data.

Table 7: Depth-wise Percentage Faunal Composition of Macro and Meiofauna

<i>Faunal group</i>	1500-1999	2000-2499	2500-2999	3000-3499	3500-3999	4000-4499	4500-4999	5000-5499	5500-5999
<i>MACROFAUNA</i>									
Polychaeta	57.2	68.6	56.2	62.2	71.0	62.5	92.2	43.4	82.2
Echiuroidea	-	1.8	-	5.4	-	10.8	-	-	-
Sipunculida	2.2	-	2.8	2.2	-	-	-	2.2	-
Cumacea	1.8	2.3	-	-	5.2	2.2	-	3.8	-
Amphipoda	12.3	8.2	6.6	10.6	9.6	6.5	-	-	6.4
Tanaidacea	8.6	4.9	2.8	-	-	4.4	-	6.4	-
Isopoda	4.9	5.2	4.3	16.4	3.2	6.5	5.2	18.6	4.4
Pelecypoda	9.4	6.2	12.5	3.2	5.2	-	-	-	-
Gastropoda	-	0.6	8.2	-	-	6.5	-	7.2	-
Ophiuroidea	1.6	2.2	4.3	-	3.2	-	-	18.1	2.6
Brachiopoda	2.0	-	2.3	-	2.6	0.6	2.6	-	4.4
Rhizopoda	-	*	-	*	*	-	*	*	-
<i>MEIOFAUNA</i>									
Nematoda	39.6	42.2	38.9	60.9	58.8	64.8	50.0	55.2	68.5
Harpacticoida	10.6	10.2	22.5	14.4	13.4	8.7	26.4	23.5	22.3
Ostracoda	8.3	12.5	3.6	2.0	16.7	8.7	-	12.8	-
Turbellaria	8.3	10.2	-	4.5	5.5	-	6.8	-	-
Kinorhyncha	-	4.5	3.6	-	-	-	4.2	-	-
Foraminifera	33.2	20.4	31.4	18.2	5.6	17.6	12.4	8.5	9.2

* gelatinous mass difficult to enumerate.
Parulekar *et al.* 1992.

Table 8: Biodiveristy Status of Feasible Sites for Marine Protected Areas

No.	Name of site	Ecosystems	Merits of sites
01	Malvan, Vengurla Rocks	Benthic, Island	<ul style="list-style-type: none"> • Naturally protected site (fort) • Total 73 marine algal species are found including some rare species • Rich algal biomass • Rich in marine fauna (Sea cucumber, sea urchin, brittle and star fish) • Rich in subtidal flora and fauna • Presence of corals and gargoniums • Turtle nesting behind the fort • Subtidal flora and fauna
02	Achra- Deogadh- Vijaydurg	Mangrove, Sand dune	<ul style="list-style-type: none"> • Well preserved sacred mangrove forests • Nursery for mangrove plantation already exists • Mangrove forests provides sanctuary for various terrestrial and avifaunal species • Sand dune vegetation
03	Ratnagiri (Along with Shirgaon creek)	Benthic and mangrove	<ul style="list-style-type: none"> • 56 marine algae are present • Diversified fauna • Well preserved mangrove forest • About 121 bird species are present around the mangrove area • Mangrove forests provides sanctuary for various terrestrial and avifaunal species
04	Mumbra- Diva, Vikroli*	Mangrove	<ul style="list-style-type: none"> • Well preserved mangrove forest of <i>S. apetala</i> • Mangrove forests provides sanctuary for various terrestrial and avifaunal species • Privately owned and conserved • Interpretation centre established • A nursery for afforestation programme
05	Colaba	Benthic	<ul style="list-style-type: none"> • Despite being in Mcgacity area, highly diversified flora and fauna • Total 64 marine algal species recorded including some rare species • Rich in biomass estimation • Fauna • Presence of corals in the intertidal zone

*Vikroli is mentioned as a special case for reference.

Table 9a: Evaluation of the Gulf of Kuchchh

<i>Evaluation category</i>	<i>Status</i>
Biogeography	<ul style="list-style-type: none"> • Fringing Corals • Only delta formation along west coast • Vast salt pans are present
Ecological status and Naturalness/ Uniqueness	<ul style="list-style-type: none"> • Largest area under mangrove along west coast of India • Extreme saline conditions in mangroves resulted into stunted growth and less species diversity • Fringing coral reef harbouring 40 coral species • Rich marine ecosystem • Highly diversified marine algal flora (>250 species) and biomass • Rare and endangered marine algae <i>Acetabularia</i>, <i>Neomeris</i> are found • Pirotan Island harbours various unique fauna including giant sea anemones, sea cucumbers, etc. • Breeding ground for Lesser flamingo and nesting for Great Indian Bustard • Wintering for various migratory birds
Socio-economical aspect	<ul style="list-style-type: none"> • Fisheries resources • Industrial development • Exploitation of corals for cement making • Eco-tourism by employing local communities
Scientific aspect	<ul style="list-style-type: none"> • Conservation and management plan • Uninterrupted scientific observations
National / International significance	<ul style="list-style-type: none"> • Pirotan Island is declared as a Marine park

Table 9b: Evaluation of Colaba-Mumbra-Vikroli site (Mumbai, Maharashtra)

<i>Evaluation category</i>	<i>Status</i>
Biogeography	<ul style="list-style-type: none"> • Corals reefs • Estuarine complex at Mumbra-Diva-Vikroli
Ecological status and Naturalness/ Uniqueness	<ul style="list-style-type: none"> • Rich marine biodiversity and highly densed coral population at Colaba • Dominant <i>Sonneratia apetala</i> forest at Mumbra-Diva • Mangrove forest provide sanctuary for many bird and wild animal species
Socio-economical aspect	<ul style="list-style-type: none"> • Mangrove forest is being utilized for firewood • Kharland / Aquaculture activities in the mangrove area • Fisheries • Development activities
Scientific aspect	<ul style="list-style-type: none"> • Interpretation centres • Conservation and management
National / International significance	<ul style="list-style-type: none"> • Marine protected areas • Unique coralline assemblage

Table 9c: Evaluation of Malvan-Achra-Deogad (Maharashtra)

<i>Evaluation category</i>	<i>Status</i>
Biogeography	<ul style="list-style-type: none"> • A 17th century 'Sindhudurg' fort is present providing natural protection to marine flora and fauna at Malvan • Mangrove forests at Achra and Deogad
Ecological status and Naturalness/ Uniqueness	<ul style="list-style-type: none"> • Rich in marine flora and fauna including 9 coral species at Malvan • Rich diversified marine algal flora • Sacred grove at Achra • Mangrove forests at Achra and Deogad sheltering many avifaunal species and wild animals • Nursery ground for prawn and fishes • Turtle nesting ground behind the fort at Malvan
Socio-economical aspect	<ul style="list-style-type: none"> • Local community depends upon the fishing activity in all the three areas • Mangrove forests provide nursery ground- aquaculture development • Tourism activity at Malvan • Development of eco-tourism
Scientific aspect	<ul style="list-style-type: none"> • Ideal site for seaweed cultivation experiments at Malvan • Uninterrupted scientific work • Conservation and management
National / International significance	<ul style="list-style-type: none"> • Marine park at Malvan • Marine protected area

Table 9d: Evaluation of Coondapur (Karnataka)

<i>Evaluation category</i>	<i>Status</i>
Biogeography	<ul style="list-style-type: none"> • Estuarine complex
Ecological status and Naturalness/ Uniqueness	<ul style="list-style-type: none"> • Diversified mangrove flora (22 species) • Nursery ground for prawns and fishes • Mangrove forests harbour many avifaunal and wild faunal species
Socio-economical aspect	<ul style="list-style-type: none"> • Human activities for development • Timber and honey collection • Aquaculture/ traditional fishing activities
Scientific aspect	<ul style="list-style-type: none"> • Ecological aspects should be investigated • Conservation and management activities
National / International significance	<ul style="list-style-type: none"> • Marine Protected Area status should be given • Marine protected area

Table 9c: Evaluation of Sundarbans (West Bengal)

<i>Evaluation category</i>	<i>Status</i>
Biogeography	<ul style="list-style-type: none"> • On the east coast, a triangular delta along the Ganga and Brahmaputra river • Covers about 9630 km² area with 4264 km² under mangrove cover
Ecological status and Naturalness/ Uniqueness	<ul style="list-style-type: none"> • Most diversified mangrove flora including some endangered species • Largest mangrove forest • Harbours many endangered species and economically important flora and fauna • Important site to preserve as gene bank • Abode of endangered animals such as salt water crocodile, olive Ridley turtle and Royal Bengal Tiger
Socio-economical aspect	<ul style="list-style-type: none"> • Supports coastal inhabitants • Produces 169000 m³ of timber • Honey collection as one of the major occupation • Fire wood and fodder • Supports local fisheries
Scientific aspect	<ul style="list-style-type: none"> • Biosphere reserve to conserve genetic diversity • Important site for biodiversity conservation
National / International significance	<ul style="list-style-type: none"> • Biosphere reserve • Unique site as tiger reserve • National Park

Table 9f: Evaluation of Bhitarkanika (Orissa)

<i>Evaluation category</i>	<i>Status</i>
Biogeography	<ul style="list-style-type: none"> • Delta of Brahmani and Baiterana river • Second largest mangrove formation
Ecological status and Naturalness/ Uniqueness	<ul style="list-style-type: none"> • Rich in biodiversity of flora and fauna • Mangrove forests covering the tidal islands • Provides shelter, feeding and breeding ground for various bird species • Nursery ground for fishes and prawns • Habitat of estuarine crocodile <i>Crocodilus porosus</i> and water monitor lizard • A living fossil 'Horse shoe Crab' is found in the mud flats • Variety of bird species are found
Socio-economical aspect	<ul style="list-style-type: none"> • Tribes sustain on fishes, crabs, etc. • Collection of honey and utilizing grass for basket making are the major occupations of tribes • Prawn farming is also being undertaken • Site provides scope for culture/education or ecotourism
Scientific aspect	<ul style="list-style-type: none"> • Conservation, management and sustainable use of the resources • Being a biosphere reserve, ideal for uninterrupted scientific research
National / International significance	<ul style="list-style-type: none"> • Wild life sanctuary • National park • Largest habitat for sea turtles and salt water crocodile

Table 9g: Evaluation of the Gulf of Mannar

<i>Evaluation category</i>	<i>Status</i>
Biogeography	<ul style="list-style-type: none"> • Chain of island formed of accumulated sand and coastal debris over dead coral core and surrounded by live fringing coral reef • Protected area between India and Srilanka
Ecological status and Naturalness/ Uniqueness	<ul style="list-style-type: none"> • Compact ecosystem with clayey and sandy substratum • Rich in marine biodiversity • Vast nursery for prawn, crab, shell fish, etc. • 106 coral species are reported • Rich in seaweed species and biomass • Seagrass beds as rich feeding ground for Dunongs and turtles • Ornamental fishes
Socio-economical aspect	<ul style="list-style-type: none"> • Rich in commercially important seaweed species that are being exploited for phycocolloids extraction (5000- 7000 tonnes/annum) • Conus, Murex and shells are commercially exploited • Rich in fisheries resources, particularly shell fishery
Scientific aspect	<ul style="list-style-type: none"> • Conservation of corals and shell fishery is important to avoid extinction • Trade in ornamental shells to be regulated
National / International significance	<ul style="list-style-type: none"> • Marine biosphere reserve • Coral reef

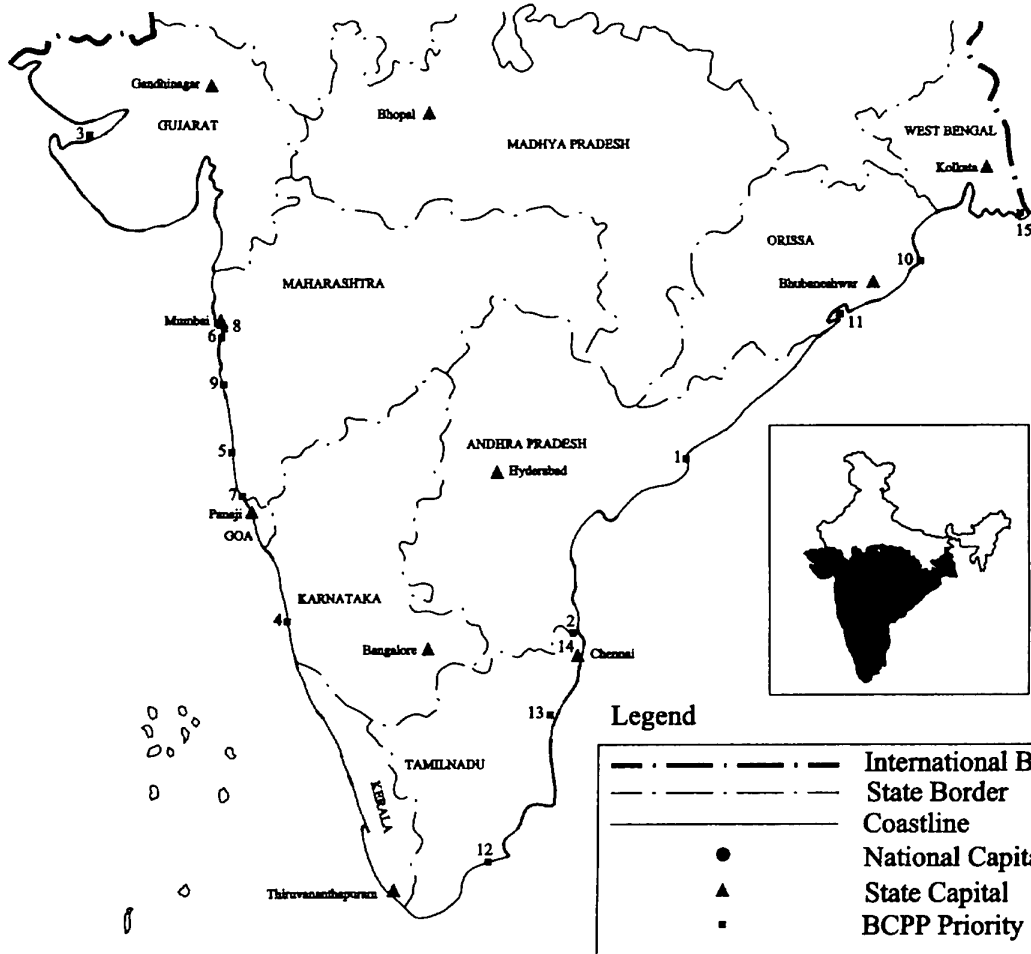
Table 9h: Evaluation of Lakshadweep Islands

<i>Evaluation category</i>	<i>Status</i>
Biogeography	<ul style="list-style-type: none"> • Archipelagos, group of islands forming atolls • Lagoon formations • Coral reefs
Ecological status and Naturalness/ Uniqueness	<ul style="list-style-type: none"> • Rich in marine biodiversity • 78 coral species, 91 sponges and 18 boring sponges • Diversified seaweed and seagrass flora with high biomass • Many coralline algae are found • Presence of Giant clam <i>Tridacna</i> sp. • Marine turtle nesting site
Socio-economical aspect	<ul style="list-style-type: none"> • Exploitation of corals for tourism and cement industries • Tuna fishery • Export of holothurians • Lobster fishery • Ornamental fish export
Scientific aspect	<ul style="list-style-type: none"> • Conservation and management • Ecotourism
National / International significance	<ul style="list-style-type: none"> • National marine park • Biosphere reserve

Table 9i: Evaluation of Andaman- Nicobar Islands

<i>Evaluation category</i>	<i>Status</i>
Biogeography	<ul style="list-style-type: none"> • Oceanic group of Islands • Coralline substrata with coral reef extending far away from shore line enclosing lagoons
Ecological status and Naturalness/ Uniqueness	<ul style="list-style-type: none"> • Rich mangrove flora (25,000 ha area under mangrove cover) harbouring several bird species and endangered wild animal species • Extensive coral reefs (135 species of hard corals) • Rich in fishery resource • 22 species of echinoderms are endemic to these islands • 50 species of avifauna • 4 turtle and one crocodile species are inhabiting • Feeding and breeding ground for many wild animals • Damage to the coral ecosystem due to oil pollution
Socio-economical aspect	<ul style="list-style-type: none"> • Inhabitants largely depend on the marine resources for their livelihood • About 50,000 to 100,000 tonnes of fishes are annually harvested from this site • Timber and honey collection from the mangrove forest
Scientific aspect	<ul style="list-style-type: none"> • Detailed information on the biodiversity of flora and fauna required to be undertaken • Southern part of islands borders a major oil tanker route from Gulf countries to far East and Japan. Monitoring of oil pollution is a must to assess its effect on the flora and fauna
National / International significance	<ul style="list-style-type: none"> • Marine biosphere reserve of India

BCPP PRIORITY SITES ALONG THE COAST OF THE INDIAN MAINLAND



ANDHRA PRADESH	KARNATAKA	MAHARASHTRA	ORISSA	TAMILNADU	WEST BENGAL
1 - Coringa Sanctuary	4 - Kundapur	5 - Achara, Deogad and Vijaydurg	10 - Bhitarkanika Sanctuary	12 - Gulf of Mannar Marine National Park	15 - Sundarban National Park
2 - Pulicat Lake Sanctuary		6 - Colaba	11 - Chilika Lake	13 - Kaliveli Tank	
3 - Gulf of Kachhbh Marine National Park and Sanctuary		7 - Malvan (Marine) Sanctuary		14 - Pulicat Lake Sanctuary	
		8 - Mumbra-Diva, Vikroli			
		9 - Ratnagiri			

The sites shown in this map include sites prioritised by Dr. Untawale and Dr. Kanwade

MAP PREPARED BY THE INDIAN INSTITUTE OF PUBLIC ADMINISTRATION