
Marine Protected Area Needs in the South Asian Seas Region Volume 2: India

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Marine Protected Area Needs in the South Asian Seas Region Volume 2: India

**Edited by John C. Pernetta
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Contents

Contents	v
Acknowledgements	vii
1. General Description	
1.1.1. Geography & Geology	1
1.1.2. Climate	2
1.1.3. Coastal and off-shore topography	2
1.1.4. Oceanographic features	6
2. Marine and Coastal Ecosystems	
2.1.1. Mangroves	9
2.1.2. Marshes and wetlands	11
2.1.3. Coral reefs	12
2.1.4. Seagrasses and algal communities	14
2.1.5. Beaches	14
2.1.6. Islands	16
3. Economic Aspects of Marine and Coastal Resource Use	
3.1.1. Fisheries	17
3.1.2. Aquiculture	19
3.1.3. Other living marine resource exploitation	19
3.1.4. Mangrove exploitation	21
3.1.5. Non-living marine resource use: minerals and sands	21
3.1.6. Coastal tourism	22
4. Conservation Issues and Problems	
4.1. Habitat degradation and destruction	23
4.1.1. Mangroves	23
4.1.2. Coral reefs	24
4.1.3. Sea level rise and coastal erosion	25
4.1.4. Overfishing	25
4.1.5. Pollution	25
4.1.6. Coastal tourism	25
4.2. Species of conservation concern	26
4.2.1. Mammals	26
4.2.2. Birds	29
4.1.3. Reptiles	31
4.1.4. Amphibians	35
4.1.5. Fish	35
4.1.6. Invertebrates	35
4.1.7. Plants	37

5.	Environmental and Conservation Legislation	39
6.	Institutional Infrastructure	41
	6.1.1. Governmental Organisations	41
	6.1.2. Non-governmental Organisations	43
	6.1.3. Universities	44
7.	Conservation and Environmental Management Activities	
	7.1.1. Current research	47
	7.1.2. Coastal zone management	48
	7.1.3. Existing protected areas	48
	7.1.4. Mangrove management and protection	53
8.	Recommendations for Future Action	
	8.1.1. Proposed protected areas	55
	8.1.2. Species protection	59
	8.1.3. Mangrove conservation and management	60
	8.1.4. Other recommendations	61
9.	References	63

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1. General Description: India

1.1.1. Geography and Geology:

Area:	2,973,190 km ² ;
Coastline:	12,700 km;
EEZ:	2,014,900 km ² ;
Continental shelf:	452,100 km ² ;
Population:	853,400,000 (1987).

The mainland coastline of India is remarkably unindented and is generally emergent. However, the edge of the continental shelf is strongly asymmetrical, being broad off the Ganges Delta, but extending to only 30-35 km off-shore from the other major river deltas. It is widest off the Gulf of Khambhat (Cambay) on the west coast where it reaches 400 km. In the west, the slope is extremely gentle, and the substrate near shore is generally sand, covered with mud (Ahmad, 1982a), while to the east sediments are dominated by clay. There are three groups of islands, the chain of atolls comprising the Lakshadweep in the southern Arabian Sea and the Andaman and Nicobar Island groups in the eastern Bay of Bengal.

The Deccan, the southernmost section of the Indian peninsula is a large, triangular plateau of Cambrian rocks which slopes gently northeastward from the Western Ghats. These fall steeply 900 metres down to the narrow coastal strip on the west coast. Three principal river systems, the Kaveri, the Godavari and the Krishna, flow eastward across the plateau through an arid landscape of poor savanna which results from the rain shadow of the Western Ghats. In contrast the west coast is covered with luxuriant tropical vegetation and the rivers form short torrents. The two coasts are markedly different in their geomorphology. The west coast is generally exposed, with heavy surf and rocky shores and headlands; the east coast is generally shelving with beaches, lagoons, deltas and marshes, and is relatively low lying with extensive alluvial flood plains and deltas. The major rivers flow into large deltaic rice lands where few remnants of the original landscape remain. There are several coastal lagoons, Chilka Lake and Pulicat Lake being the two largest. Some excellent areas of mangrove forest remain in the Kaveri Delta; around Coringa in the Godavari Delta; at Bhitarkanika; and, in the Sundarbans.

Under the biogeographic classification drawn up by the Wildlife Institute of India (GOI, 1982; Rodgers & Panwar, 1988), a distinction is drawn between the islands and the mainland coast. The islands are divided into three provinces representing the three main island groups; and the mainland coast is divided into two provinces, east and west, the dividing point being at Kanya Kumari. Under this scheme the coast is defined as all areas of marine influence, including the area within one kilometer of the salt zone. Some of the other provinces such as the Malabar Plain are relevant to this review if the definition of the coastal zone is taken as being broader than this.

1.1.2. Climate

Stretching for some 3,000 km from 8°N to 35°N, India is subject to a great variety of climatic conditions. In all regions the seasonal winds and associated rainfall patterns are dominated by the subcontinent's location between the vast continental land mass of Asia to the north and the tropical Indian Ocean to the south. Essentially there are two monsoon seasons and much of the country receives the majority of its rainfall between June and October (southwest monsoon). Rainfall is unequally distributed, with over 4,000 mm in Bengal, on the west coast, but insufficient for agriculture without irrigation over most of the Deccan plateau and from Gujarat northward. Much of the country is therefore semi-arid with frequent periods of drought; areas with average annual rainfall receive between 500 mm and 1,000 mm. Linked with this variability is the temporal unreliability of the rains which in many years start late and finish early causing a pronounced deficiency in soil moisture for the dry winter season that follows.

Rainfall is heaviest over most of India in June/July as a consequence of the southwest monsoon. However, the southeast (including the Tamil Nadu coast), with an annual average rainfall of 900 mm, has most rain in the last few months of the year. This is sufficient to lower the surface salinity of the sea to 25‰ in January, despite the absence of any important river systems in the region (Couper, 1983; Pillai, 1971a; Stoddart & Fosberg, 1972). At the end of the year, cyclones develop in the Bay of Bengal which affect reefs in this region, particularly those of Palk Bay. The Andamans and Nicobars are also affected by the southwest monsoon and cyclones. Lakshadweep is affected by both the southwest and northeast monsoons and has an annual rainfall of about 1,500 mm accompanied by strong winds. The Gulf of Kutch, in contrast, is semi-arid. In the extreme south, the annual range of temperature is only 20°C

1.1.3. Coastal and off-shore topography

Gujarat

The most northwesterly state has a coast which is characterized by a wide continental shelf, high salinity and few major rivers or estuaries (Dwivedi, 1989). The peninsulas of Kutch and Saurashtra are almost separated from the Deccan Plateau by the Gulf of Khambhat (Cambay) and were formerly isolated as islands by the Arabian Sea. A combination of tectonic uplift, silt deposition by the Indus, and aeolian input has caused the marine recession.

The Kutch peninsula comprises the large coastal wetlands and vast saline flats of the Great and Little Rann. The modern Great Rann is now flooded only between May and October, when seawater driven by high winds and tides from the Arabian Sea and monsoon runoff from the hills mix together over the plains. Throughout the rest of the year, the area is a sun-baked mud and sand expanse with halite and gypsum efflorescences. At its western extremity it merges into the southern part of the Indus Delta, in a region of numerous low-lying muddy islands, tidal creeks, mangrove swamps and extensive intertidal mudflats (Scott, 1989). It is linked by a narrow channel to the Little Rann which in turn is linked to the Gulf of Khambhat through a marshy depression in which Nalsarovar Lake survives as a freshwater remnant of the inland sea that once covered all three areas (Mohauti *et al.*, 1988). This region is distinctly arid. The Little Rann is also a flat saline plain and during the southwest monsoon large areas are inundated by up to two metres of water, much of which is pushed up from the Gulf of Kutch by strong westerly

winds. Grassy 'bets' in the Ranns are not strictly coastal but support considerable wildlife, such as blackbuck and the wild ass. The Kutch peninsula also has several small estuaries along the south and west coasts and a few larger areas of saline and brackish marshes.

The Gulf of Kutch is a large inlet of the Arabian Sea, covering 7,350 km², about 60 km wide at its widest and tapering northeastward for 170 km, with a maximum depth of 60 m. Most of the coast of the Gulf is criss-crossed with mangrove lined creeks, the intertidal zone being sandy or muddy, or of exposed limestone. A vast area of intertidal mudflats, salt marshes and seasonally inundated coastal flats extends northeastward along Wagardhrai Creek which connects with the Little Rann but detailed information on this area is lacking. There are several towns along the southern edge of the Gulf which exert a considerable influence on it. Tidal range is large and there are no large river inflows so there is little sedimentation.

The west coast of the Saurashtra peninsula, which lies between the Gulfs of Kutch and Khambhat, is straight and subject to continuous erosion. The tidal barrier formed by the Gulf of Kutch prevents outflow and sediment from the Indus River flowing along this coast (Nair, 1984). The Gulf of Khambhat, which covers an area about 400,000 ha, has an extensive area of estuarine habitat around its periphery. The Tapi, Marmada, Mahi, Sabarmati and several other rivers have deposited large volumes of alluvium which together with the marine recession have resulted in Saurashtra being joined to the mainland of Gujarat. Large quantities of silt are still being deposited and there are extensive areas of intertidal mud and sandflats, coastal salt marshes and degraded mangroves especially in the deltas of the Mahi and Sabarmati (Scott, 1989). There are several mud islands north of Bhavnagar and at the mouth of the Narmada but these may be covered at high tides. Rocky, mile long Piram Island lies at the mouth of the Gulf. Tidal range is about 40 ft, and the Gulf receives the full force of monsoon waves so that there is little shelter for marine life, unlike the Gulf of Kutch.

Maharashtra

A discontinuous series of fertile alluvial fans separated by mountain spurs stretches south from Maharashtra to Cape Comorin in Tamil Nadu. There are headlands of basalt rock, small beaches, and off-shore islands and overall the coast is exposed. The coastal zone of Maharashtra covers an estimated 800 km² and has a varied topography with mangroves, raised coral and sandy beaches. There is a narrow continental shelf and no upwelling. The area around Bombay is highly degraded (Dwivedi, 1989; Rodgers & Panawar, 1988).

Goa

This tiny state has an estimated 30km² of coastal zone (0.8% of the State). The coastline is varied with a large estuarine area, the Mandovi estuary, on the north shore of Dona Paula Bay, with raised limestone and mangrove islets and extensive intertidal mudflats and sandy beaches, now intensively developed for tourism (Rodgers & Panawar, 1988; Scott, 1989).

Karnataka

The coasts of Karnataka and Kerala have a narrow continental shelf with strong upwelling and mud banks. Fast flowing rivers descending from the western Ghats to the Arabian Sea slow down as they reach the coast and spread out into wide estuaries and lagoons with extensive mudflats and many small patches of mangrove forest, such as the series of small estuarine

systems along the 150 km stretch between Coondapur and Karwar. Much of the intervening coastline is sandy beach backed by coastal dunes with some short stretches of rocky shore.

Kerala

The coast from Kerala south to Cape Comorin is known as the Malabar coast and consists largely of sand beaches backed by plantations of coconuts, cashews and hit. The coastal zone of Kerala (around 700 km²) is backed by the Nilgiri and Anamalai Hills (Nair, 1987). The coastal plain is abundantly watered by the rivers rising in the western Ghats. The coast, exposed to heavy surf in many areas, is largely degraded with long continuous rocky and sandy shores, broken by small creeks with remnant mangrove scrub, and an intensively exploited and polluted internal lagoon system protected by seaward sandbars. Despite a long history of exploitation, some of these lagoons retain an estuarine fauna of some significance.

Tamil Nadu

The southern coast of Tamil Nadu has a very narrow continental shelf, with high salinity, a rocky shore and strong wave action. There are mangroves, sandy beaches, mudflats, coral reefs and seagrass beds and the geomorphology has been well studied (Loveson & Rajamanickam, 1989). The Gulf of Mannar and Palk Strait are fairly sheltered waters owing to the presence of numerous bays, islands and the Cauvery Delta. These two bodies of water are separated by the Mandapam peninsula, Rameswaram Island and the Talaimannar Islands. The Rameswaram coast is being mapped using remote sensing (Franklin *et al.*, 1989). The Gulf of Mannar has a line of low islands running parallel to the coast from Tuticorin to the Mandapam peninsula. There are four main groups of islands, the Tuticorin group lying in Tirunelveli District and the other three in Ramanathapuram District, details of which are given in UNEP/IUCN (1988). Raised reefs at Ramanathapuram have been described by Stoddart & Pillai (1972) and the Yedanthittu estuary is described by Pieter (1985).

A broad ridge at least 6 km wide and only about 5 m deep lies between the coasts of India and Sri Lanka, the maritime distance between the two countries being only about 30 km. Numerous rocky islets making up Adam's Bridge lie scattered along the ridge; these are very arid and have well developed dunes on their south facing coasts.

Further north on the east coast is the great Vedaranyam Salt Swamp which stretches 50 km east to Point Calimere and is bounded to the south and east by Palk Straits. The eastern shore is flat and sandy, and the sea is very shallow. The swamp itself comprises a vast area of open mudflats and lagoons behind a long sand bar breached at various places by tidal channels. The Coromandel coast from Cape Comorin to Lake Pulicat is 20-300 km wide and is being mapped using Landsat imagery (Ramasamy *et al.*, 1989).

Andhra Pradesh

The northeast coast of India bordering Andhra Pradesh, Orissa and West Bengal is mainly estuarine with a very high riverine silt load and large inputs of freshwater during the monsoon months. Andhra Pradesh has, an estimated 2,000 km² of coastal zone (170 of the State). Pulicat Lake, on the border with Tamil Nadu, is a vast brackish to saline lagoon of around 72,000 ha which includes 20,000 ha of swamps to the north. 46,000 ha of the lagoon is located in Andhra Pradesh and 6,000 ha in Tamil Nadu and it is separated from the sea by Siharikota Island to

the east. It has two large islands, Irrukam and Venadu, and several smaller islands in the northern part. The southern coast of the state has pockets of dry evergreen forest, perhaps the most threatened of all India's forest types and the coastal deltas have some remaining mangroves. The Godavari estuary and Delta are bounded to the north by Godavari Point, a peninsula 20 km long enclosing Kakinada Bay (11,000 ha). The southernmost of the delta's principal channels links up with the Krishna Delta which divides into three major channels. Much of the western portion of this deltaic system has been reclaimed for agriculture, but some mangroves remain in the east.

Orissa

The coastal zone of Orissa covers unestimated 1,800 km² and includes the important mangroves of the Mahanadi Delta; sandy beaches important for olive ridley nesting, especially the 35 km long Gahirmatha Beach; and a major waterfowl wintering ground at Lake Chilka (Chilika), which is a shallow brackish lake of about 116,500 ha (the largest in India) separated from the Bay of Bengal by a long sandy ridge. Vegetation mapping has been carried out in the Mahanadi, Brahmani and Baitarani Deltas using photographs taken in the course of the Indo-USSR joint manned space mission (Bardhan, n.d.).

West Bengal

Most of the West Bengal coast consists of the Sundarbans, which cover the area from the Hooghly-Matlah estuary east to the Bangladesh border. The Indian portion of the Sundarbans (about 40% of the total) lies at the apex of the Bay of Bengal and covers about 450,000 ha of which mangrove makes up 200,000-300,000 ha, covering the outer portion of the Ganges/Brahmaputra Delta. A large area of saline lagoons, ponds and brackish marshes lies at the head of the Matlah waterway on the southeastern periphery of Calcutta (Salt Lakes Swamp), some 7,000 ha of the original area (c. 12,000 ha) has been reclaimed (Scott, 1989). Vegetation in the Ganges, Haldi and Subamarekha Deltas has been mapped and described in numerous publications (Bardhan, n.d.; Mukherjee, 1975).

The Ganges flows for 2,525 km from Gangotri in the Himalayas to the mouth, Ganga Sagar. 43% of the total irrigated land in India is located in the Ganges basin and uses the waters of the Ganges and its four major tributaries, the Yamuna, Ghagra, Kosi and Gandak, which provide 60% of the Ganges water.

Andamans and Nicobars

The Andaman and Nicobar Islands are emergent remnants of a Tertiary mountain chain, the Andaman Ridge, (Ahmad, 1982a) and are located off the Asian continental shelf in the Bay of Bengal between India and Myanmar. There are about 500 islands, islets and rocks in the Andamans, the largest of which are mountainous reaching altitudes over 500 m. Several are forested and about 21 are inhabited (Menon & Bagla, 1989). Barren and Narcondam Islands to the east are volcanic and isolated. The Nicobars comprise about 20 islands. Until recently the Andamans and Nicobars had been relatively untouched by environmental degradation, being lightly settled (Cipriani, 1969). Much of their extensive mangrove forest remains relatively undamaged.

Lakshadweep

The Lakshadweep archipelago lies on the northern part of the Laccadive-Chagos Ridge and is

the second largest group of atolls in the Indian Ocean. The 11 major atolls and five submerged banks arising from this volcanic basement lie well outside the Indian continental shelf UNEP/IUCN (1988) and support about 25 islands (Mukherjee & Rae, 1970). These are divided into two main groups, the Amindiv Islands to the north which have five inhabited islands, and the Laccadive or Cannanore Islands to the south with four inhabited islands. The southernmost atoll, Minicoy, is separated from the others by the Nine Degree Channel. The islands are generally narrow and arcuate and situated on the eastern rims of the atolls, with an average altitude of 3-5 m. Lagoon depth is about 3-5 m, and the outer slopes of the atoll drop steeply to depths of several hundred metres (UNEP/IUCN, 1988). Submerged terraces and storm beaches in the Lakshadweep archipelago are described in Siddiquie (1975; 1980).

1.1.4. Oceanographic Features

To the west of the Indian subcontinent oceanic conditions are dominated by the monsoon surface current reversals characteristic of the northern Indian Ocean and Arabian Sea. To the east the high runoff entering the Bay of Bengal dominates the ocean water conditions and again surface currents are driven by the monsoon winds.

In the northern Indian Ocean sea surface temperatures to 10 m depth range from 21- 24°C in February to 28- 30°C in June/July. Tides are mixed, semidiurnal with two highs and two lows every day. Tidal range in areas such as the Gulf of Kutch may be as high as 12 m, decreasing as one passes south. Average salinity values for the Arabian Sea are 34-37 ‰ while salinity in the inshore waters may be higher in backwaters and tidal creeks, and much lower in areas of high freshwater input. Upwelling of nutrient-rich cool water does occur along the Karnataka and Kerala coastlines, and in general the eastern coast is subject to high wave action for much of the year.

During the southwest monsoon and for a period before and after, currents in the Arabian Sea are clockwise. Currents are reversed for a shorter period of 2-4 months during the northeast monsoon, when winds are from the northeast. At this time the Somali current flows northwest up the African coast and then eastward along Arabia, Pakistan and northwest India (UNEP, 1986).

Further south in the vicinity of the Laccadives, Maldives and southwest Indian coast hydrographic conditions are characterised by a seasonally fluctuating mixed layer of relatively saline water from the Arabian Sea (around 36‰) and less saline water from the Bay of Bengal (around 34‰). In the insular area surface temperatures vary between 28 and 29°C with a slightly decreasing gradient from south to north. A rapid downward decrease in temperature to below 20°C occurs at around 90-100 m depth. Salinities to 500 m depth fall within the range 35-36‰, and at 500 m the oxygen content is generally around 1.2 ml l⁻¹

In contrast the Bay of Bengal has an unusually large seasonal fluctuation in salinity and in mean sea level; the average sea level in the northern Bay of Bengal during March is about 94 cm lower than in September. The dominant semi-diurnal tidal range increases northwards as one passes from the Indian border towards the Meghna estuary where it reaches a maximum (5 m). In the north, the spring tidal range can exceed 6 m at equinoxes because of the shallowness and funnel

effect of the Hatiya River (ESCAP, 1988). In the Sundarbans, the tidal pattern is semi-diurnal with a maximum amplitude of 3 m during spring tides. Tidal range decreases as one passes southwards towards the tip of India with ranges becoming less than one metre.

Salinities vary widely at different sites and at different times of year. In general, salinity increases north to south, and is highest from February to April when freshwater inflow is at its lowest. Coastal water salinity falls abruptly in June with the onset of the rainy season.

Surface currents tend to follow the monsoon winds. For several months at the end of each year currents come from the northeast, the Bay of Bengal and along the coast of India, rather than from the open ocean.

Marine Protected Areas Needs in the South Asian Seas Region: India

2. Marine and Coastal Ecosystems

2.1.1. Mangroves

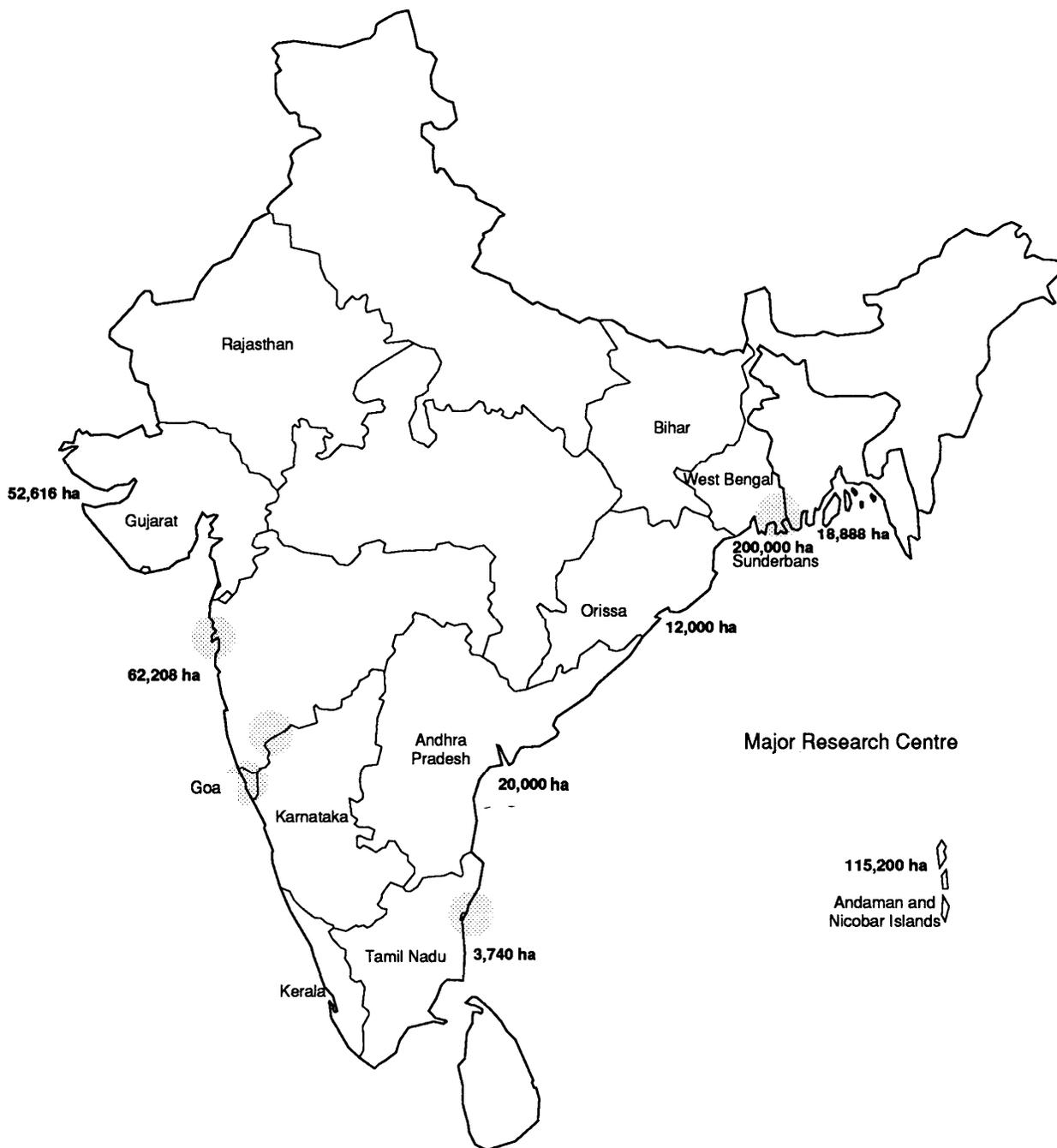
Mangrove habitat is extensive and profuse, although many of the mangroves themselves have been destroyed (Anon, 1979; Blasco, 1975; Champion & Seth, 1968; GOI, 1987); the Sundarbans and the Andamans and Nicobars are particularly important (UNEP, 1985). Although mangroves in the Sundarbans, and to a certain extent those in the Andamans and Nicobars, have received considerable attention, mangroves elsewhere such as those in the Godavari-Krishna Delta; Mahanadi Delta; Cauvery (Kerala coast); Karwar Goa; Bombay; Gulf of Khambhat; and, the Gulf of Kutch, have not been well studied.

Various estimates have been made of the total area. Mathauda (1957), Waheed Khan (1957) and Sidhu (1963) produced rather similar estimates of 1,402,940 acres (567,750 ha), 1,548,480 acres (626,650 ha) and 679,976 ha, respectively including open water areas and denuded mudflats. In the mid 1970s, Blasco (1977) estimated that the total area of mangroves had been reduced to some 356,500 ha, nearly 85% of which was in West Bengal and the islands in the Bay of Bengal. This figure remains the most widely accepted, and has been followed by Untawale (1987) in his recent review of the status and management of mangrove ecosystems in India. However, a Pre-investment survey of forest resources in the early 1980s estimated that the area covered by dense tree or shrub formations was only 96,000 ha (FAO, 1984). Bhosale (1987) gives the following figures: Kutch 52,616 ha; Maharashtra 62,208 ha; Cauvery 3,740 ha; Krishna - Godavari 20,000 ha; Mahandi 12,000 ha; Sundarbans 200,000 ha; Andamans and Nicobars 115,200 ha; total 465,764 ha. UNEP (1985) gives the following breakdown by state: Gujarat 52,616 ha; Maharashtra 62,208 ha; Goa 2,000 ha; Karnataka 1,000 ha; Kerala less than 100 ha; Tamil Nadu 2,640 ha; Andhra Pradesh 18,424 ha; Orissa 12,000 ha; West Bengal 418,888 ha; Andamans and Nicobars 115,200 ha; total 681,976 ha (Figure 1).

Mangroves in the Great Rann are mostly poor and disturbed; the dominant species is *Avicennia alba*. There is considerable mangrove in the Gulf of Kutch from Okha to Navlakhi and from Mandvi-Mundrato Jakham, and of the estimated 53 to 57 thousand hectares, 3,000 ha are within the National Park and Sanctuary (Anon, 1985a; Scott, 1989). These mangroves are described by Chavan (1985) and Rashid (1985). The dominant species is *Avicennia marina* but good mangrove now only remains on four islands: Ajad, Bhaidar, Pirotan and Kharachusa and in a small area on the mainland near Okha which is protected by sacred traditions. There were formerly extensive tracts of mangrove in the Gulf of Khambhat but now there are probably less than 20,000 ha (Scott, 1989).

Some mangrove forest occurs along the northern coast of Kamataka, in the Kalinadi, Gangivali and Agnachini estuaries and at the confluence of the Chakra Nadi, Kollur and Haladi Rivers near Gangolli. There has been some planting of mangroves to prevent erosion and Untawale & Wafar (1985) recommend an extensive programme of afforestation to be initiated in all estuaries. There has been some mapping by remote sensing of mangroves in Goa (Untawale *et*

Figure 1.
Extent of mangroves and location of major research centres in India
(Bhosale, 1987)



al., 1982). There are still some areas of mangrove around Bombay and in the Kerala backwaters but these are much degraded.

Mangroves occur in Tamil Nadu around the Vedaranyam Swamp (Scott, 1989), on uninhabited islands (Loveson & Rajamanickam, 1989), and on a number of islands such as Shingle, Krusadai, Pullivalel and Poomarichan, off the Rameswaram coast (Silas *et al.*, 1977). Genera found here include *Schizophora*, *Avicennia*, *Bruguiera*, *Ceriops* and *Lumnitzera* (Franklin *et al.*, 1989). In Andhra Pradesh, the main mangrove area is located in the Godavari and Krishna Deltas. Although the total area of these mangroves is now probably only 10,000 ha, the forests are unique for their stands of *Sonneratia apetala* and *Avicennia*. The Krishna mangroves have been studied by Prasad (1987). In Orissa, mangroves are found in the Mahanadi Delta and in Bhitarkanika Wildlife Sanctuary.

The Sundarban mangroves are the most extensive in India with all species recorded from India being found in this area. However the forest is now largely confined to a number of islands east of the Matlah River (Scott, 1989). *Heretierafomes* used to be the most common species but the reduction in freshwater inputs has resulted in its replacement by species of Rhizophoraceae. Some information is available on the molluscs of the mangroves (Subbarao *et al.*, (1983).

Ranganath *et al.* (1989) used satellite data to map mangrove distribution in eight islands in the Middle Andamans (Havelock, Peal, Nicholson, Wilson, John Lawrence, Henry Lawrence, English and Outram Islands). Mapping of mangroves in this way has also been carried out in the Andamans and Nicobars by NARESA (1988). Bagla & Menon (1989) give a figure of around 66,261 ha of mangrove in the Andamans and Nicobars; further information is provided in Rajagopalan (1987), Singh *et al.*, (1986) and Dagar (1987).

The mangroves of Pitchvaram are described by Krishnamurthy (1983) and the molluscs of this system have also been studied in detail (Kasinathan & Shanmungam, 1988). The chank *Xancus pyrum* occurs in the Rameswaram area and is an important economic species. Chakrabarti (1978-79) and Silas (1986) have reviewed the fisheries resources of the Sundarbans mangroves and the relationship between floral and faunal diversity (Chakrabarti, 1984), while Samant (1985) provides details of the avifauna of mangroves around Ratnagiri.

2.1.2. Marshes and wetlands

Swampy deltas are common (Champion, 1983; Biswas, 1976). About 134 brackish and 19 coastal wetlands have been identified (Daniel, 1985; Gopal *et al.*, 1982; Varshney, 1987). Recent estimates of the total area of wetlands without mangroves in India include the following coastal areas:

Brackish water suitable for fish culture	2,000,000 ha
Estuaries	3,900,000 ha
Back waters	3,540,000 ha

Dehadrai (1986) estimated the total inland fishery resources to include about 0.9 million ha of brackish water and mangrove swamps. Several coastal lakes such as Chilka Lake have been well

studied. This lake is designated as a MAB site and consequently much is known about its ecology and environment (e.g. Asthana, 1979; Banerjee & Raychoudhery, 1971; Patnaik, 1971; Rajan, 1971).

2.1.3. Coral reefs

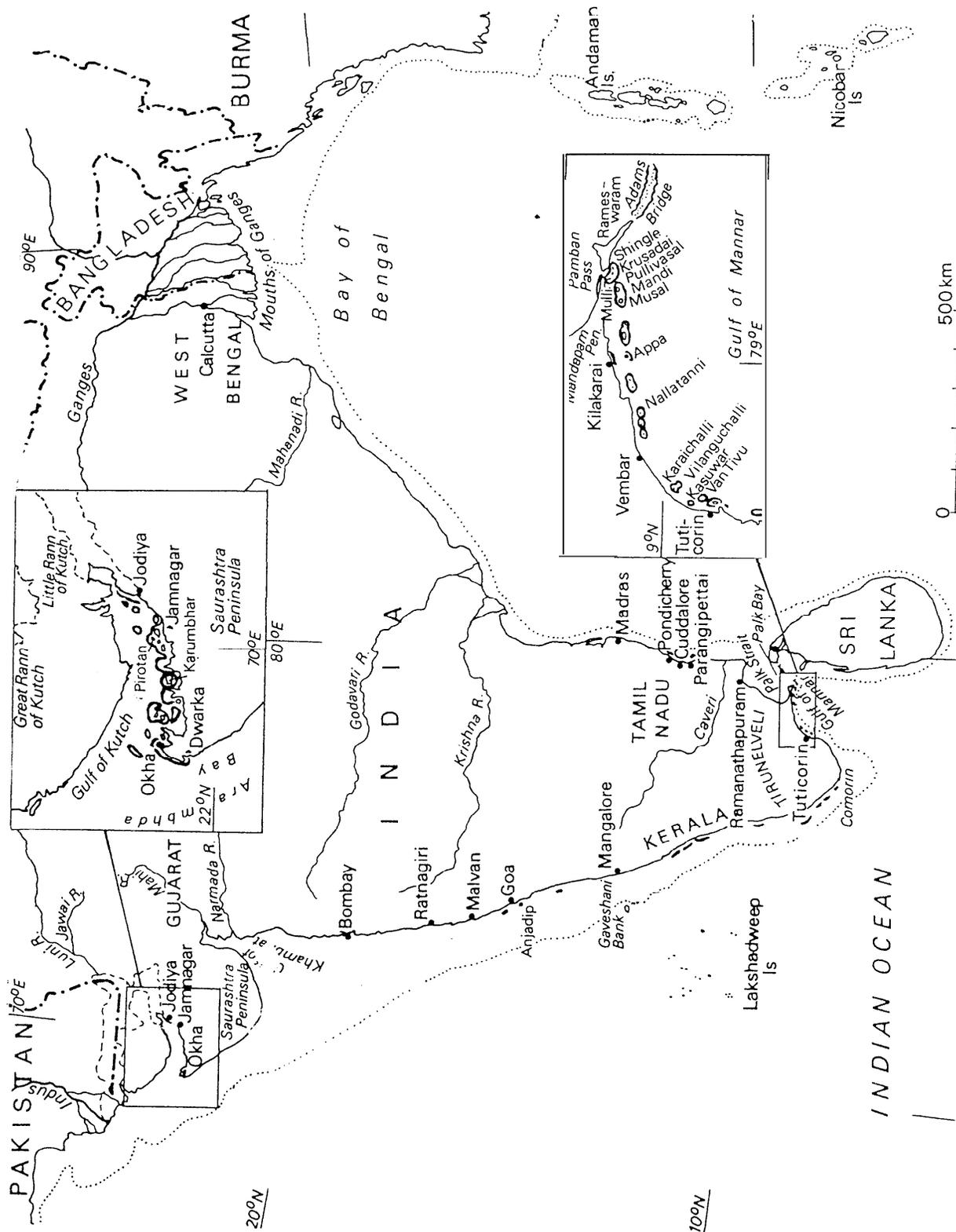
Despite the vastness of the Indian subcontinent and the warm temperature of its coastal waters, coral reefs are present on only a few widely scattered parts of the mainland coast: the Gulf of Kutch in the northwest; off the southern mainland coast; and around a series of small islands opposite Sri Lanka (Figure 2). This is principally due to the presence of major river systems and the sedimentary regime on the continental shelf. The reefs off the mainland coast and on nearshore islands are mainly fringing and, apart from a few areas, are still poorly known.

The Gulf of Kutch has many islands on its southern side around which are shallow reefs, often backed by mangroves. These are the most northerly reefs in the Indian Ocean (Patel, In press). The marine fauna of the Gulf is described in Gideon *et al.*, (1956) and Menon *et al.*, (1961). The extent and variety of reefs has declined over the recent geological past as tectonic uplift has diverted the flow of the Indus away from the Gulf of Kutch and caused marine regression. Corals are most extensive in the western part of the Gulf especially near Poshitra Pt and on Boria Reef. Coral cover can be high although most areas tend to be comprised of patchy coral growth on sandstone and banks rather than occurring as true coral reefs (Pillai *et al.*, 1980). Coral growth is mainly found in areas of strong current, because of the comparatively high turbidity which is however much lower than in the Gulf of Khambat owing to large tidal range and flow. Coral reefs are not known from the Gulf of Khambat, as a result of excessive suspended sediments, although Scott (1989) reports reefs around small islets in the western part of the Gulf. Geological aspects of the Kutch Reefs are described in Mohanti *et al.* (1988); corals are described by Patel (1985a).

Qasim & Wafar (1979) recorded coral patches in the intertidal regions of Ratnagiri, Malvan and Redi, south of Bombay. Eight genera were recorded and *Porites* was dominant at "all three sites, followed by *Goniastrea* and *Pseudosiderastrea*. Ramose forms with small polyps were totally absent. These coral communities are of particular scientific interest since they survive low salinity during the monsoon months of June-August (20-25‰), very high turbidity, silting and strong wave action (Wafar, 1986). About 100 km off the west coast, off Mangalore, is the Gaveshani Bank (13024 'N, 73045 'E) at 38m depth. Several corals have been recorded from the Bank and the genera *Porites* and *Cyphastrea* are common between the Bank and the mainland coast (Nair & Qasim, 1978). Corals also occur on the east coast between Parangipettai (Porto Novo), south of Cuddalore (1 0050'N, 79080 'E) and Pondicherry but these communities have not been surveyed (Ramaiyan & Adiyapatham, 1985).

Reefs at the southern tip are among the most well known. Palk Bay has a long fringing reef and the small islands of the Gulf of Mannar are surrounded by numerous fringing and patch reefs which extend as far south as Tuticorin. Corals in this area are much more diverse than further north. Reefs south of Adam's Bridge and in the Gulf of Mannar tend to be better developed than to the north and in Palk Bay. There are numerous publications on the reefs of this area (Pillai, 1967a; 1967b; 1967c; 1969; 1971a; 1971b; 1972; 1973; 1977; Rajendran & David, 1972;

Figure 2.
Coral reef areas on the mainland coast of India (UNEP/IUCN, 1988)



Venkataramanujam *et al.*, 1981; Reddiah *et al.*, 1974; Mahadevan & Nayar, 1972; Mergner & Scheer, 1974; Reddiah, 1970; Balasubramaniam & Wafar, 1974). Further information is given in UNEP/IUCN (1988).

Reefs in the Andamans and Nicobars are mainly fringing with some patch reefs (Figure 3). There is a 320 km barrier reef along the west coast of the Andamans with a 4 m deep lagoon (Sewell, 1935). Reef flats in the Andamans are about 500 m wide, but reach 1,000 m in width in the Nicobars (Bagla & Menon, 1989). Further descriptions can be found in Eibl-Eibesfeldt (1966); Hass, 1965; UNEP/IUCN (1988); Reddiah (1977); and, Wafar (1986). The reefs of Lakshadweep are considered to be prolific but ecological and descriptive information is very scarce (UNEP/IUCN, 1988).

A total of 342 species of coral in 76 genera were recorded in India (Pillai, 1972), 32 genera from Minicoy, 34 from Palk Bay and the Gulf of Mannar, 31 from the Andamans, 9 from Lakshadweep and 42 from the Nicobars. More recent studies include Pillai (1983a; 1983b), Scheer & Pillai (1974) and Scheer (1960; 1971; 1984). Bagla & Menon (1989) give a total of 59 coral genera from the Andaman and Nicobars, with 110 species of stony corals and 25 soft corals, and state that the Nicobars have richer coral growth and fauna than the Andamans.

2.1.4. Seagrass beds and algal communities

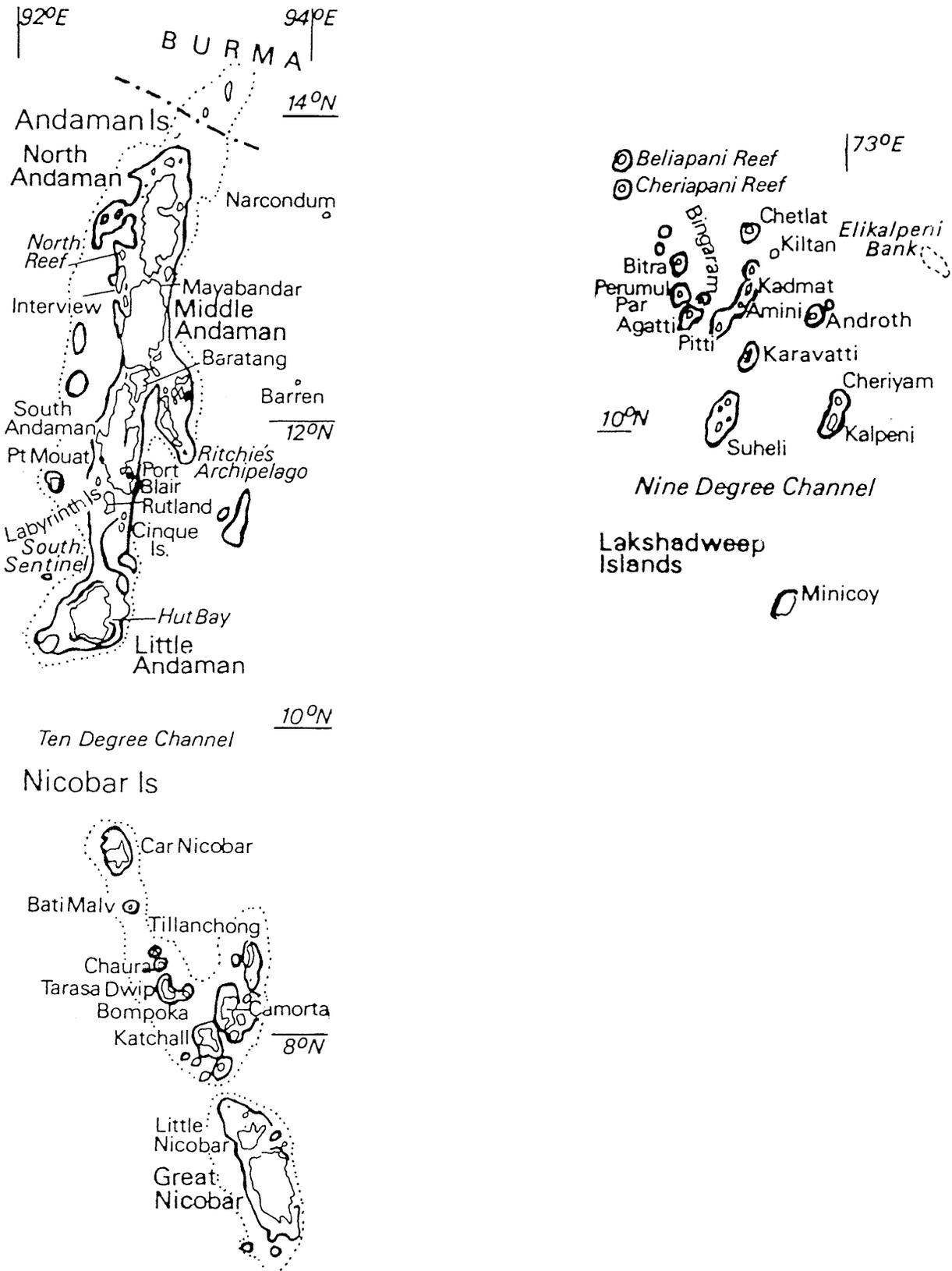
Large seagrass beds are found in Palk Bay and the Gulf of Mannar where the main species are *Cymodocea ciliata* (dominant and the main food of the dugong), *Cymodocea rotundata*, *Halodule uninervis*, *Syringodium isoetifolium*, *Enhalus acoroides*, *Halophila ovalis* and *Halophila stipulacea*. Some authors give *Thalassodendrum ciliatum* and *Halodule* as the principle species. The main areas in the Gulf of Mannar are around Musal Island off Mandapam, and Appa and Valliamunai Islands off Kilakarai; in Palk Bay they are most extensive in and around Devipattanam. They are described in greater detail in Jones (1976) and also by Subramanian *et al.*, (1985) and Silas *et al.*, (1985 b). Seagrass beds on Minicoy in Lakshadweep are described by Ansari (1984), and those around Kavaratti by Qasim & Bhattathiri (1971) and Qasim *et al.*, (1972). Seagrass beds occur in the Gulf of Kutch to a lesser extent (Rashid, 1985), but are possibly most extensive around the Andamans.

About 20 research institutions are involved in marine algal research and a recent checklist recorded 624 species (Untawale *et al.*, 1983). A Marine Algal Flora of the Indian region is in preparation. Almost all the coast has been surveyed and assessments of resources have been carried out for Gujarat, Maharashtra, Goa, Lakshadweep, Tamil Nadu, Andhra Pradesh and Orissa (references in Subbaramaiah, 1987). Surveys are still needed for Andaman and Nicobars, Kerala and some other areas and in deeper waters (Franklin *et al.*, 1989). According to Scott (1989), 100 species of algae have been recorded from the Gulf of Kutch but only 74 have been found in recent surveys. One hundred and eleven species have been recorded from the Andamans and Nicobars (Menon & Bagla, 1989).

2.1.5. Beaches

Beaches of material coarser than mud and under the influence of monsoons or currents occupy

Figure 3.
Insular coral reef systems of India (UNEP/IUCN, 1988)



55% of the mainland coast. Beach forest occurs at the head of wide sandy beaches and on the seaward side of most river deltas. The most characteristic species is *Casuarina equisetifolia*, replaced by *Manilkara Zittoralis* in the Andamans, where undergrowth is dense and maritime grasses such as *Spinifex* and sand binding surface creepers are conspicuous (Rodgers & Panwar, 1988).

2.1.6. Islands

Islands off the west coast include Vengurla Rocks, Oyster Rocks (near Karwar), and St Mary's Rocks (off Mangalore) which has columnar basalt formations. These are largely uninhabited and isolated but may be important for sea birds, as are the islands at the southern tip in Adam's Bridge. Islands are considered by Rodgers & Panwar (1988) to makeup 0.3% of the total area of India. This figure includes the islands of the Lakshadweep, the Andaman and Nicobar archipelagos, described above (Bryan, 1953).

3. Economic Aspects of Marine and Coastal Resource Use

The human population of India has more than doubled since 1947. The area of forested land has correspondingly diminished from 30% of the total land area in 1947 to less than 11% in 1987. The production of food crops, chiefly rice, wheat, pulses, millet and maize, has been constantly increased to meet the demands of the expanding population. This has led to extension of agricultural areas and intensification of agriculture facilitated through diverse improvements in irrigation, particularly in Punjab, Haryana and western Uttar Pradesh. The growing development and increasing populations of the Andaman, Nicobar and Lakshadweep islands poses a threat to these fragile and unique environments (Whittaker, In Press).

3.1.1. Fisheries

In 1981, about 180,000 non-mechanised boats, making up 90% of the total fishery fleet, carried out small scale subsistence fishing. A further 20,000 mechanised boats and 75 deep sea vessels operated out of Maharashtra, Kerala, Gujarat, Tamil Nadu and Kamataka. The total commercial marine catch was about 1.4- 1.6 million tonnes. Clupeoid Fishes including sardines, *Sardinella spp.*; Indian shad, *Hilsa hisa*; and whitebait, *Stolephorus sp.* accounted for about 30% of the landings. The Gujarat coast is rich in benthic fisheries; Kerala and Kamataka are rich in pelagic fisheries, and Tamil Nadu is rich in pelagic and semi-pelagic fisheries (Dwivedi, 1989). The average annual marine catch reported to the the FAO between 1987 and 1989 was over 1,9 million tonnes - a 60% increase since the period 1977 to 1979 (WRI, 1992).

The most important fishing grounds in order of importance are those of: Kerala; Maharashtra; and, Tamil Nadu. In the early 1980s, it was thought that there was potential for increased catches of catfish in the northwest coast; of deep sea lobsters on the southwest coast and upper continental slope off Quiland; and of squid off the southwest and southeast coasts along Gujarat and Maharashtra. Lantemfish (Myctophidae), a mesopelagic species providing Vitamin A and 110 litres of oil/ton, are found off the Bombay shelf and Angina Paks. Grenadiers (Lutjanidae) and macrurids are found off the west coast (UNEP, 1985).

Sivasubramaniam (1985) reviews marine fishery resources on the east coast. The northeast catch comprises 37.2% pelagic, 51.7% demersal, 5.7% shellfish and 5.4% unclassified. The southeast catch comprises 34.070 pelagic, 50.9% demersal, 10.6% shellfish and 4.5% unclassified. There has been an increase in pony fish production in the area which together with sardines are important components of catches in Andhra Pradesh, Tamil Nadu and Pondicherry. In Orissa, catfish, pomfrets and shad are the main species. Catfish, pomfret, tunnies, anchovies, carangids, perch and penaeid prawns are important in Bengal. Shrimp and small pelagic catches have decreased especially in Tamil Nadu. There is some potential for expansion of tuna fishing on the east coast; further information on the tuna industry is given in Anon (1985 b). Trawling is described by Raja (1987). Fishing is also important in the Andamans, where about 1,500

fishermen landed some 1,650 tons in 1981 (Whitaker, 1985a).

The most important coastal fishery, involving some 10,000 people, is in the Sundarbans, where the forests and mudflats provide breeding and nursery grounds for many commercially important fin fish, crustaceans and molluscs. Fish and prawns caught here are sold throughout markets in northern India. Prawns are the most valuable resource and major efforts are being made to develop this fishery; 20% of the Bengal catch comes from inshore waters. Some 35% of the total marine fish catch is of species dependent on the Sundarbans at some period in their life; about 33% of the annual catch of *Hilsa hilsa* in West Bengal and Orissa comes from the Hooghly and Matlah Estuaries (Scott, 1989). The shad fishery in the Bay of Bengal is described in Raja (1985), and may be declining after a peak in 1978. There is also an important fishery at Chilka Lake (DOF, 1970) for finfish and prawns with an estimated annual catch of 700 tonnes, and in the Mandovi estuary in Goa (Scott, 1989).

Reef fisheries are generally at the subsistence level and catches are unrecorded. Wafar (1986) estimates the potential yield to be about 0.2 million tonnes a year, or about 10% of the total marine fish production in India. The Gulf of Mannar in particular is used by many fishermen from the mainland and from Rameswaram Island, especially in winter; catches include parrotfish, carangids and triggerfish; some 2,150 tonnes were taken in 1983 (Salm, 1975a; Venkatesan, n.d.; Venkataramanujam & Santhanam, 1985). Fishing is an important activity in the Gulf of Kutch but catches have declined in recent years (Scott, 1989).

Shrimp fisheries are reviewed by Silas *et al.* (1984). Non-penaeid prawns are taken mainly off the Maharashtra and Gujarat coasts and the most abundant species are *Acetes indius*, *Papaemon tenuipes*, *Papaemon styli ferus* and *Hippolysmata ensirostris* (George, 1968a). About ten species of penaeid prawns are taken along the entire coastline in the narrow inshore area, making up about 50% of the total prawn and shrimp catch (Mohamed, 1968). Marine prawns are closely dependent on the brackish waters of inland bays, lakes and backwaters. Prawns are taken off Kakinada (UNEP, 1985) and the green tiger prawn *Penaeus semisulcatus* is extensively harvested in the Gulf of Mannar for export (Manisseri, 1982). Shrimp trawling grounds and the potential for deep sea crustacean resources are described in Virabhadra & Dorairay (1986). Both marine and brackish water crabs are taken, mainly as part of subsistence fisheries. The crab fishery mainly targets swimming crabs in the family Portunidae and in the 1960s there was evidence of increasing demand (Verayana *et al.*, 1968). Swimming crabs are harvested on the northeast and east coasts (UNEP, 1985).

About half a dozen species of spiny lobsters are taken in different coastal areas. *Panulirus homarus* is the most commercially important and the main fishery area is off Kanyakumari on the southwest coast (George, 1968 b). There is also spiny lobster fishery along the southeast coast, notably at Tuticorin, Madras and Mandapam (UNEP, 1985). *Panulirus polyphagus* is caught by trawling on both west and east coasts (Deshmukh, 1964).

The extensive molluscan resources are considered to be neglected in some regions and over-exploited in others. Mussels could be profitable but there is little demand for edible bivalves (UNEP, 1985). Two main species of mussel *Mytilus spp.* are both fished (Jones 1968; Jones & Alagarswami, 1968). The clam, cockle and oyster resources are described by Alagarswami &

Narasimham (1968); *Eswarametal.*, (1969) and Alagarswami & Qasim (1973), and *Turbo* and *Trochus* resources are detailed in Nayar & Appukutta (1983).

James (1976) describes *Bêche-de-mer* resources and the distribution of commercial species in India. A more detailed account of the southeast coast fishery, which extends from Rameswaram to Kollukadu and in a few places in the Gulf of Mannar, is given in James (1985a). This is the only fishery at present although Lakshadweep and the Andamans have rich sea cucumber resources. The catch here is made up of *Holothuria scabra* (90%) and *Holothuria spinifera* (10%) but the quality of this is low compared with other species such as *Microthele nobilis*, *Actinopyga mauritiana*, *Actinopyga miliaris*, *Actinopyga echinites*, *Actinopyga lacanava* and *Thelenota ananas* which occur in the Andamans, Nicobars and Lakshadweep. Fishing of the latter would relieve pressure on the former. *Bêche-de-mer* is not consumed locally but is exported to Singapore (Conand & Sloan, 1988).

3.1.2. Aquiculture

Brackish water fishfarming is traditionally practised in estuaries, lagoons and the coastal area in West Bengal, Kerala and Tamil Nadu (Dehadrai, 1980). A number of prawn species in the genera *Penaeus* and *Metapenaeus* are farmed, particularly *Penaeus indicus* and *Penaeus monodon* (Franklin & Palanivelu, 1989). Aquiculture in the Sundarbans is described in Scott (1989).

Mariculture projects for prawns, pearls and mussels, are being encouraged in Tamil Nadu under government subsidies and training Programmes. A research centre for seaweed culture has been established at Mandapan. Areas or mangrove around Pamban, and north of Tuticonn around Thiruchendur are considered particularly suitable for mariculture (Loveson & Rajamanicham, 1989). An artificial breeding and rearing programme for sea cucumbers has been started at CMFRI.

In 1977 the Government of Gujarat sanctioned a small scheme for pearl culture at the Gujarat Fisheries Aquatic Science Research Station in Sikka. CMFRI in Cochin is using raft culture to grow pearl oysters (Patel, 1985c), and a pearl culture centre has been established in Tuticorin (Loveson & Rajamanickam, 1989).

There is considerable potential for mariculture of a variety of species including clams, crustaceans, and pearl oysters in the Andamans and Nicobars (Alagarswami, 1983).

3.1.3. Other living marine resource exploitation

The ornamental fish trade is said to be flourishing in Calcutta, Madras, and Bombay (Shenoy, 1984) but is largely centred on captive bred species.

Shells of commercial value are described by Jones (1968) and Durve (1973). ornamental shells, chanks and pearl oysters are the basis of an important industry in the south (Wafar, 1986; Silas *et al.*, 1985a). Over **2,000** people rely on the shellcraft industry for their livelihood, annual exports averaging 490 tons. The industry is concentrated along the east coast with some 40

establishments in the Ramanathapuram District of Tamil Nadu; about 20 in the Calcutta District of West Bengal; and, others in the Andamans and Nicobars (Shenoy, 1984). Shell jewelry made from a wide range of species in Rameswaram, Keezhakkarai and Cape Comorin is sold along the coast. Considerable shell collecting takes place around Port Blair in the Andamans (Daniel & Rajagopal, 1969; Whitaker, 1985a). India exports large quantities of other shells including powder and waste (438 tonnes in 1986), mostly to Middle Eastern countries for industrial purposes. Indian exports of cowries have declined from some 60 tonnes in 1979 to none in 1986 (Wood & Wells, 1988).

Trochus niloticus and *Turbo marmoratus*, are the most important molluscs collected for their shells and both species are collected in the Andamans for export (Silas *et al.*, 1985a). *Trochus* was over collected in the Andaman and Nicobar Islands in the 1920s when the Japanese were given licenses to collect (Rae, 1937). In 1976, 400 tons of trochus and 105 tons of green snail, *Turbo* were landed in the Andamans (Appukuttan, 1977, 1979). Nayae and Appukuttan (1983) give annual production as 400-500 tons of *Trochus* and 100-150 tons of *Turbo*. Shelling is licensed by the Revenue Department of the Andamans and takes place in seven defined zones; fishing grounds are leased to traders and royalties from the catch are collected by the government.

Exports of chanks *Turbinella pyrum* have declined from 55 tonnes in 1976 to none as it is now illegal to export chanks in their natural state (Wood & Wells, 1988). Chanks are mostly collected by skin diving, nets and hand collecting, around Rameswaram in Tamil Nadu (Franklin *et al.*, 1989); and elsewhere in the Gulf of Mannar and Palk Bay. They are sent to West Bengal where they are carved and manufactured into bangles and other items of jewelry. In 1978/79, the annual collection in Tamil Nadu was an estimated 4 million shells (total weight probably about 2,000 tonnes). The proportion retained for domestic use is unknown but chank shell plays an important part in Indian cultural life. In the 1960s, chanks were estimated to provide a livelihood for about 1,000 divers in Madras and others in Gujarat and Kerala (Mahadevan & Nair, 1968).

Until the early 20th century, Jamnagar in the Gulf of Kutch was the centre of one of the biggest pearl fisheries in the world, exploiting the eastern Gulf islands, where the dominant species was the pearl oyster, *Pinctada scata*. The pearling beds stretched from Positra Kaddas to Mungra Reef along the Halar coast. An even larger pearl fishery existed at Tuticorin in the Gulf of Mannar. *P. fuscata* is still fished in waters around Rameswaram (Franklin *et al.*, 1989), and elsewhere in the Gulf of Mannar and occasionally in Palk Bay, but this fishery is unpredictable (Mahadevan & Nair, 1968) and has declined. The last commercial pearl fishing was in 1966/67, but pearl culture is now being promoted. A window-pane oyster *Placuna placenta* fishery developed at Okha in 1910, but uncontrolled exploitation has led to a temporary ban on the collection of all oysters in the Gulf of Kutch (Scott, 1989). There has also been a *Placuna* fishery in the Gulf of Mannar (Durve, 1973; Venkataramanujam *et al.*, 1981).

Shells from mangrove molluscs are used extensively in the lime industry. *Telescopium telescopium* is collected in particularly large quantities in the Pitchavaram mangroves and Vellar estuary (Kasinatham and Shanmugam, 1988). According to Loveson & Rajamanickam (1989) about 160,000 tonnes of shells are used annually for lime production, about 12,000

tonnes coming from Tamil Nadu.

National export statistics record small or no exports of coral, but US trade statistics record imports of over 60 tonnes of coral from India in 1986 (Wood & Wells, 1988). Corals of commercial value are described by Pillai (1973). Sea fans and seaweeds are exported (13 tons annually) for decorative purposes (Shenoy, 1984). There is some concern about the extent of exploitation of gorgonians on the east coast as they are taken as a bycatch by trawlers and chank divers at Tuticonn, Keelakarai and Rameshwaram for export to Europe (The Netherlands) for use in the drug industry (Venkatarmanujam & Santhanam, 1989).

Corals are traditionally used for building in Lakshadweep where other sources of construction material are scarce, and it is also used for the production of white wash and mortar. With the rapid development of these islands it is increasingly being used for modern buildings. There is extensive collection of 'challi', small fragments of *Acropora*, for lime production on the south coast in the Gulf of Mannar. *Tubipora musica* is used for traditional medicinal purposes (Pillai, 1973).

The collection and commercial potential of marine algae is described in UNEP (1985). Seaweeds harvested in the Gulf of Mannar are the basis of the alginate and agar industries throughout most of the country; they include *Sargassum*, *Gracilariaria* and *Gelidiella* (Silas *et al.*, 1977; 1985a; Franklin *et al.*, 1989).

3.1.4. Mangrove exploitation

Mangroves have a broad range of traditional uses in construction, as fuel, human food, fodder and for medicinal products. Timber and charcoal are exploited commercially under well regulated plans in some areas. In West Bengal large numbers of people are employed in mangrove exploitation where *Bruguiera gymnorhiza* is a particularly valuable timber. *Herifi"era minor* is a hard durable timber used for construction and boat building; *Nypa fruticans* is used for thatching. In the Gulf of Kutch, mangroves are used for food, fodder and fuel; 10,000 people of the Wagher community were until recently entirely dependent on these resources. An average of 300 tons of fuel and 130 tons of fodder are gathered from this area annually (Davie, 1991). The importance of mangroves as fish nurseries of economic importance is well recognised (Jeyaseeland & Krishnamurthy, 1980), and their conversion for aquiculture and coastal agriculture is widespread (Vannucci, 1987).

3.1.5. Non-living marine resource use: minerals and sand

There is significant mining for monazite, ilmenite, rutile and garnet, and for smaller amounts of zircon and sillimanite, along the Tamil Nadu coast, where these minerals are found in placer deposits. It is thought that this activity will increase (Loveson & Rajamanicham, 1989; Mallik, 1983; Mallik & Ray, 1975). India was recently granted the right to mine metal rich nodules over 53,000 km² of the sea bed south of Kanyakumari (Govind, 1989).

It has been estimated that there are some 2,000 million tonnes of pure calcareous sand available in the lagoons of Lakshadweep which would be suitable for a variety of industrial purposes

(Qasim & Sankaranarayan, 1970). There are many environmental problems associated with its extraction but it has been estimated that about 700 tonnes could be taken safely (Siddiquie & Mallik, 1973; 1975; Mallik, 1976; 1979 UNEP/IUCN, 1988).

3.1.6. Coastal tourism

Coastal tourism is developing comparatively slowly in India, the majority of visitors traditionally coming for the cultural attractions. However, Goa and the southeast coast are becoming increasingly popular as package tour holiday destinations and the State Government of Goa plans to build 35 luxury resorts on the 75 km stretch of beach (Tyler, 1989). There is considerable tourist potential in the Gulf of Mannar and the west coast of Rameswaram has considerable amenity value with watersports and other tourist attractions. The Gulf of Mannar is most suitable for visitors during the northeast monsoon and Palk Bay during the southwest monsoon (Loveson & Rajamanicham, 1989). Small numbers of tourists visit the Sundarbans and a few go to Chilka Lake which has potential for further tourism development (Scott, 1989).

The islands have obvious tourist potential although at present they are comparatively inaccessible. The Lakshadweep Islands have recently been opened to tourists under a fairly strict policy to control development. Bangaram (120 ha) is the only island to have any tourist accommodation and the number of beds is limited to 60. It has no native population, but the resort provides employment for people from Agathi. All waste is returned to the mainland (Tyler, 1989). Resorts have been established on some of the Bay Islands in the Andamans and this area is being increasingly developed for tourism. The Andamans receive about 5,000 tourists a year at present (Bagla & Menon, 1989).

4. Conservation Issues and Problems

4.1. Habitat degradation and destruction

Settlement, industry, increased fishing pressure, pollution, reclamation of wetlands and mangrove areas and deforestation are causing increasing pressure on the coastal environment (Ahmad, 1987; Silas *et al.*, 1985a), although it has also been suggested that ecological deterioration and pollution is not yet widespread (Ahmad, 1982b).

4.1.1. Mangroves

Mangroves are under pressure from agriculture; industry; fuelwood extraction; aquaculture; and diversion of water for irrigation, which leads to a reduction in freshwater inflow and increased soil salinity (Ranganath *et al.*, 1989). Prawn aquaculture is often carried out at the expense of mangroves (Franklin & Palanivelu, 1989).

Damage to mangroves have been particularly serious on the west coast where there is no established forest industry. Indiscriminate exploitation for timber, firewood, charcoal and tannin; conversion of mangrove areas to residential or industrial estates; the extension of harbours and docks; and, uncontrolled pollution from tankers, sewage, industrial effluents and agricultural pesticides have degraded the mangrove associations on this coast. In the Great Rann there is excessive grazing by camels (Scott, 1989) while in the Gulf of Kutch, loss of mangroves as a consequence of cutting for fuel and timber, and camel grazing has led to saltwater penetration inland. In the past trees were taller and denser but many areas are now reduced to scrubby growth by grazing and development; 95% of mature trees have been cut in the last 20 years (Chavan, 1985; Scott, 1989). In the Gulf of Khambhat mangroves are heavily exploited and reduced to open scrubby forest. Rhizophoraceae are now rare or absent and there is a very simplified zonation (Scott, 1989). Mangrove destruction proceeds almost unhindered in Karnataka, Goa and Maharashtra, and *Lumnitzera racemosa* in particular is now virtually extinct on this coast. Mangroves in Goa have been polluted by oil, which has also affected *Sonneratia spp.* near Elephant Island, Bombay. Mangroves on the Karnataka coast are being seriously damaged by pollution, and felling. The large coastal lagoons of Kerala have suffered from uncontrolled urban development; mangroves have been felled, agriculture has claimed large areas, and extensive bunds have been built drastically altering the ecology of these swamps (Scott, 1989). There has been some damage to mangroves in the Gulf of Mannar (Silas *et al.*, 1985a).

Damage to the Sundarbans mangroves is summarised in Scott (1989). In the western part of the Sundarbans, large areas are settled and cultivated and very little natural mangrove forest remains. Furthermore there has been a major reduction in the inflow of fresh water into this part of the Sundarbans as a result of the construction of the Farakka Barrage in 1971 designed to divert fresh water southwards and to alleviate the rapid siltation in the port of Calcutta; inflow

is now confined to the monsoon period (May-Nov.).

Mangrove destruction in the Andamans and Nicobars is described by Bagla & Menon (1989) and Singh *et al.*, (1986); about 10,000 ha have reportedly been cut since 1960, mainly for fuel.

4.1.2. Coral reefs

There has been some damage to reefs from the crown of thorns starfish, *Acanthaster planci*, in the Andamans in Wandur Marine Park (Wood, 1989) and in Lakshadweep in the 1970s, although in the latter case this was not considered too serious (INTACH/SANE, 1989; MUIY *et al.*, 1979; Pillai, 1983a; Bhaskar, 1979b; Sivadas, 1977). Coral bleaching and signs of White Band disease have been seen in Wandur Marine Park (Wood, 1989).

Several studies (e.g. Salm, 1975a; 1975b; 1981) have described widespread deterioration of reefs on the mainland and some of the off-shore islands. Wafer (1986) describes the status of the genera *Pseudosiderastrea* and *Porites* in Bombay waters, which are subject to heavy oil, sewage and industrial pollution. The development of Tuticorin Harbour, and associated oil pollution and industrial discharges have caused significant damage in the Gulf of Mannar and Palk Bay area (UNEP, 1985). Reefs of the Gulf of Kutch are said to be under serious threat from sand mining and industrial pollution. The Reefs of the Gulf of Mannar have been damaged by a variety of fishing methods (UNEP/IUCN, 1988). The Andaman, Nicobar and Lakshadweep Islands are less threatened but there are reports of oil pollution (UNEP, 1985).

Pillai (1973) and Salm (1975a) describe the coral mining industry which has caused major damage to the reefs of the Gulf of Mannar, Gulf of Kutch, Andamans and Nicobars. Wafar (1986) points out that this is increasing, although in the Gulf of Kutch it has been controlled. Sand mining is a major problem in the Andaman and Nicobar Islands (Whitaker, 1985a; Nair, 1986; Mathai, 1985). Although mining on Narara Reef, Pirotan, Kalvan, Jindra and Dhani is no longer permitted since they lie within a Park, enforcement is poor. Dera and Goose Island may still be mined but their leases were to be taken back in 1985. Coral mortality was estimated at 50% as a result of these activities (Patel, 1985b; Rashid, 1985). The impact of siltation on the reefs has not been studied but it is thought to be a problem in the Andamans and Nicobars; silt has reportedly damaged reefs in Hut Bay on Little Andaman (Bagla & Menon, 1989). Further information on reef damage is given in UNEP/IUCN (1988).

Reefs in Minicoy Lagoon in Lakshadweep were seriously damaged by dredging of harbours and channels in the 1970s (Pillai, 1983a); similar but less serious damage occurred on Kavaratti (Mallik, 1979; 1985a; 1985b). Coral and sand mining is a major threat in Lakshadweep where there are further plans to mine sand from lagoons for building (Anon, 1986) and natural movements of sand are not well studied (Venkatesh, 1974). Corals have been removed during the construction of shore protection around Kamorta Island (Bagla & Menon, 1989). In Tamil Nadu, over 400 people are employed in the Gulf of Manna-r where 10,000 tons of lime are produced a year from *Acroporaformosa* fragments or 'challi'. This continues even though it was banned in 1979. The massive corals *Porites* and *Favia* are mined for building and roads; about 15,000 tons are taken a year. These activities have damaged reefs in both the Gulf and in Palk Bay (Venkataramanujam *et al.*, 1981; UNEP/IUCN, 1988). Silas *et al.* (1985a) report

disturbance of seagrass beds from stake net and wall net fishing in the Gulf of Mannar.

4.1.3. Sea level rise and coastal **erosion**

There appears to be little discussion of the potential impact of global changes, but certain areas of the coastline are extremely vulnerable particularly: West Bengal and the Sundarbans which is comparable to the situation in Bangladesh; and, the Lakshadweep atolls where vulnerability is comparable to that of the Maldives.

James *et al.* (1989) describe salinity intrusion on the Malabar coast which currently causes problems to water supplies and irrigation schemes. This area is particularly vulnerable on account of its high population density and increasing sea level is likely to aggravate this problem. Ramasamy *et al.* (1989) describe the extensive natural coastal erosion on parts of the Coromandel coast, particularly at Mahabalipuram and north of Madras, and make recommendations for improvement, in the context of rising sea levels.

4.1.4. Overfishing

In the Gulf of Kutch, degradation of coastal habitat has meant that fishermen have to go into deeper off-shore waters of the Gulf (Scott, 1989). Molluscs have been over-exploited for lime production in the Pitchavaram mangroves. In 1961 they were abundant but collectors now have to go further afield (Kasinathan & Shanmugam, 1988). Gorgonians are reported to have been overfished in the Gulf of Mannar (Anon, 1987; Venkatarmanujam & Santhanam, 1989). Depletion of some marine species is reviewed in Anon (1987).

4.1.5. Pollution

There is concern about pollution around the Andamans and Nicobars (Menon & Bagla, 1989; Bagla & Menon, 1989). This includes intensification of oil drilling, effluents around Port Blair, and ship grounding such as the wreck on N. Sentinel Island in 1983 when oil was pumped out to sea during salvage operations (Qasim *et al.*, 1974). Agricultural pollution of major drainage systems is a widespread problem in intensively farmed areas of the coastal plains and deltaic swamp. For example, about 2,500 tons of pesticides and 1.2 million tons of fertilisers are used in the vicinity of the Ganges each year, and fifty two cities with populations of over 50,000 are located along the Ganges, causing extensive pollution. (DOE, 1985). Human impacts on the Hooghly estuary are detailed in Ray (1981).

4.1.6. Coastal tourism

Reefs in the Andamans off Jolly Buoy tourist beach have been damaged by snorkelers and the Labyrinth Islands are particularly vulnerable (Menon & Bagla, 1989; Wood, 1989). In Goa, the Vigilant Goans' Army was established in 1987 to oppose indiscriminate development of the coastline especially for tourism and to prevent loss of access to the beach by fishermen (Tyler, 1989).

4.2. Species of Conservation Concern

A list of threatened species with status categories in the Gulf of Kutch is provided by Chavan (1985). This categorization does not however, conform to the IUCN system and is compiled from a regional perspective. In the following paragraphs, species listed by IUCN (1990) as globally threatened are considered individually. Other species, including those considered threatened regionally or nationally are discussed in the general paragraphs. Status categories follow the IUCN definitions, namely: endangered (E); vulnerable (V); rare (R); indeterminate (I); insufficiently known (K); threatened (T) and commercially threatened (CT).

4.2.1. Mammals

Plantanista gangetica, Ganges river dolphin (V)

Found in the Sundarbans in most coastal areas of the Ganges, Brahmaputra, Meghna and Karnaphuli River systems. Although it is common in the tidal reaches of the delta areas it does not enter the sea. Of the total world population of about 5,000, India has 3-4,000, of which between 3,000 and 3,500 occur in the Ganges Delta below the Farakka Barrage; the Brahmaputra below Tistamukhghat; and, the Meghna below Bairab Bazar. It is now absent from many places where it formerly occurred. This species is threatened in India by agricultural pollution; construction of dams for irrigation and hydroelectric power, which have divided the population of the Ganges system into small isolated subpopulations; decreased volumes of water and water flow rates through extraction of water for irrigation; increasingly heavy industrial river traffic; and hunting for meat and oil, about 40 are caught each year. The species is protected and although hunters are liable to a fine of up to 2,000 rupees or six months imprisonment for killing these dolphins, there have been no convictions to date (Lal Mohan, 1989; Pernn & Brownell, 1989).

Orcaella brevirostris, Irrawaddy dolphin (K)

This species may occur in coastal waters since it is known from the Bay of Bengal and the Ganges (Klinowska, 1992) and is reported to occur in the Sundarbans (Scott, 1989).

Balaenoptera musculus, blue whale (E)

Balaenoptera physalus, fin whale (V)

Megaptera novaeangliae, humpback whale (E)

No specific information on the status of these species in Indian waters is available.

Other cetaceans:

Silva (1987) records strandings and sightings of 24 species of cetaceans in Indian waters; IClinowska (1992) gives 28 species. *Sousa chinensis* and *Neophocaena phocaenoides* occur in the Gulf of Kutch (Scott, 1989). Information on the dolphins *Delphinus delphis tropicalis*, *Stenella longirostris*, *Tursiops aduncus* and *Stenella chinensis* obtained from gill net landings at Calicut on the southwest coast, is provided by Lal Mohan (1985 b). Of the specimens entangled, *S. Zongirostris* was the most common, followed by *T. aduncus*. Rajaguru & Natarajan (1985) give some information on the status of *S. Zongirostris* and *T. aduncus* on the southeast coast. *S. chinensis*, *D. delphis*, and *N. phocaenoides* also occur in the Sundarbans (Scott, 1989)

while *N. phocaenoides* is said to be abundant off Bombay (Klinowska, 1992) There are also regular sightings of small cetaceans off Vedaranyam Swamp (Scott, 1989).

N. phocaenoides is probably not at risk but there is concern about populations of *S. chinensis* particularly as its distribution is closely correlated with mangroves. Populations of *S. Zongirostris*, *S. attenuata* and *S. coeruleoalba* and *Grampus griseus* are also of conservation concern since large numbers of dolphins are killed in coastal gill net fisheries and the meat used for local consumption (Klinowska, 1992.; Perrin, 1989). Catches are being monitored by CMFRI. Other species recorded include *Steno bredanensis* and *Mesoplodon densirostris*, both recorded from the Nicobars but not considered of conservation concern (Klinowska, 1992).

Canis lupus, the wolf (V)

Occurs in Great Rann of Kutch (Scott, 1989).

Viverra civettina, Malabar large spotted civet (E)

Endemic to rainforest in southwest India this species was previously found along the coastal hinterland of the Western Ghats. The species has probably disappeared from most coastal tracts and its' continued existence in the Western Ghats need confirmation (Schreiber *et al.*, 1989).

Panthera tigris, the royal Bengal tiger (E)

About 300 individuals occur in the Sundarbans, making this the largest population of this species worldwide (Scott, 1989).

Aonyx cinerea, the Oriental small-clawed otter (K)

Lutra perspicillata, the smooth-coated otter (K)

Information on the occurrence and status of these two otters in the coastal region is scanty. There is a move to make otters the symbol of wetlands in India and a country-wide survey is being planned by the Indian Wildlife Institute (Asian Otter Specialist Group Newsletter).

Dugong dugon, dugong (V)

The species is totally protected under the Wildlife Protection Act, 1972. The Gulf of Mannar and Palk Bay are the most important areas in the South Asian region for this species. The extensive seagrass beds around Musal Island off Mandapam Camp and around Appa and Balayamunai Islands, off Kilakarai are the main grazing grounds (Jones, 1967; Silas & Fernando, 1985) where large herds used to occur. Catches were higher in Palk Bay between Devipattanam and Pamban on Rameswaram Island than in the Gulf of Mannar between Musal and Appa Islands and the mainland. There maybe coast to coast migration between India and Sri Lanka through Palk Bay which is shallow while migrations across the deeper Gulf of Mannar may take place around the coast (Jones, 1976). Following reports in 1983/84 of 250 dugongs being killed at the villages of Kilarei and Peripattinum (Silas & Fernando, 1985) the status of populations was investigated in 1987 (Marsh, 1988). The present harvest is considered to be less now because of political problems in the area. CMFRI has some individuals caught in the Gulf of Mannar, in captivity at Mandapam Camp (Jones, 1967; Anon, 1989).

The species has become rare throughout most of the Andamans and it is currently known definitely only from Ritchies Archipelago and North Reef. There have always been fewer

reports of it from the Nicobars and it is considered by Snow (1970) to be extinct in this area.

Jones (1976) and Frazier & Mundkur (In prep.) reported small numbers in the Gulf of Kutch, the only west coast populations; and Jones (1976) records occasional stranding and landings here but there is no fishery. The small population may constitute a straddling stock moving between adjacent Indian and Pakistan waters (IUCN, 1983). Scott (1989) reports sightings from Lake Chilka and frequent records in the Vedaranyam Swamp. According to Snow (1970) it no longer occurs on the Malabar coast or in Lakshadweep.

Equus hemionus khur, the Indian wild ass (E)

Known to occur in the Little Rann of Kutch Wildlife Sanctuary, and in the Great Rann of Kutch. The population in the Little Rann has increased to nearly 2,000 but is subject to much disturbance (Scott, 1989; Groombridge, 1983).

Gazella dorcas, Dorcas' gazelle (V)

Known from both the Great and Little Rann of Kutch this species has been decimated by hunting in Little Rann (Scott, 1989).

Other mammals:

Macaca silenus, the lion-tailed macaque, (E) is found only in the Western Ghats Mountains of southern India, typically in tropical wet evergreen and semi-evergreen broadleaf forest (Wolfheim, 1982). It is highly endangered but there is no particular evidence that it occurs in the coastal region and therefore may not be relevant in the context of this review. *Trachypithecus johni*, the Nilgiri Langur, is also restricted to forest areas of the Western Ghats region, and as in the previous case there is no evidence that it occurs in the coastal region. An endemic subspecies of the crab-eating macaque, *Macaca fascicularis umbrosa* is restricted to three islands in the Nicobars (Great Nicobar, Little Nicobar and Katchall). It is found from the coast to 1,000 m altitude and is threatened by habitat destruction and hunting. A small population of *Semnopithecus entellus dussumieri* occurs in coastal Kerala. *Semnopithecus hypoleucos* is recognised by some authorities as a distinct species, the Malabar langur, and occurs from the coast to the Western Ghats (Eudey, 1987). The latter three species, although not of global conservation concern may be considered of regional concern.

A number of other Indian mammal species are considered to be globally threatened and/or endangered but their distribution in the coastal region is not known. These species include: *Cuon alpinus*, the dhole (V); *Melursus ursinus*, the sloth bear (I); *Felis marmorata* (E), the marbled cat; *Felis temmincki*, Asiatic golden cat (I); *Panthera pardus*, the leopard (T); *Elephas maximus*, the Indian elephant (E); *Rhinoceros unicornis*, the great Indian rhinoceros (E); *Bos gaurus*, the gaur (V); and *Bubalus bubalis* the water buffalo (E).

The brown palm civet, *Paradoxurus jerdoni* is endemic to the seaward slopes of the Western Ghats but does not appear to be coastal (Schreiber *et al.*, 1989) and is not listed as threatened by IUCN although it may be of local conservation concern. *Antelope cervicapra*, the blackbuck occurs in Point Calimere Sanctuary in Tamil Nadu, which is reported to contain India's largest population of this species. According to Scott (1989) this population was introduced to this site. The species also occurs in Gujarat in the Ranns of Kutch, within the Wild Ass Sanctuary. Like

the brown palm civet this species may be of local conservation concern.

4.2.2. Birds

Pelecanus philippensis, the spot-billed pelican (I)

Fewer than 400 pairs are known from four colonies in southeast India. This species breeds in Tamil Nadu, Andhra Pradesh, and some inland states (Neelakantan, 1980) and occurs as a vagrant in the Nicobars (Collar & Andrew, 1988). Recorded in Connga Wildlife Sanctuary, Pulicat Lake where it visits the lagoon in large numbers from neighbouring breeding colonies). At Vedaranayam Swamp, Yadayanthittu estuary (Tamil Nadu) it is a regular visitor in flocks of 30-200 individuals. It is also reputed to breed in Sundarbans (Scott, 1989).

Pelecanus crispus, the Dalmatian pelican (E)

A winter migrant in northern India - Kutch, Saurashtra, Gujarat, West Bengal (Collar & Andrew, 1988) threatened by hunting for its fat which is highly valued in Indian medicine.

Leptoptilos javanicus, the lesser adjutant (V)

Resident and nomadic in Madhya Pradesh, Gujarat, West Bengal, Orissa, Tamil Nadu, Andhra Pradesh (Collar & Andrew, 1988) this species is regularly seen and presumed to breed in Sundarbans (Scott, 1989).

Leptoptilos dubius, the greater adjutant (E)

A very rare species the only breeding records are for Assam but previously may have been coastal (Collar & Andrew, 1988).

Marmaronetta angustirostris, the marbled teal (V)

Winters in India (Collar & Andrew, 1988)

Haliaeetus leucoryphus, Pallas' fish eagle (R)

Resident and partly migrant this species occurs only at low density over its range (Collar & Andrew, 1988); breeds in Pulicat Sanctuary (Scott, 1989).

Spilornis elgini, the dark serpent eagle (R)

Known only from the Andamans where it is found in the interior forests being replaced in coastal areas by the local race of the crested serpent eagle *Spilornis cheela davisoni* which occurs more commonly in coastal forest and mangrove (Collar & Andrew, 1988).

Megapodius nicobariensis, the Nicobar megapode or scrubfowl (R)

Endemic to the Nicobars where it occurs in forest undergrowth, laying its eggs in a mound within a few metres of high watermark. The species is still believed to be locally common but vulnerable to predation and egg harvesting as development of islands proceeds (Collar & Andrew, 1988). Traditionally hunted by Shompens and Nicobarese who are excluded from provisions of Wildlife (Protection) Act, the species is now also hunted by immigrant labourers who also collect eggs (Bagla & Menon, 1989).

Limnodromus semipalmatus, the Asian dowitcher (R)

Winters in eastern India (Collar & Andrew, 1988) and a regular visitor at Chilka Lake where it may be seen in small numbers (maximum 41 individuals) and at Vedaranyam Swamp (15 individuals) (Scott, 1989). Found on the sea shore and coastal mud flats.

Eurynorhynchus pygmeus, the spoon-billed sandpiper (I)

Winters in India (West Bengal) (Collar & Andrew, 1988). This species is recorded at Chilka Lake and in very small numbers in winter at Vedaranyam Swamp (Scott, 1989). Found on the seashore and mud flats.

Caloenas nicobarica, the Nicobar pigeon (R)

Although not endemic to the Nicobar islands the species only occurs thereon small wooded islets in Nicobars and Andamans where it has declined markedly (Collar & Andrew, 1988).

Psittacula caniceps, the Nicobar parakeet (I)

Endemic to Great Nicobar, Monstschall and Kondul where it occurs in forest habitat. Status unknown but island development may be a threat (Collar & Andrew, 1988).

Aceros narcondami, the Narcondam hornbill (R)

Endemic to Narcondam, an uninhabited island of 682 ha in the Andamans. The population of 400 individuals is coming under pressure (Collar & Andrew, 1988).

Rhinomyias brunneata, the brown chested flycatcher (V)

The disjunct population of this species in the Andamans could be a different species since the remainder of the distribution of this species is in China (Collar & Andrew, 1988).

Other birds:

Seabirds breeding in the Lakshadweep, Andaman and Nicobar archipelagos (Feare 1984) are as follows:

Lakshadweep: *Anousstolidus*, *Sterna fuscata* and possibly *Puffinus lherminieri*, *Suladactyla*, *Sula sula* and *S. leucogaster*; there are important colonies on Pitti and Baliapani (Rodgers & Panwar, 1988);

Andamans: *Sterna dougalli*, *Sterna sumatrana* and possibly *S. fuscata*;

Nicobars: possibly *Sterna sumatrana* and *A. stolidus*.

Seabird colonies are poorly known around the mainland coast; terns nest on Vengurla Rocks off the west coast and on some of the islets in Adam's Bridge.

Important coastal areas for shore birds and waterfowl include the Great Rann which is the focus for the Asian population of the lesser flamingo *Phoeniconaias minor* (Mundkur *et al.*, In press) and supports a much reduced population of greater flamingos *Phoeniconaias ruber* (Ali, 1945; 1960; Naik & Lavkumar, 1960). Other important coastal areas include: the Little Rann, Gulf of Kutch, which includes Khijadia Sanctuary; the Gulf of Khambhat; Chilka Lake, which

supports one of largest concentrations of migratory waterfowl in India; Connga Wildlife Sanctuary; the Krishna and Godavari Deltas; the Mandovi estuary, and the Sundarbans (Ali & Hussain, 1982; 1984; Hussain, 1987a; 1987b; Hussain *et al.*, 1984; Hussain *et al.*, 1985; Karpowicz, 1985; Mundkur & Naik, In prep.; Mundkur & Pravez (1986; Palmes & Briggs, 1986; Parasharya, 1984; Perennou; 1987; In press; Sugathan, 1982)).

Birds of the Andaman and Nicobar archipelagos are described by Abdulali (1964) and of Lakshadweep by Betts (1938). Lal Mohan (1985a) describes the catching of coastal birds, mainly terns and waders, at Mandapam and on Rameswaram Island by nomadic tribesmen.

The following species are considered to be globally threatened or endangered although the importance of the coastal zone to the continued survival of these species is not known: *Heliopais personata*, the masked finfoot (V) is known to breed in India and is threatened by habitat loss (Collar and Andrew, 1988). *Chettusia gregaria*, the sociable plover(R) winters in India but its use of the coastal zone is unknown. *Parus nuchalis*, the white winged tit(V) occurs in scrub and woodland habitat in semi-deserts of the Kutch, Gujarat and Rajasthan Provinces along the Eastern Ghats. Very rare in the south of its range, the species is considered vulnerable in the north (Collar and Stuart, 1988).

4.2.3. Reptiles

Batagur baska, the Batagur river terrapin (E)

Occurring in West Bengal the species was said to be common at Calcutta in the 19th century, but heavy exploitation for food and habitat loss have reduced the populations. There are recent records from the Sundarbans region in the Mongla and Passur Rivers (IUCN/SSC, 1989; Scott, 1989).

Caretta caretta, the loggerhead turtle (V)

Caught and possibly nests in India (Groombridge, 1982), the species occurs off the Sundarbans (Banerjee, 1985).

Chelonia mydas, the green turtle (E)

The only significant nesting of this species on the mainland is in Gujarat, on the north and south shores of the Gulf of Kutch and around the south and west coast of the Saurashtra Peninsula (Bhaskar, 1984b). Elsewhere nesting is unrecorded or very sporadic as in the case of Thane District of Maharashtra (Shaikh, 1984). *C. mydas* is found sporadically around much of the mainland but feeding concentrations are known only in the Gulf of Kutch which may represent individuals from the population that nests on Hawkes Bay and Sandspit beaches at Karachi; and the Gulf of Mannar and Palk Strait. One was found in Chilka Lake in 1915 (Groombridge & Luxmoore, 1989). Scott (1989) reports nesting along the coast of the Gulf of Khambhat and on Piram Island and further information is provided by Whitaker (1985b) and Siraimetan (1985).

In Lakshadweep, this species nests on Suheli Valiakera, a 1 km x 300 m coral island near Kavaratti); Tinnakara; Bangaram; Suheli Chenahkara; Parali; and, Pitti Islands (Bhaskar, 1980; 1984b), all of which are uninhabited in the nesting season. Nesting is only sporadic on inhabited islands which include Minicoy. Foraging *C. mydas* are encountered on Minicoy

2. Rasdu - Zoning plan proposed by Kenchington (1985) with two national parks. Small atoll, some reef research; some tourism; site account in IUCN/UNEP (1988).
3. North Male' - Kenchington (1985) recommends a zoning plan to include two national parks and several sanctuaries; Edwards (1989) suggests that this atoll might be more appropriate for the development of a Marine and Agriculture Research Station because of access e.g. Meerfenfushi or Villingili. North Male' is the main centre of development and tourism etc. and natural resources may be most threatened here; - there would seem to be a need for some protected areas within the atoll; site account in IUCN/UNEP (1988).
4. South Male' - zoning plan proposed by Kenchington (1985) to include national parks and strict sanctuaries in the south of the atoll.
5. Faadhippolhu (Lhaviyani) - the northeast reef area, including the island chain from Guraidhoo to Maidhoo and Bodu Huraa recommended as a strict nature reserve; A broad central area, including a number of northern and eastern islands, and the southern island of Aligaa as a nature reserve (Danish survey); these areas have received little scientific attention (see IUCN/UNEP, 1988/89 for site account).
6. The Danish survey referred to above recommended establishment of reserves at: Felidhu (including Wataru, Vaavu); Makunudu (South Thiladhunmathi, HaaDhaal); Mulakatholhu (Meemu); North and South Nilandhe (Faafu and Dhaalu); Hadhdhunmathi (Laamu) and Kolhmadulu (Thaa).

8.1.2. Species protection

One recommendation by a Danish consultancy in the early 1980s was for a survey of the wildlife of the islands, particularly turtles and seabirds and to develop plans for the establishment of a Wildlife and Conservation Unit (Kirby, 1986). The turtle survey of Frazier & Frazier (1987) resulted from this recommendation. Areas recommended by Frazier & Frazier (1987) for protection of vestiges of original vegetation (*Pisonia grandis*) and nesting sea birds are:

1. Olhugiri (Baa).
2. Suvadiva atoll.
3. Small uninhabited atolls such as Vattura.

Other recommendations given in Frazier & Frazier (1987) include to:

1. Carry out further survey and research work to establish actual status of populations and their exploitation.
2. Create protected areas, especially in feeding and nesting areas, and islands that still have vestiges of original vegetation (*Pisonia grandis*) and nesting sea birds e.g. Hurasdoo (Ari), Olhugiri (Baa) and Suvadiva atoll - also perhaps small uninhabited atolls such as Vattaru.
3. Ban killing of all nesting female turtles for 15 years; prohibit or monitor sale of turtles and eggs in Male'; establish closed seasons for egg collection and quotas that can be taken from each island; monitor all exploitation.

which may be the main feeding ground as it is the only island where they are not hunted (Groombridge & Luxmoore, 1989).

In the Andamans and Nicobars, *C. mydas* does not appear to be widespread but has not been fully surveyed. Nesting has been confirmed on four of the 12 uninhabited islands: Interview; South Reef; South Brother; and, Snark (Bhaskar, 1984a; 1984b) but it may also nest on S. Sentinel (Davis & Altevogt, 1976; James, 1985b).

Eretmochelys imbricata, the hawksbill turtle (E)

Nesting is very sparse and sporadic on the mainland; for example a single nest was recorded in 1980 from a beach on the Tirunelvel coast (Tamil Nadu) used mainly by olive ridleys. Nesting is recorded occasionally along the east coast off Orissa and Andhra Pradesh, the Krishna Delta, in the Sundarbans and Bhitarkanika Wildlife Sanctuary. The main feeding area is the Gulf of Mannar and Palk Bay and to a small extent the Gulf of Kutch.

In Lakshadweep, the hawksbill nests on Suheli Valiakara and in small numbers on the inhabited islands of Androth, Kadmat and Agathi; there is probably some nesting on all uninhabited islands.

The Andaman population is the largest in India and of regional importance. Nesting is widespread and is dense at a few sites; South Reef and North Brother are the most important. Other important sites are South Brother, Snark, Kwangtung, South Cinque, Interview, E. Twin, W. Twin and Latouche. Numbers are highest on islands with minimal human disturbance and where the monitor lizard, *Varanus salvator* is absent. About 15 other islands are suitable for nesting but have not been surveyed (Groombridge & Luxmoore, 1989; Whitaker, 1985a).

Lepidochelys olivacea, the olive Ridley turtle (E)

This is the most common turtle in India and the main populations occur in Bay of Bengal. About 300,000 nest in Orissa, which has two important sites in the northeast: in the late 1970s, 100,000 females nested at Gahirmatha within the Bhitarkanika Wildlife Sanctuary; while a further 100,000 nest south of this between Nadiakhia Muhana and Akasia Muhana. Mass nesting at Gahirmatha occurs annually, mainly around Ekkula where a total of 500,000 turtles have been estimated to nest (see Silas *et al.*, 1985b for references; also Scott, 1989). Small numbers nest at many sites elsewhere around the coast including the Gulf of Kutch; Saurashtra Peninsula; Gulf of Khambhat; Piram Island, Bombay; near Goa; Gulf of Mannar; along the entire east coast, including near Madras and the seaward areas of Vedaranyam Swamp; the Krishna Delta; the Sundarbans; Kanak Island, Bakha beach, Lothian, Mechua, Chaimari Sagar; and on the Andaman, Nicobar and Lakshadweep islands.

The species is threatened by incidental catch in shrimp trawlers (Groombridge, 1982; Banerjee, 1985; Scott, 1989) and by collection in the Sundarbans (Rant & Nandi, 1985). Captive rearing has been attempted at Bhagabatpur Crocodile project (Banerjee, 1985); and a hatchery at Point Calimere hatches eggs collected from adjacent beaches (Ponnuswamy & Rahaman, 1985; Rahaman *et al.*, 1985). Rearing of *L. olivacea* also takes place at Sajnakhali Forest Office using eggs collected from Mechua, Sainmai and Kanak Island in West Bengal (Rant & Nandi, 1985).

Dermochelys coriacea, the leatherback turtle (E)

Small scale nesting occurs in Lakshadweep; Goa; along parts of the west coast to south Kerala; and along the east coast including the Krishna delta. The species was once common in Kerala but is no longer abundant. Larger aggregations occur in the Andamans and Nicobars islands. The species occurred on Great Nicobar and Little Andaman in late 1970s but has been adversely affected by coastal development as is the case on the mainland (Groombridge, 1982; Scott, 1989; Whitaker, 1985a).

Marine Turtles are exploited for their meat, eggs, oil, shell and leather. All five marine species are protected and export of turtle products is banned. Egg collection is intensive in West Bengal, mainly of *L. olivacea* and in Saurashtra of *C. mydas*. *C. mydas* is eaten mainly in Tamil Nadu and *L. olivacea* on the east coast. Most fishing is carried out in the gulf of Mannar, some in Gujarat and some off the Okha coast. In Lakshadweep, *C. mydas* and *E. imbricata* are heavily exploited mainly for oil and eggs. Some shell is exported to the mainland. In the Andamans, four turtle species are exploited for local use (Groombridge & Luxmoore, 1989). Turtle breeding beaches have also been threatened by sand quarrying, egg poaching and pollution (Bagla & Menon, 1989). Information on sea turtle distribution is also given in Bhaskar (1978; 1979a), and Groombridge (1985) reviews the role of Indian populations of marine turtles from a global perspective.

Government Programmes to collect eggs and rear turtles are now underway at the Madras Snake Park Trust in Tamil Nadu; at CMFRI in Orissa and in West Bengal.

Crocodylus palustris, the mugger crocodile (V)

Found throughout India, not just in coastal areas the best populations occur in Tamil Nadu and Gujarat. The coastal distribution is not well known (Groombridge, 1982) but the species may still occur in river mouths in Maharashtra and Goa. The species has been severely depleted throughout its range (Whitaker & Daniel, 1980) by trapping; egg predation; habitat destruction; and the skin trade. A conservation programme is now underway (Scott, 1989).

Crocodylus porosus, the estuarine or saltwater crocodile (E)

Formerly occurred from Cochin on the west to the Sundarbans in the east this species is now reduced in numbers and rare or extinct over much of its former range (Kar, 1984; 1985). The total Indian population is probably less than 1,000 individuals. It is extinct in Kerala and the last recorded occurrence along the west coast, where it was once common, was in the 1920s (Scott, 1989). Small numbers are found in the Sundarbans where it has been depleted by hunting; and in Orissa. A population of 35 adults is found in the Bhitarkanika Wildlife Sanctuary (Bustard & Choudry, 1981; Groombridge, 1982; Kar, 1985). Populations are depleted in Andamans and Nicobars where it has been subject to heavy egg collection and habitat loss. The total Andaman population is between 170 and 330, including North Andaman, Middle Andaman, South Andaman. The population in the Nicobars is reported to be healthy but no precise data are available (Choudry & Bustard, 1979; Whitaker & Whitaker, 1978). The Nicobars may be its last stronghold in India (Bagla & Menon, 1989). Breeding Programmes are operated through the West Bengal Forest Department; the Orissa State Forest Department; and the Madras Crocodile Bank. Hatchlings are released in Bhitarkanika; in the Project Tiger Reserve (Sundarbans); and in the Coringa Wildlife Sanctuary (Luxmoore et al., 1985). There is an urgent

need for habitat protection and the species receives some protection in a conservation area in the Mahanadi Delta (Scott, 1989).

Gavialis gangeticus, the Gaviial (E)

The coastal distribution of this species is not known in any detail. Populations have been reduced and a conservation programme is now underway (Groombridge, 1982).

The status of Asian crocodiles is reviewed by Whitaker and Daniel (1978). In 1975, the Government of India initiated a major programme for the conservation and captive breeding of *C. palustris*, *C. porosus* and *Gavialis gangeticus*. Thirteen sanctuaries covering an area of approximately 800,000 ha have been established, and successful captive rearing and in some cases breeding are taking place at 34 crocodile rehabilitation stations in these sanctuaries and in 21 national parks and other sanctuaries. By January 1987, at least 609 *C. palustris*, 877 *C. porosus* and 1,439 *G. gangeticus* had been released in crocodile sanctuaries (further information in Luxmoore *et al.*, 1985; Saharia, 1981; Whitaker & Daniel, 1980).

Other reptiles:

The Cochin forest cane turtle *Geomyda silvatica*, considered vulnerable, and the Travancore tortoise *Zdootestudo forstenii*, considered to be rare, occur near the coast but in forested hill habitat rather than true coastal habitat. Whitaker (1985b) considers Bibron's softshell turtle *Pechchelys bibroni* to be rare. The species is known to occur in mangroves in West Bengal and Orissa; is the most salt tolerant of the Asian soft shelled turtles; and may occur in the sea. It nests on Gahirmatha Beach with the olive ridley (Moll, 1985). This species, as well as *Geocchemys hamiltonii* (Z), *Kachuga kachuga* (I), and *Chitra indica*, are considered of conservation concern in the Ganges Delta and recommendations are made for their conservation (IUCN/SSC, 1989). A number of other turtle species are found in estuaries and are mapped in Das (1987).

There are four species of *Varanus* in India, none of which are considered globally threatened by IUCN, although all are considered endangered by the Zoological Survey of India. *Varanus bengalensis* occurs throughout the peninsula and maybe found on the coast in tidal creeks and on beaches. *V. salvator* occurs in: the Sundarbans, Bhitarkanika Wildlife Sanctuary; the Andamans, Narcondam Island Wildlife Sanctuary and Jarawa tribal reserve; the Nicobars, Katchak and Great Nicobar as well as inland in secondary forest and abandoned house compounds. *V. flavescens* is found on the Indo-Gangetic plains and *V. griseus* in arid northwest India. It seems unlikely that either of these latter species have a coastal distribution. The four species are hunted for food, skins and other traditional use and populations have declined. Official trade has declined considerably reflecting the impact of the Wildlife Protection Act, but illegal trade continues (Luxmoore & Groombridge, In press; Das, 1988); *V. bengalensis* is probably smuggled into Bangladesh and Pakistan for export; *V. flavescens* is also heavily exploited.

Python mohmus, the Indian python, considered vulnerable by IUCN (V) is known in the Sundarbans (Scott, 1989). This species is widely distributed throughout the country and is threatened by habitat loss and the skin trade. Information on coastal distribution and the status of coastal populations is unavailable.

Some 20 species of sea snakes have been recorded in India, most of which are common, but all are poorly known (Whitaker, 1985 b). Elsewhere these reptiles are subject to extensive mortality as bycatch in the prawn trawl industry but the extent of such impacts on Indian populations is not known.

4.2.4. Amphibians

An endemic Andaman mangrove hog and a Nicobar toad are mentioned by Menon & Bagla (1989). The coastal distribution and conservation status of these species is indeterminate.

4.2.5. Fish

Coral reef fish have been studied in the region of Parangipetti on the east coast of the mainland (Adiyapatham & Ramaiyan, 1985) and in Minicoy Lagoon, Lakshadweep (Pillai, 1983a). There is some concern that *Chromis coerulosus* may be becoming scarce as a result of over collecting as bait fish for the tuna industry (Pillai, 1983a). No other information on the status of threatened marine or coastal fish species appears to be available.

4.2.6. Invertebrates

Trochus niloticus, trochus (CT)

Collected in the Andamans and Nicobars, unsuccessful attempts were made to cultivate trochus in the Andamans in the 1920s (Rae, 1937). Also found in Lakshadweep (Shenoy, 1984), the status of these populations is unknown..

Turbo marmoratus, the green snail (CT)

Collected in Andamans and Nicobars (Appukuttan, 1977 and 1979); also found in Lakshadweep (Shenoy, 1984).

Charonia tritonis, the giant triton (R)

Known from the Lakshadweep where the status of this species is unknown (Mallik, 1979).

Tridacna maxima (IQ,

Tridacna squamosa (I),

Tridacna crocea (IQ,

Hippopus hippopus (I)

One or all of these species may occur on the mainland coast, and these giant clams are present in the Andamans and Nicobars. *T. maxima* and *T. squamosa* are also found in Lakshadweep where the former is very common (Mallik, 1979). Exploited for subsistence purposes only in the Andamans and Nicobars (Munro, 1988; Ramadoss, 1983).

Pinctada spp., pearl oysters (CT)

Found in Gulf of Kutch, Bombay, Malvan Bay, Vizhinjam, Madras, Tuticorin, Palk Bay, Gulf of Mannar, Orissa. The most widespread and common species is *Pinctada fuscata* (Patel, 1985c).

Carcinoscorpius rotundicauda, & *Tachypleus gigas*, horseshoe crabs (K)

West Bengal probably represents the western limit to the distribution of these two species, which occur sympatrically in this area. They have been collected at Digha, Canning, Kakdip, Freserganjand Junput (Sekiguchi *et al.*, 1978; Sekiguchi & Nakamura, 1980) being found on muddy coastlines in bays and estuaries. *C. rotundicauda* has been recorded in a river 90 miles from the sea (Annandale, 1909). The conservation status of these species in Asia is unknown.

Panulirus spp. tropical spiny lobsters (CT)

There are about six species found in different coastal areas of which *Panulirus homarus* is the most commercially important (George, 1968a; 1968 b). *P. polyphagus* is taken off both the west and east coasts (Deshmukh, 1964).

Emerita emeritus, sea grasshopper, sand crab (K)

Known from the east coast of India this species is threatened by over-exploitation in Thailand but its status in India is unknown (Boonruang & Phasuk, 1975; Bain & Humphrey, 1982). Found on intertidal sandy beaches the species is commercially harvested for bait in Thailand.

Birgus latro, the coconut crab (R)

Found only on South Sentinel Island in the Andamans this species has declined elsewhere within its range (Anon., 1981; Reyne, 1939; Altevogt & Davis, 1975; Saharia, 1981; James, 1985b; Davis and Altevogt, 1976). Studies in the Andamans have indicated it may be possible to farm coconut crabs (Chatterjee, 1977). The species is also found in Galathea Bay in the Nicobars.

Antipatharia, black corals (CT)

Reported to occur in the Gulf of Mannar and in the Lakshadweep (Pillai, 1973), black coral does not seem to be commercially exploited as is the case in other countries.

A number of butterfly species are endemic to either the Andaman or Nicobar Islands and are considered threatened or endangered. In most cases information on their habitat preference and coastal distributions is lacking. They include:

Andamans: *Doleschallia bisaltide andamana*, (R) endemic (Collins & Morns, 1985); *Neptis sankaranar* (R) endemic (Collins & Morris, 1985); *Graphium epaminondas*, which may only occur on South Andaman (Collins & Morris, 1985).

Nicobars: *Tirumala guatama* (R) endemic (Collins & Morns, 1985); *Letheuropa tamuna* (R) endemic (Collins & Morris, 1985);

Not on the IUCN Red List, but endemic to the Andamans are the swallowtail butterflies *Papilio mayo* and *Atrophaneura rhodifer*, both of which are probably forest dwelling rather than coastal species (Collins & Morris, 1985).

Populations of the hemichordate *Ptychodera flava* are reported to have been depleted by collecting as marine biological specimens (Azariah & Pillai, 1985), while the echiuroid, *Rubricelatu spirotansis*, is considered endangered (Haldar, 1985).

4.2.7. Plants

Large numbers of higher plants are considered threatened in India and at the global level, including many palms and orchids; however in most instances there is no information on their coastal distribution.

Depletion of the economically important seaweeds has been noticed in the Mandapam region due to over-exploitation, and a decline in species diversity in the Gulf of Kutch (Scott, 1989) may reflect increasing levels of pollution. There is an urgent need for management of *Gelidiella acerosa* resources in Tamil Nadu. This is being considered by the Marine Algal Task Force at C. S. M. C.R.I. There is also a threat to algal resources of the Maharashtra coast from pollution which is being evaluated by N.I.O. The potential for propagation of economically important seaweeds is also being investigated.

5. Environmental and Conservation Legislation

The Wildlife (Protection) Act 1972

This provides special legal protection to wildlife (threatened species of fauna in particular) on a unified national basis. It provides for the establishment of national parks and sanctuaries by state governments for the purpose of protecting, propagating and developing wildlife, or the environment therein, and provides for stringent punishment if the various provisions are infringed.

There is a complete ban on all cattle grazing and fishing in national parks, but in wildlife sanctuaries grazing and fishing may be regulated, controlled or prohibited. Game Reserves may be established to provide a sustainable yield of wildlife for monetary and recreational value. Even in game reserves there is a complete ban on the hunting of all species on Schedule I of the Act. Hunting of all animals and the destruction of flora is prohibited except in special circumstances, when the state government can approve the granting of a permit.

Schedule I includes over 65 species of mammals, 42 birds, and 20 amphibians and reptiles, as well as certain crustaceans and insects which are unable to withstand hunting pressure. It includes a number of marine and coastal species including all marine turtles; the crocodiles, *C. porosus*, and *C. palustris*; the gaviel; all four varanids; the dugong; the crab-eating macaque; coconut crabs; and all cetaceans. *Platanista gangetica* and *Delphinus delphis* are listed on Schedule II. The Act has been adopted by all coastal states and union territories.

An Expert Committee, set up by the Indian Board of Wildlife, has recently recommended several amendments to the Act, such as the inclusion of threatened plant species, and the creation of Biosphere Reserves at a coordinated central level.

Forest (Conservation) Act 1980

This act attempts to reduce the rate of deforestation by controlling the de-gazetting of forest lands and their improper use for commercial forestry or non-forest purposes. It supersedes the Indian Forest Act of 1927 from which the National Forest Policy of 1952 was derived.

Environment(Protection) Act 1986 and Rules 1986

Provides for pollution control; further information needed.

Exports (Control) Order 1977: Export Trade Control Order 1988

Following Import and Exports (Control) Act 1947, these orders ban exports of all wildlife except that listed on schedules; seashells are listed, but not most other marine species.

The Territorial Waters, Continental Shelf, Exclusive Zone and Maritime Zones Act 1976

Coast Guard Act 1978

Maritime Zones of India (Regulation of Fishing by Foreign Vessels) Act 1981 and Rules 1982

All foreign vessels require a permit to operate within the EEZ and territorial waters.

Water Prevention and Control of Pollution) Act 1974 and Water (Prevention and Control of Pollution) Cess Act 1978

Central and state government water pollution boards exist to control pollution and amendments to legislation by the Department of the Environment refer directly to pollution of mangroves (Davie, In prep.).

Indian Fisheries Act 1897

Chank Fisheries Act

Prohibits the export of unworked chanks. In Tamil Nadu there is a minimum size limit for chanks of 55 mm diameter (Silas *et al.*, 1985a).

Andamans and Nicobars Shell Fishing Rules. 1978

Prohibits collection of corals except for *bonafide* local use, this is not enforced.

Other legislation

A Government Ordinance prevents occupation within 500 m of the shoreline thus establishing a 500 m setback. There is no statutory requirement for Environmental Impact Assessments (EIA) as yet.

There is extensive legislation on trade and export, including specific regulation banning the import of all cetacean products.

Regulations on the size of sea cucumbers that may be processed for export were passed in 1982; the minimum size is 77 mm (Anon., 1985b; Conand & Sloan, 1988). According to Sivasubramaniam (1985) new fishing regulations are under consideration whereby the first 10 km from shore would be reserved for traditional and non-mechanized fishing craft; from 10-23 km off-shore is to be reserved for mechanized craft, and large shrimp trawlers; and deep sea vessels would only be permitted to operate beyond 23 km from shore.

An order has been issued by the Andaman and Nicobar Administration prohibiting all coral extraction (Bagla & Menon, 1989). In Lakshadweep, corals may only be collected for scientific purposes (UNEP/IUCN, 1988).

6. Institutional Infrastructure

Some information on marine environmental centres is given in UNEP/FAO (1985).

6.1.1. Governmental Organizations

Ministry of Environment and Forests

The Department of Environment, Forests and Wildlife, created in 1985, attends to all matters concerning nature and natural resources, and environmental pollution. All major chemical, industrial, hydroelectric, mining and other projects require clearance from this Department before they can be initiated (although a formal EIA is not required). The Ministry was formed later and is responsible for planning, promotion and coordination of all protected areas and environmental Programmes in the country. Eight states have now set up their own State Departments of the Environment. At central level there is a Director, Wildlife Conservation, whilst at state level, the senior official is the Chief Wildlife Warden (replacing the former Deputy Chief Conservator of Forests). Important sanctuaries and national parks are generally administered by separate park and sanctuary superintendents.

The Central Board for Prevention and Control of Water Pollution, established in 1974, became part of the Department of Environment in 1982. There are also State Pollution Control Boards set up following the Water (Prevention and Control of Pollution) Act 1974; the Karnataka board is based at Bangalore and is planning an intensive study of pollution of the coastline; there is also a board at Kerala.

The Department also administers the Zoological (which has a marine biological station in Madras) and Botanical Surveys of India, the Wildlife Institute of India and the Wetland Working Group. The Botanical and Zoological Surveys of India have tended to specialize on the taxonomic aspects of aquatic plants and animals. Under the Man and the Biosphere Programme, the Department of the Environment has funded a number of studies on various wetlands in the country. It has also prepared guidelines for the development of beaches and coastal zones (Silas *et al.*, 1985a).

Planning Commission

Chaired by the Prime Minister, this body decides on major policies for economic growth and allots funds for various schemes. Great emphasis is given to all round economic growth with minimal environmental damage.

Ministry of Irrigation and Power

The Central Irrigation Department and State Irrigation Departments are responsible for conceiving and implementing multipurpose schemes to harness river water, including the construction of dams, reservoirs and canal systems, the development of catchment and command areas, and the storage and release of water for irrigation.

Ministry of Agriculture

The Ministry promotes better crop management, the development of fisheries, and the eradication of weeds. Its main agencies are the Central and State Fisheries Departments (e.g. Gujarat Fisheries Aquatic Science Research Institute (formerly Marine Biological Research Station) at Okha which is concerned with research, monitoring and training in fisheries), the Indian Council for Agricultural Research, the Central Marine Fisheries Research Institute, the Central Inland Fisheries Research Institute (based at Cochin, regional centre at Mandapam Camp, 12 research centres, 25 field centres), the Central Institute of Brackish water Aquaculture (studies on the fisheries of coastal waters) and a network of Agricultural Universities.

Indian Board for Wildlife

The chief advisory body to the Government on matters concerning wildlife, forests, estuaries, mangroves and general wilderness areas; established in 1952; chaired by the Prime Minister.

State Wildlife Advisory Boards

Established by the 1972 Wildlife (Protection) Act under statutory provisions to advise state governments.

Forest Research Institute

The Institute includes the Directorate of Wildlife, Environment, Education and Research, established under the Fifth National Plan.

Ganga Water Authority

Recently established by the Government to contain the pollution of the Ganges and to protect wetland systems of the Ganges floodplain.

Institute of Wetland Management and Ecological Desire (IWMED)

Established by the Government of West Bengal in 1985 to carry out research on ecologically viable development of wetlands.

Environmental Monitoring Organisation.

National Ecodevelopment Board.

National Institute of Oceanography

Based in Goa, this carries out fundamental and applied research on all aspects of oceanography and marine sciences; there are also regional centres at Bombay, Cochin and Waltair. Research is carried out on the Karnataka coast.

Institute of Wetland Management and Ecological Desire (IWMED)

Established by the Government of West Bengal in late 1985 to address the need for the conservation of wetlands through research on ecologically viable development.

The National Committee on Oceanography

Responsible for coral reef matters; its research priorities are domestic sewerage and dredging.

In 1980, the Government setup a Coral Reef Committee, under the auspices of the Department of Science and Technology, to look into the ways and means of preserving India's reefs (Rashid, 1985)

Other organisations:

A Coast Guard Organisation was established in 1978 to combat oil spills and carry out appropriate training in oil spill response and combatting emergencies.

Individual states have in some cases developed their own conservation legislation in addition to adopting the national policies. The level of conservation interest varies greatly between the states, as each state and union territory authority is responsible for conservation within its area of jurisdiction. The protection of forests and wild animals is included in the concurrent list in the Constitution under the 42nd Amendment, 1976. This empowers Central Government to control their protective status and also includes forest areas and sanctuaries of national importance under the powers of acquisition of property (entry 42 on the list).

6.1.2. Non-governmental Organisations

Bombay Natural History Society

The Society, which was established in 1883, has been undertaking wetland studies at several fresh and estuarine sites for over fifteen years. A field station has been established at Point Calimere to study the ecology of this area. Studies on migratory and resident waterfowl have been undertaken at Chilka Lake, Kolleru Lake and Point Calimere.

WWF-India

WWF-India has promoted various campaigns to protect Indian wetlands; it has 600 Nature Clubs scattered throughout the country, and supports a Data Centre for Natural Resources in Bangalore.

UNDP/UNESCO Regional Project on Mangrove Ecosystems in Asia and the Pacific

The international headquarters of the Project are located in New Delhi. The Indian National Coordinator is based at the Department of Environment, and the National Project Scientist at the National Institute of Oceanography.

French Institute (Pondicherry)

The Ecology Department is working on vegetation maps for all India.

Ecological Society (Pradesh)

The Society conducts field surveys and ecological enquiries, particularly in Maharashtra.

Indian Society of Naturalists (Baroda)

The Society publishes the journal "Environmental Awareness".

Society for Andaman and Nicobar Ecology (SANE)

Indian National Trust for Art and Cultural Heritage (INTACH)

Established in 1984, and aims to interact with State and Central Government to draw up a National Conservation Strategy; has received grant aid from NORAD to setup educational Programmes and determine human damage to coral reefs; the Andaman and Nicobar chapter of INTACH is closely involved in reef protection, mainly through education.

Andaman Prakriti Sausad

Tourism and Wildlife Society of India (Jiapuur)

Wildlife Preservation Society of India (Dehra Dun)

The Society was established in 1958, and publishes the journal "Cheetal".

Other non-governmental organisations which conduct field surveys and ecological enquiries include the Madras Naturalists' Society and the Andhra Pradesh Natural History Society.

6.1.3. Universities

Andhra University. Visakatatnam

The Institute of Coastal and Off-shore Research has conducted studies at Kolleru Lake (not strictly coastal).

Annamalai University. Tamil Nadu

The Department of Marine Biology has carried out some work on shorebirds at Point Calimere and Pichavaram Mangroves.

Cochin University

Department of Marine Sciences

D.N.R. College. Bhimavaran

The Department of Zoology is studying the impact of cultural fisheries at Kolleru Lake.

Jawaharlal Nehru University. New Delhi

The School of Environmental Sciences has been involved in the All India Wetland Survey and has carried out various studies on wetland ecosystems.

Osmania University. Hyderabad

The University has carried out some studies at Pulicat Lake.

University of Kerala

Department of Aquatic Biology and Fisheries.

University of Madras

Zoology Department.

Saurashtra University

The Department of Biosciences has worked on the wetlands of Saurashtra, particularly Khijadia sanctuary.

Marine Biological Research Institute, Sagar Island, West Bengal

Involved with mangrove work and Project Tiger.

Central Salt and Marine Chemicals Research Institute, Bhavnagar

Major seaweed programme for commercial purposes.

Marine Biological Research Station (Konkan Krishi Vidyapeeth), Ratnagiri.

In addition to the above there are several regional research laboratories and institutes of technology which carry out wetland and coastal related research projects, especially in relation to pollution and weed control.

7. Conservation and Management Activities

7.1.1. Current research

A considerable amount of research has been carried out on mangroves under the auspices of the UNDP/UNESCO Regional Project on Mangrove Ecosystems in Asia and the Pacific. A National Mangrove Committee for India, appointed by the Department of Environment, Government of India, in 1979, recommended a major programme of research, development and management of the mangrove environment. The location of major mangrove research centres in India is shown in Figure 1. Numerous research projects have since been initiated, particularly by the National Institute of Oceanography in Goa (Untawale, 1985 & 1987).

The principal ecological work on the coral reefs of mainland India has been carried out by Pillai (1969; 1971a; 1972; 1973; 1977) and Mergner & Scheer (1974) who concentrated on the southeastern section. Reddiah (1977) and Sewell (1922; 1935) visited the Nicobars and Gardiner (1901; 1903; 1903-6) and Pillai (1971a; 1971b; 1983a) studied the reefs of Lakshadweep. The 2nd Xarifa Expedition visited the Nicobars (Sheer and Pillai, 1974). Wafar (1986) provides an overview of the distribution and available knowledge on Indian reefs.

A national inventory of wetlands, the All India Wetland Survey, was initiated by the Government in the late 1960s and a Wetland Working Group was established by the Department of Environment in the early 1980s (Varshney, 1984). This has been carrying out a survey, preliminary results of which are given in Varshney (1987). Although a considerable amount of wetland research has been undertaken, most information has come from a few well known sites, such as Point Calimere, Chilka Lake and the Sundarbans, or from specific regions, such as Gujarat. The Gulf of Kutch was first studied by Homell (1908-09), then followed general survey work including that of the Oxford University Expedition in 1984 (Palmer & Briggs, In press) and now a research station is being established on Pirotan (Scott, 1989).

Waterfowl counts have been made on a regular basis at several of the major waterfowl sanctuaries such as Point Calimere (Ali, 1963). Some regional assessments have also been attempted, such as those of Savage & Abdulali (1970), Koning & Koning-Raat (1975); Ali (1981); De Block (1981) and Gole (1984). In 1987, simultaneous waterfowl counts were carried out at wetlands throughout India, as part of a major international waterfowl census in southern Asia organized by the International Waterfowl Research Bureau. The Indian counts were coordinated by the Bombay Natural History Society; they included some 500,000 waterfowl of over 130 species (approximately 2,000 grebes, 2,700 pelicans, 6,300 cormorants and darters, 17,300 herons and egrets, 4,100 storks, 4,150 ibises and spoonbills, 8,800 flamingos, 4,800 geese, 320,000 ducks, 21,400 cranes, 43,400 rails and coots, 60,000 shorebirds and 6,600 gulls and terns) (Van der Ven, 1987). The proportion of these that were from coastal sites is not distinguished in the synopsis of results. A second nationwide census was carried out in January 1988, and there are plans to continue the counts on an annual basis.

A symposium organized by the Marine Biological Association of India in Cochin in January 1985 highlighted the problems and prospects of endangered marine animals and marine parks. Following reports in 1983/84 of 250 dugongs being killed at the villages of Kilaree and Peripattinam (Silas & Fernando, 1985,) the status of populations was investigated in 1987 (Marsh, 1988). The present harvest is considered to be less now because of political problems in the area but there is still a need for an aerial survey, increased surveillance and public education (Marsh, 1988). CMFRI has some individuals caught in Gulf of Mannar, in captivity at Mandapam Camp (Jones, 1967; Anon, 1989). A survey carried out in the Andamans by INTACH with the assistance of the Indian Navy and Shipping and Marine Department of the A & N Administration in 1986-87 revealed serious stock depletion.

7.1.2. Coastal zone management

India is starting to take active steps in coastal zone management. There is a 500 m setback within which no occupation is permitted. The importance of the Tamil Nadu coast for numerous economic activities such as mining, fishing, and pearl collection has resulted in coastal zone management activities being started in this area. These include aquaculture projects, improvement of water supplies and the promotion of Ocean Thermal Energy Conversion (OTEC) (Loveson & Rajamanickam, 1989). Coastal zone planning is also being carried out along the Coromandel coast, where sites vulnerable to erosion have been identified. Recommendations for the siting of tourist developments and for reforestation Programmes and other schemes to stop erosion have been made (Ramasamy *et al.*, 1989).

The Ganga Action Plan has been drawn up to bring about a rapid reduction in the pollution load of the Ganges. It involves the establishment of financially self sustaining treatment schemes along a 2,525 km river course (Department of Environment, 1985; Govind, 1989). Ghosh (1983) describes recent innovations in the use of sewage from Calcutta in fisheries. A paramilitary organisation of Coast Guards has been created to monitor pollution at sea and protect economic interests within the EEZ (Govind, 1989). India participates in the Bay of Bengal Programme for small-scale fisheries and for the tuna fishery.

7.1.3. Existing protected areas

There are many discrepancies in the published information on existing protected areas, their size and date of establishment. Information for this section has been taken from PADU (1990): a draft list of protected areas of India compiled by the World Conservation Monitoring Centre from information included in Rodgers & Panwar (1988), Kothari *et al.* (1989) and a list produced by the Department of Environment, Forests and Wildlife in October 1989. This list is currently being reviewed by the relevant authorities and organisations in India.

Information has also been taken direct from Rodgers & Panwar (1988) who have provided a detailed analysis of protected area coverage in the country. The coast, which comprises 2.4% of the whole country has two national parks and 17 other protected areas. Islands comprise 0.3% and have six national parks and 100 protected areas, the latter consisting largely of small sanctuaries in the Andamans. The Lakshadweep and Nicobars are identified as having a particularly low protected area coverage. The different types of protected area are defined in

Rodgers & Panwar (1988). Under this project, computerised maps have been developed and a database established. The Indian Institute of Public Administration is also reported to be compiling a database and directory of protected areas on behalf of the Department of Environment.

A national committee has been established for the UNESCO MAB programme. Although no coastal biosphere reserves have been established to date a number have been proposed including the Gulf of Kutch, Gulf of Mannar, Chilka Lake and Sundarbans (Scott, 1989). A biosphere reserve has been created in the Nicobar Islands but this does not come under the MAB programme.

India is a signatory to the World Heritage Convention and the Sunderbans National Park to the southeast of Calcutta became a World Heritage site in 1987.

In June 1981, India became a party to the Bonn Convention on the Conservation of Migratory Species of Wild Animals and has since negotiated a bilateral convention on migratory birds with the USSR (October 1984). India acceded to the Convention on Wetlands of International Importance especially as Waterfowl Habitat (The Ramsar Convention) in October 1982, and has designated six sites, of which one, Chilka Lake, is coastal (IUCN, 1987). Several other sites, including the coastal sites, Point Calimere and Khijadia, have been proposed as Ramsar sites; the Gulf of Kutch has been recommended several times for designation (Anon, 1984; Scott, 1989).

Gujarat

1. Gulf of Kutch Marine Sanctuary (45,792 ha) and Marine National Park (16,289 ha), established in 1986 and 1982 respectively (Briggs, In press; PADU, 1990); both lie on the southern shore of the Gulf and include 42 islands and a complex of fringing reefs backed by mud and sand flats, coastal marsh and mangrove forest under various degrees of exploitation; park boundaries are largely determined by the distribution of corals (UNEP/IUCN, 1988). Additional information in Scott (1989) and Chavan (1983).
2. Khijadiya Wildlife Sanctuary -604.9 ha, established 1981 (PADU, 1990); comprises three lakes which are adjacent to extensive marshes on the south shore of the Gulf of Kutch; some mangrove but degraded; no effective management yet but the local WWF Group (Jamnagar) and Maharajah Jamsaheb have taken an interest in preserving the wildlife (Scott, 1989).
3. Little Rann of Kutch Wildlife (Wild Ass) Sanctuary -495,370 ha, established in 1973 (PADU, 1990); established for wild ass; also important for waterfowl, especially the mouth of the Banas River, a major staging area for migratory shorebirds; almost no management and no clear demarcation of boundaries; cattle grazing, wood collecting, agriculture, shooting, and trapping all occur within the sanctuary (Scott, 1989).

Maharashtra

1. Malvan Sanctuary: 2,912 ha, established in 1987 (PADU, 1990); listed as National Park by Rodgers & Panwar (1988); includes coral, sandy beaches, turtle nesting and mangrove; planned to include a chain of rocky islands (15013 'N, 73027 'E) from Vengurla Rocks in the south to Sindhurdurg Fort in the north (NIO, 1980; Qasim, 1980; Silas *et al.*, 1985a); reported to have abundant living corals. The Fort is a National Monument under the Archaeological Survey of India. The Government of Maharashtra has proposed developing the area for tourism, focused around the Fort, including the building a marine aquarium; a zoning plan has been drawn up (Silas *et al.*, 1985a).
2. Sanjay Gandhi (Bonvili) National Park; 8.696 ha, established in 1983, to the north of Bombay (Rodgers & Panwar, 1988; PADU, 1990); possibly not coastal; further information in Gratton (1970).
3. **Phansad Wildlife Sanctuary**; 7,000 ha, established in 1986, south of Bombay; mangroves (Rodgers & Panwar, 1988; PADU, 1990).

Goa

1. Chora Island Wildlife Sanctuary; established in 1988, 180 ha (PADU, 1990); (3 km² - Rodgers & Panwar, 1988); in the mouth of the Mandovi estuary; developed as a recreation and education centre concerning mangroves; large investment in reforestation (Davie, 1991).

Karnataka None.

Kerala None.

Tamil Nadu

1. Guindy National Park; established in 1976, c. 271 ha, near Madras (PADU, 1990; Rodgers & Panwar, 1988).
2. Vedanthangal Wildlife Sanctuary; 30 ha, established in 1936, south of Madras (PADU, 1990; Rodgers & Panwar, 1988).
3. **Vettangudi Wildlife Sanctuary; 38 ha, established in 1977; south of Pt Calimere** (PADU, 1990; Rodgers & Panwar, 1988).
4. Point Calimere Wildlife Sanctuary; 17 km² (1,726ha), established in 1967 (PADU, 1990); lies on east end of 50 km long Vedaranyam Salt Swamp covering 25,435 ha; blackbuck, waterfowl, wintering migrants; mangrove, saltmarsh, mudflat, dry evergreen forest and scrub; holiday resort; BNHS field research station; Forest Department sea turtle project in Vedaranyam area, hatcheries at Pt Calimere, Vanamandhevi and Vizhundaumavadi; Ecological Monitoring Committee set up to advise on protection and conservation

(Rodgers & Panwar, 1988; Scott, 1989; Hussain *et al.*, 1985; Hussain & Azariah, 1985).

5. Pichavaram Forest Reserve: 1,416 ha; covers part of mangrove system of 11,000 ha; only large remaining mangrove area in Tamil Nadu and one of richest and most interesting in India; coastal lagoon, inflow from Coleroon River; 51 mangrove islands and islets; limited fishing permitted; crocodile rehabilitation project underway; turtles rare; many waterfowl etc; fishing important; molluscs described (Kasinathan & Shanmugam, 1988); heavy exploitation and disturbance; conservation proposals recommend development for tourism rather than exploitation (Scott, 1989).
6. Pulicat Lake Sanctuary; established in 1980, 46,102 ha (Zoological Survey of India, 1984; PADU, 1990) but 6,000 ha threatened by salt pans; fishing important; very important for migratory shorebirds (Scott, 1989).
7. Gulf of Mannar National Park; 20,000 ha (623 ha land), established in 1986 (PADU, 1990); most important mangroves in southern India; major sea turtle feeding ground, dugong and dolphin; corals (Rodgers & Panwar, 1988; UNEP/IUCN, 1988).

Andhra Pradesh

1. Pulicat Lake Sanctuary; Andhra Pradesh Sanctuary covers 58,000 ha, including 17,250 ha of lagoon (see also Tamil Nadu); established in 1976; action plan drawn up by expert group; Pulicat Lake is second largest salt water lagoon in India; 84% lies in Andhra Pradesh (Scott, 1989).
2. Coringa Sanctuary; northeast part of Godavari Delta; mainly mangrove and shallow lagoons; 23,570 ha; established in 1978 for re-introduction of *C. porosus*; management plan being implemented (Scott, 1989).
3. Krishna Reserved Forest; mangroves; logging discontinued in 1976 (Scott, 1989).

Orissa

1. Chilika (Chilka) Lake Wildlife Sanctuary; 116,500 ha; given sanctuary status in 1978 under Orissa Forest (Shooting) Rules 1972; 1,533 ha declared as wildlife sanctuary in 1987; designated a wetland of international importance in 1981; core area designated around Nalban Island where fishing and grazing will be banned; proposals being drawn up for regulation of fishery and improved management (Scott, 1989); see below for proposals for Nanda Island.
2. Mahanadi Delta crocodile conservation area; reportedly designated for *C. porosus*; mangroves (Scott, 1989); 16,835 ha, designated in 1981 (PADU, 1990).
3. Bittarkanika (Bhitarkanika) Wildlife Sanctuary; 17,000 ha, established in 1975 (PADU, 1990), but 65,000 ha according to Scott (1989); situated on Kanika Island in Brahmani-Baitarani Delta, but includes 12 off-shore islands and several beaches.

4. Gahirmatha Wildlife Sanctuary; declared in 1975; fishing and tree felling banned; *C. porosus* project (main crocodile populations); mangroves; turtle nesting; protection good (Scott, 1989); recommendations for improved management for *C. porosus* in Kar (1985).
5. Balukhand Wildlife Sanctuary; established in 1984, 7,200 ha, (PADU, 1990; Rodgers & Panwar, 1988).

West Bengal

1. Sundarbans National Park; 133,010 ha, established in 1984 (PADU, 1990) for tiger; (c. 258,500 ha; declared in 1973 as original tiger reserve?); includes most of mangrove in Indian Sundarbans; core area declared national park in 1982 (?), adjoining Bangladesh Sundarbans Wildlife Sanctuary; management described in Scott (1989).
2. Lothian Island Wildlife Sanctuary; 3,885 ha, established in 1976 (PADU, 1990).
3. Halliday Island Wildlife Sanctuary; 583 ha, established in 1976 (PADU, 1990).
4. Sajnakhali Wildlife Sanctuary; 36,234 ha, established in 1976, near Bangladesh border (PADU, 1990).

Andaman Islands

1. Wandur (Wandoor) Marine National Park (UNEP/IUCN, 1988); established in 1983, 23,400 ha (PADU, 1990); west coast of South Andaman, comprising Labyrinth Islands; nesting turtles; 281.5 km² (Bangla & Menon, 1989).
2. Saddle Peak NP; established in 1979, 3,318 ha (PADU, 1990).
3. North Butten Island National Park; established in 1979, 4,400 ha (PADU, 1990); includes some coastal habitat.
4. Middle Butten Island National Park covers 4,400 ha and was established in 1979; includes some coastal habitat.
5. South Butten Island National Park: established in 1979, 300 ha (PADU, 1990); named as a Sanctuary in Scott (1989).
6. Mount Harriet National Park; established in 1979, 4,622 ha (PADU, 1990).

PADU (1990) lists 94 separate Sanctuaries as having been established in the Andaman and Nicobars. Many of these are probably small islands and therefore should be considered as part of the coastal zone. It is not known if Sanctuary legislation extends to the submarine habitat but it is thought that it covers mainly terrestrial habitat; according to Rodgers & Panwar (1988), the total protected area is 700km² of which 500 km² is terrestrial. The Island Sanctuaries, with area and date of establishment according to PADU (1990) are:

Arial (55 ha, 1987); Bamboo (5 ha, 1987); Barren (811 ha, 1977); Belle (8 ha, 1987); Benett (346 ha, 1987); Bingham (8 ha, 1987); Blister (26 ha, 1987); Bluff (14 ha, 1987); Boudoville (255 ha, 1987); Cinque (951 ha, 1987); Clyde (54 ha, 1987); Cone (65 ha, 1987); Crocodile (Lohabarrack) (10,600 ha, 1983); Curlew (16 ha, 1987); Curlew (3 ha, 1987); Defence (1,049 ha, 1987); Dot (18 ha, 1987); Dottrel (13 ha, 1987); Duncan (73 ha, 1987); East (611 ha, 1987); East or Inglis (355 ha, 1987); Egg (5 ha, 1987); Entrance (96 ha, 1987); Flat (936 ha, 1987); Gander (5 ha, 1987); Goose (1 ha, 1987); Gurjon (16 ha, 1987); Hump (47 ha, 1987); Interview (13,387 ha, 1977); James (210 ha, 1987); Jungle (52 ha, 1987); Kwangtung (57 ha, 1987); Kyd (800 ha, 1987); Landfall (2,938 ha, 1987); Latouche (96ha, 1987); Mangrove (39ha, 1987); Mask (78 ha, 1987); Mayo (10 ha, 1987); Montgomery (21 ha, 1987); Narcondam (681 ha); 1977); North Brother (75 ha, 1987); North (49 ha, 1987); North Reef (348 ha, 1987); Oliver (16 ha, 1987); Orchid (10 ha, 1987); Ox (13 ha, 1987); Oyster no 1 (21 ha, 1987); Oyster no 2 (8 ha, 1987); Paget (736 ha, 1987); Parkinson (34 ha, 1987); Passage (62 ha, 1987); Patric (13 ha, 1987); Petman (137 ha, 1987); Pocock(62ha, 1987); Point (307 ha, 1987); Potanma(16ha, 1987); Ranger (426 ha, 1987); Reef (174 ha, 1987); Roper (146 ha, 1987); Ross (1 ha, 1987); Row (1 ha, 1987); Sandy (158 ha, 1987); Sea Serpent (78 ha, 1987); Shark(60 ha, 1987, Shearme (785 ha, 1987); Sir Hugh Rose (196 ha, 1987); Sisters (36 ha, 1987); Smike 1 (3 ha, 1987); Snake 2 (73 ha, 1987); South Brother (124 ha, 1987); South Reef(117 ha, 1987); South Sentinel (161 ha, 1987); Spike 1 (1,170 ha, 1987); Spike2 (42ha, 1987); Stoat (44ha, 1987); Surat (31 ha, 1987); Swamp (409 ha, 1987); Table (Delgarno) (229 ha, 1987); Table (Excelsior) (169 ha, 1987); Talakaicha (321 ha, 1987); Temple (104 ha, 1987); Tree (3 ha, 1987); Trilby (96 ha, 1987); Tuft (29 ha, 1987); Turtle (39 ha, 1987); West (640 ha, 1987); Wharf (11 ha, 1987); White Cliff (47 ha, 1987).

Nicobars

1. Battimalve Island; 223 ha, 1985.
2. Megapode Island; 12 ha, 1985.
3. Tillongchong Island; 1,683 ha, 1985.
4. Great Nicobar Biosphere Reserve; established 6 Jan 1989; 885 km²; southernmost island of group; zonation includes priority areas for research for marine biology and mangroves.

Lakshadweep

Pitti Island; a bird sanctuary according to Bhaskar (1979b) but not cited elsewhere.

7.1.4. Mangrove management and protection

Land use in mangroves is still largely unplanned especially on the west coast, where there is no long established forestry industry (Davie, 1991). Forest Working Plans have been developed for managed forests in the Sundarbans, Deltas of the Mahanadi, Godavari and Krishna Rivers, and Andaman-Nicobar Islands and these determine commercial forest production (Davie,

1991). Mangrove afforestation Programmes are underway in some areas such as in the Gulf of Kutch (Chavan, 1985). The Department of the Environment (DOE, 1985) has recently developed an Action Plan for the control of pollution in the Ganges.

8. Recommendations for Future Action

8.1.1. Proposed protected areas

In 1982, the Department of the Environment produced a working document entitled “National Wildlife Action Plan” (GOI, 1982) which envisaged the establishment of a representative network of protected areas (Government of India, 1982). The state governments have executive authority over the management of designated areas and this is considered to hamper the development of an integrated national system of protected areas. Recently the Wildlife Institute of India has produced a proposal for a protected area network, aimed at being biogeographically representative as well as geographically well distributed (Rodgers & Panwar, 1988). The general principle is that 5% of each biogeographic province should be protected.

This principle has resulted in the proposal, under this scheme, to increase the number of parks to 18 and of protected areas to 40 for islands and to 7 parks and 32 protected areas for coasts (Rodgers & Panwar, 1988). This would significantly increase protection for the majority of threatened species mentioned in this report.

Gujarat

1. Kori Creek Wildlife Sanctuary -20 km²; for mangrove and coral systems (Rodgers & Panwar, 1988); lies off the coast of the Great Rann of Kutch.
2. Aliabet Island - in Kori Creek, mangrove island off the Narmada River (Rodgers & Panwar, 1988).
3. Cambay (Gulf of Khambhat) Wildlife Sanctuary -10 km²; the Gulf includes mangroves (most important resource but degraded), some coral reefs around small islets in western part of Gulf, mudflats and sandbanks; fishing important; important for shorebirds; survey needed to identify suitable area of varied habitat with green turtle nesting population (to include shoreline and littoral vegetation); *C. mydas* and *L. olivacea* nest in large numbers along the coast and on Piram Island (Rodgers & Panwar, 1988; Scott, 1989). The estuary of the Shetrunji at Talaga has been recommended as a sanctuary for wintering roosts of cranes. A relict mangrove patch exists near Bhavnagar Port; the islands in the Gulf have been suggested as habitat for black buck overspill from the Velavadar Sanctuary.
4. A proposal was made for the establishment of a Flamingo Sanctuary in the Great Rann of Kutch to protect the colony at Pachham Island (Flamingo City) but the site was abandoned by the birds (Scott, 1989). There is a proposal to upgrade the Wildlife Sanctuary in the Little Rann of Kutch to a biosphere reserve; there is an urgent need for improved monitoring and an integrated management plan for the entire area (Scott, 1989). It has also been suggested that a major sanctuary should be established to incorporate both the Great and Little Ranns.

Maharashtra

1. Dasgaon Wildlife Sanctuary -5 km²; Kolaba District; mangrove (Rodgers & Panwar, 1988).
2. Achra Wildlife Sanctuary-1 km²; Sindudurg District; mangrove already under protection by local religious community (Rodgers& Panwar, 1988).
3. Vikrohli Wildlife Sanctuary - 7 km²; Bombay; badly degraded mangrove but could recover to provide an educational, aesthetic and pollution control benefit to Bombay estuaries (Rodgers & Panwar, 1988).

Goa

A Marine Park was reportedly recommended for Anjadip Island, off Binge Bay near Goa (Salm, 1975a)

Karnataka

1. Kundapur (Coondapur) Wildlife Sanctuary - 1 km²; mangrove (degraded) (Rodgers & Panwar, 1988); Scott (1989) describes estuaries of the Karnataka coast; these are important for mangroves and shorebirds but are under heavy pressure; at Coondapur, *Rhizophora* seedlings are being planted by local people on a very large scale to protect bunds from erosion.
2. Honavar (Hanovar) Wildlife Sanctuary-50 km²; surviving relict of Malabar plains forest to be identified for protection (Rodgers& Panwar, 1988).
3. Pilarkhan Wildlife Sanctuary-20 km²; type locality for Champion and Seth's West Coast Semi-Evergreen Forest (Rodgers & Panwar, 1988).
4. Wildlife Sanctuary to be identified for a representative sand-rock beach with typical littoral vegetation (Rodgers & Panwar, 1988).

Kerala

1. Wildlife Sanctuary for Leatherback turtle nesting beach if appropriate -5 km²; (Rodgers & Panwar, 1988).
2. Trivandrum area Wildlife Sanctuary -20 km²; to protect any fragments of lowland forest remaining among the plantations (Rodgers & Panwar, 1988).
3. Kumarkon Wildlife Sanctuary-On Vembanad Creek in Kottayam District, part of Cochin backwaters described by Scott (1989).
4. Ezhimala Wildlife Sanctuary-5 km²; in Cannanore District; relict and degraded mangrove

(Rodgers & Panwar, 1988).

Andhra Pradesh

1. Smiharikota Island Wildlife Sanctuary -20 km²; type locality for Champion and Seth's description of Dry Evergreen Forest, a biome scarcely protected in India; *C. porosus* released in adjacent creeks (Rodgers & Panwar, 1988); adjacent to, or within, Pulicat Lake Sanctuary (see description above) (Scott, 1989).
2. Nachugunta-Kottavalem Wildlife Sanctuary -50 km²; survey needed to identify suitable sites to protect Krishna Delta mangroves (Rodgers & Panwar, 1988); description of Krishna Delta and Krishna Reserved Forest (see above) in Scott (1989); there has also been a proposal to upgrade the Krishna Reserved Forest to National Park status (Scott, 1989).
3. Navpada Wildlife Sanctuary - 20 km²; brackish swamp community, with resident and migratory waterfowl including pelican nesting site (Rodgers & Panwar, 1988).

Orissa

1. Bhitarkanika National Park-70 km²; (Rodgers & Panwar, 1988) (see above description).
2. Gahirmatha North Wildlife Sanctuary -50 km²; turtle nesting site on northern extremity of beach (Rodgers & Panwar, 1988); reported by Scott (1989) to have been declared in 1975- see above for Bhitarkanika Wildlife Sanctuary.
3. Nanda Island National Park -20 km²; adjacent to/within Chilika Wildlife Sanctuary (see above), to protect important turtle nesting and feeding ground on and around Nanda Island (Rodgers & Panwar, 1988).

Tamil Nadu

1. Point Calimere National Park -10 km²; upgrading of core area of Wildlife Sanctuary (Rodgers & Panwar, 1988). There is also a proposal to declare the entire Vedaranyam Swamp as a sanctuary and the Swamp has also been proposed for designation as a Wetland of International Importance under the Ramsar Convention; the Swamp is very important for birds and is the site of a major commercial fishery (c. 300 boats carry out large-scale fish trawling at sea; smaller scale fishing in lagoons); overfishing has caused drastic depletion; area also threatened by salt companies, two large marine chemical companies, siltation and desiccation; a major research programme is underway (Scott, 1989).
2. Pichavaram Wildlife Sanctuary - 11 km²; mangroves, waterfowl (Rodgers & Panwar, 1988); see above for Pichavaram Reserved Forest.
3. Kazhiveli Wildlife Sanctuary - 10km²; mangroves, waterfowl (Rodgers & Panwar, 1988); Kazhiveli (Kaliveli) Tank is a semi-permanent, fresh to brackish water lagoon emptying into the sea via the Yadayanthittu estuary; a number of individuals and organisations have

recommended the creation of a bird sanctuary here and reforestation with mangroves has been considered; the wetlands and entire watershed have been recommended for designation as a Biosphere Reserve under the MAB programme; one of the last high quality lagoon and estuarine systems on the east coast of India but threatened with development; very important for waterfowl (Davis, 1985; Scott, 1989).

The reefs in Palk Bay, although not recommended for protection need some form of management.

Andaman Islands

The following sites are listed in UNEP/IUCN (1988) or Rodgers & Panwar (1988); many already receive some degree of protection and there needs to be further clarification of the changes required.

1. North Andaman Peninsula Wildlife Sanctuary.
2. North Reef Island National Park; according to Scott (1989), established and covers 161 ha; proposal is to improve crocodile protection.
3. South West Mangroves Wildlife Sanctuary.
4. South Reef Island National Park.
5. Landfall Island National Park.
6. Table Island Group National Park.
7. Shearme Island Group National Park.
8. Outram and Button Islands National Park extension.
9. Narcondum Island National Park: to protect the hombill.
10. Barren Island National Park.
11. Rutland Island National Park: or sanctuary, to act as a bufferzone for Wandur Marine Park.
12. Mount Harriet National Park extension.
13. South Sentinel Island National Park: for turtles.
14. Little Andaman National Park: to cover the entire southwest of the island.

Nicobars

1. Tillachong Island National Park.
2. Kamorta Island Wildlife Sanctuary.
3. Little Nicobar National Park: the entire island and adjacent islets.
4. Mount Thullier National Park.
5. Campbell Bay Wildlife Sanctuary.

Lakshadweep

No specific recommendations available.

3.1.2. Species protection

Rodgers & Panwar (1988) discuss the effectiveness of the existing protected areas for the protection of threatened species and the new proposed protected area network should improve this.

In the case of the Ganges river dolphin there is urgent need for census surveys in the Brahmaputra River; establishment of research centres at major universities on the Ganges/Brahmaputra river systems e.g. Gauhati on the Brahmaputra and Benares on the Ganges; development of a suitable substitute for dolphin oil.

Recommendations concerning other marine mammals are given in James (1985 c). Detailed recommendations for the dugong are in Jones (1976) with particular reference to the Gulf of Mannar/Palk Bay area; they include the establishment of a field centre for survey work and data collection at Kilakkarai; the protection of the area extending from Rameswaram to Hare Island near Tuticonn as a sanctuary; and the development of a co-operative programme with Sri Lanka. The status of dugong populations was investigated in 1987 (Marsh, 1988) and although the present harvest is considered to be less now because of political problems in the area there is still a need for an aerial survey, increased surveillance and public education (Marsh, 1988). There is urgent need for protection of this species in the Andamans where it is now known only from Ritchies Archipelago and North Reef and where it was traditionally hunted by the Onge people (Cipriani, 1969; INTACH/SANE, 1989b; Jones, 1976).

Pernn (1989) recommends the monitoring of incidental gill net catches. The *N. phocaenoides* population needs monitoring as do the populations of *S. chinensis* particularly as its distribution is closely correlated with mangroves. Populations of *S. longirostris*, *S. attenuata* and *S. coeruleoalba* and *Grampus griseus* are also of conservation concern and require monitoring since large numbers of these dolphins are killed in coastal gill net fisheries and the meat used for local consumption (Klinowska, 1992; Pernn, 1989).

The following recommendations were made by Silas (1984) and Silas *et al.* (1985b) concerning improved protection for marine turtles:

1. Bhitarkanika Sanctuary to be extended to include Wheeler and Short's Islands on north Orissa coast and Hukitola Island and False Point (near Paradip Port) for ridley nesting; extension on seaward side to protect ridley nesting beaches and mating areas. Possible establishment of a biosphere reserve for the Bhitarkanika and Gahirmatha area to include mangroves, crocodiles, beaches and turtles.
2. Kujang-Astrang, Orissa: establishment of a reserve for ridley nesting grounds near mouth of Devi River in Cuttack District and/or extension of proposed Konarok-Balukhand Sanctuary in Puri District to cover 48 km beach with turtle nesting grounds north of Keluni Muhana River mouth.
3. Sandy beaches and islands of Sundarbans and Godavari and Krishna Deltas to be studied for location of turtle nesting sites for improved protection.
4. Extension of Pt Calimere Sanctuary to include the seaward beaches used for turtle nesting.
5. Beaches south of Dwaraka and the coast of Diu Islands on west coast, important for green turtle nesting, should be protected from sand mining for cement industry (best west coast nesting site, Bhaidar Island in Gulf of Kutch, is already protected in Marine Park).
6. Kwangtung, N. Reef Island, Latouche, N. Cinque, S. Cinque, Interview Island, and Twin Islands: turtle nesting beaches on these islands in the Andamans and Nicobars should be protected. Addition reserves are needed for turtles and crocodiles on Great Nicobar, Middle Andaman, Car Nicobar and Camorta Island
7. Green turtle nesting beaches around Suheli Veliyakaran, Bangaram, Thinnakara and Parali Islands in Lakshadweep should be declared reserves; hawksbill nesting beach on Minicoy and off-shore feeding areas also.

8.1.3. Mangrove conservation and management

Silas *et al.* (1985a) recommend the protection of particular sites as follows:

1. Mathupet Swamp and Pitchavaram backwaters (Tamil Nadu).
2. Gulf of Kutch.
3. All tidal inlets and swampy deltas of the east coast.
4. Suitable areas on the Andamans, Nicobars and Lakshadweep.

In the western Sundarbans, 'silvopisciculture' is being developed experimentally to combine demands for aquaculture and forest products in ways which conservative coastal land and are of greater value to local people (Lahiri, 1987).

8.1.4. Other recommendations

The creation of protected areas in the Andamans, Nicobars, Lakshadweep and the Gulf of Mannar is considered a high priority in the Corbett Action Plan for Protected Areas of the Indomalayan Realm (Thorsell, 1985).

Scott & Poole (In press) consider the following areas as priorities for improved protection and management: the southern Gulf of Kutch (the marine park is now considered threatened due to lack of management); the Gulf of Khambhat; the Sundarbans; Chilka Lake; the estuaries of the Karnataka coast; the Yedayanthithu estuary (proposed Kazhiveli Wildlife Sanctuary); the Cochin backwaters and the Andamans and Nicobars.

Silas *et al.* (1985a) recommended encouraging the development of artificial reefs in the Gulf of Mannar and Palk Bay and the establishment of the following fishery management areas:

1. Palk Bay: seasonal spawning of *Chanos* Feb-April and Sept-Oct; fry move into tidal creeks and inlets and are fished at this stage; could cause over exploitation problems as fry are used for mariculture; closed season needed for *Chanos* from Rameswaram to Point Calimere, following appropriate research; squid breed May-July; need to declare area of 50 km² off Rameswaram east coast in which seine nets or stake nets would be restricted; destruction of eggs by fishing should be monitored.
2. East coast - Madra sto Pt Calimere: flying fish fishery needs protection in spawning period; fishery has declined in recent years, possibly due to heavy fishing; part of this region could be declared a reserved zone with restrictions on fishing.
3. Gulf of Mannar and Palk Bay: possible sites for protected breeding reserves for chanks e.g. 100 km² of sandy seabed 16-30 m deep in Gulf of Mannar, and 100 km² 8-15 m deep off Tandi in Palk Bay.
4. Little Nicobars, Katchal, Camorta Islands: surrounding waters up to 500 m from shore could be declared reserves for *Trochus* and *Turbo*; leasing out operations for commercial exploitation should be terminated in these areas.
5. Estuaries to protect fishery for clams *Paphi* and *Meretrix casta*; several fisheries e.g. Kali River estuary in Karnataka and possibly estuaries in Dakshina Karnataka, have been damaged by dredging of dead clam and oyster shells for lime industry; traditional subsistence clam fishery should be permitted.

A national policy for the management of the coastal zone is necessary (Silas *et al.*, 1985a) including the establishment of a conservation monitoring centre. The implications of future sea level rise should be investigated in the context of future coastal zone management and development plans. A Survey of islands and sea bird colonies is required and there is an urgent need for planning for tourism and sand mining in the Lakshadweep archipelago.

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