Marine Protected Areas Needs in the South Asian Seas Region

Volume 5: Sri Lanka

A Marine Conservation and Development Report

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Marine Protected Area Needs in the South Asian Seas Region Volume 5: Sri Lanka

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Marine Protected Area Needs in the South Asian Seas Region Volume 5: Sri Lanka

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This report was prepared as one of five background documents for a review of marine protected areas needs in the South Asian Seas Region. The draft report was prepared in 1989 by Ms S. Wells, consultant to IUCN and subsequently reviewed in Sri Lanka by Dr P. Dayaratne, Director Marine Biological Resources Division, National Aquatic Resources Agency. Additional information on legislation was provided by Mr L. Gündling of IUCN's Environmental law Centre. The report was edited for publication by Dr John C. Pernetta. The opinions expressed in this document do not necessarily reflect the views of IUCN or UNEP.

1. General Description: Sri Lanka

1.1.1. Geography & Geology

Area:	65,610 km^2;
Coastline:	1,770 km;
EEZ:	256,410 km^2 (200 miles);
Continental shelf:	30,000 km^2;
Population:	17,000,000 (1990).

Sri Lanka is a pear-shaped island in the Indian Ocean, situated between latitudes 5° 54'N and 9° 52'N, and longitudes 79° 39'E and 81° 53'E, and separated from India by a channel generally less than 20 m deep and only 35 km wide at its narrowest point. The island is 435 km from north to south, and 225 km from east to west at its widest points. Geologically Sri Lanka is a detached part of the continental Deccan plateau. Nine-tenths of the island is composed of crystalline rocks of pre-Cambrian age (Cooray, 1967). The greater part of the lowland is composed of metamorphic Palaeozoic rocks of the Vijayan series. There are areas of Miocene limestone in the northwest and southeast, and very small patches of fossiliferous Jurassic formations in the northwest (Puttalam) and Sabaragamuwa Province (Ratnapura). Plio-Pleistocene gravels occur as isolated patches in the northwest and southeast, and there are quaternary deposits in river valleys and along much of the east and west coasts.

Sri Lanka probably separated from the Indian sub-continent in late Miocene times, the southwestern sector having been the first to separate with alternate shallow flooding and elevation at various times thereafter. There are also indications of three peneplains or erosion levels between: 0 - 120 m; 300 - 700 m; and, 910 - 2,438 m. The island has a low-lying coastal plan and mountainous interior; two-thirds is lowland, with the highlands, at a general elevation of 1,400-1,800 m, covering some 10,400 km^2 in the south-central part of the country.

1.1.2. Climate

The overall climate is monsoonal with a southwest monsoon between May and September and northeast monsoon from December to February (Anon, 1988). The most extensive climatic regime is that of the low country dry zone, which encompasses almost the entire northern half of the island, together with much of its eastern side to the southeast coast. Although heavy rains occur during the northeast monsoon, this region is otherwise hot and dry, and is mostly covered with secondary forest and scrub. The annual rainfall ranges from 600 to 1,900 mm. The climate in the southwestern lowlands is very different, and is generally hot and humid, the annual rainfall on occasions exceeding 5,000 mm. The rainfall in this region is concentrated into the period of the southwest monsoon, but also occurs during the northeast monsoon (Hoffmann, 1983). Further details are given in UNEP (1986).

In the lowlands, temperatures are typically tropical, varying from about 24°C to 32°C with a mean annual temperature of 27°C. At higher elevations much lower temperatures are recorded (10-20°C), and the temperature occasionally approaches zero at localities such as Nuwara Eliya, Horton Plains and Mount Pidurutalagala. At mid-altitudes mean annual temperature is around 24°C, and in the highlands about 15°C. There are only slight seasonal variations in temperature, the fluctuations being 1.8°C at the coast, 2.7°C in the uplands and 2.4°C in the highlands. Cyclones affect Sri Lanka every 10-15 years and in 1964 and 1978 they caused considerable damage on the north and east coasts (UNEP, 1986).

1.1.3. Coastal and off-shore topography

The continental shelf is narrowest at Kalpitiya (2.8 km) in the west and in the south between Matara and Dondra (6 km) (Anon, 1988). It is broadest in the west and north where it merges with that of India. In this area there are three elevated areas:

- Pedro Bank, stretching northwards from Jaffna Peninsula to the coast of India;
- Pearl Banks, off the coast of Mannar, and Adam's Bridge - a narrow, long sandbank making the Palk Straits impassable for ships; and,
- Wedge Bank around the southern extremity of India.

The continental shelf has a depth which ranges from 20 - 65 m (Anon, 1988). Deep water occurs close to the coast in a few areas such as Trincomalee, Kumana, Matara and Panadura. Further details of the continental shelf and slope are given in UNEP (1986).

Some 30% of the total land area can be considered coastal if this is defined as land rising from sea level to 30 m altitude; the coastal area is about 40 km wide at its broadest (UNEP, 1986). The Coast Conservation Act uses a very narrow definition of the coast, as that area within 300 m landward of mean high water (MHW) level and 2 km seaward of mean low water (MLW) level.

The coastline is dominated by sandy beaches with coastal lagoons and rocky headlands but a few high cliffs are found in some areas. Coastal ecosystems include: coral reefs; estuaries; brackish or saline lagoons; mangrove swamps; seagrass beds; rocky sea coasts; sand dunes, barriers and spits; salterns and salt pans. It is estimated that there are a total of 80,000 ha of estuaries and deep lagoons and 40,000 ha of shallow lagoons, tidal flats and mangroves. The north-west coast has deposits of sedimentary limestone of miocene origin (UNEP, 1986). Further general information on the coast is available in Bird (1982) and Swan (1981), and for the west coast, GOSL/ESCAP (1985).

1.1.4. Oceanographic features

Surface currents tend to follow the monsoon winds. For several months at the end of each year currents come from the north-east, the Bay of Bengal and along the coast of India, rather than from the open ocean, which increases sedimentation in inshore waters. In general therefore the sedimentary regime of coastal waters is classed as terrigenous rather than bioclastic (Couper, 1983) although calcareous sediment patches may dominate near coral reefs.

Coastal currents are long-shore and are stronger off the east coast than the west coast. They are particularly strong around the Little Basses from October to January, and in the waters between Sri Lanka and India during the monsoons. Tides are semi-diurnal with a small range: 0.75 m at spring and 0.25 m at neap tides. Tidal ranges are highest at Colombo and lowest around Delft and Trincomalee. High waves are generated in the southwest during the southwest monsoon (UNEP, 1986).

2. Marine and Coastal Ecosystems

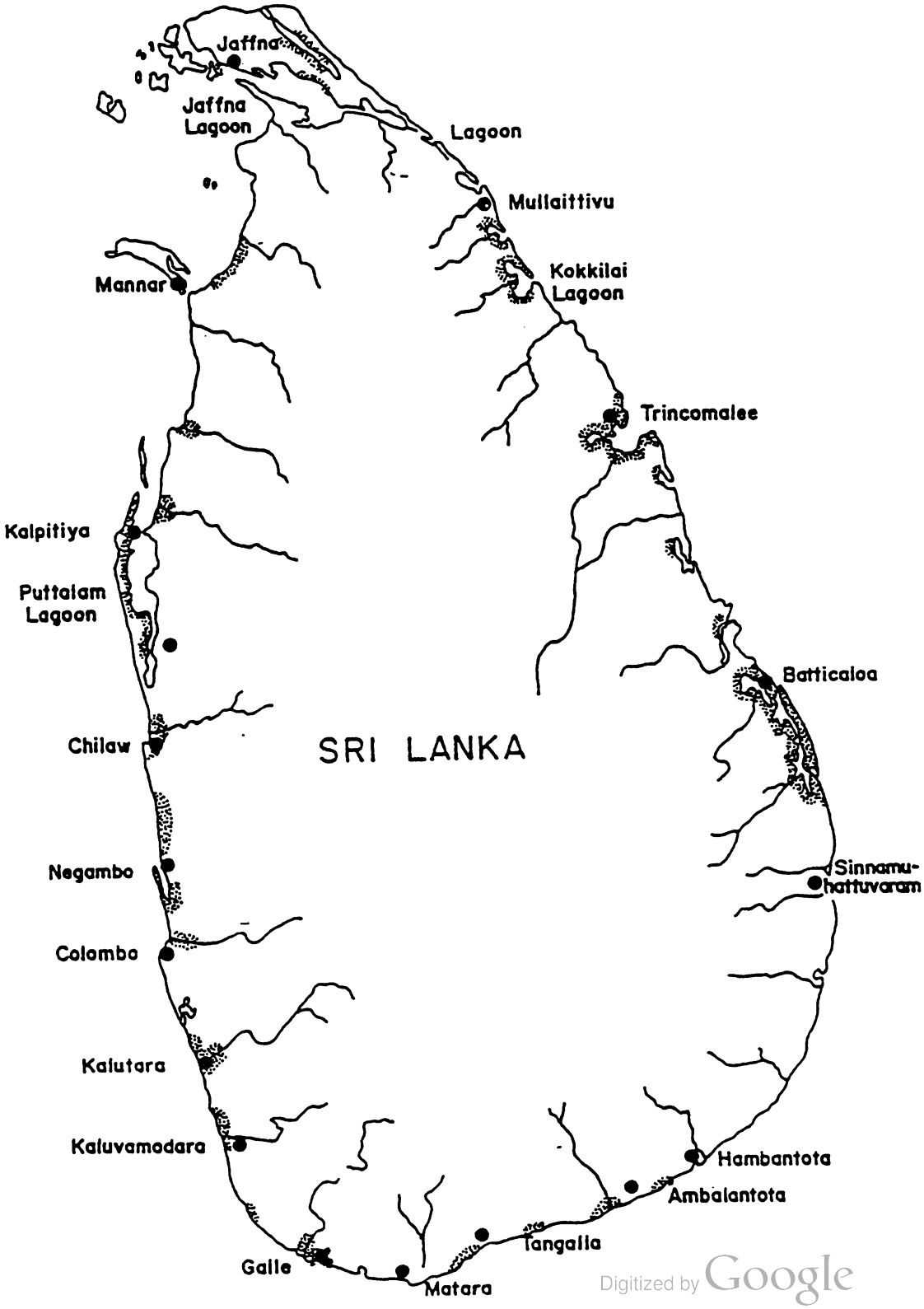
Information on marine and coastal ecosystems was recently reviewed at a series of conferences including the Conference on Critical Habitats, organized by the Coast Conservation Department (CCD). The Conference on Coastal Ecosystems, organized by the National Aquatic Resources Agency (NARA, 1986) was held as a preparatory activity during the development of the Coastal Zone Management Plan (CZMP). Detailed information on most coastal ecosystems in Sri Lanka is therefore available and broad surveys of most habitats have been carried out. The CCD has mapped coastal habitats on a scale of 1:63,360 using aerial photography and other sources, and has produced a summary map at a scale of 1:253,340 (Government of Sri Lanka, 1987). The CZMP focuses on six dominant habitats but recognises that other habitats and ecosystems may need attention in the future, particularly sandstone reefs and mudflats (Anon, 1986b).

2.1.1. Mangroves

Mangroves are discontinuously distributed along the coastline (Figure 1), being absent along exposed shorelines, particularly in the southwest, south and northeast. Over 60% occur on the northwest coast, in the Puttalam Lagoon and the Dutch and Portugal Bay areas (UNEP, 1986). In 1969, the total area of mangroves was conservatively estimated at 3,000-4,000 ha. More recent remote sensing studies have indicated that there are 6,296 ha of mangroves just in the districts of Colombo, Amparai, Gampaha, Trincomalee, Batticaloa and Puttalam (Samarakoon & Pinto, 1986), and that the total area for the whole country is likely to be close to 10,000 ha (Scott, 1989). According to GOSL (1987), the total area is 12,189 ha or 5-10% of the country's sheltered tidal habitats. A habitat survey has been completed by NARA and a distribution map of mangrove areas produced. CCD has carried out island wide mapping from aerial photography and NARESA and NATMANCOM are preparing more detailed maps of the west coast, based on remotely sensed images and ground truthing (Anon., 1986b). The most recent information is found in Anon (1986c and 1991a), Amarasinghe (1989; 1990), Kanakavine *et al.* (unpubl.), Pinto (unpubl.), and Samarakoon (unpubl.).

The main mangrove areas are situated in Mullaitivu, Trincomalee, Kathiraveli, Vakarai, Panichankerni, Valaichenai, Batticaloa, Karativu, Komari, Potuvil, Hambantota, Pilinawa, Matara, Galle, Gintota, Muthurajawela, Negombo, Chilaw, Mundel, Puttalam, Kalpitiya and Mannar, and on the Jaffna Peninsula (Samarakoon & Pinto, 1986). Scott (1989) identifies the following areas as having important stands: west end of Jaffna Peninsula (Kayts Island), Uppu Aru Lagoon, Thondamannar Lagoon, Chalai Lagoon, Nai Aru Lagoon, Periyakarachchi and Sinnakarachchi Lagoon, Upaar Lagoon and Uppu Alan, Vandeloos Bay, Elephant Point and Thenadi Bay, Batticaloa Lagoon, Arugam Kalapuwa, Lunama Kalapuwa and Kalametiya Kalapuwa, Muthurajawela Swamp. Vankalai Kalapuwa and Periya Kalapuwa, Palk Bay, Devil's Point and Vidattaitivi Lagoon. According to GOSL (1987) the most extensive mangrove stands are in Puttalam, Batticaloa, Trincomalee, Jaffna and Gampalia.

Figure 1.
Mangrove distribution along the coastline of Sri Lanka (Salm, 1975b)



Twenty eight mangrove and mangrove associated species have been described by UNEP, (1986) while GOSL (1987) lists 14 mangrove species and 12 mangrove associates. The genera *Rhizophora, Avicennia, Excoecaria, Lumnitzera* and *Aegiceras* are distributed island-wide. *Xylocarpus granata* occurs on the west and the east coasts, *Bruguiera cylindrica* occurs only on the west coast, *Ceriops tagal* is absent from Jaffna, and *Nypa fruticans* occurs only in the southwest. Some studies have been carried out on zonation and succession in mangrove forests, and limited information is available on the associated fishes and invertebrate fauna. The small tidal range of less than a metre around most of the coast means that there is little zonation within the mangroves which form a narrow inter-tidal belt, extending less than one kilometre landwards. More obvious zonation may be seen in estuaries, deltas and tidal creeks (GOSL/ESCAP, 1985; GOSL, 1987). Further information on mangroves is available in several publications (e.g. Aruchelvam, 1968; Flueeler, 1983; Jayewardene, 1985; 1987; Macnae & Fosberg, 1981a; 1981b; Modenke & Modenke, 1983; Pinto, 1982; Seneviratne, 1978; 1979; Sivakumar, 1979).

2.1.2. Marshes and wetlands

Saltmarshes consisting of herbaceous salt tolerant plants growing in sandy or muddy coastal flats in arid areas, occur mainly as sparse, short growth, interspersed with scrub mangroves (Pemadasa *et al.*, 1979). They are more prevalent in the drier regions of the country in the north and west from Pullikulam to Manthai; the total area is estimated at 23,819 ha (GOSL, 1987; Samarakoon & Pinto, 1986). In Mannar District where tidal flats are more extensive, the marsh vegetation contains up to 56 species. Salt marsh vegetation may also develop where the mangrove canopy has been removed. This ecosystem is important for waterfowl and as grazing areas for cattle.

The total area of estuaries and lagoons has been estimated at 158,017 ha by GOSL (1987) (Figure 2). There are some 45 estuaries belonging to two types: basin estuaries where rivers discharge into relatively shallow basins which in turn open into the sea as in the case of the Puttalam, Negombo and Jaffna Lagoons; and riverine estuaries, where rivers discharge into the sea by way of relatively narrow channels as in the Kaluganga and Kelaniganga estuaries (Samarakoon & Pinto, 1986). The total extent of the basin estuaries is estimated at 40,000 ha. Some hydrographic information is available for the major basin estuaries and a few riverine estuaries (for example Perera & Sachithananthan, 1977) and a little information is available on primary productivity and phytoplankton biomass. Several studies have been carried out on seasonal changes in zooplankton diversity and abundance (for example Jayasinghe *et al.*, 1980) and on other invertebrates, particularly annelids, molluscs and crustaceans. Considerable research has been carried out on the fisheries (Scott, 1989); further information is available in Samarakoon & Pinto (1986).

There are about 40 true coastal lagoons (Samarakoon & Pinto, 1986) which are most common along the southern, southeastern and eastern coasts, where littoral drift causes accumulations of sand as barriers and spits at river mouths, restricting freshwater discharge. The total area of the lagoons is estimated at about 20,000 ha. Sand barrier formation has transformed some basin estuaries into lagoons (e.g. Koggala Lagoon). In some cases, such as Batticaloa and Kokkilai lagoons (Figure 3), seasonally formed sand barriers result in temporary lagoons with restricted

Figure 2.
Location of major basin estuaries and coastal lagoons in Sri Lanka (Source: NARA)

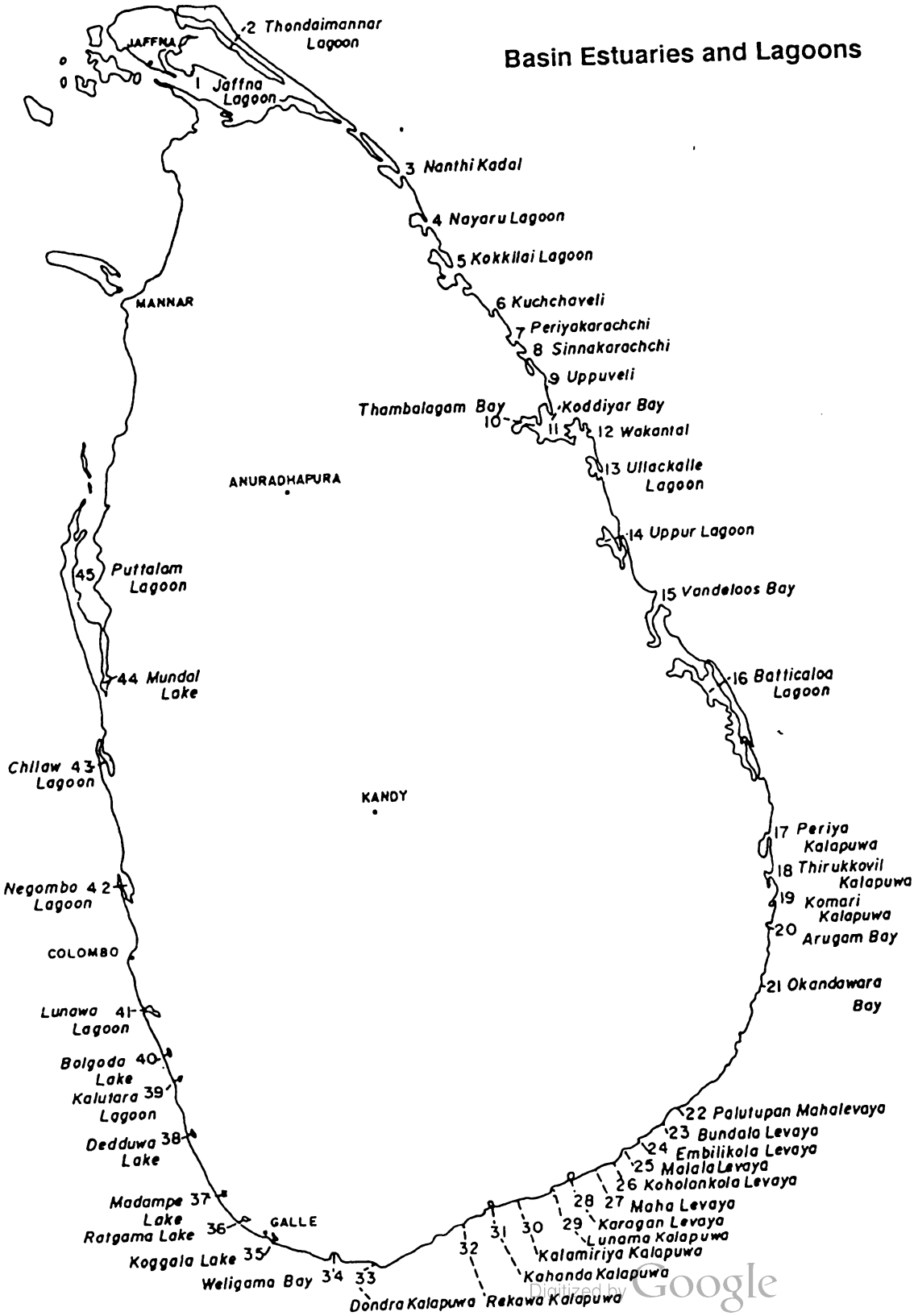
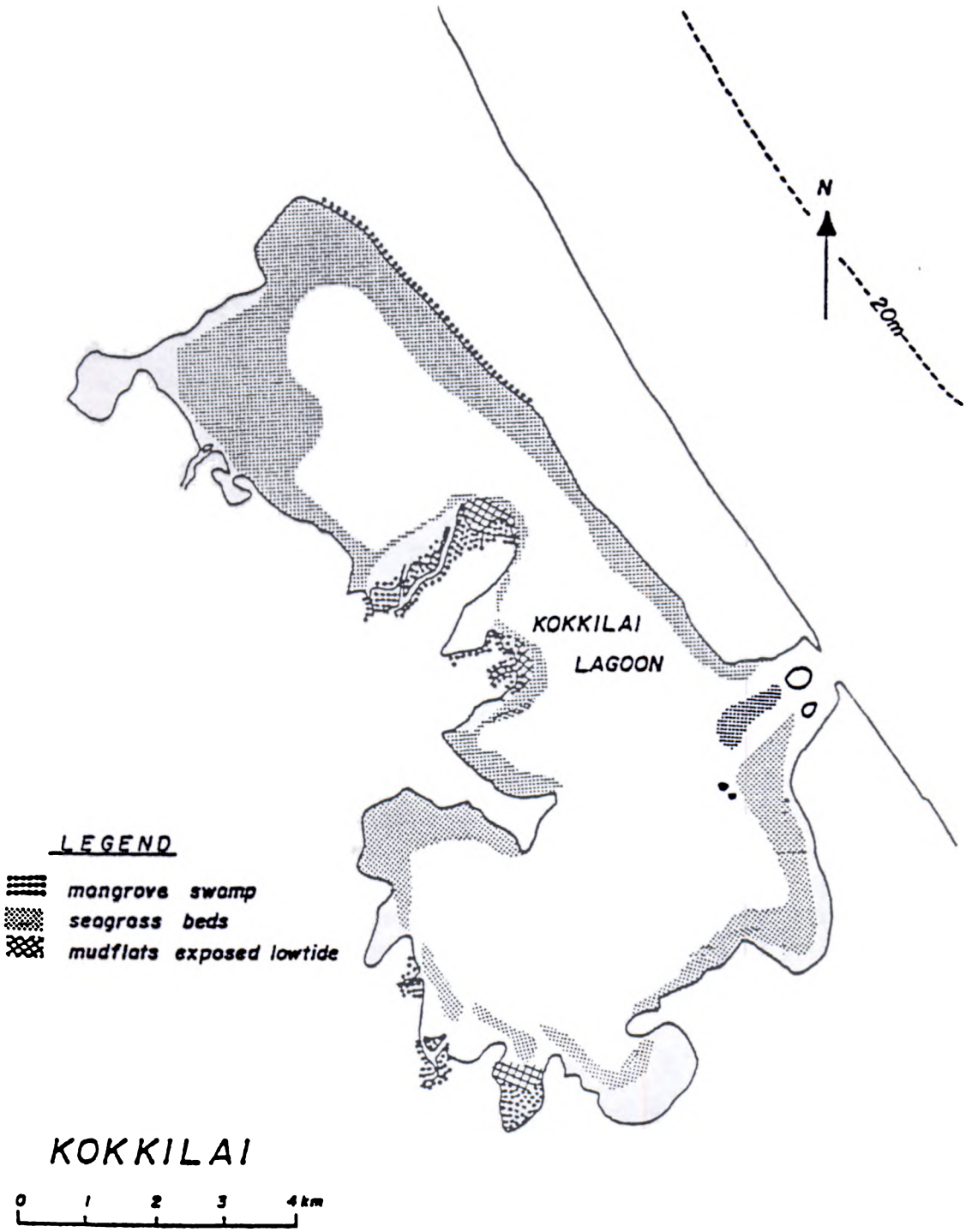


Figure 3.
Sub-tidal habitats of the seasonal closed coastal lagoon of Kokkilai (Salm, 1975b)



connection to the open sea. Many seasonal lagoons form during the wet season and subsequently dry out during the dry season. In some cases, the water becomes hypersaline when sources of fresh water dry up and water exchange with the open sea is restricted by the sand barriers. In others, freshwater run-off has a dominant effect and the salinity is very low. These lagoons are important for fisheries and salt production; as wildlife habitat; for tourism; and, land reclamation for agriculture and human settlement.

Further information on estuaries and lagoons is given in Abeywickrema (1960; 1966), Anon (1977), Arudpragasam (1975; 1984), Fernando (1983), Marga Institute (1985a; 1985b) ,Norris, (1957), Samarakoon & Pinto (1986), Silva (1984) and UNEP (1986). West coast lagoons at Mundel, Chilaw, Negombo, Muthuragawela, Bolgoda Lake, Lunawa, Kalutara, Dedduwa Lake, Bentota Ganga, Madampe Lake, Ratgama Lake, and Koggala Lake are described in GOSL/ESCAP (1985).

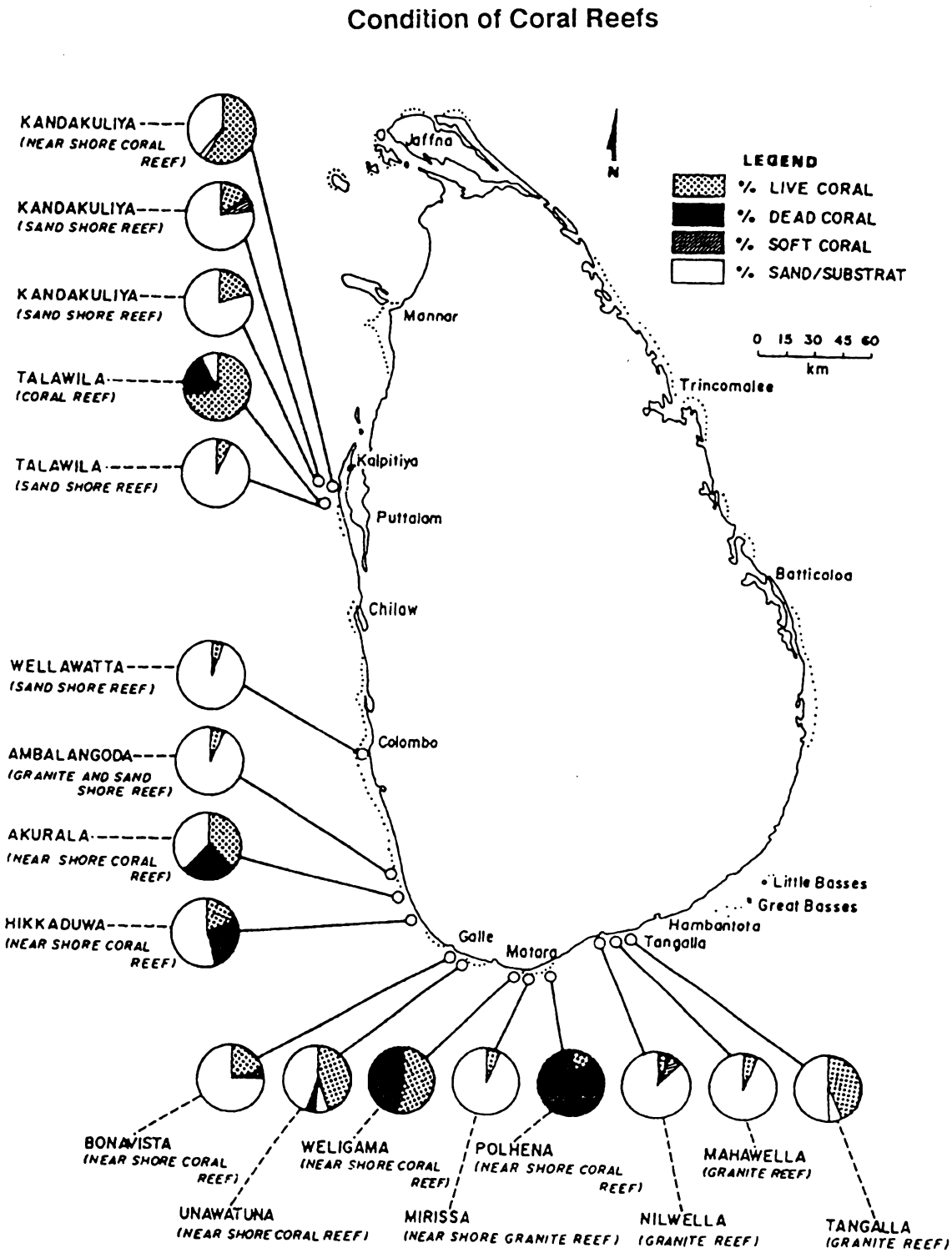
2.1.3. Coral Reefs

There are few purely coral reefs but there are extensive areas of coral around the coast, mainly close to the shore. Most consist of corals growing on ancient sandstone (largely along the west coast) or gneiss or granite outcrops along the east coast (Jonklaas, 1981; Salm, 1975a; 1975b; Silva, 1986a;). A band of exposed sandstone is found on the west coast, often on the edge of lagoons enclosed by sand spits. The Pamunugama reef, which fringes the shore from the mouth of the Kelani River to the headland off Negombo is one of the most conspicuous examples of this coastal type. Samarakoon & Pinto (1986) identify three types of reef in Sri Lanka: fringing (e.g. Hikkaduwa); apron (found on rocky substrates near shore); and barrier (e.g. Vakalai and Silavathurai). Reefs found at the latter sites are not true barrier reefs but off-shore patch reefs. Rajasuriya & Silva (1988) surveyed 50 sites on the southwest coast from Kandakuliya to Tangalle and found three types of reef: 12 sites had true coral reefs; 14 were crystalline rock; and 24 were sandstone reefs. Coral cover on the latter two was mainly less than 10% except at Kandakuliya were the sandstone reefs had a cover of up to 25% (Figure 4).

In the north, the Jaffna Peninsula has extensive areas of coral inshore, although the water is reportedly green or turbid. Corals are also reported to occur around Delft, Palitivu and Iranativu Islands off the north-west coast. On the west coast, Vankalai, Silavatturai and Arippu are three reefs, over 5-7 miles (8-11 km) long and lying 4-5 miles (6.4-8 km) off shore in the Gulf of Mannar. These reefs have abundant coral formations although the water is usually turbid (Salm, 1975a). Other reefs on this coast include Bar Reef, west of Karaitivu Island (north of Kalpitiya), also off shore and apparently still in very good condition and Kandakuliya with two extensive coral areas. Coral reefs are few in this area although they do occur west of the Karaitivu Islands.

In the south, there is a fringing reef with corals on rocky outcrops at Akurala, and extensive fringing reefs at Hikkaduwa, Galle and Unawatuna. At Kapparatota, towards the western end of Weligama Bay; at Polhena, near Matara; and at Dondra Head, there used to be spectacular rock formations with coral growing on them. On the north-west side of the bay at Dickwella and at Nilwella, several bays had fine coral formations; while at Tangalla, there used to be a good reef off the headland. The status of reefs from Kandakuliya south to Tangalla has been assessed by NARA (Silva, 1986a) and further information is given in Rajasuriya & Silva (1988). Despite

Figure 4.
Status of Sri Lankan coral reefs (Source: NARA)



the tourist pressure, the reefs at Unawatuna and Weligama are considered to be the richest in this area (Rajasuriya & Silva, 1988). GOSL/ESCAP (1985) lists the west coast reefs.

The eastern coast is reported to have the most extensive coral areas. The offshore Basses Reefs in the south are considered to be perhaps the most spectacular in the country. There are many areas of fringing reef around Trincomalee, including Pigeon Island, Nilaveli (Ava Point), Poduwakattumalai Bay (off Kuchchaveli), Dutch Bay, Coral Cove and Foul Point. South to Batticaloa reefs are found at Kalkudah, Pasekuday and Kalavanchikudi, which were once good but are now seriously damaged. Panichchankeni to the north of Kalkudah also had a fringing reef (Salm, 1975a). There are excellent formations 300-600 yds (274-549 m) off Kalmunai which extend in large patches north to Batticaloa. There is no recent information on the status of the east coast reefs.

Pillai (1972) reports a total of 90 species of stony coral for Sri lanka in 39 genera; Scheer (1984) lists 40 scleractinian coral genera. The National Aquatic Resources Agency (NARA) has set up a coral reference collection with 134 species, including 59 new to Sri Lanka (Silva, 1986a; Rajasuriya, 1986). The total number of corals known from Sri Lanka is now 171 species in 65 genera (Rajasuriya & Silva, 1987; 1988). NARA has carried out some mapping on the south and west coasts (Anon., 1986b) and a number of status surveys (Anon, 1991d; Silva, 1986b).

2.1.4. Seagrass beds and algal communities

Seagrass meadows are most important on the north-west and north-east coasts and they may support more than 50% of the country's near-shore fishery production (GOSL, 1987). The most extensive beds extend from Dutch Bay north of Kalpitiya to Jaffna Lagoon and from Mannar to Rameswaram (Figure 5). Beds are also found at Punkudutivu, Thondamannar, Chalai, Nai Aru, Periyakarachchi, Sinnakarachchi, and Upaar Lagoons, and at Uppu Alan, Batticaloa Lagoon, Negombo Lagoon (Figure 6), Mundel Lake, Puttalam Lagoon and Adam's Bridge. Seagrass beds are also found in Chundikkulam and Kokkilai Sanctuaries (Samarakoon & Pinto, 1986; Scott, 1989). The main genera are *Zostera, Cymodocea,* and *Halophila*. Seagrasses are sometimes dried and used as fodder (UNEP, 1986). The distribution and composition of seagrass beds in Puttalam and Negombo Lagoons is described in Jayasuriya (1989b; 1990).

About 78 genera and 174 species of algae have been recorded (47 Chlorophyceae, 42 Phaeophyceae, 85 Rhodophyceae) from Sri Lankan waters. *Sargassum* is the most abundant brown algal genus, of which 20 species have been identified, the most common being: *Sargassum cervicone*, *Sargassum tenerrimum*, and *Sargassum cinereum*. Extensive algal beds are found off Jaffna, in Palk Bay, the Gulf of Mannar, Pearl Banks off Silavathurei and along the south-west coast from Ambalangoda to Galle. Red algae is found mainly in the southwest, the most abundant species being *Gracilaria edulis* and *Gracilaria lichenoides*. *Gracilaria verrucosa* is the most abundant species on the east coast especially around Trincomalee where it occurs in association with *Gracilaria crassa* and *Gracilaria corticata*. Green algae are most abundant on the north coast, *Ulva* being the most abundant genus.

Figure 5.
Estuarine and marine habitats of Mannar district (Salm, 1975b)

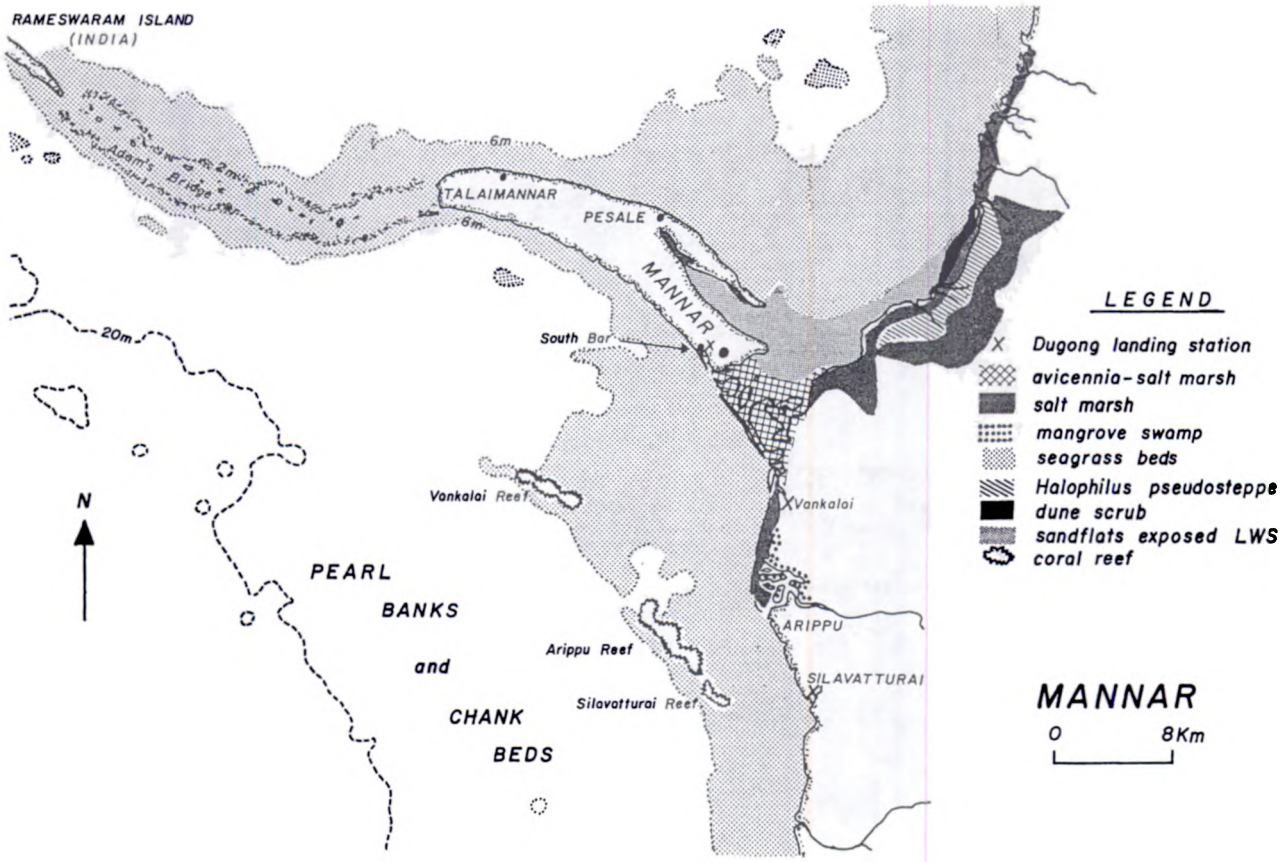
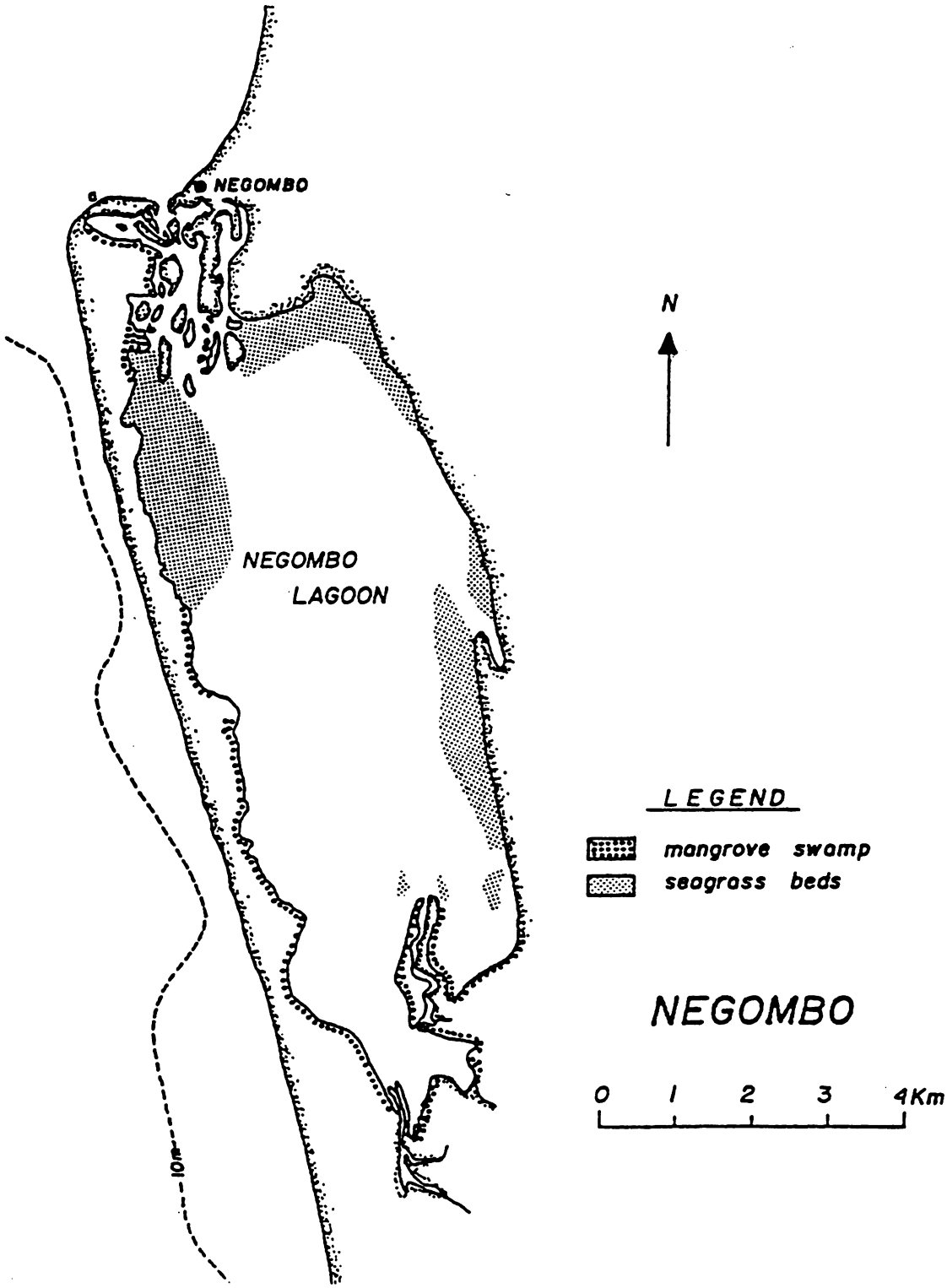


Figure 6.
Mangrove and seagrass habitats of Negombo lagoon (Salm, 1975b)



2.1.5. Beaches, dunes, sand bars and sand spits

Beaches are found along 75-90% of the coast. The majority are sandy barrier beaches, backed by lagoons and swamps, although some are pebble such as that at Galle Buck. They are usually narrow because of the small tidal range and relatively low wave energy, and are narrowest in the south and widest near Chilaw on the west coast and Kalkudah on the east coast (UNEP, 1986). Along the southwest coast, from Matara to Colombo, sand bars enclose coastal lagoons. North of Colombo there are several narrow spits up to 25 miles long connected to the mainland at the southern end and enclosing wide lagoons which run parallel to the coast. Further information on west coast beaches is given in GOSL/ESCAP (1985) and for the whole country in Samarakoon & Pinto (1986). Beaches and spits are estimated to cover about 11,800 ha (GOSL, 1987).

Dunes occur along 22% of the coastline and are estimated to cover 7,606 ha (GOSL, 1987). Dunes 1-1.5 m high are fairly common between Chilaw and Kalpitiya on the west coast, and there are minor ones at Matara and Akurala (GOSL/ESCAP, 1985). Less conspicuous highly weathered dunes are found on the north and north-east coasts while the best dunes are found between Mullativu and Pt Pedro, Elephant Pass and Chavakachcheri, across Mannar Island and Pooneryn Peninsula, along the south-east coast from Kirinda to Sangamakanda Pt, and intermittently along the Kalpitiya Peninsula (Samarakoon & Pinto, 1986).

2.1.6. Other coastal ecosystems

Rocky shores comprise a small area only and are found at the northern edge of the Jaffna Peninsula; along the coastline opposite Karativu Island and Portugal Bay; at Beruwela between Balapitiya and Ambalangoda; at Weligama Bay, between Dondra Head and Tangalle; and at Trincomalee, Unawatuna and a few other headlands (UNEP, 1986).

Islands, open ocean and other ecosystems have received little attention. There are a number of islets and islands of significance around the coastline for example at Adam's Bridge and islets off Hikkaduwa and Trincomalee. Sandstone reefs and mudflats have been poorly studied to date (Anon, 1986b).

3. Economic Aspects of Marine and Coastal Resource Use

The coastal resources of Sri Lanka are economically important as the basis for coastal tourism and fisheries. The high density of population in coastal areas has led to some user conflicts and integrated coastal zone management is now well established in the country. The unsettled political situation has resulted in sporadic development in the tourist sector with major setbacks to international tourism during periods of heavy fighting. It has also resulted in uneven development of the coastal provinces. Socio-economic use of the west coast is covered in some detail in GOSL/ESCAP (1985), Samarakoon & Pinto (1986), and numerous other recent publications which emphasize the economic importance of coastal resources.

3.1.1. Fisheries

Fishing is the main economic activity in the coastal zone. Fish make up 61% of the animal protein in the diet of the human population and in 1981, fish accounted for 2% of Sri Lankan export earnings (GOSL/ESCAP, 1989). Total production of marine fisheries in the early 1980s was 183,000 tonnes, of which 41,000 tonnes was demersal fish and the rest pelagic. According to recent statistics the total marine fisheries production was 174,231 tonnes in 1991. Coastal fish production was 159,151 tonnes and the off-shore and deep-sea production was estimated at 15,080 tonnes (Anon, 1992)

It is thought that the coastal fishery may have reached the maximum sustainable yield but there is scope for expansion in offshore (and inland) fisheries (UNEP, 1986). Coastal fishery resources are defined as those occurring up to 30 nautical miles from the coastline and a 1978/80 survey estimated a total biomass on the coastal shelf and adjacent areas as 750,000 tonnes. The annual sustainable yield was estimated at 250,000 tonnes of which 80,000 tonnes represent large demersal and semi-demersal fish species.

Offshore and deep sea fishery resources which are found between 30 and 60 nautical miles offshore and beyond 60 nautical miles offshore respectively, consist of yellow fin and big eye tuna, skipjack, marlin, swordfish and shark. Biomass estimates vary from 30,000 to 60,000 tonnes and annual production was small in the early 1980's (UNEP, 1986). In 1981, offshore and deep sea fisheries accounted for 2,144 tonnes, while coastal fisheries accounted for 172,318 tonnes (GOSL/ESCAP, 1985). The Wedge Bank, formerly within the fishing areas of Sri Lanka, was transferred to India in 1979.

Sivasubramaniam (1985) provides a review of marine fishery resources. In 1982, pelagic fish comprised 64.7% of the catch, demersal fish 26.8%, shellfish 4.1%, the remainder being unclassified. There has been an overall increase in production although catches of small pelagic fish have declined. Demersal fisheries are described by Sivasubramaniam & Maldeniya (1985). Production figures for the west coast in the early 1980s are given in GOSL/ESCAP (1985).

The tuna fishery is described in Anon (1985) and in Amarasiri *et al.*, (1987) and potential for its expansion seems to be good although there is already intensive exploitation in some areas. Oceanic long-lining for tuna was suspended in 1977 (Sivasubramaniam, 1985). In the early 1980s, 6,000 tonnes of tuna and skipjack were caught annually by gill-netting, about 30-40 km offshore (UNEP, 1982).

Ninety eight per cent of fisheries production is accounted for by small-scale coastal fisheries (Anon, 1984b; UNEP, 1986). About 78,000 people are directly involved in fishing and the industry supports a total of around 330,000 ancillary workers, distributed among 371 fishing centres and 969 fishing villages. Some fishermen exploit the eastern and northern coasts in the southwest monsoon and the southern and western coasts in the northwest monsoon (UNEP, 1986). On the west coast the main catches are sardine, herring, redbait and anchovy; on the east coast sardine and herring predominate (UNEP, 1982).

The government has made coastal fisheries a primary development priority, providing subsidies for boats and engines; developing marketing, harbour and anchorage facilities; and providing training and extension programmes. There has already been a significant increase in mechanised craft and a decline in traditional fishing vessels, although non-mechanised craft still made up 51% of the fleet in 1985 (Sivasubramaniam, 1985). According to Sadarachan (1985) and Lowry & Wickremeratne (1989) there were about 14,000 non-mechanised fishing craft in 1986 but most of the catch (just over 14,000 tonnes) was harvested by the 9,600 mechanised craft and 2,700 large vessels with inboard engines. There are ten fishing harbours which are used mainly by the larger fishing vessels. Most of the traditional craft and fibre glass boats are beach-landed in close proximity to fishing villages. Beaches are also used for drying fish, and boat and net repair, and for temporary huts and storage facilities for migrant fishermen. Beach seining is an important technique in many areas, and accounted for production of 9,000 tonnes in 1981 (GOSL/ESCAP, 1985). Bottom trawling is limited by the topography of the sea bottom, but is used off Negombo, Chilaw, Puttalam, Manar and Mullative, for prawns (GOSL/ESCAP, 1985).

The national fisheries development plan for the period 1990-1994 envisages that the marine fisheries sector will receive high priority. Among the sub-sectors, coastal fisheries is considered the most important since it currently provides over 90% of the catch; over 90% of the employment and 100% of foreign exchange earnings. The number of craft to be introduced over the plan period is 4,000 and a significant policy change has been towards the development of fisheries co-operatives which will be entrusted with the delivery of all state assistance, including subsidies. At present there is an over-emphasis on pelagic gill netting in the coastal fishery which has lead to conflicts where resource constraints have appeared and catch per unit effort declined. As a deliberate policy measure new boats as well as sections of the existing fleet will be encouraged to take up other fishing methods in the demersal fishery including bottom set nets, bottom long lining and trap fishing (GOSL, 1990a)

Spiny lobster resources are described by Bruin (1970), Jayakody (1991), Jayakody & Kensler (1987), and Jayawickrema (1991) and the present annual catch is around 700 tonnes with catches having declined significantly over the last six years. Holothurians are abundant off Palk Bay, the Gulf of Mannar and Kalpitiya. *Holothuria scabra* is collected for export to Singapore

and Hong Kong, 50-95 tonnes being produced annually (UNEP, 1986). A description of the fishery and the present status of holothurian stocks is given in Joseph & Moiyadeen (1988).

Fisheries in estuaries and lagoons are very important and include harvesting fish, crustaceans and molluscs. The status of estuarine fisheries has been summarized by Samarakoon (1986), Anon (1991a), Wijerathna & Costa (1987), and Jayasuriya (1985). The economic value of fisheries in Negombo and Puttalam Lagoons is described in Samarakoon & Pinto (1986). It supports 4,000 people and involves the harvesting of 62 species of fish, crustaceans and molluscs (GOSL/ESCAP, 1985). Other work on estuarine fisheries includes Bruin (1971) and Fernando (1973) on prawns; Fernando (1965) and Pillai (1967) on brackish water fish; Raphael (1977) and Ramanathan (1969) onChanos fry in Mannar, Puttalam and Negombo; Pinto & Wignaraja (1980) on the oyster *Crassostrea cucullata;* and Senanayake (1981). Prawns fished in lagoons are an important export commodity and other important commercial species include *Scylla serrata*, *Holothuria scabra* and various bivalves (GOSL/ESCAP, 1985). The grey mullet fishery is described by Wijerathna (1984); the pearl spot, *Etrophus suratensis* is also an important commercial species. Polychaetes are harvested in seagrass beds and lagoons such as that at Negombo for use as feed in commercial aquaculture (GOSL, 1987).

Sri Lanka takes part in the Bay of Bengal Programme on small-scale fisheries which has resulted in a number of publications including Anon(1984b), Sivasubramaniam & Maldeniya (1985), Weerasooriya (1987), Weerasooriya *et al.* (1985), and Maldeniya & Suraweera (1991).

3.1.2. Aquaculture

As yet there is no large scale coastal aquaculture industry (Samarakoon, 1988) although a major private prawn culture programme has been initiated (UNEP, 1986) and it is government policy to expand this industry. The potential of the west coast lagoons for aquaculture is described in GOSL/ESCAP (1985). Pen culture would be possible in Puttalam and possibly Chilaw, Rathgama and Bolgoda. There is potential for cage culture of finfish in Negombo and Bolgoda. Species recommended for aquaculture include milkfish, mullet, rabbit fish, pearl spot, tilapia, giant sea perch, shrimps, oysters, mussels and seaweeds. There is a pilot project on oyster culture in Puttalam Lagoon. Abandoned coral pits have been used for aquaculture in the Rathgama area.

Funegaard (1985), Samarakoon (1986; 1988), and Samarakoon & Raphael (1972) provide further information on various aspects of mariculture. Raft culture of mussels and oysters is being carried out experimentally in Trincomalee Bay, Puttalam Lagoon, Rathgama Lake and Mirissa Harbour (GOSL, 1987). NARA and the Inland Fisheries Division of the Ministry of Fisheries is investigating the potential for aquaculture in selected lagoons (NARA, 1985).

The inland fisheries division of the Ministry of Fisheries and Aquatic Resources was closed in 1990. Government policy is now not to provide any state support through subsidies to the inland fisheries sector. NARA continues research activities on aquaculture and inland fisheries in support of the private sector which is encouraged to carry out aquaculture development. NARA has surveyed the south and west coasts with a view to selection of suitable sites for aquaculture (NARA/EDB, 1985). Present research focusses on studies of disease outbreaks, growth and

surveys of problems of prawn culture, including sociological and environmental problems such as acid soils and constraints to developing coastal aquaculture sites (Jayasinghe, 1991). Studies are also being undertaken on *Artemia* resources and culture.

3.1.3. Other marine living resources

The collection of coral reef fish for the aquarium trade is a substantial business and is described by Wood (1985). The export trade is promoted by the Government and probably about 500 people are involved. Exports are valued at around US $ 2 million a year or 30% of all marine fisheries export earnings. Collecting is seasonal, depending on the monsoon, and occurs in all inshore areas including Kalpitiya, Negombo, Beruwala, Akurala, Galle, Weligama, Tangalle, Kirinda, Trincomalee (once the most important area), and around Pigeon Island, Kuchaveli, Nilaveli and off Pasekudah and Kalkudah. The Jaffna peninsula used to be important for certain species (GOSL, 1987).

Fish make up 80% of the aquarium trade exports and invertebrates account for the remainder. At least 139 species of fish are involved, including 29 species of butterfly fish. In the early 1980's annual exports comprised about 390,000 invertebrates and 200,000 fish, including about 60,000 damsel fish, 60,000 anemone fish and 21,000 butterfly fish, although these figures are only approximate (Wood, 1985). The Painted Coral Shrimp *Stenopus sp.* and the relatively deep water corals *Euphyllia, Cynaria* and *Lobophyllia* are also taken in increasing numbers (Silva, 1985). Information on trade in ornamental fish and invertebrates is also given in Jonklaas (1985).

About 60 tonnes of coral and coral products are exported annually (Wood & Wells, 1988). Chanks are fished around the Gulf of Mannar, Palk Bay and Jaffna Peninsula and about 100 tons are exported, mainly to Bangladesh to be made into jewelry and trinkets (UNEP, 1986). Pearl oysters have been commercially exploited in the Gulf of Mannar for centuries. The oyster fishery for pearls has progressively declined and only 20-30,000 oysters were harvested in 1983, compared with 4,5 million in 1958 (UNEP, 1986). The window-pane oyster *Placuna placenta* fishery at Thanbalagam Lake, near Trincomalee, yielded 4 million oysters in 1954 but was decimated by floods in 1958 (UNEP, 1986; Samarakoon & Pinto, 1986). The bivalves *Gaffrarium tumidum* and *Marcia opima* are collected in Puttalam Lagoon for food and the shells burnt for lime. Small quantities of black coral carvings are exported mainly to the US (Wood and Wells, 1988).

The alga *Gracilaria verrucosa* is collected in large quantities in the Trincomalee area, cleaned, dried and exported to various countries including Japan. Exploitation has not yet been attempted on an industrial scale as it is thought that stocks are not large enough, but it is estimated that about 250 tons of this species could be taken from the east coast (Jayasuriya, 1991). It has been estimated that about 120 tons of *Sargassum cervicone* could be collected annually from the southwest coast alone. Further research and survey work is required and is being initiated at a number of institutes (Jayasuriya, 1989a; 1991; Sivapalam, 1987; UNEP, 1986). *Gracilaria edulis* is collected from Puttalam Lagoon and dried for export to Japan (GOSL/ESCAP, 1985).

3.1.4. Mangrove exploitation

Mangroves have a variety of uses including as food, fodder, firewood and construction materials and in some cases mangroves are an integral part of small industries for which special cultivation methods have been adopted to ensure efficient production. About 80% of fishermen living in mangrove areas depend on these fishing grounds for their subsistence, especially in the 'brush pile fisheries'. Branches of *Rhizophora apiculata* and *Lumnitzera racemosa* are used to create 'brush parks' to attract fish near Negombo and Chilaw Lagoons on the west coast. *R. apiculata* is used to make poles, and *Rhizophora* and *Avicennia marina* are used for firewood. Tannin is extracted from *Rhizophora mucronata* and *Ceriops tagal*, in some cases on a sustainable basis by removing bark from one side of the stem only. *R. mucronata* bark is used for making plaster casts for fractured bones, and the pneumatophores of *Sonneratia caseolaris* are fashioned into bottle stoppers and net floats (Davis in prep; GOSL/ESCAP, 1985). The economic value of mangroves on the west coast is described in Amarasinghe (1988) and further information is given in Samarakoon & Pinto (1986).

3.1.5. Coral and sand mining

The 1980s saw a major construction boom promoted by the government which resulted in an increase in exploitation of coastal coral and sand resources (Tampoe, 1988). Coral is used extensively in the south-west and its exploitation has caused a number of environmental problems (Hoffmann, 1976; 1977; Premeratne, 1985). It is the main source (90%) of lime for the construction industry and is also used to improve acidic soil (GOSL, 1987). Traditionally, coral mining was restricted to inland deposits and fossil reefs in the south-west at Akurala, Seenigama and Peraliya (UNEP, 1986). However, with the construction boom, the reefs started to be used, as mining these is less labour intensive. In 1985, in the Hikkaduwa area in the south-west, 1,225 people were directly engaged in coral mining; of these 13% actually mined on the reefs, and the rest collected coral on the shore, mined in back beach areas, worked in the lime kilns or in other associated activities. A further 3,500 people were indirectly dependent on the industry. The industry is relatively lucrative; miners work for four months of the year and receive Rs 2,000/month (US$80) comparable to the wages received by management personnel in the civil service (Premeratne, 1985). A Coast Conservation Department survey showed that 7,730 tons were being extracted from beach coral formations and coral debris washed up on the beach and 2,140 tons direct from the reef (Tampoe, 1988), accounting for 42% of total production; a further 58% comes from inland deposits (UNEP, 1986). Coral is processed in 208 lime kilns. According to UNEP (1986) and GOSL (1987), about 18,000 tons of lime were being produced from coral between Ambalangoda and Dickwella in 1984.

A survey of the location, extent and socio-economics of coastal sand mining has been conducted by CCD. In the area from Puttalam to Dondra which includes most of the major sand mining locations in Sri Lanka, approximately 500,000 m^3 of sand were mined from coastal locations. About 1,990 individuals were directly employed as sand miners providing income for 6,000 dependents. Figures for sand production in different areas are given in GOSL (1990c) and guidelines for sand removal in the coastal zone have been set by CCD which will be applied in the issuance of future permits.

3.1.6. Other non-living resource use

Over 4 million tons of mineral deposits (40,000 tons ilmenite, 10,000 tons rutile, 5,000 tons zircon, 30 tons monozite) are mined each year by the Mineral Sands Corporation at Pulmuddai. Mining of deposits at Beruwela had to cease because of coastal erosion (UNEP, 1986). Mayer (1982, cited in UNEP, 1986) estimates that a further 0.95-1.34 million tonnes of these minerals may occur in offshore areas. Other commercially valuable deposits have been reported (UNEP, 1986) and NARA has been carrying out further work in this area. The occurrence of monozite bearing heavy mineral placers was reported by Wickremaratne (1986) and research on other non-living resources is reviewed in Wijayananda (1992). Wijayananda & Katupotha (1990), Niwas *et al.*, (1990) and Wickremaratne *et al.*, (1988) provide additional information on non-living marine resources. Offshore oil and gas exploration has been initiated; four wells have been drilled in Palk Bay and the Gulf of Mannar but to date no reserves have been found (UNEP, 1986).

Sedimentary limestone from the Jaffna Peninsula and along the north-west coast to Puttalam is used by two cement factories producing nearly 800,000 tons of cement a year; it is thought that there needs to be some control over its exploitation (UNEP, 1986).

Salt production is carried out at Elephant Pass, Murunchative, Kallundai, Irupalai, Pulari, and Mannar in the north west of the country and at Hambantota Mahalewage, Palatapana and Bundala in the south. The State owned National Salt Corporation produces about 130,000 tons of salt a year and small quantities of refined epsom, iodised salt and gypsum.

3.1.7. Coastal tourism

Sri Lanka's recreational and scenic sites within the coastal zone have been inventoried by the CCD (CCD, 1985). This inventory details 89 such sites mostly located along the western, south western, southern and eastern coasts. Sri Lanka's tourist industry centres on scenic recreational beaches with 75.2% of the countries graded hotels and 80.8% of hotel rooms located on the coast. Tourism declined steeply during civil unrest over the period from 1983 to 1989. Peak arrivals occurred in 1982 with an estimated 407,230 visitors generating a revenue of 3,050 million rupees. Tourism has again demonstrated a sharp upward trend since 1990 and both high and low projections for the year 2000 anticipate over a million visitors annually (GOSL, 1991b). Whilst many of Sri Lanka's important scenic and recreational areas remain pristine, others have been degraded through over-development, water pollution from human wastes and coconut husk retting, incompatible uses, and over-exploitation of resources (GOSL, 1990b).

3.1.8. Coastal agriculture

About 400,000 acres of coconut are under cultivation in coastal areas, mainly by small landowners. There is also rice cultivation (Fernando, 1978).

4. Conservation Issues and Problems

4.1. Habitat Destruction and Degradation

The human population was estimated at 17 million in mid-1990 with an average growth rate of 1.1% per annum (GOSL, 1990c). Approximately 50% of the population live on the coastal strip, the majority in the southwest and northeast. Conservation issues are covered in many of the publications mentioned above including: GOSL (1990b; 1991a; 1991c), GOSL/ESCAP (1985), and Samarakoon & Pinto (1986), which give details of threats to each of the major coastal ecosystems briefly discussed below.

4.1.1. Mangroves

Many mangrove swamps, notably those in Jaffna, Batticaloa, Trincomalee, Puttalam and Negombo, are under threat from extraction of fuelwood and timber for construction; and reclamation for housing development, particularly in densely populated areas such as Negombo (Scott, 1989). There is also some conversion of mangroves for coconuts and paddy cultivation (Lowry & Wickremeratne, 1989). According to Davie (in prep.) and Jayewardene (1987) threats are most serious in the arid areas on the west coast near Puttalam Lagoon where mangroves have been extensively impoldered for coconut and banana plantations and salt pans. Firewood and pole production especially from *Avicennia* and *Rhizophora* has resulted in over-exploitation. As yet, large-scale transformation of mangrove swamps to brackish water ponds for aquaculture has not occurred in Sri Lanka. Some 300 ha of shrimp ponds have been constructed in the mangroves (e.g. in Negombo and Chilaw), and a further 1,000 ha have been leased for expansion of aquaculture, but most of this land is situated in areas where mangroves have already been degraded (Scott, 1989).

In the Madu Ganga area, barrages have been built to prevent salt water intrusion to rice fields and this has affected mangroves. Mangroves near Colombo have been converted for residential and industrial areas, and they are increasingly being converted for recreation and tourism purposes, particularly along the south-western coast. Pollution from human sewage seems to be a significant threat, and has been implicated in the defoliation and death of *Rhizophora apiculata* at one location. On the southwest coast the organic by-products of anaerobic decay of coconut husks has been suggested as the cause of the disappearance of *Nypa fruticans* which was previously abundant in the area (Davie, in prep.; Jayewardene, 1987; GOSL/ESCAP, 1985).

4.1.2. Marshes and wetlands

Marshes and wetlands are threatened by overgrazing and conversion to salt pans and aquaculture (Lowry & Wickremeratne, 1989; GOSL, 1987). Many estuaries and coastal lagoons are threatened by sewage and industrial pollution; erosion; overfishing; sand mining; desalination

through irrigation; diversion of freshwater inflow (e.g. Puttalam where the salinity has increased from 20-35 ‰ to 50 ‰); landfilling and dumping; and, aquaculture (GOSL/ESCAP, 1985; Anon, 1986b; GOSL, 1987). There is a potential threat to the coastal wetlands from the major irrigation schemes being developed for the Mahaweli, Kelani and Gin rivers. Increased saline intrusion upstream during dry periods may occur, and water diversion could alter vegetation in the coastal zone (UNEP, 1986).

4.1.3. Coral reefs

A population explosion of *Acanthaster planci* caused serious problems in the early 1970s (Bruin, 1972; Salm, 1975a) but there have been no recent infestations (Silva, 1981; 1985).

The principal human-induced threats to coral areas are quarrying for lime, use of explosives for fishing, collection of coral and shells for sale to tourists and of fish for the aquarium trade and pollution (Salm, 1975a; 1975c; Samarakoon & Pinto, 1986).

Lime manufacture leads to devastation not only of the reefs but also of mangroves and terrestrial forests whose wood is used to fuel the lime kilns. Coral areas near Kandakuliya are exploited and reefs at Akurala, Galle, Unawatuna, Tangalla and sites along the south coast are depleted by coral collecting. Coral mining has also affected reefs on the east at Vandeloos Bay, Thenaddi, Kalavanchikudi and Trincomalee. It has caused serious erosion problems, its impact having been greatest in the southwest especially between Akurala and Dodanduwa (UNEP, 1986).

Modern fishing techniques are damaging reefs in many areas. Bottom-set nylon nets are used, particularly in inshore coral areas on the east coast; this necessitates the flattening of corals and breakage of new growth so that nets can be set (Salm, 1975b). Dynamite fishing is commonly practised on both the east and west coasts (Silva, 1981; 1985; UNEP, 1986) and has damaged reefs on the south coast at Dondra Head, Polhena (near Matara), Kapparatota (in Weligama Bay) and Nilwella. At Tangalla, the reef at the headland has been damaged by the construction of the fisheries harbour (Anon, 1986b).

4.1.4. Seagrass beds

These habitats are threatened by destructive fishing gear including bottom trawls and drag nets; by digging for polychaetes (e.g. Negombo Lagoon); by siltation, and eutrophication (Lowry & Wickremeratne, 1989).

4.1.5. Sea level rise and coastal erosion

A regional seminar on reduction of vulnerability to rising sea level was held in Colombo in 1991. This issue must be considered given the serious problems of erosion which exist already.

Erosion is most severe on the west and southwest coasts, where some 500 km from the Jaffna Peninsula in the north to Weligama Bay in the south, are exposed to the southwest monsoon and battered with great intensity from June to September (Lowry & Wickremeratne, 1989; Tampoe, 1988). A storm and associated floods in 1985 left many hundreds of families homeless and

damaged roads. Tidal waves were most severe at Hikkaduwa. The history of coastal development on this coast and its vulnerability to erosion is described in Tampoe (1988). Average annual erosion is 1-7 m (UNEP, 1986) and it has been estimated that the west coast loses about 175,000-285,000 m^2 annually of which around 145,000 m^2 are lost from the 137 km segment that extends from the mouth of the Kelani River just north of Colombo to Talawila on the Kalpitiya Peninsula (GOSL, 1987). A detailed account of erosion effects on different parts of the coast is given in GOSL/ESCAP (1985).

Many beaches, coastal dunes, sand bars and sand spits are threatened by erosion resulting from sand, coral and ilmenite mining; construction and vegetation removal; and coastal engineering. Sand is mined from rivermouths and dunes for construction use, and in some areas such as the Kelani River, is mined at rates greater than it can be replenished naturally, thus contributing to coastal erosion (Samarakoon & Pinto, 1986). A survey of the south and south-west coast showed that the total amount of sand mined is about 1.2 million cu ft, four times the permissible amount (Alwis, 1985). The Kelani River is the main source for the construction industry because of its proximity to Colombo and about 600,000 tonnes are mined a year, or three times the annual rate of sand deposition. The Maha Oya near Chilaw is exploited to 9 times its sustainable capacity; 35,000 cu ft are deposited annually and 300,000 cu ft are removed (Tampoe, 1988). Salm (1975a) reported that mining of mineral sands from beaches had led to considerable destruction of turtle nests.

Examples of ill designed coastal construction leading to erosion, include erosion control structures and harbours and breakwaters for the fishing industry (Lowry & Wickremeratne, 1989). At Wellamankara, north of Colombo, a breakwater built as part of the fishery harbour caused extensive erosion such that the fishing village to the north was washed away before the breakwater was eventually removed (Lowry & Wickremeratne, 1989). At the Panadura River outlet, a long groyne was constructed to ensure that the river mouth remained open as an outlet from Bolgoda Lake to prevent periodic flooding of adjacent paddies and to provide access for fishing boats. The groyne resulted in serious erosion north of the river mouth and blocked littoral supplies of sand to the entire coastline from Egodanyane to Ratmalana. Houses were washed away, beaches disappeared and the railway was threatened. Examples of buildings sited on unstable beach-front land are seen on the west coast (UNEP, 1986). At Negombo, Nilaveli, Hikkaduwa and Beruwala, hotels have been sited less than 15 m from the shoreline and expensive revetments have had to be built to control erosion (Figures 6, 7, 8). At Negombo, this led to problems for fishermen beaching their boats. In the final settlement of negotiations, the Coast Conservation Department constructed four off-shore breakwaters and two groins close to Negombo Lagoon and provided 500,000 m^3 of sand nourishment (Sadacharan & Lowry, 1987). The economic costs of erosion are therefore substantial and further examples are given in GOSL (1987).

4.1.6. Overfishing

While the majority of fish stocks in coastal waters are exploited at an optimal level, there is room for expansion of a few fisheries in specific areas (Dayaratne, 1989a; 1989b). The small pelagic fisheries along the western and southern coastal areas of the country have been studied over the last decade. The small mesh gill net fishery on the west is detailed by Dayaratne (1984; 1985)

Figure 7.
Coastal tourist hotel development in the vicinity of a major tern colony at Nilaveli (Salm, 1975b)

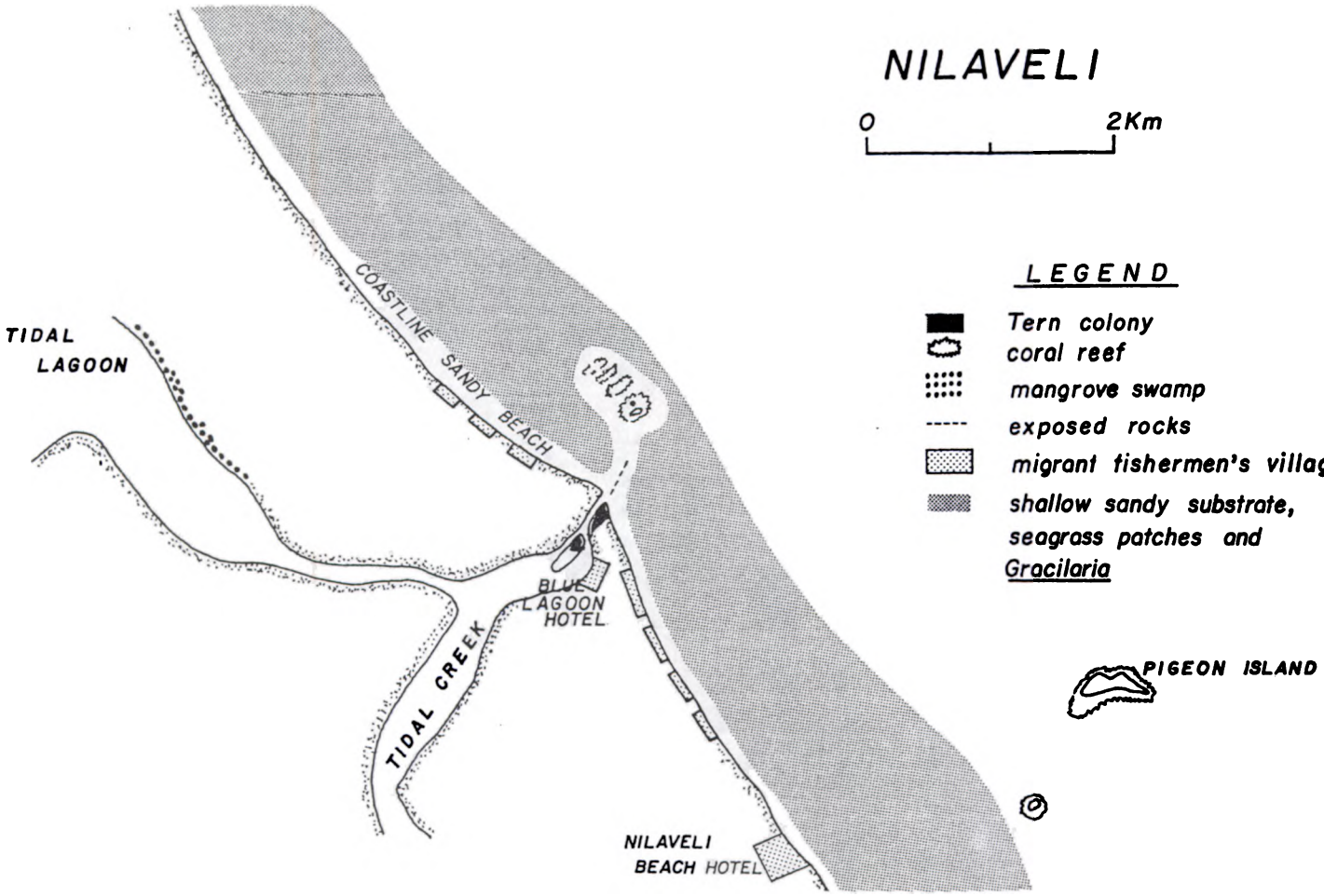
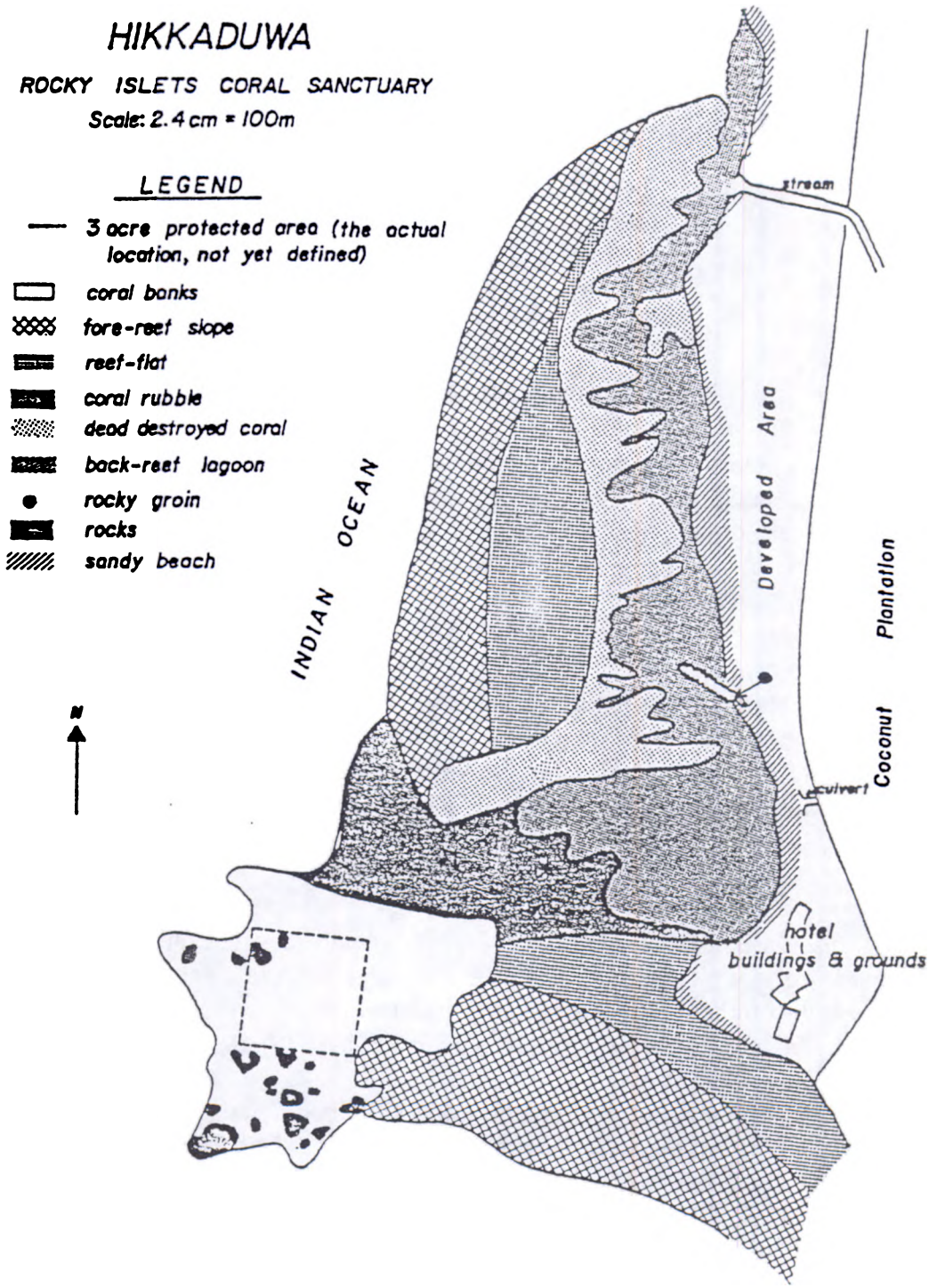


Figure 8.
Coastal resort development in close proximity to reef habitats at Hikkaduwa (Salm, 1975b)



and Karunasinghe & Fonseca (1985) while the purse seine fishery off the south-west coast and the status of the sardine stocks are discussed in Dayaratne (1990; 1991). Small tunas in the coastal waters of the west and south have been shown to be an under-exploited stock (Dayaratne & Silva, 1990a; 1990b; 1991) while the present status of tuna stocks in the country is reviewed by Amarasiri *et al.*, (1987), Dayaratne & Maldeniya (1988), Dayaratne & Silva (1990b), and by Maldeniya *et al.*, (1987). Seerfish resources are apparently exploited at the optimum sustainable level. A preliminary review of hand line fisheries is given in Dayaratne & Amarasinghe (1991) while prawn and lobster fisheries are reviewed by Jayakody (1987; 1990) and Jayawickrema (1991). Experience with Fish Aggregating Devices (FAD's) for fisheries resource enhancement and management in Sri Lanka is described in Atapattu (1991).

Turtle and dugong numbers have been reduced through habitat loss, hunting and egg-collecting, despite nominal protection. The tortoise-shell industry, centred on Galle in the south, has practically ceased but tortoise-shell jewellery and handbags are on sale in many tourist and souvenir shops in Galle, Hikkaduwa and Colombo (Wells pers. obs., 1986). Salm (1975b) reported that deliberate Dugong hunting had ceased although there was some accidental catch in large mesh nets and some were killed by explosives used in fishing.

Many aquarium fish collectors and exporters believe that fish are less abundant now but there is no scientific data on the status of many stocks. Wood (1985) lists species that may be particularly vulnerable to over-exploitation, such as anemone fish which are easy to catch, and those with localised distributions such as certain butterfly fish and the endemic pygmy angelfish *Centropyge flavipectoralis*. The trade is also wasteful since many fish die in transit and collecting methods requiring the removal or systematic breaking of coral are damaging.

Spiny lobster populations have been reduced around the entire coastline (Salm, 1975a).

Collection of corals and shells for sale as tourist souvenirs and for export has stressed reefs in resort areas in the south-west and east (Silva, 1981; 1985). Corals are sold to tourists in Galle, but in 1986 (Wells pers. obs., 1986) there was little evidence of corals for sale in Hikkaduwa, reportedly because of improved enforcement of sanctuary regulations.

4.1.7. Pollution

Pollution is discussed in detail in UNEP (1982; 1986) but there is little quantitative data. There is little evidence that oil pollution has caused damage yet, but there is a potential threat, particularly to the southern tip of the country, which lies only 10 miles from the main oil supply route from the Middle East to the Far East (GOSL/ESCAP, 1985).

UNEP (1986) describes pollution problems in the Colombo Canal system, at Beira Lake, at Lunawa Lagoon and the northern Bolgoda Lake system, and at Kelani River where 60 industrial operations discharge effluent. Control over domestic and industrial wastes is fragmented and weak and large areas of the coast receive untreated sewage. Even in population centres where sewage systems exist, the sewage is frequently untreated prior to discharge. Most problems are in the Colombo region (Lowry & Wickremaratne 1989). Sludge from paper factories at Valaichchenai and Embilipitiya has caused some damage in Valaichchenai Lagoon and

Walawe River respectively. Further information on the impact of pollution on the west coast is given in GOSL/ESCAP (1985) and Anon (1991a). Samarakoon & Pinto (1986) described pollution threats to estuaries and lagoons.

Boat anchoring and possibly the discharge of waste oil may have contributed to coral damage in some lagoonal areas (Silva, 1985). Tourist pressure has certainly contributed to the decline of reefs in several areas in the southwest and northeast. An important source of pollution in the south, where many reefs have been damaged, is the habit of soaking coconut husks in shallow water for the fibre industry.

4.1.8. Coastal tourism

Tourism has had an impact on many coastal ecosystems resulting in increased coastal erosion from hotel construction; habitat degradation from improved access to beaches; damage to reefs, dunes and marshes; and, increased pollution. It is also often in conflict with local fishing interests, as is the case on the Hendala-Maha Oya section of the west coast which is an important natural area attractive for the development of tourism but also critical for fisheries. Tourism has caused extensive damage in the Hikkaduwa area which has now probably exceeded its carrying capacity (GOSL/ESCAP, 1985).

4.2. Species of Conservation Concern

In the following paragraphs species listed by IUCN 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

Balaenoptera musculus, blue whale (E)
Some sightings of the Pygmy Blue Whale subspecies are reported. This may be a separate non-migratory stock. Around 32 individuals were identified off the northeast coast in 1983/84 (Klinowska, 1992); equal numbers of strandings occur on both east and west coasts (Silva, 1987).

Balaenoptera physalus, fin whale (V)
Recorded in Sri Lankan waters but no specific information is available (Klinowska, 1992); all strandings occur on the west and south coasts and none are recorded on the east (Silva, 1987).

Megaptera novaeangliae, humpback whale (E)
No specific information, but there may be a small resident population (500+) in the northern Indian Ocean (Klinowska, 1992).

Other cetaceans:
Twenty three species have been recorded in Sri Lankan waters, according to Silva (1987); some additional species are reported by Klinowska (1992) and NARA reports 27 species for Sri Lankan waters.

The annual catch of small whales and dolphins (perhaps as high as 42,000) is taken both as by-catch and deliberately and is marketed for human consumption. The species most commonly taken as by-catch are *Grampus griseus* (25% of the 1983/86 catch), *Tursiops truncatus* (also hunted for meat), *Stenella longirostris, Stenella coeruleoalba* and *Stenella attenuata*. The three *Stenella* species and *G. griseus* are considered to be at risk in the Indian Ocean. *Sousa chinensis* and *Neophocaena phocoaenoides* are also taken and other species taken include *Steno bredanensis, Kogia breviceps, K. simus, Lagenodelphis hosei, Peponocephala electra* (also hunted for meat), *Feresa attenuata, Pseudorca crassidens* and *Globicephalus macrorhynchus*.

Cuon alpinus, Asiatic wild dog (V)
Coastal distribution not known.

Melursus ursinus, sloth bear (I)
Occurs in Ruhuna (Yala), Yala East, and Wilpattu National Parks (PADU, 1988; Scott, 1989).

Panthera pardus, leopard (T)
Occurs in Bundala Sanctuary, Ruhuna (Yala), Yala East, and Wilpattu National Parks (PADU, 1988; Scott, 1989).

Aonyx cinerea, oriental small-clawed otter (K)
Coastal distribution not known.

Elephas maximas, elephant (E)
Occurs in Bundala Sanctuary, Ruhuna (Yala), Yala East, and Wilpattu National Parks (PADU, 1988; Scott, 1989).

Dugong dugon, dugong (V)
Mainly found on the extensive seagrass beds of the north-west coast between Puttalam lagoon and the Jaffna Peninsula (Salm, 1975b), particularly in the Gulf of Mannar and Palk Bay (Bertram & Bertram, 1973); formerly found in Kalpitiya Lagoon (Scott, 1989) and possibly also Dutch and Portugal Bays. In the 1970s the species was sporadically taken elsewhere but even then was virtually absent from the south coast (Bertram & Bertram, 1973). Protected since 1970, but still threatened by hunting and incidental catches. In the 1970s a ban on the use of large nylon nets in Dutch and Portugal Bays was recommended as well as an extension of Wilpattu National Park to encompass these areas (Bertram & Bertram, 1970).

Bubalis bubalis, water buffalo (E)
Occurs in Bundala Sanctuary, Ruhuna (Yala), Wilpattu and Yala East National Parks (Scott, 1989).

Paradoxurus zeylonensis, golden palm civet:
Endemic to Sri Lanka, this species occurs throughout the island, although its status and distribution are poorly known. The extent to which the species occurs on the coast is not known but it occurs in Wilpattu National Park; it needs further study (Schreiber, *et al.*, 1989).

4.2.2. Birds

Pelecanus philippensis, spot-billed pelican (I)
About 900 pairs are known to breed in 23 colonies. The population is thought to be stable (Collar & Andrew, 1988); occurs in Yala East, Ruhuna (Yala) and Wilpattu National Parks, the Bundala Sanctuary, and Puttalam Lagoon, (Scott, 1989).

Leptoptilos javanicus, lesser adjutant (V)
About 100 breeding pairs (Collar & Andrew, 1988). Occurs in the Ruhuna (Yala) and Wilpattu National Parks and is resident on the flood plains of Mahaweli (Scott, 1989).

Other birds:
The following are important coastal sites for waterfowl and waders: Chundikkulam Sanctuary, Kokkilai Sanctuary, Seruvila-Allai Sanctuary (Ullackalie Lagoon), Bundala Sanctuary, Ruhuna (Yala) NP, Wilpattu NP, Yala East NP (Kuman Villu Bird Sanctuary), Delft Island, Punkudutivu Lagoon, west end of Jaffna Peninsula, Uppu Aru Lagoon, Jaffna Lagoon, Chalai Lagoon, Nai Aru Lagoon, Periakarachchi and Sinnakarachchi Lagoons, Upaar Lagoon and Uppu Alan, Vandeloos Bay, Elephant Point and Thenadi Bay, Batticaloa Lagoon, Arugam Kalapuwa, Palatupana Maha Lewaya, Maha Lewaya and Karagan Lewaya, Lunama Kalapuwa and Kalametiya Kalapuwa, Muthurajawela Swamp, Negombo Lagoon, Mundel Lake, Puttalam Lagoon, Vankalai Kalapuwa and Periya Kalapuwa, Adam's Bridge, Palk Bay, Devil's Point and Vidattaitivu Lagoon, Iranaitivu Island (Scott, 1989).

Seabirds are less well known. There are tern colonies on the coral islands in Thenadi Bay (Scott, 1989) and probably on other islets around the coast. Rocky Islets at Hikkuduwa were protected on account of their seabird colonies but these have since been disturbed by tourists.

4.2.3. Reptiles

Caretta caretta, loggerhead turtle (V)
This species is occasionally caught and is known to nest in Ruhuna (Yala) National Park (Groombridge, 1982; Scott, 1989).

Chelonia mydas, green turtle (E)
Considered uncommon and declining the main nesting sites for this species are Kosgoda (most important), Yala and Bundala (second most important) and Hambantota, Batticaloa and Kalmunai (Dattari & Samarajiva, 1983). Still recorded at Puttalam Lagoon according to Scott (1989) and Tamblegam (Groombridge & Luxmoore, 1989). Salm (1981) reported it to be common in seagrass beds in the Gulf of Mannar.

Eretmochelys imbricata, hawksbill turtle (E)
Nesting is sparse and this species is considered uncommon. It is found mainly around Batticaloa and Kalmunai, in Ruhuna (Yala) National Park, Bundala Sanctuary, hambantota, Kosgoda and the south coast (Dattari and Samarajiva, 1983). Foraging is probably concentrated in the Gulf of Mannar and Palk Straits (Groombridge & Luxmoore, 1989). Also recorded from Pasekudah to Kalkudah (Scott, 1989).

Lepidochelys olivacea, olive ridley turtle (E)
The most abundant species in Sri Lanka; several thousand nest annually, mainly in the southwest, especially at Kosgoda. Other major nesting sites are: Bundalla, Hambanthota, Tangalle and Kirinda in the south and Balapitiya and Abungalle in the southwest. It is found all round the coast throughout the year but populations are believed to be declining (Groombridge, 1982; UNEP, 1986).

Dermochelys coriacea, leatherback turtle (E)
Nests mainly on the Yala coast, but less than 100 females in total and the population is declining due to tourism and beach disturbance (Groombridge, 1982). Breeds in Ruhuna (Yala) National Park (Scott, 1989).

All 5 species of turtle are protected but are still fished, mainly in the Gulf of Mannar and on the south and west coasts. *C. mydas* is the preferred species for consumption. The export trade in tortoiseshell has declined significantly in recent years (Groombridge & Luxmoore, 1989). There are turtle hatcheries at Palatupana (outside Yala National Park), Bentota Beach (eggs are collected from the beaches between Kosgoda and Bentota) and Kosgoda (eggs collected from Induruwa to Balabitiya), supported by the Wildlife and Nature Protection Society (Wickremasinghe, 1981; 1982; Wijesekera, 1987). Hatcheries have also been established within Bundala and Yala National Parks (Dattatri & Samarajiva, 1983).

Crocodylus palustris, mugger crocodile (V)
The largest population of this species in the world occurs in Sri Lanka; around 2,800 individuals. It is found in the Bundala Sanctuary, Ruhuna (Yala) and Wilpattu National Parks (Groombridge, 1982; Scott, 1989; Whitaker & Whitaker, 1979).

Crocodylus porosus, estuarine or saltwater crocodile (E)
Populations of this species are very depleted with only around 250 individuals on the southwest coast and 125 in the rest of the island. The main breeding population is found from Puttalam in the west to the southern tip, particularly around the rivers Maha Oya, Kelani Ganga, Bentota Ganga, Gin Ganga and Nihivali Ganga. Still present in Batticaloa Lagoon on the east coast and also in the Mahaweli Ganga and Yala. The Mutharajavela swamp between Negombo and Colombo used to be an important area for this species but this has now been cleared.

Python molurus (P. m. molurus), Indian Python (V))
Occurs in Bundala Sanctuary and Wilpattu National Park.

Other reptiles:
Two species of monitor lizards occur on the coast as well as inland; *Varanus salvator* and

Varanus bengalensis. Both are moderately common, and unlike elsewhere, they are minimally exploited. *V. salvator* is protected (Luxmoore & Groombridge, in prep.). An endemic flying snake *Chrysopelea taprobana* is found in Bundala Sanctuary (Scott, 1989).

4.2.4. Amphibians

An endemic toad *Bufo athukoralei* is found in Bundala Sanctuary (Scott, 1989) but no details concerning its status are available.

4.2.5. Fish

No Sri Lankan marine fish are listed by IUCN as threatened. Wood (1985) lists a number of reef species as being of conservation concern, because of collecting for the aquarium trade. The pygmy angelfish, *Centropyge flavipectoralis* is considered to be endemic to Sri Lanka but is reported to be common at present despite its collection for the aquarium trade.

Eleven species of endemic Sri Lankan freshwater fish are listed by IUCN as threatened (Evans, 1981). From the information available it seems unlikely that any of these can be considered coastal although the distribution maps of some of the species: *Barbus cumingi, Barbus nigrofasciatus, Barbus pleurotaenia, Barbus titteya, Rasbora vaterifloris, Lepidocephalus jonklassi, Sicydium halei, Belontia signata, Malpulutta krestseri* and *Channa orientalis*) show localities near the coast.

There is some information on estuarine cichlids (Samarakoon, 1981; 1983; Ward & Wyman, 1975; Ward & Samarakoon, 1981) although the status of most species is unclear. Concern has been expressed about the pearl spot *Etrophus suratensis*, a commercially important cichlid, as its reproductive behaviour has been disrupted by destruction of the seagrass beds in Negombo Lagoon (Samarakoon & Pinto, 1986).

4.2.6. Invertebrates

Panulirus spp. tropical spiny lobsters (CT)
There was some concern in the early 1980s about overfishing of the main commercial species *Panulirus homarus, Panulirus versicolor, Panulirus ornatus, Panulirus polyphagus, Panulirus longiceps* and *Panulirus penicillatus*. The current status of the spiny lobster fishery is described by Jayakody (1991), Jayakody & Kensler (1987), and Jayawickrema (1991). The present total annual production is around 700 tonnes and declines in catch rates on the south coast over the last 6 years indicate that over-fishing is occurring. The use of fishing methods such as bottom set trammel nets which take undersized and berried females may be responsible for stock decline. Some habitat destruction may also be a contributing factor to this decline.

Tridacna maxima (K) and *Tridacna squamosa* (I), giant clams
These two small species occur and their shells are sold to tourists (Munro, 1988). Their status in the country is not known.

Antipatharia spp., black coral (CT)
Black corals are threatened by excessive netting and removal by divers for sale as semi-precious materials for the curio and jewelry industry. Whip corals *Cirrhipathes spp.* are fairly common on reefs on the south-west coast.

Other invertebrates:
IUCN lists a number of threatened butterflies in Sri Lanka but there is no indication that any of these are purely coastal in distribution. Relevant publications on coastal crustaceans include Selvarajah & Costa (1978), Pinto (1980), Ingle & Fernando (1963), Jayakody & Costa (1988) and Jayawickrema (1990); and on other marine molluscs include Fernando (1977), Pinto & Wignaraja (1980), Indrasena (1989), and Ekaratne (unpubl.). *Trochus niloticus*, *Turbo marmoratus* and *Pinctada* spp. may be commercially threatened while *Charonia tritonis* is known to be rare.

5. Environmental and Conservation Legislation

Legislation is inadequately enforced (Silva, 1985; Salm, 1975b) but NARA, under the Ministry of Fisheries, is currently investigating means to improve this.

The Coast Conservation Act. No. 57 of 1981 (Coast Conservation Regulation No. 1 of 1983; the Coast Conservation Act Amendment No 1 of 1988)

Designed to protect and preserve the coast from erosion or encroachment by the sea and include control over the planning and management of development activities within the designated coastal zone (2 km offshore to 300 m inshore) (Wijewamsa, 1985). Provision exists for extending the landward jurisdiction of the coastal zone by 2 km, to cover rivers, streams, lagoons or other bodies of water connected to the sea (Lowry & Wickremeratne, 1989) by publication in the gazette. The Act mandated the CCD to prepare a Coastal Zone Management Plan within three years of the gazetting of implementing regulations and provided the CCD with authority to review permits for all development activities within the coastal zone. Under the Act, sites considered to be critical habitats can be designated for protection. Implementing regulations were gazetted in October 1983, when the Act came into force (Anon., 1986a). A draft Plan was completed in November 1987 (Lowry & Wickremeratne, 1989) and received the assent of the cabinet of Ministers in April 1990.

The Act has been used to control coral mining on the east coast to some extent (Hoffmann, 1983) but mining started up again in early 1985. There have also been difficulties of enforcement in other areas, particularly in the west. Amendments to the Act were to be put before Parliament in 1985 which would make it illegal to own or operate lime kilns and to use vehicles and equipment for coral extraction within the coastal zone, infringements being liable to fairly severe penalties and confiscation of equipment. Those engaged in the industry were to be offered alternative employment and/or land for settlement (Silva, 1985; Hoffmann, 1983).

National Environmental Act No. 47 of 1980; amended 1988

Established the Central Environmental Authority (CEA) in 1981. Initially the CEA functioned as a policy making and co-ordination body. The amendment No 56. of 1988 transformed the CEA to an implementing and enforcement agency. Provisions are made for the protection, management and enhancement of the environment and for the prevention, abatement and control of pollution.

National Aquatic Resources Research and Development Agency Act No. 54 of 1987

Established NARA to conduct research, and development and activities related to the management and conservation of aquatic resources in the inland waters, coastal wetlands, and offshore areas, and for the formulation of national policies relating to the management and development of the national aquatic resources of Sri Lanka.

Urban Development Authority Act No. 41 of 1978
Designates all areas within 1 km of the coastline as 'urban areas' subject to the planning and regulatory requirements of the Act; established the Urban Development Authority (UDA); requires that all building constructions within coastal areas receive a permit from the UDA.

Crown Lands Ordinance of 1929
Prohibits removal, except by permit, of sand, coral and stone from Ambalangoda to Hikkaduwa. Sand mining is regulated at particular sites by quotas, stipulated mining schedules, setbacks, site rotation and imposition of monitoring schemes (Sadacharan & Lowry, 1987). The permissible limit for sand extraction from rivers draining the south-west is 345,000 cu ft yr^{-1} (Tampoe, 1988).

Maritime Zones Law 1976; Maritime Zones Proclamation 1977

Natural Resources, Energy and Science Authority of Sri Lanka Act No. 78 of 1981
Provides for establishment of NARESA (see below) to protect and develop natural resources.

Tourist Development Act No. 14 of 1968
Allows the Ceylon Tourist Board (CTB) to offer tax concessions, liquor permits and tax free imports to hotels located, constructed and operated consistent with CTB guidelines.

Marine Pollution Prevention Act No. 59 of 1981
Governs sewage disposal, oil pollution etc., established the Marine Pollution Prevention Authority and provides for ratification of international treaties.

Whaling Ordinance (Chapter 215) of 1936
Prohibits the taking of baleen and sperm whales in territorial waters and allows for extension of provisions to other cetaceans. The taking of right whales, immatures and females accompanied by calves is prohibited.

Fauna and Flora Protection Ordinance No. 2 of 1937)(revised 1 March 1938); amended 20 July (Act No. 1 of 1970); Regulations by Minister of Fishing 1972
This regulates and establishes a series of protected areas which include Nature Reserves, Sanctuaries, Strict Natural Reserves, National Parks, Intermediate Zones and Sanctuaries. It also regulates hunting, which is now illegal for most species of wildlife. Penalties are often very low, and many destructive practices continue (Hoffmann, 1976; 1983; Salm, 1975a). The Ordinance is being revised and will include specific reference to marine parks and sanctuaries.

The importation, without a permit, of live reptiles belonging to non-indigenous species is prohibited. The exportation, without a permit, of indigenous species, dead or alive, or of their eggs, skins or any other parts is also prohibited. The following species are totally protected: it is an offence to capture, kill, injure or possess these animals or their eggs: *Caretta caretta, Chelonia mydas, Eretmochelys imbricata, Lepidochelys olivacea, Dermochelys coriacea, Dugong dugon, Crocodylus palustris* (this may be hunted under a special license), *Crocodylus porosus, Varanus salvator.*

Forest Ordinance No. 10 L (1885) amended 1966, 1979 and 1982
Provides for the establishment of sanctuaries and for the controlled commercial exploitation of forest resources (PADU, 1988), including mangroves.

National Heritage Wilderness Areas Act No. 3 of 1988
Provides additional protection for unique areas (PADU, 1988).

Fisheries Ordinance (Chapter 212 of Legislative Enactments) No. 24 of 1940; amended 1973
Section 14 prohibits use of dynamite, poisons and stupefying substances for fishing and, under Fisheries Amendments Law 20 of 1973, prohibits possession of fish killed by dynamite or poison. Import of spear fishing guns is prohibited. A draft new Fisheries Bill has been prepared and includes provisions for marine reserves and fish sanctuaries (GOSL/ESCAP, 1985).

Fisheries (Regulation of Foreign Fishing Boats) Act No. 59 of 1979; amended 1982
Provides for fishing in EEZ beyond 35 and up to 200 nautical miles offshore under licence.

Spiny Lobster and Prawn (shrimp) Regulations 1973
Prohibits catch, sale, transport or export of spiny lobsters which are berried, soft-shelled or undersized (less than 8 cm carapace length, less than 11.5 cm tail length.

Chank Fishery Act (Chapter 213) of 1953
Stipulates minimum size of chanks.

Pearl Fisheries Ordinance (Chapter 214) of 1956
Regulates the use on any such bank of net, dredge, fishing line or fishing tackle.

There are reported to be regulations to control the size of processed holothurians (sea cucumbers) for export (Conand & Sloan, 1988).

An attempt by the Government to ban export of live fish was abandoned due to protests by exporters who claimed that some 50,000 people were dependent on the industry although less than 500 are probably involved.

6. Institutional Infrastructure

6.1.1. Governmental Organisations

Thirty two different governmental agencies have jurisdiction over primary uses and activities affecting coastal resources and areas (Premeratne, 1987).

Central Environment Authority (CEA)
The CEA is an advisory and co-ordinating organization, created in 1980 to look after all environmental issues. Its mandate is to conduct studies, prepare environmental standards, conduct educational and training programmes and increase environmental awareness. It is to have wide-ranging legislative powers which will enable it to prevent implementation of projects which are environmentally undesirable, and is currently in the process of preparing a National Conservation Strategy. Additional activities of the CEA are described in UNEP (1986).

Ministry of Environment and Parliamentary Affairs
Established in June 1990 with responsibility for all policy decisions relating to the protection of the environment.

Department of Wildlife Conservation, Ministry of State
The Department includes the National Park Service and is responsible for the administration of protected areas designated under the Fauna and Flora Protection Ordinances.

Forest Department, Ministry of Lands and Land Development
Manages the c. 127,000 ha of forest (74% of total forest area) not covered by Department Wildlife Conservation; administers these Forest Reserves as 'productive' forest; administers MAB reserves.

Natural Resources, Energy and Science Authority (NARESA)
Established to protect and develop the natural resources of the country, to explore, use and develop energy and sponsor and co-ordinate scientific research; responsible for promoting and creating public awareness in the field of scientific research; conducts the Zoological and Botanical Surveys of Sri Lanka and the National Mangrove Study, through NATMANCOM, the National Mangrove Committee (see below).

Ministry of Fisheries
The Ministry and its Departments are responsible for all fisheries in the sea, coastal lagoons and inland waters. A description of the ministry is given in UNEP (1986). It includes the National Aquatic Resources Agency (NARA), the coordinating administrative infrastructure for planning and management of natural aquatic resources. Fisheries and ocean resources are NARA's primary concern but it is also responsible for inland waters and coastal wetlands and takes the lead in reef conservation and has an active programme described by Silva (1986a). It has a research laboratory near the mouth of the Kelani River and a field station in Negombo

(Trincomalee station closed); projects include development of information database.

Coast Conservation Department (CCD), Ministry of Trade and Shipping
Established under the Ministry of Fisheries in 1978, with three sub-components: Planning and Development, Coastal Works and Coastal Research; subsequently moved to the Ministry of Defence and most recently to the Ministry of Trade and Shipping; responsible for the administration of all coastal areas including areas designated as non-development zones; exercises control through permit programme and ability to require EISs for development projects; responsible for Coastal Zone Management Plan (see below).

National Hydrographic Office
This office is the focal point for all hydrographic survey work in Sri Lanka and is responsible for conducting bathymetric surveys of the EEZ and all inland waters.

Marine Pollution Authority
Responsible for marine pollution issues.

Mahaweli Authority of Sri Lanka, Ministry of Mahaweli and Mahaweli Development
Responsible for development in the Mahaweli River system.

Department of Irrigation
Responsible for reservoirs of all sizes.

Low Lying Reclamation Board
Responsible for certain marsh areas.

Urban Development Authority, Ministry of Local Government, Housing and Construction.
This body exercises comprehensive management authority over development within and outside the coastal zone, including all areas within one kilometre of the coast which have been designated as "Urban".

Other more specialised development oriented agencies operating in the coastal zone include:

Sri Lanka Ports Authority
Sri Lanka Land reclamation and Development Corporation
Ceylon Fisheries Harbours Corporation
Greater Colombo Economic Commission

6.1.2. Non-governmental Organizations

Sri Lanka Environment Congress
Co-ordinates all non-governmental conservation bodies.

Wildlife and Nature Protection Society of Sri Lanka
By far the largest and oldest NGO in Sri Lanka, established in 1894. The Society publishes the journal "Loris".

Ceylon Bird Club
The Bird Club has maintained records of bird observations throughout the island for nearly 50 years, and has organized mid-winter waterfowl counts since 1983.

March for Conservation
A conservation body established in 1980 and focusing on education and research.

Centre for Research on Indian Ocean Marine Mammals
Formed after the international symposium held in Sri Lanka in March 1982.

Field Ornithology Group
The Group was established in 1976; it focuses on field studies and holds an annual conference.

ICBP National Section
The Section includes representatives of the four NGOs concerned with birds and the Government Department of Wildlife Conservation.

Coastal Resources Management Project (CRMP) of Sri Lanka

Marga Institute

6.1.3. Universities

Open University of Sri Lanka.
University of Batticaloa.
University of Kelaniya.
Ruhuna University, Fisheries Science.
University of Jaffna.
University of Colombo, Marine Ecology.
University of Sri Jayawardena Pura.
The Department of Zoology conducts research on aquaculture and fisheries in coastal lagoons and mangroves, and is involved in the Coast Conservation Programme.

7. Conservation and Environmental Management Actions

7.1.1. Current Research

Emphasis has been mostly on obtaining basic biological information and much of the research has been oriented towards resource use as in the case of fisheries research. Four workshops/ symposia concerning the coast were held in Sri Lanka in 1986 in preparation for the drafting of the Coastal Zone Management Plan (ICRMP, 1986) and a further six have been held since 1988 emphasizing training and various areas of coastal zone management.

Mangroves received most attention and research funds during the early 1980s (Anon., 1986b). Projects carried out include the compilation of a bibliography by NARA, a study of socio-economic aspects of mangroves, studies on taxonomy and productivity, mapping, basic biology and impact of pollutants. A mangrove productivity study is currently underway in the Puttalam Lagoon and Dutch Bay areas (UNEP, 1986). Detailed information on mangrove quality and zonation has been collected in the Negombo and Kalpitiya areas (Anon., 1986b).

Considerable research has been carried out at two coastal wetlands near Colombo: Colombo Lake (now a highly polluted and silted lagoon) (e.g. Costa, 1972; Costa & Abesiry, 1978; Costa & Silva, 1969; 1978a; 1978b; 1978c; 1978d; 1978e; Costa & Starmuhlner, 1972; Liyanage, 1978; Liyanage and Starmuhlner, 1972; Starmuhlner, 1972; Mendis, 1964; Radda, 1973) and Negombo Lagoon (see under proposed protected areas). UNEP (1986) lists a large number of research programmes underway at that time and currently NARA has three major programmes covering coastal estuaries, mangroves and selected southern lagoons. The first of these programmes funded through SAREC aims to describe and quantify the relationships between important coastal ecosystems and the productivity of the coastal zone. The southern lagoon study aims to understand the present status of the fisheries and evaluate the potential for future fisheries development.

Sri Lankan corals have been relatively little studied. Early studies include Ridley (1883), Ortmann (1889) and Bourne (1905) who describe coral collections. The only major account is that of Mergner & Scheer (1974) who describe the biological structure of the reefs of Hikkaduwa. More recent studies have been carried out by NARA and have included survey and mapping of the reef at Kapparatota and Unawatuna; investigation of the Bar reef; examination of sandstone reefs of the western coast; studies of the distribution of coral reef fishes; and a study of the impacts of coconut husk retting in the reef lagoon at Polhena.

Avifaunal surveys and waterfowl censuses have been carried out at wetlands throughout the country; the results have been summarized by Hoffmann (1985; 1987), Powell (1984a; 1984b) and Van der Ven (1987), and the most important sites for waterfowl listed by Hoffmann (1982; 1984), Jayawardhane (1987) and Karpowicz (1985). Monthly censuses of shorebirds at

Bundala have been carried out since the early 1980s, annual mid-winter waterfowl counts have been organized by the Ceylon Bird Club since 1983, and selected ecological studies have been carried out on the avifauna of other coastal sites by the Field Ornithology Group. The recent interest shown by the aquatic agencies NARA and CCD has given an impetus to research, and conservation oriented ecological research is likely to become more prevalent in the future.

A joint benign research project on whales was carried out by UNEP and NARA, aimed at surveying the distribution of whales, dolphins and dugong in Sri Lankan waters; identifying methods to reduce the by-catch of marine mammals in fishing nets; training scientists in benign research; and increasing awareness among local people of the potential value of marine mammals to tourism (UNEP, 1988). A Centre for Research in Indian Ocean Marine Mammals was set up by NARA at Trincomalee (UNEP, 1986) but work has been temporarily suspended due to security problems associated with the civil disturbances.

The WWF/Netherlands Indian Ocean Sperm Whale Study (1982-1984) (the Tulip Expedition) worked mainly in Sri Lankan waters studying blue and sperm whales; this area may be an important calving ground of the larger whales between March and October. All strandings of Sperm Whales occur on the west and south coasts and none on the east (Silva, 1987). Sri Lanka has taken the initiative for research in the Indian Ocean Whale Sanctuary.

There have been several studies on the incidental by-catch of small cetaceans; about 15,000 dolphins are killed annually as a by-catch in gill net fisheries and marketed for local consumption (Alling, 1985 and 1988). All gill net catches should be monitored (Klinowska, 1992; Perrin, 1989). A one year project was initiated by NARA in 1991 to study dolphin kills in Sri Lanka.

7.1.2. Coastal zone management

The problems involved in the management of the coastal zone have been discussed at some length by authors such as De Alwis (1980), Amarasinghe (1978; 1985), Amarasinghe and De Alwis (1980), Anon (1983), Marga Institute (1978; 1982; 1985b), Ranasinghe (1985), Sadacharan (1985), Soysa *et al.* (1982), Wickremaratne (1985), Amarasinghe (1989) and International Coastal Resources Management Project (1986). A detailed account of environmental management and planning for the coastal and marine zone is given in UNEP (1986) and more recent publications include Anon (1991b; 1991c), GOSL (1990b; 1991b), Lowry & Wickramaratne (1989), and Wickremaratne & Sadacharan (1991).

The need for the integrated management of the coastal zone in Sri Lanka was recognized in the mid-1970s, largely as a response to the coral mining problem. Although specific legislation existed under the Crown Lands Ordinance 1929 covering removal of coral and other substances from specific areas in the island it was virtually unenforced. In the 1970s an attempt to enforce a ban on coral mining was withdrawn due to the claims made concerning the socio-economic impacts of such a ban (20,000 people were said to be dependent on this activity).

CCD now takes the initiative in coastal zone management but works with a variety of other agencies whose activities affect the coastal zone. Setback lines were delineated in 1978 by the

CCD, Ceylon Tourist Board and Urban Development Authority. Since 1981, CCD has conducted a significant amount of research, prepared a Master Plan for Coast Erosion Management (MPCEM) and the Coastal Zone Management Plan (CZMP) (GOSL, 1987; 1990b) and the draft "Coast 2000: A resource management strategy for Sri Lanka's coastal region", GOSL (1991b). NARA, NARESA, the Central Environment Authority, the Forest Department, the Fisheries Department and other governmental and non-governmental agencies helped to prepare the CZMP, which seeks to provide for sustainable yields from multiple uses of the estuaries, lagoons and mangroves in the coastal zone. By 1987 the CCD had issued 764 permits for development activities, organized seminars and developed relationships with agencies having management responsibilities in coastal areas (Lowry & Wickremeratne, 1989).

The CZMP also covers archaeological, historic, cultural, scenic and recreational resources. It proposes setback standards as appropriate at different localities around the coast; requires EIAs for development activities likely to have a significant impact; gives guidelines for the removal of sand (to be prohibited on non-accreting beaches, spits etc. and close to reefs); prohibits certain activities, such as coral removal, except for research; prohibits any development that would significantly degrade the quality of any designated natural areas; covers the prevention of degradation of natural coastal habitats; controls development in existing marine, bird and wildlife sanctuaries in the coastal zone; and allows for the designation of other protected areas.

The Plan places most emphasis on the control of erosion and coral and sand mining, and on reef protection. Fisheries are not covered as these come under the administration of another government department, although it is recognised that fisheries are dependent on healthy coastal ecosystems. It is proposed that there should be co-operation with other agencies concerned with coastal management to map and develop a zoning system for coral reefs, identifying areas for preservation and establishing categories for allowable uses; priorities should be for recreational and tourism uses.

As a pilot project for the CZMP, the Central Environment Agency (CEA), with ESCAP and other agencies, prepared a Coastal Environmental Management Plan for the west coast (from Kalpitiya to Dondra head, and from the edge of the continental shelf to 5 miles inland, but also including those upstream areas that could have an impact on the coastal environment), which was adopted for submission to the Government at a national seminar in January 1984 (GOSL/ESCAP, 1985).

The strategies and management options contained in the draft "Coast 2000" document have evolved from the experiences gained during the first generation of coastal management studies in the 1980s that were led by the Coast Conservation department. This document is presented in 2 volumes the first of which reviews the current status of coastal management in Sri Lanka and the second of which presents the policies and strategies necessary to bring about improved scenarios under coast 2000. The themes and strategies for Coast 2000 are as follows:

> A second generation coastal resources management programme will proceed simultaneously at national, provincial district and local levels: government and non-government participation will be central to the new programme; special area management plans will

be development and implemented for specific geographic sites of natural and/or economic significance. Monitoring and research programmes will be undertaken to answer specific questions relating to the improvement of local habitats, fisheries, water quality, non-living resource use, aquaculture and tourism; the institutional and human capacity to address the management problems will be strengthened and public awareness and education will be priorities for all aspects of the programme.

Environmental impact assessments are now mandatory for all major development projects within both public and private sectors (Wijewamsa, 1985); details of the process are given in UNEP (1986).

7.1.3. Existing protected areas

1. Chundikkulam Sanctuary - 11,149 ha; lies in Chundikkulam Lagoon adjacent to Jaffna Lagoon and once connected with it; subsistence fishery, some aquaculture; mangroves, seagrasses, waterbirds; threatened by salt water exclusion scheme; sanctuary never adequately protected; site account in Scott (1989).

2. Kokkilai Lagoon Sanctuary - north-east coast, 2,995 ha; estuarine lagoon, seagrasses, little mangrove; important for waterbirds; prawn fishing, some aquaculture; channel to sea often blocked; poorly protected; site account in Scott (1989).

3. Pigeon Island Sanctuary - 5 ha; marine areas not included; site account in UNEP/IUCN (1988) under 'Trincomalee Reefs'; information also in Anon. (1984a).

4. Trincomalee Naval Headworks Sanctuary - established 1963; see Pearson (1912) for harbour description.

5. Great Sober Island Sanctuary - established 1963; 65 ha.

6. Madhu Road Sanctuary - 26,677 ha.

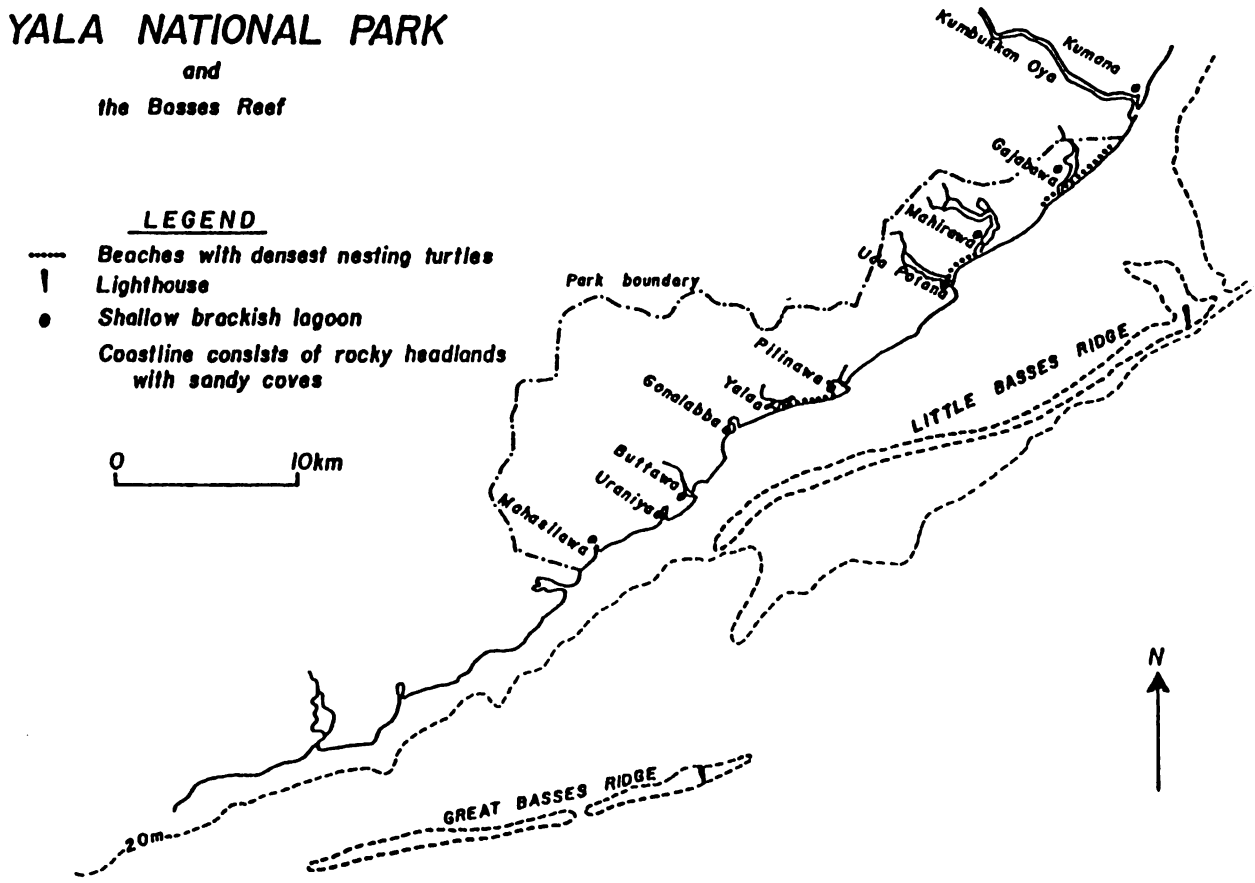
7. Seruvila-Allai Sanctuary - 15,540 ha; includes the western part of Ullackalie Lagoon which is a shallow brackish lagoon (1300 ha) south of Trincomalee with extensive mangrove; important for waterbirds; subsistence fishing; site account in Scott (1989) under 'Ullackalie'

8. Kudumbigala Sanctuary - 4,403 ha.

9. Yala East National Park (Figure 9) - 18,148 ha; coastal area includes a chain of shallow brackish/saline lagoons and extensive sandy beaches; Kumana Villu Lagoon has extensive mangroves and is protected as a Bird Sanctuary; site account in PADU (1988) and Scott (1989).

10. Ruhuna (Yala) National Park - 103,883 ha; coastal area includes a complex of brackish lagoons, several estuaries and 64 km of shore; mangroves and abundant wildlife;

Figure 9.
Location of Yala National Park (Salm, 1975b)



disturbance from fishermen who take turtles and lobsters and leave debris on beach; site account in PADU (1988) and Scott (1989).

11. Bundala Sanctuary - 6,216 ha; includes four shallow brackish lagoons with salt pans, interconnecting channels and marshes, and adjacent sea coast west of Hambantota; tourism and fishing; poor protection; site account in PADU (1988) and Scott (1989).

12. Kalametiya Kalapuwa Sanctuary - 712 ha; covers two brackish lagoons fringed with mangrove; very important for waterbirds; prawn fishing but this has declined; threatened by siltation, fishing, mollusc collection for lime kilns, reclamation and pollution; site account in Scott (1989).

13. Rocky Islets Sanctuary - 1.2 ha; lies within Hikkaduwa Marine Sanctuary; site account in PADU (1988).

14. Hikkaduwa Marine Sanctuary - 45 ha declared in 1979 and is the only officially protected reef area in the country, although regulations are poorly enforced and fishing is permitted; site account in PADU (1988) and UNEP/IUCN (1988); see also Jonklaas (1981).

15. Honduwa Island - 8 ha.

16. Wilpattu National Park - 131,694 ha; west coast north of Puttalam Lagoon bordering Dutch Bay and Portugal Bay, including c. 40 km of coastline; coast is mainly rocky with limestone cliffs, some sandy beaches (mainly east of Kudirimalai Pt), dunes and mangroves; abundant wildlife; site account in PADU (1988) and Scott (1989).

Regulations for a spiny lobster reserve near the Mount Lavinia Hotel were drawn up but this area was never gazetted (Silva, 1985; UNEP/IUCN, 1988). Mount Lavinia beach is however listed as a recreational site on the inventory compiled by the Coast Conservation Department (CCD, 1985).

A 32 ha site has been purchased near Tangalle and named the Rekawa Turtle Sanctuary under a project run by the UK-based society Care for the Wild.

Sri Lanka is a signatory the Ramsar Convention.and interest in protecting critical wetland habitats is shared by the CCD, NARESA, and NARA. Bandula, designated in 1990, principally represents coastal lagoon habitat.

Sri Lanka is a party to the World Heritage Convention but no natural sites have been inscribed.

There is a national committee for the UNESCO MAB programme but none of the existing biosphere reserves are coastal.

7.1.4. Mangrove protection

Activities initiated by the National Mangrove Committee of NARESA have included mapping of selective mangrove areas, strengthening the protection of mangrove areas, assessing the status of mangroves along the west coast under a UNDP/UNESCO regional mangrove project, and supporting several biological and environmental research projects in mangroves and adjacent estuarine waters. Protected areas with mangrove include sanctuaries at Chundukkulam, Kokkilai, Seruvila-Allai including Ullackalie Lagoon, and Ruhuna (Yala) National Park (Buttawa, Yala, Pilinawa), Yala East National Park and Wilpattu National Park.

7.1.5. Artificial reefs

In the 1970s an attempt was made to create an artificial reef from tires off Wellawatte, but was unsuccessful because of strong monsoonal currents. Another attempt was made off Bambalapitiya in 1984; both attempts were aimed at improving fisheries (UNEP, 1986). Efforts to establish FADs (Fish Aggregating Devices) are described by Weerasooriya (1987).

7.1.6. Erosion control

In 1986 the CCD prepared a master plan for Coast Erosion Management with the assistance of DANIDA (Tampoe, 1988). The master plan identifies erosion prone sites along the coast where structural solutions to the erosion problem are appropriate. It provides for protection of a total of 155 km of Sri Lanka's coastline, leaving between 160 and 255 km of erosion prone coasts in western, southwestern and southern areas untouched (GOSL, 1987; 1990b; Tampoe, 1988). An erosion control/coral mining project is currently underway in collaboration with the University of Rhode Island.

8. Recommendations for Future Action

The CZMP contains numerous proposals and recommendations for each of the major habitats identified (GOSL, 1987). Recommendations have also been drawn up in a variety of other publications including Samarakoon & Pinto (1986), Anon. (1986b) and GOSL/ESCAP (1985). These are not repeated in detail here, most emphasis being put on critical sites recommended for further protection. An inventory of coastal sites of importance for reasons other than their biological value has been compiled. Eighty nine recreation and scenic sites are included (CCD, 1985; GOSL, 1987). The major resource management issues and opportunities and the policies and strategies necessary to bring about an improvement under Coast 2000 are detailed in GOSL (1991b).

8.1.1. Proposed protected areas

The following areas have been recommended for protection by various authorities:

1. Hikkaduwa Harbour Area - an extension of the existing Marine Sanctuary has been recommended; also recommended as a Marine Park (a high priority) by NARA Working Group (Silva & Rajasuriya, 1985; Silva, 1986b); a multiple use zoning plan has been prepared by NARA.

2. Unawatuna - a proposal for a Marine Park has reportedly been drawn up by NARA as the Hikkaduwa reefs are considered too badly damaged for Marine Park status.

3. Polhena Reef - south coast, near Matara; important for tourism; recommended as a Marine Sanctuary.

4. Karagan Lewaya - classified as a Site of Scenic Beauty on CCD's Resource Base Map; proposed as a sanctuary by Ceylon Bird Club and other NGOs (Scott, 1989); site account in Scott (1989); a brackish/saline lagoon (900 ha) in western suburbs of Hambantota; lies near Maha Lewaya (260 ha), a lagoon developed for salt production; important for waterbirds; threatened by development of salt industry and sand removal; further information in Silva & Rhaman (1987).

5. Great and Little Basses - off the southeast coast; rocky ridges with corals; recommended as a Marine Sanctuary; also recommended for inclusion within Ruhuna (Yala) National Park (Salm 1975b; 1975c; 1981); site account in UNEP/IUCN (1988).

6. Thenaddi Bay, Vandeloos Bay and Elephant Point: recommended for protection by the Ceylon Bird Club; site account in Scott (1989). Salm (1975a; 1975c) recommended protection for Thenadi Bay; site account in UNEP/IUCN (1988). Vandeloos and Thenadi Bays are separated by the promontory of Elephant Point; Vandeloos Bay in the south contains the estuarine system of the Valaichchenai and Maduru Oya rivers, including

Valaichchenai Lagoon; there are extensive mangroves and marshes. Elephant Point is fringed with mudflats, marshes, mangroves and has offshore coral reefs and a large tidal lagoon. Thenadi Bay has sandy shores with offshore reefs and a coral debris island supporting a large breeding colony of sea birds. Prawn fishing is important. Threats include coral mining, mangrove exploitation, dynamite fishing; and pollution of the lagoon by paper mill discharge.

7. Pasekudah and Kalkudah Bay - east coast, adjacent to Thenadi Bay area; sandy beach with fringing reef around the promontory separating the two bays; reefs threatened by pollution and coral mining; recommended as a Marine Sanctuary; site account in UNEP/IUCN (1988).

8. Pigeon Island - Trincomalee; recommended as a Marine Sanctuary; Trincomalee reefs described in UNEP/IUCN (1988).

9. Vankalai Kalapuwa (200 ha), Periya Kalapuwa (650 ha) and Mannar Causeway (c. 7,500 ha) - there is a long standing proposal that this area should be made into a sanctuary or nature reserve chiefly for waterbirds; a complex of tidal lagoons, mangrove swamps, salt marshes and mudflats in the northwest; prawn fishing; important for waterbirds; site account in Scott (1989).

10. Puttalam Lagoon, Dutch Bay and Portugal Bay: Dutch Bay area recommended for protection (Thorsell, 1985); brackish/saline lagoon with broad connection to sea at north; 36,426 ha; connected to Karaitivu lagoon (260 ha) and Kalpitiya Lagoon (390 ha), Mundel Lake, and to Dutch Bay; mangroves (c. 3,000 ha), marshes, seagrasses at north, mudflats; salt pans; major commercial fishery for prawns, mussels and fish (see Jayasuriya (1984); prawn aquaculture; threatened by expansion of current activities; very important for waterbirds; dugong once occurred; Green Turtle still found; NARA laboratory at Kalpitiya; site account in Scott (1989); further information in Amarasinghe & Perera (1984), Perera & Siriwardena (1982), Durairatnam (1963) and GOSL/ESCAP (1985). This may be the same area as that proposed for a Marine Park for dugong (Anon., 1986b). The impediment to the latter was said to be accommodation of existing fisheries.

11. Negombo Lagoon - NARA and NARESA are expected to declare a large part of the lagoon as a Mangrove Park in the near future; 20 km north of Colombo; 3,502 ha; large estuarine lagoon opening to sea in north;mangroves and seagrass beds; important for fishing and aquaculture; threatened by mangrove exploitation; there has been considerable research in the lagoon; site account in Scott (1989); see also GOSL/ESCAP (1985); Pinto (1980; 1982), Pinto & Wignaraga (1980), Wijerathna (1984).

12. Muthurajawela Swamp - recommended for protection and as a recreational area (Hoffmann, 1987), supported by local NGOs; 10 km north-east of Colombo; 2,429 ha; brackish marshes, mangroves and freshwater marshes; threatened by reclamation, mangrove exploitation, hunting, over-fishing; important for waterbirds; site account in Scott (1989); see also GOSL/ESCAP (1985).

NARA set up a Working Group on Marine Parks and Sanctuaries in 1982 which made a number of recommendations, including identifying 33 areas of importance around the coast (Silva, 1986a). Cabinet approval was granted in July 1980 to the Ministry of Fisheries to enact the necessary regulations under the Fisheries Ordinance to declare several of the sites above as Marine Sanctuaries and in 1985 these regulations were prepared. Currently authority for the marine sanctuaries and reserves is vested in the Department of Wildlife Conservation. There are plans to establish the Bar reef in north-western coastal waters and the Unawatuna reef in the south as marine sanctuaries.

8.1.2 Species protection

A reserve is urgently needed for *Crocodylus porosus* (Groombridge, 1982; Whitaker & Whitaker, 1979) although it is known to occur in the Ruhuna (Yala) National Park and possibly also in the Bundala Sanctuary (Scott, 1989).

The three *Stenella* species and *G. griseus* are considered to be at risk in the Indian Ocean and populations should be monitored. *Sousa chinensis* and *Neophocaena phocoaenoides* are also taken and populations of these species also need monitoring.

8.1.3. Wetland protection and management

Scott & Poole (in press) identify priorities for wetland protection or improved protection as follows: Chundikkulam Sanctuary, Bundala S., Thenadi/Vandeloos Bay, Karagan Lewaya, Muthurajawela Swamp, VankalaiKalapuwa, Jaffna Peninsula, Jaffna Lagoon, Mahaweli Ganga Flood Plains, Mundel Lake, and Puttalam Lagoon. Recommendations in GOSL/ESCAP (1985) include the declaration and protection of environmentally sensitive areas at Hikkaduwa, Unawatuna, Kalpitiya and Mundel and the zoning of mangroves as conservation areas. Coastal wetlands of significance described in Scott (1989), but not specifically recommended for protection to date include:

1. Delft Island: 40 km southwest of Jaffna in Palk St between Jaffna Peninsula and Rameswaram; a low-lying coral island of 6,000 ha; important for fisheries, flamingoes and ducks; little information available.

2. Punkudutivu Lagoon: a brackish to saline tidal lagoon of 390 ha on Punkudutivu Island, off the west tip of the Jaffna Peninsula; significant for seagrasses, prawn fishery, flamingoes, ducks, shorebirds.

3. West end of Jaffna Peninsula: a complex of shallow sea bays, intertidal mudflats, mangroves and saline marshes covering about 20,000 ha; some mangrove (north side of Kayts Island and between Kayts and Mandaitivu Islands), extensive sea grass beds, salt marsh community on east shore of Karaitivu Island; significant for finfish and prawns, migratory ducks, shorebirds etc.

4. Uppu Aru Lagoon: on Jaffna Peninsula; 3,000 ha; brackish with mangrove, mudflats and salt marshes, linked to main Jaffna lagoon; important for flamingoes, shorebirds, ducks;

little information available.

5. Thondamannar Lagoon: north side of Jaffna Peninsula; 7,787 ha; brackish/saline, connected to Indian Ocean by narrow channel; extensive mangroves, seagrasses and mudflats; prawn fishing, some experimental fish and prawn cage culture; several threats including salt water exclusion scheme to convert part of lagoon to freshwater lake; important for flamingoes, ducks and shorebirds especially in the western portion of the lagoon; some research by Univ. Jaffna; Thondamannar Field Research Centre of Dept Education located on north shore of lagoon; see also Kugathasan (1969).

6. Jaffna Lagoon: between Jaffna Peninsula and mainland; c. 40,000 ha; mudflats, mangroves, seagrasses; broad connection with sea; fishing; most important site in Sri Lanka for flamingoes and important for many other birds. Other references include Arndpragasam (1975), Sachithananthan (1969), and Sachithananthan & Perera (1970).

7. Chalai Lagoon: north-east coast; 1,460 ha; brackish with some mangrove and seagrass beds; adjoins Chundikkulam Lagoon in northwest; salt production in dry season; fishing and some aquaculture; important for water birds; little information.

8. Nai Aru Lagoon: brackish estuarine lagoon with mangroves and seagrasses; 1,760 ha; north-east coast; prawn fishery, but silting up as water is diverted for irrigation is causing diminished recruitment of penaeid post-larva; important for waterbirds.

9. Periyakarachchi Lagoon (650 ha) and Sinnakarachchi Lagoon (780 ha): northwest of Trincomalee; shallow brackish lagoons with mangroves, seagrasses and mudflats; threatened by development for aquaculture and salt pans; small subsistence fisheries, salt production, important for waterbirds.

10. Mahaweli Ganga Flood Plan System: area of coastal component not known. The Mahaweli Ganga is Sri Lanka's largest water resource and enters the sea on the east coast. The distributaries Kandakadu Aru and Verugal Aru discharge near Verugal. The main channel and the distributary Koddiya Aru discharge into Koddiya Bay, a large, deep bay at the head of a submarine canyon.

11. Upaar Lagoon and Uppu Alan: 50 km north of Batticaloa; 2,590 ha; two seasonally tidal, estuarine lagoons; mangroves and seagrasses; fisheries; important for waterbirds but very little information.

12. Batticaloa Lagoon: east coast; 14,118 ha; seasonally tidal estuarine lagoon; mangroves and seagrasses; prawnfishing, aquaculture, threatened by aquaculture and mangrove exploitation; important for water birds; some research by Univ. of the East at Chenkaladi.

13. Arugam Kalapuwa: east coast, 3 km south of Pottuvil; 248 ha; seasonally tidal shallow brackish lagoon; marshes and mangroves; prawn fishing; important for waterbirds; little information.

14. Palatupana Maha Lewaya: in Hambantota Province; 194 ha; seasonally tidal, brackish lagoon, much converted to salt pans; important for waterbirds; no information.

15. Mundel Lake: 20 km south of Puttalam, west coast connected to Puttalam Lagoon; 3,361 ha; brackish lagoon; marshes, mangrove, mudflats, seagrasses; seasonal prawn fishing, aquaculture; threatened by aquaculture, fishing and hunting; very important for waterbirds; see also GOSL/ESCAP (1985).

16. Adam's Bridge: chain of c. 20 small islands between Sri Lanka and India with sand banks and mudflats, stretching for almost 30 km; seagrasses; fishing; important for waterbirds; little information.

17. Palk Bay, Devil's Point and Vidattaitivu Lagoon (1,300 ha): c. 70 km of coastline in north-west; mudflats, sand banks, mangroves, brackish lagoon; several small islands of Devil's Point; fishing; important for waterbirds especially Crab Plovers *Dromas ardeola*; little information.

18. Iranaitivu Islands: Palk Bay; two small islands with fringing reefs; important for waterbirds; little information.

8.1.4. Mangrove conservation

The Government is proposing a series of activities designed to facilitate the integration of mangrove management activities in economic development plans. A proposal has been drawn up by NARESA, the Ministryof Lands, Irrigation and Mahaweli Development, and IUCN to develop a detailed conservation plan for mangrove resources and a series of pilot projects to demonstrate techniques for integrated management of mangroves. This will include survey work using satellite imagery where this is available and a review of the status of mangrove resources. A variety of other recommendations have been given for mangroves in numerous publications.

The shore of Koddiya Bay is a sandy beach ridge with mangroves fringing small lagoons and tidal creeks. In the west the Bay opens into shallow Tambalagam Bay surrounded by extensive mangroves. Mangroves occur along the main rivers up to 5 km inland. These are less diverse than in other parts of Sri Lanka. The main species are *Rhizophora mucronata, Avicennia marina, Acanthus ilicifolius, Lumnitzera racemosa, Aegiceras corniculatum* and *Scyphiphora hydrophyllacea. Sonneratia apetala* is found in small numbers near the mouth of the main channel. There is an important fishery in Koddiyar Bay and adjacent waters (see Hettiarachchi, 1983). Although most of the Flood Plain is protected in a system of protected areas (PADU (1988) states that the proposed integrated system of protected areas have not been established), the lower deltaic plan and river mouth have no legal protection. The Mahaweli Ganga Project (Accelerated Mahaweli Development Programme) is aimed at bringing a large area of land under irrigation and includes several dam projects (Anon, 1980). Decreased water flow is likely to lead to many major changes including increased salinity intrusion at the river mouth. The mangroves are currently under pressure from exploitation. An Environmental Plan of Action has been prepared to help mitigate adverse impacts of development in the Mahaweli basin. An

environmental assessment of the Project was carried out in the late 1970s (Tippets *et al.*, 1980) and more recently the Centre for Environmental Studies (State University of Leiden) has made an evaluation (Drijver *et al.*, n.d.); see also Jansen (1981).

8.1.5. Other recommendations

Since several Government agencies hold jurisdiction over the marine environment at the present, there is a need for the establishment of a separate authority with particular expertise and for local participation in the management of reserves. There should be collaboration with the tourist industry in the planning of zones and reef use. There is a particular need for environmental education on marine issues (Silva, 1985). Priorities for research on the Sri Lankan reefs are given in Silva (1986b). Wood (1985) gives recommendations for the improved management of the aquarium fish trade.

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