REGIONAL SEAS

UNITED NATIONS ENVIRONMENT PROGRAMME

Environmental problems of the marine and coastal area of Sri Lanka: National Report

UNEP Regional Seas Reports and Studies No. 74

UNEP 1986

Note: This report was prepared by the United Nations Environment Programme (UNEP) under projects FP/5102-84-01 and FP/5102-85-05 as a contribution to the development of an action plan for the protection and management of the marine and coastal environment of the South Asian Seas region.

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For bibliographic purposes, this document may be cited as:

UNEP: Environmental problems of the marine and coastal area of Sri Lanka: National Report. UNEP Regional Seas Reports and Studies No. 74, UNEP 1986.

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PREFACE

The Regional Seas Programme was initiated by UNEP in 1974. Since then the Governing Council of UNEP has repeatedly endorsed a regional approach to the control of marine pollution and the management of marine and coastal resources and has requested the development of regional action plans.

The Regional Seas Programme at present includes ten regions[1/] and has over 120 coastal States participating in it. It is conceived as an action-oriented programme having concern not only for the consequences but also for the causes of environmental degradation and encompassing a comprehensive approach to controlling environmental problems through the management of marine and coastal areas. Each regional action plan is formulated according to the needs of the region as perceived by the Governments concerned. It is designed to link assessment of the quality of the marine environment and the causes of its deterioration with activities for the management and development of the marine and coastal environment. The action plans promote the parallel development of regional legal agreements and of action-oriented programme activities[2/].

In May 1982 the UNEP Governing Council adopted decision 10/20 requesting the Executive Director of UNEP "to enter into consultations with the concerned States of the South Asia Co-operative Environment Programme (SACEP) to ascertain their views regarding the conduct of a regional seas programme in the South Asian Seas".

In response to that request the Executive Director appointed a high level consultant to undertake a mission to the coastal States of SACEP in October/November 1982 and February 1983. The report of the consultant on his mission was transmitted to the Governments of the South Asian Seas region in May 1983, and the recommendations of the Executive Director were submitted to the Governing Council at its eleventh session.

By decision 11/7 of 24 May 1983, the UNEP Governing Council noted "the consultations carried out in accordance with Council decision 10/20 of 31 May 1982" and requested "the Executive Director to designate the South Asian Seas as a region to be included in the regional seas programme, in close collaboration with the South Asia Co-operative Environment Programme and Governments in the region, and to assist in the formulation of a plan of action for the environmental protection of the South Asian Seas".

1/ Mediterranean Region, Kuwait Action Plan Region, West and Central African Region, Wider Caribbean Region, East Asian Seas Region, South-East Pacific Region, South Pacific Region, Red Sea and Gulf of Aden Region, Eastern African Region and South Asian Seas Region.

2/ UNEP: Achievements and planned development of UNEP's Regional Seas Programme and comparable programmes sponsored by other bodies: UNEP Regional Seas Reports and Studies No. 1. UNEP, 1982.

As a first follow-up activity to decision 11/7 of the Governing Council, the Executive Director convened, in co-operation with the South Asia Co-operative Environment Programme (SACEP), a meeting of national focal points of the States of the region in order to seek their views on how to proceed in developing a comprehensive action plan for the protection and management of the marine and coastal environment of the South Asian Seas region (Bangkok, Thailand, 19-21 March 1984).

The meeting discussed the steps leading to the adoption of an action plan and reached a consensus on the items to be considered for further development of the action plan[3/].

The meeting recommended that the Governments, with the assistance of UNEP and other organizations as appropriate, should initiate the preparation of country reports reviewing their:

- national environmental problems defined as priority areas of regional concern;

- activities which may usefully be carried out under the action plan to resolve or mitigate these problems; and

- national institutional and manpower resources which are, or may be, involved in dealing with these problems, including the identification of the need to strengthen their capabilities.

It was also recommended that UNEP prepare in cooperation with SACEP, and other organizations as appropriate:

- a draft overview report, based on the country reports, reviewing the environmental problems of the region defined as priority areas;

- a document addressing the essential legislative aspects relevant to the action plan; and

- a draft action plan reflecting the conclusions of the country and regional reports.

The present document is the country report on environmental problems in Sri Lanka prepared by experts designated by the Government of Sri Lanka. The assistance of a consultant, A.H.V. Sarma, was provided to the Government of Sri Lanka to facilitate the preparation of this report. The authors' contributions are gratefully acknowledged.

3/ Report of the meeting of national focal points on the development of an action plan for the protection and management of the South Asian Seas region, Bangkok, 19-21 March 1984 (UNEP/WG.105/5).

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INTRODUCTION

Sri Lanka lies off the Southern tip of peninsular India between 5°55' and 9°51 North and 79°41' and 81°54' East. The island covers an area of 640,000 sq km and is separated from the Indian sub-continent by a narrow strip of sea, which at its narrowest is about 40 km wide. The Bay of Bengal lies to the North with no land mass right down to the South Pole. The island is 435 km long with a maximum width of 225 km. The central part of the Southern half of the island is mountainous with several isolated hills arising abruptly from the Eastern plain; the rest of the country is flat and is known as the coastal plain.

The island has a coastline of 1700 km, of which nearly 9/10 consists of sandy beaches. In the country's coastal areas are located a multiplicity of human activities vital to the life of the nation. The capital city as well as most of the major urban centres are located along the coastline.

One of the features of the coastal environment is the presence of extensive fresh and saltwater lagoons along both Eastern and Western coasts, at the Northern extremity of the island and to a limited extent on the Southern coast. Along the greater part of the South-western and Eastern shoreline, beaches are located between rocky headlands and many of the beaches are backed by lagoons and estuarine deltas, and marshes indicating progradation. High cliff formations are rare. Coral reefs are found scattered along the Northern, South-western and South-eastern coasts. A considerable part of the South coast is fringed by a shallow reef of sedimentary sandstone. Along the Northwestern coast, deposits of sedimentary limestone of miocene origin is found.

A variety of coastal resources (finfish, shellfish and a variety of other invertebrate fauna, coastal vegetation including seaweeds and coastal minerals, beaches etc.) provide the resource base for a number of economic activities such as fisheries, mining, coastal recreation and tourism, the construction industry and coconut-based industries.

The most prominent feature of the marine environment of Sri Lanka is the continental shelf which extends for a distance varying from 8 to 40 km. and at an average depth of 65 m. below sealevel. The outer edge of the shelf is a comparatively steep shelf (the continental slope) falling to 1,800 m or more, and taking 20 km to reach the general level of the Indian Ocean. Notched into this cliff are several submarine valleys, where deep water occurs within a few kilometers of the coast near Tricomalee, Kumana, Matara and Panadura (Cooray 1967).

The continental shelf is narrow around the Southern part of the island, but towards the North it widens out and merges with the platform that surrounds India. On this Northern area of the shelf there are three elevated areas, viz;

- 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 and long sand bank between Mannar and the Indian coast which makes the Palk Straits impassable for ships; and

- Wadge bank around the Southern extremity of India.

The resources presently exploited in the marine waters are fishery resources, especially tuna, but there is no commercial exploitation of marine minerals at present. These waters are used for maritime traffic entering Sri Lankan ports, as well as for traffic around the South Asian Region.

Serious concern for environmental problems is a relatively recent phenomenon in Sri Lanka. For a long time, there has been little awareness of the close relationship between development and environment; much of the already existing legislation could not be effectively enforced because of socio-economic considerations. The lack of environmental considerations in Sri Lanka's economic development planning in the past is clearly manifested in the problems emerging today in the coastal and marine environment.

Because of population growth, accelerated industrial and commercial development and rapid urbanisation, the coastal and marine ecosystems and their resource base has been greatly affected. Over-exploitation of resources, both renewable and nonrenewable, and the degradation of the coastal and marine waters are the most urgent problems the country is facing today.

With the creation of specialised agencies and environmental legislation, a more positive approach has been taken in recent times towards integrating environmental dimensions in the development planning process at the national level. Important recent legislation pertaining to the protection and management of the coastal and marine environment include the National Environmental Act, Coast Conservation Act, National Aquatic Resources, Research and Development Act, Amendments to the Forest Conservation Act, etc.

The recognition of the need for an integrated environmental policy in the country is also reflected in the work already being undertaken for the preparation of a National Conservation Strategy, a National Science Policy and a National Energy Policy. The role of regional co-operation in environmental management especially that of the coastal and marine environment has also been recognized. This is clearly indicated in Sri Lanka's participation in the South Asia Co-operative Environment Programme and the South Asian Seas Regional Programme.

This report reviewing the status of the coastal and marine environment in Sri Lanka, together with similar reports from other countries in the South Asian Seas Region will provide an overview of the situation regarding this environment in the region for the preparation of an action plan directed towards the protection and management of the Seas of South Asia.

THE PHYSICAL ENVIRONMENT

Climate and seasons

Separated from the continental land mass of India by relatively shallow seas, and situated in the equatorial belt, Sri Lanka has a mean annual temperature which shows little variation over the island, and the annual thermic amplitude is below 5°C at any given altitude. The temperature is around 27°C at sea level, 20°C at 1200m and 15°C at 1800m (Gaussen et al 1968). The humidity is generally high, and while there are no clearcut seasons, the island is subject to rainy and dry periods due to the effects of

two monsoons, the South-west (May to October) and the North-east (December - March). These seasonal airflows which reverse direction are related to regional atmospheric changes associated with the heating and cooling of the Indo-Asian land mass and adjoining oceans (Swan, 1981). The general climatic conditions of the equatorial belt are characterized by heavy rainfall presenting two maxima according to latitudinal zonation. In Sri Lanka, however, the S.W. monsoon and high frequencies of cyclonic depressions aided by the insularity, and geological reliefs in the form of a central backbone of high ridges and plains, results in a variety of climatic regimes based primarily on rainfall. Three principal types are:

(a) The equatorial regime - showing two maxima of annual rainfall;

(b) Sub-equatorial regime - derived by the diminution of one or both of the rainfall maxima; and

(c) Tropical regime - with only one marked rainfall during the November-January months characteristic of the tropical inverted type.

All types of transitions exist between these three principal types (Gaussen et al 1968). On the basis of rainfall distribution, the island can be divided into two distinct areas - the wet and dry zones. The wet zone has two rainy seasons, an annual average rainfall of 242 cm and lies along the South-west coast of the island. The rest of the island consists of the dry zone with an average annual rainfall of 145cm and only one rainy season from October to March (Arumugam, 1969).

Wind patterns and cyclonic disturbances

Sri Lanka experiences two monsoons, namely the North-east (December to early March) and South-west (late May to October). Winds are usually of less than 50km/hr velocity and gale force winds of significant duration are rare, although early SW monsoon squalls have gusts with velocities between 80 - 100 km/hr. Inter-monsoonal periods are characterized by weak variable breezes, landwards by day and seawards by night (Swan, 1981). Throughout the season, winds intensify and often change direction during the afternoon. By early March the trade winds (locally the NE monsoon) cease to blow over the island. The winds of the Northern Inter-tropical Convergence Zone (ITCZ) now operate from South to North and typical equatorial convergence storms are experienced all over the country usually during late afternoon. During May, the ITCZ passes to the North towards Southern India and rainfall is received all over the country, but concentrated over the South-western reliefs. In June, when ITCZ is over Northern India, the SW monsoon is at peak force, and the South-western quarter of the island and the windward slopes receive all the rain, while the Northern and Eastern parts only get occasional rains from convection storms formed during the periods of calm called the 'monsoon breaks' (Gaussen et al 1968). Although both the Bay of Bengal and the Arabian Sea are areas of cyclogenesis, the majority of tropical convection storms with winds in excess of 120km/hr follow paths North of the island. However, once every ten or fifteen years, cyclones come closer and cross over the island, apparently because of the persistence of the Northern ITCZ close to the island in November-December and March-April. Considerable damage along coastal areas, such as that wrought upon the Northern and Eastern coasts by the cyclones of December 1964 and November 1978, are ample evidence of the violence of these storms (Swan, 1981 : Gaussen et al 1968). The fringing coral reefs along the coastline are particularly damaged by such cyclones, as shown by the large quantities of coral rubble washed ashore. Normally, ITCZ retreats to the South

during December to February, with the re-establishment of the trade winds. The persistent disturbances coming in from the East often make January the rainiest month along the South-east coast of the island (Gaussen et al 1968). The Sri Lanka navy maintains a cyclone early-warning system in Trincomalee, utilizing computer-enhanced radar telemetry, for minimizing loss of life and property in the event of a major cyclone off the East coast.

Waves, tides and ocean current regimes

Much of the swell that affects Sri Lanka originates in the South Indian Ocean (40^{o} - 50^{o}S), under the influence of westerly depressions and storms. This moves northwards and is felt most along the coasts of the Southern half of the island. Most large waves have a southerly component, but they rarely reach a height of over two metres. The highest waves are during the SW monsoon season, but the effective fetch is only about 800km between the Maldive Island chain and Sri Lanka. During the NE monsoon, the northerly winds blow over short stretches of water from the North, and even when blowing across the bay of Bengal, are not steady enough to generate large waves. By and large, the energy of the waves are relatively low during this period as well as during the inter-monsoonal periods (Swan, 1981).

Several types of currents are found around Sri Lanka. This is because many currents from the Bay of Bengal and the Arabian Sea as well as the equatorial region meet in this area and are affected by the monsoons. The strongest currents are felt along the Southern coastline. Coastal currents over the continental shelf are parallel to the coastline and are stronger off the East coast than off the West coast. In addition to the distinctive patterns of currents in the Bay of Bengal and the Arabian Sea, the equatorial oceanic zone is characterized by easterly and westerly flows (Figure 1 from Swan, 1981). These massive water exchanges result in current velocities of about 1 metre per second or more between October and January around the Little Basses Reef off the Southern coast of Sri Lanka. Strong currents (2.5 - 3.0m/sec) are also experienced, especially during the monsoons in the waters between Sri Lanka and India. The coastal currents are complicated by the interaction of shelf topography, contour of coastline, water depth, wind intensity and direction as well as wave incidence and tidal influences (Swan, 1981).

The period between tides is approximately 12 hours and is thus semi-diurnal. The seas of Sri Lanka are micro-tidal with a tidal range of within 75 cm during spring tide and 25 cm at neap tide. The tidal range is higher around Colombo and is least around Delft and Trincomalee. Weather conditions can give rise to monthly tidal level variations. Tidal waves move southwards along the West coast of India, towards Sri Lanka twice a day so that the West coast of the island experiences high tide synchronously. The tidal crest which arrives at Galle in about 12 minutes time then moves anti-clockwise heading eastwards and northwards reaching the East coast port of Trincomalee and the North-eastern coast some six hours later (Swan, 1981).

Soils, sands and sediment

The beach sands of Sri Lanka vary in their minerological composition, specific gravity, texture and shape. They are predominently quartose, being derived from quartz containing silica rocks, and are considerably resistent to weathering. Natural concentrates of weathering resistent heavy minerals such

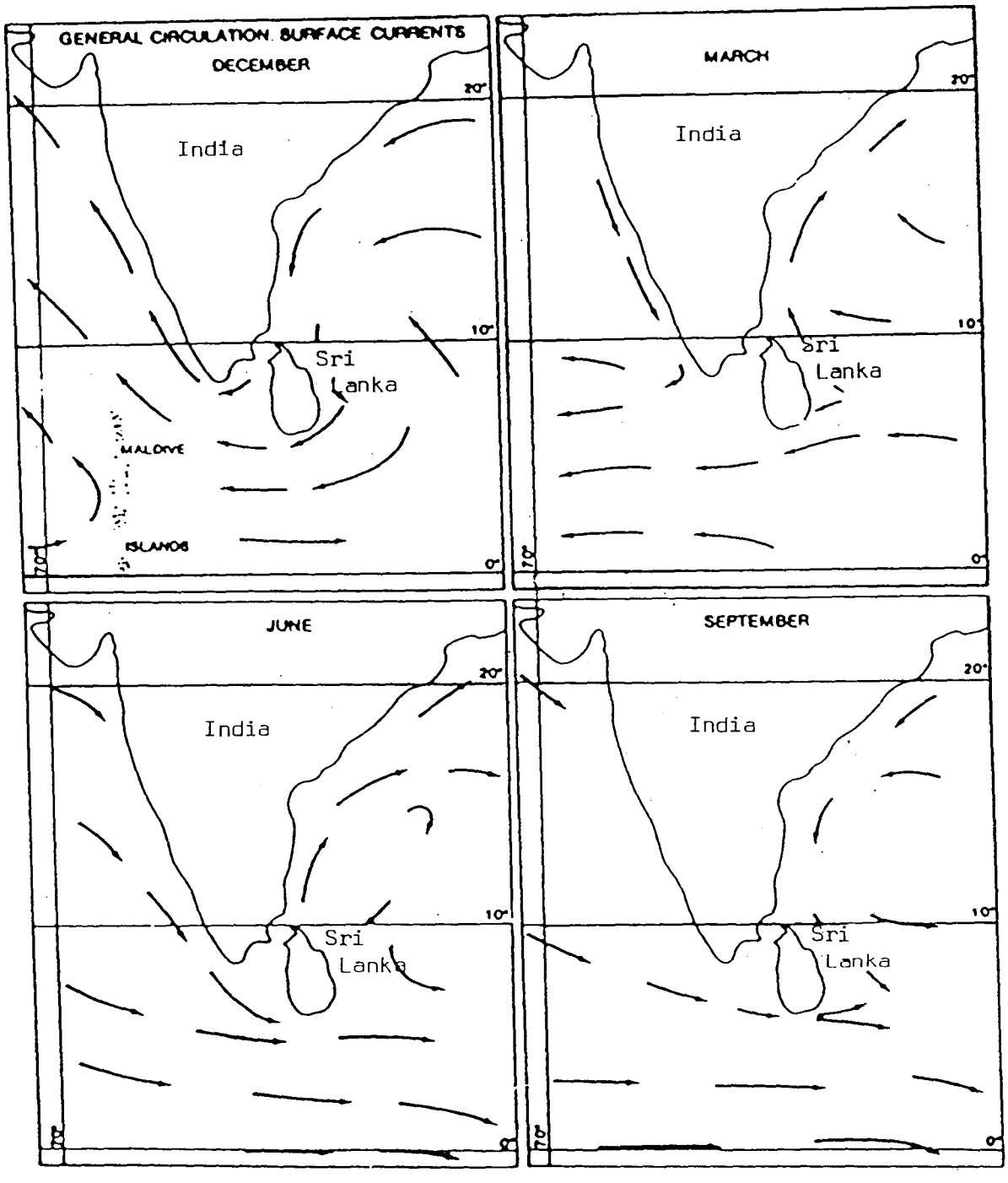

Figure I: Surface currents around Sri Lanka

(Source: H.M. Hydrographic Office, London)

as zircon, monazite, rutile, ilmenite, spinel and garnet are found everywhere along the entire coast, but extensive deposits that could have commercial importance are localised. These minerals are all common as accessories in the crystalline rocks. Feldspars and micas are also found, generally in close proximity to river outlets and in sheltered localities, where they are deposited, but being more weatherable, are less common. Least persistent minerals such as pyroxenes and hornblends are rarely encountered.

Textural differences are observable along the shore profile. The zone of maximum particle size and of widest size range (i.e. poorest sorting) is the breaker zone. Size usually diminishes and sorting improves shorewards towards the upper beach zone, to the berm and dunes beyond. Seawards of the breaker zone, size decreases and sorting is optimal (Swan 1979). They also tend to be coarser and poorly sorted at increasing depths.

At present, the major source of sand and sediment supply to the coastal areas is fundamentally the material which is brought down from land towards the coast by eroding forces of rain, storm-water run-off, streams, rivulets and rivers. The sand supply to the Eastern and Western littoral between Hambantota and Point Pedro and, between Hambantota and Puttalam was estimated to average 100,000 and 250,000 m^3 per year respectively. More information on relationships between rainfall incidence, vegetation, land use lithology, etc., would be required to make more accurate estimates.

Not all rivers deliver their full load to the sea. Many cross wide flood plains in their lower reaches where part of the load is deposited, or enter lagoons which act as traps for coarser materials including sand. The Mahaweli Ganga, for example, discharges its sediment into Koddiyar Bay which has a submarine canyon at the river mouth that collects most of the sand load, and only some silt and clay are carried in suspension to other parts of the Bay. Most of the larger rivers that make substantial contributions of sand to the littoral zone are located between Chilaw and Kumana along the South-west coast.

Shoreline geomorphology

Beaches

Over three fourths of the coastline is beach-fringed, the principal determinants of their characteristics being wave energy, supply of beach material, contour and lithology of the coastline, and nature of coastal and sub-marine landforms. Most of the island's beaches are barriers, backed by lagoons, swamps and ill-drained terrains, and are sometimes contained between headlands or river outfalls. Some barriers are islands free at both ends, e.g. Karativu Island. Cheniers characteristic of shorelines destroyed by erosion are found at Akurala and East of Weligama.

Most of the beaches in the island are sandy although beaches of pebble, rubble and boulders sometimes occur along restricted stretches, e.g. Galle Buck. Pocket beaches formed by deposition of sand in small embayments of coastal bedrock stretches are also found, e.g. between Dondra and Tangalle.

Owing to the small tidal range and relatively low wave energy, the beaches in Sri Lanka are generally narrow. The beach deposits increase in width from the South-western corner of the island in both directions attaining maximum width on the West coast near Chilaw and on the East coast near Kalkudah. The berm which is a reservoir of sand which supports the coastline against wave attack is variable around the island depending on the effective-

ness of constructive waves; where the waves deliver large quantities of sand the beach develops a negative gradient landwards. The width of the seaward sloping swash zone which is constantly washed by waves is also variable depending on the presence of a berm and energy of the waves. Swash zone gradients range from 2 - 6°; steep swash zones are characteristic of beaches undergoing accretion and also indicates degrading berms (Swan, 1979). While the swash zone and berm usually seem parallel to one another, at times the boundary between them may be thrown into seaward facing concave cusps. Beach cusps may be observed during the monsoon and inter-monsoon seasons especially where the swash zone is developing at the expense of the berm.

Absence of prominent sand dunes along the South-west coast has been attributed to the poor sand delivery and the lack of bedrock relief conducive to the development of stable beaches.

Rocky shorelines

Rocky shorelines of bedrock-related in situ materials comprise only a small proportion of the coastline. They occur along the Northern margin of the Jaffna Peninsula, the coastline opposite Karativu Island and Portugal Bay, Beruwela, between Balapitiya and Ambalangoda, around Weligama Bay, between Dondra and Tangalle, Trincomalee and at several headlands interspersed between beaches. Most rocky shores comprise of crystalline bedrock, but some are characterized by shores that are low-lying and relatively flat, and are associated either with limestone or coral deposits quite similar to bedrock, as at Akurala.

Sand bars and spits

Sand bars and sand spits are common at the mouth of rivers, lagoons and bays, and usually grow in the direction of predominant drift. Along the South-west coast, from Matara to Colombo, sand bars enclose lagoons, which are typical drowned valley systems, characteristic of a submerged coastline. In contrast, the sector from Colombo northwards is characteristic of a stationary emergent shoreline and contains several narrow spits up to 25 miles in length, connected with the land at the Southern end and enclosing wide lagoons which run parallel to the spit.

Sand dunes

Sand dunes formed by accumulation of wind-blown sand are found along most of the shoreline except in the South-west sector. They are widely developed along the North-east coast between Mullaitivu and Point Pedro; reaching a maximum width of two meters just South of Point Pedro. Extensive sand dunes are also found between Elephant Pass and Chavakachcheri across the Mannar Island and Pooneyn Peninsula, on the West coast between Battulu Oya and Kalpitiya Peninsula, and on the Southeast coast from Kirinda to Sangamakanda Point.

Older, highly weathered dunes, sometimes reddened due to a coating of iron oxide, are usually fixed by dense monsoon scrub forest. The less weathered younger dunes are more active.

Sandstone deposits

A band of corse to fine sandstone which is exposed at low water along the toe of the beach slope is characteristic of the Western coast. The rock is

composed of quartz grains and shell fragments with a calcareous cement and frequently encloses paralled bands of ilmenite and garnet grains (Coates 1935).

These sandstone reefs often occur on the edge of lagoons enclosed by sand spits; in some places widening of the spit by accumulation of sand covering lagoons, tends to conceal their original relations. One of the most conspicuous sandstone reefs is the Pamunugama reef, which fringes the shore almost the whole way from the mouth of the Kelani River to the headland off Negombo and runs out to sea for a short distance beyond it. On the East coast between Kalmunai and Batticaloa and at Mullaitivu, a sandstone bed exists a short distance inland and does not extend to the present shoreline.

Coral reefs and deposits

Coral reefs of late Holocene origin occur along sections of the South-western coastline where the beaches are usually poorly developed and where large rivers do not enter, e.g. between Ambalangoda and Matara. Coral reefs are also found along the Southern and Eastern coasts, near headlands such as Dondra, Tangalle, Kalkudah, Elephant Point, Foul Point, and between Nilaveli and Mullaitivu. On the Western coast they are found North of the Kalpitiya Peninsula in the Gulf of Mannar. They also fringe the Northern margin of the Jaffna Peninsula.

Coral reefs of Sri Lanka usually grow in patches and discrete colonies forming small platforms. Fringing reefs adjoining the shore and incipient fringing reefs (apron reefs) are also common, while lagoon reefs and barrier type reefs are rare, and atolls are not found. Over a hundred species of corals have been reported of which about 65 species are hermatypic.

(see further in document for more detail)

Lagoons, brackish-water lakes and wetlands

Sri Lanka's coastline of 1,770 km is broken by extensive lagoons, bays, brackish-water lakes and wetlands. These are formed by (a) inunduation of flood-plains or river courses, such as in Bentota, Hikkaduwa, Dedduwa, Valaichchenai etc., (b) inundation and barrier formation as in Jaffna, Batticaloa, Hambantota and Tambalagam; (c) beach formation as in Puttalam, Negombo, Mundel and Kalutara; and (d) destruction of beach as in Beruwela. The freshwater bodies include about 94,800 ha. of major and medium sized reservoirs with a perennial supply of water and 42,800 ha. of minor tanks and villi with a seasonal supply of water. An additional 18,000 ha of perennial water bodies will be added under the Mahaweli Development Project. The brackish-water area comprises about 80,000 ha of estuaries and large deep lagoons and about 40,000 ha of shallow lagoons, tidal flats and mangrove swamps.

Of the coastal lagoons, the smaller ones, especially, those along the Southwestern, Southern and South-eastern regions are mostly permanently enclosed water bodies. Some may, however, be connected with the sea for short durations. In some cases such as Batticaloa, Kokkilai and Nayaru lagoons on the East coast, sandbar formation occurs across the mouth during the dry season. Some of the larger lagoons, such as Puttalam and Negombo on the West coast and Jaffna in the North are perennially connected to the sea. Tidal flats and mangrove areas exist associated with Mannar and Kalpitiya lagoons.

Salinities of these lagoons vary to a great extent from about 15-40 ppt, depending on the area where they are situated and such factors as rainfall, evaporation and connection to the sea. In the South-western region where rainfall is high and evenly distributed throughout the year, discharge of water is high and salinity in the lagoon is comparatively low. In those regions where rainfall is low and river discharge is seasonal, salinities are relatively high.

Saltflats are found along the Northern and North-western coasts of Sri Lanka. Few such flats are also found in the South-eastern region. Many saltflats in the dry zone have been converted to saltpans to produce salt. Physical features of major lagoons in Sri Lanka are given in Annex I.

Continental margin and seabed characteristics

Sri Lanka has a fairly consistant continental shelf with an area of about 28,000 km. It is narrowest in the South between Matara and Dondra (6 km), moderately wide off the West coast North of Galle and near Tangalle-Pillinawa Point (20-35 km) and relatively narrow off most of the East coast. The shelf widens significantly North of Kalpitiya peninsula on the North-west and in the Palk Strait where it is contiguous with that of the Indian sub-continent.

A prominent feature of the shelf is a wide depression paralleling the coast at an average distance of 20 km (Sommerville, 1908). It is about 50-75 metres below sea level and lies about 10 - 18 metres below adjoining portions of the shelf. This is believed to be the result of isostatic changes that take place in response to continental separation and drift (Swan, 1981). The positive relief features of the shelf include islets, tors and large rock formations, reefs and coral patches, the most prominent feature being the Great and Little Basses Ridge off the South-east coast.

The continental slope in Sri Lanka is relatively steep averaging about 10^{o} and in one place near the Trincomalee Canyon, a slope of $43^{o}32'$ has been recorded, one of the steepest known (Stewart et al 1964). Another feature of the slopes is the slumping reported in the slope bordering the Gulf of Mannar and the West coast of the island. The Colombo Slump which occurs at depths of 1500 - 2600 m is about 35 km long, 50 - 60 km wide and about 500 - 600 metres thick (Swan 1981).

The continental rise extending beyond the shelf is bounded on the East by the Bay of Bengal with its complex meandering and braided net of valleys (Curray & Moore 1971) and the Ninety East ridge, and on the West by the Laccadive-Chagos Ridge, Carlsberg Ridge and the Arabian Abyssal Plains. The Southern extremity of the continental rise is bounded by the Ceylon Abyssal Plain and Central Indian Ocean Basin. The continental rise which extends to approximately $2^{o}S$ latitude is underlain by a substantial thickness of sedimentary rock ranging upto 4.5 - 5 km.

Drilling in the Palk Bay area has shown that the shelf is underlain by charnockitic gneisses and granites, the predominent rocks of the island. Overlying these rocks are sedimentary limestones, calcareous claystones and sandstones. The sediments covering the shelf are predominately quartzose sand, biogenic material, fossiliferous shells, coral fragments and mud. Sand increases North-west both off the East and the West coasts while mudbanks are found off Kochchikade, Chilaw, Kalpitiya, Pedro bank and Mullativu.

COASTAL/MARINE LIVING/NON-LIVING RESOURCES AND AREAS OF SPECIAL ECOLOGICAL INTEREST: THEIR STATUS, TRENDS IN THEIR UTILIZATION AND SOCIO-ECONOMIC IMPORTANCE

Offshore oil and gas

Exploration for offshore oil and gas has been given priority in the development strategy of the country and 13 off-shore concessionery blocks have been designated for exploratory activities on a production-sharing basis, of which eleven are on the continental shelf and the other two are in deeper waters. Based on seismic and other geological data collected during exploratory surveys, 4 off-shore wells have so far been drilled in Park Bay and the Gulf of Mannar.

Although these wells did not strike oil or gas, information gathered has been useful in reconstructing the tectonic and geological history of the area, and exploratory work is being continued. A seismic survey from Colombo to Mannar has been completed and interpretation of data is now in progress.

Offshore minerals

Major offshore minerals that are presently being exploited in the country are placers (ilmenite, rutile, zircon, monozite, garnet and sillimanite). Heavy mineral placers, usually called "black sand", occur in some localities along the Western and Eastern coast, but only the deposits at Kudremalai Point, Beruwela, Pulmuddai and Nayaru are of sufficient concentration for economic exploitation.

Deposits at Beruwela were mined until recently which was stopped only because of the coastal erosion hazard in that area. Deposits at Pulmuddai, estimated at over 4 million tons are mined by the Mineral Sands Corporation. The Corporation mines about 40,000 tons ilmenite, 10,000 tons of rutile, 5,000 tons of zircon, and about 30 tons of monozite annually. A recent survey has shown that 0.95 to 1.34 million metric tons of these minerals may occur in the offshore areas (Mayer, 1982).

Other offshore minerals reported in the vicinity of Sri Lanka are Barium nodules, glauconite and phosphorates. Concentrations containing over 75% Barium sulphate have been collected off Colombo at depths of 1235 metres. Glauconite is found characteristically as a continuent of green mud and sand along the Western, South-western and North-western coasts at depths ranging from 15 - 1300 metres. Phosphorite nodules have been reported off the South-east coast.

Information on deposits of economically useful offshore minerals in Sri Lanka is very limited, however, exploitation of these minerals will need an environmental study to minimize the damage which may be caused to the marine environment.

Construction materials

Principal construction materials found in the offshore waters are sedimentary limestone, coral and sand. The sedimentary limestone which is primarily used in the cement industry is most extensive in the Jaffna penin-

sula and extend along the Northwest coastal belt of the island as far as Puttalam. Two cement factories producing nearly 800,000 tons of cement per annum, are operating in these areas using Miocene limestone as raw materials. Deposits estimated at around 40 million tons of limestone are known, but in terms of output, mining for limestone is a large industry and strict conservation measures should be taken regarding its exploitation. Coral is another source of lime and the best known coral beds lie along the South-western coastal stretch from Ambalangoda to Matara.

The demand for lime is ever increasing in view of the Government policy of expanding the construction industry. At present, it is estimated that about 18,000 tons of coral-based lime is produced annually by about 20,000 - 22,000 people engaged in the mining/burning industry.

Removal of coral from areas where natural disequilibrium exits, results in coastal erosion (Swan 1974). Adverse consequences of coral mining are greatest along the South-west and South-east coasts (Salm 1979). Factors attributed to the continued removal of coral in these areas include attractive financial returns, tradition and problems in law enforcement (Amarasinghe and de Alwis, 1980).

Probably the most important commodity from a standpoint of tonnage mined in Sri Lanka is sand. The demand for sand for building and construction has increased rapidly over recent decades.

Sand is obtained by mining at river outfalls such as Kelani, Kaluganga and Mavi Oya, as well as from beaches. Uncontrolled removal of sand from either of these sources could cause damage to the coast as exemplified by sand deficiencies and beach problems North of Colombo, as it affects beach replenishment in those areas where the sand would have been carried and deposited by natural processes. Extraction of sand from the beach maintenance system creates or intensifies coastal erosion risks and should be effectively prevented.

Other coastal resources

Sea salt

In Sri Lanka salt is extracted from seawater by solar evaporation. Salt producing pans exist at Elephant Pass, Murunchative, Kallundai, Irupalai, Pulari, Mannar in the Northern and Western regions and at Hambantota Mahalewage, Palatapana and Bundala in the Southern region.

The state owned National Salt Corporation produces around 130,000 tons of salt per annum, which is quite sufficient to supply the annual requirement of salt in Sri Lanka. The Corporation also produce small quantities of refined epsom, iodised salt and gypsom. Plans are also underway for the construction of a plant to convert gypsom to Plaster of Paris and chalk, and for the manufacture of PVC.

Sand dunes

Dune sands are found along 22 percent of the coastline of Sri Lanka (Swan 1979). Well-developed dunes are mostly found along the North-east, West and South-east coasts. Less conspicuous, highly weathered dunes are found in the North and North-west.

Most coastal dunes vary in size and age and include isolated, undulating sand platforms, transverse, transgressive and hill top types and are aligned in the direction of locally dominant winds. (Swan, 1979). Dune-forming sands are mainly quartzose (Cooray, 1963). They include traces of heavy minerals, including rutile, zircon, hornblende, garnet, hypersthene, sillimanite and monazite. The dune around Hambantota is highly granetiferrous with applicable amount of spinel and corrundum and could be used as an abrasive material.

Strict conservation measures should be taken to prevent overgrazing by livestock and uncontrolled clearing of coastal vegetation that could cause migration of sands and dune erosion by wave overwash.

Seaweeds

174 species of seaweeds belonging to 35 families and 78 genera have so far been recorded from Sri Lanka. Of these species 47 are green algae (Chlorophyceae), 42 brown algae (Phaeophyceae) and the other 85 red algae (Rhodophyceae). Sargassum is the most common seaweed in Sri Lanka, extensive beds of which are found in Jaffna, Palk Bay, the Gulf of Mannar, Pearl Banks off Silavathurei and the South-west coast of Sri Lanka, extending from Ambalangoda to Galle. Most of the red algae occur in the South and West coasts of Sri Lanka where the coast is rocky and fringed with coral reefs.

Green algae are most abundant in the Northern coast, which is also rich in brown algae especially Sargassum. The red alga Gracilaria verrucosa is most abundant on the East coast, particularly in the Trincomalee area. Twenty species of Sargassum have been reported in Sri Lanka. Of these S.cervicone, S.tenerrimum and S. ciinereum are the most common and occur abundantly.

The most abundant red seaweed occuring in Sri Lanka waters is Gracilaria. The most common species include G. edulis (G.lichenoides), G. verrucosa, G.crassa and G.corticata.

Ulva is the most abundant and fairly widely distributed green alga in Sri Lanka. Several species have been recorded of these, U. fasciata, U.lactuca, and U.reticulata have been reported to be present in large quantities. Enterocarpha, Chaetocorpha, Canlerpa and Palimeda also occur commonly along Sri Lanka coasts. Commercial extraction of agar (from red algae) and alginic acid (from brown algae) has been carried out by various institutions in Sri Lanka. Antibiotic substances occuring in seaweeds also have been investigated.

At present, G. verrucosa is collected in large quantities from Trincomalee area, cleaned, dried and exported to countries including Japan. It is estimated that about 250 tons of G. verrucosa could be collected annually from Trincomalee area and 120 tons of S. cervicone from the coast extending from Beruwala to Ambalangoda.

As the presently available natural seaweed resources are limited the culture of seaweeds has to be practised to sustain a viable commercial operation. Research has been undertaken to investigate the culture methods and growth rates of seaweeds.

Fisheries

The fishing industry in Sri Lanka can be divided into marine and inland fisheries. Over 85 percent of the total production or about 183,000 metric tons comes from marine fisheries. Out of this 98 percent of the fish is produced by the coastal small scale fishery and therefore proper management for sustained development and conservation is essential. There are indications that the coastal small scale fishery is approaching the maximum sustainable yield levels, but there is still scope for expansion in offshore and inland fisheries. Major constraints in the development of these resources is the lack of information base and trained manpower.

With the declaration of the Exclusive Economic Zone (EEZ) in 1976, the total marine area available for exploitation of resources is about 8 times the land area, viz., about 525,000 km^2. The inland fishery resource base comprises of about 123,000 ha. of brackish water lagoons, estuaries and mangrove swamps, and about 137,600 ha. of fresh water tanks and reservoirs.

Coastal fishery resources

Information on commercially exploitable fishery resources, especially in the marine sector in Sri Lanka, is limited. For purposes of management, the marine areas are broadly categorised into coastal (up to 30 nautical miles from the coastline) offshore (30-60 nm) and deep sea (beyond 60 nautical miles). Several surveys have been conducted over the years to assess the stocks in these sectors, especially in the coastal areas. According to the most recent survey conducted by Dr. Fridtjof Naman during 1978 - 1980, the estimated total biomass on the coastal shelf and adjacent areas was 750,000 metric tons. The annual sustainable yield from these resources is estimated to be about 250,000 metric tons of which 80,000 metric tons represent large demersal and semi-demersal fish. The present production is in the region of about 183,000 metric tons of which about 41,000 metric tons are demersal fish and the balance 142,000 metric tons are pelagic fish.

Offshore and deep sea fishery resources

The magnitude of this resource is not fully known. The resources in this area consist of yellow fin and big eye tuna, species of skipjack, marlin, swordfish and shark. There are various estimates on this resource. An annual sustainable yield of about 30,000 mt. was estimated before the recent estimate of 60,000 mt. The present production is around 1,000 mt. which is far below the available resource.

Inland fisheries

The freshwater fish production in 1982 amounted to about 33,500 mt. mainly from large inland tanks. Over 80 percent of this was Tilapia mossambica. Some reservoirs have reached the optimum levels of exploitation. With proper management practices 20,000-25,000 metric tons could be obtained from seasonal tanks and about 4,000 metric tons from Mahaweli waters.

Culture fisheries

In Sri Lanka, almost the total production of fish comes from capture fisheries. At present the contribution from culture fisheries is negligible. Nevertheless, the effort in popularising fish production by culture, mainly in freshwater bodies, has been increased during the past few years.

Culture practices in fisheries could be divided into (a) freshwater fish culture, and (b) mariculture. The latter could be further sub divided into coastal aquaculture and open sea mariculture. An intensive programme in the developent of aquaculture, especially in pond culture, has been commenced. A producer subsidy is available for construction of ponds and fingerlings of culturable species, like Tilapia mossambica, T.nilotica, carps etc., are provided free to popularise freshwater fish culture. Culture of Chanos in brackish water is also being undertaken. Prawn culture on a large scale has been started by some private sector firms and experimental cage and pen culture for fin-fish has commenced recently. This indicates that a firm foundation has been laid to propagate freshwater fish culture and coastal aquaculture. Hydrobiological surveys to be conducted in inland water bodies (both fresh and brackish water) will ascertain the availability of resources, suitable for culture of fin-fish and shell-fish.

Other marine living resources

Turtles

Six species of marine turtles are known to occur around the waters of Sri Lanka. The majority of these species have been known to nest during the November to February period (Siri Wickremasnghe, 1981). A naturally high rate of attrition, combined with the human exploitation of adults and their eggs have taken a heavy toll on the turtle population. Estimates range from 200 to 500 adults being slaughtered and some 20,000 eggs being collected annually. The Wildlife & Nature Protection Society's turtle hatchery programme initiated in 1970, has enjoyed considerable progress since 1982. The present legislation offers complete protection for all species of turtle.

Marine mammals

The marine mammals are represented by several members of the order Cetacea and a single member of the order Sirenia, the Dugong dugon. Both India and Sri Lanka have declared the dugong to be a protected animal, since it is facing the threat of extinction having been heavily hunted for it's flesh. Records put the estimated numbers slaughtered during 1957 to 1970 as between 100 - 150 per annum (Jones 1983). Some 15,000 dolphins are killed annually as by-catch in gill net fisheries (Alling 1983). The identification of concentrations of whales off Sri Lanka waters has led to a renewed interest in their conservation as well as their nonconsumptive uses. The World Wildlife Fund - Netherlands Indian Ocean Sperm Whale Study (1982-1984) which was conducted mainly in the waters around Sri Lanka was the first major benign research to be carried out in the Indian Ocean since the establishement of the Indian Ocean Whale Sanctuary in 1979. This study has revealed that Sri Lanka's waters provide a feeding and breeding area for whales. NARA (National Aquatic Resources Agency) has established a Centre for Research of Indian Ocean Marine Mammals (CRIOMM) at Trincomalee, on the East coast of Sri Lanka, which offers excellent prospects for benign research on marine mammals of the Indian Ocean. NARA has also been instrumental in the development of a whale watching industry, demonstrating the economic value of live whales to the country.

Oyster fisheries

The pearl banks off the Gulf of Mannar, between the three and twelve fathom lines have been commercially exploited for centuries. The last two major fisheries were held in 1925 and 1958. The latter, using dredges instead

of the traditional skin divers, yielded 4.5 million oysters. Subsequent fisheries in 1960, 1961 and most recently in 1983 yielded progressively less oysters (20 to 30 thousand in 1983). The window pane oyster fishery at Thanbalagam Lake, off Trincomalee, which yielded 4 million oysters in 1954 has been apparently decimated by major floods in 1958. Other under utilized bivalve resources include clams and cockles.

Beche-de-Mer and chank fisheries

Holothurians are abundant in the coastal water off the North and North-west areas of Palk Bay, the Gulf of Mannar and Kalpitiya. Holothuria scabra, the dominant species is picked up by skin divers, from depths of 6 to 20 metres and processed as a cottage industry, for export. The estimated production has been 50 to 95 mt. per year in recent years, and the entire production is exported to Singapore and Hong Kong.

The fishery for chanks is also carried out by skin divers in shallow coastal waters off the Gulf of Mannar and Palk Bay. The production of around 100 tons in recent years has been entirely for export.

Estuarine regions

The extent of various lagoons and estuaries of Sri Lanka, range from 40-48,300 ha. and their total area is about 121,300 ha. Of these, 80,000 ha. consist of estuaries and large deep lagoons and the rest represent shallow lagoons, tidal flats and mangrove swamps. The extent of low lying delta lands along the coastal belt is estimated to be about 70,800 ha. and brackish water areas act as fish and prawn nurseries, and are also important as fishing grounds. According to the census of marine fisheries, 9626 fishing management units or 40 percent of the total management units had been engaged in fishing in brackish water bodies in 1978. The formation of sandbars at the river mouths is a common feature to most lagoons and rivers along the South-western, Southern and South-eastern coasts so that the lagoons have connection with the sea only for a very short duration. These sandbars are normally of horseshoe shape, with an elevation of about 1.5 m. above the mean sea level. They restrict the tidal flow and larval migration, reduce the tidal range and disturb the normal water movement. Also they restrict the dilution of pollutants which may be present, by reducing the volume of incoming water.

Seagrass beds

Sea grass beds of Sri Lanka extend from the Jaffna lagoon area in the North to Kalpitiya in the North-western coast. Seagrass is also found in the Negombo lagoon area of the West coast. The main species of seagrass found in Sri Lanka are Zostera sp, Cymodocea sp and Halophila sp. 'Eel Grass' (Zostera sp) commonly found in the Puttalam area forms the main food source of dugongs. This species is also common in Mannar, Sillavathurra and Mulaitivu areas, especially in the shallow coastal areas of the sea. Sea grass is also used as fodder in the dried form.

Mangrove swamps and mud flats

Over 60 percent of nearly 6000 ha of mangrove forests found in Sri Lanka are located in the Puttalam lagoon area in the North-west coast, and Dutch Bay

and Portugal Bay areas of the East coast. Twenty eight mangrove and mangrove associated species have been recorded in Sri Lanka. Since most of the existing mangroves are in dry and arid zones, average tree height records exceed five meters.

In Sri Lanka there exists no management plan for mangrove vegetation. The setting up of the National Mangrove Commission and the research studies being conducted by the Forest Department, NARA and the universitites are important developments in this field.

The exploitation of mangrove forests by coastal dwellers for fuel wood and the destruction for land reclamation by hoteliers have caused untold damage to these forests. However, it has been proposed that important mangrove areas should be proclaimed forest reserves and be protected as "Man and Biosphere" reserves, purely for study purposes.

The cultivation of mangroves is not practised in Sri Lanka except in the Negombo lagoon area in the West coast where species like Rhizophora mucronata, Ceriops tagal and Lumnitzera racemosa are grown for economic reasons such as land reclamation, extraction of tannins etc.

Mangroves are important as feeding and breeding grounds for a number of fish and shellfish varieties, especially during the early stages of their life. Hence, much concern is expressed for the protection and rehabilitation. NARA has already completed the preparation of a distribution map and carried out a survey of mangrove communities. Plans are underway to expand these activities. NARA has also undertaken a mangrove productivity study in Puttalam Lagoon and Dutch Bay areas. The Department of Wildlife is also interested in protecting mangrove areas as they act as visiting grounds for water birds including migratory species.

Coral reefs

Sandstone reefs with scattered coral colonies fringe a major part of the coastline of Sri Lanka, the better known ones being those that fringe the North-eastern coast near Trincomalee and South-western coast near Dondra Head and Hikkaduwa. Seventy species of hermatypic corals belonging to 27 genera and 20 ahermatypic corals belonging to 12 genera have been recorded for Sri Lanka (Pillai, 1972).

No information is available on the quality of the reefs in terms of biological richness and diversity, live and dead coral cover and economic value of the reefs. Although no quantitative estimates are available, the quality of most of the known coral reefs around the island have deteriorated rapidly during the past two decades. Use of explosives in fishing activities, mining of coral for lime, the capture of exotic reef fish for export and feeding activities of the "Crown of thorns" starfish, Acanthaster planci have been reported as major causes of destruction and deterioration of coral reefs (De Bruin, 1972; De Silva, 1981). The reefs of the Eastern coast, in particular have been largely damaged due to predation by the "Crown of thorns" starfish. Sedimentation has also contributed to coral reef damage particularly in Palk Bay and Gulf of Mannar areas. Effluent discharge from the Eastern Paper Mills Corporation is suspected to contribute to the declining health of corals in the vicinity of Valachchenai, off the East coast. Collection of shells and corals by tourists and recreational impacts (Scuba, snorkelling, boat and anchor damage) are also identified as major causes of damage to coral reefs in Sri Lanka (De Silva, 1983)

Island ecosystems

Sri Lanka is a continental island which was once a part of the Indian Sub-continent, and was separated from it mainly by sea level changes and land upheavals in geological times. Due to its origins in the Indian Sub-continent, most of the island's flora and fauna show characteristics typical of continental ecosystems. Of the total land area of 65,627 km^2, 30 percent could be classified as coastal land. The coastal belt rises from sea level up to 30 metres and is perhaps 40 kilometres across at its widest point.

Narrow strips of mangrove forests grow in most of the coastal regions covering a total area of 4500 ha. Mangroves have been removed in the past for coconut cultivation, agriculture and for human settlements. Problems of management and conservation include conflicts in jurisdiction and lack of awareness of its importance to national economy.

The coral reef ecosystem around certain parts of the country is seriously threatened due to increasing extraction of corals, for the manufacture of lime. In areas of intense coral mining, large brackish water pools from abandoned inland coral mines have made surrounding areas agriculturally sterile. Coastal coral mining has also aggravated the extent of coastal erosion, especially in the vicinity of areas where extensive coral mining has taken place.

The abundance of marine life in coastal lagoons, coral reefs and coastal waters around Sri Lanka is a potentially important factor in the overall economy of the island. Nearly 90 percent of all fish and shellfish (160-175,000 metric tons per year) landed in Sri Lanka in recent years have come from coastal waters and estuaries.

Both the maritime as well as land based development activities in Sri Lanka have affected the coastal ecosystem in a number of ways. The major problems facing the coastal ecosystem have been identified as, (a) coastal erosion and sedimentation (intense in certain areas, mostly from natural causes, but aggravated by human activities) (b) general degradation of the marine environment and related ecosystems from effects of aquatic pollution, and (c) constant threat of oil pollution from the heavy oil tanker traffic near the Southern tip of Sri Lanka (80 percent of the oil supply to Eastern Asia pass through this area).

Shipwrecks and artificial reefs

Shipwrecks around the waters of Sri Lanka have been well documented dating back to over 100 years, although specific locations have not been mapped.

The Government claims ownership of sunken treasures from ancient ships, wrecked inside the territorial waters. The Merchant Shipping Act No. 52 of 1971 lays down the procedure to be followed for the salvage and removal of wrecks. The Merchant Shipping Division comes under the Ministry of Trade and Shipping and the Director of Merchant Shipping is authorised to execute the provisions of the Act.

According to this Act, the State is entitled to all unclaimed wrecks within any part of Sri Lanka. Removal of wrecks is allowed after consultation with a number of Ministries and Agencies such as the Ministry of Fisheries,

NARA, Ports Authority. However, permission is not granted for the removal of wrecks over 75 years old, unless such wrecks have become a seious hazard to the safety of navigation.

Artificial reefs are established to protect the coast against waves and erosion or to create new habitats for fish communities. There has been only a limited attempt at creating artificial reefs in Sri Lanka, and these have been for fishery purposes. Discarded tyres were used about a decade back to create an artificial reef off Wellawatte. However, this attempt was unsuccessful due to strong monsoon currents. In early 1984, burnt cars were used as an artificial reef off Bambalapitiya.

ENVIRONMENTAL ASSESSMENT OF MARINE POLLUTION AND DEVELOPMENT

General

The chief cause of environmental pollution is human settlement and activity on a scale beyond the natural recuperative capacity of the environment. It is thus one of the aspects of man's use and misuse of land and water resources in the course of development. This is seen in the use of modern methods of agriculture with high inputs of chemical fertilizer and pesticides, in problems of sewage and waste disposal caused by the increasing shift of the population from the countryside to the towns, and in new industrial technologies whose wastes and residues are dumped onto the land, surface waters and sea or emitted into the air.

Persistant non-degradable pollutants finally end up in the sea. Air pollutants are washed out by percipitation (e.g. acid rain) on to the land and surface waters. Pollutants on land get leached into ground water and both this and surface run off carry the pollutants into water course, lakes and finally the sea. The same is true of effluents entering surface waters, while other flow directly into coastal waters and the sea.

Because of the lack of quantitative data on pollution, attention is drawn to some of the inputs taken from Customs Returns (Annex II) and the approvals of applications for new industries.

Historical background

Sri Lanka is in the main an agricultural country, and its recorded history commenced some twenty five centuries ago with the first immigrants from the India subcontinent settling along the river banks of the North central dry zone and there developing the ancient hydraulic civilization with the cultivation of paddy. With shifting of the capital from Anuradhapura, the population shift was to the wet midlands and lowlands with some settlement along the coast. The development of the forested areas in the midlands and highlands took place in the plantation area in British times, while industry was confined to the primary products from the traditional crops of coffee, tea, rubber and coconut. Industrial development commenced with import substitution during the latter part of World War II, and with Independence in 1948 an attempt was made to create an independent economy with emphasis on industry (eg. the IBRD Report of 1952). Industrialisation was encouraged by various measures under the Industrial Corporations Act. Within 25 years of independence there were over 4000 industries with about 80 percent of them concentrated in and about Colombo.

The number of Industries up to 1977 is given in Annex III and IV. This development and the corresponding expansion in trade and commerce also attracted to the city and its suburbs, the excess rural population crowded out by subsistence farming, by population growth and by plantations. One of the consequences was the vast increase in shanty dwellings in various parts of the city, notably along the canal banks where they are the chief source of direct faecal pollution, refuse and garbage.

Subsequent to 1977 the open policy on imports has meant the closing down of many industries based on import substitution, while new industries and the Investment Promotion Zone (IPZ) have been established. Government policies on rural housing, industrial development and village re-awakening and the accelerated development of the Mahaweli area have also affected the population shift from the village to the town.

Pollution from domestic waste and sewage

The largest amount of organic pollution (as well as the chief cause of eutrophication in water bodies) is due to human settlement. Garbage and solid wastes are deposited on the land and are leached into soil and groundwater, surface waters and the sea. Apart from some small establishments and the Katunayake Investment Promotion Zone, there is no sewage treatment. In Colombo untreated sewage enters the Kelani River at Madampitiya and the sea at Wellawatte. Both these are now being modified to provide for ocean outfalls.

The inshore breakdown of the organic compounds of sewage is brought about by bacterial action. This can be inhibited by compounds such as halogenated phenols, cyanides, sulphides, metals such as copper, nickel, cadmium, zinc, mercury and chromium, and pesticides.

One effect of sewage in the coastal environment and estuaries is the contamination of commercial shellfish by human pathogens. In the proposed ocean sewage outfalls there is no provision for the removal of suspended solids and floatables. The former will affect the benthic fauna in the vicinity, with reduction of the population as well as of species diversity. A similar effect due to sewage sludge dumping in a 4 square mile area at Barroch Head in the Clyde estuary in the U.K. was found to cause a loss of prawn catch to the value of 84,000 Sterling Pounds per annum. (MacIntyre A.D., & Johnston R. 1974). There is a lack of control of floatables such that after a time these greasy materials will accumulate and be washed ashore by wind and tide at a faster rate than the soluble effluent. This time interval will be shorter than the "die away" time calculated for the bacteria in the effluent, so that further pollution of the beach by pathogens as well as unsightly floatables will take place.

Sewage pollution by beach tourist hotels and by urban settlements will similarly affect marine fauna through oxygen depletion. These effects would be greater on larval and juvenile stages, and impacts on these and on corals etc. need to be studied.

Pollution from industrial wastes

Water pollution

The chief purveyors of water pollution are public bodies (sewage and domestic waste from the Colombo and other Municipal and Town Council areas)

and State owned industries. Chief among these are the two paper and pulp factories. The soda process of the Embilipitiya Paper Mills, has failed to recover the alkali, and the attempted chemical recovery system has accordingly been abandoned. Hence there are numerous fish kills in the Walawe Ganga as well as much fibre and organic pollution. At Valaichchenai (Neutral sulphite semi- chemical process) the lagoon is dark brown while the bottom sediment is black with lignite residues. Puthuvella Aru is completely anoxic with fibres, H_2S, etc. The fish population has decreased while even the corals and reefs out at sea, are probably affected. Similarly the large textile industries have contributed to the pollution of rivers, canals and lagoons and finally the sea.

The Colombo canal system

A greater part of the large city catchment covering 487 km^2 drains into the Kelani River. The sea outfalls at Wellawatte and Galle Face (from the Beira Lake) and the different canal openings into the Kelani River constitute the main outlets of the city storm water and canal system. The major sources of pollution of these canals are slums and industrial discharges as well as outflows from the city's sewers.

The BOD is very high varying from 20 to 350 mg/l while oil and heavy metals are present. These are from repair garages, workshops and numerous industries including electroplating and textile printing. These pollute the water, sediment and ground water. Among the units contributing to wastes (in addition to shanties) are:

Mutuwal main drain	-	Timber Depot, Star Toffee
St. Sebastian North	-	Sedawatte Mills (oil) Kelanitissa Power House, Jafferjees
St. Sebastian South	-	Levers, Jafferjees, BBC (Oil, Soap) CIC Sewer overflow
Urugodawatte	-	Lankem (pesticides), Cyntex (textiles), Refuse dumps
Dematagoda North	-	Stanley Power Station, Kolonnawa factory, Petroleum Corporation Installation
Dematagoda South	-	Oil Mills, Municipal dump
Mahawatte Ela	-	Ayuvvedic hospital
Heen Ela	-	Milk Board, Marketing Dept., Cannery, Municipal dump
Kirillapone	-	Dairy farm, Municipal dump, Concrete works
Wellawatte	-	Wellawatte Mills (textiles), Municipal Sewage outlets, Overflows

Locks are maintained between the canals and the harbour and Beira Lake on one side and the Kelani River on the other. Sand bars at Wellawatte and Dehiwela at the ocean outfalls make the system land locked for at least part of the year so that there is much stagnation, while many areas are choked with growths of water fern (Salvinia) and water hyacinth (Eichhornia). Dissolved oxygen levels are very low and some areas are completely anaerobic with generally acidic conditions.

The original canal system commenced by the Dutch and continued by the British made it possible for a boat to travel by inland waterways from Kalpitiya to Kalutara. Its re-development is now being studied.

The Beira Lake

While the Colombo Canal System has now deteriorated to an open sewer, the other outlet for part of the Colombo storm water is the Beira Lake with its spill at Galle Face. This Lake shows a high degree of eutrophication with the formation of water blooms from time to time. A detailed study of the hydrobiology of this lake and its productivity found generally high dissolved oxygen levels and a high pH and low levels of carbon dioxide and ammonia. Mass mortality of fish occurs after heavy showers correlated with high organics and the complete absence of dissolved oxygen (Costa, H.H. 1969 and 1978).

Lunawa Lagoon and the Northern Bolgoda Lake system

To the South of the city, drainage takes place through the Bolgoda Canal and Weras Ganga through the Panadura river to the sea and through Lunawa Lagoon. As in all areas around the metropolitan city there is marked confusion in relation to establishment and expansion of industries and discharge of industrial wastes. Here, as elsewhere around the city, factories are often found side by side with residential areas. This renders acute any problems due to air and noise pollution by the factories, which is further aggravated when opera- tions continue through the night. Among the pollution causing units are an asbestos products factory, a shoe factory, a galvanising plant, a confectionery plant, pharmaceuticals, pesticides packing plant, a paint industry, Ceylon Transport Board depots and workshops, saw mills and a number of textile factories. Only one factory making a synthetic paint vehicle, treats its effluent. All others make no effort at all to treat their effluents. Waste water enter storm drains and ditches and finally end up in the lagoons. Meanwhile they cause pollution of groundwater and wells drawing on them and acres of cultivated land have become marshy, polluted with oil, dyes and oxygen consuming organic compounds.

The lagoons receive the wastes which cause poisoning of aquatic organisms as well as particulate matter which discolours the water, causing turbidity, and choking the vegetation along the bottom. Among the complaints about these lagoons is lowering of the fish catch, the disappearance of particular species from certain areas, and oily taint in some fish catches which prevents them from being sold in the market. The ditches and streams feeding them are discoloured and completely anoxic with production of hydrogen sulphide.

Similar problems can be seen East and North of Colombo, including the industrial estate at Ekala, and around Ja-Ela up to Negombo. It is only in the Katunayake IPZ that the factory effluent and sewage undergo treatment.

The Kelani River

The lower Kelani has a concentration of large water-using industries which in turn send untreated waste waters back into the river. Annex V lists most of these together with their effluent as well as some base line data of the water quality of the river 10 years ago (Annex VI).

Among the effects observed have been chromium uptake from the wastes of the state sector leather factory and private tannery effluents, by edible

greens ("Keera") cultivated on the banks near the river mouth; endemic enteric diseases since nearly 3/4 of the city's sewage is discharged here, untreated by the Colombo Municipality, and recently, periodic fish kills with symptoms of ammonia poisoning. The present water quality at Ambatale, where the intake for part of the city's water supply is situated, often goes below that for raw water for public water supply.

Pollution by cottage and small industries such as batik printing

Among major polluting industries are widely scattered small back yard units carrying out batik (wax) printing of garments and textiles which discharge effluents high in dyes, oil and organic compounds into ground and surface waters. They are found not only in the "garbage fringe" or "pollution perimeter" surrounding the city but all over the island close to places of tourist interest.

Coconut based industries : Brown fibre

Another is the coir industry. Brown fibre production is estimated as follows (Coconut Development Authority):

Exports : (1982)	Matress fibre	40,466 mt
	bristle "	9,500 mt
	twisted "	27,866 mt
	yarn and twine	2,391 mt
Local use:	yarn and fibre	11,000 mt (estimated)

In all 91,000 tonnes equivalent to 717 million coconut husks. This is carried out in about 1,000 mills chiefly in the coconut triangle. The pith or coir dust accumulates as large hillocks outside each mill, contributing to ground water pollution. In addition, in some cases where there are nearby streams, the soaking is done in surface water even though it is a condition of registration, that the mill should have its own soaking/retting tanks.

White fibre and lagoon pollution

Even more serious from the point of view of surface (and subsoil) water is the production of 5,000 to 7,000 mt of white fibre estimated equivalent to 40 to 55 million husks. The bulk of the retting (3-9 months duration) is carried out in all the lagoons (and also in pits at the sides of rivers) where there is slow movement of water, from Bentota to beyond Dondra (to Kirinde). Some inshore retting is also done at Dondra and the fibre from this is used for marine cordage and tug boat hawsers (often "eked out" by lagoon retted fibre washed in salt water). The retting process is highly anaerobic, with the production of toxic hydrogen sulphide and organic compounds with high oxygen demand which lower the dissolved oxygen in the lagoon water. This affects and limits the types of fauna which can live and breed in these areas.

Desiccated coconut

Another waste is that from desiccated coconut mills producing about 40,000 metric tons of desiccated coconut annually. There are about 65 mills, all in the coconut triangle, processing up to 100,000 nuts each per day. The coconut water and washwater is high in oxygen demanding organics and oil which pollute nearby surface or subsoil water and fields.

Arrack distilleries

The arrack distilleries are found at Seeduwa, Wadduwa, Paiyagala, Maggona, Beruwela and Alutgama. The spent wash from toddy distillation has a high concentration of organics and sulphur compounds which go to pollute streams and the ocean. Copper and tin are also dissolved out from the stills.

Rubber

In the primary production of rubber from latex the rubber serum together with the formic or acetic acid used for coagulation is discharged into streams. The annual production of 140,000 mt of rubber means the discharge of the equivalent of 330,000 tonnes of serum and acid. These are toxic to aquatic life and create an oxygen demand in the water. In latex processing industries putrefaction readily occurs and effluent also contains ammonia.

Some approximate figures of wastes and oxygen demand

Industry	BOD (mg/1)	COD (mg/1)
Rubber and latex (incl. block rubber and latex concentrate)	750-5,300	900-8,000
Tannery	1,500	
Distillery (toddy/molasses) starch processing	2,000	
Textiles; batiks	1,000	6,300
Meat & fish packing	1,000	
Milk processing Brewing; Paper and Pulp		
Coconut husk retting	1,000	2,200
Paper and pulp	1,000	
Sewage	100-300	

Atmospheric pollution

The sources of atmospheric pollution are mainly industry, transport and domestic. Part of the energy requirement is met by the combustion of fuels. The total requirements for Sri Lanka are given as :

	Metric Tonnes	1977	1990 (predicted)
Firewood (from overmature rubber trees)	1.0		
Agricultural residues	0.5	6000	6300
Forest wood (largely illicit felling)	2.4		
Oil products (1000 mt)		2800	3150
Electricity		1200	4093

	1976	1990 (predicted)	1982	Sulphur Content	Lead Tetraethyl
Domestic Kerosene	206.1	252	174.1	0.2-0.3%w/v	
Gasoline	101.4	450	114.2	0.5 ppm	0.035%w/v
Auto diesel	206.7		464.6	0.7%	
Furnace	126.0	348	299.8	1.2%	
Fuel naptha			22.7	0.15%	
Fuel gas			39.9	1.3% H_2Sw/v	

This indicates the total lead particulates and sulphur dioxide produced from oil sources in addition to sulphur dioxide leaks in industrial uses (eg. S for Sulphiting processes).

Pollutants due to incomplete combustion are unburnt hydrocarbons (including carcinogenic compounds) nitrogen oxides, carbon dioxide and particulates.

The global inputs in millions of tonnes/year are:

	Natural	Man's Activities
Carbon monoxide	200	250
Hydrocarbons	80:methane	30: C_1 -C_{12} compounds
Nitrogen oxides	50	48
Particulates	20	?
Sulphur dioxide	129	66

Source: R. Johnstone (1976)

Hydrocarbons and nitrogen oxides form photochemical oxidants, so that nitrogen compounds and sulphur dioxide form nitric and sulphuric acids which are the cause of acid rain. The particulates can also absorb SO_2 and form corrosive acid smuts. These contaminate rivers, lakes and lagoons either directly or through ground water and affect aquatic life by causing acid reaction in the water. These do not affect the open sea because dissolved CO_2 as bicarbonate has adequate buffering capacity. There is serious toxic air pollution by chlorine from the chlor-alkali industry run by the State Chemicals Corporation at Paranthan. The acid rain aspect as discussed above will not affect the open sea, though there may be local effects during the Shallow Water Monsoon.

There has been much dust pollution from Cement Factories at Kankasanturai and Puttalam. Emissions of saw mill dust (equivalent to about 10% of the production) amounting to about 120 tons daily are produced by the Puttalam Cement Works. Among its effects are earthing of wires of the Sri Lanka Broadcasting Corporation in the Kalpitiya peninsula. The dust plume is clearly visible in satellite pictures. Its effects on Kalpitiya Bay and the sea need to be studied. Many factories and other installations produce smoke, particulates and acid smuts, with absorbed SO_2, carbon monoxide and unburned hydrocarbons all due to incomplete combustion in the furnaces.

Other pollutants are metals and their derivatives - aluminium, silver, cadmium, copper, mercury, lead, tin and zinc, as well as compounds of arsenic, fluorine, sulphur, antimony and iron and manganese. The effects of atmospheric pollutants are felt more on the land surface where the materials are washed out by rain and falling as droplets or particles which have much more local and concentrated effects than in the sea.

Some general data on inputs of chemical elements and their occurence in sediments and bottom-dwelling organisms and biological concentration are given in Annexes VII and VIII.

Land pollution - solid and liquid wastes

This includes dumping of solid and liquid wastes on land. Among these are the dumping of domestic refuse and garbage by the Colombo Municipal Council and other bodies, workshop and industrial wastes especially along the canal banks and even the beaches and estuaries (e.g. mouth of the Kelani River). Degradation products are leached out by rain water and seep into ground water which will finally find its way into surface water and the sea. Fuel oils and lubricants from garages and factories seep into groundwater and thus contaminate wells. Perhaps, the worst example of ground water pollution is the result of fertilizer storage in the open yard.

A serious problem is the disposal of wastes from factories in surface dumps and pits - including old torch cells and manufacturing waste (manganese dioxide, zinc etc.) electroplating and metal purification wastes (chromium, cianides, zinc, cadmium, nickel, lead etc.) which can pollute air, ground water and surface waters.

Pollution from Agrochemicals

Fertilizers

A large part of fertilizers and pesticides used in agriculture end up in ground and surface waters and if not degraded in time, end up in the sea. For example it is estimated that half of the DDT ever used on land is now in the seas.

An international Rice Research Institute study estimated that 83 percent of applied fertilizer entered surface and sub-soil waters. A Sri Lanka study of inadequate storage of fertilizer has shown one of the worst examples of groundwater pollution. At the Fertilizer Mixing/Storage Complex in Hunupitiya the wells up to a kilometer around it have polluted water which fails to pass the standard for drinking water, and the water in the immediate vicinity cannot even be used for bathing; while surface runoff kills garden plants and trees. Similar complexes are being set up in each of the other districts.

Fertilizer, particularly nitrogen compounds and phosphates, aid eutrophication of fresh water bodies and alga Microcystis aeruginosa is known to produce toxins which causes death in animals. It could possibly cause poisoning of lagoon and estuarine organisms though we have no data on these nor episodes of mass mortality of fish etc.

Pesticides

A large part of pesticides used are also leached out, only about 0.1 percent reaching target organisms. Annexes IX, X and XI give the usages of fertilizers and pesticides in Sri Lanka. These may be related to the river basins where cultivation takes place, taking into account crop requirements and the number of crops per year.

Of the persistent organochlorine pesticides the usage of DDT was over 2.5 million pounds in 1971. It was banned for agricultural use in 1972, and has not been used for health purposes since 1976, being replaced by Malathion with Fenetrothion as second string. BHC, Aldrin, Dieldrin and Chlordane are still used in agriculture. The organophosphates are degraded relatively quickly (1-2 weeks) by microbial systems, though the carbamates may persist somewhat longer. There are no data on these in Sri Lanka waters. The copper compounds and organometallic fungicides containing mercury, zinc etc. and arsenicals are toxic to aquatic organisms. Some of these are accumulated and concentrated through food chains as has been shown in the case of DDT.

Siltation/sedimentation/reclamation

Siltation/sedimentation in estuaries and coastal waters in Sri Lanka can be attributed mainly to the river runoff carrying sediment, agricultural and industrial wastes and products of upland soil erosion. Other sources are industrial and domestic sewage from industries and human settlements on the fringes of estuaries and in the coastal belt, and dumping of dredged spoil. Although excessive siltation and sedimentation has been reported in some of the major lagoons, there has been no quantitative studies conducted to date.

Another aspect of sedimentation is the formation of sand spits (ex. Kalpitiya Peninsula) and the formation of sand bars across mouths of lagoons and rivers. The latter problem is encountered in several lagoons and rivers around the country, and in certain cases the formation of sand bars has completely isolated the lagoon (Mundel Lake, Kalutara Lagoon and Koggala Lagoon). In the majority of the cases ,however, there is seasonal connection to the sea (ex Chilaw Lagoon, Batticaloa Lagoon, Kokilai Lagoon).

Shoaling and sand bar formation causes several problems; navigation of fishing boats into the river or lagoon is hindered, and due to lack of exchange (by tidal flushing) the salinity decreases and may eventually become fresh water, and the quality of the water, too, degrades. The fishery potential on such bodies of water have been reported to have declined due to poor water quality, the absence of recruitment from the marine waters and inability of adults to migrate to the estuaries for breeding (ex prawn sp.).

Large sums of money are spent annually by the Government to maintain these outlets open, so as to allow free exchange of water, by dredging open the sand bars; this however, is only a temporary solution. In a few cases, (ex. Panadura river mouth, Madu Ganga river mouth) permanent solutions have been attempted (i.e. construction of groynes and training walls), but these structures have not proved to be successful and have led to increased erosion in the coastal areas to the North of the river mouth.

Undesired sedimentation causing shoaling is also encountered inside man made harbours (ex. Beruwala and Tangalle). This can be attributed to inadequate predesign studies and ill-designed coastal structures such as breakwaters, the result being the need for regular dredging inside these harbours.

In Sri Lanka, as in many other countries coastal marsh and mangroves are generally considered wasteland with no agriculutral value. Therefore, the tendency is to increase their utility value by landfill for housing or industrial development. This is specially so in locations in the vicinity of coastal towns where the demand for land is considerable. Several such areas surrounding the environs of Colombo and Negombo have already been filled.

In addition to loss of habitat (which plays an important role in the total coastal ecosystem), such reclamation activity alters the entire ground water regime by an interfacing with seepage of water especially when such areas are built upon. These areas which earlier served to absorb excess freshwater run off into the coastal areas during floods, will no longer serve this function, the result being that the excess freshwater (including pollutants contained therein), will enter the coastal waters or the estuaries directly.

Haphazard dumping of garbage is often used in reclamation. This material usually contains a high percentage of organic material that will decompose with time. Water that seeps through such an area will dissolve large quantities of organic and inorganic matter that will reduce the quality of both groundwater and adjacent open water bodies.

Oil pollution

Although there have been no reported oil spills in Sri Lankan waters there have been unconfirmed sightings of particulate petroleum matter (tar balls), being washed ashore along the Southern coast. The presence of large numbers of oil tankers calling at the Port of Colombo or passing through the narrow traffic separation zone of Dondra, poses a constant threat to the marine environment in Sri Lanka.

The principle ways in which oil could reach the marine environment in Sri Lanka, according to their degree of importance, are spills of crude oil and refined products during loading, transport and unloading, deballasting of tankers or washing of ship tanks (operational discharges).

Oil pollution could cause the chemical alteration of habitat, destruction of coral leading to an increased erosion of the coast formerly protected by reefs, and the destruction of mangroves.

Preliminary investigations carried out during an oceanographic cruise around Sri Lanka waters in 1983, for the presence of petroleum hydrocarbon, have shown that the levels of pollutants are still within acceptable international standards (25-65 ug/l). However, more extensive monitoring is required before conclusions can be made.

The source of oil in effluents is from processes such as printing, from machine lubricants, spilled fuel oil etc. There are marked spillages around fuel oil tanks, and transport and motor repair garages, which are washed out with storm water or seep into ground water thereby polluting wells.

Oil slicks are extremely common in ditches, marshes, lagoons and the sea. A slick with a silvery surface is equivalent to 0.25 ppm oil in the top 30 cm layer. The accepted maximum of oil in water for fish culture is 0.1 ppm, but even low concentrations of 0.01-0.02 ppm of crude oil, petrol and diesel oil can impart taints to the flesh of fish and shellfish.

Oil can coat the gill filaments of fish causing suffocation even at low concentrations; coat and destroy algae, plankton and benthic organisms; interfere with re-aeration of the water and photosynthesis by phytoplankton and algae and destroy aquatic insects. Some crude oils contain highly toxic water soluble fractions. Among the most toxic are the aromatic compounds, but the most persistent are the alicyclic compounds. Phenolics from refinery wastes and oils impart pronounced tastes to water. Tainting of fish catches in Lunawa and Boloda Lagoons is frequent.

Simple traps need to be installed in all factory workshop yards and final effluent lines to prevent the oil polluting surface waters. In some cases additional oil filters may be required.

Thermal and nuclear pollution

Future trends include the installation of coal fired thermal plants and possibly even a nuclear plant. Unfortunately the present project proposal for a coal plant at Trincomalee is highly parochial and does not take into account overall plans for development of the area, while there is every prospect of gross thermal and chemical pollution from ash in shallow bays interfering with shell fish and other projects.

Another future possibility is ocean thermal energy conversion for which the deep water off Trincomalee is one of the earth's ideal sites.

Microbial pollution

Microbial pollution of the marine environment around Sri Lanka arises essentially as the result of contamination with human faeces. The sources of such pollution can be divided into two distinct categories.

1. Point Source Discharges: these arise mainly from the sewerage system serving the City of Colombo. The existing outflow from the North Colombo area flows into the Kelani Ganga from Madampitiya, while the Southern outflow is a sea outfall extending 82 metres offshore at Wellawatte. The Northern outfall carries approximately 70 percent of the sewage flow from the system amounting to 15 mg/d.

Other point source discharges are identifiable, particularly in association with the urban centres on the coast, where canals, open waterways and storm water drains carrying raw sewage and waste water discharge into the major rivers or directly into the sea.

2. A more wide spread source of pollution arises from open defaecation practised by the population, on the beaches throughout the coastal area. This is resorted to by a large number of the population particularly in the suburban and rural areas which have no access to any type of toilet facility.

Proposal for improvements to the sewerage system:

Under the South-west Coastal Area - Water Supply, Sewerage and Drainage Project - a Master Plan Proposal is to be implemented for improvements to the existing sewerage system in Colombo and the sewering of other urban and peri-urban areas along the South-west coast of the island.

The proposal includes:

- Development of the Greater Colombo Sewerage System to include the Peri-urban Local Authority areas as and when necessary.

- Construction of a sewerage system in stages for the remaining urban centres - Galle, Negombo, Kalutara and Ambalangoda.

The recommendation for the Greater Colombo Scheme presently under implementation in stages is as follows:

- Modify and improve the existing Colombo Sewerage System and construct a new Southern outfall.

- Install sewerage in the peri-urban areas of Kolonnawa, Kotte and Dehiwela-Mt. Lavinia.

- Construct a Northern outfall and sewer portions of peri-urban Colombo North.

- Construct a Moratuwa outfall and sewer Moratuwa and Panadura.

- Construct a second Colombo South outfall.

For the rest of the urban centres, sewerage systems would be planned on completion of the water supply schemes with Galle and Negombo as the two priority areas.

The Master Plan proposes the discharge of raw sewage through properly designed sea outfalls as follows:

- New Northern Colombo Outfall approx. 2052 metres in length and 1500 mm diameter.

- New Southern Colombo Outfall approx. 1180 metres in length and 1500 mm diameter.

- Negombo marine outfall 590 metres in length and 300 mm diameter

- New Galle marine outfall approx. 410 metres in length and 300 mm diameter.

The above outfalls are based on design criteria to achieve a faecal coli-form count of less than 2500 organisms per 100 ml. on the shore line. However, the significance of the existing levels of beach pollution is such that studies carried out for the purposes of these outfalls indicate that these new outfalls will not significantly reduce the existing levels of faceal pollution unless measures are taken to reduce the non-point source pollution along the beaches. This applies to all coastal marine waters, particularly along the West coast where population and population densities are much higher than on the Eastern coast.

Microbial pollution resulting from raw sewage and sewage effluent

The bacterial content of normal human faeces is 10 - 20 percent of the faecal mass and contains approx. 10^{11} bacteria per gramme. The bacteria occuring are mainly the anaerobic types such as Bacterioides, Clostridia and a smaller percentage of the gram negative Coliforms including E.coli type I. Smaller numbers of Proteus, Pesudomonas, Streptococci and Lactobacilli are also present. While the E.coli type I and the Streptococci are significant in terms of indicators of faecal pollution these organisms are generally not pathogenic to man. The main importance of faecal pollution of the marine environment is the discharge of endemic enteropathogenic organisms which reinfect the population either through the marine food chain or through direct contact. Contamination of groundwater plays a significant role in the maintenance of these diarrhoeal diseases in an endemic form, particularly in the coastal plain where a majority of the population is dependent on shallow wells for their domestic water supplies.

The common diarrhoeal diseases such as typhoid, salmonellosis, bacillary dysentery and viral hepatitis are endemic to the entire Island. In addition cholera and poliomyelitis occur as regular epidemics. All the pathogenic microorganisms responsible for the endemic diarrhoeal diseases are regularly isolated from the marine environment, particularly from the waters around the coastal urban settlements.

In addition to the health hazards posed by the high level of beach pollution this also affects the aesthetic quality of the beaches of Sri Lanka which are a major resource of the tourist industry.

The proposed marine outfalls on the West coast will also mar the aesthetic quality of the coastal waters as a result of floatables, oil and grease released through these outfalls when they are in operation.

Pollution from seabed exploration and exploitation

Although at present Sri Lanka has not engaged in exploration (except for deep water hydrocarbons and exploitation of the seabed), steps have been taken and every effort is being made to build up local capabilities. Deep water hydrocarbon exploration activities are currently being carried out by the Ceylon Petroleum Corporation in the Gulf of Mannar and the Palk Straits and involve high environmental risks which require the parallel development of relevant technologies.

There is no doubt that environmental consideration will play an important role in legal, political and economic deliberations concerning the exploration and exploitation of mineral resources of the seabed. This work will not only affect the sea floor and the deep bottom environment at the mining site, but it may also have effects on the epi and mesopelagic zones by the introduction of bottom material and tailings from processing into the surface and sub-surface water layers.

To calculate the consequences of seabed exploration and exploitation on the marine environment, baseline studies in the mining area should encompass (a) physical (b) chemical and (c) biological oceanography, as well as (d) sedimentology (Roles, 1974, Mustafa et. al., 1980). Seasonal changes in the oceanographic system are also to be considered. A good knowledge of the large scale oceanic circulation and cycling of inorganic and organic constituents is of special importance in determining disturbances.

Projects for seabed exploration and exploitation require a separate evaluation of their environmental impact, taking into consideration the local hydrographic and environmental conditions, the methods used for exploration and mining activities and the characteristics of the materials to be disposed of.

Environmental health aspects

Of the 24 administrative districts into which Sri Lanka is divided, 13 abut the coastline. The total population and population density per sq. km. of these Districts (enumerated anti-clockwise from the Northern-most Jaffna District is as follows:

District	Total Population	Pop. Density per km^2
Jaffna	831 112	300-500
Mannar	106 940	Less than 100
Puttalam	493 344	100-300
Gampaha	1 389 490	800-1000
Colombo	1 698 322	1000-3000
Kalutara	827 189	500-800
Galle	814 579	300-500
Matara	644 579	500-800
Hambantota	424 104	100-300
Amparai	388 786	Less than 100
Batticaloa	330-899	100-300
Trincomalee	256 790	Less than 100
Mullaitivu	77 512	Less than 100
Total	8 283 298	

The total population of the Coastal Districts is 8,283,298 which is 55 percent of the total population of the island.

Including the Jaffna district the first eight of these districts cover the West coast of the island and have a total population of 5,978,018 and the last five cover the East coast with a total population of 2,405,280. These are comprised of 40.23 percent and 16.20 percent of the total population of the island respectively (Annex XII).

Water supply

Annex XII shows that the percentage of the population served by pipe borne water is very small in all districts except Colombo. The majority are dependent on shallow wells for their domestic water supply. These shallow wells particularly along the coastal plain are dug in soil having a very high water table.

Under the South West Coastal Area Water Supply, Sewerage and Drainage Project, pipe bourne water supplies are being provided to most of the urban and peri-urban areas of the West and South coast. However, this programme will not significantly alter the high dependence on ground water for water supply in the rural areas.

Sewerage and toilet facilities

The City of Colombo is the only area supplied by a mains sewerage system in the 13 coastal districts. The Water Supply Sewerage and Drainage Project envisages the sewering of certain urban and periurban areas along the South-West Coast and work is presently in progress in the Greater Colombo area. However in all the coastal districts except Colombo, where toilet facilities are available, these are either of the septic tank or pit latrine types. Additionally significant numbers of the population have no access to any type of toilet facility. The types of toilet in use and the wide spread practice of open defaecation results in faecal pollution of the soil, groundwater and the marine coastal environment.

Environmental health

Lack of proper sanitary facilities and the utilisation of polluted groundwater for domestic purposes ensure the persistence of the diarrhoeal diseases in an endemic form throughout the coastal areas of the island.

This is borne out by the health statistics of the island which indicate that the diarrhoeal diseases are high on the list of priority diseases. Interventions proposed to reduce the morbidity and mortality from these diseases are:

- the adequate supply of safe water;
- construction of sanitary latrines; and
- health education.

Food contamination

Significant contamination of shellfish crabs, prawns and lobsters results from the high levels of population at the coastal gathering grounds. This industry is carried out mainly in the coastal lagoons and estuaries of the major rivers of the island. These are highly polluted waters as the development of all the major coastal towns have taken place around the river mouths and the lagoons. Waste water from these towns including raw sewage and effluent, flow directly into these lagoons, rivers and the sea. The future plans for the development of this industry includes aquaculture in the lagoons. Development of this industry will depend on the water quality of the gathering grounds if these harvests are to reach acceptable international standards.

Vector borne deseases

The two major vector borne diseases in the country are malaria and urban filariasis. These are both water-related mosquito borne diseases, the vectors and pathogens being:

Disease	Vector	Pathogen
Malaria	Anopheles culicifacsiens	Plasmodium vivax Plasmodium falciparum
Urban filariasis	Culex quinquefacsiatus	Wuchchereria bancroftii

Malaria is the number 1 priority disease in the country and occurs in all coastal districts except Colombo. Morbidity rates are high. Malignant tertian malaria caused by Plasmodium falciparum is spreading to more areas within the country resulting in an increase in the mortality figures.

Urban filariasis occurs in an endemic belt along the West coast from Puttalam to Hambantota. The overall microfilaria rate for the endemic belt is 0.7.

Other environmental aspects of coastal development, resource exploitation and natural phenomena

Coastal tourism development

Wide sandy beaches, warm waters with narrow temperature gradients, sheltered bays, lagoons, variety vegetation, and coastal fish and shellfish resources are major factors that led to Sri Lanka's tourist industry to be primarily coast-based. In 1976, 70 percent of all approved hotels and 77 percent of rooms were located in the coastal belt. Of the seven resort regions identified by the Ceylon Tourist Board, five, viz, Colombo, Greater Colombo, South Coast, East Coast and North Coast are in the coastal areas.

During the last decade an added dimension to Sri Lanka's tourist industry was the growth of an informal, low cost tourist sector. This sector is at present well established in a few coastal centres such as Negombo, Mt. Lavinia, Hikkaduwa, Kalkudah and Arugambay.

Most of the hotels which were constructed prior to 1980 did not take into consideration the imperatives of coastal stability, the need to maintain an adequate setback from the shoreline, aesthetic and visual environment. Some hotels have even been constructed on sand spits adjacent to migratory river mouths. Such development especially in the South coast has resulted in erosion and loss of beach necessitating the construction of protective structures which are not only cost intensive but also lead to visual degradation of the beaches.

During the development stages of coastal tourism, infrastructure development by the State did not keep pace with hotel development. It's consequences are today manifested in the deteriorating conditions of roads, inadequancy of water supply to the local communities, frequent power failures, and in towns, heavily overloaded sewerage systems. Even at the resort sites, the waste disposal system for waste water and solid wastes were inadequate. This situation was made much worse by the rapid development of the informal sector which grew as an immediate response to the increased demand for accommodation with very little planning or control of the local authorities. The growth of this sector has therefore contributed considerably to the adverse impacts of coastal tourism on the environment.

The development of coastal tourism has also led to several conflicts especially with respect to the traditional fishing industry. These problems are encountered mainly in areas of high density tourism development such as Negombo and Hikkaduwa and are mainly land use conflicts where the traditional fishermen now find that they do not have an adequate beach space for drawing of beach seines, drying their nets, beaching of boats etc. Coastal communities have also experienced several other socio-economic effects, e.g. change of economic level, dropping out of low income generating traditional activities such as fishing to take up high income generating tourism related employment, increasing value of fish and shellfish, changing land values etc.

The effects of the development of coastal tourism on the marine environment are: degradation of the coral reef resources (by collection of corals and associated fauna and flora, destruction caused while snorkelling, diving, anchoring of boats, etc.); degradation of mangrove areas and sand dunes; removal of coastal vegetation; degradation of coastal water quality by pollution and loss of access to the shorefront.

Coastal erosion from sand and coral mining and dredging.

Of Sri Lanka's 1600 km coastline, nearly a third is subject to varying degrees of coastal erosion. Average annual rates of erosion ranging from 1-7 m per year have been recorded for the South-west and West coasts. Erosion and its concommitant land loss especially in densely populated areas have necessitated relocation of roads, dwelling units, public utilities, displacement of traditional fishing activities such as beach seine operations and the implementation of protection schemes which are not only cost intensive but very often only temporary solutions that may even lead to increased erosion in adjacent areas.

Whilst the causes and intensity of coastal erosion varies from site to site, two activities aggravating coastal erosion are sand mining and coral mining.

Coral mining

Coral is a source of lime which is widely utilized for a diversity of purposes; traditionally it has been used in the construction industry for mortar plaster work and as whitewash. It is an important chemical in several industrial processes e.g. manufacture of sugar, ceramics, fertilizer and steel. It is also used as an ameliorant to reduce acidity in soils. Although large quantities of lime are obtained from processing of coral, the exact proportion of it in the total lime production in the country is not known.

Earlier, coral mining was restricted to inland deposits found in the South-western sector of the coastline especially at Akurala, Seenigama, and Peraliya. However, with the increase in demand for lime, people resorted to the mining of coral reefs which is less labour intensive. Small pieces of coral are detached during the breaking of coral and due to wave action eventually get washed ashore by wave action and accumulate on the beach. Collection of such accumulated coral debris constitutes a significant proportion of the coral used for lime production. Processing of coral for the lime industry is now well established in the South-western and some parts of the Southern coast

Coral reefs are extremely productive ecosystems, supporting highly diverse faunal and floral populations, and in addition provide a defense against the erosive potential of waves. Adverse consequences of coral mining are now greatest along the South-west coast especially between Akurala and Dodanduwa.

During a recent survey conducted in the area between Ambalangoda and Dickwella, it was revealed that 5377 tons of coral are collected from the beach and 2140 tons of coral are mined from the reefs annually. This amounts to 42 percent of the coral mined in the area. Mining of inland coral deposits accounts for the balance 58 percent (Premaratne 1984). The coral so obtained is processed in 208 kilns. 1355 persons are engaged in mining and collecting of coral, transport and operation of the kiln (Premaratne 1984).

Although in terms of the Coast Conservation Act, mining of coral within the coastal zone without a permit is a punishable offence, this activity has continued unabated largely due to the lack of enforcement.

Maritime and coastal construction

Maritime construction includes the construction of harbours, fishery harbours, sewage outfalls, salt water extrusion schemes, river training schemes, coast protection structures, jetties and pipelines. Since these structures inevitably interfere with the littoral sand transport, unless they are well designed and planned, they can lead to increased instability of the adjacent coastlines, (erosion, sedimentation and sand bar formation.) There have been several instances where construction of maritime structures has led to adverse consequences on adjacent coastal areas e.g. fishery harbours at Beruwela, Wellamankara (the latter has now been removed) and river training schemes at Panadura.

In addition to causing adverse impacts on adjacent areas, many of these structures have also failed to meet the objectives for which they were constructed.

Construction of buildings on unstable beach fronted land (houses, hotels etc.) and the shoreline of verticle walls intended to protect the land behind could lead to environmental problems by interfering with the onshore-offshore sand transporting system. Several examples of such ad hoc construction can be seen in the West and South-west coasts especially in the Negombo and Hikkaduwa areas.

The adverse consequences arising from the construction of maritime structures have been primarily caused by the absence of environmental impact assessment procedures in the past. If such assessment procedures were implemented it would have been possible to predict the effects on littoral transport of sand and enabled the inclusion of mitigation measures, where possible.

River discharges

Sri Lanka can be divided into 103 component natural river basins of which 83 are in the dry zone and 20 are in the wet zone. The streams in the dry zone have poor runoff as compared to the streams in the wet zone. The dry zone river basins have a total area of nearly 46,632 km^2 and an annual river discharge of approximately 20,600 acre.ft. The wet zone basins have a total area of nearly 12,176 km^2 and a runoff of approximately 20,900 acre.ft. The discharge from the four main rivers Mahaweli, Kelani, Kalu and Walawe totals to nearly 18,200 acre.ft/annum or 45 percent of the total. The major irigation schemes which involve the diversion of rivers like Mahaweli, Kelani and Gin could be expected to bring about an inflow of salt water upstream during dry periods. On the other hand, diversion of water from these major rivers to others via tributories will alter the zones of vegetation in the riverine habitats and in the coastal region, i.e. the diversion of Mahaweli waters to the Kala Oya. The sand and soil supplies from river discharges have contributed to the sedimentation of certain areas of the coast. Increased human activity upstream has often aggravated this problem.

Discharges from rivers are often contaminated with agricultural chemicals and industrial wastes to varying degrees. The sludge from the paper factories at Valaichchenai and Embilipitiya has caused some damage to the aquatic life forms in the Valaichcheni Lagoon and 'Walawe River' respectively. There is also a danger from increased use of fertilizers, pesticides and insecticides in predominantly agricultural areas. The high degree of chemical contamination of the Kelani River, with nearly 60 industrial establishments discharging effluent into it, has been well established.

Transport and other maritime activities

a) Shipping

Of the three ports, located in Colombo, Galle and Trincomalee, the Port of Colombo handles a greater part of the maritime traffic entering the Sri Lankan waters. Maritime transport is utilized for the import and export of cargo and import of petroleum products; the volume of passenger transport including yachts are of much lower magnitude. A smaller harbour in Kankesanthurai, in the Northern peninsula mainly supports the cement factory situated there, whilst certain quantities of food and other items are also transported to the northern peninsula through this harbour.

In addition to the vessels that enter the Sri Lankan harbours, a large volume of East-West (and vice-versa) bound traffic passes in close proximity to the Southern coast. A major component of this traffic includes VLCC's carrying petroleum products to the East from the Gulf. The volume of traffic passing the Southern coast is not known. However, fig. 1, showing the major tanker routes, indicates that this volume of traffic is considerable. It is also known that approximately 244.7 million tons of oil was transported along this route in 1983 (Source: BP Statistical Review of World Energy). In addition to oil carrying tankers, a large volume of cargo carrying traffic also utilises this route.

In view of the possible threats of oil pollution, due to this heavy volume of traffic (oil leakages due to accidents, other maritime casualties, and cleaning of oil tanks) a traffic separation scheme for the area off the Southern coast was proposed and developed by the Ministry of Trade and Shipping to be implemented by the recently established Marine Pollution Authority; however this scheme is not yet in operation. A study on the state of oil pollution in the Northern Indian Ocean, carried out by Gupta and Kureishy (1981) has revealed that in the areas around South India and Sri Lanka, high concentration of oil slicks are observable. Tar balls are frequently encountered along the beaches of the South-western sector, which includes some of the most popular recreational beaches.

b) Fishery harbours

There are 11 fishery harbours in Sri Lanka providing anchorage to fishing boats, the majority of which are 8.5 m boats with inboard engines and smaller F.R.P. boats with outboard engines. These mechanised fishery vessels are fitted with diesel, kerosene or petrol powered engines. A seaworthiness certificate is not a requirement for the operation of these boats and very often these boats are not properly maintained; faulty engines with oil leakages are common. Further, the major fishery harbours have terminals for the supply of fuel to the crafts. The spillage of oil during refuelling also results in the constant presence of oil slicks in and around the harbour areas.

c) Other activities

Other maritime activities which have been proposed and not implemented yet are a coal powered power plant in the Trincomalee Harbour, an oil tank farm in Trincomalee, a SPBM project in the vicinity of the Colombo Harbour, ship breaking (one project is already in operation in the Galle harbour) and private marinas. These could have serious implications with respect to the environmental quality and therefore needs cautious consideration prior to their implementation.

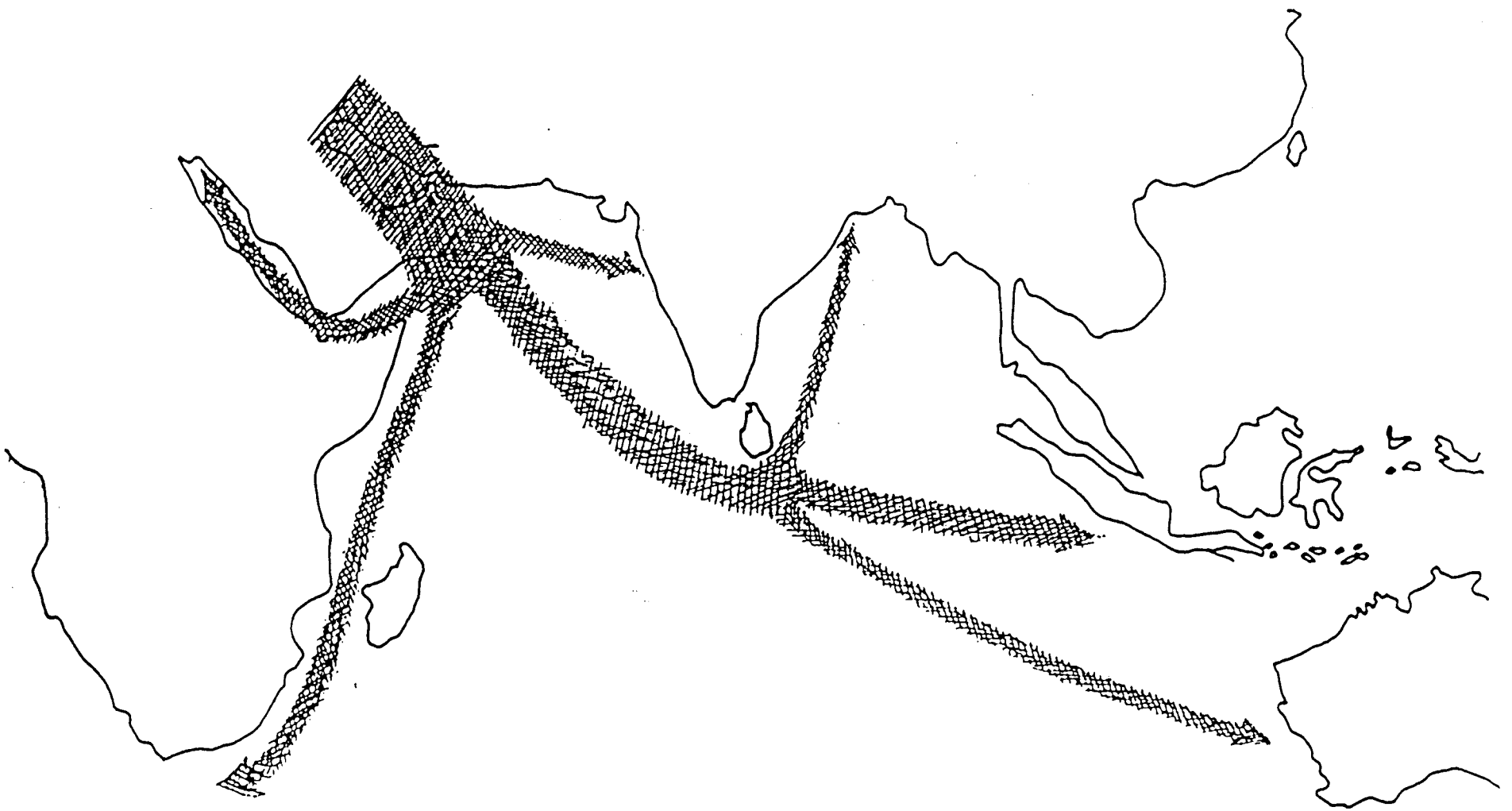

Figure II: Oil tankerroutes through the Indian Ocean
(Source: The Times Atlas of the World)

Marine dumping

There is no legislation relating to marine dumping in Sri Lanka. The country is not a party to the Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter (IMO, 1972)

Overfishing and harmful fishing activities

The annual sustainable yield (ASY) in Sri Lankan coastal waters is about 250,000 mt. of which about 170,000 mt. are pelagic fish and the balance 80,000 mt. are demersal and semi-demersal fish. The present level of exploitation is in the region of 142,000 mt. of pelagic fish and 41,000 mt. of demersal fish. Thus, it is seen that the level of exploitation of pelagic fish is fast reaching the ASY. If planned management measures are not exercised, over-exploitation will take place, thus affecting fishery resources. From recent studies on catch per unit effort computations it is evident that over-exploitation already exist in certain areas. In inland fisheries, some reservoirs have evidently reached optimum levels of exploitation and if attempts are made to increase fishing effort, the fishery will be affected.

In Sri Lanka, there are several harmful fishing activities practised in marine waters i.e. the use of small meshed nets to catch juveniles, laying of nets in mouths of lagoons, and killing of fish by explosives such as dynamite. There is a well established mechanism to prosecute the offenders under the Fisheries Ordinance. Yet in the case of dynamiting of fish, this activity still takes place in some parts of the country (e.g. Mannar and Trincomalee) in spite of the stiff penalties imposed. Under Section 14 of the Fisheries Ordinance, killing of fish by explosives or poisonous and stupefying substances is completely prohibited.

Recently, there had been a proliferation of purse-seine fishing. In some countries, there are instances where extensive purse-seining has affected fish stocks. Therefore, action is being taken to properly manage this fishery by framing regulations under the Fisheries Ordinance.

Due to increased levels of exploitation of crustaceans, some prawn and lobster resources have been gradually depleted, but unfortunately a reliable assessment of prawn and lobster resources is lacking.

Red tides and mass mortalities

A total of approximately 175 species of marine algae have been reported in the island's coastal waters, of which over 50 percent belongs to the group Rhodophyceae (Red Alga). However, there are no reports on the occurrence of Red Tides in Sri Lanka though seasonal peaks in red algal populations have been reported. The main species of dinoflagellates found in the coastal waters are Peridum sp. and Nautiluca sp. with Senatum sp. appearing in areas with a heavy flow of fresh water.

Mass mortality of fish is rarely encountered in the marine environment though it is of common occurrence in fresh water bodies, and estuarine habitats. Oxygen depletion due to eutrophication and chemical pollution has been shown to be the main causative factors in most cases of reported mass mortality of fish.

Souvenir collection

Several commercial shell collectors have operated in Sri Lanka and as a result several coral reef areas are claimed to have been depleted of its molluscan populations. One such area that has been subjected to heavy exploitation is Hikkaduwa. With the development of tourism at Hikkaduwa a ready market for souvenirs such as shells and black corals has been established. This can be considered as the primary cause of depletion of these organisms. Easily picked up molluscs such as Lambis sp., Cyprea sp. and Murex sp. have especially been heavily exploited. Although black coral such as Antipatharia sp. grow in deep water, with the development of scuba diving facilities in many of the beach resort areas in Sri Lanka its exploitation is carried out unchecked.

There is a ready demand for ornamental Scleractinian corals such as Pocillopora sp., Acropora sp. and small heads of Favia sp., Platygyra sp. and Favites sp. by tourists. Such exploitation of ornamental corals is also carried out in several areas in Sri Lanka. Gorgonian corals whenever available are also exploited as souvenirs.

Natural calamities and coastal hazards

Along the South-west Coast of Sri Lanka coastal erosion becomes a serious problem during the South-west monsoons. The strong wave action and rough seas accompanying the South West monsoons hamper the fishing activities and also often cause much damage to vegetation and property.

Human interference with natural processes in the South-west coastal belt has been shown to be a factor which contributed to coastal erosion. South-west monsoon surges occur several times during the seasons giving rise to gale-force winds. Cyclonic winds are experienced in the North-east and Eastern parts of the island towards the onset of the N.E. Monsoon and these are often responsible for much damage to vegetation, property and human life - eg. the cyclone in the East coast in 1978.

The submerged sedimentary sandstone reef and rocky reefs, especially near the South West coast has often caused much damage to standard shipping vessels. Submerged reefs are also found elsewhere in the coastal belt and the numerous ship wrecks found along the coast, numbering over one hundred, points to the hazardous nature of these to navigation.

Socio-economic aspects of marine pollution and changes in environmental quality

Concentrated along the 1,500 km long coastline of Sri Lanka are the human settlements, the urban centres, the commercial and fishing harbours and a substantial volume of the commercial and tourist activities in the Island, impinging on the fragile natural systems of the coastal zone. This marine environment is subject to complex and diverse use patterns comprising a range of human activities such as agriculture, industry, mining, fishing, housing, tourism, commerce and transportation.

The major change in environmental quality observed in the marine environment is the loss of coastal land due to erosion. Insufficient beach replenishment resulting from sand mining has intensified coastal erosion in Sri Lanka. No firm estimate of the quality of river and sea sand extracted is available, although sand removal occurs at many locations along the rivers and the coastline. River sand is used in the construction industry which has expanded con-

siderably during the last ten years. It is a major source of beach replenishment supplied by the network of radial rivers in the Island. The decreased supply of such materials to the beaches has aggravated the coastal erosion, particularly along the Western coast.

A major change in the quality of the marine environment has been brought about by coral mining activities. Along the South-western coast, erosion has been intensified by the breaking up of the coral reef. Although an estimate of the annual loss of land and trees is not available, it has been estimated that an extent of land 305 m wide had been eroded during a period of 60 years at Seenigama, on the South-western coast. The Coast Conservation Department (CCD) spends Rs. 20 million annually for the construction of coast protection structures.

Despite the legislative measures to ban coral mining, continued extraction of coral is taking place owing to the existence of socio-economic pressures. On the benefit side are the supply of over 40 percent of the island's total annual requirements of lime and the direct employment of about 2,000 people in coral mining. The nature of this employment reveals that people are engaged in the reef mining in the sea, inland mining of coral pits and the collection of corals on the shore. Kiln operations and the transport and marketing of lime provide further avenues of employment. About 8,000 people are dependant on the coral mining and ancillary activities on the South-western coast of Sri Lanka. The environmental costs of this activity far exceed any economic gains from employment, their enhanced incomes and the quantity of lime produced. The loss of coastal lands, trees and houses and the cost of engineering structures to protect the highways, the railway track and other buildings, together with the depletion of the coral resource - the very attraction for the tourist pose a long term cost which far outweigh the present gains enumerated above. The depletion of marine life, the disappearance of mangrove communities and the formation of swamps are secondary costs arising from the coral mining activity.

The rapid growth of beach-oriented tourist development in the 1970s has had a major adverse impact on the coastal zone, as due attention has not been paid to the fragile nature of this zone in planning the layout of hotels. It has been reported that by 1976, more than 70 per cent of all the hotels and 77 per cent of the available hotel rooms were located in the coastal areas. While the tourist industry provided about 30,000 persons direct and 35,000 indirect employment in 1982, the adverse changes brought about in the coastal environmental quality are significant. The absence of adequate setback areas from the beaches led to the instability of the beach fronts creating severe problems of coastal erosion. Such unplanned hotel growth also aggravated the problem of outflow of waste water and sewage into the beaches.

Dumping of industrial pollutants and domestic sewage have affected the quality of the estimated 3 - 4000 hectares of mangroves in the Island which is a vital buffer zone for shoreline and river bank protection against winds, currents, tidal action and erosion as well as a spawning ground for fish. These mangroves are also threatened by their over-exploitation for fuelwood in lime kilns, pollution from household effluent and land reclamation for construction work.

The above socio-economic consideration reveals that the human activities taking place in the area which interacts between the land and the sea create serious user conflicts which need to be assessed in terms of the continued productivity and viability of the natural systems of the coastal zone.

ENVIRONMENTAL MANAGEMENT AND PLANNING

National policies and strategies for environmental protection and management; policy guidance and overall co-ordination

The Government of Sri Lanka, since 1977, has taken several positive steps in the establishment of a much needed institutional legislative and policy framework for the protection and management of the environment. Concern for the environment has been duly recognized in the Constitution of Sri Lanka. One of the major problems that Sri Lanka faced was the absence of a comprehensive legal and insitutional framework on the environment. There were nearly 80 different laws on the Statute Books enacted over a period of 100 years. But all these laws were scattered and administered by different agencies at different levels. There was no overall co-ordination or policy direction. Sri Lanka is a small country with a high density of population and clearly visible delinquency rate as far as natural resources are concerned. Therefore, it was of paramount importance that the planning and execution of projects which have an impact on the environment should be carefully monitored by an environmentally concerned central agency. In this context, the Government of Sri Lanka gave priority to the establishment of the policy-making legal and institutional framework. The National Environmental Act which came into operation in 1980 provided for the establishment of the Central Environmental Authority as the lead agency for the co-ordination of all activities for the protection and mangement of the environment.

The Government of Sri Lanka, through the Central Environmental Authority (CEA) has identified and prepared implementation strategies on several priority areas for the protection and management of the environment. They include:

- preparation of a National Conservation Strategy (NCS),
- establishment of a National Environmental Reference Centre (NERC),
- direction of a public awareness programme on environment,
- building and strengthening of capabilities of District Environmental Agencies (DEAs),
- professional development for environmental protection and management,
- introduction of environmental impact assessment (EIA) procedures,
- development of a National Environmental Code,
- strengthening of environmental policy monitoring capacities.

While the CEA acts as the leading agency for policy-making and co-ordination on environment, there are several agencies responsible for various aspects of the marine environment.

The National Aquatic Resources Agency (NARA) came into being in September 1983 by an Act of Parliament as a direct consequence of the aftermath of the Convention on the Law of the Sea, which gave Sri Lanka sovereign rights over a vast off-shore area. It is the principal national institution charged with the responsibility

of carrying out and co-ordinating research, development and management activities on all aquatic environments under national jurisdiction.

The broad statutory mandate of this agency brings within the purview of a single governmental entity the entire spectrum of the aquatic environment. When combined with the multi-disciplinary character of the agency and its interagency Aquatic Research Management Council, the agency provides for an integrated and comprehensive approach to the management of the aquatic environment. The Environment Study Unit (ESU) facilitates the investigation, assessment and co-ordination of matters of environmental concern, insofar as they pertain to the aquatic medium.

The broad national policy and strategy for protection and management of the coastal environment is manifested in the Coast Conservation Act of which coastal zone management is an important aspect. The Coastal Zone Management Plan (CZMP) which will be prepared as a mandatory requirement of the law will spell out the strategy to be adopted for the protection and management of the coastal environment, and once it is ratified by the Cabinet of Ministers will provide a framework for planning of all development activities within the coastal zone. In addition, the plan will delineate coastal areas of special ecological, historic and aestetic significance that require special alternation. In order to obtain optimal guidance and overall co-ordination during the preparation of the CZMP, a Coast Conservation Advisory Council (CCAC) represented by senior officers of all relevant agencies has been established.

National policies and strategies pertaining to fisheries have been developed taking into consideration the importance of environmental aspects. In the early seventies, the six species of lobsters found in Sri Lankan coastal waters were endangered. The Shrimp and Spiny Lobster Regulations of 1973, were drawn up and implemented to overcome this problem. Some varieties of inland fish are protected under the Fisheries Ordinance. These are fully discussed under legislative developments. There are other regulations applicable to local areas, such as bays and protected areas, which have been framed to protect juvenile fish. Limitations on fishing gear have been imposed in areas where they are necessary.

Another important aspect which needs attention at present is the level of exploitation in the coastal fishery. The ASY of 180,000 mt. of pelagic fish is being reached with increase in fishing effort. According to a recent analysis of catch-effort data, with increased numbers of mechanized boats, there is a drop in catch per boat in many districts. Therefore, it is not too early to contemplate on some measures to manage this fishery with a view to prevent any drastic effects on the environment due to over-exploitation.

Legislative development

As mentioned earlier, Sri Lanka had a large number of laws relating to the environment. However, it was only in 1977 that the Government of Sri Lanka initiated action for the introduction of umbrella legislation on the Environment. The National Environmental Act No: 47 of 1980 established the CEA and provided broad powers, functions and duties. The Act provides that the Authority, in addition to administering the Act should:

- recommend to the Minister national environmental policy and criteria;

- undertake surveys and investigations relative to prevention of pollution;
- conduct, promote and co-ordinate research on environmental matters;
- specify environmental quality standards, norms and criteria
- publish reports and information;
- assure compliance with provisions of the Act through investigations and inspections;
- specify sampling and testing methods;
- provide the public with information and education about environment;
- co-ordinate with other countries and international organizations on environmental matters;
- report to the Minister on environmental matters and suggest any legislative amendments;
- promote, encourage, co-ordinate and carry out long-range planning relative to environmental protection and management; and
- encourage, promote and give effect to methods for converting and using residues.

The actual text of these entries is in Section 10 of the Act.

In addition to the National Environmental Act, there are several legislations directed specifically towards the marine environment.

Legislation specifically concerned with coastal zone management was enacted in Parliament in 1981 (i.e., the Coast Conservation Act) and the law became operative in October 1983. Its provisions with regard to coastal zone management include:

- requirement of a survey of the coastal zone,
- requirement of preparation of a Coastal Zone Management Plan (CZMP),
- specification of interim guidelines and criteria until the plan is prepared,
- specification of a permit procedure for coastal development activities,
- environmental impact assessments as a pre-requisite for those development projects deemed to have adverse impacts on the environment.

The fisheries industry of Sri Lanka is managed by the following legislation:

- Fisheries Ordinance (Chapter 212 of Legislative Enactments) No. 24 of 1940, as amended from time to time and regulations framed thereunder,
- Chank Fishery Act (Chapter 213) of 1953,

- Pearl Fisheries Ordinance (Chapter 214) of 1925,
- Whaling Ordinance (Chapter 215) of 1936,
- Maritime Zones Law of 1976,
- Fisheries (Regulation of Foreign Fishing Boats) Act of 1979,
- National Aquatic Resources, Research and Development Agency Act of 1981.

Although some of this legislation has been framed as far back as 1925 (Pearl Fisheries Ordinance), important elements of conservation and environmental management have gone into them. Schedule 1 of the Fisheries Ordinance (FO) has introduced controls on the export of Belontia signata (Pulutta), Puntius cumingi (Potheya), Puntius titteva (Lai titteya), Puntius nigrofasciatus (Bulath sapeya), and Rasbora vaterifloris (Hal mal dandiya). Section 14 of the FO has controls on harmful fishing methods using explosive (e.g. dynamite), poisonous or stupefying substances, which have a direct impact on the destruction of the marine ecosystems.

Scientific studies in the latter part of the 1960s had shown that stocks of six species of spiny lobsters available in Sri Lankan coastal waters were depleting due to over-exploitation. Further, the studies showed that the lobster breeding grounds between the Galle Buck Lighthouse in Colombo and Mount Lavinia Hotel were being over-exploited and during breeding seasons egg-laden female lobsters were caught. By Prawn and Spiny Lobster Regulations of 1973, lobster fishing in the above area was completely banned and several controls on catching, transport, sale and export of lobsters were imposed. It is prohibited to catch, transport, sell or export lobsters of size less than 8 cm carapace length or 11.5 cm tail length. Similarly, there are other controls like the mesh sizes of nets to be used in local fisheries depending on the requirements of a particular fishery. These types of controls are essential in the management of the environment. These are important aspects in sustained development of fisheries through conservation.

As a primarily research-oriented unit, NARA has no direct legislative powers. However, on the agency's advice, the Ministry of Fisheries can implement legislation pertaining to the aquatic environment. In this regard, the agency has been instrumental in seeking enhanced penalties for the use of explosives for fishing and for the decimation of threatened and endangered species. The agency has played an important role towards the designation of the Indian Ocean as an international marine mammal sanctuary. Well aware of the importance of marine parks and santuaries a long term goal of NARA is to identify, develop and co-ordinate management of such regions around the island. NARA is also seeking the formulation of a policy which will cover matters of marine archeological interest such as the numerous shipwrecks and other sub-merged artifacts.

Institutional arrangements

As stated earlier, the Government of Sri Lanka has established the CEA as the lead agency responsible for policy-making and co-ordinating activities on the environment. Legislation establishing the CEA did not provide for a regulatory authority but provided essentially for a co-ordinating agency.

Sri Lanka is one of the few countries which has a separate Ministry of Fisheries. The Ministry of Fisheries has the overall responsibility in the development of fisheries. Various divisions of the Ministry of Fisheries and Statutory Bodies, like the National Aquatic Resources Agency (NARA) assist the Ministry in developing the national policy on fisheries. The Marine Division has offices in coastal districts. Each of these district offices is in charge of a District Fisheries Extension Officer, under whom there are several Fisheries Inspectors covering smaller areas. Their duties include the enforcement of regulations framed under Fisheries Law. Similarly, the Inland Fisheries Division has aquaculturists in charge of districts, where inland fishing activity takes place. Their work, at present is concerned with the development of inland fisheries, aquaculture and an enforcement of regulations. In this institutional set up, the basic strategy has been the development of fisheries and little emphasis on environmental management has been given. In recent years, however, information had been collected as to the available resources in fisheries and management measures have been taken to prevent over-exploitation. Some specific instances of fish mortality due to discharge of harmful effluents by industries have been scientifically investigated and measures are being taken to control this. The Ceylon Fishery Harbours Corporation is engaged in the construction and maintenance of a fishery harbour and other shore facilities.

The Coast Conservation Act established a Coast Conservation Department (CCD) in the Ministry of Fisheries for the implementation of the Act. The Coastal Resources Planning and Development Branch of the Department is responsible for administering the permit system, encouraging public education and awareness regarding coastal resources management and for the preparation of the Coastal Zone Management Plan (CZMP). Inter-agency co-ordination required in the preparation of the plan will be obtained through the Coast Conservation Advisory Council, represented by senior officials of all relevant agencies. Further co-ordination when necessary in the formulation of zoning schemes will be sought through workshops.

For the purpose of environmental management and planning NARA has instituted an Environmental Study Unit (ESU) to investigate and report on matters of environmental concern. In addition, affiliated to the agency are the National Hydrographic Office (NHO) and the Centre for Research on Indian Ocean Marine Mammals (CRIOMM). The former NHO is jointly overseen by NARA, the Surveyor-General's Department and the Sri Lanka Navy and is primarily concerned with hydrographic survey activities in the waters of Sri Lanka. An outcome of the International Symposium on Marine Mammals held in Sri Lanka during March 1982, where the island's waters were identified as a premier site for marine mammal research, was the formation of CRIOMM. Preliminary studies on the behaviour, feeding and breeding of the large whale populations off Trincomalee in the East Coast of the island are underway and more detailed marine mammal studies are anticipated, under the auspices of CRIOMM. The Oceanography Unit of NARA is primarily concerned with oceanographic studies as well as the assessing of the marine resource potential of the off-shore territories that come under the jurisdiction of NARA. As the institution responsible for research, development and management of the aquatic milieu, NARA liaises frequently with other governmental and international organizations on matters that fall within its purview.

Environmental quality criteria and standards

It is necessary to lay down quality criteria for air and water quality as well as tolerance limits for emissions and effluents.

The CEA has adopted certain interim standards which could be used as guidelines in interpreting these and some relevant standards are given in Annexes XIII, XIV and XV.

Approach to environmental impact assessment

From 1 January 1984 environmental impact assessments (EIA) of major development projects in Sri Lanka are mandatory.

Under the present procedure, all projects undergo an initial environmental examination at which stage, it can be decided whether a full EIA will be necessary. An environmental covenant can be drawn up to mitigate comparatively simple environmental effects.

The full procedure will involve a "scoping meeting" at which involved agencies and experts will draw up a list of environmental problems on which a full EIA report will have to be prepared before the project can be assessed, and adequate mitigatory measures incorporated.

Sixteen institutions/organizations have been identified as major project approving agencies as listed below, with the CEA acting as the Co-ordinating Agency:

Urban Development Authority (UDA),
Greater Colombo Economic Commission (GCEC),
State Gem Corporation (SGC),
National Aquatic Resources Agency (NARA),
Coast Conservation Department (CCD),
Ceylon Tourist Board (CTB),
Ministry of Fisheries (MF),
Ministry of Textile Industries (MTI),
Ministry of Industries and Scientific Affairs (MISA),
Ministry of Land and Land Development (MLLD),
Ministry of Agricultural Development and Research (MAD&R),
Ministry of Plantation Industries (MPI),
Ministry of Finance and Planning (MFP) -
National Planning Division,
Ministry of Mahaweli Development (MMD),
Ministry of Health (MH),
International Economic Co-operation Division
of the MFP (IECD).

Environmental monitoring and surveillance and standardization of analytical techniques

This will involve the development of a network of laboratories among which the work can be distributed.

Among the laboratories presently involved in environmental water quality are:

National Aquatic Resources Agency (NARA),

Ceylon Institute for Scientific and Industrial Research (CISIR),

Coast Conservation Department (CCD),

Universities - Kelaniya (Botany, Zoology)
Colombo (Chemistry)
Peradeniya (Chemistry, Geology)
Jaffna
Batticaloa
Matara,

Water Resources Board (WRB),

National Water Supply and Drainage Board (NWS&DB),

Division of Occupational Hygiene, Labour Department (DOH-LD).

Analytical techniques will have to be standardized so that all laboratories will obtain the same result on any one sample.

Water quality monitoring programme

This will include analyses of water in the estuaries of major rivers, coastal waters and offshore (including bioassays and analyses or sensitive species).

The goal should be regular monitoring commencing with 4 times a year and increasing to once a month in the more important areas.

Coastal zone management plan and coastal land-use planning

The recently enacted Coast Conservation Act[1/] specifically mandates for coastal zone management and requires the preparation of a national CZMP within 3 years of its operation, i.e. before October 1986. It also requires the conduct of a Coastal Zone Survey the results of which will be utilized as a basis for the formulation of Coastal Zone Management Guidelines. The elements of the survey are detailed in the Act.

The CZMP will also include zoning schemes for various coastal land-uses; such schemes will be formulated with the aid of inter-agency co-ordination (e.g. with the UDA, Tourist Board, NARA, Wildlife Department, Fishery Ministry Forest Department) using the results of the coastal zone surveys.

The elements of the CZMP are as follows:

(a) guidelines to be used in determining the suitability of particular development activities in the coastal zone;

(b) proposals which deal with the following subjects within the coastal zone:

[1/] The Act came into operation in October 1983

- land-use,
- transport facilities,
- preservation and management of scenic and other natural resources,
- recreation and tourism,
- public works and facilities, including waste disposal facilities, harbours and power plants,
- Mineral extraction,
- living resources,
- human settlements,
- agriculture,
- industry;

(c) proposals for the reservation of land or water in the coastal zone for certain uses, or for the prohibition of certain activities in certain areas of the coastal zone;

(d) comprehensive programme for the utilization of manpower displaced as a direct result of more effective coastal zone regulation;

(e) recommendations for strengthening governmental policies and powers and the conduct of research for the purposes of coast conservation.

After considering the many strategies available for the formation of the CZMP, it has been agreed that a problem oriented approach is the more expedient. The plan will be prepared on an incremental basis, and the initial phases of the plan will be more skewed towards regulation of coastal activities, because information and understanding of resources available at present is not adequate for management of resources.

Once the CZMP is ratified and is in operation, the management guidelines and land use zoning schemes contained therein will be employed as a tool for the regulation of all development activities and use of resources within the coastal zone.

It is also noteworthy that the Act makes provision for environmental impact assessments for those projects deemed to have significant impacts on the environment. Thus, future development projects will be assessed not only on economic considerations but also on ecological and environmental considerations.

Management of areas of special ecological interest and critical or vulnerable coastal areas

NARA has identified a number of areas of special ecological interest to the agency. The main emphasis has been on the identification and the formulation of management strategies for the optimum utilization of available resources together with preservation of the existing ecological habitats. Areas of interest identified in this connection include studies on the various threatened and endangered species of marine mammals, the fast disappearing

mangrove swamps and corals and coral reefs threatened by commercial exploitation, pollution and explosives. Environmental impact studies on the effects of development projects, industrial pollution and increased human activity in the coastal estuarine and riverine regions are presently being prepared.

Identification of areas of special ecological interest and critical areas will also be a component of the CZMP. In addition, the Plan will include guidelines for the management of these areas.

Oil spill contingency plan and other protection measures

The Southern coast of Sri Lanka presents an area which is directly exposed to the major shipping routes linking the Western and the Eastern Hemispheres, as well as bordering the major corridors of oil transport, from the Middle East to the Far East. The IMO meeting in Sri Lanka in January 1982 revealed that like many countries in the South Asian region, Sri Lanka had little or no concrete oil spill contingency plans. The setting up of the Marine Pollution Authority in 1982, and the enactment of the Marine Pollution Prevention Act coupled with the institution of an IMO traffic routing scheme with ample space separating shipping lanes off the Southern coast of Sri Lanka have ameliorated, but not removed, the threat of a major oil spill occurring. The disastrous consequences of such an occurence to the ecology and revenue of Sri Lanka, in the form of lost livelihood, tourism and aesthetic beauty, cannot be over-emphasised. The Ceylon Petroleum Corporation (CPC) has recently commissioned an environmental impact study to assess the damage of an oil spill from Single Point Bouy Mooring (SPBM) operations off the port of Colombo, on the surrounding coastal areas.

While the CPC vessels are equipped to handle a small oil spill no plan exists to combat a major one. The IMO meeting has resulted in a draft agreement calling for mutual assistance in the South Asian Seas community (or if needed, international co-operation) to help combat marine pollution by oil and other harmful substances such as radioactive waste.

Environmental management of ocean energy potential development

Vast renewable sources of energy exist both in the motion of the water and the temperature gradients of the sea. We can harness this limitless energy either by tapping the kinetic energy of moving water in tides, waves and currents or the energy inherent in vertical and lateral temperature gradients.

The tidal range in Sri Lanka is micro by world standards and therefore, no possibilities exist for developing this type of energy. Among other sources of energy under consideration today are wave energy and energy from ocean currents. However, because there are no major ocean currents circulating around Sri Lanka, energy from currents cannot be harnessed. Although off the great and little basses there exists sufficient wave energy to generate power; very high costs mean that there is no future potential in Sri Lanka for developing this kind of energy.

The most promising source of energy in Sri Lanka in the future is Ocean Thermal Energy Conversion (OTEC). In view of the present state of technological development in relation to OTEC, Sri Lanka is proceeding with considerable caution in evaluating any option for commercial application of

these technologies. An option which may be given serious consideration at the present juncture would be to utilize an area having OTEC potential, such as Trincomalee or any of the East and South coast submarine canyons, for the deployment and operation of a pilot scale OTEC plant. Area intensive utilization of the thermal gradient raises questions of environmental limits (Beck,1975). Plant operations involve vertical displacement of massive quantities of water from depths and both cold and warm water streams entrain living organism. Environmental consideration should be given in the selection of the control method used in inhibiting the growth and attachment of biofouling, as chlorine used for this purpose could pose a serious threat if used in high dosages. The operation of OTEC plants may involve planned or accidental discharge of various materials. Caution should be taken in the selection of highly toxic working liquids used in closed cycle OTEC plants and the practical use of these liquids will require evaluation of environmental effects of effluent discharge in the surface (epi-pelagic) layer (Gritten, 1980).

Conservation

Conservation of mangrove swamps and coral reefs

Legislation exists in Sri Lanka to prevent degradation of coral resources under the Crown Lands Act, the Flora and Fauna Protection Ordinance and the Fisheries Ordinance (De Silva, 1983)

The Government of Sri Lanka has enacted several laws to curb the use of explosives and to restrict coral mining. However, due to problems of enforcement, both coral mining and the use of explosives is often reported in several coastal areas.

The Crown Lands Ordinance, enacted in 1929, prohibits removal of sand (other than by permit), coral and stone from Ambalangoda to Hikkaduwa. Attempts by the Government in the late 1970s to re-activate this legislation as well as ban coral mining in Sri Lanka met with some degree of success especially in the East coast.

The Ambalangoda - Hikkaduwa Rocky Islets were declared a sanctuary in 1940, under the Flora and Fauna Protection Ordinance. Although it was believed that this declaration included coral areas, the sanctuary catered only for the protection of a few species of birds.

Regulations were published under the Fisheries Ordinance in 1961, prohibiting the removal of fish from territorial waters adjacent to the coast of Hikkaduwa, except on permit. This regulation became ineffective in the absence of bouys indicating the boundaries of the area (Anon, 1976). Attempts have been made to conserve some coral reef resources by declaring specific areas as marine sanctuaries or areas from which specific organisms, such as lobsters, should not be removed.

Protection of endangered and threatened species and habitats

Endangered and threatened species among the marine organisms in the seas around Sri Lanka include the marine mammal, Dugong dugon, the six species of

turtles[2/], and the six species of lobsters (Panulirus homarus, P.versicolor, P.matus, P.polyphogus, P.longiceps and P.penicillatus).

The dugong and the turtles are protected under the Flora and Fauna Protection Ordinance. There is no effective enforcement of the law, as a result of which the dugong is still being hunted whenever possible and the turtles as well as the eggs are being taken in increasing numbers. The Lobster Regulation (1973) under the Fisheries Act placed a complete ban on lobster fishing in a stretch of coastline from Colombo to Wellawatta as the lobster stocks were found to be heavily depleted in this area. In addition, these regulations also imposed an island wide restriction on minimum size of lobsters to be taken out and a ban on taking of gravid females. These regulations too were found difficult to enforce in practise, and are being increasingly and openly flouted, particularly with increased development in tourism.

The Chank Fishery Ordinance stipulates the minimum size of chanks which could be taken, while the Pearl Fishery Ordinance prohibits even a fishing vessel sailing over the pearl banks. These Ordinances were more to protect the resources against over-exploitation. The Whaling Ordinance outlaws killing of sperm or baleen whales. However, the killing of dolphins, which is neglegible compared to those killed accidently as by-catch in fisheries, seem to have gone unnoticed despite the regulations.

Marine fisheries

In Sri Lankan fisheries, some elements of conservation have gone into fisheries legislation enacted as far back as 1940. But, as in most other developing countries, the emphasis has been on mechanization and increased effort in exploiting fishery resources. Where conservation is necessary, action has been taken to regulate fisheries. The conservation of lobster fishery is one instance where such measures have been taken. Regulations limiting mesh sizes have been framed to protect small fish in breeding areas. Killing of fish by explosives, poisonous and stupefying substances is completely prohibited. With the increase in fishing effort in recent years, attempts are being made to match the effort with the available resource in order to prevent over-exploitation. Where conservation practises have been exercised, it is important to realize the socio-economic conditions of small scale fishermen who are engaged in fishing in the coastal areas. It should be realized that conservation should be matched with measures to meet short term economic needs.

In addition to the management programmes outlined above, it is necessary to contemplate action on other marine resources being over-exploited. In this connection, lack of reliable data on the resource is a major drawback.

2/ Dermochelys coriaceae (Leathery Turtle)
Chelonia mydas (Green Turtle)
Caretta caretta (Loggerhead Turtle)
Etetmochelys imbircata (Hawksbill Turtle)
Lepidochelys Olivacea (Oliveridley)
Chelonia depressa (Flat-back Turtle)

Marine parks, sanctuaries and protected areas

Attempts have been made to establish marine sanctuaries in a few locations around Sri Lanka, such as Hikkaduwa, the Rocky Islands, the Pigeon Island and the area West of Wilpattu National Park. There has been little success in this respect. In a fresh attempt to work towards an effective establishment and administration of marine reserves, the NARA convened a Working Group on Marine Parks and Sanctuaries in September 1982. The Working Group was able to identify approximately 33 areas around the coast as requiring some degree of protection for conservation purposes. However, several constraints stand in the way of any effective measures being implemented. One of the difficulties is with regard to administrative responsibilities. As in the case of the National Hydrographic Office (NHO) which functions under the NARA on an inter-agency basis, preparatory arrangements are being examined with a view to possible constitution of a Marine Parks Administration which would be set up jointly by the NARA and the Department of Wildlife Conservation.

Research, survey and management programmes

Several major studies are being continued so as to provide a data and information base for the formulation of national environmental policies and strategies

Among those already concluded are:

- survey of the industrial plants discharging trade effluents into the lower reaches of the Kelani River and Estuary;

- environmental assessment study carried out in the Hikkaduwa Tourist area. (Recommendations based on this study have been proposed to the Government).

Preparation is underway for a National Conservation Strategy by a task force appointed by His Excellency the President. Action has been initiated to prepare guidelines for the prevention of marine pollution.

The CEA, with the assistance of the ESCAP and in collaboration with other national agencies and local experts formulated a Coastal Environmental Mangement Plan (CEMP) for the West coast of Sri Lanka. The Plan was adopted for submission to the Government at a National Seminar held in January 1984.

Several research/survey programmes required of the CZMP have already been initiated or completed (e.g. socio-economic survey of the coral and sand mining industries, and removal of seashells, assessment and preparation of a Master Plan for coast protection of sea erosion, survey of reefs; historical coastline study) and action is on-going for the inititation of the inventories required.

Research, survey and management activities on the marine environment form an important area of work coming under the Agency's work programme. This work is undertaken by multi-disciplinary teams consisting of researchers from various technical divisions of the Agency, such as Oceanography, Marine Biological Resources, Inland and Brackish Water Fisheries, Environmental Study Unit, CRIOMM and National Hydrographic Office. The recently instituted Environmental Study Unit (ESU) has carried out studies on the discharges into

the Kelani River, Wellawatta Canal and the Valachchenai Lagoon in the East coast to evaluate the possible harmful effects they have on the aquatic life form, both in the waterways and in the coastal environments. Work is also underway to study the effects of Mahaweli waters on the marine life forms in the coastal waters around Trincomalee. The CRIOMM has undertaken studies on the feeding and breeding habits of the whale population located off Trincomalee. Surveys of dugongs and dolphins are in progress in other areas of the island with the view of working out a strategy for their conservation. The Agency also hopes to undertake studies to broaden existing knowledge on corals and threatened species of marine fish. The establishment of marine parks and sanctuaries could be expected to play an important role in this connection.

The inland fisheries and aquaculture division of the Agency is presently undertaking studies on the brackish water areas of the island and their ecological systems with special reference to mangrove vegetation, a habitat important for the larval and sub-adult stages of shell-fish species. The Agency is also involved in carrying out surveys of aquatic resources in the coastal and offshore marine environments, a statutory responsibility of this Agency.

Institutions and scientists/experts engaged in environmental research and management

As part of its public awareness programme, the CEA has compiled a Directory of Scientists/Experts in the field of Environmental Research and Management. Each entry in the Directory is based on a form filled by the Scientist/Expert who indicates his/her field of expertise in terms of a subject-listing arranged to enable easy computer storage and quick retrieval. The Directory is maintained as an ongoing process and as of December 31, 1984, it lists over 125 names. A list of field expertise is provided. The Experts represent the Academic circles, the administrative hierarchies and private citizenry. The selection of Scientists/Experts was effected, in the first instance, by the CEA. At the second stage, some experts volunteered to fill in the forms, taking the initiative themselves. Ideally, the Directory should expand to include even those indigenous experts in fields related to environment, even though they may not possess academic qualifications, their traditional pragmatic approach to issues is likely to prove of considerable value.

Training programmes and activities

The CEA organized an Environmental Impact Assessment Procedures Development Programme, with the assistance of the United States Agency for International Development (USAID), for developing guidelines as well as for training of personnel of project approving agencies of the Government. This Programme included a policy development seminar for top level officals and a three week workshop for those responsible for environmental assessment in approving agencies. The guidelines developed under this Programme have been approved by the Government for compliance from January 1984. Further training is planned as follows:

- training of representatives of non-governmental organizations in the field of environment;

- awareness programmes for media personnel; and

- strengthening of capabilities of District Environmental Agencies (DEAs) through the conduct of district seminars.

Training programmes and activities in conservation of marine fisheries are extremely limited in Sri Lanka as in most of the other developing countries. During ordinary training programmes for grass-root and higher level officers, some elementary ideas on conservation are given, but this is not adequate. As a result, information on important aspects of conservation do not ultimately trickle down to small-scale fishermen. In future training programmes, it is intended to incorporate important aspects of sustained management through conservation, highlighting conservation-based rural development. Lack of trained personnel is a major drawback in implementation of conservation programmes.

An important aspect of the CCD's action plan for the protection and management of the coastal environment is public awareness programmes. Such activities include exhibitions, seminars, workshops for schools and public, and also programmes for the District Administrators in order to provide them with an understanding of the rational for the implementation of the Coast Conservation Act.

International co-operation and development of regional approach

International co-operation has played a significant role in the development of legislation and the CZM Programme. There have been several foreign experts, including coastal engineers, legal experts and coastal resources managers, who have carried out short-term missions under the UNDP, DANIDA and USAID Programmes.

At present, two Danish consultants are working on the preparation of a Coast Protection Master Plan, and there is on-going UNDP expert assistance in the CZM Programme and the preparation of the CZMP. Action is on-going to obtain USAID funding for the inventory work required for the CZMP. Expert assistance will be a considerable component of this aid package.

Senior officers of the CCD have also served in the capacity of advisers and resource personnel in the CZM Programmes in several countries and have published several papers on Sri Lanka experience in coastal management.

The proposed USAID project is a regional one and it is envisaged that once the Sri Lankan CZMP is prepared, it will be used as a model in the other countries of the South East Asian Region. CCD has also actively participated in those activites of the ESCAP, SACEP, etc., relating to the coastal and marine environment.

CCD organized the first International Conference in Coastal and Port Engineering in developing countries. The Conference will be held once in 4 years and a permanent secretariat has been established within the CCD for this purpose.

Some living resources, like whales and tuna can be conserved only by international action. The International Whaling Commission has designated the Indian Ocean as a sanctuary, where all commercial whaling is prohibited. Palk

Bay area is rich in prawn and fish resources. There are annual Indo-Sri Lanka bi-lateral talks on fisheries, and related matters where conservation of fish resources could be discussed for the common benefit of both countries. Conservation of resources in the seas of both countries is important due to the fact that over-exploitation will lead to depletion of stocks. Further, there has been reported cases of poaching in Sri Lankan waters by some nations. Fishing (Regulation of Foreign Fishing Boats) Act of 1979, provides for fishing in the EEZ of Sri Lanka (beyond 35 miles) on licence. This has been done with a view to exploit resources not being exploited by Sri Lankan fishermen at present. About three instances of foreign collaboration under this Act have been finalized. A research survey to determine stocks in the coastal waters was conducted during 1978-80 with FAO assistance. This was a major step forward in conservation as previously information on the available resource was scanty. An important pilot project for the preparation of a Coastal Environmental Management Plan (CEMP) was undertaken, with the assistance of the ESCAP. A component of marine fisheries and aquaculture is included in the plan. This is a major step in the management of the coastal environment in the West coast from Kalpitiya to Dondra.

The NARA has a number of projects on research, development and management aspects of the marine environment to be carried out in collaboration with various international agencies and organizations. Work on Marine Mammals is carried out with the co-operation and support of UNEP and WWF.

The IDRC sponsored project on mollusc culture now being carried out at Trincomalee adopts an integrated approach focussing on offshore environmental monitoring. In the field of training, the International Ocean Institute (IOI) has helped the Agency, providing its officers with training facilities on marine environment management and other related fields.

Information exchange, data collection in research and management work on mangroves and corals will be carried out in collaboration with other regional bodies such as the AIT, SACEP, ESCAP and UNEP. The Agency has also sought the assistance of the IAEA, through AEA of Sri Lanka, to carry out collaborative radio-tracer studies on the coastal environment.

Policy and planning outlook for the next decade

The planning and implementation programmes of the CEA during the next 10 years will be based on the following priority areas:

establishment of a National Environmental Reference Centre (NERC),

build and strengthen capabilities of DEAs,

organize and direct a public awareness programme on environmental protection and management,

build up programmes in professional development for environmental protection and management,

environmental consequences of development (environmental impact assessment (EIA)),

prepare proposals for environmental information exchange programme (EIEP),

development of a National Environmental Code (NEC),

preparation of a National Conservation Strategy (NCS),

Special Programmes in the following areas which have been identified as priority problem areas:

deforestation
soil erosion
water and water management
coastal zone
solid waste disposal,

education and training in environment.

Sri Lanka has already instituted a coastal zone permit system for regulating development in coastal areas. This permit system is an important interim procedure for dealing with coastal problems.

Management of coastal problems in Sri Lanka requires some form of regulation, but it is also clearly preferable to develop a management programme that is anticipatory or pro-active rather than a reactive approach. It requires:

- further research on the dynamics of coastal problems,
- identification of a system of incentives to encourage particular coastal uses and discourage others,
- identification of particularly valued or threatened resources,
- the development of systems for setting priorities amongst coastal uses and activities and the identification of priorities for public investment in public works,
- co-ordination of the activities of several government agencies,
- development of education and training programmes for resource managers, and
- development of public education and awareness programmes.

NARA's policies and work plan for the next decade will be mainly directed at identifying and monitoring areas which need special attention and compiling a data base to work out a strategy for proper environment management for the future.

Mangrove ecosystems and coral ecology are two special areas on which studies have already begun. The rapidly dwindling mangrove forests, which form an important habitat for the early stages of fish and shellfish life, has attracted the Agency's special attention. The study of corals, a biological indication of environment pollution and their ecology is another area to be covered by the Agency.

Studies on feeding and breeding habits of whale populations located off Trincomalee and its interaction with other environmental factors will be carried out under CRIOMM. The Agency also hopes to carry out a comprehensive study on the coastal environment and various factors which affect the coastal ecosystem.

ENVIRONMENTAL PROMOTION

Environmental information

Data base and sources

Since environment is a relatively recent area of national concern in Sri Lanka, specialized mechanisms for the handling of environmental information have not yet become fully established.

Provision has been made under the Public Awareness Programme for Environmental Management and Protection (PAPEMAP) of the Central Enviromental Authority to set up an Environmental Resources Centre. When this Centre becomes operational it will function as the National Environmental Sources and Data Bank.

In terms of the current situation the only specialized environmental information centre in Sri Lanka is the Library of the Central Environmental Authority. This institution is in its formative stage. Presently, information regarding environmental matters is scattered among a number of libraries and information centres in the country. Data relevant to the marine environment, for instance are not being centrally gathered at any particular institution.

No formal mechanism has been established for environmental information exchange. But provision exists for the informal exchange of information in the field of environment between various libraries and information centres associated with academic insitutions and specialized agencies working on a particular environmental area.

The proposed centre will be a recipient of information from formal sources; it would collect and store materials and references appropriate to its role, but not duplicate already existing and specialized libraries; it would respond to requests for information and it would develop links or a network (ENVIRONET) among other resources centres and libraries for further referral on specific issues. This function of ERC is an expansion of the services performed by traditional libraries. Efforts to carry out this part of the centre's programme would be a first step in launching the project. A year would be required before the centre would be fully operational in this phase.

A second step involves an outreach or extension programme in which staff members of ERC visit districts on a regular schedule to establish and strengthen contacts between ERC and District Environmental Agencies and organizations and institutions involved in the public awareness programme initiated under a UNDP/UNESCO project. The purpose of the extension programme is to overcome limitations of traditional libraries and provide on the spot information, training programmes in environmental protection and management and media materials, as well as instruction in their use. The service would help to overcome the severe restrictions on resources of districts and establish close communication with DEA programmes.

A third step would be one of the most critical of ERC activities. It would be the phase in which close ties are established among ERC and resource-development agencies, NGOs, donors and private investors for the purpose of providing them with information they need to assure that proposals, plans and development projects have incorporated into them information leading to the most appropriate design for protection and management of the environment. The intent of this management information system would be to help development-oriented ministries, authorities, and firms save time, money and effort and enable projects and programmes to be soundly designed and long-lasting. ERC could thus provide information support to the national policy and programme on environmental assessment when it becomes implemented.

A fourth step is suggested, but as with the above, careful preparation is required. This programme would include establishment of an inter-agency basic resource data network. Such a system would require intimate cooperation with sources possessing existing data banks and involve ERC in a coordinator and special service role. The objective would be to identify data sources in existence, assess, to the extent possible, quality and quantity of data and determine what needs to be done to bring these resources into a form that can be used by development agencies which need basic data for environmental protection and management.

There is considerable hesitancy in proposing a national system for collection, storage and retrieval of basic data. The hesitance is based on concern about inadequate identification and definition of a problem which may result in collection of irrelevent and useless data. Furthermore, data collection, storage and retrieval are expensive and interagency requirements for data vary and often result in considerable differences and conflict that strain coordination and operation of an integrated system. There are many sources of data, some more complete and up to date than others. Nevertheless there is no central data bank in Sri Lanka for information that cuts across interdisciplinary lines in environmental protection and management. The lack of reliable and comprehensive data may frustrate proper project design, scheduling and implementation.

This is a serious matter because projects may go forward that have very harmful environmental consequences which might have been predicted with some advanced warning based on knowledge of the ecosystem and the results of environmental change. A sound data base could help developers design projects that were more environmentally sound if better information were available.

Information and scientific data accumulated by NARA are disseminated to other national and international organizations as well as other interested parties through status reports, publications like the Journal of the National Aquatic Resources Agency (J.NARA), symposia, seminars, workshops and exchange programmes with established oceanographic institutions abroad. The agency held a symposium on Indian Ocean Marine Mammals in April 1982 and a workshop in maritime history and marine archaeology in 1983. The agency is in the process of developing a computerized information network with a view to serving as a central data base and repository of information on matters pertaining to the aquatic environment. Over the last few years NARA has begun to upgrade the library facilities at the NARA Headquarters which are available to the public and cover a wide field of interests with special emphasis on the aquatic environment. Arrangements are underway to establish a computerized system to index and assist in the setting up of a central repository of aquatic resource and marine mammal data for the Indian Ocean Region.

Environmental education

The purpose of environmental education is to create and enhance the awareness of citizens to their own responsibility for protecting and managing their environment, so that they will participate in actions to solve their environmental problems. In the formal educational system, an environmental consciousness is increasingly emphasized at all levels in the school curriculum.

Educational programmes have been evolved to create a growing environmental awareness in students as they move upward in the primary and secondary educational levels. At the primary level, a spiral curriculum encompasses the following topics: location of the school and nature of the houses around the school; the material of which the houses are made; water and its uses; how water is polluted; streams, rivers and lakes cultivation; local food; pots and pans; and local transport.

Environmental education in the sense of educating children in continual relationship to their local environment, taking them out of the classroom as a normal and regular practice and relating children's education in schools directly to personal experiences outside is evident in most primary schools to some degree.

At the secondary level, environmental dimensions have been integrated into the different subject areas in the school curriculum. These have been done either by the introduction of new courses of environmental studies or science, often aiming at examinations at the GCE ('O' and 'A' levels) or by the introduction of environmental concerns into courses of geography, biology and to a lesser extent in history and general studies.

Although the traditional curriculum of the formal school system lacked much environmental contents, the science curriculum launched in the early sixties emphasised the imparting of knowledge, skills and behaviours concerning the environment, especially through the secondary school biology curriculum. During the early seventies further environmental concepts were introduced into the existing curriculum in the science and social studies. At the primary level the curriculum has been reformed to include a major subject area entitled "environmental activities".

In higher education, there have been significant steps with degree courses in environmental studies or sciences being well established in the universities. Increasing attention is being paid to environmental themes in the universities. Currently there are three universities which offer M.Sc. courses in the following fields:

- A M.Sc. course in environmental sciences conducted by the Department of Zoology of the University of Colombo (Annex XVII).

- A M.Sc. course in forestry conducted by the Department of Biology at the University of Sri Jayewardenepura.

- A M.Sc. course in town and country planning; and a M.Sc. in environmental engineering at the University of Moratuwa.

At an undergraduate level, general environmental courses and modules are offered in the biology and botany departments in the universities. In the University of Colombo, the Department of Botany conducts a course for third year undergraduates on "man and environment".

As for future activities, the Ruhuna University plans to inaugurate a Faculty of Fisheries. The schools have been requested to introduce two subjects - marine and inland fishery - into their curricula in an effort to inculcate and sustain the interest of the younger generation in the fishing industry.

Professional environmental training

Efforts to reach specific target groups outside the school system are reflected in the training programmes of a number of agencies in the government sector. They range form civil service staff colleges to sector training and research institutes. The Agricultural In-service Training Institutes of the Department of Agriculture disseminate environmental education in the field of subsistence agriculture through the demonstration and application of soil conservation measures. Similarly, the Tea Research Institute, the Rubber Research Institute, the Coconut Research Institute and the National Institute of Plantation Management are involved among other things in the dissemination of environmental information through the improvement of cultural practices in their respective fields of activites, by the inclusion of topics such as soil conservation, ecology, productivity, waste disposal and recycling, and use of alternate sources of energy in processing activities.

In-service training at the above institutes may take various forms (a) seminars and workshops; (b) intensive, short study sessions; (c) field demonstrations; (d) advisory services to farmers; and (e) training of extension workers. The in-service trainees at these institutes act as catalysts, contributing to the development of environmental knowledge.

Environmental dimensions have been introduced into the induction and in-service training programmes for public officers at the Sri Lanka Institute of Development Administration (SLIDA). Marine environment is one component in the training module on environment for the new recruits to the Sri Lanka Administrative service. One course in the Diploma in Public Management offered by SLIDA for middle and senior public officers has the following module on environment with a section on the marine ecosystems.

Diploma in Public Management
Economic & Social Development

Module VI: Environment

a. Concept of Environment and Development
b. Agriculture, Forestry & Land Use
c. Water - Its Use & Misuse
d. Marine Ecosystems
e. Impact of Tourism on the Environment
f. Causes, Effects and Control of Pollution

In addition to the above, the Project Planning and Implementation programmes incorporate a session of environmental assessment of development projects.

At the National Institute of Business Management (NIBM), training modules have been structured to incorporate environmental dimensions. For this purpose, the total discipline of production management has been split into eight sub-modules as follows:

1. The need for Managing the Environment - A system approach

2. The Environment Dimension in Production Management

3. The Environment Dimension in Designing Outputs: Designing Products

4. The Environment Dimension in Process Design

5. The Environment Dimension in Designing Production Systems

6. The Environment Dimension in Designing and Controlling Human Inputs

7. The Environment Dimension in Managing Production Systems

8. The Use of Operations Research in Planning and Developing Environmentally Sound Production Systems

About 3000 participants, consisting of employees in the public and private sector enterprises enroll in the NIBM Training Programmes annually. Environmental components have thus been introduced into the training curriculum of senior managerial and administrative personnel in the state and corporation sectors in Sri Lanka.

Policies and strategies

In reviewing the national planning and strategies of environmental education in Sri Lanka, it may be useful to consider the target population. As the preceding discussion clearly illustrates, environmental dimensions have been incorporated into the school curriculum at primary and secondary levels.

The strategy of incorporating environmental concerns into the formal school system had been through the curriculum reform of existing subject areas. Thus, environmental education is not viewed as another subject in schools to be introduced into an already crowded curriculum but instead is considered to permeate all disciplines.

An area where intensive work is required in future is the development and design of teaching materials. The CEA is presently taking steps to prepare a school publication with the assistance of the Curriculum Development Centre and the Ministry of Education for creating an awareness among the school children of 12 - 16 age level.

Environmental education clearly goes beyond the capacity of a teacher of a single subject. Hence, the approach should be inter-disciplinary. Continued in-service supplementary courses for teachers would be a necessity for the success of such a programme. Thus, the teacher education institutions will need to reform their curricula as well.

Involvement of the universities in environmental monitoring is another strategy that may pay many dividends. For instance, the Department of Chemistry of the University of Kelaniya has been requested to monitor the air quality in the immediate environs of the State Fertilizer Manufacturing Corporation at Sapugaskanda in the aftermath of an ammonia leakage at the plant in November 1984. Universities equipped with proper laboratory facilities could undertake such work as part of the undergraduate teaching whilst the state agencies would benefit by the data generated over a period. Such a scheme will mutually benefit the higher educational institutes constrained by budgetary limitations and the state agencies constrained by manpower.

Environmental awareness

The CEA has identified the creation of public awareness in environmental matters as a top priority item in its agenda. The basis for the environmental awareness programmes and campaigns is the unerring recognition that the masses should be persuaded to adopt an environmentally sound style of life.

The end-aim of the public awareness programme for environmental management and protection is to bring about a concerned alertness to environmental issues at mass level. This would eventually lead to practices that will mitigate environmental hazards and lessen adverse impacts on the environment.

PAPEMAP, is one of the eight action programmes in the 1982 Five Year Plan of the CEA. The project objectives of PAPEMAP are: (a) the evolving of strategy for a national and local level public awareness programme and a plan for the implementation of the strategy; (b) the preparation of a training programme, based on the problem solving process at the local level; and (c) designing and creating public awareness materials.

As a preliminary step in the implementation of PAPEMAP a local level survey was made in all the 24 districts, with the assistance of District Environmental Agencies (DEAs). The purpose of the survey was to formulate an environmental profile for the nation as a whole. To gather information on a district basis, a questionnaire drawn up by the CEA was sent to DEA's for distribution.

The media campaign of PAPEMAP involved the preparation of an awareness package for media materials. Media materials are created to generate public awareness in those environmental sectors that have been identified as priority areas and persistent environmental problems. The identification was done in terms of the response to the DEA Questionnaire.

The priority sectors are:

Deforestation: includes forest fires, woodcutting and chena cultivation

Soil erosion: includes upland erosion leading to siltation downstream and chena cultivation

Water pollution: includes contamination of the water supply

Inadequate biomass management: includes solid waste disposal and littering.

The media material to be evolved for the campaign will include: videotapes, slide/sound presentations, 16 mm films, posters, charts, brochures and exhibits. The media materials will be field tested before they are utilized at national level.

Parallel to PAPEMAP the CEA conducted other material - level awareness campaigns. Among them:

exhibition and competition of photographs on environmental themes;

environmental film competition;

exhibition on recycling; and

exhibition on the status of the environment in Sweden.

Public talks, seminars and workshops are also being conducted as part of the campaign to bring about environmental awareness. Three major seminars formed part of the CEA campaign towards mass environmental awareness:

Sweden - Sri Lanka Environmental Week

Seminar for Media Personnel

Seminar for Representatives of NGOs in the field of environment.

Coastal problems and marine eco-systems have almost always been a themetic area in most of these public awareness campaigns.

The CEA has identified voluntary non-governmental organizations active in the field of environment. Some of these have environment as their total focus and others treat environment as only one of their areas of interest. Several NGO's specialized in a particular segment of environment - forests, trees, water, soil.

The CEA has registered those NGO's that could be considered outstanding. Their role largely is to create public awareness and alertness. Some active groups implement such programmes as tree-planting. The most constructive role they play is being alert to the least possible damage to environment. Through their concern they get the members of the public and state to take note of the environmental status. The authorities, as a result, are kept informed of environmental problems and can initiate mitigatory measures in time.

The CEA has formulated an action plan for NGO's. As a direct outcome of a National Seminar for NGO's jointly sponsored by the CEA, Sri Lanka Foundation Institute and Earthscan - London, an apex body to unify all environmental NGO's has been set up. The work of this body will be reviewed by the CEA.

The initial role of mass media in environmental awareness is to create an intense alertness to environmental hazards and mitigatory methods. The media plays a useful role by highlighting environmental degradation through feature articles, interviews, news items and by drawing public attention to the constructive roles of individuals and groups in bringing about sound environmental well-being.

SRI LANKA: PRIORITY AREAS FOR CONSIDERATION IN THE DEVELOPMENT OF A SOUTH ASIAN SEAS ACTION PLAN

Survey and research

Objectives

An estimation of the extent and status of marine resources and specialized marine ecosystems.

An evaluation of the effects of exploitation and pollution of the marine environment and its resources.

Project component

Survey of the extent and present status of marine resources and specialized ecosystems.

Research on the effects of exploitation and pollution on the quality, quantity and sustenance of marine resources and specialized marine ecosystems.

Input needs

Training, with special emphasis on field and laboratory methodology and techniques (fellowships/group courses/study tours; national/regional/extra-regional; short-term/long-term).

Equipment for laboratory and field work.

Standardization and inter-calibration exercises.

Environmental pollution and problems

Objectives

Estimation of the extent of marine environmental problems and level of pollution, and their effects on the marine environment and its resources.

Project component

Environmental effects of marine pollution and maritime activities such as coastal erosion, coral and sand mining and oil pollution and marine dumping.

Environmental effects of pollution from land-based activities such as sanitation, vectors and microbiological pollution, toxic hazardous wastes from industrial and agricultural sources, non-toxic wastes from domestic, industrial and agricultural sources and erosion of topsoil, siltation and sediment transport.

Input needs

Training, with special emphasis on field and laboratory methodology and techniques (fellowships/group courses/study tours; national/regional/extra-regional; short-term/long-term).

Equipment for laboratory and field work,

Standardization and intercaliberation exercises,

Regional discussions (conferences, workshops, etc.,) for exchange of experiences and technology transfer.

Bilateral technical discussions on aspects of joint utilization of multi-national resources and control of trans-national pollution.

Environmental management

Objectives

Identification of how problems can best be managed in an effective manner and prepare programmes for the same.

Provide any technical inputs necessary for the same.

Project component

Environmental quality criteria and standards (effluent standards, water quality standards etc.).

Waste treatment, utilization and recycling programme.

Coastal zone management and land use planning.

Oil spill contingency plan.

Vector control programme.

Environmental impact assessment of projects.

Environmental conservation, i.e. marine parks and sanctuaries for endangered wildlife and aquatic species (aquatic birds, crocodiles, turtles, mammals, etc.) and specialized marine ecosystems, mangrove forests and coral reefs.

Input needs

Regional discussions (conferences, workshops etc.) for exchange of information and technology transfer.

Regional and international expertise.

Equipment for field work.

Study tours (regional/extra-regional).

Legislative and institutional aspects

Objectives

Draft supplementary legislation for effective management of marine environment and its resources.

Identify measures for effective implementation of environmental legislation.

Propose modalities for institutional facilitation of legislative implementation and co-ordination of environmental management.

Project component.

Adoption of supplementary legislation.

Adoption of measures for effective implementation of environmental legislation.

Modalities of institutional arrangements for effective implementation of environmental legislation and co-ordination of environmental management.

Input needs

Regional/sub-regional discussions on adoption of an oil spill contingency plan.

Bilateral discussions on legislative arrangements for management of transnational marine pollution.

Regional discussions on adoption/formulation of international/regional conventions/protocols/treaties dealing with conservation of marine environment and its resources.

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ANNEX I

PHYSICAL FEATURES OF MAJOR LAGOONS IN SRI LANKA

NAME	SURFACE AREA (km^2)	AVERAGE DEPTH (METRES)	TEMP (DEG.C)	SALINITY (ppt)	TURBIDITY	GEOLOGY
1. TAMBALAGAM (TRINCO-MALEE)	20	0.5 - 2	-	variable	turbid	recent Alluvium
2. NEGOMBO LAGOON	28.8	2	-	22 - 27	very turbid	-do-
3. PUTTALAM	172.8	2 - 4	26 - 29	20 - 35	turbid	recent Alluvium overlying miocene limestone
4. PORTUGAL BAY AND DUTCH BAY	2561	6	31 - 32	27 - 30	turbid	recent Alluvium
5. JAFFNA	N.A.	less than 1	25 - 34	26 - 40	turbid	--
6. KOKKILAI LAGOON (MULLAITIVU)	N.A.	0.5 - 3	24 - 33	30 - 35	very turbid	--

ANNEX II

1981 IMPORTS OF SELECTED CHEMICALS ETC., WHICH COULD CAUSE ENVIRONMENTAL PROBLEMS IN USE

(in kg)

Hydrides of Se,Te, Si, B	108
Hydrides of As, P	5,645
Mercury	12,211
Alkali & Rare Earth Metals	106
Boric Oxide, Acid	32,581
Phosphorous Trisulphide	23
Ammonium and Ammonia (Aqueous)	99,287
Sr, Ba, Mg Oxides, Peroxides	14,612
Zn Oxide, Peroxides	500,990
Cr Oxides, Hydroxides	655
Mn Oxides	416,203
Ti Oxides	63,219
Pb Oxides	10,712
Fluorides	4,879
Sulphides	33,890
Dithionates, Sulphirylates	44,001
Cyanides	2,030
Borates, Perborates	302,714
Crude Natural Borates	128,303
Chromates, Permangantes	10,266
Fissile Elements, Isotopes and Compounds	8,290
Compounds of Thorium, Uranium, Rare Earth Metals	3,862
Halogenated Hydrocarbon Solvents	143,129
Phenols, Cresols and Derivatives	15,378
Phythalic Anhydride and Derivatives	342,839
Aromatic amino CPDS	102,342
Nitrides	139
Naphthol	1,273
Carboxy Amide CPDS	103,179
Carboxy imide CPDS	20,595
Carboxy Imine CPDS	60,520
Azoxy Diaze CPDS	19,352
Organo Sulphur CPDS	12,398
Organo Mercury CPDS	Rs. 23,286
Lead - Unrefined	764,989
Nickel Electroplating Anodes	1,365
Antiknock Preparations	530,187
Polymarisation Products in liquid form	94,669
Polymetrication Products in primary form	107,668
Vinyl Acetate Monomer	430,381
Wood and Wood Tar Oils	421,087
Quarternary Ammonium CPDS	23,009

Source: Sri Lanka External Trade Statistics 1981 (Customs Returns)

ANNEX III

MANUFACTURING ESTABLISHMENTS - SUMMARY

Approvals by Department of Small Industries not included

Approval by Ministries of:	Industries & Textile Industries	Finance & Planning	
	Public	Private	
Meat Fish & Milk Products	1	35	2
Fruit & Vegetable Products	1	108	2
Confectionery, Bakery & Cereal Products	2	141	1
Spirits, Alcoholic Beverages & Aerated water	2	31	-
Other Food Products & Tobacco	3	166	1
Spinning, Weaving & Finishing of Textiles & Woven Textile Products	4	415	6
Manufacture of Made-up Garments	-	1031	29
Petroleum, Petroleum Products & Petro-chemicals (inclusive plastics)	3	184	2
Salt & Salt-based Chemicals	3	13	-
Other Chemicals	2	96	3
Pharmaceuticals, Medical Supplies and Cosmetics	2	90	2
Soap, Vegetables and Animal Oils, Fats	3	593	3
Leather & Rubber Goods	3	420	8
Manufacture of Wood, Paper & Pulp	3	319	2
Clay, Sand & Cement Products			
Basic Metal Industries & Machinery (excl. transport machinery)	2	158	-
Ferrous & Non-ferrous Metal Products	5	411	2
Transport Equipment & Spares	1	194	3
Electrical Goods	-	236	3
Optical, Photographic & Precision Instruments	-	69	1
TOTAL	48	4915	71

Source: Industrial Development Board of Ceylon (1980)

Directory of Registered Manufacturing Establishments in Sri Lanka Up to 1977 (Provisional)

ANNEX IV

Directory of Unregistered Manufacturing Establishments in Sri Lanka

DISTRICT-WISE	
Amparai	838
Anuradhapura	432
Badulla	525
Batticaloa	93
Colombo	4,799
Galle	924
Hambantota	214
Jaffna	213
Kalutara	658
Kandy	1,935
Kurunegala	1,459
Mannar	13
Matale	281
Matara	883
Monaragala	258
Nuwara Eliya	83
Polonnaruwa	91
Puttalam	809
Ratnapura	140
Trincomalee	150
Vavuniya	10
TOTAL	15,404

PRODUCT-WISE (Selected)	
Aerated water	3
Batiks	201
Coir fibre	276
Coir ropes	172
Dyeing	2
Electroplating	6
Fertilizer	4
Fruit Canning	5
Lime Kilns	178
Manioc Starch	47
Meat & Fish Products	2
Paints	1
Soap	48
Tanning	3
Textile Printing	43
Textile Weaving	1,707

Source: Industrial Development Board of Ceylon (1980)

ANNEX V

Major Treated Waste Discharges in the Lower Kelani Catchment

km from river mouth	Location of effluent discharge	Name of Industry	Industry	Main components of effluents	Max. discharge (approx) Cu meters/day
1.2	Mattakkuliya	Ceylon Leather Products Corporation	Tannery - vegetable & chrome tanning	Salt renderings, oil, glue, hair, flesh, alkali, acid, chrome salts	50
1.5	Madampitiya	Madampitiya Sewage works	Sewage treatment	Untreated raw sewage - nearly 3/4 of city load	80,000
1.5	Madampitiya	Ocean & Food Trades	Food processing	Food processing wastes (organics) alkali, oil	100
3	St. Sebastian Canal	British Ceylon Corp. Lever Bros., Sedawatte mills	Soup, vegetable, oils	Oil, sewage, alkali, cooling water	500
4	St. Sebastian Canal	Ceylon Petroleum Corp., Kollonnawa	Storage and distribution	Oil, phenolics, washings	400
3.2	Mattala	Ceylon Tyre Corp.	Motor vehicle tyres	Oil, cooling water	10,000
4.8	Kollonnawa	Kelani Tissa Thermal Power Stat.	Thermal power station	Oil, cooling water	30,000
11	Sapugaskanda	Ceylon Petroleum Corporation	Crude oil refinery, Nylon proj.	Oils, sulphides, aromatics, phenolics, ammonia, cyanides, washings. Process wastes	4,000

ANNEX V (cont.)

Major Treated Waste Discharges in the Lower Kelani Catchment

km from river mouth	Location of effluent discharge	Name of Industry	Industry	Main components of effluents	Max. discharge (approx) Cu meters/day*
11.25	Sapugaskanda	State Fertilizer Manufact. Corp.	Urea from naphtha	Ammonia, urea, cooling water	9,000
12	Kelaniya	Tanneries	Vegetable and chrome tanning	see above	300
14.5	Ambatale	Water works Department	Water treatment plant	Wash water, alum floc and sediments	5,000
19.3	Kaduwela	Steel Corp., Oruwala	Steel rolling & wire drawing	Acid pickling waste, iron compounds washings	10,000
30.5	Hanwella	McCallum Breweries Migoda	Brewery	Process waste, bottle washings	250
33.8	GAL Oya	CMC Water works Labugama and Kalatuwawa	Water treatment plants	see above	1,200 4,500
37	Kosgama	Ceylon Plywood Corp., Wood working complex	Plywood, chip-board, furniture	Process and domestic waste	20,000
43.5	Pugoda	Ceylon Textile Corporation	Textile manufacture	Alkali, dyes, sulpher compounds, organics, fibre, detergents, oil	2,000

ANNEX VI

WATER QUALITY OF THE LOWER KELANI RIVER 1973 - 1974

	FLOW Cu m/Sec	pH	TSS mg/l	-S	NH_3-N (free)	NO_3-N	TOTAL N	$-PO_4$	COD	BOD	DO %sat	OIL	COLI-FORMS /100ml
MODARA	90.8-1275	6.1-7.6	15.6-454	0.02-2.6	0.16-2.2	0.35-2.26	1.00-5.86	0.06-2.04	0.8-30.2	0.35-7.55	21-91	1.22-23.5	7,000-94,500
MATTAKKULIYA	40.3-1275	4.45-7.65	28-2600	0.03-3.75	0.18-17.8	1.04-8.2	2.51-26.39	0.08-4.2	1.9-22.4	0.8-11.8	28-84	1.44-18.15	18,500-104,800
MADAMPITIYA	40.3-1275	5.6-7.9	69-2124	0.04-0.8	0.12-1.64	0.13-3.4	1.57-8.85	0.14-4.3	1.7-8.7	1.79-6.7	36.36-83.11	0.0-15.27	4,400-160,800
KELANIYA	38.07-1268	5.5-7.8	26-42	0.01-6.13	0.11-3.05	0.44-3.12	0.71-5.73	0.20-1.80	1.12-5.28	0.50-3.5	53.24-101.12	1.06-64.2	200-244,000
AMBATALE	36.33-1137	5.10-7.5	11.6-180	0.01-0.45	0.08-1.80	0.25-2.65	0.63-5.22	0.09-1.66	1.2-3.9	0.8-2.6	17.56-107.9	0.0-0.03	200-682,000
KITULGALA	16.79-149.8	9.6-8.0	2.9-101.2	0.01-0.33	0.28-1.66	0.02-1.38	1.26-4.97	0.12-1.32	1.0-3.9	0.16-2.5	67.57-115.55	0.0-0.0	2,000-56.500

ANNEX VII

Inputs of Chemical Elements and their Occurrence in Sediments and Bottom Dwelling Organisms and Concentration

	Production 10^3t y^{-1}	Air input 10^3t y^{-1}	Air[b] concentration 10^{-6}gm^{-3}	River[a] input 10^3tyr^{-1}	Sediment concentration 10^{-6}g g^{-1}	Benthos(range) concentrations 10^{-6}g g^{-1} dry wt. tissue
Ag	10	0.07	1	10	0.01-0.5	0.001-5
Al	9000	-	1200	15000	10000-90000	10-50
As	30	0.7	4.6	70	2-15	1-50
Ba	-	-	-	-	60-800	30 (mean)
Cb	-	-	0.8	-	40-70	0.2-3
Cd	15	10	-	0.5	0.2-2.0	0.1-10
Co	22	0.7	1	15	1-200	0.001-0.5
Cr	2800	20	9.5	240	10-200	0.02-1
Cs	-	-	-	-	0.3-15	0.2-0.4
Cu	6000	200-300	280	250	10-700	4-50[c]
Dy	-	-	-	-	0.2	-
Eu	-	-	0.06	-	0.2-10	0.01-0.06
Fe	400000	2220	1900	25000	20000-60000	1-500
Hf	-	-	-	-	0.1-18.0	0.4 (mean)
Hg	9	3.2	1.8	3.5	0.1-0.4	0.06-5
K	-	21	-	-	3000-30000	1000-30000
La	-	-	1.3	-	2-60	0.1 (mean)[c]
Lu	-	-	-	-	0.2	0.003 (mean)[c]
Mn	8100	50	62	2200	100-10000	1-60
Mo	70	-	-	40	-	0.2-0.5
Na	-	350	-	-	2000-40000	500-1500
Ni	660	300	-	170	-	0.4-25
Pb	3000	300	-	150	10-200	0.5 (mean)
Rb	-	-	-	-	1-100	0.5-8
Sb	70	-	6	1.3	0.5-15	0.0001-0.05
Sc	2	-	1.2	-	0.2-30	0.00001-0.002
Se	1	0.5	2.5	7	0.5-1	0.5-50
Sm	-	-	0.24	-	0.5-15	0.04-0.08[c]
Sn	200	30	-	5	200-2000	0.2-20
Sr	-	150	-	-	0.03-3.0	20-500
Ta	-	-	-	-	0.1-7	4-10
Tb	-	-	-	-	0.3-10	0.006-0.01[c]
Th	-	-	0.3	-	10-500	0.003-0.3
V	12	12	5	312	1	2 (mean)
Yb	-	-	-	-	5-4000	0.02(mean)[c]
Zn	5000	6700	160	600	100-400	10-200

Source: R. Johnston (1976)

a Soluble portion
b Particulate
c Relates to calcareous species

ANNEX VIII

Accumulation factors for metals in molluscs relative to (a) soluble, (b) sediment and (c) visceral concentrations of some metallic elements (calc. from Brooks and Rumsby, 1965)

Element	Scallop			Oyster			Mussel		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
Ag	2300	7	0.5	18700	5.6	0.08	330	1	0.5
Cd	2.2×10^5	12	0.1+	3.2×10^5	1.8	0.6	10^5	0.5	0.5*
Cr	2×10^5	0.03	1	60000	0.01	1*	3.2×10^5	0.05	0.6
Cu	3000	0.09	0.4	13700	0.4	0.8	3000	0.09	0.5
Fe	2.0×10^5	0.4	1	68200	0.01	0.6	2×10^5	0.3	0.1
Mn	55510	0.16	7	4000	0.01	4	13500	0.4	0.1
Mo	90	0.6	0.5	30	0.2	0.6	60	0.4	0.1
Ni	12000	0.03	3	4000	0.01	4	13500	0.4	0.3
Pb	5300	3	2	3300	2	2*	4000	2.4	0.5
V	4500	0.01	0.3	15000	0.004	1.5*	2500	0.006	0.2
Zn	28000	2.8	0.7	1×10^5	11	1	9100	0.9	0.2
Visceral fraction			17%			33%			14%

*Value imprecise, based on limit of detection
+Analysis of viscera suspect

Brooks and Rumsby (1965) give accumulations relative to dry wt. tissue; to obtain approximate A.F. relative to wet wt., divide valued under cols (a) by 8.

Sources: R. Johnston (1976). and Brooks R.R. & Rumsby (1965).

ANNEX IX

PESTICIDES APPROVED FOR IMPORT IN 1984

NAME OF PRODUCTS	QUANTITY
1. Vydate L.	100 l.
2. Polyram M.	5 Mts.
3. Monocrotophos	12,500 l.
4. Methamidophos	15,000 l.
5. Alachlor	1,000 l.
6. BPMC	15,000 l.
7. Dimethoate	4,000 l.
8. Sulphur	10 tons
9. MCPA 60%	5,000 l.
10. MCPA 40%	53,000 l.
11. Surcopur	7,600 l.
12. Aldrin (Aldrex 20)	1 Mt.
13. Aldrin 2.5% DC	1 Mt.
14. Azodrin 60	15,000 l.
15. Dieldrex 20	1 Mt.
16. DD soil fumigant	10,000 l.
17. Bassa (BPMC) 50EC	10 Mt.
18. Dimethoate 40	10,000 l.
19. Elsan 50% EC	5 Mt.
20. Methamidophos 60	10,000 l.
21. Sumicidin 25	2,000 l.
22. Benlate	2 Mt.
23. Manzate 200	10 Mt.
24. Sulphur 80% WP	10 Mt.
25. MCPA	30 Mt.
26. 3,4 DPA (Propanil)	40,000 l.
27. Lasso (Alachlor)	10,000 l.
28. Machete EC (Butachlor)	10,000 l.
29. Roundup	10,000 l.
30. Methyl Bromide	5,000 l.
31. Monocrotophos	10,000 l.
32. MCPA	40,000 l.
33. 3,4 DPA	100,000 l.
34. Paraquat	50,000 l.
35. Sulphur	35 Mt.
36. Captan	5,000 kg
37. COC	6 Mt.
38. Basfapon	2 Mt.
39. Perfekthion	1,050 l.
40. Kumulus S.	18 Mt.
41. Chlorpyrifos	1,000 l.
42. Basfapon	3 Mt.
43. Perfekthion	2,100 l.
44. Basamid granular	1 Mt.
45. U46 M6	5,000 l.
46. Polyram M	5 Mt.
47. Monocrotophos	2,000 l.
48. Kumulus	18 Mt.
49. Mackfos	2,000 l.
50. Pillaron	2,000 l.
51. Raid Aerosol tins	50,000
52. Teknar liquid	20 l.
53. Teknar granules	5 kg

ANNEX IX (cont.)

54.	Copper Sandoz	12 Mt.
55.	Diuron 80WP	5 Mt.
56.	Propanil 36EC	14,000 l
57.	MCPAK salt	5,000 l.
58.	Hinosan Tech.	2,000 kg
59.	Surcopur 36%	28,800 l.
60.	Movilith	3,000 kg
61.	BPMC	10,000 l.
62.	Carbofuran	15 Mt.
63.	Paraquat Dichloride	6 Mt.
64.	Paraquat Dichloride	6 Mt.
65.	Lindane	500 kg
66.	BHC 52%	3 Mt.
67.	Actellic	4,000 l.
68.	Ambush 25	1,600 l.
69.	Klerat	1,000 l.
70.	MCPA	6 Mt.
71.	Monocrotphos	4,000 l.
72.	Perenox	5 Mt.
73.	Paraquat Dichloride	6 Mt.
74.	Paraquat Dichloride	6 Mt.
75.	Dimethoate	1,000 l.
76.	2,4D Amine Salt	2,000 l.
77.	Tri Miltox Forte	2,000 kg
78.	Tillex liquid 4%	2,000 l.
79.	Sandovit	1,000 l.
80.	Thiovit	15,000 kg
81.	Anthio 33	2,000 l.
82.	Sandoflor	1,000 kg
83.	Thuricide HP	50 kg
84.	Safrotin (aerosol)	240 cans
85.	Ekalux D15ZP	1,000 kg
86.	Solvirex granules	10,000 kg
87.	Metaldehyde	500 kg
88.	2,4 D	2,000 l.
89.	Seradix No. 1	540 x 30 g
90.	Seradix No. 2	900 x 30 g
91.	Seradix No. 3	540 x 30 g
92.	Heptachlor 36%	1,000 l.
93.	Chlordane 70%	3,000 l.
94.	Captan 50% WP	2,000 kg
95.	Teknar liquid	20 l.
96.	Teknar granules	5 kg
97.	Copper Sandoz	12 Mt.
98.	Antimucin WB	30 x 50 l.
99.	Ekalux 25 EC	10,000 l.
100.	Vondozeb	12 Mt.
101.	MCPA 40%	20,000 l.
102.	3,4 DPA	15,000 l.
103.	Simazine 50%	2,000 kg
104.	Vondozeb	12 Mt.
105.	2,4 D	10 x 200 l.
106.	Slimicide 508	6 drums
107.	Herbit 20% EC	10 l.
108.	Herbit 1.4% granules	10 kg

ANNEX IX (cont.)

109.	Magtoxin (cont. 70 tablets)	100 tins
110.	Magtoxin (cont. 350 tablets)	100 tins
111.	Furadan 75DB	8 Mt.
112.	Propineb	7,500 kg
113.	Aliette 80 WP	5,000 x 100 grams 2,000 x 250 grams
114.	Aliette 80 WP	5,000 x 100 grams 1,000 x 250 grams
115.	Brassicol (PCNB 75 WP)	1 kg
116.	King Brand M.C.	30,000 sheets
117.	Pybuthrin 33	200 gals.
118.	Coopex WP 25%	100 kg
119.	Cialin EC 2.5%	30 1.
120.	Primaton 510-GL.	1 can (60 gls.)
121.	Raid House and garden bug killer mosquitocide	25,000 tins
122.	Ekalux 25 EC	2,500 1.
123.	Herbit plus Emulsifiable concentrate	10 1.
124.	Grakill grns. 1.5% Grakill grns. 2.5%	10 kg 10 kg
125.	Baycor 300 EC	200 1.
126.	King brand mosquito repellant mats	200,000 mats
127.	Paraquat Dichloride	6.5 Mt.
128.	Paraquat Dichloride	6.5 Mt.
129.	Agroxone	8 Mt.
130.	Folimat Premix B	1,030 kg
131.	Zinc Phosphide	500 kg
132.	Miral 3G	500 kg
133.	Miral 200EC	20 1.
134.	Sofit	30 1.
135.	Baythroid 050 EC	1,600 1.
136.	"Secto" fly killer	25 dozs.
137.	"Secto" flying insect killer	25 dozs.
138.	"Secto" House Ant & Crawling Insecticidal Lacquer	10 dozs.
139.	"Secto" Hormone rooting powder	100 dozs.
140.	Antracol WP 70%	6,500 kg
141.	Cidial (Phenthoate)	1,000 1.
142.	Vondozeb	12 Mt.
143.	BHC 12% Tech.	10 Mt.
144.	Baythion dust	4,000 kg
145.	Propoxur Tech.	1,000 kg
146.	Baygon Aerosol spray	10,000 cans
147.	Dipterex Tech.	2,100 kg
148.	Emulsifier W	250 kg
149.	Dimethoate	2,000 1.
150.	Kelthane	600 1.
151.	Oncol 88% Tech.	2 Mt.
152.	Moon Tiger brand mosquito coils	6,000 boxes
153.	Homai	500 kg
154.	Morice (MCPA)	10,000 1.
155.	Fumakilla Mosquito coils	100 cartons
156.	Copper Sandoz	12 Mt.
157.	Seradix No. 1	540 x 30 grams
158.	Seradix No. 2	540 x 30 grams
159.	Seradix No. 3	540 x 30 grams

ANNEX IX (cont.)

160. Savlon	60 x 1 l. cans
	60 x 5 l. cans
161. Sheltox Mosquito coils	500 cases
162. Paraquat Dichloride	16,733 kg
163. Tamaron Premix B	2,300 kg
164. Emulsifier 1074	600 kg
165. Emulsifier 373	400 kg
166. Rosefresh Air Freshner	348 dozs.
167. Rosetox Insect Killer	288 dozs.
168. Diverside "K"	10 drums of 204 l.
169. Diversol CX	10 drums of 150 kg
170. Copper Sandoz 50%	4,5 Mt.
171. Nuvacron 56 SCW	30 x 220 kg drums
172. Baycarb Tech.	20,000 kg
173. Bayrusil Tech.	1,000 kg
174. Dipterex Tech.	1,000 kg
175. Tokuthion Tech.	2,000 kg
176. Unden Tech.	1,500 kg
177. MCPA Tech. Dry	45,000 kg
178. 2,4 D Tech.	2,000 kg
179. 3,4 DPA Tech.	15,000 kg

Emulsifiers:

180. 1074	4,200 kg
181. 373	800 kg
182. W	3,600 kg
183. NP 10	600 kg
184. 368	630 kg
185. APM	1,400 kg
186. 1061	2,310 kg
187. TBE	8,820 kg

Auxiliary compounds:

188. Movilith	5,000 kg
189. Extrusil	2,000 kg
190. Antracol WP 70	45,000 kg
191. Sulphur	20,000 kg
192. Morut	500 kg
193. Pomarsol	1,000 kg
194. Baycor	300 Ls.
195. Baythroid EC050	5,000 Lts.
196. Morestan WP 25%	1,000 kg
197. Surcopor	100,000 Lts.
198. "No Rat" rat exterminator	01 ctn.

ANNEX X

LIST OF REGISTERED PESTICIDES 1984/85

NAME OF ACTIVE INGREDIENT	PERCENTAGE
1. Acephat	75
2. Aldecarb	10
3. Aluminium phosphide	
4. Benfuracarb	3
5. BPMC	50
6. BPMC	47
7. BPMC	50
8. BPMC	50
9. BPMC	95
10. BPMC	50
11. BPMC	50
12. BPMC	50
13. BPMC	50
14. Carbaryl	85
15. Carbaryl	85
16. Carbaryl	4
17. Carbaryl	43.7
18. Carbaryl	43.7
19. Carbaryl	85
20. Carbaryl	5
21. Carbofuran	3
22. Carbofuran	3
23. Carbofuran	3
24. Carbofuran	75
25. Carbophenothion	25
26. Carbosulfan	20
27. Carbosulfan	20
28. Chlorfenvinphos	
29. Chloropyrifos	20
30. Cyfluthrin	5.7
31. Dazomet	98
32. Deltamethrin	
33. Deltamethrin	
34. Deltamethrin	2.5
35. Demeton - S - Methyl	
36. Diazinon	5
37. Diazinon	50
38. Diazinon	50
39. Diazinon	
40. Dicofol	42
41. 1,2-Dichloropropane + 1,3-Dichloropane	50
42. Diethyl Quinalphion (Quinalphos)	26
(")	1.5
(")	25
43. Diethyl toluamide	
44. Dimethoate	40
45. Disulfotan	5

ANNEX X (cont.)

46.	Endosulfan	35
47.	Esbiol	
48.	Fenamiphos	5.2
49.	Fenthion	50
50.	Fenthion	4
51.	Fenthion	48.7
52.	Fenthion	85
53.	Fenvalarate	25
54.	Formothion	33
55.	Hydrocyanic Acid	
56.	Isoprocarb	50
57.	Magnesium Phosphide	
58.	Methamidophos	60
59.	Methamidophos	17.2
60.	Methomyl	18
61.	Methomyl	90
62.	Methomyl	24
63.	Methyl Bromide	98
64.	Monocrotophos	60
65.	Monocrotophos	20
66.	Monocrotophos	56
67.	Monocrotophos	40
68.	Omethoate	51
69.	Oxydemeton-methyl	24.8
70.	Permethrin	25
71.	Permethrin	10
72.	Permethrin	
73.	Permethrin	33
74.	Phenthoate	
75.	Phenthoate	50
76.	Phoxim	
77.	Phoxim	50
78.	Pirimiphos methyl	25
79.	Pirimiphos methyl	2
80.	Pirimiphos methyl	50
81.	Profenophos	50
82.	Propetamphos	
83.	Propoxur	
84.	Propoxur	1
85.	Propoxur	3
86.	Propoxur	18.3
87.	Prothiofos	
88.	Quinalphos (Diethquinalphion)	25
89.	Quinalphos (Diethquinalphion)	1.5
90.	Thiodicarb	
91.	Trichlophon	43.8
92.	Ametryn + Atrazine	
93.	Benomyl	50
94.	Bitertanol	27.8
95.	Captafol	50
96.	Captan	80
97.	Captan	50
98.	Carbendazim	50
99.	Carbendazim	75
100.	Carbendazim	

ANNEX X (cont.)

101.	Chlorothalonil	50
102.	Copper oxychloride	50
103.	Copper oxychloride	87
104.	Cuprous oxide	56
105.	Cuprous oxide	50
106.	Edifenphos	51
107.	Ethoxy ethylmercury hydroxide	4
108.	Fenaminosulf	10
109.	Fentin Acetate + Maneb	54
110.	Fesetyl Aluminium	80
111.	Brunolium Plantarium	
112.	Kasugamycin	2
113.	Mancozeb	80
114.	Mancozeb	75
115.	Maneb	80
116.	Metalaxyl	8
117.	Orthoside powder	83
118.	Quinomethionate (Orthioquinox)	25
119.	PCNB (Quintozene)	
120.	Phenyl mercury acetate	17
121.	Propineb	70
122.	Propineb	74.9
123.	Sulphur	80
124.	Sulphur	85
125.	TCMTB & MTC	
126.	TMTD (Thiram)	84
127.	Thiophanate-methyl	
128.	Alachlor	45.1
129.	Alachlor	48
130.	Bromacil	80
131.	Butachlor	
132.	Butralin	36
133.	Dalopon	74
134.	Diruon	80
135.	Diruon	
136.	3,4-DPA (Propanil)	36
137.	3,4-DPA (Propanil)	35.6
138.	3,4-DPA (Propanil)	35
139.	Glyphosate	36
140.	Linuron	50
141.	MCPA	
142.	MCPA	52
143.	MCPA	35
144.	MCPA	3
145.	MCPA	40
146.	MCPA	63
147.	MCPA	41
148.	MCPA	60
149.	Methabenzthiazyron	
150.	Metribusin	70
151.	Nitralin	75
152.	Oxadiazon	12
153.	Oxadiazon	25
154.	Oxyfluorfen	23.5
155.	Paraquat dichloride	25

ANNEX X (cont.)

156.	Paraquat dichloride	24
157.	Piperophos	
158.	2,4-D Sodium Salt or Potassium Salt	88
159.	Dichlorvos (DDVP)	
160.	Dichlorvos (DDVP)	0.5
161.	Dichlorvos (DDVP)	48
162.	Dioxacarb	
163.	Neo-pynamin	
164.	Neo-pynamin	0.1
165.	Triethylene glycol	
166.	Brodifacoum	.005
167.	Chlorophacinone	0.25
168.	Cumatetralyl	
169.	Dimanin A	
170.	Metaldehyde	
171.	Sodium Phosphate	
172.	Zinc phosphide	
173.	Alpha-naphthyl acetic acid	4.5
174.	Ethephon	
175.	Indolebutyric acid	
176.	Indolebutyric acid	0.1
177.	-do-	0.3
178.	-do-	0.8

ANNEX XI

FERTILIZER USAGE IN SRI LANKA

Sri Lanka External Trade Statistics (Customs Returns)

	1979 Metric tons	1980 Metric tons	1981 Metric tons
Sodium nitrate (natural)	--	1.8	0.6
Ammonium nitrate	760	28	16,132
Ammonium sulphate	--	97,824	89,372
Calcium nitrate	0.5	--	10.1
Urea	112,509	103,310	41,886
		81,345*	57,891*
Other nitrogenous fertilizers	2.1	--	--
Superphospates	4,980	49,963	22,811
Other phosphatic fertilizers	21,741	--	110
	3,671*	14,071*	15,294*
Potassium chloride	33,529	75,018	61,701
Potassium sulphate	--	45-	50
Other potassic fertilizers	5,000	19,465	10,600
Other NPK fertilizers	5,000	23,509	25,010
Other NK fertilizers	0.9	--	--
Other fertilisers less than 10 kg	6,598	6,274	4,505
Total Imports	290,572	375,943	282,188
Local	3,671	95,416	73,185
GRAND TOTAL	294,243	471,359	355,373

Imports - from Sri Lanka External Trade Statistics (Customs Returns)

* Locally manufactured: net local use

Apatite - State Mining and Mineral Sands Corporation

Urea - State Fertilizer Manufacturing Corporation

ANNEX XII

Availability (%) by type of Water Supply & Toilet

Facilities to the Occupied Housing Units for the Coastal Districts of Sri Lanka

DISTRICT	Water Sources			Type of Latrine			
	Pipe Bourne	Well	River Tank etc.	Flush toilet Water seal	Pit	Bucket	None
JAFFNA	10.7	85.0	4.3	35.8	14.9	3.9	45.4
MANNAR	21.5	75.6	2.8	10.3	8.6	5.1	76.0
PUTTALAM	6.7	86.5	6.7	26.3	10.1	1.7	61.9
GAMPAHA	8.7	87.6	3.7	37.6	43.8	1.6	17.0
COLOMBO	50.5	46.1	0.4	51.1	25.4	5.3	11.2
KALUTARA	4.9	88.2	6.9	41.6	31.3	0.7	26.4
GALLE	5.7	39.3	5.0	33.5	38.5	0.2	27.0
MATARA	10.0	83.6	6.4	24.0	54.2	0.3	21.5
HAMBANTOTA	11.1	71.6	17.3	9.9	63.8	0.6	25.7
AMPARAI	7.3	75.3	17.4	12.1	14.7	1.7	71.5
BATTICALOA	3.7	85.1	11.2	7.1	4.9	5.2	82.8
TRINCOMALEE	4.8	81.8	13.4	9.8	17.7	7.6	64.9
MULLAITIVU	3.3	87.8	8.3	10.0	5.2	1.5	83.3

ANNEX XIII

CENTRAL ENVIRONMENTAL AUTHORITY - INTERIM STANDARDS

TOLERANCE LIMITS FOR INDUSTRIAL WASTE WATERS DISCHARGED INTO:				
		INLAND SURFACE WATERS	MARINE COASTAL WATERS	PUBLIC SEWER FOR FURTHER TREATMENT
PARAMETERS		VALUES	NOT TO	EXCEED
1. BOD 5 day/20°C	mg/l	30	50	200
2. Total suspended solids for process waters	"	50	100	500
for cooling water effluent	"		TSS of influent plus 10%	
3. Particle size of floatable solids		--	3 mm	--
Settlelable solids		850 microns	850 microns	--
4. Temperature	°C	40	45 at point of discharge	45
5. pH		6 - 8.5	6 - 8.5	6 - 8.5
6. Oils and Grease	mg/l	10	20	30
7. Ammoniacal N	"	50	50	50
8. Residual chlorine	"	1	1	--
9. Fluorides as F	"	2.0	15	--
10. Cyanides as CN	"	0.2	0.2	2
11. Phenolics as C_6H_5OH	"	1.0	5.0	5 (up to 50 subject to secondary treatment)
12. Sulphides as S	"	2.0	5.0	--
13. Arsenic as As	"	0.2	0.2	--
14. Selenium as Se	"	0.05	0.05	--
15. Pesticides Organo-phosphorous cpds as P	"	0	1.0	--
Chlorinated hydrocarbons as Cl	"	0	0.02	--
16. Copper as Cu	"	3.0	3.0	3
17. Lead as Pb	"	0.1	1.0	1
18. Chromium as Cr	"	0.1	1.0	2 (haxavalent)
19. Cadmium as Cd	"	2.0	2.0	--
20. Mercury as Hg	"	0.0005	0.01	--
21. Nickel as Ni	"	3.0	5.0	2
22. Zinc as Zn	"	5.0	5.0	10

ANNEX XIII (cont.)

CENTRAL ENVIRONMENTAL AUTHORITY - INTERIM STANDARDS

TOLERANCE LIMITS FOR INDUSTRIAL WASTE WATERS DISCHARGED INTO:

PARAMETERS		INLAND SURFACE WATERS VALUES	MARINE COASTAL WATERS NOT TO	PUBLIC SEWER FOR FURTHER TREATMENT EXCEED
23. Radio activity	micro/			
Alpha emitters	curies/ml	10^{-7}	10^{-8}	10^{-7}
Beta emitters	"	10^{-6}	10^{-7}	10^{-6}
24. Colour	(Pt-Co scale)	50	--	50
25. Odour		no unpleas.odour	--	FOR IRRIGATION
26. COD	mg/l	250	--	Boron 2 mg/l Sodium 60% Total dissolved solids 2,100mg/l Sulphates 1,000mg/l Chlorides 900mg/l

ANNEX XIV

Greater Colombo Economic Commission

Quality of Inland Surfaces Waters (fresh water) Suggested Norms

PARAMETERS		FOR RAW WATER FOR PUBLIC WATER SUPPLY/BATHING	FOR FISH CULTURE
		VALUES NOT TO EXCEED	
BOD 5 day/20°C	mg/l	3	--
Dissolved oxygen		40% Satⁿ min.	40% Satⁿ min
pH		6.5 - 8.5	6 - 9
Fluorides (as F)	"	1.5	--
Arsenic (as As)	"	0.2	--
Chromium (as Cr)	"	0.05	--
Lead (as Pb)	"	0.01	--
Colour		tolerable	--
Taste and odour		no undesirable taste & odour	--
Cyanides (as Cn)	"	0.01	--
Ammonia (as N)	"	--	1.2
Electrical conductivity	25°C	--	1000×10^{-6} mhos
Turbidity		--	not excessive
Free CO_2	mg/l	--	6 or less
Coliforms MPN/100 ml - monthly average		5000 less than 5% of samples with value over 20000	--
Aesthetics		no visible floating matter of Sewage or industrial waste origin	
ADDITIONAL PARAMETERS FROM ISS 2296			
Phenolics	mg/l	0.005	--
Nitrates (as NO_3)	"	50	--
Oils and grease	"	0.1	0.1
Selenium (as Se)	"	0.05	--
Alpha-emitters	u curies/ml	10^{-9}	10^{-9}
Beta-emitters	"	10^{-8}	10^{-8}
Insecticides		absent	--
Bioassay		--	90% survival after 96 h

ANNEX XV

CRITERIA FOR CONTROLLING POLLUTION OF MARINE COASTAL AREAS

ISS: 1967 - 1976 TOLERANCE LIMITS FOR WATER QUALITY AFTER RECEIVING DISCHARGES

Characteristics	For Bathing, Recreation Shell Fish & Commercial Fish Culture & Salt Manufacture	For Harbour Water
1. Colour and Odour	No noticeable colour or offensive odour	No noticeable or offensive odour
2. Floating material	No visible floating matter of sewage or industrial origin	No visible floating matter
3. Suspended solids	No visible suspended solids of sewage or industrial origin	-
4. pH	6.5 - 8.5	6,5 - 9.0
5. Free ammonia (as N) mg/l max.	1.2	-
6. Phenolics (as C_6H_5OH) mg/l max.	0.1	-
7. Dissolved oxygen	40% saturation or 3 mg/l whichever is higher	-
8. Pesticides - chlorinated hydrocarbons (as Cl) mg/l max.	0.0002	-
9. Arsenic (as As) mg/l max.	0.2	-
10. Mercury (as Hg) mg/l max.	0.0003	-
11. Oils and grease (sampled in 30 cm surface layer) mg/l max.	0.1	10
12. BOD	5	5
13. Coliforms MPN/100ml	1,000	2,500
14. Bioassay test	Not less than 90% survival in 96 h	-
15. Radioactive emitters	(various)	-
16. CO_2 mg/l max.	6	-

ANNEX XVI

TEAM OF NATIONAL EXPERTS

Mr. A.R. Atapattu	-	Ministry of Fisheries
Mr. G.B.A. Fernando	-	Ministry of Power and Energy
Mrs. D. Sadacharan	-	Coast Conservation Department
Dr. R. Pereira	-	National Aquatic Resources Agency (NARA)
Dr. S. Subasinghe	-	- do -
Dr. W. Wickramaratne	-	- do -
Dr. Leslie Joseph	-	- do -
Mrs. Amarasinghe	-	- do -
Mrs. Kanakaratne	-	- do -
Dr. C.S.S. de Silva	-	Colombo Municipal Council
Mr. W.D. Ailapperuma	-	Central Environmental Authority (CEA)
Mr. E.E. Jeyaraj	-	- do -
Mr. Edwin Ariyadasa	-	- do -
Mr. V.K. Nanayakkara	-	- do -
Mrs. C.M. Samarakoon	-	- do -
Mrs. S.E. Yasaratne	-	- do -

ANNEX XVII

M.Sc. IN ENVIRONMENTAL SCIENCE
DEPARTMENT OF ZOOLOGY, FACULTY OF SCIENCE, UNIVERSITY OF COLOMBO

Outline of Syllabus

1. Ecological Concepts

Biosphere and its components. The flow of energy and the cycling of materials in the Biosphere. Major types of ecosystems within the Biosphere.

2. The Sri Lankan Environment - Terrestrial

Climate, climatic zones, geomorphology, natural vegetation, fauna and the inter-relationships of these features, soils, geochemistry and mineral resources. Agricultural patterns. Impact of human activity on terrestrial environment.

3. The Sri Lankan Environment - Aquatic

River systems and catchment areas, reservoirs, tanks and ponds, lagoons, estuaries and mangroves, coastal seas. Aquatic flora and fauna and exploitable and exploited resources. Water chemistry, ground water, water storage, irrigation, urban water supplies.

4. Human Geography and Resource Utilization in Sri Lanka

Population parameters, distribution and growth, economic, social, agricultural and industrial development, natural resources, their distribution, exploitation and potential.

Pollution and Pollutants

Sources and types of atmospheric, terrestrial and aquatic pollution and its control. Effects on living organisms, habitats and ecosystems. Permissible levels of pollutants.

6. Environmental Planning and Management and Community Health

Resource allocation, decision theory, and cost-benefit analysis. Conservation and pollution economics, relating to the environment and pollution, major development projects, environmental impact statements, community health.

7. Elective courses

The following were expected to be available in the 1982 courses:

Conservation and wildlife management
Industrial pollution
Management of water resources

ANNEX XVIII

INTER-AGENCY COMMITTEE

NAME	DESIGNATION	OFFICIAL ADDRESS
Mr. K.H.J. Wijayadasa	Chairman	Central Environmental Authority, Maligawatte New Town, Colombo 10
Mr. W.D. Ailapperuma	Director-General	-do-
Mr. Aloy W. Fernando	Additional Secretary	Ministry of Fisheries Maligawatte Secretariat Colombo 10
Dr. Hiran W. Jayewardene	Special Legal Adviser	Ministry of Foreign Affairs, Republic Bldg., Colombo 10
Mr. David Soysa	Director (Merchant Shipping)	Ministry of Trade and Shipping "Rakshana Mandiraya" Vauxhall Street Colombo 02
Mrs. S.E. Yasaratne	Environmental Officer	Central Environmental Authority Maligawatte New Town Colombo 10

PUBLICATIONS IN THE UNEP REGIONAL SEAS REPORTS AND STUDIES SERIES

No. 1 UNEP: Achievements and planned development of UNEP's Regional Seas Programme and comparable programmes sponsored by other bodies. (1982)

No. 2 UNIDO/UNEP: Survey of marine pollutants from industrial sources in the West and Central African region. (1982)

No. 3 UNESCO/UNEP: River inputs to the West and Central African marine environment. (1982)

No. 4 IMCO/UNEP: The status of oil pollution and oil pollution control in the West and Central African region. (1982)

No. 5 IAEA/UNEP: Survey of tar, oil, chlorinated hydrocarbons and trace metal pollution in coastal waters of the Sultanate of Oman. (1982)

No. 6 UN/UNESCO/UNEP: Marine and coastal area development in the East African region. (1982)

No. 7 UNIDO/UNEP: Industrial sources of marine and coastal pollution in the East African region. (1982)

No. 8 FAO/UNEP: Marine pollution in the East African region. (1982)

No. 9 WHO/UNEP: Public health problems in the coastal zone of the East African region. (1982)

No. 10 IMO/UNEP: Oil pollution control in the East African region. (1982)

No. 11 IUCN/UNEP:Conservation of coastal and marine ecosystems and living resources of the East African region. (1982)

No. 12 UNEP: Environmental problems of the East African region. (1982)

No. 13 UNEP: Pollution and the marine environment in the Indian Ocean. (1982)

No. 14 UNEP/CEPAL: Development and environment in the Wider Caribbean region: A Synthesis. (1982)

No. 15 UNEP: Guidelines and principles for the preparation and implementation of comprehensive action plans for the protection and development of marine and coastal areas of regional seas. (1982)

No. 16 GESAMP: The health of the oceans. (1982)

No. 17 UNEP: Regional Seas Programme: Legislative authority. (1985)

No. 18 UNEP: Regional Seas Programme: Workplan. (1982)

No. 19 Rev. 2. UNEP: UNEP Oceans Programme: Compendium of projects. (1985)

No. 20 CPPS/UNEP: Action Plan for the protection of the marine environment and coastal areas of the South-East Pacific. (1983)

No. 21 CPPS/UNEP:Sources, levels and effects of marine pollution in the South-East Pacific. (1983) (In Spanish only)

No. 22 Rev. 2. UNEP: Regional Seas Programme in Latin America and Wider Caribbean. (1985)

No. 23 FAO/UNESCO/IOC/WHO/WMO/IAEA/UNEP: Co-ordinated Mediterranean Pollution Monitoring and Research Programme (MED POL) - Phase I: Programme Description. (1983)

No. 24 UNEP: Action Plan for the protection and development of the marine and coastal areas of the East Asian region. (1983)

No. 25 UNEP: Marine pollution. (1983)

No. 26 UNEP: Action Plan for the Caribbean environment programme. (1983)

No. 27 UNEP: Action Plan for the protection and development of the marine environment and coastal areas of the West and Central African region. (1983)

No. 28 UNEP: Long-term programme for pollution monitoring and research in the Mediterranean (MED POL) - Phase II. (1983)

No. 29 SPC/SPEC/ESCAP/UNEP: Action Plan for managing the natural resources and environment of the South Pacific region. (1983)

No. 30 UNDIESA/UNEP: Ocean energy potential of the West and Central African region. (1983)

No. 31 A. L. DAHL and I. L. BAUMGART: The state of the environment in the South Pacific. (1983)

No. 32 UNEP/ECE/UNIDO/FAO/UNESCO/WHO/IAEA: Pollutants from land-based sources in the Mediterranean. (1984)

No. 33 UNDIESA/UNEP: Onshore impact of offshore oil and natural gas development in the West and Central African region. (1984)

No. 34 UNEP: Action Plan for the protection of the Mediterranean. (1984)

No. 35 UNEP: Action Plan for the protection of the marine environment and the coastal areas of Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. (1983)

No. 36 UNEP/ECLAC: The state of marine pollution in the Wider Caribbean region. (1984)

No. 37 UNDIESA/UNEP: Environmental management problems in resource utilization and survey of resources in the West and Central African region. (1984)

No. 38 FAO/UNEP: Legal aspects of protecting and managing the marine and coastal environment of the East African region. (1983)

No. 39 IUCN/UNEP: Marine and coastal conservation in the East African region. (1984)

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