BOBP/REP/67

AN ENVIRONMENTAL ASSESSMENT OF THE BAY OF BENGAL REGION

SWEDMAR
Swedish Centre for Coastal Development and Management of Aquatic Resources
A unit within the National Board of Fisheries

An environmental assessment of the Bay of Bengal region

by

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1994

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This document is the final report of an environmental assessment in the Bay of Bengal carried out between April 1991 and February 1993, with special reference to fisheries. It includes edited versions of the status reports from every member country of the Bay of Bengal Programme (BOBP). They were presented at the regional workshop held in Colombo, February 2-6, 1993 at the conclusion of the assessment.

The country reports and the state reports from India were prepared by representatives of each country/state. Figure and data in these status reports are sometimes difficult to compare due to different methods of analysis, insufficient information sampling etc.

The assessment was funded by the Swedish International Development Authority (SIDA), and executed by the Swedish Centre for Coastal Development and Management of Aquatic Resources (SWEDMAR), a unit within the National Swedish Board of Fisheries, and carried out under the umbrella of the Bay of Bengal Programme (BOBP).

The objective was to assess the problems of environmental degradation in the coastal ecosystems in the Bay of Bengal by reviewing the existing information, analyzing available data and collating it all as a fundamental information base. In the long-term, the project could result in recommendations for coordinated activities in the countries as well as the region to achieve sustainable productivity from the coastal ecosystems and reduce the negative effects on the fisheries resources.

The Bay of Bengal Programme (BOBP) is a multiagency regional fisheries programme which covers seven countries around the Bay of Bengal — Bangladesh, India, Indonesia, Malaysia, Maldives, Shri Lanka and Thailand. The Programme plays a catalytic and consultative role: it develops, demonstrates and promotes new technologies, methodologies and ideas to help improve the conditions of small-scale fisherfolk communities in member countries. The BOBP is sponsored by the governments of Denmark, Sweden and the United Kingdom, and also by UNDP (United Nations Development Programme). The main executing agency is the FAO (Food and Agriculture Organization of the United Nations).

March 1994

Published by the Bay of Bengal Programme, 91 St. Mary’s Road, Abhiramapuram, Madras 600 018, for SWEDMAR and printed by Nagaraj & Co., Madras 600 041.

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List of abbreviations

ADB	=	Asian Development Bank
ADI	=	Acceptable Daily Intake
A S	=	Arsenic
ASP	=	Amnesic Shellfish Poisoning
AWWA	=	American Water Works Association
BHC	=	Benzene hexachloride (lindane)
BHC-Y	=	Gamma BHC
BOD	=	Biological (Biochemical) Oxygen Demand
BOBP	=	Bay of Bengal Programme
Bq.	=	Barque (Bark)
Cd	=	Cadmium
CEA	=	Central Environmental Authority
CIDA	=	Canadian International Development Agency
COD	=	Chemical Oxygen Demand
CPUE	=	Catch per unit of effort
Cr	=	Chromium
c o	=	Cobalt
CU	=	Copper
DSP	=	Diarrhoetic Shellfish Poisoning
DDE	=	Dichloro - Diphenyl - Ethelene
DDD	=	Dichloro - Diphenyl - Dichloro - Ethane
DDT	=	Dichloro Diphenyl Trichloroethane
DO	=	Dissolved Oxygen
DOE	=	Department of Environment
DOF	=	Department of Fisheries
DW	=	Dry Weight
DBCP	=	Dibromochloropropane
ECD	=	Efficiency of Conversion of Digested Food
EDB	=	Ethylene Dibromide
ENSEARCH	=	Environment Management and Research Association
EPZ	=	Export Processing Zone
ESI	=	Environmental Sensitivity Index
ESCAP	=	Economic and Social Commission for Asia and the Pacific, United Nations
EC	=	E. Coli (Faecal coliform)
EP	=	Environmental Policy
EEZ	=	Exclusive Economic Zone
EIA	=	Environmental Impact Assessment
ETP	=	Effluent Treatment Pond
EQS	=	Environmental Quality Standards
EUS	=	Epizootic Ulcerative
FAO	=	Food and Agriculture Organization
FC	=	Faecal coliform
FS	=	Faecal streptococci
FRI	=	Fisheries Research Institute
Fe	=	Iron
GDP	=	Gross Domestic Profit
Hb	=	Haemoglobin
Hg	=	Mercury
HCH	=	Lindane (BHC)
HYV	=	High Yielding Varieties
IAA	=	Indole Acetic Acid
ICLARM	=	International Centre for Living Aquatic Resources Management
ICOD	=	International Centre for Ocean Development
IMC	=	Integral Mean Concentration
ITM	=	Integrated Test Management
ITCZ	=	Inter Tropical Convergent Zone
IUCN	=	International Union for Conservation of Nature and Natural Resources (Morges, Switzerland)
IUPAC	=	International Union of Pure and Applied Chemistry
Ind.	=	Individuals
K	=	Potassium
LNG	=	Liquified Natural Gas
LPG	=	Liquefied Petroleum Gas
Mn	=	Manganese
MSY	=	Maximum Sustainable Yield
MRLs	=	Maximum Residue Limits
N	=	Nitrogen
Ni	=	Nickel
NO_3	=	Nitrate
NGO	=	Nongovernment Organization
NORAD	=	Norwegian Agency for International Development
o c	=	Organochlorine
ODA-UK	=	Overseas Development Administration, United Kingdom
OP	=	Organophosphorous
P	=	Phosphorous
PCB	=	Polychlorinated Biphenyls
PCB	=	Pollution Control Board
Pb	=	Lead
ppb	=	Parts per billion
ppm	=	Parts per million
ppt	=	Parts per thousand
POC	=	Particulate Organic Compounds
PO_4	=	Phosphate
PSP	=	Paralytic Shellfish Poisoning
RI	=	Republic of Indonesia
SAARC	=	South Asian Association for Regional Cooperation
SAREC	=	Swedish Agency for Research and Cooperation with Developing Countries
SEPA	=	Swedish Environmental Protection Agency
SEAFDEC	=	Southeast Asian Fisheries Development Center
SIDA	=	Swedish International Development Authority
STP	=	Standard Temperature and Pressure
THM	=	Trihalomethane
TSP	=	Triple superphosphate
TSS	=	Total suspended solids
UNDP	=	United Nations Development Programme
UNEP	=	United Nations Environment Programme
UNESCO	=	United Nations Educational, Scientific and Cultural Organization (Paris, France)
WPCF	=	Water Pollution Control Federation
WHOI	=	Woods Hole Oceanographic Institute
WWF	=	World Wide Fund for Nature/World Wildlife Fund
WHO	=	World Health Organization
WTO	=	World Tourism Organization
Zn	=	Zinc

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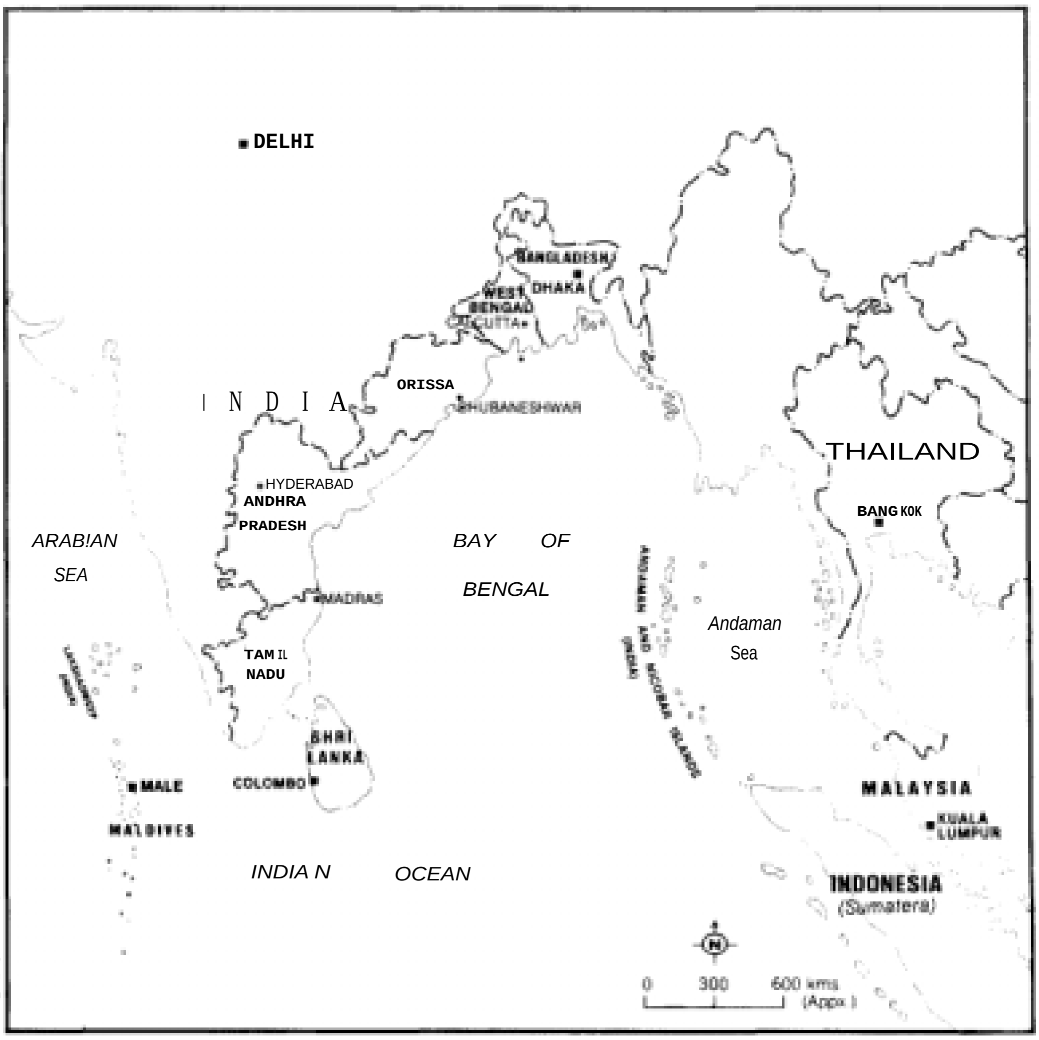
Fig. 1. The countries of the Bay of Bengal region



Cartography: TT Maps, Madras-44

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1. *INTRODUCTION*

Fisheries, with its supporting activities, provides a livelihood for millions of people in the Bay of Bengal region (see figure 1 on facing page). Fish is an important part of the diet of much of the population. It is also a valuable source of foreign exchange for many countries in the region. It is, therefore, important that the marine environment be used in a sustainable way and that the resource base is not damaged or destroyed.

Unfortunately, the coasts of the Bay of Bengal are deteriorating. The causes for this are:

- Siltation.
- Pollution.
- Uncontrolled coastal development.

Some parts of the coasts are particularly bad, affected by industrial and municipal effluents as well as by indiscriminate development of brackishwater culture systems. This poses a serious threat to the production of wild finfish and shellfish as well as to mariculture.

The damage done is often unintentional, being a consequence of

- bad planning,
- lack of basic knowledge, and
- little coordination between agencies and authorities.

The first step towards remedial action needs to be the collection of relevant data on the state of the coastal environment and the processes that are changing it. Unfortunately, the information about the effects of pollution, and other types of environmental degradation, on fish and fisheries *is* scattered, unsystematically recorded or not available in a comprehensible form in most areas. The Swedish International Development Authority (SIDA) in 1990-91 decided to support a project to assess the potential environmental threats to fisheries in the Bay of Bengal region.

The activities of the project started in April 1991 under the umbrella of the Bay of Bengal Programme (BOBP) and were executed by SWEDMAR, a unit of the National Swedish Board of Fisheries.

The objective of the project was to assess environmental problems by reviewing the existing information, analyzing available data and collating it as a fundamental information base.

1.1 *Methodology*

To obtain basic data on the marine environment of the Bay of Bengal, desk studies of the member countries were made and the countries were visited by the project expert as part of a study programme. To identify local and regional problems, local consultants were involved in the work. They analyzed and interpreted data from the authorities, agencies and research institutes and compiled the information acquired in country reports, which form part of this report. The issues to be discussed and elaborated were specified in the terms of reference given the consultants (see Appendix I).

A Workshop on Environment and Fisheries in the Bay of Bengal was held February 2 - 6, 1993, in Colombo, Shri Lanka, as the culmination of this multinational exercise. The workshop's agenda included:

- Country presentations by the country consultants.
- Studies of the marine habitats, coral reefs, mangroves and seagrass beds by invited specialists in order to provide an overview of their status, management and importance to fisheries.
- Remedial suggestions from invited scientists who offered examples of ways to mitigate the problems of the marine environment and make it more beneficial to fisheries.

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- A discussion to arrive at a consensus about problems, solutions and need for further Research and Development.

A list of the issues that were discussed and a consensus of the priorities is presented in Appendix III. These issues arose from the findings presented in the country papers, which are summarized in the following pages and presented in detail in subsequent country sections.

2. COUNTRY FINDINGS

2.1 Indonesia

- The west coast of northern Sumatera, adjacent to the Bay of Bengal, is still a comparatively unpolluted area. The east coast of this area, along the Straits of Malacca, does, however, have, in some areas around Lhokseumawe, Asahan and Deli Serdang, a deteriorated water quality due to industrial and municipal wastes. Organic compounds, heavy metals and coliform bacteria often exceed national standards for bathing and swimming as well as for the health of marine organisms. The concentrations of lead and cadmium in the tissue of molluscs have sometimes exceeded environmental standards. The concentrations of hydrocarbons in the Malacca Straits also sometimes exceed the limit of 5 ppm for marine organisms. The heavy use of the straits by oil tankers evidently has a negative impact on the water quality. There have been, of late, several large oil spills, following oil tanker accidents in the Straits.
- An ODA study of the mangroves of Sumatera compared remote sensing data from 1977 with that of 1989-90 and found that the primary mangroves along the east coast of Sumatera had diminished by 30 per cent, while the secondary mangroves had increased by almost 90 per cent during this period. The reason was that earlier cultivated land had been abandoned and the mangroves could recover. In 1977, there were about 300 ha of ponds, mainly for milkfish, in extensive *tambaks.* There are now 11,000 ha of ponds, mainly shrimp – an increase of almost 40 times! Only about 7 per cent of those new ponds occupy earlier primary mangrove forests, while about 15 per cent cover earlier cultivated land.

2.2 Malaysia

- Bacterial contamination seems to be a problem in the coastal waters of western peninsular Malaysia, with 50-90 per cent of the analyzed samples being above the limit for recreational purposes, namely 100 MPN/100 ml. Discharge of municipal sewage and wastes from piggeries are the reasons. Only the large piggeries can afford waste treatment.

  Turbid water and sedimentation from existing land management is another coastal problem and it could possibly cause more damage to fisheries than bacterial contamination. The diminished light penetration reduces primary production, which means lower growth rates of fish.
- A recent study of the rivers of peninsular Malaysia showed that about 50 per cent of them were heavily polluted, 10 per cent moderately polluted and only 40 per cent could be characterized as clean.

  Concentrations of heavy metals found in most of the rivers and coastal waters are well above proposed standards. Fortunately, the biomagnification is insignificant and all samples of residues in fish and molluscs are well under health limits. The same is true for pesticide residues that are well under the limit of acceptability for human consumption in spite of widespread and, often, indiscriminate use of pesticides. Oil and grease in the marine environment also exceed the standard for marine aquatic resources, with 75 - 100 per cent samples from the southern states above the limit. All samples from Penang and Kedah/Perlis were below the limit.
- Red tide is often reported from the Malaysian coasts, but only innocuous genera like *Noctiluca* have bloomed on the west coast. ***Hornellia marina,*** however, has caused fish and shrimp

kills in Johor in the south. Paralytic Shellfish Poisoning (PSP) has been reported only from Sabah. As the frequency of toxic algal blooms have increased in Korea and Japan significantly over the last decade, great care should be taken to prevent any similar development in Malaysia.

2.3 *Thailand*

Tin-mining used to be carried out on a very large scale in Thailand, with Phuket accounting for 10 per cent of the world production. Low prices on the world market have now reduced the activities considerably. Offshore dredging for tin sand has had negative impacts on primary production because of reduced light penetration. A study has shown that an area about 5 km square had a 50 per cent reduction of primary production. Any increase in tin-mining activities along the Andaman coast in Thailand would, consequently, have serious impacts on fish production.

— Mariculture has taken up about 400 ha along the Andaman coast, while mollusc beds cover 1030 ha. Shrimp farming has increased and production was 16,000 t in 1988. To avoid the pollution problems that occurred in the upper part of the Gulf of Thailand, regulations have been introduced that require treatment of waste water discharged by the larger establishments.

— The annual sustainable yield of commercial pelagic and demersal fish is estimated to be 50,000 t and 200,000 t respectively. The present catch is approaching these figures and there is a risk of overfishing.

— Urban development and the tourist industry have caused increased loads of organic compounds and bacterial contamination of the coastal waters, especially along the southern coasts and around Phuket. Monitoring by the Phuket Marine Biological Centre shows that the northern coasts are still rather clean, whereas the southern coasts show signs of environmental degradation. In general, however, the Andaman Sea is still rather unpolluted and clean, especially when compared with conditions in the Gulf of Thailand.

2.4 *Bangladesh*

– Several water resource development projects have been built recently in Bangladesh to protect the villagers from devastating floods and to increase foodgrain production. These have resulted in changes in the country's aquatic ecosystems and in its fish production. The free movement from freshwater to brackishwater has been hampered and the migration of *Hilsa* and other anadromous and catadromous species obstructed.

– The Sundarban mangrove forests in the southwestern part of the country cover almost 600,000 ha. It is the largest single compact mangrove resource in the world. An Overseas Development Administration (ODA), U.K, sponsored survey in 1985 showed that the standing volume of the main species had declined alarmingly in the Sundarbans since the previous inventory 20 years earlier. Overcutting and overestimation of regeneration times were reasons for a smaller inventory being recorded. The Farakka Barrage across the border, which diverts as much as 40 per cent of the dry season flow of the Ganga, causes increased salinity, and this is another reason given for the impaired growth of the mangroves.

There is growing conflict among mangrove forests, shrimp farms and rice cultivation. The Chakaria Sundarbans in the delta of the Matamuhari River, in Cox's Bazaar District in eastern Bangladesh, has been virtually cleared for aquaculture. But the very low productivity of shrimp – only 50 kg/ha/yr – indicates that the conditions are not optimal. On the other hand, felling of the mangrove forests has entailed loss of protection from cyclones and tidal waves, increased salinity due to tidalwater being retained longer, and greater evaporation and acidification of surface water. The conversion of mangrove forests for aquaculture would appear to be uneconomic if the potential yields are compared with the combined yields, now both lost, of the forests and the traditional fisheries.

– Nearshore fisheries are overexploited. The extensive use of destructive set bagnets is believed to be responsible for this in the estuarine and neritic waters. In the absence of an adequate number of hatcheries, the collection of wild tiger shrimp post-larvae in estuaries and nearshore waters by this fishing method leads to destruction of other shrimp and finfish species. Estimates indicate that more than 1,600 individuals of nontarget macro-zooplankton are killed while collecting one single tiger shrimp post-larva.

– Bangladesh is not an industrialized country – only about a tenth of its GDP comes from this sector. But industrial production has grown substantially, by about 50 per cent, over the last few years. Since there is no treatment before waste products are discharged, local environmental degradation has occurred. Fish kills and accumulation of toxic substances in fish and shrimp flesh have been recorded in the countries five industrial zones: Dhaka, Chittagong, Narayanganj, Khulna and Ghorashal.

  Dhaka has a sewage treatment plant, but it can only take care of about a fifth of its population's wastes. Other big cities have no waste treatment facilities at all. Most freshwater in Bangladesh is, therefore, badly polluted arid huge quantities of untreated wastes find their way through open drains, canals and rivers into the Bay of Bengal.

– Since the introduction of HYVs, the use of fertilizers and pesticides have increased many fold (more than four times since 1977). There are 340 different brands of pesticides in use, with organochlorides, organophosphorus and carbamates being their major components. The annual transport of pesticides into the Bay of Bengal has been estimated at 1800 t. There are few studies on the impact of agrochemical residues on fisheries, but toxic residues have been recorded in both shell and finfish.

– Siltation at the mouth of the Ganga-Brahmaputra-Meghna river systems is actively reshaping the coastal and nearshore habitats. As the rate of sedimentation has increased exponentially during the last century, this is believed to have had a great impact on fisheries. Change in bottom topography, increased turbidity, entrapment of pollutants are some of the detrimental effects.

– Existing environmental laws cover marine pollution control, use of pesticides, fishing and conservation of fishery resources, shipping etc. But the enforcing mechanism is inadequate, due to institutional, strategic and financial constraints.

2.5 India

The situation in the four Indian states which have a Bay of Bengal coastline is as summarized below:

WEST BENGAL

– The Hugli Estuary in West Bengal is probably the most polluted estuary in the world. There are 96 major factories from Nabadwip inland to the bar mouth, discharging almost half a billion litres a day of untreated wastes. Almost everything producing hazardous wastes is to be found in this industrial concentration : Pulp and paper mills, pesticide manufacturing plants, chloralkali plants, distilleries, thermal power plants and factories manufactnring yeast, rayon, cotton, vegetable oil and soap, fertilizers, antibiotics etc. Bioassays have shown that cotton effluents are very toxic to ***Macrobrachium.*** Varnishes, rubber, and rayons are deleterious to shrimp. Distillery wastes cause most damage to ***Puntilus sophore*** and Mystus ***vittatus.*** The cycle rim factory wastes are highly toxic to ***Carla catla*** and ***Labeo rohita.***

  A rather comprehensive study of the environmental conditions in the Ganga and the Hugli Estuary was made in 1960. When a similar study was made in 1988, it showed a clear deterioration in conditions: chloride concentrations and alkalinity had increased, while oxygen had decreased. But the nutrients too had increased significantly. And, surprisingly, there were no significant changes in the chemical parameters in the estuary during the two decades. The regular flushing by tidal water had evidently taken most wastes out to sea and the estuary itself had not changed significantly.

  A look at the statistics for fish catches is still more intriguing. The catches in the Ganga have fallen from 50.3 kg/ha/year in 1960 to less than 20 kg now. Of the 600 species found in the Ganga, 100 are endangered. But in the estuary, the catches have increased:

  – 1960: 7.5 t; 1970: 14.6 t; and 1980: 24.0 t!

Most of the increase has been from the outer zone of the estuary. Scientific measurement of the primary production shows that it is a real increase in production of fish and not due to increased fishing effort. If average primary production is set at 1 in the Ganga, it is 0.5 in the inner and middle zones, but 2 in the outer zone. There is evidently damage in the inner zones due to pollution, but the increased loads of nutrients have been beneficial to fish production in the outer zone ! Almost 200 kg of fish is produced per ha per year in the estuary and only 30 kg is harvested. The fishing could, consequently, increase significantly without endangering the stocks.

– The sewage treatment system in Calcutta is most interesting. Almost all municipal wastes pass through one or two systems of fish ponds before being released into the Hugli River.

  The Mudiali fishermen's cooperative is one of the 80 cooperatives in Calcutta. By getting the industrial waste water to pass through an ingenious system of ditches dense with a vegetation of water hyacinths, *Eichhornia* and *Valesneria,* they reduce the toxic compounds and use the treated water to produce 5-7 t of fish per hectare without any additions of feed or fertilizers! By refining this method, it will be possible to produce 15-20 t of fish/ha/yr.

  The treated waste water is also used for irrigating and fertilizing gardens and orchards. The income from the fish ponds, together with that from vegetables and fruit, supports about 2000-3000 people on 65 ha. The area was earlier wasteland belonging to the Port authorities who used it for waste disposal.

  Most cooperatives and private enterprise fishponds in Calcutta take their waste water from the sewage canal that mainly contains the municipal waste. Most of the industrial waste is led into a separate storm drainage canal. The mercury and pesticide residues in the flesh of fish grown in the ponds, as well as the bacterial contents, are below WHO recommendations.

ORISSA

– More than 80 per cent of the population here earn their living from agriculture. Orissa is not very industrialized, but is very rich in natural resources, its mineral deposits equal to those of Western Europe.

  The marine environment of Orissa is still in good condition, but algal blooms occur occasionally. They are mainly caused by diatom genera, like *Asterionella, Chaetoceras* and *Skeletonema,* which are innocuous to marine organisms.

  A marine monitoring programme was started in the state in 1990. Since then, bottom samples have been collected along five transections at the main river mouths twice every year. Rather large amounts of mercury and lead have been found far from possible industrial sources. Complicated current patterns evidently transport these pollutants long distances. Analyses of mercury in fish downstream a chloro-alkali industry in the Rushikulya Estuary showed values well above the of 0.5 mg/kg w.w. limit recommended by WHO.

– Significant environmental degradation has taken place in Chilika Lake in southern Orissa. The main problems here are the large siltation load, causing decreased water exchange with the sea, and the proliferation of weeds in the lake. No significant change in fish catches has yet been demonstrated, but an increase in freshwater species has been observed.

ANDHRA PRADESH

– The annual use of pesticides, including such toxic types as DDT, CHC endosulphan, lindan and heptachlor, exceeds 26,000 t in Andhra Pradesh. This is a third of the total used in India. Residues are found in shrimp, bivalves, gastropods, molluscs and fish. But, considering the amounts released, the concentrations are surprisingly moderate. It is evident that bio-magnification in the tropics is lower than in cold climates. One reason could be that pesticides are volatilized into the atmosphere. A better understanding of the relevant food chains and associated conditions connected with pesticides in the tropical aquatic environment is badly needed.

  A particularly appropriate area for such studies would be the Kolleru Lake, located between the deltas of the Godavari and Krishna Rivers. The drainage area of this lake has

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been identified as the area where pesticides and fertilizers are most intensely used in Andhra Pradesh, and perhaps even in India and the tropics.

- The marine environment in Andhra Pradesh is still in a good condition and no great threats to fisheries have been identified.

TAMIL NADU AND PONDICHERRY

- Tamil Nadu is a fairly heavily industrialized state, having over 12,000 industrial units of which about 80 per cent are located close to the coast. There are three major industrial concentrations on the coast, Madras, the Union Territory of Pondicherry and Tuticorin. There are also 2,200 tanneries in the state, accounting for more than 80 per cent of the total leather production in India.

  The industrial pollution is worst in the Madras area, with high concentrations of heavy metals in water and sediments. Surprisingly, though, the concentrations of metals in fish and seafood are still well below health limits.

  Bacterial contamination of seawater is most prominent in the coastal areas around Madras, but almost all samples taken close to the shore in Tamil Nadu indicate bacterial pollution. A study should be made on how to improve the water quality. The bad water quality along the coasts is a serious health threat to the coastal population and the establishment of a tourist industry.

- Electricity is generated from coal-fired thermal stations (70 per cent) and nuclear plants (10 per cent). The coal-fired units cause damage to fisheries through the elevation of water temperatures and the discharge of fly ash slurry. The environmental effects of nuclear plants are little known and better studies are required. Statistics on the discharge of radioactive tritium shows an increasing trend, which has caused concern. It is planned to construct a new nuclear plant near Tirunelveli in southern Tamil Nadu, and this may increase the radioactive discharges significantly.

2.6 Shri Lanka

- The open sea appears to be unaffected by pollution, even though Colombo Municipality discharges sewage into the coastal waters by means of two ocean outfalls. Sometimes, signs of oil pollution are seen in increased occurrence of tar balls along the southern beaches. But no signs have been found of the pelagic fishery being influenced by pollution or environmental degradation. The main marine problem, however is coral-mining, which has degraded many coral reefs along the coasts and caused severe local erosion.

- Many lagoons and estuaries have been damaged by overfishing, sedimentation and other types of environmental degradation. Industrial discharges have been detrimental to fisheries in the Lunawa Lagoon, south of Colombo, where there are regular fish kills and the fish has a tainted taste. Fish kills have also been reported from the Kelani River, due to ammonia discharges, and downstream the Embilipitiya pulp and paper mill. Irrigation schemes have diverted freshwater to some lagoons in the south, like Kalametiya and Rekewa, and significantly reduced the production of shrimp and fish.

- Most industries in Shri Lanka are situated in the Greater Colombo area and only a few have inhouse waste treatment facilities. All new industrial activities will have to get a licence according to the National Environmental Act, which requires installation of treatment facilities. The industrial zones established under the Greater Colombo Economic Commission have been provided with central waste treatment facilities that are regularly monitored.

- Coastal degradation caused by unplanned utilization of resources, like municipal development, agriculture and tourism, has caused local pollution and sedimentation problems. Pollution of coastal waters, however, has had negative effects on shrimp farming. The use of pesticides is high in Shri Lanka, but the environmental impacts have not been studied.

- Shri Lanka is fairly well equipped with legal provisions to protect the marine environment. Enforcement is, however, inadequate. NGOs in Shri Lanka play a vital role in mobilizing people to improve the environment. This growing awareness among the general public is probably the best way of strengthening law enforcement and the monitoring of the environment.

2.7 Maldives

- Sewage disposal is one of the most challenging issues in the more densely populated islands. Septic tanks can leak and destroy the groundwater – the only source of freshwater – and lack of space makes it impossible to construct sewage treatment plants. The only practical solution, consequently, is to discharge the sewage into the sea, and that is a potential danger to coral reefs and marine water quality, though water currents, wave action and other water movements, it is hoped, might act as mitigative factors. In thinly populated islands, where only small amounts of sewage are discharged into huge areas of water, this solution is certainly adequate, but sewage discharge poses a serious threat in Male and other densely populated islands.

  The potential threats from this practice are:

  - Eutrophication, which causes algal blooms and algal growth on coral (thereby killing them) changes fish species composition and bicmass, lowers diversity etc.
  - Oxygen depletion, causing fish kills.
  - Silt formation, smothering coral and killing them.
  - Microbial pollution, causing health threats to swimmers and contaminating seafood.

- When a reef flat is reclaimed, the renewable fish resource is lost for ever. There is no production of coral, aquarium fish, giant clams, bait fish and other commercially valuable resources. The reclamation of a sandy lagoon, however, has less environmental and economic effects. Dredging and harbour construction also cause sedimentation and turbid water that can kill coral and change fish species composition.

- While coral- and sand-mining, land reclamation and sewage discharges cause local environmental degradation in the Maldives, they have negligible effects on the deep reef habitats and the open sea, the grounds for commercial fishing. No reduction in overall catch of commercial reef fish or open water fisheries can be related to environmental degradation in shallow reef habitats. There are also no other obvious threats to the open water fisheries. But reef-associated organisms are susceptible to over-exploitation. Present threats to the fisheries are connected with this problem rather than with pollution or other forms of environmental degradation.

3. CONCLUSIONS

The impact of environmental degradation on fisheries in the Bay of Bengal is, as yet, slight or, at worst, moderate. Only the coastal areas, lagoons and estuaries in some parts of the region have been affected. Algal blooms are rare and there have been few outbreaks of Paralytic or Diarrhoeic Shellfish Poisoning (DSP) or other such diseases. Even where high concentrations of pesticides and heavy metals have been found in the water, or in the sediments, the residues in fish and other marine organisms are still below recommended health limits. The threats that have been well documented are summarized below.

Sewage pollution is of particular concern in all countries around the Bay of Bengal. Wastes, without any treatment, are directly discharged into the waters of the densely populated coastal regions. Rivers, lakes, lagoons, bays etc are anoxic for shorter or longer periods during the year, causing fish kills. In addition, serious health problems connected with such pollution are also prevalent. About three-quarters of all diseases in India are caused by waterborne micro-organisms. The most promising remedy suggested is sewage-fed fish farming and biological treatment in oxygen ponds or ditches. These methods offer a revenue in addition to serving as a waste-treatment process.

Some farming methods have been developed, but others will have to be explored to suit differing local conditions.

Siltation, causing reduced primary production and obstruction of the outlets of lagoons and estuaries, is another major problem. Large amounts of fertile soils are lost due to existing agricultural and forestry practices. Some studies indicate that the sedimentation loads in the large rivers entering the Bay of Bengal have increased a hundred times in the last century. This reduces carrying capacity, both in the terrestrial and aquatic habitats, and the long-term consequences can be disastrous in view of the continued population growth. It is, therefore, important that this problem is at least mitigated, if not solved, as soon as possible.

Destruction of marine habitats has also been causing great concern over the future of fisheries in the region. Coral reefs and mangroves are degraded in all countries bordering the Bay and many coastal areas are overexploited. The delicate balance between marine life and such coastal habitats as lagoons, estuaries, mangroves and coastal wetlands is disturbed almost everywhere. Only small pockets along the west coast of Sumatera and the northern Andaman Sea coast of Thailand are still pristine to an extent.

Overexploitation of the marine living resource and the environmental **impact of aquaculture** are also major concerns of the region and need new management plans, a closer look at habitat destruction and a review of fishing methods.

The pollution problems in the Bay of Bengal, as prioritized by the countries concerned, and the suggested remedies for them are tabulated on the facing page. Scientific research on many of these problems are needed if the suggested remedies are to be effective.

On the more positive side is the fact that, in spite of large discharges and lack of treatment of industrial wastes, pesticide residues and fertilizer leakages — all dangerous to the environment in many ways — residues of heavy metals and pesticides seldom exceed health limits in fish and other seafood caught in the region. The tropical aquatic food web seems to be more beneficient than in temperate habitats. But studies have shown that young herbivorous fish here often have higher concentrations of mercury than the top predators, which, in cold climates, always have the highest toxic residues. This phenomenon deserves further scientific research.

The present situation in the Bay of Bengal is not too alarming, but this is no reason for complacency; it only means that there is still time for appropriate action to be taken to, at least, preserve the Bay as it is, if not improve it.

Coastal planning must be strictly vetted and rigorously implemented. Ways must be found to curb not only the loss of valuable fertile soils by the side of rivers inland, but also to prevent these soils making coastal waters turbid and silting estuaries and lagoons. Better management of fisheries, by preventing overfishing, is also necessary to ensure that the limited resources are sustainable.

The growing aquaculture industry is constrained by different types of environmental degradation of the coast, but aquaculture has its own environmental impact and could itself suffer from it. Lessons must be learnt from Taiwan and Thailand, which have had large economic losses due to these reasons, if future problems in the Bay are to be avoided.

Pollution problems in the Bay — and some remedies for them

Country	Problems (as prioritized)	Remedies
Indonesia	Oil, sewage and pesticide pollution. Mangrove, coral reef and sea grass destruction. Overexploitation.	Better data collection analysis. Seawater standards. Waste recycling. Waste disposal guidelines. EIA implementation. Resource use planning base on sustainable use. Education and community involvement. Legislation and enforcement.
Malaysia	Sewage, oil and siltation pollution and agro-industrial waste. Mangroves, coral reef and seagrass destruction. Overexploitation.	
Thailand	Sewage pollution. Mangrove, coral reef and seagrass destruction. Siltation and agro-industrial waste. Over-exploitation.	
Bangladesh	Dumping of untreated sewage into rivers, estuaries and neritic waters Destruction of mangrove and other forests. Siltation causing turbid water and leading to formation of sandbars and closure of estuary mouths. Discharge of industrial effluents of various origins. Overfishing — capture fisheries and shrimp seed collection. Release of agrochemicals — fertilizers and pesticides. Solid water disposal in aquatic ecosystems.	Promote quality research relating to environmental issues. Creation of data bases. EIAs should be made before implementation of activities which might effect the environment. Need for the creation of chartered environmental auditors who are authorized. Common standards for different aquatic environments should be introduced. Regular monitoring of aquatic ecosystems should be introduced and all data must be published. Exchange of personnel information should be encouraged, particularly amongst the countries of the BOB region.
India	Dumping of untreated sewage into rivers, estuaries and neritic waters. Discharge of industrial effluents of various origins. Siltation causing turbid water and leading to formation of sandbars and closure of estuary mouths. Release of agrochemicals — fertilizers and pesticides. Aquaculture practices causing environmental degradation. Pollution, generated by power plants. Solid waste disposal in aquatic ecosystems. Overfishing — capture fisheries and shrimp seed collection. Destruction of marine habitats, such as coral reefs, mangroves and seagrass beds.	
Shri Lanka	Coral-mining. Sewage/industrial/aquaculture and agriculture discharges Solid waste disposal Construction of unplanned structures on the coast. Sand-mining. Mangrove destruction. Overexploitation of marine living resources. Land reclamation/siltation. Oil pollution Dredging.	Control land filling. EIA before dredging. Develop management plans for M.S.Y. Remove subsidies on boats and gear. Control over destructive fishing methods. Strict enforcement of forest ordinances. Rehabilitation of mangroves. Water quality monitoring in chronic areas of oil pollution. Implementation of coastal zone management plan. Guidelines for resort development. Education and awareness. Strict enforcement of laws. Feasibility studies on locations available for sand-mining. Support to sewage treatment disposal plan proposal in critical areas. Improving existing sewage farms and ensuring better management. Improving collection/handling systems of solid waste. Establish suitable land fill sites.
Maldives	Coral-mining. Sewage/industrial/aquaculture and agriculture discharges. Solid waste disposal. Overexploitation of marine living resources. Land reclamation/siltation. Sand-mining. Dredging. Construction of unplanned structures on the coast. Mangrove destruction. Oil pollution.	

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APPENDIX I

Terms of Reference

For the consultants who conducted the surveys on environmental threats to marine fisheries in the Bay of Bengal

1. The consultant shall collect relevant data on the environmental situation in the marine environment in the Bay of Bengal.
2. The objectives of the survey shall be to obtain baseline information on the present environmental situation by collecting the following data:

   RESEARCH AND INSTITUTIONS

   – Review of existing publications and reports on the marine environment published by environmental and fisheries authorities, universities, NGOs etc.

   – Present a list of institutions and authorities engaged in environmental research and monitoring.

   – Present a list of laboratories that are making environmental analyses, with a short description of facilities (types of chemical and biological analyses, equipment for analyses of pesticides, heavy metals etc.) and name and address of responsible scientist in each.

   – Review of ongoing projects on marine environment. Foreign supported research should also be included.

   – Present a map with main industries, cities, municipalities etc. that are discharging hazardous waste, sewage etc. that are a threat to coastal fisheries along the coasts of the Bay of Bengal. Information of production per year, type of waste treatment and amounts of waste discharge, when production started etc. is essential. Both activities located at the coast and inland should be included.

   – Describe ongoing landbased activities that are influencing water quality, like the use of pesticides in agriculture, types of forestry practices that can cause siltation, mining, energy production etc.

   – Present recent reports of fish kills, algal blooms, cases of shell fish poisoning etc.

   ENVIRONMENTAL LEGISLATION

   – List of environmental laws regulating threats to marine environment.

   – Description of enforcement of environmental legislation. What authority is checking waste discharges, in the case of a serious accident with a hazardous transport of waste what authorities are responsible for appropriate action, who are contacted when a fish kill is reported etc?

   MARINE HABITATS

   – Map or description of mangrove forests, coral reefs, lagoons and estuaries and seagrass beds and their present and future status.

   OTHER ORCANIZATIONS engaged in protection and studies of the marine environment

   – Name and addresses of NGOs engaged in issues concerning the marine environment.

   – Recent articles in local papers and magazines on the marine environment.

3. A joint report shall be furnished as per format suggested by the Bay of Bengal Programme as far as possible.
4. The report should result on an improved knowledge and understanding of environmental problems and constraints adversely affecting fisheries in the Bay of Bengal.
5. The report will provide baseline information for a workshop on the environmental situation in the Bay of Bengal in Penang in early 1993.
6. The survey and report must be completed by the 1st of July 1992 at the latest.

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APPENDIX II

The area reports received

I. **Threats to Marine Fisheries in the Bay of Bengal — (Indonesia).**
Rokhmin Dahuri and Reza Shah Pahlevi
Environmental Research Centre, Bogor Agricultural University, Kampus IPB Darmaga, Bogor, Indonesia.

2. **A Survey on Environmental Threats to Marine Fisheries in the West Coast of Peninsular Malaysia.**
Choo Poh Sze and Ismail Ishak
Fisheries Research Institute, Jalan Akuarium, I 1700 Glugor, Penang. Malaysia.

3. **Review of the Environmental Situation of Andaman Sea Coastal Water, Thailand.**
Prawin Limpsaichol
Phuket Marine Biological Centre, P 0 Box 60, Phuket 8300, Thailand.

4. **A Review of the State of Environment Relating to Marine Fisheries of Bangladesh.**
Nuruddin Mahmood
Institute of Marine Sciences, University of Chittagong, Chittagong. Bangladesh.

5. **Environment Situation and Threat to Marine Fisheries in West Bengal.**
P K Chakraborthy
Central Inland Capture Fisheries Research Institute, Indian Council of Agricultural Research, Barrackpore 748 101. West Bengal.

6. **A Review of the State of the Marine Environment in Relation lo Fisheries in the Bay of Bengal: Orissa Coast.**
R C Panigrahy
Department of Marine Sciences, Berhampur University, Berhampur 760 007, Orissa

7. **Environmental Pollution in Rushikuliya Estuary and Chilika Lake.**
Rajashree Gouda
Department of Marine Sciences, Berhampur University, Berhampur 760 W7, Orissa.

8. **Report on the Study of Environmental Threats to Fisheries in Orissa.**
Sirajuddin Khan
Directorate of fisheries, Cuttack, Orissa.

9. **Report on the Study of Environmenlal Threats to Fisheries in Andhra Pradesh.**
V Sree Krishna
Consultant/Bay of Bengal Programme, 91 St. Mary's Road, Abhiramapuram, Madras 600 018.

IO. **Report on the Study of Environmental Threats to Fisheries in Tamil Nadu and Pondicherry.**
Joseph Jerald
Consultant/Bay of Bengal Programme, 91 St. Mary's Road, Abhiramapuram. Madras 600 018.

I 1. **Marine Environmental Pollution and its Impact on the Fishery Resources of Shri Lanka.**
Hemantha Dassanayake
NARA, Crow Island, Mattakuliya, Colombo IS, Shri Lanka.

12. **Potential Environmental Threats to Fisheries in Maldives.**
Hassan Shakeel
Marine Research Section, Ministry of Fisheries and Agriculture, Male.

APPENDIX III

Issues for discussion at the workshop and priorities agreed on

1. What are the main marine environmental problems in your countries? Try to agree on how to prioritize them for urgency of action.

2. Are there any areas where you feel that environmental problems do exist but no scientific proofs are available? Identify areas where more research is necessary to assess size and type of damage and to advise appropriate remedies. (Geographical areas).

3. Discuss and suggest types of solutions to marine environmental problems in your countries

4. Are there any areas where you feel that more scientific research is necessary to prevent future environmental damage to fisheries and coastal communities. (General issues such as types of algal blooms, health problems connected with toxic marine organisms, polluted water etc.)

A variety of craft in an Indonesian fishing village in Langkat District.

Northern Sumatera, Indonesia

by

Rokhmin Dahuri
Environmental Research Centre, !PB, Bogor, Indonesia

and

Reza' Shah Pahievi
Directorate General of Fisheries, Indonesia

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4. *INTRODUCTION*

Marine fisheries play an important role in the economic development of Indonesia. They provide employment to thousands who live on the coasts, besides being a primary source of animal protein; fish is the most affordable source of animal protein in the diet of most people in the country.

This study is intended to collect baseline information on the present environmental situation in the Bay of Bengal region of Indonesia in order to assess whether any environmental threats exist to the marine fisheries in this area. The results of the study, it is expected, could be used as a basis for further detailed environmental research in relation to marine fisheries as well as for marine environmental management in Indonesia.

The area of this study covers the marine waters under the jurisdiction of three Indonesian provinces, namely Aceh, North Sumatera and West Sumatera (see Figure 2).

Fig. 2. Marine waters of northern Sumatera

Environmental threats in three categories were apparent in the area studied. Namely:

- Pollution from both marine and land-based activities, particularly near industrial urban centres, which contribute substantial amounts of pollutants to the coast waters.
- Physical habitat degradation, such as coral mining, excessive mangrove conversions or cuttings, and fish blasting.
- Overexploitation of marine fisheries resources.

5. *MARINE HABITATS*

Indonesia, the largest archipelagic state in the world, stretches 5,000 km from the Indian Ocean to the Pacific Ocean and straddles the equator over a north-south distance of *2,500* km. Indonesia has an area of 5 million km2, of which 62 per cent is sea area within the 12 m limit. Under the 1982 Law of the Sea Treaty, Indonesia's EEZ (Economic Exclusive Zone) has been increased by 2.7 million km2 of sea area. Almost half Indonesia's territorial seas are underlaid by the continental shelf (see table alongside).

Land and sea territorial area of Indonesia

No.	*Entity 7*	*Area (milion km2)*	*Remarks*
1	Indonesian territory (12 nm limit)	5.0	
2.	Territorial seas	3.1	62 per cent of total Indonesian territory
3.	Territorial land	1.9	
4.	Enclosed marine waters	2.7	87 per cent of total seas
5.	Open ocean waters	0.4	13 per cent of total seas
6.	Continental shelf waters	1.5	47 per cent of total seas
7.	EEZ	2.7	

Source Polunin, (1983)

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Indonesia's coast is 81,000 km long, the second longest coastline in the world after Canada's (Soegiarto and Polunin, 1982). The coast is endowed with rich and varied natural resources, including both living resources *(e.g.* fish, mangrove forests, seagrass beds and coral reefs) and nonliving ones, like oil and gas, iron ores, tin and bauxite.

As far as living resources are concerned, the Indonesian part of the Bay of Bengal is one of the richest coastal/marine areas in the country. Various marine habitats, such as mangroves, seagrass beds, coral reefs and estuaries exist along the Straits of Malacca as well as on the west coast of Sumatera.

5.1 Mangrove forests

Mangroves are found in nearly all parts of Indonesia (Burbridge and Maragos, 1985). The country has more mangroves than any other country (FAO, 1985). The total area of mangroves in Indonesia has been estimated at between 1.6 million ha and 6 million ha. It is generally accepted that Indonesia has approximately 4.25 million ha of mangroves (see table alongside), a substantial acreage considering that 6-8 million ha is the estimated acreage of mangroves worldwide (FAO, 1982).

Information on mangrove forests in the study area is still poor. Aceh and North Sumatera Provinces have *54,335* ha and 60,000 ha of mangrove forests respectively. Although there is no data for the extent of mangroves in West Sumatera Province, some coastal areas in Pesisir Selatan and Pasam Districts nurture mangroves.

In the island of Sumatera, most mangroves grow along the east coast, which is ecologically better suited for growth of mangroves than the west coast. One of the five basic requirements for mangrove growth is a deltaic coast with estuaries where soft mud, composed of fine silt, and clay rich in organic matter are available for the growth of seedlings (Walsh, 1974). Such conditions exist extensively on the east coast of Sumatera. However, in the study area, mangrove stands were found on both coasts (see Figure 3 on facing page).

Mangroves in Indonesia have a greater species diversity than in other tropical areas, about 90 species being found (Nontji, 1987). Mangrove species found in the study area mainly belong to the families *Rhizophoracea, A vicenniaceae* and *Sonneratiaceae* (field observation, 1992).

Distribution of mangrove areas in Indonesia

Province	*Estimated*	*% of Total mang area*
SUMATERA		
Aceh	54,335	
North Sumatera	60,000	
Jambi	65,000	
Riau	276,000	
South Sumatera	195,000	
Lampung	17,000	
Subtotal	667,335	15.7
KALIMANTAN		
West Kalimantan	40,000	
Central Kalimantan	10,000	
East Kalirnantan	266,800	
South Kalimantan	66,650	
Subtotal	383,450	9.0
JAVA AND BALI		
DKI Jakarta	95	
Central Java	13,577	
West Java	28,513	
East Java	7,750	
Bat	1,950	
Subtotal	51,885	1.2
NUSA TENGGARA		
West Nusa Tenggara	3,678	
East Nusa Tenggara	1,830	
Subtotal	5,508	01
SULAWESI		
South Sulawesi	66,000	
Southeast Sulawesi	29,000	
North Sulawesi	4,833	
Subtotal	99,833	2.3
MALUKU	100,000	2.4
IRLkN JAVA	2,943,000	69,3
Total	4,251,011	100

Source; FAO, (1985)

The mangroves are generally in good condition, except in coastal areas where oil and gas as well as *tam bak** development has taken place.

Activities that threaten the existence of mangroves in Sumatera include:

- Conversion of land for other purposes, like *tambaks,* industrial sites and settlements.
- Excessive harvesting of mangrove wood for fuel, poles, timber and chip production.
- Pollution from domestic, petrochemical and industrial wastes.
- Sedimentation, due to poor upland management.

* Brackishwater shrimp/fish ponds.

The most serious of these activities appear to be the conversion of mangrove areas, particularly into *tambaks,* and over harvesting. The table below shows estimated areas of *tambaks,* that were previously under mangrove in the three provinces under study. An extensive conversion of mangroves into *tambaks* has taken place in Aceh Province, particularly along its east coast. Almost 70 per cent (35,988 ha) of the total area of mangroves in Aceh had been converted into *tambaks* by the end of 1990. Whereas in 1979 the total *lambak* area in North Sumatera was only 839 ha (Burbridge *et a!.,* 1988), by 1990 it had become 7581 ha. In West Sumatera Province, *tambaks* only covered an area of 11 ha in 1990.

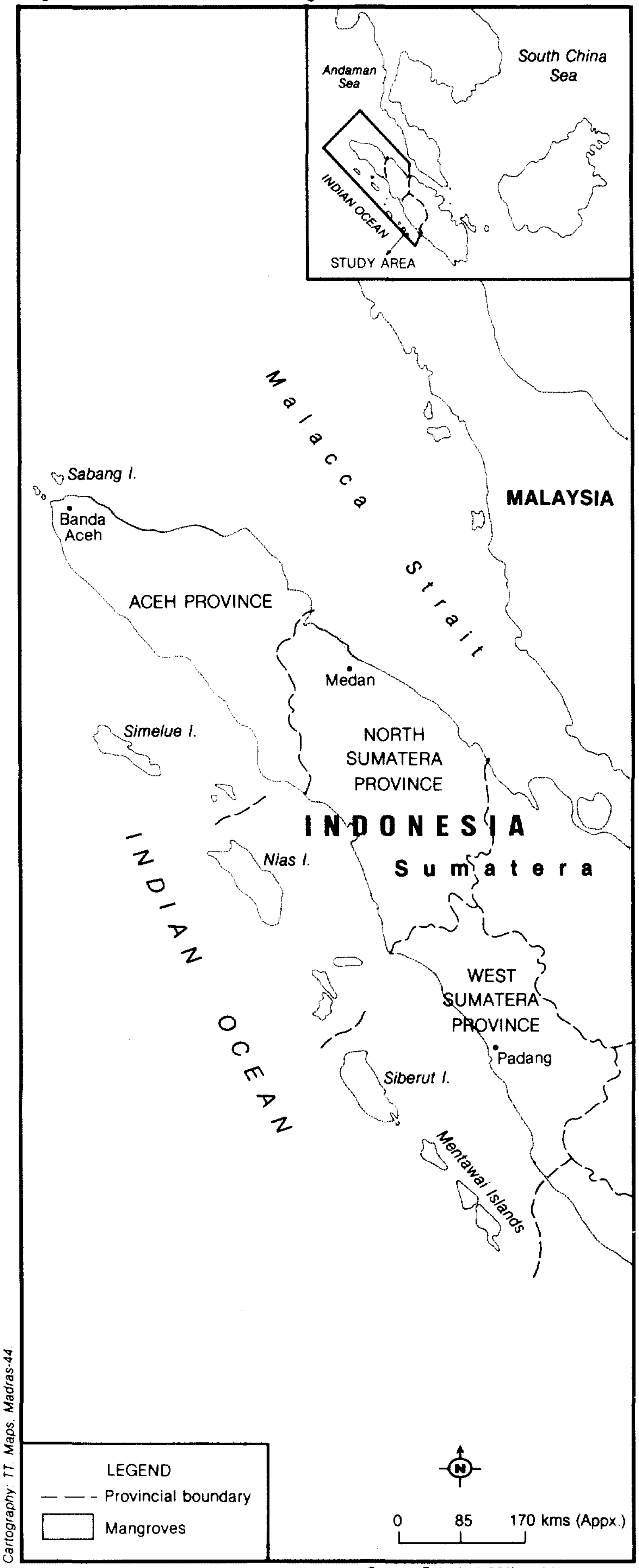
Estimated areas of brackishwater ponds in the study area, 1990

Province	*Estimated area (haj*
ACEH	35,998
East coast	35,753
Banda Aceh	538
Aceh Besar	573
Pidie	4,282
North Aceh	15,516
East Aceh	14,836
Sahang	9
West coast	245
West Aceh	238
South Aceh	
NORTH SUMATERA	7,851.1
East coast	7,354.8
Labuhan Bats	179
Asahan	1,966.7
Deli Serdang	1,705.1
Langkut	3,016.5
Medan	487.5
West coast	226.3
Central Tapanuli	226.3
WEST SLIMATERA	11.3
Pesisir Selatan	
Padang Pariaman	8.3

Source. Population and the Environment Bureaux: Aceh Prov. (1992), North Sumatera Pros. (1992), and West Sumatera Pros, (1992)

Mangroves are essential for the supply of nutrients, to serve as nursery and spawning grounds, and to protect coastal land from wave and storm actions. But the

Fig. 3. The distribution of mangrove forests in northern Sumatera



Cartography: TT. Maps, Madras-44

Source: Polunin (1983) and Nontji (1987)

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local population values mangroves only for its produce that can be marketed, such as wood and crabs. Mangrove areas are, therefore, generally considered as low value or even 'waste land'. The actual value of mangroves has not been considered in any economic analysis or evaluation of development projects.

Pollution, particularly from oil and gas as well as petrochemical industries, have degraded mangrove ecosystems along the coast of the Straits of Malacca since the early 1970s. Extensive damage occurred after an oil tanker (*Sho wa Maru)* spill in the Straits in 1975 (Soegiarto, 1982).

5.2 Seagrass, algae beds and coral reefs

Seagrass and algae (seaweed) are deliberately lumped together, because seaweed are common in many seagrass beds, including such sandproducing genera of green algae, as *Halimeda* sp. and *Neomeris* sp. (Nontji, 1987). Green, red, brown or bluegreen algae are also common on shallow coral reef flats and frequently occur in mangroves, estuaries and even in brackishwater shrimp/ fish ponds (Burbridge and Maragos, *1985).* Seagrass beds frequently occur landward of coral reefs, where they are protected from heavy wave actions.

Information concerning both the extent and conditions (structure, species composition, ecology etc.) of seagrass and algae beds in Indonesia is very scarce. Fisheries Departments at the provincial level in Aceh, North Sumatera and West Sumatera, have neither the interest nor the capability to collect such data (due to constraints mainly on budget and human resources).

In interviews with the Provincial Fisheries Department and Environmental Studies Centres in these three provinces in 1992,

Fig. 4. The distribution of coral reefs and algae beds in northern Sumatera

Cartography: TT. Maps, Madras-44.

Source. Nontji (1987)

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it was learnt that nearly all seagrass and algae beds and coral reefs are on the west coast of the study area (see Figure 4 on facing page). Coral, seagrass and algae require clean (unturbid) waters, and these exist only there.

Most of the coral reefs around Sumatera are fringing reefs, *i.e.* growing out from the land. However, atolls and barrier reefs are found between the west coast of Sumatera and the islands of Simeulue, Nias and Mentawai (Whitten, et *al., 1984).*

The coastal waters of West Sumatera Province have considerable potential for producing algae. *Gelidium* spp. (Nontji, 1987). *Eucheuma* sp. and *Gracilaria* sp. are found along the west coast of Aceh and North Sumatera Provinces.

Several human activities have been detrimental to coral reefs and the associated seagrass and algae beds. The use of explosives to capture reef fish and to mine coral are probably the most significant and widespread negative factors. The use of poisons, collecting coral rock from reef flats, sedimentation and pollution also have negative impacts.

In the Padang District of West Sumatera Province alone, coral reefs damaged due to coral-mining, fish-blasting and sedimentation on account of poor upland management practices amounted to about 64,000 ha in 1991 (Bureau for Population and the Environment of West Sumatera Province, 1992). Explosives have also been used to capture reef fish (Yellowtails) and ornamental fish as well as to mine coral along the west coast of Aceh Province, especially in the vicinity of Weh Island, one of the most popular tourist islands.

There has been no report, so far, about the damage to coral ecosystems by human activities in the marine waters of North Sumatera Province.

Unless more stringent regulations are implemented to ensure proper management of seagrass and algae beds, and coral reefs, these ecosystems will, with the increase in developmental activities, slowly but surely be threatened.

5.3 Estuaries

Extensive estuarine areas are found where the rainfall is high and the coastal plains gently slope to the coast – as along the east coast of Aceh and North Sumatera Provinces. Estuaries are also found on the west coast of Aceh Province, where the open areas are subject to significant seasonal salinity variation and several large rivers discharge their freshwater into the sea (Figure 5, overleaf). There are 75 rivers and streams in Aceh Province which can be grouped into five main watersheds. Four of them (Krueng Aceh, Peusangan, Jamboaye and Peureulik/Tamiang Rivers) flow into the Straits of Malacca, forming estuarine areas. The Wayla, Teripa, Simpang Kiri and Simpang Kanan Rivers, on the other hand, discharge their freshwater into the Indian Ocean and form a major estuarine area on the west coast of Aceh Province (Figure 5, overleaf).

Major estuarine areas along the coast of North Sumatera are formed in the Bampu, Asahan, Kuala, Bila and Barumun Rivers. Only two major rivers flow into the Indian Ocean, the Batangaris and the Batan Gadis (Figure 5, overleaf).

Because of the geological structure of Sumatera, there are no large rivers in West Sumatera Province that flow into the Indian Ocean (Figure 5, overleaf). As a consequence, there are no major estuarine areas here.

Estuaries are among the most productive ecosystems and valuable fishing grounds in Indonesia, supporting large fish and crustacean populations in the adjacent coastal waters (Soegiarto, 1989). Doty et *al.* (1983) reported a primary production twenty times higher in the Deli River Estuary (North Sumatera) than in the open water (20 km from the estuary).

In spite of the importance of estuaries, information on them is still very scanty.

In the study area, especially in the eastern part, estuaries are generally associated with other coastal landforms, such as deltas and embankments, as well as with highly valuable coastal ecosystems like mangroves and tidal swamp forests.

Environmental threats to estuaries by human activities are worse on the east coast of the study area than on the west. There are three major environmental threats:

- Sedimentation, causing highly turbid water.
- Changes in hydrological regime.
- Pollution.

Fig. 5. The distribution of main rivers and industries in the provinces of Aceh, North Sumatera and West Sumatera in northern Sumatera

Source: Pemda Dati I Sumut (1992)

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Highly turbid water is common in many rivers, especially in areas where the uplands are intensively used for agriculture and plantation but with poor land management. Such areas are the Alas River in southeast Aceh (Whitten *et* al., 1984), and the Asahan River and Deli River regions of North Sumatera.

Changes in the salinity regime are caused by brackishwater entering further out to sea during the rainy season, while salt intrusion is more extensive in dry periods.

Pollution caused to estuarine ecosystems, by industrial and domestic waste (see Figure 5, facing page, for major industrial and urban centres), pesticides and herbicides from intensive agriculture and other pollutants being discharged into the estuaries, is a growing problem. Some riverine estuaries, such as the Tamil River in Langsa, Aceh, and the Asahan River, North Sumatera, have frequently been found to be polluted by pesticides, herbicides and organic wastes from the oil palm industry.

6. MARINE POLLUTION

The marine environment of the west coast (Indian Ocean) is still relatively unpolluted by anthropogenic sources. An exception is the Teluk Bayur harbour of West Sumatera, which is polluted by oil and garbage.

The pristine west coast is a very valuable asset for the future and needs to be protected. The eastern coastal waters (the Malacca Strait), however, show signs of pollution (table below). In some locations, such as Lhokseumawe in North Aceh, and Asahan and Deli Serdang in North Sumatera, the concentrations of BOD and COD and heavy metals (mercury, lead, cadmium and copper) exceed the national environmental standards for bathing and swimming as well as for marine organisms and mariculture (Dardak *et* al., 1988; Sembiring *et* al., 1984; Simanjuntak *et* al., 1984; Harwinata *et* al., 1986; and Rozak *et* al., 1984). Moreover, concentrations of lead and cadmium in the tissue of molluscs are reported as exceeding environmental standards (Harwinata *et al.*, 1986).

Values and National Environmental Standards for some water quality parameters in the Straits of Malacca

Parameters	*Lowest* (*mg*/l)	*Highest* (*mg*/l)	*Environmental Standard* * (*mg*/l)	
			Required	*Allowable*
1. BOD	3.3	56.6	<25	≤ 45
2. COD	0.8	766.1	≤ 40	≤ 80
3. Hg	ad	0.013	<0.0001	≤ 0.0003
4. Pb	0.035	0.060	<0.00002	≤ 0.01
5. Cd	0.009	0.014	0.00002	≤ 0.01
6. Cu	0.07!	0.107	< 0.001	≤ 0.06

Source: Rozak *et al.* (1984).

= Based upon standard for fisheries uses of marine waters (Environmental Ministerial Decree No. 02/MENKLH/1988).

ud = undetected.

Five major sources of pollution in the marine environment have been identified

1. Domestic waste from major population centres.
2. Industrial waste.
3. Hydrocarbons, both from oil spills and landbased discharges.
4. Landbased sedimentation/siltation.
5. Pesticide compounds from agricultural and forestry activities.

6.1 Domestic wastes

Seventy per cent of the population of Aceh and North Sumatera live on the east coast. A consequence of this is that the waters here receive more organic substances and coliform bacteria originating from domestic waste than elsewhere.

6.2 Industrial waste

Most industrial activity takes place on the eastern coast, adjacent to the Malacca Straits (Dardak et ***al.,*** 1988 and Pian ***et al.,*** 1988). The distribution of industries and their potential environmental impact are shown in Figure 5 (see p. 20) and the table below.

Major industries and their potential impact on the marine environment in the study area

Type of industry	Location		Potenttial impact
ACEH			
Oil palm industry	East Aceh, east coast; West Aceh, west coast	–	Organic pollution
Lhokseumawe Industrial Zone (LNG fertilizer, LPG, paper kraft and olefin)	Lhokseurnawe, North Aceh, east coast	– –	Mercury pollution Ammonia pollution Sulphuric pollution
Oil and gas industry (drilling and processing)	Lhokseumawe, North Aceh, east coast	–	Oil pollution Organic pollution Heavy metal pollution
Forestry industry (sawmill, plywood)	Along the east coast, and West Aceh District	–	Organic pollution Chlorinated hydrocarbon
NORTH SUMATERA			
PLTU	Belawan, east coast	–	Thermal pollution, Oil discharge
Oil and gas industries	P. Brandan, east coast	–	Oil pollution, Sulphuric pollution
Aluminium smelter	Kuala Tanjung, east coast	–	Heavy metal pollution
Mining of sand quartz	Tanjung Tiram. east coast	–	Coastline erosion. Sedimentation
Oil palm and Crent processing plant	Lowland of east coast	–	Organic pollution
Forestry industry (pulp mills)	Spread in lowland areas	–	Organic pollution PCB
WEST SUMATERA			
Padang industrial complex	Padang, West Sumatera	–	Organic pollution Heavy metal pollution

Sources : Dardak et al., (1988); Pian et al., (1988); and Bappeda Propinsi D1. Aceh (1988).

One of the most polluted areas is the Lhokseumawe Industrial Zone (described by Burbridge ***et al.,*** 1988). The LNG (Liquified Natural Gas) plant faces problems in disposing of mercury solid waste extracted during the gas liquification process. In 1983, mercury waste at Lhoksuemawe was being stored in oil drums in an open, exposed location, 2 km from the nearest well and 1 km from the sea. A concrete bunker had been built to store the drums which were found to be rusting and with waste leaking out. The dump contained some 175 t of mercury waste, of which 10.5 t was mercury sulphide. At the moment (1992), the annual production of mercury waste is about 85 t/year. Unfortunately, there has been no analysis of mercury residues in fish and other organisms.

Other potential sources of pollution from the Lhokseumawe Industrial Zone are: carcinogenic smoke from gas flares at the LNG plant; various chlorinated organic substances, such as AOX, dioxins and furanes, from the kraft paper mill; urea dust from two fertilizer plants; and mercury and ethylene from the olefin plant which daily produces some 7 t of mercury-contaminated wastes. In addition, substantial quantities of wastewater containing urea, mercury and ammonia wastes are also discharged into the surrounding marine environment (Pusat Penelitian UNSYIAH, 1987 and 1989).

Information on the pollution load from Asahan, Medan, Meulabah, Padang and other industrial areas is scant. However, pollution problems, though local and accidental, have already occurred in these places.

6.3 Oil

The Malacca Strait is one of the world's major oil tanker routes. Figures from 1979 show an average concentration of hydrocarbon (oil) in the water column ranging from 0.1 to 6.3 ppm (Soegiarto, 1982). The environmental standard of oil concentration for marine organisms is 5 ppm. Many oil spill accidents have taken place in the straits. The largest oil spill occurred with the grounding of the 237,698 dwt *Showa Maru* on January 6, 1975, when more than 7,000 t of crude oil reached marine waters (Soegiarto, 1982). Since then, there have been many smaller oil spills in the straits.

6.4 Sedimentation

One of the most serious environmental problems is sedimentation in lowland and coastal areas due to soil erosion from poor upland management. In the Aceh Province, three watershed systems (i.e. Krueng Aceh, Jamboaye and Peusangan) out of five have been seriously damaged by sedimentation, partly due to land clearance for agriculture and plantations (Pian et *al.,* 1988).

Serious soil erosion problems have also occurred in the upper watersheds of North Sumatera Province due to uncontrolled conversion of upland areas with natural vegetation into agricultural use. Both flooding and siltation have been cited as having negative impacts on coastal ecosystems and fisheries. The rivers most severely affected were the Asahan, Bila, Kuala, Baruman, Silam, Percut and Bahbolan (Burbridge *et al., 1988).*

The impact of poor upland management on the lowland and coastal areas of West Sumatera has also been observable, but the effects here are less severe.

6.5 Agriculture

The eastern lowlands have been used intensively for agriculture and plantations, particularly oil palm cultivation, since the Dutch colonial period. North Sumatera now has the largest average of oil palm plantations in the country. The extent of use of herbicides, rodenticides, and fungicides in agricultural activity in the coastal districts of the study area is presented in the table alongside.

The pesticide residues mainly enter the river systems through run-off, and eventually reach the marine ecosystems. No analysis, however, has been made of residues in fish and other marine organisms.

The use of pesticide compounds in agricultural activities on the coasts of Aceh, North Sumatera and West Sumatera Provinces (kg)

Coastal area/district	*Insecticide*	*Fungicide*	*Rodenticide*	*Herbicide*
EAST COASI				
Aceh				
Banda Aceh	–	–	–	–
Pidie	2,000,295	100,200	-	–
North Aceh	585,704	142	–	1,100
East Aceh	239	6,100	–	2.305
Sabang	331	275	34	32
North Sumatera				
Langkat	129,050	362	3,329	3,770
Deli Serdang and Medan	856,461	3,183	283,813	-.712
Labuhan Batu	67,502	37	3,076	4,928
Asahan	140.463	175	1,138	6,450
Kodya Binjali	–	–	–	–
WEST COAST				
Aceh				
West Aceh	2,101		–	–
South Aceh	2,071,316	140,110	–	12
North Sumatera				
Central Tapanuli	33,736	29	623	1,483
South Tapanuli	93,553	725	2,994	1,127
Nias	11,790	37	890	409
West Sumatera				
Pasaman	112	161	25.531	–
Padang Pariaman	449	–	1,081	–
Kodya Padang	346	–	100	–
Pestsir Setatan	3,414	65	1,062	4,541
Total	5,996,866	251,601	323,671	33,869

Sources : Bureau for Population and the Environment. Provinces of Aceh. North Sumarera and West Sumarera (1992).

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7. MARINE FISHERIES

Marine fisheries resources in Indonesia are usually classified into five major groups :

- Demersal;
- Small pelagic;
- Large pelagic, consisting of tuna and skipjack;
- Shrimp; and
- Others, which include molluscs, seagrass and jellyfish.

There has so far (1992) been no accurate data on the maximum sustainable yield (MSY) of the marine fisheries resources. MSY data are available only for the whole of the Straits of Malacca and the marine waters of West Sumatera, except for the small stretch of western Lampung Province.

The sustainable potential of fisheries resources in the Straits of Malacca and the west coast of Sumatera amount to 366,860 t/year and 211,330 t/year respectively (Naamin and Hardjamulia, 1990). With such potential, the Malacca Strait has the second largest fisheries resource in Indonesia, after the north coast of Java.

The Straits of Malacca, however, are already overfished (Naamin and Hardjamulia, 1990). But resources off the west coast of Sumatera have still not been fully utilized. This condition is also reflected by the CPUE (catch per unit of effort) figures of these two marine waters (see table below).

CPUE by number of fishing boats by year (1980 - 1990)

Year	CPUE by number of fishing boots (t/ no.)				
	Aceh Province east coast	Aceh Province west coast	N. Sumatera Province east coast	N.Sumatera Province west coast	W. Sumatera Provmce
1980	5.67	6.69	8.92	5.14	6.23
1981	6.65	5.44	5.72	2.87	6.74
1982	5.64	4.44	5.86	4.70	6.39
1983	6.69	5.49	8.05	4.94	4.38
1984	5.17	5.96	7.49	5.36	4.65
1985	10.88	5.27	7.04	5.21	4.84
1986	9.98	5.39	6.69	6.18	5.62
1987	9.48	5.35	6.51	5.46	5.70
1988	8.37	6.45	7.49	6.28	6.71
1989	12.82	7.06	7.58	6.73	8.87
1990	8.46	8.05	7.56	6.92	8.88

Source : Directorate General of Fisheries (1980-1991)

It is clear that the marine fisheries of the eastern part of the study area are threatened not only by physical degradation of habitats and pollution but also by overexploitation. Although environmental threats to marine fisheries in the western part of the study area are relatively minor, careful environmental management should be undertaken to ensure sustainable development of fisheries resources there.

8. REFERENCES

BAPPEDA PROPINSI DI. ACEH. 1988. *Proposal to Improve Pollution Monitoring in North Aceh.* Mimeo. 8p.

BURBRIDCE, P.R. and MARAGOS, J.E. 1985. *Coastal resources management and environmental assessment needs for aquatic resources development in Indonesia.* International Institute for Environment and Development, Washington D.C.

BURBRIDGE, P.R., KOESOEBIONO and DAHURI, R. 1988. Problems and issues in coastal resources management and planning in Eastern Sumatera and the Straits of Malacca. IN: Coastal zone management in *the Strait of Muluccu.* School of Resources and Environment Studies. Dalhousie University, Halifax, Canada. pp. 8-l 15.

BUREAU FOR POPULATION AND THE ENVIRONMENT OF ACEH PROVINCE. 1992. *Nerucu kependudukun dun lingkungan hidup dueruh 1991* (State of Regional Population and the Environment 1991). The Province of Aceh. Banda Aceh.

BUREAU FOR POPULATION AND THE ENVIRONMENT OF NORTH SUMATERA PROVINCE. 1992. *Nerucu kependudukan dun lingkungun hidup dueruh* 1991 (State of Regional Population and the Environment 1991). The Province of North Sumatera, Medan.

BUREAU FOR POPULATION AND THE ENVIRONMENT OF WEST SUMATERA PROVINCE. 1992. *Neraca kependudukun dun lingkungun hidup dueruh* 1991 (State of Regional Population and the Environment 1991). The Province of West Sumatera, Padang.

DARDAK. A., DARTIUS, SYAMSINAR, HARAHAP, B. and TOBING, A.T.L. 1988. Gagasan pola perencanaan dan pengelolaan sumberdaya alam dan lingkungan hidup di pantai timur Sumatera Utara (Proposal for the planning and management of the resources and environment of the east coast of North Sumatera) IN: Sjarkowi, F., Verheugt, W.J.M.. and Dirschl, H.J. (Ed.), *1988. Coastal zone environmental planning in the Strait* of Muluccu. Development of Environmental Study Centres (DESC)' Project UNDP/IBRD/GOI. pp. 19-39.

DOTY, M.S. SOERIATMADJA, R.E. and SOEGIARTO, A. 1983. *Marine* resources, *Indonesia.* pp. l-25

FAO. 1982. *Management and utilization of mangroves in Asia and the Pacific.* FAO Environmental paper 3: 160p. Food and Agriculture Organization of the United Nations, Rome, Italy.

—— *1985. Mangrove management in Thailand, Malaysia and Indonesia.* FAO Environmental paper 4: 60 p. Food and Agriculture Organization of the United Nations, Rome, Italy.

HARWINATA, E.F, OKILIA MAESEN, DARTIUS and CHAIRUDDIN. 198511986. *Penentuan kandungan logam berat pada jenis kerang-kerangan di muara sungai feli.* Departemen Pendidikan dan Kebudayaan, Direktorat Jenderal Pendidikan Tinggi, Proyek P3T. Universitas Sumatera Utara, Medan.

NAAMIN. N. and HARDJAMULIA, A. 1990. Potensi, pemanfaatan dan pengelolaan sumberdaya perikanan Indonesia (Potential, utilization and management of Indonesian fisheries resources). IN: *Proceedings Fisheries Forum-f.* United States Agency for International Development Fisheries Research and Development Project (USAID/FRD).

NONTJI. A. 1987. *Laut nusantara* (The archipelagic seas). PT. Djambatan, Jakarta.

PIAN, Z.A., MOESA, S., RISYAD, T. and DJAKARIA. 1989. Gambaran umum pantai utara dan timur Propinsi Daerah lstimewa Aceh (General View of the northern and eastern coast of the Provincial Special Territory of Aceh). IN: Sjarkowi, F, Verheugt, W.J.M. and Dirschl, H.J. *(1988). Coastal zone environmental planning in the Strait of Muluccu.* Development of Environmental Study Centres' (DESC) Project UNDP/IBRD/GOI. pp. 39-57.

POLUNIN, N.V.C. 1983. The marine resources of Indonesia. *Oceunogr. Mur. Biol. Ann.* 1983, 21:455-531

PUSAT PENELITIAN UNSYIAH. 1987. *Analisis mengenui dampak lingkungun PT. Kertas Kraft Aceh* (Environmental impact analysis of PT. Kertas Kraft Aceh). Pusat Penelitian, Universitas Syiah Kuala, Banda Aceh.

______ 1989. *Studi evaluasi lingkungun industri pupuk urea. PT. Pupuk Iskandar Muda* (Environmental evaluation study of urea fertilizer industry, PT. Pupuk lskandar Muda). Pusat Penelitian Lingkungan. Hidup, Universitas Syiah, Kuala, Banda Aceh.

ROZAK, H., HUTAGALUNG, H.P. and SURTIPANTI, S. 1984. Theobservations of Chemical Oxygen Demand (COD) and heavy metals. IN: *The Straits of Muluccu Water Conditions.* Jakarta: LON-LIPI.

SEMBIRING, N., EYANOER, H.F., BRAHMANA, H., MADJNU HIDAYAT, H., DAMANIK, S.H., DAHLAN, F, ANWAR, 1. and WHITTEN, A.J. *1984. Stundurd kwalitas lingkungun laut dun kehidupun biologi pantai pesisir Selat Malaka di Sumatera* Utara. Kantor Menteri Negara Kependudukan dan Lingkungan Hidup (KLH), Proyek Pengelolaan Sumber-sumber Alam dan Lingkungan Hidup.

SIMANJUNTAK, M., MUCHTAR. M. and HERMANDY, M. *1984. Kondisi beberapa parameter kimia di perairan Selat Malaka 1978-1980.* Lembaga Oseanologi Nasional. Lembaga Ilmu Pengetahuan Indonesia, Jakarta.

SOEGIARTO, A. and POLUNIN, N.V.C. 1982. *Marine ecosystems of Indonesia: A basis for conservation,* IUCN/WWF Indonesia Programme. Bogor, Indonesia.

SOEGIARTO. A. 1982. The potential impact of pollution on Indonesian coastal resources with special reference to the major energy shipping routes. IN: Valencia, M.J., Gold, E., Sien, C.L., Letalik, N.G. (Ed.). 1982. *Shipping, energy and environment: Southeast Asian perspectives for the Eighties.* Dalhousie University, Halifax, Nova Scotia. Canada. pp. 119-140.

____________ 1989. Penelitian ekologi laut dan wilayah pesisir yan penting dilaksanakan di Indonesia (Important coastal and marine ecological research needs in Indonesia). IN: Burhanuddin, Hutagalung, H.P., Rochyatun, E.. and Azkab, M.H. (Ed.), 1992. *Proceedings of Seminar Ekologi Laut dan Pesisir I. Jakarta, November 27-29, 1989.*

WALSH, G.E. 1974. Mangrove. A review. pp. 51-172. *IN: Ecology of Holophytes.* Remold and Queen.

WHITTEN, A.J., DAMANIK, S.J., ANWAR, J. and HISYAM, N. 1984. *The ecology of Sumatera.* Gadjah Mada University Press, Yogyakarta.

APPENDIX IV

Institutions engaged in environmental research, monitoring and enforcement

The following institutions and authorities are engaged in environmental research and monitoring as well as enforcement when violations of environmental regulations take place:

Institution	*Environmental management functions*		
	Research	*Monitoring*	*Law enforcement*
NATIONAL LEVEL			
Ministry of State for Population and the Environment	Yes	Yes	No
Agency for Environmental Impact Control (BAPEDAL)	Yes	Yes	Yes
Ministry of Communication and Transportation	No	Yes	Yes
Ministry of Public Works	No	Yes	No
Ministry of Industry	No	Yes	Yes
Ministry of Research and Technology	Yes	No	No
Directorate General of Fisheries	Yes	Yes	Yes
Minjstry of Defence	No	Yes	Yes
Research and Development Centre for Oceanology (P_3O-LIPI)	Yes	Yes	No
Research Institute for Marine Fisheries, Dept. of Agriculture	Yes	Yes	No
Research Institute for Oil and Gas (LEMIGAS) Pertamina	Yes	No	No
Hydrooceanography Institution, Indonesian Navy (DISHIDROS)	Yes	No	No
Centre for Research, City Development and the Environment (P_4L)	Yes	No	No
Environmental Research Centre (IPB)	Yes	No	No
Agency for National Survey and Mapping (BAKOSURTANAL)	Yes	No	No
Indonesian Environmental Forum (WAHLI, an NCO)	Yes	Yes	No
PROVINCIAL LEVEL			
Environmental Studies Centre, University of Syiah Kuala (UNSYIAH)	Yes	No	No
Environmental Studies Centre, University of North Sumatera (USU)	Yes	No	No
Environmental Studies Centre, University of Andalas (UNAND)	Yes	No	No
Bureaus for Population and the Environment, Provinces of Aceh. N. Sumatera and W. Sumatera	No	Yes	Yes
Governor's Offices. Aceh, N. Sumatera and W. Sumatera Provinces	No	No	Yes
Provincial Fisheries Departments, Aceh, N. Sumatera and W. Sumatera	Yes	Yes	Yes
Regional Offices of Ministry of Defence, Aceh, N. Sumatera and W. Sumatera Provinces	No	Yes	Yes
Regional Offices of Ministry of Justice, Aceh, N. Sumatera and W. Sumatera Provinces	No	No	Yes
Yasika (Environmental NGO) in Medan, N. Sumatera.	Yes	Yes	No

LABORATORIES UNDERTAKING ENVIRONMENTAL ANALYSES

Centre for Industrial Research and Development, Banda Aceh, D.I. Aceh Province.

Overseas Development Administration Northeast Sumatera Prawn Project Laboratory, Medan, North Sumatera Province.

The Environmental Studies Centre of North Sumatera University, Medan, North Sumatera Province.

The Environmental Studies Centre of Syiah Kuala University, Banda Aceh, D.I. Aceh Province.

The Environmental Studies Centre of Andalas University, Padang, West Sumatera Province.

The Environmental Studies Centre of Bogor Agricultural University, Bogor, West Java Province.

SEAMEO-BIOTROP Bogor Laboratory, West Java Province.

Centre for Resources and Development of Oceanology, Indonesia Institute of Science, Jalan Pasir Putih 1, Ancol. Jakarta.

Research Institute for Oil and Gas (LEMIGAS), Pertamina State Oil Company, Cileduk Raya Street, Cipulir, P 0 Box 89/Jkt, Jakarta 1002.

Centre for Research, City Development and the Environment (P4L), Jalan Casablanka No. 4, Kuningan, Jakarta.

Institute for Hydrooceanography *(DISHIDROS),* Indonesia Navy, Jakarta. Jalan Pasir Putih No. 2, Ancol, Jakarta.

APPENDIX V

Legislation against threats to the marine environment

Decree	Subject matter	Enacting Institutions
GENERAL		
Ministerial Decree No.03/MNKLH/11/1991	Issue guidance for standard of environmental quality	Ministry of State for Population and the Environment
Ministerial Regulation No. 5/PRT/l990	Water quality control on water resources.	Ministry of Public Works.
Ministerial Decree No. 02/MNKLH/1/1988	Guidance on standards of environmental quality	Ministry of State for Population and the Environment.
Government Regulation No. 29/1986	Environmental impact analysis.	President, Republic of Indonesia (R.I.)
Government Act No. 4/1982	Basic provisions for management of the living environment.	Parliament and President.
Joint Ministerial Decree No. 23/1979 and Decree No. 002/MNPPLH/2/1979.	Institutions managing natural resources at provincial levels.	Ministry of Home Affairs, and Ministry of State for Environment and Development Supervision.
Governor Decree No. 660/295/1991.	The establishment of a technical team for arranging NKLD of Aceh Province.	Governor's Office of Aceh.
Governor Decree No. 660/358/1989.	The implementation of sustainable development in Aceh Province.	Governor's Office of Aceh.
Governor Decree. No. 660/348/1989 *tahun* 1989.	The establishment of AMDAL (Env. Impact Analysis) committee in Aceh.	Governor's Office of Aceh.
Provincial Regulation No. 2/1985.	Management and preservation of the living environment.	Governor's Office of N. Sumatera.
Governor Decree No. 051 2134/ PLH-89/ 1989	AMDAL studies for industrial activities	Governor's Office of W. Sumatera.
POLLUTION		
Ministerial Decree No. I / 1985.	Procedures of pollution control for investing companies.	Ministry of Home Affairs.
Government Regulation No. 20/1990.	Water pollution control.	President, R.I.
Governor Decree No. 08/1991.	Management of water quality standard in Aceh Province.	Governor's Office of Aceh.
Ministerial Decree No. 12/M/SK/l978.	Prevention and mitigation of environmental pollution caused by industrial activities.	Ministry of Industry.
Ministerial Decree No. KM 86/1990.	Prevention of oil pollution caused by ships.	Ministry of Transportation.
Ministerial Decree No. KM 215/Al 506/ PHB.87.	The provision of waste reception facilities for ships.	Ministry of Transportation.
Presidential Decree No. 46/1986.	Ratification of international convention for the prevention of pollution from ships, 1973 and its protocol, 1978.	President. R.I.

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Degree	*Subject matter*	*Enacrrng Institutions*
Ministerial Decree No. KM/167/HM/207	International certificate on prevention of pollution caused by liquid toxic substances.	Ministry of Transportation.
Director General Decree No. Py 69/ 1/I l-86.	lmplementation guidelines of Decree No. KM/167/ Decree No. KM/HM/207.	Directorate General for Marine Transportation.
Presidential Decree No. 19/1978.	Ratification of international convention on the establishment on international fund for compensation for oil pollution damage.	President, R.I.
Presidential Decree No. 18/1978.	Ratification of international convention on civil liability for oil pollution damage.	President, R.I
Governor Instruction No. 07/GSB/87/1987.	The obligation for industrial companies to conduct AMDAL and waste water monitoring.	Governor's Office of W. Sumatera
Governor Instruction No. 07/GSB/86/1986.	The obligation of industrial companies to analyze their industrial waste water.	Governor's Office of W. Sumatera
Governor Instruction No. 218/GSB/l985.	Regulation of quality standard of industrial waste water.	Governor's Office of W. Sumatera

CONSERVATION OF HABITAT AND RESOURCES

Governor Decree No. 188. 341/01/K/1988.	Implementation guidelines of Provincial Regulation No. 2/1985.	Governor's Office of W. Sumatera.
Government Act. No. 5/1990.	The conservation of natural resources and its ecosystems.	Parliament and President, R.I.
Presidential Decree. No. 32/1990.	The management of protected areas.	President, R.I.
Presidential Decree No. 65/1980.	Ratification of international convention for safety of life at sea, 1974.	President, R.I.

Note : It is apparent from the above that sufficient laws and regulations exist to manage the utilization of the marine environment and its resources on a sustainable basis. The primary constraint, so far, has been in the implementation of most regulations; the implementation has been inconsistent.

APPENDIX VI

Other publications on the marine environment

ANON. 1982. *Penjelasan scara umum don petunjuk plaksonaon lapangan kegioton.* The bioeconomic and socioeconomic study of shrimp fisheries on the east coast of northern Sumatera, Indonesia. A cooperative project between FAO-BOBP and Dinas Perikanan Propinsi Dati I Sumatera Utara, Medan.

ARINIARDI, O.H., QUARAISYIN ADNAN. and SUTOMO, A.B. *1984. Zooplankton diperairan Selot Moloko* 1978-1980. Lembaga Oceanologi Nasional. Lembaga ilmu Pengetahuan Indonesia.

BANGUN, D. 1984. Mill Effluent Problems in Oil Palm and Rubber Plantations. *IN: Proceedings of the Regional Symposium on Plantation Environment.* Medan, June 8-10. 1983. pp. 114-128.

BORGESE, E.M. and GINSBURG, N. (Eds). 1982. Ocean *Year Book* 3. University of Chicago Press, Chicago.

'BURBRIDGE, P.R. and KOESOEBIONO. 1981. IN: MacAndrews, C and Chia, L.S. (Ed.), *1981. Southeost Asia seas: Frontiers for development.* McGraw-Hill. Singapore. pp. 110-135.

BURBRIDGE, P.R. and KOESOEBIONO, N. 1984. *The management of mangrove exploitation in Indonesia.* Paper presented at the Asian Mangrove Symposium, Kuala Lumpur.

DARTIUS, RUSSON, W.A., BARUS, T.A., SIBURIAN, A. and WIDODO, U. 1987/1988. *Foktor-foktor lingkungon hidup don sosio/ekonomi dalam pengelolaan mangrove seponjang pesisir timur Sumatera Utara (Tahap* I). Universitas Sumatera Utara-Lembaga Penelitian Medan.

DARUS, B. 1985. The management and development of Southeast Asian small-scale fisheries and the example of the Bubun Coastal Village Development Project, North Sumatera. IN: *The traditional knowledge and management of coastal systems of Asia and the Pacific,* by K. Ruddle and R.E. Johannes, pp. 207-28. Jakarta: UNESCO.

D.H.V. CONSULTING ENGINEERS. *1982. Lhokseumowe area development study.* Final report prepared for the Bappeda D.1. Aceh.

DONCELMANS, L. 1985. *Largescale industries in Aceh Utara. Banda Aceh:* BAPPEDA I/IDAP Employment Survey. Mimeo.

KASTORO, W. 1984. Pengamatan fauna bentik di perairan Selat Malaka. 1978.1980. *IN: Evoluosr kondisiperoiron Selat Moloko,* 1978-1980. Lembaga Oseanologi Nasional. Lembaga Ilmu Pengetahuan Indonesia, Jakarta.

KNOX, G. and MIYABARA, T. *1984. Coastalzoneresource development and conservation in Southeast Asia with special reference to Indonesia.* Jakarta: UNESCO regional office for science and technology and East-West Center Resource System Institute, Honolulu.

NATIONAL ACADEMY OF SCIENCE. *1970. Waste management conceptfor the coastal zone.* Washington, D.C. 126 p.

ONGKOSONGO, O.S.R. 1982. The nature of coastline changes in Indonesia. *lndonesion Journal of Geography* 12: I-22.

PEMDA DATI I SUMATERA UTARA. *1992. Rencono struktur tata ruong Propinsi Sumotera Utara* (Proposed spatial planning for the Province of North Sumatera). Pemerintah Daerah Tingkat I, Sumatera Utara, Medan.

POLUNIN, N.V.C. *1983. Morineconservation in Indonesia.* Cambridge: Dept. of Marine Biology, Cambridge University, Mimeo.

PRASENO, D.P. 1980. Phytoplankton in the Straits of Malacca waters. *IN: The Evaluation of the Straits of Molocca water conditions.* Jakarta. LON-LIPI.

__________ 1984. Fitoplankton di perairan Selat Malaka, 1978-1980. *IN: Evoluosi kondisiperoiron Selot Maloko,* 1978-1980. Lembaga Oseanologi Nasional. Lembaga Ilmu Pengetahuan, Indonesia, Jakarta.

QASIM, S.Z. 1973. IN: Zeitschel, B. (Ed.). *The Biology of the Indian* Ocean. Springer-Verlag. New York. pp.l45-154.

SIVALANGAN, P.M. 1988. Impact of domestic and industrial waste disposal on the coastal zone environment of the Straits of Malacca. IN: *Coastalzone management in the Straits of Malacca: Proceedings,* ED. P.R. Burbridge et *al.,* School for Resource and Environmental Studies, Halifax, Dalhousie University, Canada.

SOEGIARTO, A., and POLUNIN, N.V.C. *1980. The marine environment of Indonesia.* IUCN. Gland.

SOEGIARTO, A. 1988. Pencegahan dan penaggulangan pencemaran laut di Selat Malaka (Prevention and control of marine pollution in the Malacca Strait). IN: Sjarkowi, F., Verheugt, W.J.M. and Dirschl, H.J. 1988. *Coastal zone environmental planning in the Strait of Malacca.* Development of Environmental Study Centre's (DESC) Project UNDP/IBRD/GOI. pp. 119-137.

SOETAMIHARDJA, R.T.M. 1984. Pesticide usage and its impact on the environment. *IN: Proceedings of the regional symposium on plantation environment.* Medan, June 8-10, 1983. pp. 218-230.

WHO, 1982. *Rapid assessment of sources of air, wafer and land pollution,* WHO, Geneva

An oyster hatchery in a mangrove-lined creek in Malaysia.

The West Coast of Peninsular Malaysia

by

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9. *INTRODUCTION*

With increasing industrialization and urbanization since the 1980s, pollution problems have featured more prominently in Malaysia and public awareness has increased. Hazards to the coastal environment in Malaysia include domestic discharge, sewage (including animal wastes), industrial and agricultural effluents, as well as pollution caused by major engineering and development projects.

Furthermore, the accelerated development of improperly planned coastal aquaculture has also had negative environmental impacts. Extensive conversion of mangrove swamps into ponds, changes in hydrologic regimes in enclosed waters due to proliferation of aquaculture structures and the discharge of high levels of organic matter into coastal waters (Chua *et a!.*, 1989) are among these negative impacts.

Sheppard (1992) analyzed fish catch data by plotting resource use against demand and showed that there was a steep decline in fish catch per unit population from 1970 to 1990. This is indeed alarming, as it indicates that fish resources are being exploited beyond maximum sustainable yield (MSY) levels despite the numerous management programmes already being implemented. The effect of mainly land-based pollution and destruction of natural habitats, such as mangrove swamps, coral reefs and seagrasses, could be major factors responsible for this situation (Lulofa, 1977, Sasekumar, 1980, Phang, 1990).

This report describes the state of the coastal environment of western Peninsular Malaysia.

10. *MARINE HABITATS*

10.1 *Mangroves*

The total acreage of mangrove forests in Peninsular Malaysia has been estimated around 103,000 ha, the bulk of these fringing the west coast (Tang *et a!.*, 1990). Of this total, the Larut Matang mangrove swamp in the state of Perak is not only the largest (40,000 ha), but is also stated to be the best managed mangrove forest in the world (Gong *et a!.*, 1980). Other major areas of mangroves include Merbok, Kedah (9,037 ha), Kelang mangrove swamps, Selangor (22,500 ha) and the Johor mangrove swamps, Johor *(25,618* ha). Figure 6 alongside shows the extent of the mangrove forests on the west coast.

Fig. 6 Map of Peninsular Malaysia showing marine habitats of the west coast and major aquaculture activities

The threat to Malaysia mangroves lies in land conversion or deforestation for agriculture, industry and, to a lesser extent, for aquaculture. Aquaculture sites are shown in Figure 6. It has been estimated

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that 27,000 ha of mangrove swamps are suitable for aquaculture (Cedney et *al.,* 1982). Malaysia, however, has a national committee of experts to oversee its mangrove forest management (NATMANCOM, 1986).

10.2 *Coral reefs*

There are only two significant coral reef sites on the west coast:

- The Payar group of islands in the north of Kedah, and
- The Sembilan group of islands off Perak (see Figure 6).

A smaller site is at Cape Rachado, near Port Dickson, Negri Sembilan . The reefs are of the shallow water, fringing type, which are found around many offshore islands (De Silva, 1982). There is a comprehensive paper on the status of the coral reefs on the west coast of Peninsular Malaysia (Jothy, 1973).

The biggest threats to the coral have been due to exploitation for commercial and educational purposes, coupled with siltation and sedimentation caused by development projects (Liew and Hoare, 1982). The Department of Fisheries has taken steps to conserve and rehabilitate the country's coral reefs by gazetting as marine parks many of the islands where corals are found. The Payar group of islands is the best-known beneficiary of this conservation policy.

10.3 Seagrass beds

A recent review of seagrass distribution by Kushairi (1992) indicated five areas of seagrass off the west coast of Peninsular Malaysia (see Figure 6). Five species were found in shallow waters, ranging in depth between 0.2 and 1.8 m. The species mentioned are *Halophila ovalis, H. uninervis, H. pinifolis, H. minor* and *Enhalus acoroides*. Phang (1990) for the occurrence of *Cymodocea rotunda* in Port Dickson, for the occurrence of *C. serralata* in Johor. It would seem that these two species have disappeared completely, probably due to environmental pressures. Sasekumar, quoted by Phang (1990), described the occurrence of *Syringodium* sp. from the Pulai estuary in Johor. The seagrass beds are endangered by erosion, faecal contamination and heavy metal pollution (Phang, 1990 and Kushairi, 1992).

11. *MARINE POLLUTION*

Malaysian coastal waters are mainly contaminated with oil and grease, faecal coliform bacteria and suspended solids. Land development, agriculture and high population density are among the main causes of water pollution (Environmental Quality Report — EQR — 1990). Major river basins and industrial zones are shown in Figure 7 (see facing page).

11.1 *Sewage*

The coastal waters of Malaysia show substantially high levels of faecal coliform bacteria. In 1990, for instance, 90 per cent of the 114 coastal water samples in Pinang, exceeded the proposed interim standard of 100 MPN/100 ml of faecal coliform meant for recreational purposes (Environmental Quality Report, 1990). Out of 38 coastal water samples in Perak and 138 in Johor, examination revealed that about 50 per cent exceeded the proposed standard. In Kedah/Perlis, about 45 per cent of the 75 samples analyzed were higher than the proposed standard. Seriously affected beaches in Pinang in 1990, included Batu Maung, Telok Tempoyak, Batu Ferringhi and Pantai Bersih.

Fig. 7 Map of major river basins and industrial zones in Peninsular Malaysia.

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Based on the 1990 statistics provided by the Veterinary Services Department, Malaysia, the standing pig population (SPP) of the coastal states of Peninsular Malaysia was approximately 2.3 m and averaged approximately 717 SPP/farm. By the year 2000, the SPP is projected at around 3 million. The table alongside shows the number of farms and the pig population of the west coast states in Peninsular Malaysia

Number of farms and pig population in the west coast states of Peninsular Malaysia (1990-91)

State	*No. of farms*	*Pig population*
Melaka	62	92,290
Kedah	9	5,116
Perak	559	407,688
N. Sembilan	654	618,326
Selangor	481	487,011
Pinang	1,187	390,179
Johor	164	302,470
Total	3,226	2,313,080

Pig farms generate large quantities of waste and some of these farms discharge effluents directly into estuaries and tidal rivers without any pretreatment. A report by the Veterinary Services Department, Malaysia, in 1982, indicated that most states have serious pollution problems that can be attributed to pig farms. It has been found that *45* per cent of the farms in Selangor and 82 per cent in Negri Sembilan pollute the environment. Due to economic constraints, waste abatement is practised only in the large farms. Piggery wastes not only contaminate the water with bacteria and parasites, but also exert high demand for oxygen (ROD) and cause eutrophication. Characteristics of raw wastewater from pig-pens are given in the table alongside.

Characteristics of raw waste water from pig-pens

Parameter	*Range*
BOD (mg /l)	900 – 21,690
COD (mg/l)	4800 – 39,000
Total solids (mg/l)	3690 – 22,300
Suspended solids mg/l)	636 – 15,900
Ammoniacal nitrogen (mg l)	75 – 950
Total nitrogen mg /l)	370 – 2080
Organic nitrogen (mg/l)	140 – 1370
Phosphate mgi)	60 – 1600

Source: Ho, Y. C.. *et al.,* 1984.

11.2 *Heavy metals*

The Department of Environment reported higher concentrations of heavy metals in the waters off the west coast of Peninsular Malaysia compared to other areas because of the greater extensive land use and industrialization. In 1990, among the rivers that recorded samples exceeding the standard values of 0.02 mg/litre lead were Sg. Perak, Sg. Selangor, Sg. Kelang, Sg. Linggi and Sg. Melaka. Rivers with zinc levels exceeding 0.4 mg/litre included Sg. Sepang, Sg. Langat and Sg. Kelang. Sg. Bernam, in the west coast of Peninsular Malaysia, recorded copper values higher than the proposed value of 0.012 mg/litre. Rivers that recorded values exceeding the proposed value of 0.004 mg mercury/litre included Sg. Muar, Sg. Duyong, Sg. Kurau, Sg. Bernam, Sg. Selangor and Sg. Kelang. Cadmium and arsenic concentrations were negligible in most of the rivers monitored.

Almost all the samples collected from the coastal waters of Malaysia contained values of lead, copper and cadmium above the proposed standards of 0.05 mg/litre lead, 0.01 mg/litre copper and 0.005 mg/litre cadmium. The coastal waters of Perak and Penang recorded high levels of cadmium, copper, lead, mercury and nickel. In 1990, around 50 per cent of the 41 samples collected from Perak had values exceeding the proposed standard of 0.005mg mercury/litre. In 1989, more than 80 per cent of the 42 samples collected from the coastal waters of Perak had values above the proposed standard of 0.01 mg nickel/litre. And in Pinang, all the samples analyzed for nickel exceeded this value.

Shellfish and fish analyzed by the Fisheries Research Institute (FRI) indicated that it was safe to eat fish and shellfish from Malaysian coastal waters (Jothy and Ibrahim 1987; Shahuntala. 1986 and 1989).

11.3 *Agro-based industries*

Pollution from the palm oil and rubber processing mills is the most severe in agro-based industries (Mohd. Ismail Yaziz, 1983). This is because the wastes from these effluents contain very high concentrations of organic material, suspended solids, nitrogen and phosphorous. The discharge of the concentrated waste water into surface waters leads to rapid depletion of dissolved oxygen.

PALM INDUSTRY

Close to about two million hectares are under oil palm in Peninsular Malaysia. Malaysia is currently the world's major producer of crude palm oil (CPO), producing five million tonnes in 1988. The coastal states of Peninsular Malaysia produced 3.6 million t of CPO in 1991 from 153 operating mills (see table below). The average annual production was 136,420 t CPO/mill, with each mill operating at an average of 371 hrs/mth. From the 3.6 million t CPO, about 9-11 million t (CPO x 2.5-3) of palm oil mill waste (POME) were produced (Mohd. Tayeb et al., 1987).

Crude palm oil (CPO) production in Malaysia in 1991

State	*CPO prodn. (t)*	*No. of mills*	*Avg. capacity (CPO/ T/Y)*	*Avg. operating hrs (Hr/Mill/MO)*
Johor	1,682,262	66	175,058	369.88
Kedah	91,271	4	108,000	397.06
Melaka	42,020	2	108,000	417,15
N. Sembilan	341,323	13	174,308	374.91
Pinang	61,338	4	123,600	307.86
Perak	793,174	35	138.775	397.00
Selangor	589,348	29	127,200	331.53
Total	3.600.736	153		

Methods for treating POME (anaerobic and aerobic/facultative, oxidation ponds etc.) are well established (Wong, 1980; Ma, 1988). The average characteristics of POME are listed in the table below. The effluent standards necessary for POME before discharge into a water body are shown in the table below right.

The average characteristics of untreated palm oil mill effluent (POME)

Parameter	*Range*	*Mean*
pH	3.4-5.2	4.2
BOD (mg/l)	10,250-43,750	22, 260
COD (mg/l)	15,550-100,380	50,710
Total solids (mg/ l)	11,460-78,710	40,370
Suspended solids (mg l)	4400-53,640	17.620
Volatile solids (mg/l)	8770-71,610	33,820
Oil and grease (mp/l)	130-17,970	6110
Ammoniacal nitrogen (mg/l)	4-77	35
Total mtrogen (mg/l)	180-1360	750

Source Chew. T. Y. and Yeoh. B G., 198'

Maximum standards for effluent discharge into watercourses for the oil palm industry

Parameter (mg/l)	*Concentration (mg/l) 1984 and after*
BOD	100
COD	1000
Total solids	1500
Oil & grease	50
Ammoniacal nitrogen	150
Total mtrogen	200

Source : Environmental Protection Act, 1986

Aside from the high organic load, the final effluent can also contribute to eutrophication due to the nitrogen and phosphorous load in the **POME.** Treated effluents are also known to contain certain bacterial populations. In the digested POME, for example, l-42 x 10^6/100 ml total coliform and 1-518 x 10^6/100 ml faecal coliform have been recorded (Mohd. Tayeb et *al.,* 1987).

Aspects of waste utilization have been widely researched. Some of the uses for POME are in land application, as animal feeds, and for biogas production.

RUBBER INDUSTRY

About 1.9 million ha of land in Malaysia were under rubber cultivation in 1989. The production of 1.42 million t of natural rubber placed Malaysia as the world's top producer that year. However, the rubber industry in Malaysia is slowly declining, with planters switching to more lucrative crops like oil palm and cocoa.

Factories manufacturing latex concentrates and standard Malaysian rubber (SMR) produce waste which could pollute the environment. The Rubber Research Institute, Malaysia (RRIM) states that 48 factories produce latex concentrate and 96 factories produce SMR. About 4.5 litres of effluents are produced for every litre of latex processed (Ahmad Ibrahim et *al.,* 1980) and 22 litres of effluents are generated per kg of dry rubber produced (Mohd. Tayeb et *al.,* 1980). Besides, 6.23 x 10^6/100 ml total coliform, 0.75 x10^6/100 ml faecal coliform and 0.13 *x* 10^6/100 ml ***streptococcus*** have been recorded from the raw effluent (Mohd. Tayeb et *al.,* 1980). Properties of effluents from raw rubber processing are given in the table below.

Characteristics of raw rubber effluent

Parameter	Block	Sheer	Crepe	Latex concentrate
pH				5.4
BOD (mg/l)	1769	1322	305	3524
COD (mg/l)	2899	2471	846	4849
Total solids (mg/l)	1961	1976	546	3860
Suspended solids (mg/l)	322		7	818
Ammoniacal nitrogen (mg/l)	68	73	6.4	466
Total nitrogen (mg/l)	141	143	75	602

Source : Wong. K.K. 1980

Methods of treating rubber effluents have been established and the effluent standards set by the Department of Environment, DOE, are given in the table alongside.

Maximum standards for effluent discharge into watercourse for the rubber industry

Parameter	Concenrrarron (mg/l) 1984 and after
BOD	100
COD	400
Total solids	1,000
Suspended solids	150
Ammoniacal nitrogen	300
Total mtrogen	300

Source : Environmental Protection Act, 1986

11 .4 Pesticides

Synthetic organic pesticides were first introduced in the 1940s and were not only very effective in the control of agricultural pests but also in curtailing disease vectors, such as mosquitoes. Estimates in Malaysia put the value of pesticides used at MS $3 15 million* in 1990, with an annual increase of about 8 per cent/year over the last five years (Tan et *al.,* 1992). The widespread, and often indiscriminate, use of pesticides, however, has created environmental deterioration and has had detrimental effects on nontarget organisms. Today, pesticide usage in Malaysia is controlled by the Pesticide Board of the Department of Agriculture.

* US $ I = MS $ 2.5 appx. (1990)

Little is known about the distribution of pesticides in the aquatic environment. Organochlorines, which generally cause more serious and widespread contamination than other pesticides, are still widely used, and only guidelines — not legislation — are available on their use.

Studies have shown that organochlorines have contaminated some of Malaysia's river systems and aquatic life. A survey in the Kelang River basin by Tan *et al.* (1990) reported that the river was contaminated with 0.005-0.061 ng aldrin/l, 0.009-0.256 ng endosulfan/l and 0.039-1.742 ng heptachlor/l. The study also reported that DDE, DDT and heptachlor were found to be present in all the rivers sampled on the west coast of Peninsular Malaysia. However, the levels were still below the critical values established for Malaysian aquatic life. This indicates that organochlorine pesticide pollution is less of a problem than other organic or inorganic pollutants. A survey carried out by Jothy *et al.* from 1975-1978 found that the cockle, *Anadaragranosa,* contained PCB values ranging from 0.028-0.038 ppm-HCH ranging from 0.003-0.008 ppm, dieldrin 0.001-0.005 ppm, DDT 0.004-0.009 ppm, DDE 0.016-0.042 ppm and DDT 0.027-0.050 ppm. These values were far below the limits of acceptability for human consumption. Rohani et *al.,* (1992) reported that the levels of organochlorines and PCBs in the cockle, *Anadara granosa,* the oyster, *Crassostrea belcherei,* and the green mussel, *Perna viridis,* were generally low, and within the acceptable limits prescribed by the Swedish National Food Administration.

In its efforts to minimize pesticide contamination of the environment, the Pesticide Board, in collaboration with the manufacturers and end-users (mainly oil palm and rubber estates), have introduced new, improved application techniques and strategies. Since 1980, new control strategies, such as the Integrated Pest Management (IPM) programmes, have been introduced.

11.5 Soil erosion and sedimentation

Suspended solids, which act as an indicator of soil erosion and river siltation, have caused a major environmental problem in Malaysian waters during recent years (Environmental Quality Report, 1990). The high levels of suspended solids in the river systems are associated with the continuous and intensive land clearing, uncontrolled development, mining and logging activities in the catchment areas. In Peninsular Malaysia, out of 53 rivers monitored between 1986-1990, 27 rivers (51 per cent) were classified as very polluted, six (11 per cent) were considered slightly polluted and twenty (38 per cent) were considered clean. The worst affected rivers in terms of suspended solids on the west coast of Peninsular Malaysia were Sg. Pontian Besar and Sg. Benut in Johor, and Sg. Tengi and Sg. Buloh in Selangor.

The coastal waters of Peninsular Malaysia are nowadays polluted with suspended solids, (Environmental Quality Report, 1990). River estuaries on the west coast with substantially high levels of suspended solids include Kuala Sungai Kedah in Kedah, Kuala Sungai Juru in Pinang, Kuala Sungai Kurau and Kuala Sungai Sepetang in Perak, Kuala Sungai Melaka in Melaka and Kuala Sungai Lurus in Johor.

11.6 Petroleum

The Malacca Strait is one of the world's busiest oil transport routes and, accidental and deliberate oil spills affect the marine environment. In 1990, very high oil and grease contents were found on the Perak coast. All 141 water samples collected by the Department of Environment exceeded the proposed interim oil standards set for marine aquatic conservation resources (Environmental Quality Report, 1990). Of the 70 samples collected from the coastal areas of Negri Sembilan, 90 per cent exceeded the proposed standard. In Melaka and Selangor, 75 per cent of the 24 and 23 samples collected respectively contained oil and grease levels exceeding the proposed standard. All

75 samples collected from Penang and the 61 samples from Kedah/Perlis, however, had levels below the proposed standard.

Beach tar sampling is carried out by the DOE on selected beaches, especially those designated for recreational purposes. Johor beaches have oeen found to be seriously affected with tar balls (188.7-512.9 g/m strip). Beaches in Melaka, Negri Sembilan, Perak and Selangor have relatively low levels of tar balls (0.2-10.0 g/m strip) (Environmentai Quality Report, 1990).

11.7 *Power plants*

Relatively little information is available on the effects of power generating plants on the marine environment. Anton (1990) made a study on the impact of a 3000 MW electricity-generating power station in Kapar, Selangor. Water was heated l-7ºC above ambient (29º C). Her studies indicated that the total number of cells and species diversity were high at stations which recorded higher seawater temperatures and could be advantageous to shellfish culture in the vicinity. However, studies on seagrass showed the deleterious effect of temperature elevation of just 3ºC; the sea-grasses were killed and replaced by algal mats.

11.8 *Aquacuiture*

High priority is given by the Malaysian Government to the development of aquaculture in the country. It is estimated that by the year 2000 more than 200,000 t of seafood would be produced from farming (Tengku Ubaidillah, 1985). Aquatic organisms successfully cultured in the coastal areas of Peninsular Malaysia include the blood cockle, Anadara granosa, the mussel, *Perna viridis,* the oyster, *Crassostrea belcherei* and *C. iredulei,* the penaeid prawn, mainly *Penueus monodon,* and finfish, including *Lutes culcurifer, Epinephelus* sp. and *Lutianus* sp.

Aquaculture that is badly planned or managed can cause coastal erosion and the pollution of riverine and coastal waters. However, properly planned and managed aquaculture systems should have only a minimum impact on the riverine and coastal waters and should not be a threat to the environment.

Most of the brackishwater ponds in Malaysia are utilized for penaeid prawn culture and these ponds are normally sited in mangrove areas. Guidelines have been formulated by a National Working Group of Mangroves (NATMANCOM, 1986) on the use of mangroves for this purpose.

So far, no complaints about adverse effects on the environment have been received for mollusc culture. However, Chua et al. (1989) reported that the effects of oyster and mussel culture on water quality are indirect: excessive sedimentation occurring in Sapain Bay and Himamaylan Island, Central Philippines, has been attributed to extensive mollusc farming (Young and Serna, 1982; Maragos *et* al., 1983). The high sedimentation resulted in increased water turbidity, although no marked reduction in primary productivity has been reported.

Cage culture for the rearing of grouper *(Epinephelus* sp., seabass *(Lutes culcurifer)* and snapper *(Lutianus* sp.) was introduced in Peninsular Malaysia in the mid-Seventies. Pollution associated with cage farming is caused by waste (faeces and uneaten food) and nutrient discharges which reduce dissolved oxygen in the water and cause high Biological Oxygen Demand. However, adverse effects on water quality due to cage farming have generally not been reported, but complaints of polluted water affecting fish farmed in cages are frequently received. To overcome the problem of culturing fish in coastal waters which may be polluted, the Department of Fisheries is conducting research on the cage culture of fish in the open seas, which are normally less polluted.

12. MARINE FISHERIES

In Peninsular Malaysia, landings of marine finfish and shrimp showed an increasing trend between 1970 and 1980, but, then onwards, declined untii 1986. From 1986 onwards, there has been an increase in the recorded landings, partly due to the landings from the deep sea areas of the Malaysian Exclusive Economic Zone (EEZ) (Annual Fisheries Statistics, Malaysia 1970-1990).

The fisheries resource within the inshore water appears to have reached its maximum level of exploitation, but the declaration of the EEZ has enabled the Malaysian Government to actively encourage the development of the offshore fishery (Lui, 1992).

The fisheries on the west coast of Peninsular Malaysia contribute around 70 per cent of the total marine resources of Peninsular Malaysia (Annual Fisheries Statistics, Malaysia). These resources are made up of two major groups — ihe demersal and the pelagic resources.

12. 1 Demersal resources

The demersal fish resources include species from the following families — Mullidae, Nemipteridae, Sciaenidae, Lutjanidae, Tachysuridae and Synodontidae (Mohammed Shaari *eta!.*, 1974., Lui and Ahmad Adnan, 1988). While landings of the dominant fish groups have remained quite consistent over the years, the relative abundance of certain fish groups observed some dramatic changes. The landings of cephalopods in Peninsular Malaysia have shown an increase from 3462 t in 1970 to 27,939 tin 1988. The landings of *I.actarius lactarius,* which was abundant in the early Sixties, has disappeared in the Seventies, and the landings of ray also declined over the years (Annual Fisheries Statistics, Malaysia). The shrimp resource contributed substantially to the demersal landings on the west coast of Peninsular Malaysia. The economically important species include *Metapenaeus, Parapeneopsis* and *Penaeus,* which are widely distributed in the shallow waters by the west coast (Lee, 1972).

12.2 *Pelagic resources*

The major groups of pelagic fish that contribute significantly to the commercial fisheries are the scombrids, carangids, engraulids, the clupeids and neritic tunas. The pelagic fish resources appear to exhibit a seasonal inshore-offshore migration pattern in relation to the Northeast Monsoon. During the off-monsoon season, there seems to be an inshore movement of the pelagics, and during the monsoon season, offshore migration and dispersion occur (Anon, 1989).

13. ALGAL BLOOMS AND FISHKILLS

Fish kills from natural or culture fisheries are occasionally reported. Causes of mortality include pollution, eutrophication or algal blooms. Cases of shellfish poisoning from algae blooms, such as *Pyrodinium,* have been reported only in Sabah, East Malaysia.

In Malaysia, the red tide blooms that cause Paralytic Shellfish Poisoning (PSP) have so far been reported only in the waters off Sabah. In Peninsular Malaysia, red tide bloom varieties that do not cause PSP have frequently been reported. *Noctiluca scintillans* has been reported in Johor, causing fish and shrimp mortality. The red tide occurrences in Malaysia are listed in the table alongside. The dinoflagellate, *Pyrodinium bahamensa* var. *compressa* has **been reported to cause human** fatalities as well as mortality of **aquatic life. Blooms caused by** *Noctiluca scintillans* and *Hornellia marina* have been **reported to cause only fish and** shellfish mortality.

Record of red tide occurrences in Malaysia

Date	*Site*	*Organism*	*Impact*
Feb-May '76	K. Kinabalu. Sabah	Pvrodinium	202 affected, dead, aquatic life mortality
Aug. '78	T. Kumbar, Pinang	*Noctiluca*	Fish kills.
Nov. '78	P.BetongK.Sg. Pinang, Pinang	*Noctiluca*	Fish asphyxiation
Oct. '79	T. Kumbar, Pinang	*Noctiluca*	Fish asphyxiation
May '80	Brunei Bay, Sahah	*Pvrodinium*	30 affected, 1 dead
Jan. '83	Gava Island, Sabah	*Pvrodinium*	31 affected, 3 dead
Man., May-Jul., Sep-Nov. '83	Johor St.	*Hornellia*	Fish, shrimp, crab mortality
Jan. - Mar. '84	Gava Island, Sabah	*Pvrodinium*	9 affected, 7 dead
Jan. Feb. '85	Johor St.	*Hornellia*	Shrimp mortality
Sep. '85	Kimanis Bay. Sahah	*Pvrodinium*	Toxin in *Crassostrea belcherei*
Dec. '87 . Jan '88	Sabah waters	*Pvrodinium*	31 affected, 3 dead, cats died.
Jun. '90	S8. Dindings, Perak	unidentified	Sores in fish, mussel mortality

Source.' Choo, 992.

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Fish kills in the coastal and estuarine waters of several rivers in western Peninsular Malaysia have been on the increase over the years. The table alongside shows the outbreak of fish kills and diseases. Highest mortality was probably due to either factory effluents or high organic load in the water.

In the state of Johor, a review of 1987-1991 revealed 21 written reports made to the Department of Fisheries. Of these 21 cases, six (28.6 per cent) were associated with palm oil mill effluents, five (23.8 per cent) with industrial wastes and five others (23.8 per cent) with spills and direct or indirect pollution caused by sand dredging and mining.

Fish kills in coastal waters of west coast of Peninsular Malaysia

Date	*Location*	*Outcome*	*Reported cause*
June '75	B. Feringghi, Pinang	Fish mortality	Severe organic pollution; piggery waste.
Oct. '77	Juru estuary, Pinang	Mass cockle mortality	Effluent pollution; heavy ram with salinity drop.
Nov. '19	Tebrau Bay, Johor	Mass mortality of fish fingerlings	Piggery wastes.
Nov. '80	Prai estuary, Pinang	Fish mortality	Factory effluents.
Jan. '81	Pulau Aman, Pinang	Cage-cultured fish mortality	Oil spill.
Mar. '84	Batu Maung, Pinang	Mass *cockle* mortality	Piggery wastes and soil erosion.
Apr. '85	Muar estuary, Johor	Oyster mortality	Factory effluent.
Sep. '85	Tebrau Bay, Johor	Mussel mortality	Low oxygen.
Jun. '89	Kuala Kurau, Perak	Fish kills	High sediment.
Apr. '90	Sg. Sepetang and estuary, Perak	Fish kills	Factory effluents.

Source : Department of Fisheries.

14. ONGOING RESEARCH PROJECTS

14.1 Department of Environment

The DOE implements the following programmes to reduce environmental pollution (Environmental Quality Report, 1990):

- Pollution control and prevention;
- Integrated project planning;
- Environmental inputs to resource and regional development planning;
- General environmental programmes; and
- Pro-active response to international environmental issues.

14.2 Fisheries Research Institute (FRI)

The research projects carried out by the FRI include :

Water quality monitoring and fish kills;
Heavy metals in water, sediments and fish/shrimp/mollusc tissues;
Pesticide residue studies in tissues of fish/shrimp/molluscs;
Antibiotic residue studies in fish/shrimp/molluscs;
Toxicological studies, especially of oil-dispersants and pesticides;
Impact of sediments on the coral reef ecosystem;
Conservation studies in mangrove, coral reef and seagrass habitats; and
Development of artificial reefs for fisheries conservation, rehabilitation and management.

The FRI also participates in the International Atomic Agency (IAA) Project on Marine Sediment Contaminant Survey implemented in 1990, and also in the project on Marine Sediment Pollution.

Other participants in these two projects include Universiti Pertanian Malaysia, Universiti Kebangsaan Malaysia, the Nuclear Energy Unit and the DOE.

14.3 Universities

Some on-going projects carried out in the Universiti Sains Malaysia include studies on the impact sediments have on coral reef ecosystems, toxicity studies of effluents discharged from crude oil terminals, the effect of tributyltin on the aquatic environment, and heavy metals and organic wastes treatment studies.

In the Universiti Pertanian Malaysia, research projects on marine pollution include studies on hydrocarbon pollution, the impact of sediments on the coral reef ecosystem, a study of the impact of industrial plants on the marine environment, as well as work on the Environmental Sensitivity Index (ESI) mapping.

Other current Universiti Malaya research projects include multidisciplinary studies on coastal and marine ecosystems and pollution studies related to toxicity testing for pesticides, organic chemicals and heavy metals in fish and other aquatic life.

15. CONCLUSIONS

Coastal marine environment pollution does pose a major threat to the well-being of the fisheries industry in Malaysia. However, the Government of Malaysia is well aware of the problems, and specific action plans are being mobilized to alleviate and control environmental degradation. Malaysia has been actively involved in the recently concluded UNCED Earth Summit held in Rio, in Brazil, July 1992 and is also a cosignee of the Declaration on Biodiversity. Malaysia is firmly committed to the 1982 Law of the Seas Convention. These policies are being translated into action: Thirtytwo islands have been gazetted as protected marine parks, and environmental impact assessments have been made mandatory for major development projects.

16. REFERENCES

AHMAD IBRAHIM, S. SETHU. MOHD. ZIN KARIM and ZAID, ISA. 1980. Anaerobic/facultative ponding system for treatment of latex. *Proc. Rub. Res. Inst. Malaysia* PIns. *Conf.,* pp 419-435.

ANNUAL FLSHERIES STATISTICS, 1970-1990. Dep. of Fisheries, Min. of Agriculture, Kuala Lumpur, Malaysia

ANONYMOUS. *1989. Deep-sea fisheries resources within the Malaysian Exclusive Economic Zone — survey report of demersal and pelagic* resources. Paper presented at the Seminar Sumber Perikanan Laut Dalam di Zon Eksklusif Ekonomi (ZEE). Malaysia, Kuala Lumpur.

ANTON, A. 1990. Effects of thermal discharge on marine phytoplankton. *Proc. 12th An. Sem. of the Mal. Soc. of Mar.* Sc.. Kuala Lumpur.

CHOO. P. S. 1992. *A review of red tide occurrences* in *Malaysia.* (In preparation).

CHEW, T. Y. and YEOH.B. G. 1987. Palm oil mill effluent as a source of bioenergy. *Proc. Natl. Symp. Oil Palm By-Prod. for Agro-based Ind.,* pp. 155-168.

CHUA, T.E.. JAMES, N.P. and FLORDELIZY, Y.G. 1989. The environmental impact of aquaculture and the effects of pollution on coastal aquaculture development in Southeast Asia. *Marine Pollution Bulletin.* Vol. 20, No. 7: 335-343.

DE SILVA. M. W. R. N. 1982. The status and conservation of coral reefs in Peninsular Malaysia. *Proc. of the 4th Ann. Sem. of the Mal. Soc. of Mar. Sci.*

DEPARTMENT OF ENVIRONMENT. *1990. Environmental Qualify Reports.* Min. of Sc., Tech. and Env., Malaysia, Annual report.

GEDNEY, R. H ., KAPETSKY, J .M. and KUHNHOLD. *1982. Training on assessment of coastal aquaculture in Malaysia.* Manila Sourh China Sea Fisheries Development and Coordinating Programme. SCS/GEN/82/35.

GONG, W.K., ONG, J.E., WONG, C.H. and DHANARAJAH, C. 1980. *Productivity of mangrove trees and its significance in a managed* mangrove ecosystem in Malaysia Asian Symp. *on* Mangrove Env. Res. and Mgmnt., University of Malaya and UNESCO, August 25-29. 1980.

HO, Y.C., CHEE, Y.S.. CHONG. C.N., CHOY, C.K., YEOH, B.C. and YEW, K.K. 1984. Environmental, social and economic considerations in the management of swine wastes in Malaysia. *Proc. Reg. Sem. Tech. Utilization and Mgmnt. o f Agri. Wastes.*

JOTHY, A.A. 1983. *The need for standardization of techniques and intercalibration of results in pollution assessment and monitoring in Asian seas.* Paper at Symp. on Reg. Co-op. on the Protection of the Env., 15th Pac. Sci. Cong., Dunedin, New Zealand, February 1-11 1983.

_____________ *1973. Coral reefs in the coastat wafers of West Malaysia, their utilization and conservation.* Departmental paper, Fisheries Research Institute, Penang.

JOTHY, A.A. and IBRAHIM, R. 1987. *Toxicity screening of oil dispersants in Southeast Asia.* Paper presented at the UNEP Symp. on Reg. Coop. in Env. Prot. of the Mar. and Coast. Areas of the Pacific, XVI Pacific Science Congress, Seoul, Korea, August 25-26, 1987.

KUSHAIRI, R. 1992. *The areas and species distribution of seagrasses in Peninsular Malaysia.* To be presented in the 1st National Natural Res. Symp., FSSA, Universiti Kebangsaan Malaysia, Kota Kinabalu, Sabah, July 23-26, 1992.

LEE, C.K. 1972. Commercial species of penaeid prawns in West Malaysia. Mal. *Agric. J., 48(3) : 264-277*

LIEW, H. C. and HOARE, R. 1982. The effects of sediment accumulation and water turbidity upon the distribution of *Scleractinian* corals at Cape Rachado, Malacca Strait. *IN: Proc. of the Conf. on Trends in App. Biol. in Southeost Asia.* October 11-14, 1979, Pinang, Malaysia. SBS, USM.

LUI Y .P. *1992. Multispecies fish resources and multispecies fisheries in the coastal waters of Peninsular Malaysia, with special reference* to *the West* Coast. Paper presented at the Sixth Sess. of the Standing Committee on Res., Research and Dev Colombo, Sri Lanka. May 18-21, 1990. FAO Fisheries Report *NO.* 463 Suppl. Rome, FAO, 215pp.

LUI Y.P. and AHMAD ADNAN, 1988. Demersal fish resources in Malaysian waters (15). Fifth trawl survey off the west coast of Peninsular Malaysia (Nov-Dec., 1980). *Fisheries Bull.* No. 56, Department of Fisheries, Ministry of Agriculture, Malaysia.

LULOFA, R.B. 1977. Conservation of the marine environment-coral reefs. *Proc. First Sem. of the Mat. Soc. of Mar. Sci.. 1977.*

MA, A.N. 1988. Status of treatment technologies for palm oil industrial effluents. *Proc. SLDB/PORIM workshop on Palm* Oil Milling *Technology.* pp. 96-109 IPMKS 1988.

MARAGOS, J.E., SOEGIRTO, A., GOMEZ, E.D. and DOW, M.A. 1983. Development planning for tropical coastal ecosystem. *IN: Natural Systems for Development. What Planners Need* To *Know.* Ed. R.A. Carpenter. pp. 229-298, MacMillan Publishing Company, New York.

MOHAMAD ISMAIL YAZIZ. 1983. Control and management of water quality in Malaysia. *Pertanika, 6: 69-87*

MOHD. TAYEB DOLMAT, MOHD. ZIN KARIM, ZAID ISA. and PILLAI, K. R. 1980. Land-disposal of rubber factory effluent: Its effects on soil properties and performance of rubber and oil palm. *Proc. Rub. Res. Inst. Malaysia Plns. Conf.,* pp. 436-455.

MOHD. TAYEB DOLMAT., LIM, K.H., ZIN ZAWAWI ZAKARIA and ABD. HALIM HASSAN. 1987. Recent studies on the effect of land application of palm oil mill effluents on oil palm and the environment. *Proc. of 1987 Intl. O.P./P. O . Conf. Agric.*

MOHAMMED SHAARI, S.A.L., G. RAUCK, K.S. ONG, and S.P. TAN. 1974. Demersal fish resources in Malaysian waters, 2. Trawl survey of the coastal waters off the West Coast of Peninsular Malaysia (Dec. 12, 1970 · Jan. 22, 1971). *Fish.* Bull. No. 3, Min. of Agri. and Rur. Dev., Malaysia.

NATMANCOM, 1986. *Guidelines in rhe use of rhe mangrove ecosystem for brackishwafer aquaculture in Malaysia.* Report of the working group of Mal. Nati. Mangrove Corn.

PHANG, S. M. 1990. Seagrass A neglected natural resource in Malaysia. *Proc. 12th Ann. Sem. of the Mol. Soc. of Mar. Sci.,* Kuala Lumpur.

ROHANI IBRAHIM, CHAN, S. M. and ISMAIL ISHAK. *1992. Organochlorine pesticides and PCB residues in some Malaysian shell fish.* Paper presented in the Sem. on Pesticides in the Mal. Env.: Impact on Agri. and Ecosystems, February 27, 1992, Selangor.

<<

SASEKUMAR, A. 1980. *The present state of mangroveecosystems in Southeast Asia and the impact of pollution: Malaysia.* South China Sea Fisheries Development and Coordinating Programme, Manila.

SHAHUNTALA, D. V. 1986. Heavy metal levels in Malaysian fish. *Fisheries Bulletin* 58, Ministry of Agriculture, Malaysia.

________________ (1989). *Heavy metals in Malaysian shellfish.* Paper presented in Sem. Penyelidikan Perikanan, Melaka, June 25-29. 1989.

SHEPPARD, C. R. C. 1992. *Marine parks in Malaysia: Research. development and display.* Rep. on Proj. No. ADB 862-MAL., Kuala Lumpur, Malaysia.

TAN, G. H.. YEOH, H. F., ZAIN KARIM and MOKHTAR YUSOF. 1992. *Pesticide use and control in Malaysia.* Paper presented in Seminar on Pesticides in the Mal. Env.: Impact on Agri. and Ecosystem, Dept. of Agri., Malaysia, Kuala Lumpur, 1992.

TAN, G.H., GOH. S. H., VIJAYALETCHUMY, LOONG. C.P. and ANG. K.L. 1990. Monitoring of water-borneorganic chemical pollution in the Kelang River Basin. Bull *Sing N.I. Chem., 18: 67-77.*

TAN<;, H. T.. HARON Hj. ABU HASSAN. and CHEAH, E. K. 1990. *Mangrove forests of Peninsular Malaysia — A review of management and research objectives and priorities.*

TENGKU DATO UBAIDILLAH BIN ABDUL KADIR. 1985. Aquaculture development strategy and programme. IN: *Report on Aquaculture Conference.* Fisheries Dept. (Min. of Agri.) in collaboration with International Convention Secretariat (Prime Minister's Dept.).

WONG, K. K. 1980 Application of ponding systems in the treatment of palm oil mill and rubber mill effluents. *Pertanika, 3 :* 133-141.

YOUNG, A. and SERNA, E. 1982. Country report. Philippines. IN: *Proc. of the Wkshp. on Bivalve Cult. in Asia and Pacif.* (B.F. Davy & M. Graham Eds.), IDRC · 200c. Intl. Dev. Res. Cent. of Canada, Ottawa: 16-19.

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APPENDIX VII

Institutions engaged in environmental research, monitoring and enforcement

GOVERNMENT

Department of Environment, Malaysia

The Department of Environment (DOE) is structured in three functional divisions, namely Planning and Development, Operation and Administration. The Operation Division has two main sections, Enforcement and Monitoring. The DOE does not carry out research directly, but commissions the universities and other research agencies IO undertake particular research projects.

The DOE is staffed by officers from various disciplines. In 1990, there were, at the professional level, 46.5 per cent engineers and 51.7 per cent scientists. Oneofficer was an economist. At the intermediate level, 64.8 per cent had received engineering training and 35.2 per cent held science qualifications.

Fisheries Research Institute, Malaysia

The Fisheries Research Institute (FRI), Department of Fisheries, was founded in 1957. It has a research section, the Aquatic Ecology Section, which carries out studies on water quality monitoring in areas which are important to coastal fisheries and aquaculture. Pollution research on bacteriology, heavy metals, pesticides, antibiotics and toxicology are also given priority. Conservation studies involving seagrass communities, mangrove and marine, park coral reef ecosystems, as well as artificial reef research, are also carried out.

UNIVERSITIES

Universiti Sains Malaysia (School of Biological Sciences, School of Physics and School of Chemical Sciences), Universiti Pertanian Malaysia, (Faculty of Fisheries and Marine Sciences, and Faculty of Science and Environmental Studies), Universiti Malaya (institute of Advanced Studies, Department of Zoology and Department of Chemistry), Universiti Kebangsaan Malaysia and Universiti Teknologi Malaysia are all involved with pollution research. Subjects ranging from oil and grease, hydrocarbon, metal, pesticide and organic waste pollution are investigated. The universities also study the seagrass, mangrove and coral reef ecosystems.

NONGOVERNMENTAL AGENCIES

Nongovernmental agencies involved with environmental and pollution research include :

Environmental Management & Research Association of Malaysia
36B, 2nd Floor, Jalan 20/16A, Paramount Garden, 46300 P. Jaya.

Malayan Nature Society
P. O. Box 10750, 50724 Kuala Lumpur.

Environmental Protection Society, Malaysia
17, Jalan. SS2/53, 47300 Petaling Jaya.

Malaysian Fisheries Society
C/o Faculty of Fisheries & Marine Sciences, Universiti Pertanian Malaysia, 43400 Serdang

Malaysian Society of Marine Sciences
C/o School of Biological Sciences, Universiti Sains Malaysia, 11800 Penang.

WHO Western Pacific Regional Centre for the Promotion of Environmental Planning and Applied Studies
P. 0. Box 12550, 50782 Kuala Lumpur.

World Wide Fund For Nature, Malaysia
P. 0. Box 10709, 50724 Kuala Lumpur.

Sahabat Alam Malaysia
37, Lorong Birch Penang.

Consumer Association of Penang
87, Jalan Cantonment 10250 Penang

APPENDIX VIII

Legislation against threats to the marine environment

Malaysia is relatively well served with legislation that regulates potential environmental threats. The departments involved in this, as well as the enforcement agencies, are listed in the table below and on the facing page.

Existing regulations are, for the most part, adequate in maintaining reasonable environmental quality in the country. Malaysia, however, is currently in the process of reviewing national environmental laws to block loopholes in some regulations, upgrade others and draft new directives in some cases.

The DOE is responsible for matters pertaining to the environment. In the case of a fish kill, toxic waste dumping or oil spill, for instance, the DOE would be contacted. Contingency teams involving other agencies, such as the Marine Department, the Department of Transport, the Navy, the Department of Fisheries and the petroleum companies would also be mobilized to fight the disaster.

Environmental laws relating to the marine environment

Activity	*Relevant Act or provision*	*Department involved*	*Enforcement agency*
Transportation (a) Shipping	Merchant Shipping Ordinance 1952 Merchant Shipping Ordinance 1960 (Sabah) Merchant Shipping Ordinance 1960 (Sarawak)	Ministry of Transport Marine Dept. Peninsular Malaysia Marine Dept. Sabah Marine Dept. Sarawak	Ministry of Transport Marine Dept. Peninsular Malaysia Marine Dept. Sabah Marine Dept. Sarawak
hi Transportation of petroleum by ships	Petroleum (Safety Measures) Act 1984 Petroleum (Safety Measures) Transportation of Petroleum by Water) Regulations 1985	Prime Minister's Dept.	Prime Minister's Dept.
(c) Transportation of petroleum by pipelines	Petroleum (Safety Measures) Act 1984 Petroleum (Safety Measures) (Transportation of Petroleum by Pipelines) Regulations 985	Factory & Machinery Dept.	Factory & Machinery Dept.
(d) Pollution from ships	Merchant Shipping Ordinance 1952 (Part VA) Environmental Quality Act 1974 (Section 26, 27 & 29) Exclusive Economic Zone Act 1984	Ministry of Transport	Marine Dept.
(e) Pollution from dumping	Merchant Shipping Ordinance 1952 Exclusive Economic Zone Act 1984	Marine Dept.	Marine Dept.
(f) Reception facilities	Merchant Shipping Ordinance 1952 Merchant Shipping Act 1991	Ministry of Transport Marine Dept.	Marine Dept.
Dredging	Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment
Sand-mining	Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment
Draining of wetland	Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment
Coastal reclamation	Environmental Quality (Prescribed Activities) Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment
Fisheries Development (a) Construction of fishing harbour	Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment
(b) Harbour expansion	Environmental Quality (Prevcribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment
(c) Land-based aquaculture projects accompanied by clearing of mangrove forests	Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment

Activity	*Relevant Act or provision*	*Department involved*	*Enforcement agency*
Fishing **and fish conservation** (a) Fishing	Fisheries Act 1985	Dept. of Fisheries	Dept. of Fisheries Marine Depi. Navy Marine Police
(b) Licensing of fishing vessels and fishing appliances and imposition of conditions on licences	Fisheries Act 1985 (Section 8 and 11) Fisheries (Maritime) Regulation 1967	Dept. of Fisheries	Dept. of Fisheries
(c) Prohibition of certain fishing methods	Fisheries (Prohibition of Meihod ol Fishing) Regulations 1983	Dept. of Fisheries	Dept. of Fisheries
(d) Prohibition of fishing in certain areas	Fisheries (Prohibition Areas) (Amendment) **Regulations 983**	Dept. of Fisheries	Dept. of Fisheries
(e) Establishment of turtle sanctuary	Rantau Abang Prohibited Fishing Areas **Order** 1991	Dept. of Fisheries	Dept. oF Fisheries
(f) Establishment of marine park, its control and protection	Fisheries Act 1985 (Section 41, 42. 43, 44 and 45)	Dept. of Fisheries	Dept. of Fisheries Marine Dept. Navy Marine Police
(g) Setting up fisheries marine culture systems	Fisheries (Marine Culture System) Regulations 990	Dept. of Fisheries	Dept. of Fisheries Marine Dept. Navy Marine Police
Forestry (a) logging or conversion of forest land to other land use in areas adjacent to state and national parks and national marine parks	Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environnient	Dept, ol Environment
(b) Conversion of mangrove swamps for industrial, housing or agriculture use	Environmental Quality (Prescribed Activitiesl (Environmental Impact Assessment) Order 987	Dept. of Envirotiment	Dept. of Environment
Development of ports (a) Construction of ports	**Environmental Quality (Prescribed Activities)** (Environmental Impact Assessment) Order 1987	**Dept.** of Environment	Dept. of Environment
(b) Port expansion	Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment
Exploration and exploitation (a) Oil and gas fields development	**Continental Shelf Act** 1966 Petroleum Mining Act 1972 Petroleum Development Act 1974 Exclusive Economic Zone Act 1984 Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment
)b(Construction of offshore and onshore pipelines	Environmental Quality (Prescribed Activities) (Environmental Assessment) Order 1987	Dept. of Environment	Dept. of Environment
(c) Construction of offshore structures	Continental Shelf Act 1966 Petroleum Mining Act 1972 **Euclusive Economic Zone Act 1984**	Petroleum Authority	Petroleum Authority
(d) Registration of offshore industry mobile units and offshore industry	Merchant Shipping Ordinance 1952	Ministry of Transport	Ministry of Transport
Resort **and recreation development** (a) Construction of coastal resort facilities or hotels	**Environmental Quality (Presctibed Activities)** (Environmental Impact Assessment) Order 1987	**Dept.** Of Environment	Dept. of Environment
(b) Development of tourist or recreational facilities on islands in surrounding waters which are gazetted as national marine parks	Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Dept. of Environment	Dept. of Environment
Sewage and industrial effluents discharge	Environmental Quality Act 974 Environmental Quality (Sewage and Industrial Effluents) Regulations 1979	Dept. of Environment	Dept. of Environment

APPENDIX IX

Other publications on the marine environment

ABDULLAH ALl, ABANG. 1985. Management and utilization of industrial wastes *Mal. Agri. Digest,* 4:20-21.

ABU BAKAR JAAFAR, LAW, A. T. and NOOR AZHAR SHAZILI. 1985. *A review of marine pollution monitoring and research programme in Malaysia.* Paper presented at the IOC Westpac Meeting of Pot. Res. and Monitoring Task Team, April 17 - 19, 1985, Townsville, Australia.

AHMAD MUSTAPFFA Hi. BABJEE, YAP, T. C., ChEE, Y. S., CANDIAH, P., LIM, E. S. and CHEONG, Y. L. 1983. *Proposalfor the abatement ofpollution from piggery waste in Peninsular Malaysia.* Vet. Div., Min. of Agri., Malaysia.

ANG, T. T . LI M, P. E. and SENG, C. E. 1987. *Environmental baseline studies on the Penang Development Corporation proposed land reclamation in the Proj Industrial Estate.* Rep. to PDC for the preparation of environmental impact assessment (EIA), Mar., 1987.

__________ 1986. *Physicochemical baseline study of proposed land reclamation off the Proj Industrial Estate.* Rep. to PDC for the preparation of environmental impact assessment (EtA), Jul., 1986.

__________ 1987. Heavy metal concentrations in coastal seawater and sediments off Prai Industrial Estate, Penang, Malaysia. *Mar. Pol. Bul.,* 18, 611-612.

BAKRY SHAH JOHAN, TENGKU. 1985. Control of soil erosion and river siltation. *Ilmu Alam,* 14 & 15:73-89.

BILAL, J. and KUHNHOLD, W.W. 1980. *Marine oil pollution in Southeast Asia.* FAO South China Sea Fish. Dcv. and Coordinating Prog., SCS/80/WP.92, Manila, 85p.

CHAN, E. H. and LIEW, H. C. 1988. *A review on the effects of oil based activities and oil pollution on sea turtles.* Paper at 11th Ann. Sem. of the Mal. Soc. of Mar. Sci. March 26, 1988, Universiti Malaya, Kuala Lumpur, Malaysia.

CHONG, S. F. 1985. Sediment problems and their management in Peninsular Malaysia. *Berita Ensearch,* 2:2-3.

CHOO, P. S. 1992. A study of the water quality at a coastal cage-culture site in Penang, Malaysia. *Fish. Bull.* Min. of Agri. Malaysia.

__________ 1987. The effect of ethylene diamine tetraacetic acid disodium salt on the spawning and hatching of penaeid prawn eggs. Fish. Bull. No. 49 Min. of Agri., Malaysia.

CHUA, T. E. and MATHIAS, J. A. (Eds). 1978. *Coastal resources of West Sabah: A preliminary study in relation to a potential oil spill.* Rev. ed. Universiti Sains Malaysia Press, Penang, Malaysia.

CHUA, T.E. and MATHIAS, J. A. PAW, J. N. and GUARIN, F. Y. 1989. The environmental impact of aquaculture and the effects of pollution on coastal aquaculture development in Southeast Asia. *Mar. Poll. Bull.,* Vol. 20, No. 7, pp. 335-343.

CHUA, T.E. and MATHIAS, J. A. and CHARLES, J. K. (Eds.). 1984. *Coastal resources of East Coast of Peninsular Malaysia.* An assessment in relation to potential oil spills. Universiti Sains Malaysia Press, Penang, Malaysia.

COLEMAN, J. M., GAGLIANO, S. M. and SMITH, G. S. 1970. Sedimentation in a Malaysian high tide tropical delta. IN: *Modern and ancient society of economic palaeontologists and mineralogists* (Eds: Morgan, J. M. & Tulsa, O. K.), pp. 185-197.

DIN, Z. B. and BROOKS, J. M. 1986. Use of adenylate energy charge as a physiological indicator in toxicity experiments. *Bull. Env. Contam. Toxicol.,* 36: 1-8.

DIN, Z. B., FAY, R. M. and BROOKS, J. M. 1984. The role of volatiles in the toxicity of ocean dumped industrial wastes to marine phytoplankton. *Proc. of the 5th Intl. Ocean Disposal Sym.* Corvalis, Oregon, U.S.A.

DIN, Z.B., FAY, R.M. and BROOKS, J.M. 1983. Sublethal effects for a chemical industrial waste on the growth and reproductivity for a marine phytoplankton in a flow-through laboratory culture system. *Proc. Intl. Dev. Mgmnt. Trop. Liv. Aq. Res.;* Serdang, Malaysia.

GONG, W. K. and ONG, J.E. 1985. The different uses of mangrove and their possible impacts on mangrove and adjacent coastal fisheries. IN: *Proc. MAB/COMAR Reg. Sem. on Man's Impact on Coastal and Estuarine Ecosystems.* (Eds. Saeki,T. *et al.)* pp. 21-26.

GONG, W. K. and ONG, i.E. and WONG, C. H. 1983. *Pollutants and the mangrove ecosystem.* Paper at Jt. Oc. Assembly. Halifax, Nova Scotia, Canada. August 2-13, 1983.

HO, Y. C. 1985. Control and management of pollution of inland waters in Malaysia. *Berita Ensearch* (Malaysia), 2:2-4.

ICHIKAWA T., LAW, A. T., MOHAMAD RAFFEE JUSOH and AZHAR OTHMAN. 1987. Nitrogen distribution in the coastal waters of the South China Sea. *IN: Matahari Expedition '86* (Eds. Mohsin, A. K. M., Mohd. Ibrahim, Ambak, M. A. & Abd. Ridzwan). Fac. of Fish. and Mar. Sci., University Pertanian Malaysia, 0cc. pub. No. 4.

ISMAIL ISHAK. 1988. *Cockle depuration in Malaysia.* Paper at the ASEAN Consultative Wkshp. on Mollusc Depuration, Penang, Malaysia. October 4-7, 1988.

JANGI, M. S. and ZAMZABAR A. R. 1989. Prevalence of *Vibriofluvialis* in water, sediment and cockles from a river estuary in Malaysia. *Mal. Appl. Biol.* 9: 17-25.

JANGI, M. S. and ZAMZABAR A. R. ESPARAN, M. and HAMID, M. Y. 1980. An ecological study of bacteria associated with Malaysian cockies, *Anadara granosa L. Ma!. App!. Biol.,* 9: *17-25.*

JOTHY, A. A. 1982. The fate of fisheries and aquaculture in the wake of a deteriorating aquatic environment in Malaysia. *Proc. Symp. on the Mal. Env. in Crisis.* Consumers Assn. of Penang, Penang.

________ 1982. Malaysia: Valuable and vulnerable marine resources in the shipping, energy and environment. IN: *Southeast Asian Perspectives for the Eighties* (Eds. Valencia *et a!.),* Dalhousie Oc. Studies Prog., Canada.

________ 1987. *Detection and determination of organochlorine residues in Malaysian fish.* The intl. Conf. on Pesticides in Trop. Agri., Kuala Lumpur, September 23-25, 1987.

________ 1984. Status of shellfish toxicity and related problems in Malaysia. IN: *Toxic red tides and shellfish toxicity in Southeast Asia* (Eds. A. W. White, M.Anraku and K. K. Hooi, pp., 33-34.Southeast Asian Fisheries Development Centre, Singapore, and International Development Research Centre, Ottawa.

JOTHY, A.A. ROHANI IBRAHIM and VELU MURUGAN. 1985. *Toxicity screening of oil dispersants.* Country Report-Malaysia. Review Meeting of UNEP/EAS Project 2.2; Coop. Res. on Oil and Oil Dispersants and Toxicity Testing, Sydney, Australia, November 18-22, 1985.

JOTHY, A.A. and ROHANI IBRAHIM 1990. Toxicity screening of oil dispersants in Malaysia. *Proc. Sem. Penyelidikan Perikanan,* IPP Pulau Pinang, Jab. Perikanan, Kementerian Pertanian Malaysia.

JOTHY, A.A. 1976. *Report on marine pollution problems in Malaysia.* Paper presented at the Intl. Wkshp on Mar. Poll. in East Asian Waters. Universiti Sains Malaysia, Penang, April 7-13, 1976.

________ 1986. *Biological effects of marine pollution strategies and methodologies for their measurements and monitoring in Southeast Asian waters.* Paper at IOC Symp. on Status and Trends in the Dev. of the GIPME Prog., including the Mar. Poll. Monitoring (MARPOLMON) Sys., Paris, September 22-24, 1986.

KHOO, K. H., ZUBIR DIN, LEONG T. S. and CHONG, **C.** S. 1991. *Toxicity study of effluent dischargedfrom Bintulu, Labuaand Miri crude oil terminals, andfrom Lutong refinery.* Rep. prep. for Petroliam Nasional Berhad, 110 p.

KOH, H. L., LIM, P. E., SIEH, K. C. and ZAMALI MIDUN. *Environmental impact due to pollutant discharge in Selat Johor.* ASEAN-USAID Coastl. Reso. Mgmnt. Study.

KOH, H. L., CHONG, C. S. and LIM, P. E. 1988. Impact assessment of sewage disposal in Penang Southern Channel of Malaysia. IN: *Pollution in the Urban Environment-POLMET88. Vol. 2* (Eds. Hills, P., Keen, R., Lam, K. C., Leung, C. T., Oswell, M. A., Stokes, M. & Turner, E.), pp 171-176. Vincent Blue Copy Co. Ltd., Hong Kong.

LAI, H. C. and FENG, M. C. 1984. A review of oil spills with special references to mangrove environment. IN: *Fate and effects of oil in the mangrove environment.* 4 (Eds. Lai, **H. C.** & Feng, M. C.), Universiti Sains Malaysia, pp. *5-19.*

________ 1985. Effects of oil in mangrove environment. *Berita Ensearch,* Malaysia *2:4-5.*

________ 1984. Simulation of oil spills in mangrove swamp. IN: *Fate and effects of oil in the mangrove environment.* (Eds. Lal, H. C. & Feng, M. C.), Universiti Sains Malaysia, pp. 139-147.

________ 1984. The use of dispersants in oil spills control and its guidelines. IN: *Fate and effects of oil in the mangrove environment.* (Eds. Lai, H. C. & Feng, **M.** C.), Universiti Sains Malaysia, pp. 227-246.

LAI, H. C. FENG, M. C. LIM, C. P. and LEE, K. T. 1984. Effects of naturally and chemically-dispersed oil on invertebrates in mangrove swamps. IN : *Fate and effects of oil in the mangrove environment.* (Eds. Lal, H. C. & Feng, M. C.), Universiti Sains Malaysia, Penang, pp. 123-136.

LAI, H. C. FENG, M. C. and LIM, K. H. 1984. Effects of oil on mangroves in field conditions. IN: *Fate and effects of oil in the mangrove environment.* (Eds. Lai, H. C. & Feng, M. C.), Universiti Sains Malaysia, Penang, pp. 67-98.

LAI, H. C. FENG, M. C. and FANG, M. C. 1984. Recommendations of follow-up research on oil pollution. IN: *Fate and effects of oil in the mangrove environment.* (Eds. Lai, H. C. & Feng, M. C.), University Sains Malaysia, pp. 247-252.

________ 1984. Field and laboratory studies on the toxicities of oils to mangroves. IN: *Fate and effects of oil in the mangrove environment.* (Eds. Lai, H. C. & Feng, M. C.), Universiti Sains Malaysia, pp. 539-546.

LAW, A. T. and SINGH, A. 1987. Heavy metals in fish at the Kelang estuary, Malaysia. *Ma!. Nat. J.,* 41: 505-5 13.

LAW, A.T. and ABD. RAHMAN SHAIK. 1987. Phosphate distribution in the South China Sea: Coastal waters off Kuantan to Pulau Tioman. IN: *Matahari Expedition '86* (Eds. Mohsin, A. K. M., Mohd. Ibrahim, Ambak, M. A. & Abd. Ridzwan) Fac. of Fish. and Mar. Sci., Universiti Pertanian Malaysia. 0cc. Pub. No. 4.

LAW, A.T. 1983. *Oil degrading microorganisms in Malaysian coastal waters.* Petronas Oil Spill Sem., October 18-20, 1983, Kuala Lumpur, Malaysia.

______ 1978. *Essential and toxic metals in Malaysian finfish and shellfish.* Ph.D. thesis, Universiti Malaya. 112 p.

______ 1983. *Monitoring of sewage pollution in the estuarine and coastal water of Port Kelang, Malaysia.* Preprint Intl. Conf. on Dcv. and Mgmnt. of Trop. Liv. Aq. Res., August 2-5, 1983, Universiti Pertanian Malaysia.

______ 1983. *Biodegradation for volatile hydrocarbons in continuous culture.* Petronas Oil Spill Scm., October 18-20, 1983, Kuala Lumpur, Malaysia.

______ 1980. Sewage pollution in Kelang River and its estuary. *Pertanika 3(1):* 13-19.

LAW, A.T. and ZULKIFLI B. MAHMOOD. 1988. Distribution of petroleum hydrocarbon in the South China Sea: Coastal waters off Kuantan to Pulau Tioman. IN: *Matahari Expedition* '86(Eds. Mohsin, A. K. M., Mohd. Ibrahim, Ambak, M. A. & Abd. Ridzwan) Fac. of Fish. and Mar. Sci., Universiti Pertanian Malaysia. 0cc. publ. No. 4.

LAW, A.T. 1985. *Effect of dispersant Corexit 9527 on the biodegradation of ESSO Tapis A crude oil in Port Dickson coastal water.* Fin. rep. to ESSO Malaysia Production. Inc. 17 p.

______ 1984. Population and activity of hydrocarbon-degrading microorganisms in the coastal waters of Peninsular Malaysia. *Pertanika* 7(1) 19-26.

LAW, A.T. and A. SINGH. 1987. Distribution of mercury in Kelang estuary. *Pertanika* 10: 175-18 1.

______ 1987. Distribution of manganese, iron, copper, lead and zinc in water and sediment of Kelang Estuary. *Pertanika,* 9: 209-217.

LAW, A.T. and AZAHAR OTHMAN. 1985. Faecal coliform bacteria distribution in the coastal waters of Peninsular Malaysia. *Pertanika* 8(1) 131-134.

LAW, A.T. and MOHD. KAMIL ABD. RASHID. 1986. Inorganic nitrogen and phosphate distribution in the South China Sea. IN: *Matahari Expedition '86* (Eds. Mohsin, A. K. M., Mohd. Ibrahim, H. M. & Ambak, M. A.). Fac. of Fish and Mar. Sci., Universiti Pertanian Malaysia. 0cc. pub. No. 3, pp. 93-100.

LAW, A. T. and RAHIMI BIN YUSUF. 1986. Hydrocarbon distribution in the South China Sea. IN: *Malahari Expedition '85* (Eds. Mohsin, A. K. M., Mohd. Ibrahim & Ambak, M. A.,) Fac. of Fish. and Mar. Sci., Universiti Pertanian Malaysia. 0cc. publ. No. 3, 233 p.

LEE, C. K. and LOW, S. K. 1980. Short communication (II). A study of wastewater discharge from electroplating factories. *Pertanika,* 3: 159-161.

LIM, C.K., KOH, H.L. and LIM, P.E. 1987. Perspectives of sewage treatment and disposal in Penang Island, Malaysia 2000. IN: *Proc. Intl. Conf on Water Mgmnt. in 2000 for the Dev. Countries.* Singapore. pp. 23-30.

LIONG, P. C. 1983. *Heavy metals in shellfish from the northern part of Malacca Straits.* Paper at Intl. Conf. on Dev. and Mgmnt. of Trop. Liv. Aq. Res., Universiti Pertanian Malaysia, Serdang. August *2-5,* 1983.

LIONG, P.C. and K. RAJENDRAN. 1986. On the toxicity of ammonia to cockle. *Fish. Bull.* No. 46. Min. of Agri., Malaysia.

MA, A.N., CHEAH, S.C. and ONG, A.S.H. 1988. Towards zero discharge from palm oil mill. *Proc. 1987 Intl. Oil Palm/Palm Oil Conf. – Prog. and Prospects,* pp. 429-433. IPMKS 1988.

MA, A.N. 1988. A novel process for the treatment of palm oil refinery wastewater. *Palm Oil Development* (Malaysia), *8:5-7.*

MACLEAN, J.L. 1989. Indo-Pacific red tides, 1985-1988. ***Mar.*** *Poll. Bull.* Vol. 20, No. 7, pp. 304-309.

MAHESWARAN, A. 1982. *Industrial wastewater control – Malaysian policy and legislation.* Paper at Sem. on Industrial and Hazardous Waste Control. Kuala Lumpur, October 4-8, 1982.

______ 1978. *Marine pollution and its control.* Paper at 1st Mar. Sci. Conf. 'Our Seas in Perspective'. 1978.

MAHMUD, A.A. 1988. *Protection of Malaysia's marine environment: challenges and opportunities for the petroleum industry.* Paper at Sem. on the Mar. Env.: Challenges and opportunities. March 31 - April 2, 1988. Inst. of Strategic and Intl. Studies, Kuala Lumpur, Malaysia.

MOHAMMED SHAARI BIN SAM ABDUL LATIFF. 1971. The effect of the oil slick dispersant, Esso Corexit 7664, and the joint effect with crude oil on the survival of marine glass fish, *Ambassis* sp. and Palaemonid shrimps. *Ma!. Agri. J.* 48(l): 13-19.

NORHAYATI MUSTAPHA. 1980. General introduction to solid waste management. *Sekitar* (Malaysia), 4:14-21.

ONG, H.K. 1985. Treatment of piggery wastes. *Berita Ensearch,* Malaysia, 2:6.

ONG, J.E. and GONG, W.K. 1985. The environmental impact of the use of mangroves for aquaculture. iN: *Development Forum* 15,36-44. Paper at 6th Ann. Scm. of the Mal. Soc. of Mar. Sci. on Mar; Poll. in Mal. Waters, Universiti Sains Malaysia, Pulau Pinang, Mar. 1983.

ONG, J.E., GONG, W.K. and THOMAS, C. 1984. Effect of heavy metals, zinc and lead on *Rhizophora macranata* Lam, and *A vicennia a/ba* B!. seedlings. iN: *Proc. of the Asian Symp. on Mangrove Env: Res. and Mgmnt.* (Eds. Soepadmo, E., Rao, A. N. & Macintosh, D. J.,), pp. 568-574.

OWENS, J. D. 1978. *Co/ijorm* and *Escherichia co/i* bacteria in seawater around Penang island, Malaysia. *Water Research* pp. 365-370.

PATIMAH, I. and SAMIN, K. 1989. Heavy metal content in fish in Sarawak Waters. IN: *Expedisi Matahari '87.* Occ. Pub. No. 8, Fac. of Fish. and Mar. Sci., Universiti Pertanian Malaysia.

PHANG, S.M. 1988. The potential of integrating fish culture with an algae pond system treating palm oil mill effluents. *Proc. 1987 Intl. Oil Palm/Palm Oil Conf. – Prog. and Prospects,* pp. 422-428. IPMKS 1988.

RAKMI A. R., KALM, M. and WAN NOOR W. M. 1984. Reduction of palm oil heavy metal content in the refining process. *PORIM Bulletin* (Malaysia), 9:16-21.

A. RAN! ABDULLAH and LATIFAH MAHMUD 1992. *Pesticides in the Malaysian aquatic environment.* Paper at Scm. on Pesticides in the Mal. Env.: Impact on agri. and ecosystem, February 27, 1992, Selangor, Malaysia.

ROSLY HASSAN and CHUAH, T. T. 1991. *Feeding, total N and total P loadings in a shrimp pond – some observations.* Paper at 3rd Fish. Res. inst., Penang, Malaysia, 29.9.91-2.10.91 in Penang.

SCHOLZ, N. and SHAHUNTALA D. V. 1982. Heavy metals in Malaysian fish – a preliminary study. *Mal. Agri. J.* 53(3): 169-184.

SEOW, R. C. W. and BROOM, M. J. 1980. *The effect of organic pollutants on the distribution, community structure and abundance of the pelagic ichthyofauna in a Malaysian mangrove inlet.* Asian Symp. on Mangrove Environment: Res. and Dcv., Kuala Lumpur, August 25-29, University of Malaya and UNESCO.

SHAMSUDIN, L. 1988. Water pollution and the water quality requirement of coastal carbon areas. IN: *Proc. Wkshp. Tropical Urban Ecosystem Studies,* UKM. UNESCO/ROTSEA. January 18-21, 1988.

SHAZILI, N.A.M. and CHE, A.R. MOHAMAD. 1989. *Determination of heavy metal contents in sea water from the Malacca Straits by differential pulse anodic stripping voltammetry.* Preprint: Advances in Fish. and Mar. Sci. The JICA/FPSS experience. March 10-11, 1989, Melaka, Malaysia.

SHAZILI, N.A.M., CHE, A.R. MOHAMAD, HUSAIN, M. L. and YAAKOB, R. 1986. Heavy metal content of sediments in the South China Sea. IN: *Ekspedisi Matahari '86* (Eds. Mohsin, A. K. M., Ibrahim, M.H.M. and Ambak, A.) Fac. of Fish. and Mar. Sci. Universiti Pertanian Malaysia, 0cc. pub. No. 3, pp. 113-116.

SINGAM, G. 1982. *Strategies and enforcement of industrial waslewater control in Malaysia* (A case study). Paper at Scm. on Ind. and Hazardous Waste Control. Kuala Lumpur, October 4-8, 1982.

SIVALINGAM, P.M., KHAIRUL, ANUAR and SIDHU, H.S. 1982. PCBs and persistent pesticide pollutants in Malaysian waters and some economically important marine organisms. IN: ***Proc.** Univ. Perlanian Ma!.* UNESCO and FIESEOP Reg. Scm. on Water Tech. towards Rur. Dev. University Pertanian Kuala Lumpur. Malaysia, p. 10.

__________ 1983. *Marine pollution by municipal waste treatment in Penang.* Paper at Scm. of Mar. Poll. in Mal. Waters. Universiti Sains Malaysia, Penang, 1983.

__________ 1985. Impact of domestic and industrial waste on the coastal zone environment of the Straits of Malacca. IN: *Coastal zone managemant in the Straits of Malacca* (Eds. Burbridge, R., Koesobiono, Dirsch, H. & Patton, B..) pp. 179-214. Proc. of Symp. on Env. Res. and Coast. Zone mgmt. in the Straits of Malacca. November 11-13, 1985, Medan, Indonesia.

__________ 1987. *INAA in the evaluation of heavy metal pollution in marine algae.* Paper at Asean Tech. '87 Intl. Conf. (Asia-Chem. Session), Kuala Lumpur 1987.

Erosion in a coastal village in Thailand.

The Andaman Sea Coast, Thailand

by

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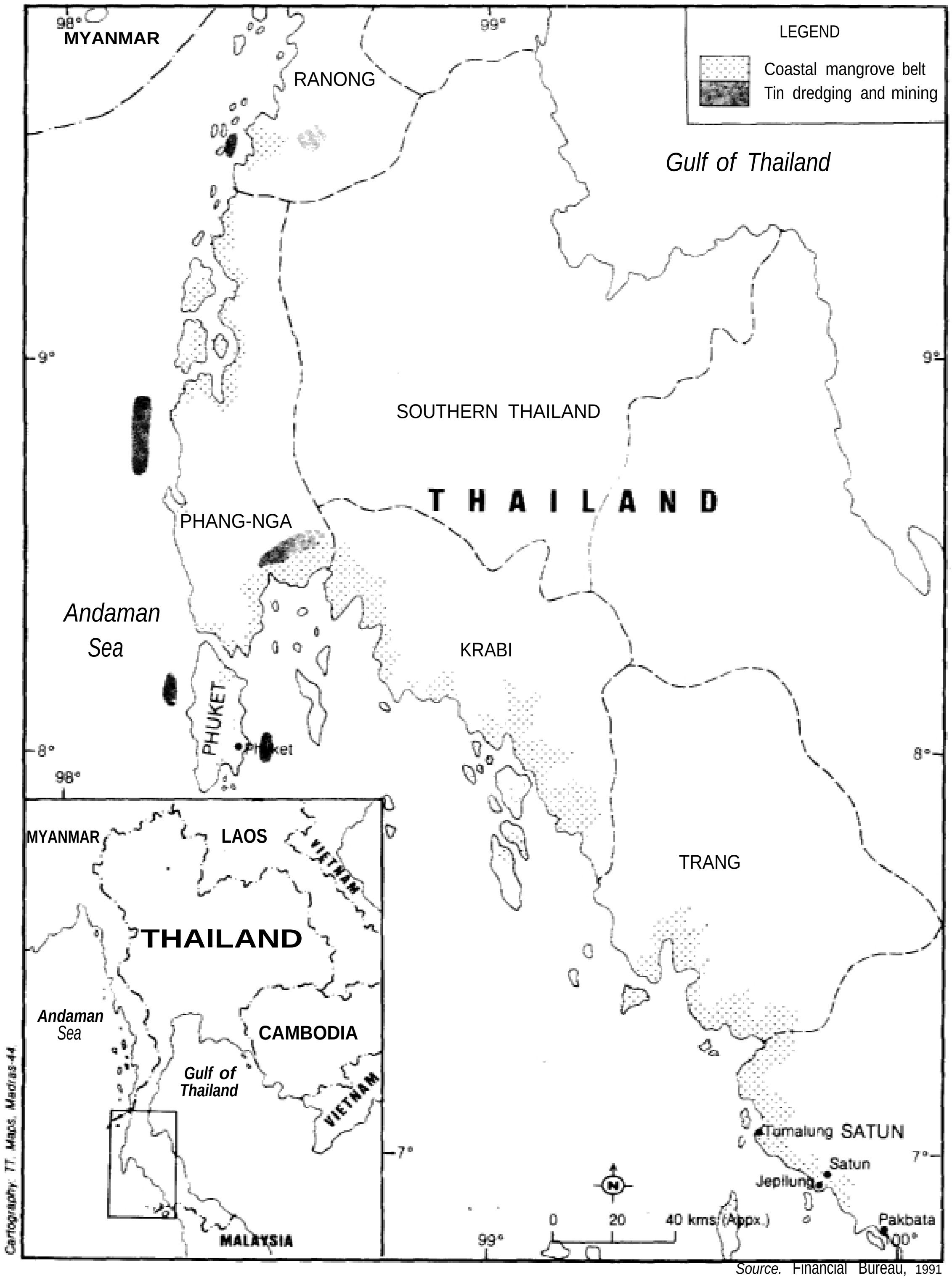
17. *INTRODUCTION*

The provinces of Ranong, Pharig-nga, Phuket, Krabi, Trang and Satun face the Andaman Sea and have a total coastline of about 700 km (Figure 8). Approximately 100,000 m^2 constitutes the narrow sea shelf, which is about 108 km wide in the north (Ranong Province), narrows down to 27 km in the middle (Phuket Province) and widens again to about 130 km in the south (Satun Province).

Fig. 8. The Andaman Sea coast of Thailand with the location of fishery harbours/ landing places, the coastal mangrove belt, tin dredging and mining areas.



Source. Financial Bureau, 1991

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The sea off the Phang-nga, Phuket, Krabi and Trang Provinces is influenced by semi-diurnal tides of approximately 3 m in spring and 1 m in neap tide. The water circulation is tidally dominated by a major flow in a northeasterly direction. During the Northeast Monsoon, the surface and subsurface flow in the nearshore areas appears to move northwards at a speed of 2-4 cm/sec , while during the Southwest Monsoon, the surface flows southwards at a speed of 5-8 cm/sec., gliding over a counter subsurface flow northwards of 2-5 cm/sec. (Limpsaichol et al., 1987).

The water characteristics have been summarized by Limpsaichol et *al.,* 1987. The northern stretch, from Ranong to Phuket Province, is influenced by deepsea upwelling resulting in high salinity (32.9-33.4 ppt), while the southern stretch (Phuket to Satun Province) is influenced mainly by surface run-off resulting in a lower salinity (32.6-32.8 ppt). The dissolved oxygen, pH and temperature values are 5.5-6.4 mg/l, 8.06-8.15 and 27.6°C- 29.3°C respectively and are fairly uniform along the coast.

The southern waters are relatively well-mixed, with total suspended solid values being 9.9-14.8 mg/l. Somewhat lower values are recorded in the northern waters. The nutrient concentrations of nitrate (NO_3) and phosphate (PO_4) ranged between 0.12-3.40 and 0.08 - 0.87 ug/l, respectively. The surface water in the south is fertilized mainly by mangrove run-off (Limpsaichol et *al.,* 1987) resulting in a primary production of 180-880 gC/m^2/year (Janekaran and Hylleberg, 1987), while surface water in the north is fertilized by upwelling bottom water (Limpsaichol *et al.,* 1987) resulting in a high primary production of around 700 gC/m^2/year (Wium-Andersen., 1977).

Along the western coast of Thailand, there are vast areas of turbid water. This is caused by silt from the rivers, especially after heavy rains. Part of it is of natural origin, but during the last decade the silt outflow has increased exponentially due to bad land management and mining. The decreased light penetration causes a loss of primary production, which has a considerable negative impact on fisheries.

18. *MARINE HABITATS*

18.1 *Mangroves*

Large areas of the Andaman Sea coast are covered by mangrove forests (see Figure 8). In the north, the mangrove area is estimated to be 21,800 - 36,700 ha, while in the south it is 26,500 - 31,500 ha, with the total area being about 50,000 ha. The largest mangrove areas are found on the Phang-nga coast (Suppapipat, 1988).

Rapid economic growth has made land prices soar and competition for land along the coasts is intense. Vast areas of mangroves are encroached upon and fish production is decreasing. Each hectare of mangrove forest is estimated to yield 24 t of marine fish and crustaceans. The fish value of one ha is US$ 2,777 (Kapetsky, 1987).

Outside mangrove forests, measurements show that dissolved oxygen, pH and temperature are 5.5-6.4 mg/l, 8.05-8.27 and 27.6-29.3° C respectively. Total suspended solids of 10.1-28.5 mg/l generally occur near the shore. Higher values, however, are frequently found. Extreme values of about 600 mg/l have been recorded during the Southwest Monsoon, particularly in the inner estuaries of Phang-nga, Krabi and Trang Provinces.

In the provinces of Phuket, Phang-nga, Krabi and Trang about 50 per cent of the mangrove forests have been denuded in the last three decades. The damage has been worst in Krabi. About 93,700 ha of mangrove forests remain unscathed (Suppapipat, 1988; Aksornkaew, 1988).

Ongoing degradation of mangrove forests also adds to coastal water sedimentation. Legislation has, fortunately, resulted in stepped-up measures to protect the mangroves.

18.2 *Coral reefs*

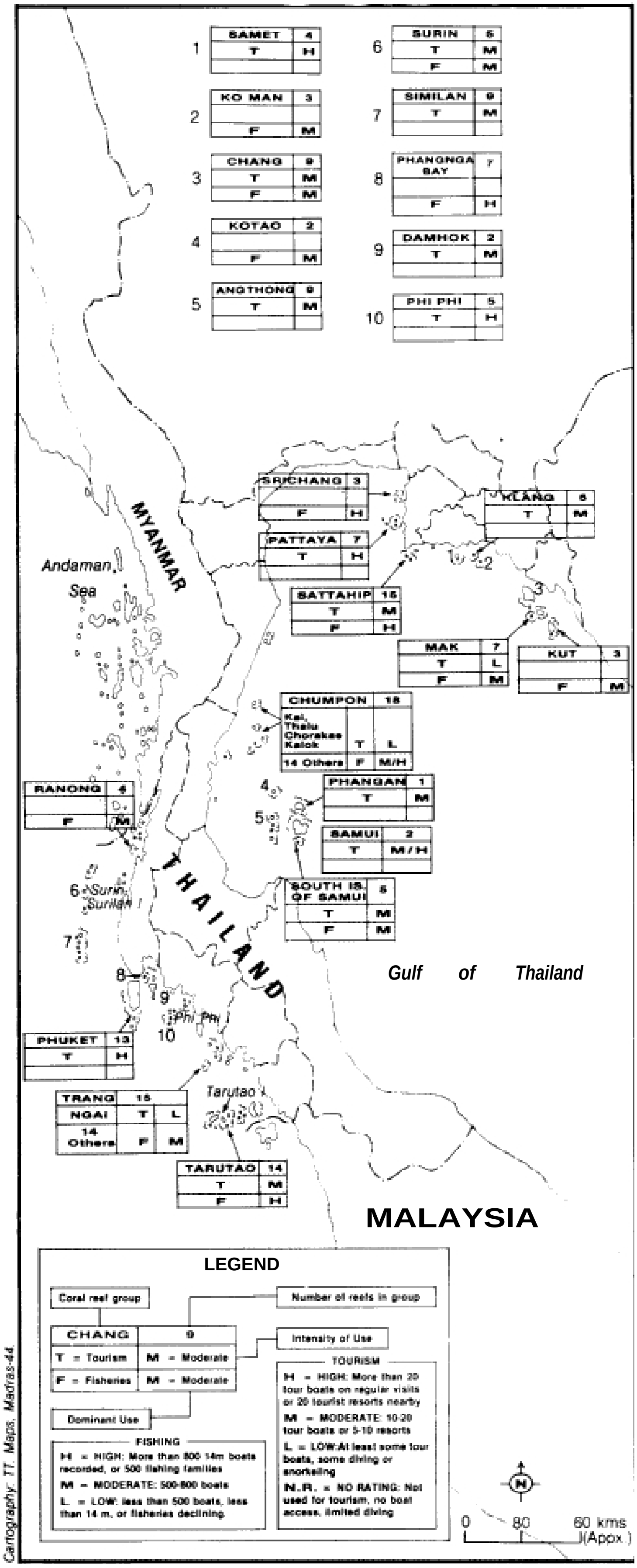
The Andaman Coast also possesses a considerable extent of coral reefs. Although large parts of the reefs have been damaged by natural and anthropogenic activities, most are still in good condition. The distribution and state of the coral reefs are presented in Figure 9. In this habitat, more than one hundred species of reef fish, including economically important ones, have been recorded. The healthiest reefs are found around the islands of Phang-nga, Krabi and Trang Provinces.

In the offshore island belt from the Rok Islands, in Trang Province, to Phi and Hong Islands, in Krabi and Phang-nga Provinces respectively, more than half the reef corals were found to be alive and in good condition during this study. The genus *Porites* appears to be dominant, both in number and percentage coverage, and is followed by *Acropora.* (Chansaeng, *et* a!., 1988). Reef degradation is mainly caused by Starfish *(Acanthaster planci),* invasions, storm damage, dynamite blasting, boat anchoring for tourism activities and sedimentation smothering. (Chansaeng, *et a!.,* 1988). In order to preserve coral reefs, marine parks have been established in the best preserved reef areas along the Andaman Sea coast, *e.g.* Surin-Similan Island, Lanta Island, Phi Phi Island and Tarutao Island.

18.3 Seagrass beds

Seagrass beds are distributed in the shallow water areas, often at the fringes of the mangrove areas and in estuaries, at depths

Fig. 9. The coral reefs of Thailand



Cartography: TT. Maps, Madras-44.

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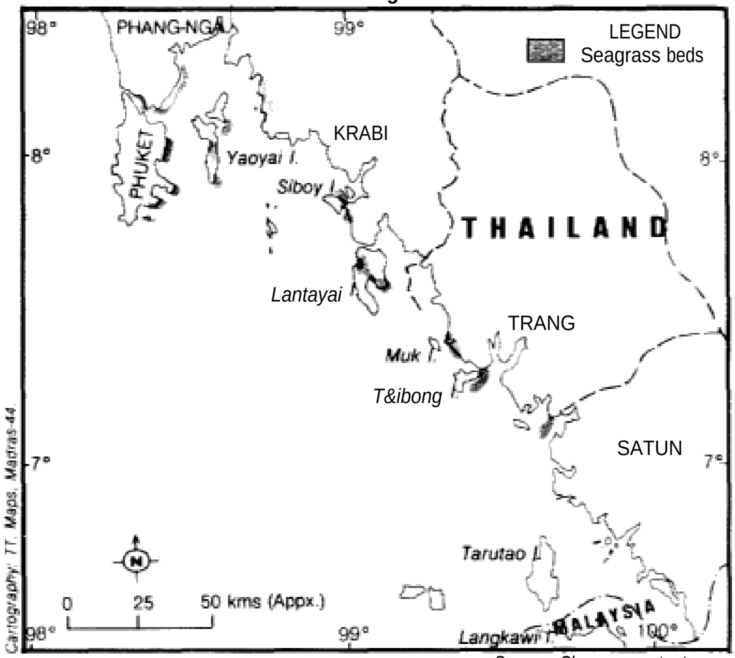
of approximately five metres (Figure 10). Many economically valuable fish species, such as groupers, molluscs and shrimps use these areas as nursing grounds. Mammals, like Seacows *(Dugong dugong)*, also depend on seagrass beds. Seagrass, however, is sensitive to turbidity and damages have been recorded in turbid zones.

An area of seagrass beds, of about 17 km^2, is found along the coastal stretch of the Andarnan Sea. The largest seagrass beds are located from Haad-chaomai to Muk Island as well as on Talibong Island in Trang Province. Other extensive seagrass beds are found in Phang-nga Bay and in Lanta Bay in Krabi province (Chansaeng *eta!.,* 1988).

Fig. 10. Seagrass beds in the nearshore areas of Phuket, Phang-Nga, Krabi and Trang Provinces



Source: Chansaeng *et at.* 1988

19. *MARINE FAUNA*

The density of macrobenthic fauna on the coastal seabed of the Andarnan Sea ranges from 200 to 1000 animals/m^2. The majority are molluscs, *Echinodermata* and *Chordata.* (Chatananthawej and Bussarawit, 1987).

Of the 49 fish families in the Andaman Sea, 25 set larvae along the Thai coasts. Of these, 64 per cent belong to economically important species. Zooplankton occur with an average density of 682 ind/m^3 corresponding to a biomass of approximately 20 mg/rn3. Clupeoids are the most abundant planktonic crustacean, comprising 30 per cent of the biomass, while *Brachyura* larvae, shrimps and bivalves comprise 1.2-10.7, 0.9-2.6, and *0.2-5.5* per cent of the biornass respectively (Boonruang, 1985). The sea around Phi Phi Island, south of Lanta Yai Island and east of Yao Yai Island, is, in fact, a spawning ground for Chub Mackerel. Fish larvae abound in March and April (Sutthakorn and Saranakomkul, 1986).

The benthic fauna has been studied along the coasts of Phuket. In Phang-nga, Krabi and Trang an average biomass of 26.5 g/m^2 was found. Polychaetes dominated in numbers and an average density of 256 ind/m^2 was noted. Crustaceans and molluscs also made up a considerable part of the bottom fauna, recording densities of 224 and 138 md/rn2 respectively. Only a few echinoderms occurred. Fish and other animals were found at a density of 23.7 and 48 ind/m2 each and with a biornass of around *I* g/m^2. The bottoms mainly consisted of the silt-clay fraction (40 per cent) (Chansaeng *et al.,* 1988).

The annual maximum sustainable yield of commercial pelagic fish in the Andaman Sea is estimated to be 50,000 t. For demersal fish it is estimated to be 200,000 t. The catches of commercial fish

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are still under the sustainable yield. During some years, however, fisheries in the Andaman Sea are close to the annual production (Phasuk, 1987). The total catch of fish and other species, such as shrimp, crab, squid and bivalves, was 300 000 t in 1985, about 85 per cent of it fish (Sudchai, 1987). This is about 15 per cent of the total catch in the country. Marine demersal fish catches in 1985 in the Andaman Sea amounted to roughly 100 000 t, valued at 450 million baht* (Department of Fisheries, 1987). Bivalve production from natural beds was 630 t valued at about 5 million baht (Department of Fisheries, 1986). Shrimp catches were about 1,660 t valued at about 80 million baht (Department of Fisheries, 1987). And the pelagic fish catches of 38,500 t were valued at about 238 million baht. The most important species found in the catch were Chub Mackerel, Spotted Tuna, Bonito, scad, Hairtail Scad. Bigeye Scad and trevallies (Department of Fisheries, 1987).

20. MARINE POLLUTION

20.1 Mining/dredging

Tin is exploited by dredging the sea bottom and by landbased mining. The dredging operations are concentrated in the coastal areas of Ranong and Phuket Province. Earlier, the tailing effluents from inland mining operations were simply discharged directly into canals and rivers transporting large amounts of silt to the coasts, causing very turbid water over vast areas. Now, the Department of Mineral Resources has tried to limit the direct discharge of suspended solids. To achieve this, a pond or sand basin is required, allowing suspended solids to settle before the water is discharged. Very turbid water from inland mining in Ranong Province is, however, still being discharged into rivers and drained into the sea.

The tailings from offshore dredging (see Figure 8, p. 57) are still discharged into the sea, leading to very turbid waters despite a piping discharge technique having been developed (AIT, 1986). An efficient technique for minimizing the suspended solids still remains to be developed. Highly turbid waters caused by tin mining have been found in the mangrove forests of upper Phang-nga. A great decline in the cockle population has, in fact, been observed in adjacent sites. When tin prices dropped and dredging operations were temporarily stopped for about a year, the cockle population recovered significantly.

Low water transparencies (1.0 - 1.8 m) occur as a result of the high content of suspended solids (Limpsaichol et *al.* 1987). It is reported that inland tin mining operations use 420,000 m^3/year of water and produce suspended solids of approximately 50,000 t/year, which are discharged into the rivers and streams (Kositrut, 1988). Kositrut also reports that inland lignite mining in Krabi Province discharges suspended solids into the waterways. Suspended solids are mainly composed of silt and clay fractions, which are deposited and resuspended in estuaries and other sheltered coastal areas (Limpsaichol and Bussarawit, 1988).

A study has shown that the turbid water from one tin mining vessel caused reduced primary production (10-50 per cent of the values in the unaffected sea) in an area of about 5 km^2 (Limpsaichol et *al.,* 1984).

The available information on toxin bioaccumulation shows that macrobenthos, including bivalves, have been affected in the vicinity of offshore dredging operations. During the post-dredging phase, the recolonization is extremely slow. The substrates of dredged areas contain more heavy metals than undredged areas (Khokiattiwong and Rojanovipart, 1986). The slow restoration of macrobenthos may be due to the high level of trace metals in the substrate. High concentrations of trace metals are also recorded in the municipal sewage discharged into the bay of Phuket City (PMBC's unpublished data).

The concentrations of heavy metals in seawater are very low around Phuket and the average values of copper, zinc and iron are 1.3 ± 0.8, 1.5±0.6 and 2.6 ± 0.5 ug/I respectively (Brown and Holley, 1982).

* US$1 = 25bahtappx.

20.2 *Industries*

The Andaman Coast is not very industrialized compared to the Gulf of Thailand coast. The table on the facing page lists the industries in the eastern provinces and Figure 11 shows where the industrial zones are/will be located.

20.3 *Oil*

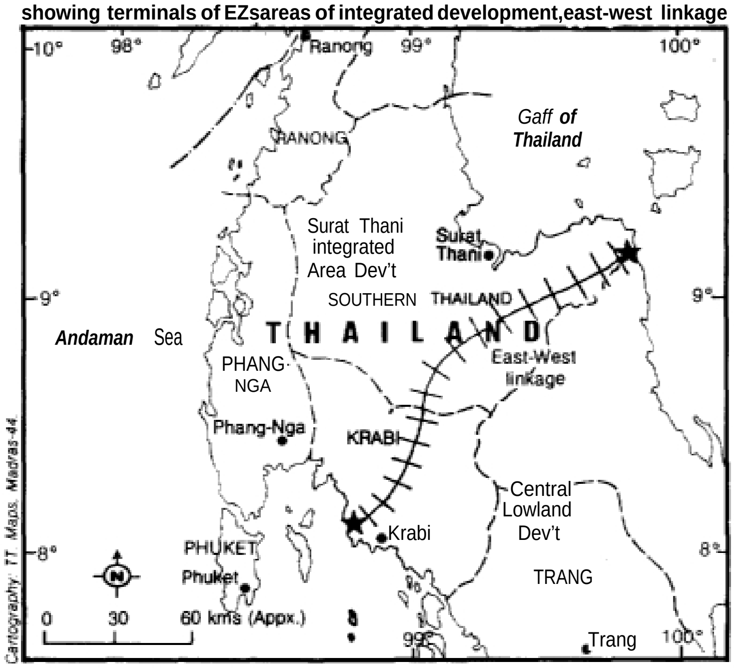
Andaman Sea water contains on average 0.69±0.17 microgram/litre of dissolved hydrocarbon, ranging from 0.04 microgram/litre to 1.21 microgram/litre (Limpsaichol *et* a!., 1987). Heavy deposition of fresh tar lumps was also recorded during the Southwest Monsoon in 1979 on beaches in the Phang-nga, Phuket and Trang Provinces. Limpsaichol 1984 registered 791, 734 and *354* g/m respectively, per beach transect. Lower amounts, were registered in 1981.

20.4 *Infrastructural development*

The proposed connection between Phuket and Surat Thani could cause great damage to the coastal environment, unless it is well planned and managed. Roads, railways and pipelines are to connect the deep sea ports of Krabi on the west coast and Khanom on the east coast (see Figure 12). This will shorten by 800-2800 km the distance for transporting crude oil and containerized cargoes. It is also hoped that the project will create competitive industrial locations and alleviate the too-intensive industrial growth in the coastal areas around Bangkok and the northern parts of the Gulf of Thailand. The project is to be financed by the Japan International Cooperation Agency, (JICA) and the World Bank.

Fig. 11. Sites for industrial estates/zones in the **upper south of Thailand**

Fig. 12. Proposed sites for industrial estates/zones in the upper south. showing terminals of EZsareas of integrated development,east-west linkage



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The coastal waters around Phuket and Chong Samui are very sensitive. Additions of suspended matter, nutrients etc., as a result of this development project, could have devastating effects for both fisheries and tourism.

Major industries along the Andaman Sea coast

Area	*Industry*	Number	Input material ton/year	Output product ton/year
Ranong Provinces	– Fishmili	8	148,200	23,000
	– Seafood (frozen/dried)	2	3680	1400
	– iron processing	2	60	60
	– **Cold** storage	2		
	– Wood processing	**14**		
	– Agriculture product processing	19		
	– Shipyard/slipway	7		
	– Miscellaneous	73		
	Total	**127**		
Phuket Province	– Marine product processing (canned, dried, frozen)	3	**924**	468
	Para rubber processing	9	89,500	59,200
	– Fishmili	3	24,860	6,240
	– Metal processing	**2**	78	67
	– Tin smelting		20,000	5,000 (pure tin) 1,765 (other metal + tin)
	– Metal plating	1	220 (chemicals)	48,000 pcs.
	– Shipyard	3	wood + iron + etc.	Repaired 1,050 **built** 5
	– Cold storage processing	2	3327 (Fish, shrimp, squid, etc.)	3270
	– Miscellaneous	262		
	Total	286		
Trang Province	– Marine product processing (dried, frozen)	3	720	36
	– Para rubber processing	13	178,000	138,700
	– Cold storage	3	17,240	17,000
	– Fishmill	2	24,738,200	5,802,000
	– Marine product canning		638	3,500,000 cans
	– Oil (extracts of plant and animal)	4	365,420	34,595
	– Miscellaneous	211		
	Total	237		
Satun Province	– Marine product canning and processing		3680	6,252,600 cans
	– Para rubber processing		8000	6000
	– Palm oil processing	2	92,000	22,700
	– Fishmill	**4**	148,800	3040
	– Cold storage	2	1500	1500
	– Shipyard	3	wood, iron etc.	**4-5** vessels/mth
	– Iron processing	3	iron + etc.	1700 pcs/month
	– Miscellaneous	121		
	Total	**137**		

Source. Provincial Industry Report, 1989. Office of Provincial Industry.

20.5 Agriculture

About one million hectares of agricultural land along the Andarnan coastline drain towards the sea. Rubber, coconut and oil palm, together with the staple, rice, are mainly grown in this area. The agricultural activities are important to the economy of southern Thailand and large amounts of pesticides, including herbicides and insecticides, like tosaphene etc, are used. It is estimated that the amount of pesticides used in 1987 along the Andaman Sea Coast was about 2,500 t/yr in 1987 (personal communication, with Provincial Agriculture Officer and unpublished). Fortunately, DDT application has been banned.

It is suspected that the coastai waters of the Andaman Sea may be contaminated with synthetic organic compounds from agricultural applications. No information, however, is available.

There are many palm oil factories in tile Krabi and Trang Prrovinces producing mainly organic wastes that are then drained into the rivers and the sea.

20.6 Fishery harbours

Fishery harbours are located along the Andaman Sea coastline, often close to mangrove forests and estuaries. They produce organic wastes, derived from fish cleaning, degutting and garbage, besides oily bilgewater The principal harbours arc the Kanong, Phuket and Satun fishery harbours (see Figure 8, p. 57). Each of these harbours provides berthing and fish handling facilities for approximately 200-400 fishing vessels. There arc also a number of smaller fishery harbours along the coast.

About 10,000 people, connected in some way with fishing activities, arc active in each main harbour. The amounts of organic waste generated by these people are difficult to estimate, but very high levels of' bacterial content have been recorded in the harbour waters Faecal coliform counts exceed the water quality standard of 1000 MPN/100 ml for general purposes (ONEB 1989).

Waters around fishery harbours are also utilized for many human activities They also often support rich marine life. Organic wastes provide an important nutrient input in estuaries, supporting primary production and improving fish growth. Phytoplankton blooms occur regularly in Patong Bay, which continuously receives treated and untreated organic wastes from hotels and other sources. It is necessary to ensure that the organic wastes are within acceptable limits otherwise there is a risk of outbreaks of PSP and DSP, as in the upper Gulf of Thailand (Piyakarnchana et al., 1987).

Fishing vessels also discharge bilgewaters and other oily wastes into the surrounding waters. Each vessel is bound to renew about thirty litres of used lubricant every month. The minimurn number of vessels, 200, will produce 6000 litres, or about six tonnes of cily bilge wastes, every month at each fishery harbour. Fortunately, dumping does not occur at the same time. All harbour5 should have facilities for collecting and cleaning this waste, since it has a commercial value and can be reused instead of being discarded.

20.7 Aquaculture

There arc three types of aquaculture practised on the Andaman coast :

– Culture of molluses.

-- Cage culture of finfish (mariculture)

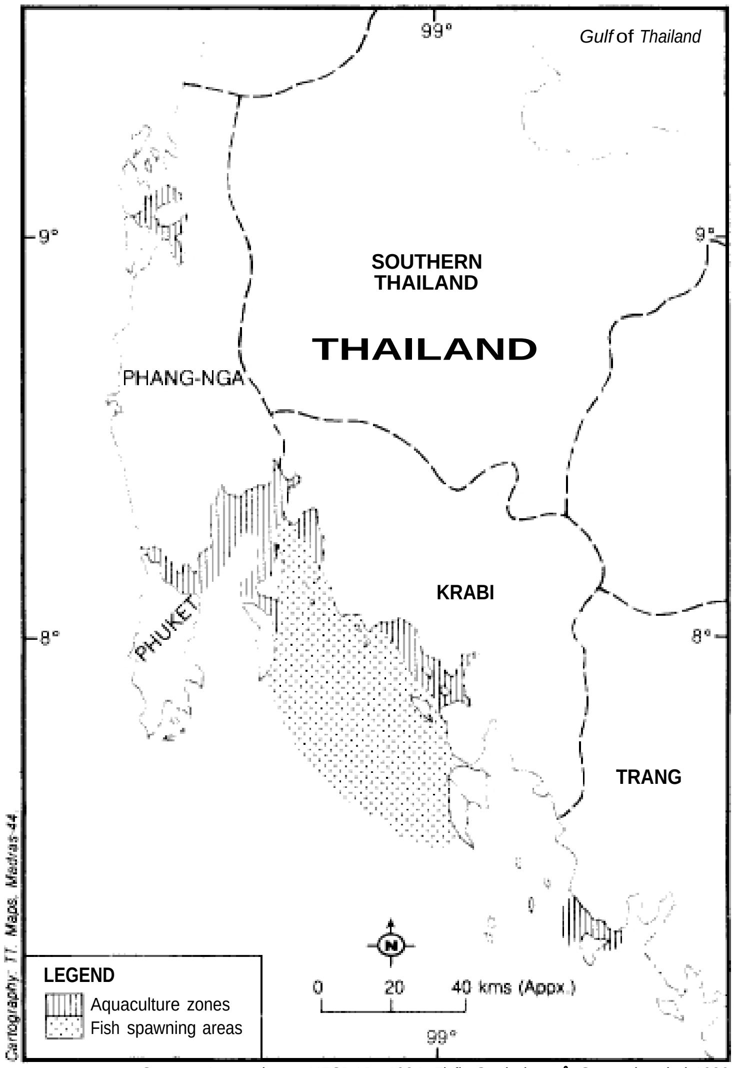
– Land-based shrimp culture.

The areas of aquaculture activities are presented in Figure 13 on the facing page. 1 he most intensely developed areas are found in Phang-nga Province, where about 85 per cent of the coast is used for farming Shrimp production here in 1986 touched about 15,800 t valued at 1,340 million baht. Cockle production yielded 4,320 t valued at 23 million baht. Farmed fish also contributed significantly; 176 t worth 15 million baht (Department of Fisheries, 1987). In addition, there was a small production of a few tonnes oysters and other bivalves in 1987, valued at about 37,000 baht (Department of Fisheries)

1988); A coastal area of 350 ha has been developed for aquaculture in the region, as shown in Figure 13. The Financial Bureau Department (1991) reported that 111,600 ha of mangrove area were being utilized for aquaculture in Thailand, a figure obtained by remote sensing. This represents 63 .4 per cent of the total damaged mangrove area in the country.

Mollusc mariculture has also been intensively promoted in the coastal region. In 1984, the total mollusc mariculture beds in the Andaman Sea covered 1030 ha. The mollusc production was 1100 **t**, including both cultured and naturally harvested mussels. The species included Bloody Cockle *(Anadara granosa, A. nodifera),* Green Mussel *(Perna viridis),* oyster *(Crassostrea belchen, C. lugubris, Saccostrea cucullata),* Horse Mussel *(Odiolus senhaysenii)* pearl shell *(Pinctada maxima, P. margaritierae* and Shortnecked Clam *(Paphia undulata)* (Department of Fisheries, 1986). It is anticipated that aquaculture and mollusc culture will be more intensively promoted in the future as part of the country's development plans.

Fig. 13. Aquaculture zones and fish (Chub Mackerel and scad) spawning areas



Source. Aquaculture NESDAB, 1984, Fisfl Sutthakorn & Saranakomkul 1986

The enormous growth of shrimp culture along the coasts has caused the pollution of adjacent waters in the northern parts of the Gulf of Thailand. In addition to conventional pollution from nutrients and organic wastes, different types of chemotherapeutants are discharged from the shrimp farms. The environmental impacts of these in tropical habitats are still unknown, but they constitute a potential threat. Many shrimp farmers from the north and east have been forced to move to the southern and western parts of the country. Unless strong action is taken to manage the shrimp farms environmentally, the same pollution problems will appear along the west coast.

The decree of July 1, 1991, states that all shrimp farms will have to register with the Ministry of Agriculture Cooperatives. Also, farms over ten hectares are required to seek official permission from the Ministry before being established. This obligatory registration is clearly an important step in the right direction. The rationale behind these recent moves can be traced back, in part, to the excessive pesticide and antibiotic residues found in cultivated Thai shrimp, which has forced Japanese authorities to reject, in many cases, shipments bound for that country.

21. *THE ENVIRONMENTAL STATUS IN THE ANDAMAN SEA AND THE GULF OF THAILAND: A COMPARISON*

The Gulf of Thailand is more environmentally degraded than the Andaman Sea due to a greater concentration of industries and other polluting activities around it. Great care should, therefore, be taken to avoid similar development on the Andaman Sea coast.

The **table** alongside compares the water quality in the two regions. Further information may be found in Appendix XIII.

22. *COASTAL RESOURCE MANAGEMENT*

The Office of the National Environmental Board (ONEB, 1989) has established coastal water quality standards in order to guide the planning of coastal resource mangement and to prevent the degradation of coastal water quality both of the Gulf and the Andaman Sea waters. Coastal waters in Thailand, are divided into five classes:

- Preservation areas.
- Natural conservation
- Propagation of marine life
- Recreation.
- Industry and navigation

Comparison of coastal water qualify in West and East Thailand

Parameter	*Andaman Sea (west coast of Phuketj*	*Gulf of Thailand. (east coast Chon buri Provincel*
Temp. °C	24.0-31.0	27.0-32.0
pH	7.7-8.7	7.6-8.7
Salinity ppt	27.0-35 0	21.1 -35.0
Dissolved oxygen ppm	5.0-7.0	2.0-8. 5
Total suspended solids ppm	1.3-21.9	3.0-97.0
Water transparency m	6.5-18.0	0.5-5.5
Total coliform bacteria MPN/100 ml	120-35,000	20-240,000

Source. Trididech et *al,* 1987

The classification of coastal waters is shown in the table below and coastal water qualities are shown in the table on the facing page.

Coastal water quality classification and objectives

Classification beneficial	*Conditions for principal uses/Objectives*
Class **AA** (Preservation area)	To ensure preservation of natural (Preservation Area) areas, the following uses are allowed — Scientific research and education, such as demonstration, observation arid,- or monitoring. — Aesthetic enjoyment — Inactive management/preservation activities
Class A	
A1 (Conservation of coral community)	A1) Conservation of coral community
A2 (Conservation of natural areas)	A2) Conservation of natural areas, such as mangrove habitats and marine spawning, nursing and feeding grounds.
Class **B**	
B1 (Propagation of marine life/aquaculture)	B1) Aqaaculture
B2 (Propagation of mar/ne life/shellfish)	B2) Shellfish
Class C	
C1 (Recreation/water-contact sport)	C1) Water-contact sport
C2 (Recreation/water-proximity sport)	C2) Water-proximity sport
Class D	
Industrial area	For protection of natural water resources used usa receiving waterbody for industrial waste discharges.

Coastal water quality guidelines

Parameter	Natural conservation Preservation			Propagation of marine life		Recreation		Industry
	Preservation	Conservation of coral community	Conservation of coral area	Aquaculture	Shellfish	Water contact sport	Water contact sport	
CLASS	AA	A_1	A_2	B_1	B_2	C_1	C_2	D
Floatable solids	n	NOB	NOB	NOB	NOB	NOB	NOB	NOB
Floatable oil/grease	n	NV	NV	NV	NV	NV	NV	NOB
Color/Odour	n	–	–	NOB	NOB	NOB	NOB	NOB
Temp **(°C)**	n	≯32.0	≯32.0	≯32.0	≯32.0			x ≯ 3*
pH	n	7.5-8.9	7.0-8.5	7.0-8.5	7.0-8.5			**
Salinity (ppt)	n	29-35	x ≯10%	x ≯10%	x ≯ 10%			**
Transparency (m)	n	x ≯10%	x ≯10%	x ≯ 10%	x ≯10%	x ≯10%		**
DO (mg/l)	n	≮4	≮4	≮4	≮4	–		
Total coliform (MPN/100 ml)	–	–	–	1000	n	1000		
Faecal coliform (MPN/100 ml)			–		ne			
NO_2-N (mg/l)	n	n	n					**
PO_4-P (mg/l)	n	n	n					**
Hg (mg/l)				≯0.0001				≯0.0001
Cd (mg/l)				≯0.005				≯0.005
Cr (mg/l)				≯0.1				**
Cr hex (mg/l)				≯0.05				≯ 0.1
Pb (mg/l)				≯0.05				
Cu (mg/l)				≯0.05				
Mn (mg/l)				≯0.01				
Zn (mg/l)				≯0.01				
Fe (mg/l)				≯0.03				
F(mg/l)				≯ 1.5				
Residue Cl_2 (mg/l)				≯ 0.01				
Phenols (mg/l)				≯ 0.03				
NH_3-N **(mg/l)**				≯0.4				
Sulfide (mg/l)				≯ 0.01				
CN (mg/l)				≯ 0.01				
PCB (mg/l)				n				
Total **chlorinated** pesticides (g/l)				≯0.05				
Radioactivity								
- x - **Gross** (BecquereVl)				≯0.1				
- ß - Gross (Becquerel/I)				≯0.1				

Source: **National Environment Board, B.E 2532 (1989).**

NOTES: NOB = Not objectionable; NV = Not visible; n = Natural condition

x = Change from natural condition

* = **Does not include natural floatable solids,**

** = **May be established as** necessary

nc = Natural condition until enough information

* = **Not more than**

= **Not less than**

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23. REFERENCES

AKSORNKAEW, S. 1988. Mangrove habitatsdegradation and removal in Phang-Nga and Ban Don Bays. Thailand. ICLARM *News Letter on Tropic01 Coastal Area* Monogemenr. Manila, April 1988:3 (I): 16.

ASLAN INSTITUTE OF TECHNOLOGY (AIT). 1986. *Field investigation. Project: Control oj waste disposal from offshore* tin mining *phase* I. Report No. 191. Department of Mineral Resources, Bangkok.

BOONRUANG, P.L. 1985. The community structure, abundance and distribution of zooplankton at the east coast of Phukct Island, Southern Thailand, Andaman Sea. *Phuket Mar. Biol. Cen. Res. Bull.* 39:1-13.

BROWN, B.E. and HOLLEY, MO. 1982. Metal levels associated with tin dredging and sampling and their effect upon intertidal reef flats at Ko Phuket, Thailand. Coral reefs, 1:131-137.

BUTLER, P.A., CHILDRESS. R. and WILSON A.J. 1973. The association of DDT residues with losses in marine productivity. Ed. M Ruivo. *Marine pollution and* sealife, Fishing News Ltd., Surrey. England 262-265.

CHATANANTHAWEJ, B. and BUSSARAWIT, S. 1987. Quantitative survey of the macrobenthic fauna along the west coast of Thailand in the Andaman Sea. *Phuker Mar. Biol. Res. Bull 47: I-23.*

CHANSAENG, H. BOONYANATE. P., POOVACHIRANON. S., PHONGSUWAN, N. and BUSSARAWIT. S. 1988. Project 2: Living resources in coastal areas with emphasis on mangroves and coral reef ecosystem: Subproject on inventory and monitoring of coral reefs, seagrass and soft bottom communities in the Andaman Sea. Asean-Australia *Cooperative Program* on Marine *Science.* Phukct Marine Biological Centre. Phuket Province, Thailand. 244 p.

U.S. ENVIRONMENTAL PROTECTION AGENCY, (EPA), U.S. 1976. Quality *criteria for* water.. U.S. Environmental Protection Agency, Washington D.C.:139-157.

FINANCIAL BUREAU. 1991. *A report on the present status of mangrove forest* urea of *Thailand.* Planning and Project Division, Bangkok, Thailand. 47 p.

HUNGSPREUGS, DHARMVANIJ, M.S. and UTOOMPRURKPORN. W. 1987 The marine environment of Ban Don Bay. *Proceedings ofthe 4th Seminar on the Water Qualify and Quality of Living Resources in Thai waters: 297-307.* July 7 - 9, 1987, by NRCT, Surat Province, Thailand.

JANEKARAN, V. and HYLLEBERG, J. 1987. The primary production along the Andaman Sea Coast *of* Thailand. *Phuket Mar. Biol. Cent. Res. Bull.*

JARACH. W. 1987. Heavy metal contents in sea water of the upper Gulf of Thailand. *Proceedings of the 4th Seminar on rhe Water Quality and Quality of Living Resource.7 in Thai Waters: 122-129.* July 7-9, 1987, by NRCT. Surat Thani Province, Thailand.

KAPETSKY. J.M. 1987. Conversion of mangroves for pond aquaculture: Some short-term and long-term remedies. FAO *Fisheries Rep. No. 370. Suppl. 1987, p. 129-141.*

KHOKIATTIWONG, S. and ROJANOVIPART, P. 1986. *Heavy metal distributions in marine sediments on the west coast of Phuket Island.* Paper presented at the Science Seminar. University of Kasetrart, January 1986.

KOSITRUT, N. 1988. *Water pollution* Paper presented in the Workshop on the Coastal Issue and Management of the Upper South Area. April II 12, 1988, Phang-nga Province, Thailand. 8 p.

LIMPSAICHOL, P. 1984. The distribution and variation of tar on beaches along the Andaman Sea coast of Thailand. *Phuker Mar. Biol. Res. Bull.* 34:1-12.

LIMPSAICHOL, P.H., KOKIATTIWONG, S and BUSSARAWIT, N. 1987. Assessing coastal water quality of the Andaman Sea of Thailand. *Proceedings of the 4th Seminar on the Water Qualify and the Quality of Living Resource.? in Thai* Waters: 309-320, July 7 - 9, 1987, Surat Thani Province by NRCT, Surat Thani Province, Thailand.

LIMPSAICHOL, P.. KOKIATTIWONG, S. and PHONGSUWAN, N. IY87. Subsurface current pattern, of the Southern Andaman Sea, Trang to Satun Provinces of Thailand. *Proceedings of the Seminar* on *Fisheries.* Department of Fisheries, Bangkok.

LIMPSAICHOL, P. and POOPETCH, T. 1984. Theeffect of dumping suspended solids at sea on chlorophyll aconcentrations and primary production values. *Phuket Mar. Biol. Cent. Res. Bull. 33.*

LIMOPSAICHOL, P. and BUSSARAWIT, *N.* 1988. *Technical report on the coastal environment of Phang-nga Boy.* Asean/US Cooperative Programme on integrated coastal resource development and management planning of the upper south Coastal Zone. *Phuket Mar* Biol. Cent.. Phuket Province, Thailand.

LERTRUENGDEJ, VONGBUDDHAPITAK, T. A. and ATIUSOOK, K. 1987. Insecticide and PCB residues in marine fauna from Thai waters. *Proceedings of the 4th Seminar on the waler Quality of Living Resources in Thani walers:* pp. 264-269, July 7-9, 1987, by NRCT, Surat Thani Province, Thailand.

MACLEAN, J. L. 1984. Indo-Pacific red tide occurrences 1972-1984. TOXIC Red Tides and Shellfish Toxicity in Southeast Asia. *Proceedings, Consultative Meefing.* Singapore, September 1 l-14, 1984:92-102.

<<

MAHAPANYAWONG, W., POLPONG, P., WANABONGSE, P. and RATIVANICH. N. 1987. Radio activity and radioactive elements in seawater, sediments and living resources in the Gulf of Thailand during 1973-1986. Proceedings *of the 4th Seminar on the Warer Quality of Living Resources in Thai Waters. pp.* 137-148. July 7 - 9, 1987 by NRCT, Surat Thani Province, Thailand.

ONEB. 1989. *Laws and standards on pollution control in Thailand* (2nd ed) No. NEB 05-02031. EQSD, ONEB, Thailand. 113 p.

PHASUK, B. *1987.* The marine fisheries in Thai waters. *Proceedings of fhe Seminar on rhe Future of Thai Fisheries* pp. 53-137. June 4-6. 1987, Pattaya, Thailand, SEAFDEC.

PIYAKARNCHANA. T., FUKUYO. and WISESSONG, S. 1987. Distribution along the coastline of the causative shellfish poisoning phytoplankton dinoflagellates in Thai waters. *Proceedings of the 4th Seminar on the Water Quality and* Qualify *of* Living *Resources* in *Thai* Waters. p. 201. July 7-9, 1987 by NRCT, Surat Thani Province, Thailand.

PIYAKARNCHANA, T.. BUNPAPONG, bl. and PHOLPUNTHI, P. 1990. Tidal influence on the distribution and population density of toxic dinotlagellate: *Alexandrium cohorticula* Balech, in the upper part of the Gulf of Thailand. Asian *Fisheries Forum,* pp. 890-902. Asian Fisheries Society, Manila.

ROJANAPANTIP, BORIBOON L.B. and BOONYASHOTIMONGKUL, T. 1987. Mercury content in marine fauna. *Proceedings of the 4th Semrnar on the Wafer Quality and Quality of Living Resources in Thai Waters: pp. 233-244,* July 7 - 9, 1987 by NCRT, Surat Thani Province, Thailand.

STRICKLAND, J. D.H. and PARSONS, T.R. 1975. *A practical handbook* of sea *water analysis,* Fish Res. Board. Can., Ottawa. 311 p.

SAITANU, K., LUANGTONGKUM S. and POONSUK. K. 1987. Microbiological quality of the east coast of upper Gulf of Thailand. *Proceedings of rhe 4rh Seminar on rhe Water Quality and Quality of Living Resources in Thailand Wafers;* pp. 149-164. July 7 - 9, by NRCT, Surat Thani Province, Thailand.

SUWAPEEPAN, S., 1984. The impact of red tide on coastal fisheries. *Proceedings of the 22nd Seminar* on Fisheries, Kasetsart University, pp. 203-312.

SUPPAPIPAT, S. 1988. Mangrove: Good policy but poor enforcement Agro-Industry *Magazine. 36:27-35.* June 1988

SUDCHAI. K. 198'. Product of marine fisheries in Gulf of Thailand and Andaman Sea. *Thai Fisheries Gazette. 40(2):* 169-175

SUTTHAKORN, P. and SARANAKOMKUL, L. 1986. *Biological aspects of Chub Mackerels. Rastrelliger* spp. *and Round Scuds* Decapterus *spp. in the* west coast of *Thailand.* Technical report. Andaman Sea Fisheries Development Centre. *97 p.*

TEMIYAVANICH, S., ROJNAVIPART 1984. Physicochemical status of eastern Gulf waters. *Proceedings of the 3rd Semrnar on rhe Water Quality and the Quality of Living Resources* in *Thai Waters.* pp. 183-198. March 26 28 at Marine Science Center, Bangsaen, Thailand.

THOOPHOM, G., ATlSOOK., LERTREUNGDEJ, Y. 1987. Insecticide and PCB residues in molluscs and rea water. *Proceedings of the 4th Seminar on the Water Quality and Quality of Living Resources in Thai Waters:* pp, 256-263, July 7 - 9, 1987, by NRCT. Surat Thani Province, Thailand.

TRIDIDECH, T., UNKULVASAPAUL, M. and SIMACHAYA, W. 1987. Coastal water quality and establishment of water quality for Thailand. *Proceedings of the 4th Seminar on the Water Quality and Quality of Living Resources* in *Thai* Waters pp. 394-404. July 7 9, 1987. by NRCT. Surat Thani Province, Thailand.

WATTAYAKORN, G. 1987 Dissolved/dispersed hydrocarbons in the Gulf of Thailand. *Proceedings of the 4th Seminar on the Warer Quality and Quality of Living Resources in Thai Waters* : pp. 105-13. July 7 - 9, 1987, NRCT. Surat Thani Province. Thailand.

WIUM-ANDERSEN, S. 1977. Primary production in waters around Surin Islands off the west coast of Thailand *Phuket Mar. Biol. Cent. Res. Bull.* 16:1-4.

<<

APPENDIX X

Institutions engaged in environmental research, monitoring and enforcement

On the Andaman Sea coast of Thailand, rhe Phuket Marine Biological Centre (PMBC) is the only laboratory that deals with marine environmental research and reconnaissance studies monitoring. There is a similar research laboratory located on the coast of the Gulf of Thailand: the Eastern Marine Fishery Development Centre, Ranong Province. The National Institute of Coastal Aquaculture is located in the lower Gulf. These three laboratories are operated by different divisions. but they all belong to the Department of Fisheries.

PMBC is not concerned with legislation or enforcement of environmental laws. However its recommendations are recognized and credited. The Department of Fisheries promulgates laws and regulations on fisheries that indirectly concern environmental conditions. The Office of Environmental Board (ONEB), under the Ministry of Science and Technology, deals with Environment Impact Assessments (EIA). Non-government Organizations (NGO) and environmental legislation. ONEB, however. has no powers of enforcement and has to depend upon other authorities, such as the provincial authorities. to deal with specific issues.

The chemical analysis methods employed by PMBC are rhose recommended by APHA. AWWA and WPCF (Strickland 1975) and are tabulated below:

Parameters	Sampling pre-analysis	Final	Methods	Sensitivity
Heavy metals				
Hg,	-	-		-
Cd, Pb	PMBC	Bangkok	Atomic absorption, Flameless emission, Perkin Elmer	3-20%
Zn,Fe,Cu	PMBC	Bangkok	Atomic absorption. Flame emission, Perkin Elmer.	3-20%
Pesticides	-	-	-	
Petroleum				
Hydrocarbon	PMBC	PMBC	Hexane extraction, Spectrofluoromety.	20%
Nutrients				
P&N	PMBC	PMBC	Spectrophotometers	0.05ugat/
Bacteria				
Coliform	PMBC	PMBC	Multiple tube	-
Faecal coliform	PYBC	PMBC	Multiple tube	
Others	PMBC	PMBC	Plare count	-
Radioactive isotope	-			
Dioxinn	-			

There are both government and private laboratories working on environmental analyses. Many private laboratories arc engaged in water, waste water and air pollution analyses. It is very difficult to include them all, so only the important ones are listed.

GOVERNMENT

1. Chemical Agricultural Division, Technical Agricultural Department, Bangkok.
   Laboratory for soil, water, waste from industry and agriculture, and pesticide analysis
2. Medical Science Department, Bangkok.
   Analysis of pesticide residues, heavy metals, microbiology of food and water quality, as well as waste water from industries.
3. Scientific Research Instrument Centre, Chulalongkorn University, Pathumwan, Bangkok.
   Both biological and chemical analyses. Atomic absorption spectrophotometer (AA) technique, either with or without flame for heavy metals detection. For pesticides (organochlorine and organophosphate), the gas chromatography (GC) technique is used.
4. Faculty of Public Health, Mahidol University, Rajvitee Road, Bangkok.
   This is an environmental, toxicology and occupational health laboratory. Coliform bacteria analyses, using multiple tube technique, are undertaken. Pesticide and heavy metal analyses of water and waste water are carried out using the same technique as Chulalongkorn University (see above).

PRIVATE

1. Sahafarm. Bangkok.
   Studies pesticide residues in meat, fat, shrimp, water, soil, raw material and feed, using the GC technique.
2. International Quality Assurance Laboratory (IQA) 2096/5-8 Ramkhumhaeng Rd., Hua Mark, Bangkok 10240.
   Specializes in waste water analyses, especially for heavy metals, using the AA technique.

APPENDIX XI

Legislation against threats to the marine environment

There are, at present, no laws and regulations on water pollution control. Many existing laws and regulations, relating to public health and safety, as well as the environment, have, however, been indirectly applied. They include:

Public Health Act (1941, 1984)

Enacted by the Ministry of Public Health (MOPH). these laws aim to protect public health. The Act authorizes local governments to issue ordinances to ensure proper collection and disposal of human and other solid wastes and to prevent adverse effects on public health. This Act, however, does not enforce adequate treatment of sewage and waste water generated by communities. Also, considering that the Act was passed almost 50 years ago, the penalties and service fees specified are insufficient to act as effective deterrents or to provide adequate services. The limited budgets and manpower that local government\ have, as well as the lack of clear guidelines on enforcement, weaken the Act's effectiveness. The MOPH is currently revising it to improve water pollution control as well as control in other specific areas.

National Environmental Quality Act (1975)

This Act aims to protect and conserve the quality of the nation's environment. It has established ONEB, EIA requirements for specific projects and standard5 of water pollution control, as well as financial and legal instruments to ensure enforcement. The limitations of the latter, however, detract from achieving the main objectives of the Act and implementation of the national policy for water pollution control, which is to preserve and enhance the quality of the nation's waters.

Factory Act (1969)

Enacted by the Ministry of Industry (MOI), this Ac! aims to control the waste discharges from industrial activities. Enforcement, however, is ineffective because small and household industries in many urban areas are not monitored. Also, the Act does not control the discharge from gas stations which are, in fact, major contributors to water pollution in urban areas.

Building Code (1936, 1979)

Enacted by the Ministry of Interior (MOInt), this Code controls building construction in urban areas. It requires the installation of a proper collection and treatment system for human waste, i.e. a leaching pit with soakway for house, and a septic tank with a cesspool for large buildings. The lack of monitoring to ensure proper construction of the treatment system reduces the effectiveness of the Code. The MOInt is currently revising the Code to effectively control waste water discharges from buildings.

Navigation in Thai Waters Act (1913)

This law aimr to control construction along public watercourses and pollution that affects living resources, besides preventing sedimentation that obstructs navigation. It prohibits the dumping of rocks, gravel, silt, mud, detritus, solid waste, sewage, oil and chemicals into public waters such as rivers, canals, swamps, reservoirs and lakes. Constraints include lack of enforcement due to limited personnel and budget. Also, the low priority given by the Harbour Department, to the Act's aims, and other social and political complications hamper the Act's effectiveness.

Provincial Authority Acts

Municipal Government Act
Sanitary District Act
City of Pattaya Act
Bangkok Metropolitan Act

Under these acts, local governments are assigned compulsory functions (such as providing water supply and drainage), as well as optional functions (such as providing public utilities) These Acts, however, lack specific authority or control over sewage and waste water collection or treatment.

All this legislation is ineffective due to budget and staff limitations as well as to a lack of enforcement will

The Division of Environmental Industry, Industrial Control Department, Ministry of Industry. has the authority 10 check waste discharge and is also responsible for appropnate action in case of serious accidents with hazardous industrial wastes. The Fishery Department is contacted first when a fish kill is reported.

APPENDIX XII

Other publications on the marine environment

AKSORNKOAE, S 1989. Mangroves Ecology *und Management,* 1SBN 974-552-881-1, (In Thai)

PHA. AWWA. and WPCF. 1975 *Standard* methods for the examination of water *and* waste water, 14th Edition. 4PH.4. Washington, 1193 p.

CHONCHUENCHOP P. and COLLEAGUE. 1987. Diseases of Cage-Culture Seabass in Satun, Trang and Krabi Province. Thor Fisheries Gazette, 40(3):315-326.

DFPARTMENT OF MINERAI RESOURCES. 1987 *Tin mining concession in Phang-nga Bay* Division of Mapping, DMR Bangkok, Thailand.

INTEGRATED UTILITY OF NATURAL RES and EN\'. DIV , NATI ENV. BOARD (NEB) 1992. Provincial State *of the Coast: Runong.* NEB (In Thai).

——— *Provincial State of the Coast Phang-ga NEB (In* That).

——— *Provincial State of rhe Coast.* Trang, NEB (In Thai).

——— *Provincial State ofthe Coast.* Phuket, NEB. (In Thai).

——— *Prov incial State of the Coast:* Krabi. NEB (In That)

——— *Prov incial State of the Coast.* Satun. NEB (In Thai).

KHOKIATTIWONG, S. 1991. Coastal hydrography of the southern Andaman Sea of Thailand, Trang to Satun Province, *Proceedings of the First Workshop of [he Tropical Marine Mollusc Programme. 67-93* August 12 - 16, 1991, Phuket Marine Biological Centre, Phuket Province, Thailand.

LIMPSAICHOL P. and BUSSARAWIT, N. 1991. An assessment of the coastal environment of Phang-nga Bay, Thailand, pp 3-11. IN ; Chou L.M., Chua T.E., Khoo H.W., Lim P.E., Paw J.M.. Silvestre G.T , Valencia M.J., White A.T. and Wang P.K. (eds). *Towards an integrated management* of tropical *coastal* resources, ICLARM Conference Proceedings 22, 455 p. National University of Singapore, Singapore; National Science and Technology Board, Singapore; and International Centre for Living Aquatic Resources Management. Philippines.

NEB 1992, Master Plan for Coral Reef Management of Thailand. (In Thai)

1991 A National Coral Reef Strategy for Thailand. Vol. I: Statement of Need

PIDO, M.D. and HODGSON, G. 1991. The Integrated Management Plan for Ban Don Bay and Phang-nga Bay Thailand, *Tropical Coastal Area Management* Vol. I, No. 3, Metro Manila, Philippines.

PROMAMON, P. 1987. Status of mariculture in Thailand and guideline for future development. *Proceedingsof rhe Seminar on the Future of Thai Fisheries.* pp. 139-307. June 4-6, 1987, Pattaya, Thailand. SEAFDEC.

PHROMLERT, C. 1992. Local government initiatives in waste management. pp. 185-188. IN : Chua T.E. and Garces L..R. (eds). *Waste management in the coastal areas of the ASEAN region. Roles of governments, banking institutions, donor agencies, private sectors and communities.* ICLARM Conference Proceedings 33. 218 p. Ministry of the Environment and Canada-ASEAN Centre, Singapore, Asian Development Bank, and International Centre for Living Aquatic Resources Management, Philippines.

RUANGPAN, *S. 1992. Results of fishing experiment with vertical bottom longline in Andaman Sea.* Technical Paper No. 1/ 1992, Exploratory Fishing Division, Department of Fisheries, Ministry of Agriculture and Cooperatives. (In Thai).

SUNDSTROM, B.. JANEKARN. V., HYLLEBERG, J. and BOONRUANG. P. 1987. Annual pelagic primary production with notes on physical and chemical variables at Phuket, the Andaman Sea, Thailand. *Phuket Mar. Biol. Cent.* Res. Bull. 47 : 1-2 1

SUDARA, S. 1992. *Coral Reefs.* Wildlife Fund Thailand: Under the Royal Patronage of H.M. The Queen. ISBN 974-88782-2-8. (In Thai).

1991. *Mangrove Forest.* Wildlife Fund Thailand: Under the Royal Patronage of H.M. The Queen. ISBN 974-88684-9-4 (In Thai).

1991. *Seagrass Beds.* Wildlife Fund Thailand: Under the Royal Patronage of H.M. The Queen. ISBN 974-88720-0-9. (In Thai).

SOCIETY OF ECONOMICS OF THAILAND. 1981 *Development plan ofsourhern resource of Thailand.* 11 p

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APPENDIX XIII

Environmental Conditions in the Gulf of Thailand

The upper Gulf Haters contain an average of dissolved dispersed petroleum hydrocarbons (DDPH) of 2.3 micro g/l (crude oil equivalents 0.65-8.30 micro g/l) T he average value of only 1 .3 micro g/l is recorded in the lower Gulf waters (crude oil equivalents 0.07-6.6 micro g/l). DDPH derives from river discharges of diesel oil and petroleum (Wattayakorn 1987). Values from the Andaman Sea coasts are only 0.04-1.21 micro g/l, i.e significantly lower.

Rojanapantip et al. (1987) reported that mercury investigations were conducted on the contaminations found in the Andaman Gulf in 1973-1986. A total of 1680 specimens were analyzed from 94 species of fish, squid, shrimp etc. The average results ranged from 0.02-0.058, 0.019-0.043 and 0.039-0.075 mg/kg of mercury from samples from the upper Gulf, loner Gulf and Andaman Sea (Phuket to Satun Province) respectively. The recorded levels are well below the highest permissible value recommended by the World Health Organisation (WH0) 0.5 mg mercury/L This limit is, however, exceeded in occasional sharks.

Jarach (1987) reported that the dissolved heavy metals found in seawater during the part four years uere copper 3.8-30.0. iron 480-1080, mercury 0.1-13.7 and zinc 3.1-190.0 micro g /l. Extreme values of 2,150 micro g Fe I and 88.7 micro g hg/l were recorded. Generally, however the levels were well below the threshold limit. Despite this, mercury showed an increasing upward trend, which could be regarded as a warning signal for potential hazards affecting marine fauna.

During 1973-1986. a radioactive survey was undertaken in the Gulf of Thailand. Gross beta activity measurements of seawater and fresh sediments resulted in 1.58± 0.1 I · I 1 .38 ± 0.76 Bq/l and 0.03 ±0.01 · 0.53 ± 0.17 Bq/l respectively, while the activity of living resources (fish and oyster) was 0.01 ± 0.0001-0.09± 0.003 Bq/l (Mahapanyawong, et al. 1987). In Sweden. sea food exceeding 150 Bq/kg is not allowed to be sold.

Microbiological quality of the seawater of the east coast of Gulf of Thailand has been analyzed Coliform, faecal coliform, faecal streptococcus and Clostridium perfringens were found in most samples. The highest values recorded were in bivalves. whilst relatively low values were found in sediment and seaw ater. However, since only Vibrio prahaemolyticus was recorded in most specimens and Salmonella spp and Vibrio cholera were absent, it was concluded that the shellfish uere acceptable and safe for human consumption (Saitanu er al. 1987)

Piyakarnchana et al. (1987, 1990) reported that four species of dinoflagellates causing shellfish poisoning were found along the gulf coastline. These caused Paralytic Shellfish Poisoning (PSP) and Diarrhoetic Shellfish Poisoning (DSP) and were identified as *Alexandrium leei, Dinophysis caudata, Protogonyaulax tamarensis and P. cohoriticula.* These species, however, have not yet been observed in the Andaman Sea samples from Phuket and nearby areas.

Suwapeepan (1984) reported that the occurrence of red tide in the Gulf was causing damage to the extent of US$ I .2 million to coastal aquaculture Maclean (1984), revealed that red tide occurrence and shellfish toxicity in Southeast Asia were caused by *Protogonyaulax bahamaensis* var *compressa, P. tamarensis, P. cohoriticula, A lexandrium leei and Dinophysis caudata.* The red tide occurred in the upper Gulf, particularly during periods of heavy rainfall. Rainwater washing out large amounts of nutrients into the upper Gulf causes increased growth of dinoflagellates. The dinoflagellate species responsible for red tides may, however, vary from year to year. Before 1983, the red tides Here dominated by Nocticula *scintillans,* but in 1983 they were dominated by *Ceratium furca* Algal blooms in the Gulf. however, generally comprise three species, namely *Noctiluca scintillans* causing green water colour. Ceratium furca causing red water colour and *Oscillatoria erythrace* causing blue-green water colouring, Temiyavanich and Rojnavipart (1984) found that *Dinophysis caudata* was causing red water colour and had poisonous decomposition products.

Thoophom et al, (1987) revealed that the insecticides Dichloro Diphenyl Trichloroethane (DDT), Dieldrin, BHC, Endrin and Lindane were detected in three mollusc samples of green mussel *(Perna viridis L).* oyster *(crassostrea commercialis)* and cockle *(Anadara graanosa)* The results showed levels lower than 0 01 mg/ kg. DDT values, however, ranged from 0.002 to 1.404 micro g/l and Lindane ranged from 0.002 to 0.1 I micro g/l. Extremely high levels uere detected only in a few samples. Samples of marine fish, shrimp and squid from the Andaman Sea (Krabi, Phuket and Trang Provinces) showed in levels lower than 0.01 mg/l. This level is well below the standard threshold limit of 0.07 mg/kg (L'S EPA, 1976, Butler et. al., 1973). Lertruengedj et al., 1987, however, found that high levels of DDT were recorded in 1973, but they decreased in the following years. This was probably due to the banning of DDT application It uas also found that PCB's were virtually absent in the Gulf water. Some values of water quality analyses are shown in the tables alongside.

Water quality of upper south regions of the Gulf (Ban Don Bay, Surat Thani Province) and the Andaman Sea (Phang-nga Bay, Phuket Province

	*Gulf**	*Andaman Sea"*
Salinity (ppt)	32 3 32.4	31 4 32 0
Mater temperature (C)	29 30	28.2 · 29
pH	8.16. 8.23	8.23 -8.35
Dissolved oxygen (ppm)	1.3 4.8	6.0 7.0
Chlorophyll a (mg/ m^3)	1 2 3.4	287 · 956
Hydrocarbon (micro g/l)	0.79 2 37	0.25 - 0.74
P (umol 1)	0-10	0.1-0.5
N (umol 1)	0 12	0 I! I 60
SiO, (umol l)	5.8 33 I	–
Organic Carbon (mg l)	1 -25 - 40	-

Sources * Hungspreugs et al 1987 ** Limpsaichol et al,. 1988

Hungspreugs (1987) reported that the major phytoplankton genera in the Ban Don Bay water were *Bacteriastrum* spp., *Pleurosigma spp., Thalassiotrix* rpp., *Cerataulina spp., Thalassionema* rpp. and *Rhizosolena* spp. These had densities ranging from 1788-24,389 ind/l. The most abundant zooplankton types were calanoid copepods and decapod larvae which ranged from 7737 to 38.514 ind/m^3. The benthic organisms reported from the area were polychaets, bivalves, gastropod5 and crustaceans and others, with an average density of 141 ind/m^2.

Longliners in a mangrove-fringed creek in Bangladesh at lowtide.

Bangladesh

by

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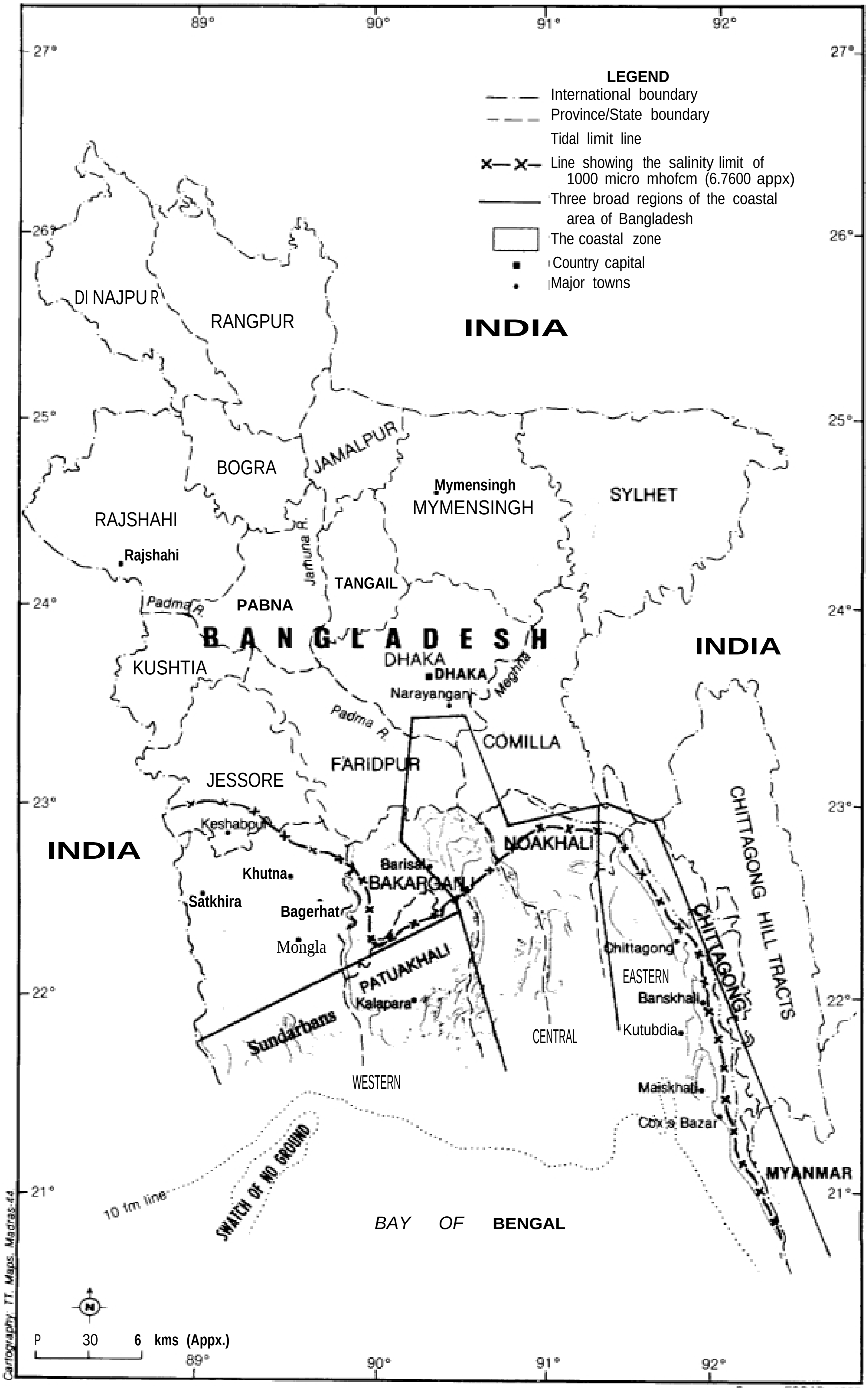
Fig. 14. Map of Bangladesh showing the limit of salt penetration in the coastal zone



Source: ESCAP, 1988

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24. INTRODUCTION

Bangladesh has a land area of 144,054 km^2 and a population of over 110 million. Land-locked on three sides, it is in the South alone that it has a coastline, the Bay of Bengal washing this southern border. Geographically, Bangladesh lies at the junction of the Indian and Malayan subregions of the Indo-Malayan realm. Most of the country is low-lying, about ten metres above mean sea level.

Fish is the most accessible animal protein for the majority of the population. It is, therefore, vital that the aquatic environment be used in a sustainable manner, and that the resource base is not damaged or destroyed. Unfortunately, however, the inland capture fishery is jeopardized by natural and man-made environmental changes as well as by increased pollution from different sources. There are also indications that natural and man-induced transformation, including land-based industrial pollution, from cities as well as coastal areas, is affecting coastal habitats and, probably, the marine environment as a whole. Unfortunately research in this line is meagre. Following the recent world trends, however, the Bangladesh authorities have recently pinpointed environmental concerns and pollution as sensitive problem areas to be redressed on a national level.

This study attempts to extend baseline information on environmental threats to the coastal zone, the offshore marine fisheries and the environment. The research is based on scanty published and unpublished data collected from different sources.

25. GENERAL FACTS

The Bangladesh coastline extends 710 kms (excluding major indentations) along the northern edge of the Bay of Bengal, from the mouth of the Naaf River in the southeast, to the mouth of the Raimangal River in the southwest. In the dry season, the salt water limit follows an irregular line (Khan and Karim, 1982). Its width varies from less than 2 km, bordering some parts of the Cox's Bazar coastline, to as much as 50 km inland in the districts of Khulna and Satkhira (Figure 14, see facing page). During the monsoon season, floodwater pushes the salinity limit to near the coast, except in the districts of Khulna and Satkhira, where seasonal salinity variations are small. According to Pramanik, 1984, the coast of Bangladesh can be classified into three distinct regions on the basis of geomorphological conditions:

- The eastern region, from Big Feni River to Badar Mokam (southern tip of the mainland);
- The central region, from Tetulia River to the Big Feni River estuary, including the mouth of the Meghna River; and
- The western region, covering the coastline from the Tetulia River to the international border at Hariabhanga River.

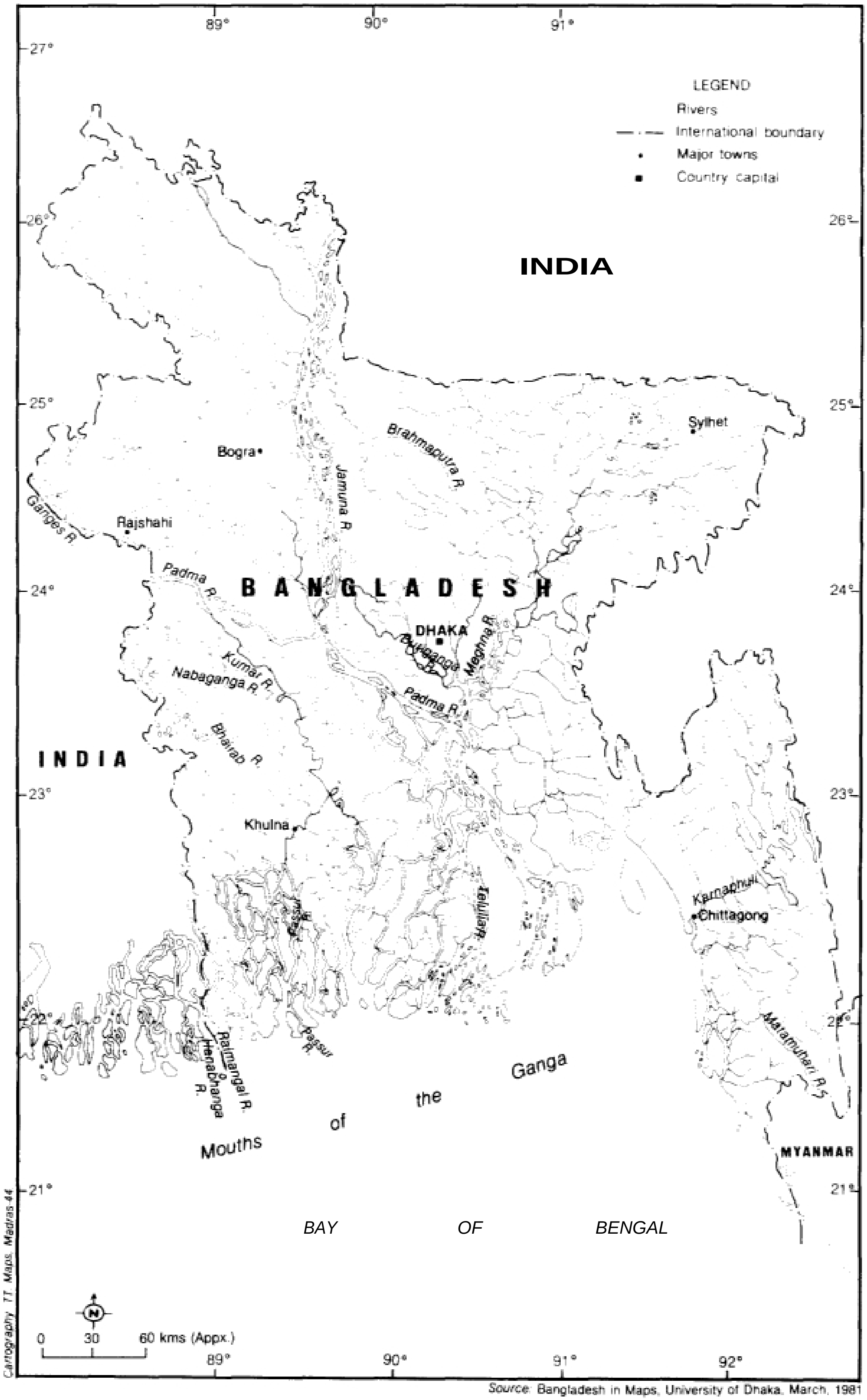
The coast for the most part is on the cyclonic tracks which form over the Bay of Bengal and suffers almost annually from severe damage caused by storms (Ali, 1979, 1980) and tidal waves. The Meghna estuary, in fact, acts as a funnel which draws the cyclones in.

The coastal zone of Bangladesh enjoys a tropical maritime climate. Its four distinct seasonal weather patterns, which are principally governed by the Southwest and Northeast Monsoons, are:

- The dry winter season, from December to February;
- The transition period, from March to May (pre-monsoon);
- The rainy season, from June to September; and
- The second transition period, between October and November (post-monsoon).

Normally about eighty to ninety per cent of the annual rainfall is confined to the monsoon months (June-September).

Fig. 15. River systems of Bangladesh



Source: Bangladesh in Maps, University of Dhaka, March, 1981

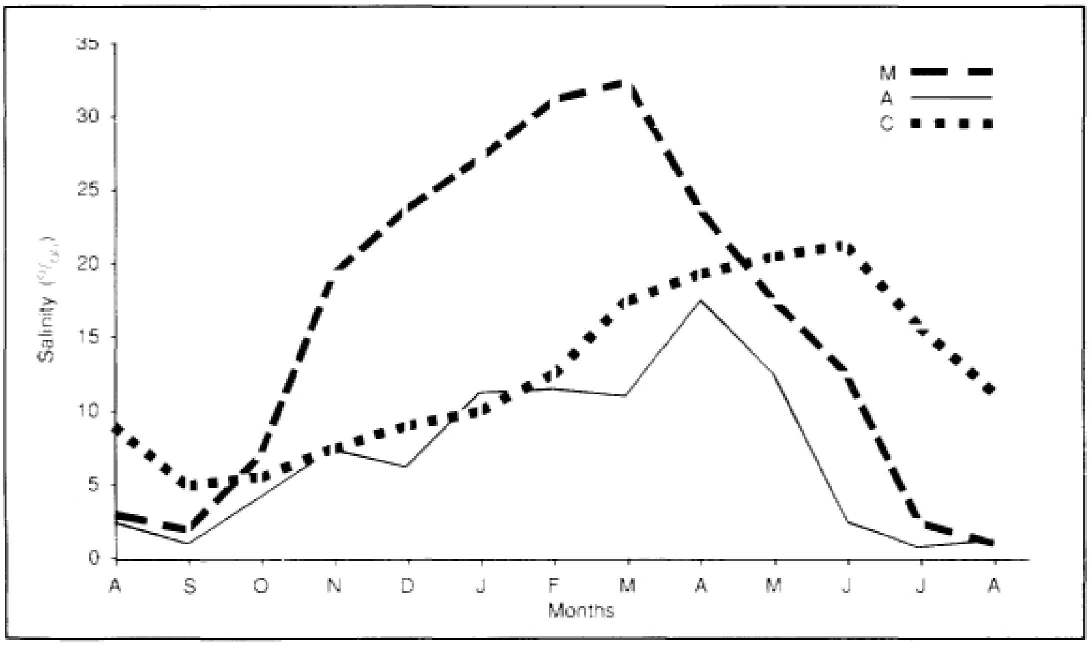
26. *MARINE HABITA TS*

26.1 *Estuaries*

Bangladesh's entire coastline is intercepted by an intricate network of interconnecting waterways, varying in width from a few metres to several kilometres. These generally run in a north to south direction (see Figure 15, facing page), Some of the world's biggest rivers, such as the Ganga, Brahmaputra, Meghna and Karnaphuli enter the Bay of Bengal through this estuarine system.

Although intensive estuarine studies have not yet been carried out, several authors have highlighted some interesting aspects of the Bangladesh estuarine system. (Mahmood and Ahmed 1976; Salam, 1976; Quader, 1976; Khair, 1976; Mohi, 1977; Das, 1977; Amin and Mahmood, 1979; Das and Das, 1980; Mahmood and Khan, 1980; Hakim *et al.*, 1981; Paul, 1981; Islam, 1982; Haque, 1983; Hossain, 1983; Mahmood, 1984 and Mahmood *et al.*, 1985). The principal feature in estuarine hydrology is the presence of a prolonged low saline regime every year, mostly during the monsoon and post-monsoon seasons (see Figure 16).

Fig. 16. Monthly variation of salinity (August 1982 August 1983) in the estuaries of Matamuhari River at Chakaria Chittagong (M) the Andhermanik River at Khepupara. Patuakhali (A), and the Coxali River at Satkhira, Khulna (C).



Note. Reconstructed after Mahmood 1986

A semi-diurnal tide is typical of Bangladesh's coastal waters, with a range of approximately three metres during the spring tide season. The mean tide level, however, is not constant throughout the year as it undergoes changes that vary with latitude and hydrography (Patullo, 1963). The Bay of Bengal has, possibly, the largest such variations known on earth. These large mean tide fluctuations have an important bearing on the overall geomorphology of the coastal area. The average level in March, for instance, is 94 cms below the average levels found in September – the month with the highest tides (Smith, 1982).

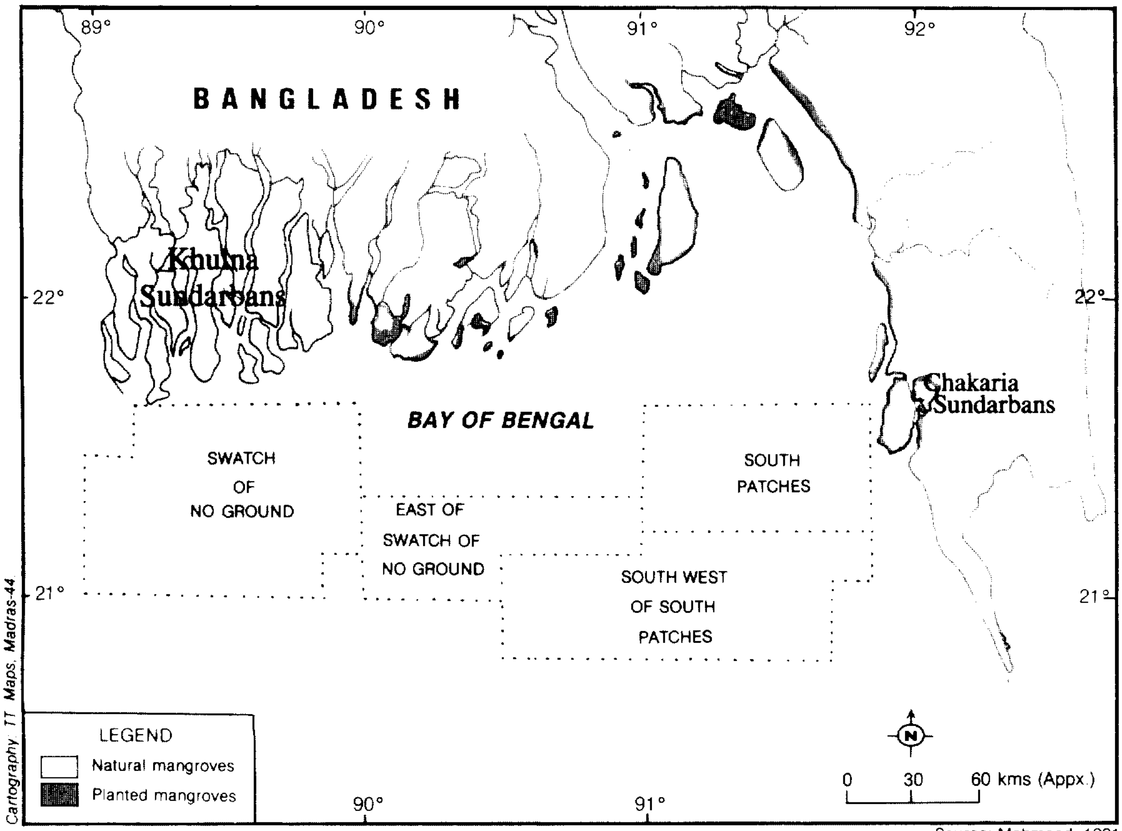
Estuarine plankton communities have also been studied (Salam, 1976; Islam, 1981; Islam, 1982; Haque, 1983; Elias, 1983; Mohi, 1977; Zafar and Mahmood, 1989; Mahmood, l990b). Until now, benthic estuarine fauna did not receive adequate attention. Only one investigation, in relation to pollution in the Karnaphuli estuary, was undertaken by Hossain 1983 (further described under 29.5: Municipal wastes).

26.2 *Mangroves*

Mangroves, locally known as *sundarban* or *peraban,* play a vital role in the national economy of Bangladesh. Besides being a source of different renewable resources, they also serve as buffer zones against the cyclones and tidal surges. The Bangladesh coast supports about 587,400 ha of natural mangroves (Mahmood, 1986) and a further 100,000 ha of planted mangroves.

The densest mangroves block, the Sundarbans (beautiful forest), is situated in the southwest (Figure 17), mostly in Khulna District, where it covers 577,040 ha (FAO. 1984), one third of this area is tidal channels. It is not only the largest single forest resource in the country, but also the largest single compact mangrove resource in the world.

Fig. 17. Showing distribution of mangroves in the coastal area of Bangaladesh and the offshore fishing grounds



Source: Mahmood, 1991

The Sundarbans represent a complex estuarine ecosystem, dominated by dense forest cover and subject to periodical tidal inundations. The structure and composition of the Sundarbans are maintained by a strong salinity gradient extending from the freshwater environment of the northeast to the saline environment of the southwest (Saengar *et a!.,* 1983). In mangrove areas, trees reach a height of upto 20 m, but the main canopy is at about 10 m.

The Chakaria Sundarbans, situated in the Matamuhari River delta in the Cox's Bazar District, is another mangrove tract. It has an area of 8,540 ha and has recently been degraded (Karim and Khan, 1980). Another mangrove forest area is a narrow belt fringing the Naaf River estuary and the offshore islands. It occupies roughly 1,800 ha.

Mangrove plantations in the different coastal districts of Bangladesh (particularly in the central region) are a recent but important attempt to improve the nation's forest cover. Afforestation in the coastal areas commenced on a modest scale in 1966, with the planting of seedlings on the slopes of embankments under the jurisdiction of the Water Development Boards (ESCAP, 1988). The success of the planting has led to other coastal afforestation programmes, with World Bank assistance, from 1980. These have the following objectives:

- To accelerate the process of siltation and stabilization of soil;

- To create forest buffer belts to protect inland life and property from extreme events, like cyclones and tidal surges;
- To create urgently needed resources to add to the national wealth;
- To create job opportunities for rural communities; and
- To create a healthy environment for wildlife, fish and other fauna.

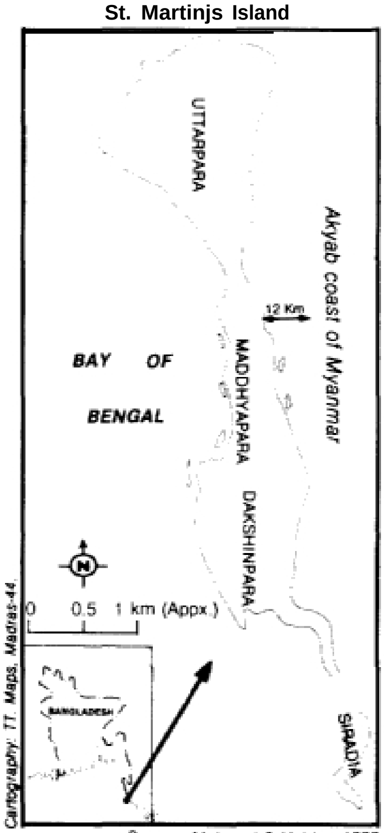
Afforestation attempts in some areas *(e.g.* Patharghata in Pat uakhali, Kukrimukri in Barisal and south Hatia in Noakhali) led to faster stable formations around the nucleus forest. From 1966, when plantation programmes commenced, to date, mangroves have been raised in about 100,000 ha. along the coast (Katebi and Habib, 1988).

The natural Sundarbans vegetation is composed of halophytic tree species dominated by *Sundri (Heritierafomes), Gewa (Excoecaria agallocha), Goran (Ceriops decandra)* and *Keora (Sonneratia apetala).* In the coastal afforestation areas, the most widely planted species are *Keora (Sonneratia apetala), Bayen (A vicennia officinalis), Sada Bayen (A. alba)* and *Kankra (Burguiere gyrnnori:a).* Other species include *Acacia arabica* and *A. catechu* in the higher lands (along the coastal embankments) and Golpata *(Nypafruticans)* in new accretions and lower areas along the embankments.

The densely forested swampy islands are the home of a variety of animals, ranging from large mammals, including tiger, deer and monkeys, to innumerable mud crabs, which, although common at the water's edge, can also be found throughout the intertidal zones. The Sundarbans harbour a number of species classified by the World Wide Fund for Nature and the International Union for Conservation and Natural Resources as endangered species. Its vast network is inhabited by at least four species of dolphins, the salt water crocodile *Crocodyluspoposus* and many other reptiles, several amphibians and numerous species of shell and finfish.

The mangroves are exploited for a wide range of forest products, such as sawn timber, fuelwood and wood for making pulp, safety matches, hardboard and bailing board. *Golpata* (Nypafruticans), *Hental (Phoenix paludosa)* leaves and *Hudo* (tiger fern) are also used as thatching materials. Considerable occupational levels have been maintained within the Sundarbans. Employment, in fact, is also generated by the industrial processing of raw materials derived from the forest. The probable direct employment is likely to be in the range of a minimum of 500,000 - 600,000 people during one half of the year, whilst the organized industrial sector employment is likely to be of the order 10,000.

Fig. 18. Geographical location of St. Martinjs Island



Source: Mahmod & Haider. 1992

The four major animal products obtained from the Sundarbans are fish, honey, bees-wax and mollusc shells. Many small-scale or subsistence capture fisheries also exist in the mangrove estuaries. Unfortunately, records of these are scant. However, about 200,000 people are engaged in these fisheries and their annual average catch is about 7200 t, representing approximately one per cent of the yearly total national capture fisheries production.

26.3 *Coral reefs*

St. Martin's Island is the only coral reef island in Bangladesh. Locally known as Jinjiradwip, this gradually decaying island (Anwar, 1988) is about 10 km south of the mainland (Figure 18). It is about 8 km long in an approximate north-south direction and has a maximum width of 1.6 km (in the north). Its area is a little over 7.5 km^2 (Haque et al., 1979).

There is little information on Bangladeshi offshore coral. A recent study (Haider and Mahmood, 1992) records four species of the genus *Acropora (A. pulchra, A. horrida, A. humilis* and *A. variabifis)* from the neritic waters of St. Martin's Island. Besides this genus, coral of ten more genera, namel y *Stylocoeniella, Pocillopora, Stylophora, Porites, Pavona, Favia, Favites, Pseudosiderastrea, Goniastrea* and *Monstastrea,* under six families, have been recorded (Mahmood and Haider, 1992)

26.4 *Seagrass*

Information on the existence of seagrass beds is also lacking. Nevertheless, *Halodule uninervis* has been reported from the sandy littoral zone around St. Martin's Island (Islam, 1980). Usually, in Bangladesh, the seafronts of newly-formed islands *(chars)* as well as some low-lying coastal areas are often carpeted with seagrass.

26.5 Beaches

Most beaches on the coast of Bangladesh are either sandy or muddy and are backed by either Casuarina plantations or agricultural lands. A long sandy beach, about 145 kms in length, runs from Cox's Bazar to the tip of the Teknaf Peninsula. There are also beaches at Patenga (near Chittagong), Banskhali, Kuakata (Patuakhali) and on offshore islands like Kutubdia, Maiskhali and St. Martin's Island (Jinjiradwip).

26.6 Islands

The river system, which carries an enormous quantity of silt, empties through the coastal zone into the Bay of Bengal and results in the formation of a large number of temporary and permanent islands called *chars*. Almost all the islands are deltaic in origin — except Maiskhali and St. Martin's Island. About 30 per cent of Maiskhali's total area (653 km^2) is occupied by hills covered with mixed evergreen forest, but this is now, largely, degraded. Sandwip and Kutubdia are large islands lying off the Chittagong coast. The flora found in these islands has been described by Huq and Khan (1984) and Huq (1986).

26.7 Offshore waters

Following its declaration in 1979 of an Exclusive Economic Zone (EEZ), with a 200 nautical mile limit, Bangladesh now avails of a sizable offshore area in the Bay of Bengal. More than 120,000 km^2 is under national economic and management jurisdiction (Sada, 1991). Moreover, during the Law of the Sea Convention, 1982, Bangladesh established rights over an area within a 200-350 nautical mile limit (Nizam, pers. comm.). This entitles the country to maintain exclusive rights over the abiotic resources within this limit.

The oceanography of the Bay of Bengal, particularly that of Bangladesh's offshore waters, is dominated by three main factors (Lamboeuf, 1987):

- Wind direction;
- Precipitations, as a consequence of the tropical monsoons, prevailing in the region; and
- River discharge, also related to the monsoons, but intensified by the fact that major river systems in India, Bangladesh and Myanmar empty into the Bay of Bengal.

These factors have a strong influence on the marine environment, affecting water circulation, salinity, turbidity, productivity and the nature of bottom. Fish distribution and migration are, in turn, influenced by these reactions.

The Southwest Monsoon, characterized by a hot humid air mass blowing from the Bay of Bengal from May through August/September, is responsible for roughly 80 per cent of the total annual rainfall in Bangladesh. The Northeast Monsoon blows from November through March/April, drawing cool, dry air from the continental areas. Between these two monsoons, that is, during the transition periods, winds are unstable and change direction, often causing cyclones.

The seasonal changes to the Northeast and Southwest Monsoons bring about a complete reversal of surface current patterns in the Bay of Bengal. They become clockwise from January to July and counter-clockwise from August to December, following the direction of wind.

Three of the main subcontinent's rivers — the Ganga, Brahmaputra and Meghna — drain vast areas of India, Bangladesh, Nepal and the Himalayas. These rivers and their tributaries, converging in Bangladesh, carry aapproximately 85 per cent of the total water volume which is flushed from the country into the Bay of Bengal. The discharges show distinct seasonal fluctuations, with extreme values reaching 195,000 m^3/s in the monsoon period, obviously as a result of melting snow precipitation in the Himalaya. The rivers clearly supply a huge quantity of water (some 1100 km^3 annually) which dilutes the surface waters of the northern part of the Bay. These can plummet as low as riverine water conditions during the post-monsoonic season (September and October), and come near to estuarine conditions prevailing in January through June.

During flooding, the rivers also transport massive amounts of suspended sediment loads — of the order of 13 million t/day — into the Bay of Bengal, Most of the suspended sediment (80-90 per cent) is transported during the monsoon season. This is calculated at some 1500 million t of which only a small portion is deposited on to the flood plains or in the lower delta; most of it is flushed out towards the deeper parts of the Bay (Eysink, 1983).

27. FISHERY RESOURCES

The fisheries sector (both inland and marine) plays a vital role in the national economy in terms' of income-generation, employment opportunities and nutrition. It contributes roughly 80 per cent to the national animal protein intake, nearly 6 per cent to the Gross Domestic Product (GDP) and more than 12 per cent of the total export earnings (Sada, 1991).

27.1 The estuarine and nearshore fishery

Traditionally, coastal and riverine fishermen, accustomed to using traditional sail and small, mechanized boats (9-14 m long with 15-45 HP diesel engines), are active in this fishery. Set bagnets, gillnets and seines are the main fishing gear (Mahmood and Chowdury, 1989). Fishing efforts are restricted to estuaries and shallow coastal waters, upto about 30 m. The fish biodiversity here is mainly exploited by small-scale or subsistence level fisherfolk. Data on the estuarine and neritic water fisheries is scarce; however, about 95 per cent of Bangladesh's marine fishery production is contributed by this sector.

Until now, bagda shrimp, ***Penaeus monodon*** post-larvae, are the only fry used to stock the coastal brackishwater ponds. Recently, however, with demand increases, intense and widescale macro-zooplankton fishing has also been undertaken in the estuaries and nearshore waters. Mahmood (1986), and Funegaard (1986), have described the gear and methods used in such fishing efforts and have also discussed the procedures of sorting ***bagda*** PL from the mixed zooplankton catches.

21.2 The offshore fishery

Offshore trawl fishing, a relatively new development in Bangladesh, gained momentum from 1974. Marine fish production from offshore trawling during the last few years has been 4,000-12,000 t a year (Sada, 1991). It is noteworthy that these production figures do not represent actual catches in offshore waters. Large quantities of finfish caught (35,000-40,000 t/year) are shrimp by-catch, for which offshore trawler fleets are responsible. These are discarded as trash fish at the catching points, and only quality finfish (a very small fraction) are retained. In 1988-89, penaeid shrimp, the most lucrative item in commercial fishing, contributed only 5000 t in a total catch from the marine sector of 233,281 t, including catches from brackishwaters (Sada, 1991). Thus, as much as 90-95 per cent of the national Bangladesh marine fishery production is due to the traditional sector; that is, artisanal fisheries operating in estuaries and neritic waters, as mentioned earlier. The principal fish species are ***Hilsa*** (shad), Bombay Duck, ribbonfish, Round Scad, Spanish Mackerel, catfish, threadfin, croaker, pomfret, eel, Red Snapper, grunter, shark, ray and shrimp. Taxonomic details of commercially important fish and shrimp are given in Hussain (1971, 1984) and Howlader (1976).

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Since 1958, a number of surveys have been conducted in the shelf area of Bangladesh by different international and bilateral agencies (Shahidullah, 1986). Several fishing grounds were identified, but it appears that greater attention was paid to demersal resources, particularly finfish. The standing stock of finfish has in three recent surveys been estimated as being 160,000 t (Saetre, 1981), 152,000 t (Khan, 1983) and 157,000 t (Lamboeuf, 1987). Several reports indicate standing penaeid shrimp stock, but these contain substantial estimate variations, ranging between 1000 and 9000 t (Khan and Haque, 1988). Apart from shrimp, pelagic resources, such as tuna, mackerel, sardine and cephalopods etc., are still untapped in Bangladesh's offshore waters. Neither has the standing stock been assessed. Minor quantities of these resources are, however, caught as Hilsa by-catch by the drift gillnetters active in the neritic and coastal waters upto depths of 30 metres.

The marine pelagic resources of Bangladesh are tuna and tuna-like fish, sardine, herring, shad, scad and the so-called unconventional marine resources, including shark and cephalopods (Begum and Ahsanullah, 1986; Huq, 1987; Ahmed, 1990 and Sada, 1991). A tentative taxonomic list is given by Mahmood and Khan (1992).

27.3 Culture fishery

Frozen food is next to jute and jute goods in national exports. It contributes about 14 per cent of Bangladesh's foreign exchange earnings. About 85 per cent of the freezing industry's production is shrimp (Sobhan, 1990). A significant portion (about 24 per cent) of this originates from coastal brackishwater aquaculture which, favoured by climate and several physical factors, is growing at a rapid pace in Bangladesh. But this growth also poses environmental challenges and socioeconomic concerns.

Shrimp farming in bheries, *ghers* or *ghonas* (that is, areas impounded by dykes) in the coastal area is traditional practice. But the rapid expansion in the coastal brackishwater areas in recent years has led to an exponential increase in production, the 1987-88 production figures of 17,889 t being eight times higher than the 1982-83 (2200 t) figures. The coastal shrimp farming area has increased from about 20,000 ha in 1980 (Mahmood and Chowdhury, 1989) to about 115,000 ha at present. Shrimp yields from the coastal aquaculture ponds are, however, very low: about 120 kg/ha/year.

The shrimp farms are primarily located in Bagerhat (29%), Satkhira (19%), Khulna (19%) and Cox's Bazar (31%). In addition, there are about 422 ha in Keshabpur Upazila of Jessore, 43 ha in Kalapara Upazilla of Patuakhali, and 87 ha in Anowara and Banskhali Upazillas of Chittagong. The average farm is about 28 ha in extent.

Four traditional styles are followed in shrimp farming (Mahmood, 1988): Salt production together with shrimp and finfish culture; round the year shrimp and finfish culture; *bheri* culture; and monoculture of *bagda* shrimp *(Penaeus monodon)*. The indiscriminate expansion of this farming, instead of planned development ensuring extensive, semi-intensive or intensive farming, has given rise to many socioeconomic and environmental problems in coastal areas (Mahmood, 195lb).

28. ENDANGERING THE MARINE HABITATS

Environmental concerns, such as pollution, ecological imbalance, environmental protection etc., are comparatively new concepts in Bangladesh. As environmental concerns became accepted worldwide, Bangladesh too became more aware of the degradation caused by natural and man-made pollution and the necessity for proper environment conservation if sustainable development was to be reached. Marine environment was no exception. National experts, development planners and government authorities first became conscious of the dangers to the marine environment in 1979, when a national seminar on 'Protection of the Marine Environment and the Related Ecosystem' was held in Dhaka under the joint sponsorship of UN/ESCAP, the Swedish Environment Protection Service (SEPS) and the National Department of Environment Pollution Control (which has now been renamed the Department of Environment).

Floor control dykes and river dams have also affected the marine fishries ecosystem (EPWAPDA, 1960; BWDB, 1978). Furthermore, the irrational expansion of coastal shrimp farming at the cost of mangrove forests (Mahmood, 1986, 1991b) and overfishing (Mahmood, 1990a) has exacerbated an already precarious situation. Overall ecological degradation, reduced tidal plains and damage to the habitual nursery grounds as well as the natural fishery stocks has been the immediate result. (Bhouyain, 1983; Bashirullah et *al.,* 1989; Ali, 1989: IUCN, 1991a). The consequences of pollutants, periodic cyclones, tidal surges and the long-term effects of sea level rise due to the global greenhouse effect are likely concerns in the long-term.

28.1 Water resources development activities

Water resources development projects, like the Flood Control and Drainage (FCD) and Flood Control, Drainage and Irrigation (FCDI) programmes, closures across rivers, obstruction of water for irrigation, diversion of channels etc. have been implemented in Bangladesh from the early 1960s to make the country flood-free as well as to increase food grain production. But these projects, though proving beneficial to food grain production and providing protection from periodic floods and cyclones, have produced adverse effects on the aquatic ecosystem, affecting the production both in terms of quantity and species diversity. The effects can be seen in freshwater as well as brackishwater fisheries in inland open water habitats, such as estuaries, rivers, canals, flood plains and *beels* (deep depressions), which become components of a single, integrated fishery production system during the monsoon (wet) season (Ali, 1989; IUCN, 1991a).

Upto the end of the Third Five-Year Plan period (June, 1990), about 3.36 million ha of flood plains that used to get inundated were protected by FDC with over 7000 km of embankment and other constructions. Thirtyone per cent of the total flood-protected area is now under the Coastal Embankment Project (CEP), located in the estuarine and coastal areas. The CEP includes about 3700 kms of embankments and 900 hydraulic sluices to prevent shallow saline water flooding and protect the area from tidal surges (MPO, 1985).

These embankments and other obstructions, however, have reduced the flood plains and inhibited fish movement and migration for breeding and feeding. It has been estimated that nearly 815,000 ha of flood plains had been removed from the openwater fishery production system until 1985, and a further 2 million ha of currently flood-prone land would be rendered flood-free by the year 2005. Thus, by the year 2000, an estimated 110,000 t of fish harvest may be lost every year (MPO, 1985). This includes not only the freshwater catch (e.g. carp), but also the estuarine and marine euryhaline species (e.g. mullet, *Hilsa* etc.) as well as freshwater prawn (e.g. the giant freshwater prawn) which live in both environments during the different phases of their life cycles. However, extensive studies are yet to be done to quantify the irreversible loss to this sector.

The impacts of the different projects on brackishwater fisheries are summarized below:

CHANDPUR FCDI PROJECT

Polders to a total extent of 555 km^2 have been created with high embankments in the project area. The South Dakatia River and associated water bodies within the project area were also cut off from the remainder of the open-water system by the project structures. The embankments and blockage of the South Dakatia River had the following impact (MPO, 1987b):

- Overall fish production within the project area declined by 35 per cent within two years of project implementation;
- A commercially high-value giant freshwater prawn species *(Macrobrachium rosenbergii),* found in the river before the project, was soon replaced by low-value, smaller-sized prawn *(i.e. Macrobrachium lammarrei* and others); and
- A fishery based on 18 fish species of tidal or estuarine origin, which used to inhabit the South Dakatia River has disappeared with the fish being prevented from entering the river by the project regulators (IUCN, 1991a). Among the species are *Hilsa ilisha, Pangasiuspangasius, Rhinomugil corsula, Glossogobius giuris, Doryichthys cuncalus, Oryzias melanostigma, A waous stamineus, Corica soborna, Sicamugil cascasia, Leiognathus equulus, Gobiopterus chuno, Odontamblyopus rubicundus, Pseudapocryptes lanceolatus, Trypauchen vagina, Setipinnaphasa, Macrognathus aculeatus,* the first three named being the most commercially important species in Bangladesh.

MUHURY PROJECT

This FCDI project encompasses 6980 km^2 in the Feni (old Noakhali) and Chittagong Districts. A cross dam, completed in February 1985, altered the physical, chemical and biological characteristics of the aquatic environment of the Feni River system. Now, backwaters remain fresh throughout the year, as the seasonal movement of the 'salt wedge' has been restricted. Nursery grounds of species requiring a brackishwater regime for their juvenile development have, thus, been destroyed during the dry season. Downstream of the dam, the Feni River estuary has also undergone drastic changes with increase in salinity. The dam prevents upstream *Hilsa* migration (for reproduction) from the estuary; it has also eliminated the commercial *Hilsa* fishery in the Feni River above the dam. Before the completion of the dam, this fishery in the upper reaches of the river was estimated at being about 500 t valued at Taka 10 million* (IUCN, 1991a).

COASTAL EMBANKMENTS

In the southern districts of Bangladesh, the low-lying lands on both sides of the tidal rivers and canals have traditionally been inundated by brackishwater during high tides. Such inundated areas act as temporary nursery and feeding grounds for the larvae and juveniles of many estuarine and marine shrimp and finfish. From the 1960s, embankments constructed to protect the land from saline water inundation have permanently eliminated these nurseries and feeding grounds for marine and estuarine fish as well as shrimp. The construction of coastal embankments also brought to an end the traditional practice of brackishwater shrimp and fish culture during dry months and alternated in the wet season with rice cultivation in the Khulna region, particularly in Sathkira District. Brackishwater shrimp and fish farming is now being undertaken by cutting the embankments, which makes the polders especially vulnerable to cyclones. This practice has also given rise to conflicts in respect of land use rights (Nuruzzaman, 1990; IUCN, 1991a).

RIVER CLOSURES AND BARRAGES

River closures and barrages across rivers obstruct upstream and downstream fish and prawn migration and thereby inhibit or disrupt their reproduction and sustenance. For example, the closure of the Kumar River, both at its source from the Rivers Kaliganga and Nabaganga, under the Ganges-Kobadak project, has cut off *Hilsa* migration from the sea *via* the Nabaganga River to the Padma River through the Kumar River. As a consequence, the *Hilsa* fishery of moderate magnitude that existed in the Kumar River is no more. The *Hilsa* fishery in the Ganges River, both in Bangladesh and India, has declined due to blockages of its upstream migration path by the Farakka Barrage (Jhingran, 1983; MPO, 1986). Jhingran (1983) reported that after the completion of the Farakka Barrage in 1973, *Hiisa* availability declined by 99 per cent.

Plans for the construction of barrages across the Ganges and Brahmaputra Rivers within Bangladesh for water diversion are in the pipeline. Such schemes would eliminate the spawning migration of anadromous and catadromous fish and prawns. It is also anticipated that the *Hilsa* population would not only decrease in the rivers but also in the sea. In addition, the catadromous migration of giant freshwater prawn *(M. rosenbergii)* and other such species would be detrimentally affected by the barrages — their breeding and return migratory patterns at risk.

28.2 Destruction of mangrove forests

Bangladesh's 687,000 ha of mangroves protect the coast from storm surges and cyclones and provide habitats and nurseries to numerous wildlife and fishery resources. Many small-scale or subsistence capture fisheries exist in the mangrove estuaries and swamps.

Unfortunately, the mangroves, overexploited by an increasing population growth and greater demand for forest products, are at a point of severe depletion. Ecological changes caused by biotic and edaphic factors as well as the horizontal expansion of shrimp farming has further exacerbated the situation.

It is estimated that the standing volume of the two main commercial species of the Sundarbans *(Sundri — Heritiera fomes —* and *Gewa — Excoecaria agallocha)* declined by 40-50 per cent between 1959 and 1983. This has been due to a local salinity increase as a consequence of the reduced river

* US $ 1 = Tk 32 appx.

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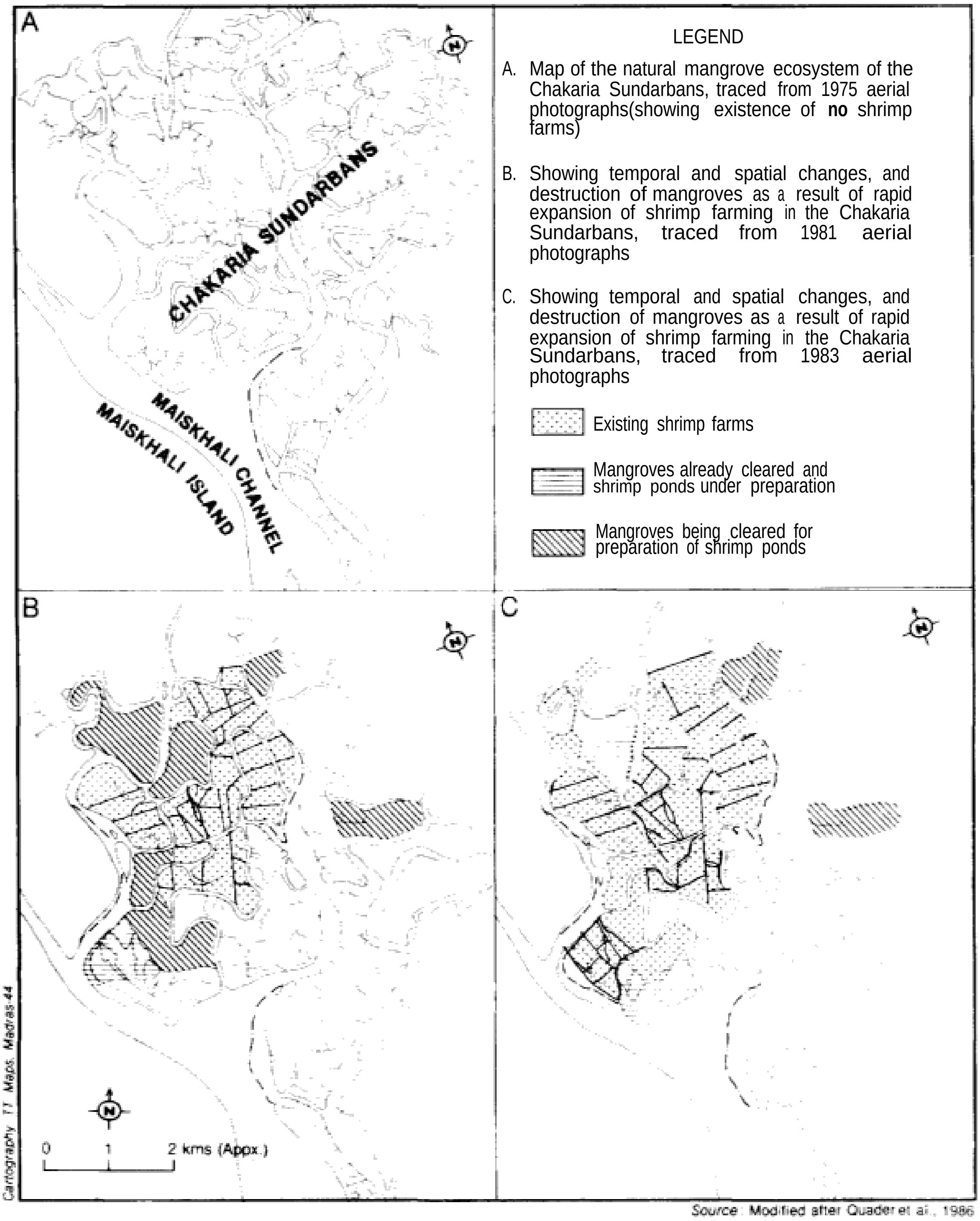
flows, following the completion of dams, barrages and embankments, as well as over-felling. Many areas within the Khulna, Barisal, Patuakhali and Chittagong Districts that once were covered by mangrove forests have since been given over to other land usage. Today, the Khulna and Chakaria Sundarbans are the only two compact mangrove tracts left intact (see Figure 17 on p. 82).

Natural calamities, such as cyclones and tidal waves, cause some damage to these forests along the sea. Spotted deer and other animals are also destructive agents (Khan and Karim, 1982). But the worst form of destruction in the Chakaria Sundarbans, located in the Matamuhari River estuary in Chittagong District, has been as a result of irrational and unplanned shrimp farming expansion since the late 1970s. Once the Chakaria Sundarbans were covered by dense mangroves and 8,510 ha enjoyed the status of a forest reserve (Katebi and Habib, 1988). After 1977, more than 50 per cent of the mangroves were cleared for preparation of shrimp ponds (see Figure 19). Now only a small patch of forest remains in the interior as a testament to the past (Mahmood, 1991b).

Fig. 19. The expansion of shrimp farming in the Chakaria Sundarbans



Source: Modified after Quader et al., 1986

Recently, the small fringe of natural mangroves on the bank of the Naaf River and the beautiful ***Keora (Sonneratia apetala)*** forest on Jaliardwip Island have also been cleared for conversion to shrimp ponds. The southern part of the Khulna region comprises the Sundarbans reserve, where shrimp farming is not permitted, but, recently, a few fish and shrimp farms have been established on the borders of the reserve (FAO, 1984) and encroachment is likely before long.

Mahmood (1990b) has described the ecological importance of the Matamuhari estuary of Chakaria after a recent investigation. Penn (1983) indicated that the highly productive fisheries found in the coastal and offshore waters of Bangladesh might be linked with mangrove proliferation on the shoreline. Rich fishing grounds in shelf areas (Hussain, 1992) are usually found off dense coastal mangrove forests (see Figure 17 on p, 82). The degradation of these mangrove ecosystems would have adverse effects on the nurseries and feeding grounds for marine and freshwater fish and shrimp as well as on the nearshore and offshore fisheries. If the present trend continues, it is bound to lead to a reduction in offshore stocks of shrimp and other finfish.

28.3 Overfishing

Small-scale and artisanal fisherfolk operating in estuaries and neritic waters have been overexploiting shrimp post-larvae, juveniles and pre-adults as well as finfish to meet the increasing demands of export and a burgeoning population (Ahmed, 1981 and 1984; Mahmood, 1990a).

AKTISANAL FISHERY

According to a frame survey in 1984-85, the coastal and estuarine fishing population includes 70,000 households and 124,000 fishermen spread over 869 villages in Greater Chittagong (i.e. Cox's Bazaar and Chittagong), Noakhali, Barisal, Patuakhali and Khulna Districts (Jahan, 1992). The fishery resources are exploited by traditional craft and motorired boats which operate marine and estuarinc set bagnets (SBN), the ***behundi jal,*** gillnets, trammelnets, longlines etc.

Among these gear, the estuarine SRN is the most popular. The SBN fishery is distributed throughout the country, active in channels, estuaries and tributaries and wherever else the brackishuater environment prevails. The SBNs are operated from less than five metres to an approximate twenty-metre zone in neritic waters. This is a very effective gear; it catches juveniles and under-sized shrimp and finfish as well as planktonic shrimp — ***Acetes*** spp. it has, however, been identified as a risk to overall biological sustenance (Ahmed, 1981 and 1984; Khan, 1992). At the cod end, its mesh sire varies from 5 to 18 mm.

Other fisheries have a limited distribution. The marine SRN is operated only during the dry season and only in certain areas, such as Sonadia Island, Dubla Island and Mohipur. The trammelnet is operated only in the neritic waters of Teknaf and Cox's Bazar. Further descriptions on this sectoral fishery have been given by Bennett and Alam (1992), Chowdhury (1992), Huq (1992), Islam (1992), Jahan (1992), Khan (1992) and Quayum (1992).

SHRIMP SEED COLLECTION

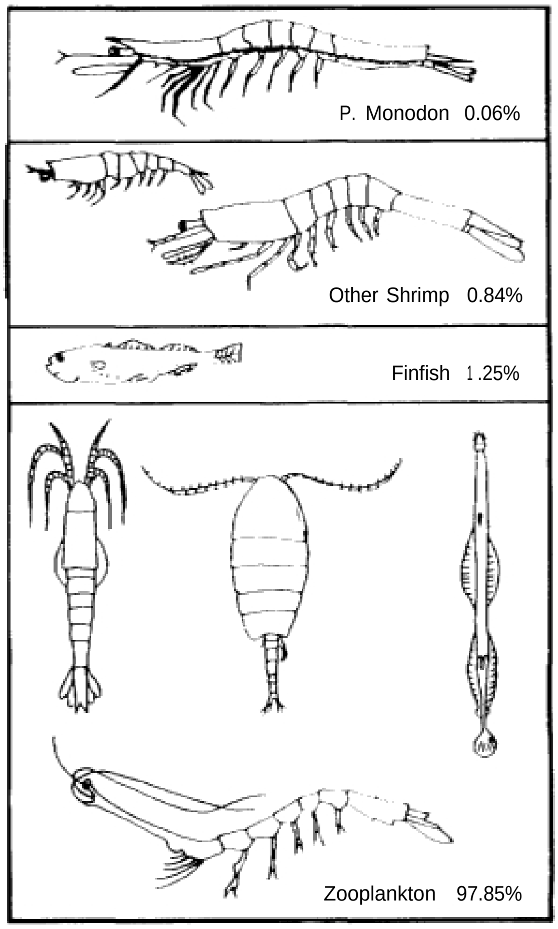
The rapid expansion of the coastal aquaculture areas in Bangladesh, coupled with the recent trend towards shrimp monoculture, has resulted in a tremendous demand for the seed of tiger shrimp, ***Penaeus monodon.*** But with the paucity of shrimp hatcheries, collecting P. monodon post-larvae (PL) from estuaries and nearshore waters has attracted thousands of coastal fisherfolk, causing immense destruction of nontarget species and damage to nursing grounds. Mahmood (1990a) has estimated the total fry collectors to be about 75,000 during peak periods, between mid-February and mid-March. But there are also estimates double that and more (BOBP, 1990).

In general, marine shrimp and many fish commonly follow a diadromous life cycle involving migration between the sea and the estuary. As a part of this cycle, the post-larvae are carried by the tide (planktonic migration) towards the shallow, estuarine mangrove areas of Satkhira, Khulna and Chakaria, as well as to nearshore waters of the southern and south-eastern part of the country — the Kutubdia, Banskhali, Maishali, Cox's Bazar and Teknaf coasts. In most of these areas, fry collector\ catch the wild fry by Set bagnets and pushnets made of nylon mosquito mesh.

In this collection, the catch is sorted out on the river banks or the coastal dykes after each half-hour haul. Besides *P. monodon* **PL** *(bagda* shrimp fry), the catch includes plenty of other zooplanktons. After the *P. monodon* PL are carefully separated, the remaining zooplankton, including post-larvae of other shrimp and finfish, are indifferently discarded (Mahmood, 1989). Thus, great loss is caused at the planktonic stage itself to other valuable resources. Figure 20 shows the average distribution of *P. monodon* post-larvae and that of other organisms. In order to capture a single *bagda* shrimp fry, 14 other shrimp and 21 finfish post-larvae as well as over 1600 other zooplankton are wasted! Alam (1990), in similar research undertaken along the Cox's Bazar and Teknaf coasts, found that for the capture of each *bagda* fry, about 21 post-larvae of other shrimp and 31 of finfish as well as 47 of other zooplankton were destroyed. Alam explained that "the dissimilarity with the findings of Mahmood l990a, might be due to the mesh size variation of the net".

This colossal loss of shrimp and finfish resources at the planktonic stage is bound to have adverse effects on the off-shore and inland stocks. Funegaard (1986) noted that the daily catch of *P. monodon* fry in 1986 was one-tenth of what it was four Years earlier when 2000 fry/net/day were caught. Today, fry collectors and local fisherfolk repeatedly mention the decreasing abundance of shrimp and finfish fry.

Fig. 20. Average distribution (in percentage(of post-larvae of *Penaeus monodon,* other shrimp and finfish, and all other zooplankton in the estuaries of Bangladesh



Source Mahmood, 1990)

Mass-fry collection is also proving a threat to the coastal ecosystem, causing damage to the nursing grounds of many species, and to newly planted mangroves as well as the reserve forests (Saikat, 1992). As most of the seed-collectors are illiterate and not environmentally conscious, they are not aware of the ultimate effects of their actions. This situation, therefore, calls for immediate control measures to regulate shrimp seed-collection in the coastal waters and the establishment of hatcheries to meet the growing demand of fry for Bangladesh's coastal shrimp farming sector.

29. *MARINE POLLUTION*

Water pollution has been endemic in Bangladesh for a long time, and has become widespread in recent years. All kinds of waste – either in solid or liquid form – are dumped into the water, resulting in the deterioration of the aquatic environment.

The numerous rivers and their tributaries that criss-cross the country carry pollutants from the whole drainage area, including upstream areas in India, Nepal, Bhutan and China. Most of the pollutants are in sediment form, municipal and industrial wastes, agrochemical residues and pollutant discharges from ships and boats **(EPC,** 1980; Bhouyain, 1983; Hossain, 1989). Although this pollution has existed over the years, information regarding the nature of pollutants and the damage they cause to marine fisheries and other resources is very scant (WPCP, 1975; EPC, 1980; Quader, 1976; Paul, 1981; Bhouyain, 1979; 1983; Hossain, 1983; Islam and Hossain, 1986; UNEP, 1986; Jalal, 1988; Hossain *et al.*, 1988; ESCAP, 1988; Hossain, 1989; DOE, 1990; Sengupta *et al.*, 1990; IUCN, 1991, a, b, c).

29.1 Industrial cen tres

Bangladesh is not an industrialized country. Even so, the gradual growth of industry in recent years has resulted in a serious problem of environmental pollution. The considerable discharge of untreated industrial effluents has led to the degrading of the aquatic and marine ecosystems of Bangladesh and has had an impact on fisheries.

The Department of Environment had by 1986 identified 903 polluting industries under 13 categories (see table below). These were estimated to have increased to over 1200 by 1990-91 (IUCN, 1991c) and have increased still further by now.

Categorywise distribution of the polluting industries of Bangladesh

Industry	Number	Industry	Number
Textiles	298	Chemicals	23
Tanneries	176	Sugar mills	16
Pharmaceuticals	166	Paper and Pulp	5
jute	92	Fertilizers	5
Iron and steel mills	57	Distilleries	3
Rubber and Plastic	34	Cement	3
Insecticides and Pesticides	25	TOTAL	903

All these industries as well as fish processing plants (see Figure 21 on facing page) have been established on the banks of canals, rivers, tributaries, estuaries etc. They directly or indirectly discharge their untreated liquid and solid wastes into the water bodies and the wastes eventually find their way into the Bay of Bengal.

The polluting industries of the country are mainly concentrated in five major industrial zones (IUCN, 1991c). These zones are discussed below.

DHAKA MUNICIPALITY

It includes the Tejgaon industrial area (housing about 150 industries, mainly food, textile, pharmaceutical and metal industries), Hazaribagh (having about 160 small- and medium- sized tanneries), and Demra, Tongi and Joydebpur, all with industries primarily associated with textile manufacture. All these industries discharge their untreated wastes into nearby open drains, canals, floodplains etc., or directly into the Buriganga River.

CHITTAGONG

There are about 150 industries, mainly textile mills, tanneries and chemical plants, in the eight industrial zones of Chittagong, namely Kalurghat, Nasirabad/Sholashahar, Patenga, Kaptai, Bhatiari, Barabkunda and Fauzdarhat, situated on the bank of the Karnaphuli River and along the coast of the Bay of Bengal. All these units discharge degradable and persistent organic and inorganic wastes as well as toxic metallic components directly into the Karnaphuli or the Bay; none have any existing or planned pollution treatment facilities (ESCAP, 1988). The second largest urea plant in the country has recently been established on the south bank of the Karnaphuli River. It has provision for treatment facilities, but the plant is reported to still contribute to river pollution (Hossain, 1992).

KHULNA

There are 165 industries located in the Rupsa, Khalispur and Shiromony industrial zones of Khulna. These discharge wastes into the Bhariab-Rupsa river system (Jalal, 1988: ESCAP, 1988), which opens into the Bay of Bengal. In addition, several match factories, the Khulna shipyard and fish processing units in the Rupsa industrial area discharge their effluents into the Rupsa River. A newsprint mill, a hardboard mill, a power station, some jute mills and some steel mills in the Khalispur industrial belt also discharge their untreated wastes into the Bhairab River.

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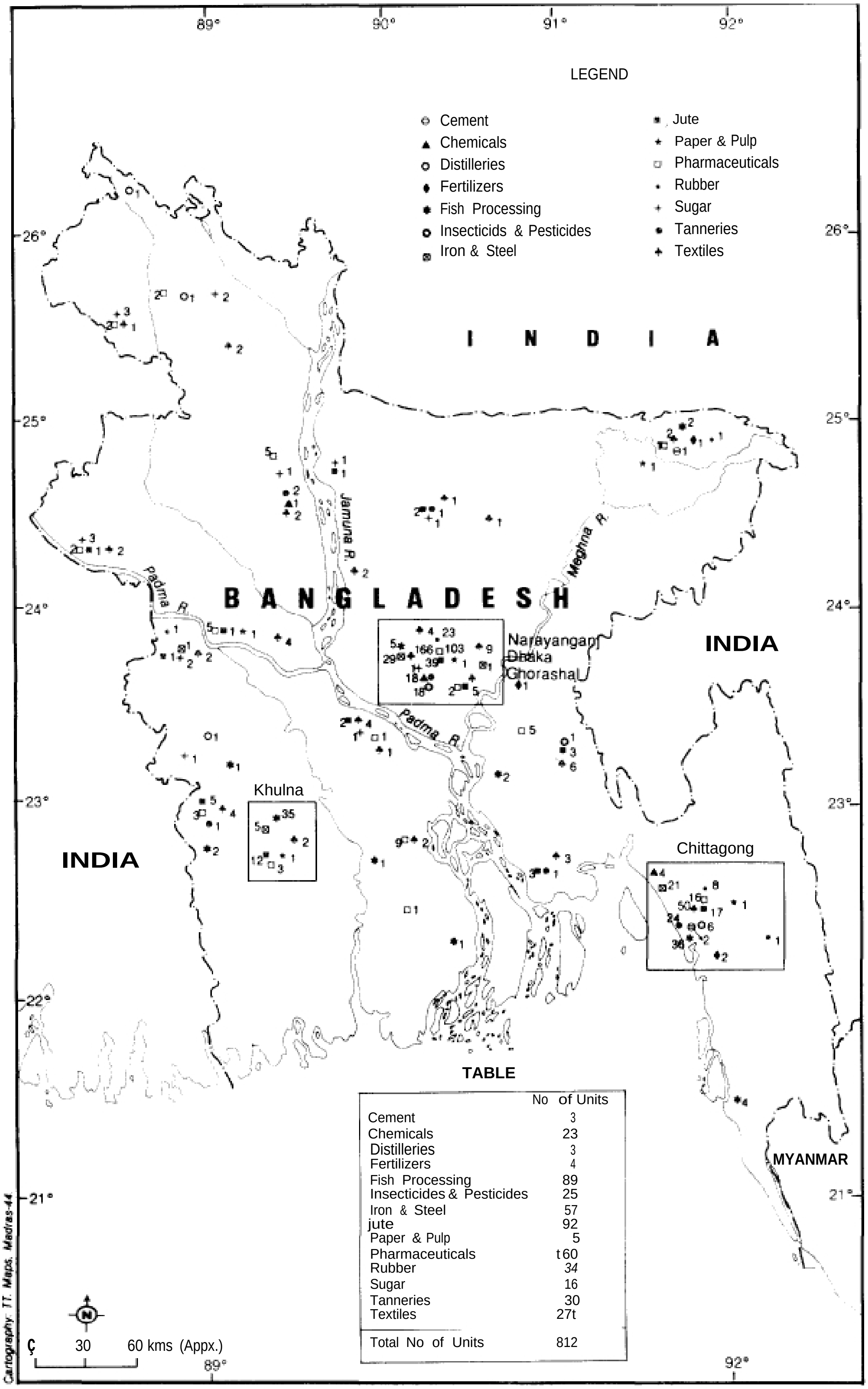
Fig. 21. Location of industries (with total numbers) in Bangladesh under different categories



TABLE

	No of Units
Cement	3
Chemicals	23
Distilleries	3
Fertilizers	4
Fish Processing	89
Insecticides & Pesticides	25
Iron & Steel	57
jute	92
Paper & Pulp	5
Pharmaceuticals	t60
Rubber	34
Sugar	16
Tanneries	30
Textiles	27t
Total No of Units	812

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Liquid waste characteristics of a typical urea plant

Measuring parameters	*Dora obtained*	*Measuring parameters*	*Dataa obtained*
Temperature	40°C	Ammonia	300 ppm
Flow	600-800 m^3 hr	TDS	8600 ppm
pH	9.12	Chromate	22 ppm
urea	2500 ppm	COD	150 ppm

Source Khair (1988)

Water quality in the Sitalakkhya River due to discharge of urea effluents

Parameter	*Sampling Location*	*Period*										
		10/ 88	11/88	12/88	1/ 89	2/89	3/ 89	4/ 89	5 /89	6 /89	7/89	10/ 89
E C	River	182	442	350	265	26'	297	220	280	219	70	76
[micromhos)	Dram	580	830	1075	1450	1400	890	580	600	510	498	890
Ammonia	River	–	–	3	2	I	I	0	0	I	3	
(mg/l)	Drain	49	61	33	18	20	21	22	14	8	14	

Soure NEMP D O E (1988-89) citd in IUCN, 1991c

Water quality in the Karnaphuli River due to discharge of urea effluents

Parameters	*Value in the river*	*Value in effluent*	*Parameters*	*Value in the river*	*Value in effluent*
				mg /litre	
Temperature (°C)	34	23	Total hardneo	133	1176
Total suspended solids (mg/l)	52	39	Ca-hardness	49	282
Total dissolved solids (mg/l)	443	294	Dissolved oxygen	4.6	5.8
Secchi depth(cm)	–	42	Ammonia	155	1.6
E.C (micromhos cm)	571	8133	Nitrate	66.1	4 5
pH	8.5	7.6	Nitrite	49.8	3 3
Total slksliniyy(mg/ l)	139	PI	Phosphate	0.55	0 18
Salinity (gm l)	0.56	4.00	BOD	118	6
Chloride (gm l)	0 36	2 28	COD	571	68

Source Hossain (1992)

NARAYANGANJ

This small industrial town is a busy inland river port, about 20 km from Dhaka. It has many jute and textile mills around it and they all discharge toxic effluents into the Sitalakkhya River.

GHORASHAL

Several industrial units have been set up in the suburbs of Ghorashal, about 30 km north of Dhaka. Two major fertilizer factories on the bank of Sitalakkhya River discharge effluents into the river.

29.2 Industrial wastes

Ammonia, chromium and other heavy metals from fertilizer factories and tanneries, mercury from chloroalkali units, phenols from pulp and paper mills, from refineries and from plastic, pharmaceutical and paint industries are the principal industrial contaminants. Acids and alkalis, suspended solids and other organic loads, which may be expressed in terms of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) respectively, must be added to this list of pollution.

Data on the overall extent of industrial pollution in Bangladesh are not available because there is no industrial monitoring system. The Directorate of Fisheries, (DOF) is, however, now developing a reviewing and quantification system to evaluate the extent of this industrial pollution. But, for the present, there is fragmentary information, on water quality parameters and pollution loads, to be found in some ESCAP and IUCN reports and this is summarized in the following pages.

UREA

Urea factories in Bangladesh severely pollute the adjacent rivers by discharging ammoniacal effluents (IUCN, 199lb,c). Although urea is not directly toxic, its hydrolysis into ammonia develops toxicity in the aquatic systems. Concentration of ammonia in the effluents vary from 100 to 400 ppm. A typical ammonia concentration in the Sitalakkhya River, 500 m downstream, is l-3 ppm and this value may rise as high as 30 ppm or more, depending on load conditions, equipment breakdown etc. (Rahman et al., 1980). Concentrations of 1.2-3 ppm of free ammonia or ammonium base are toxic to even the most resilient fish species (IUCN, 1991b). Typical effluent characteristics from a urea plant and information about the water quality in two rivers affected by urea plants are given on the facing page.

CHROMIUM

Chromium wastes are discharged from tanneries. Hexavalent chromium is carcinogenic and the threshold limit is 0.1 ppm. Serious pollution is caused in the Buriganga River by effluents from the Hazaribag tanneries, about 160 units in number. Typical waste characteristics from this area are shown in the table alongside.

The total quantity of wastewater from this source is about 4,000 m^3/day. The maximum concentration of chromium in the Buriganga River near the effluent discharge points is about 6 microgram per litre (Chowdhury, 1989). Similar levels are reported for zinc and lead.

Characteristics of waste water from Hazaribag tanneries

Parameter	*Range of variation*
pH	4- 10
Total alkalinity as $CaCO_3$ (mg/l)	185 – 6,475
Electrical conductivity (micromhos/cm)	1,670 53,000
Chloride (mg/l)	175 – 18,000
Chromium (mg/l)	2.6 – 2,800
COD (mg/l)	120 – 9,600
Ammoma-Nitrogen (mg/l)	12 – 1,970

Source: Chowdhury (1989)

MERCURY

Mercury toxicity in some commercially important shrimp and finfish species off the coast of Bangladesh has been studied by

Hossain (1989). The concentrations of mercury show that contamination is higher in the estuary than in coastal or open sea shrimp, the latter being the least contaminated. Anadromous fish, like *Hilsa ilisha,* however, have lower concentrations than those of the coastal areas or the open sea. It must, however, be recorded that mercury contamination in fish and shrimp from Bangladesh is still low in comparison with those from other Asian seas and the North Sea. Kamal (1992) also reported a concentration of four heavy metals, namely cadmium, lead, zinc and copper in green mussel, *Perna viridis,* from the Maiskhali channel near Cox's Bazar, but mentions that the concentrations are below the permitted levels recommended for human consumption. It should be noted that this particular channel is far from any industrial belt.

29.3 The Karnaphuli River

The estimated pollution load in the coastal waters of Chittagong has been reported in ESCAP (1988). The estimated pollution loads of biodegradable organic materials are summarized alongside.

The report on the river water analyses undertaken by the Department of Environment (DOE), to assess the pollution load in the Karnaphuli River, is given in the table below.

Estimated pollution load of biodegradable organics in terms of kg BOD/day in the Chittagong area

Industrial zone	*Pollution load (Kg BOD/day)*				
Pollution source in Chittagong area	*Total*	*Textile*	*Paper*	*Leather*	*Others*
Karnaphuli River					
Kalurghat	2,500	–	–	1,400	110
Nasirabad/Sholaskahar	6,400	800	–	4,100	1,500
Patenga	2,000	200	–	–	1,800
Kaptai	5,800	2,550	2,100	–	1,150
Bay of Bengal					
Bhatiari	1,000	600	–	–	400
Kumira	380	380	–	–	–
Bharbkunda	600	600	–	–	
Fauzdarhat	3,200	2,300	-	-	900
	21,880				

Note :
The Chittagong Wastewater Mission Report, 1985 (cited in ESCAP 1988) also states that there is a domestic waste load from Chittagong city in the Karnaphuh River of 3,500 kg BOD/day and a polluted load in the Bay of Bengal, from domestic and industrial sewage from the southeastern part of the country through runoff along the Kamaphuli River system, of 20,000 kg BOD/day. The report projects domestic waste loads by the year 2000 to be 5070 kg BOD/day and industrial waste load to be 2000 kg BOD/day

Typical analysis of water and pollution load in the Karnaphuli River at different locations, April 1984 - March 1985

Location	*pH*	*E.C.* (micromhos/cm)	*Chloride* (mg/l)	*Suspended solids*	*D.O.* mg/l)	*BOD* (mg/l)	*COD* (mg/l)	(mg/l)	*Remarks*
Middle of	7.7	245	18.0	55	240	6.5	38	65	MM.
Karnaphuli River	6.8	134	6.2	34	59	5.0	4.2	49	Avg.
near Kalurghat	6.0	100	2.0	16	19	4.0	0.4	30	Min.
Side of	8.5	750	100.0	460	101	5.9	22.0	68	Max.
Karnaphuli River	7.3	218	15.5	36.8	42.5	4.4	3.8	45.1	Avg.
near Dovashi Bazaar	7.0	120	3.1	18	11.0	0.1	1.0	30	Min.
Middle of	7.6	250	28	60	46	5.6	3.2	55	Max
Karnaphuli river	7.2	150	7.4	36	31	5.0	2.0	41.1	Avg.
near Dovashi Bazar	6.7	120	2.5	IS	12	3.8	c.7	26	Min.
Side of	8.4	-	-	-	58	1.4	2.9	104	Max.
Karnaphuli River	7.9	-	-	-	48.5	7.0	2.2	18.9	Avg.
near Patenga	7.6	-	-	-	23.0	6.5	1.6	39.5	Mm.
Acceptable value of the parameter in the case of use of the river for fishing	6.5 to 8.5	–	–	–	correct setting < 50.0	at least 7.0	correct setting <5.0	-	

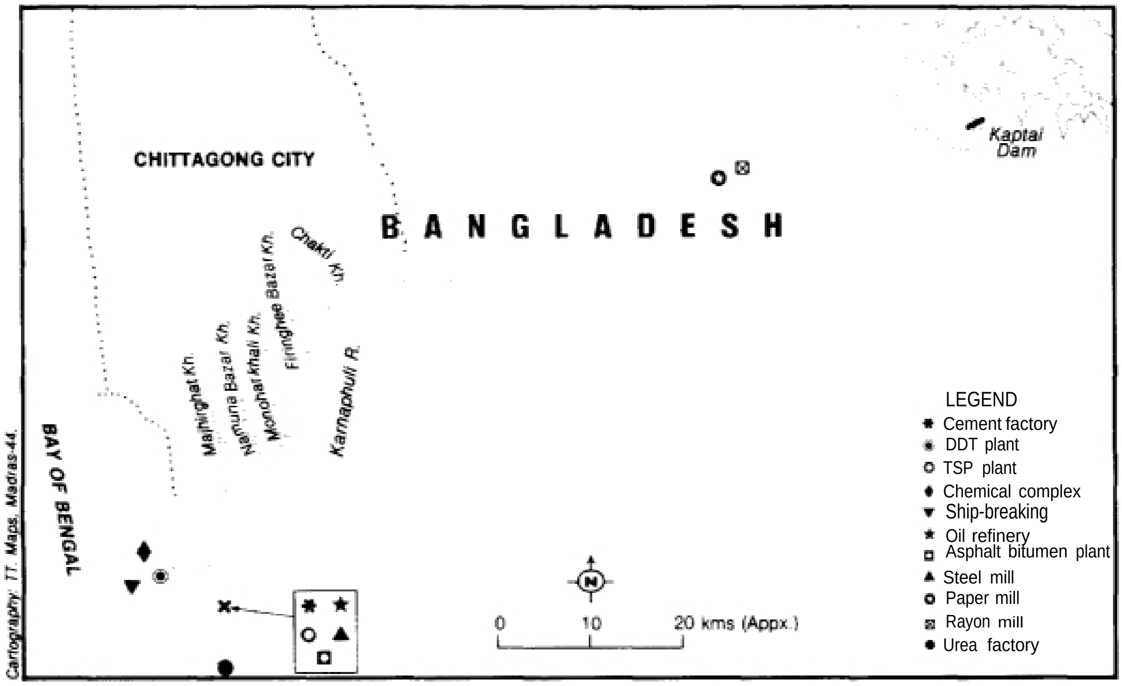
Note : The three figures for each parameter for each location indicate the maximum. average and minimum values found in the analysis of water samples,

Source : ESCAP (1988)

Although the BOD level in the river water is within the tolerance limit, the high BODs in industrial effluents cause localized pollution problems at discharge points. In fact, certain portions of the river, near outfall points at Kalurghat, Chandraghona and Patenga, are seriously polluted.

Liquid and solid wastes from tanneries at Kalurghat are dumped in the surrounding area and find their way through open drains to the Karnaphuli River, causing pollution of BOD levels 6,000 - 12,000 ppm for vegetable tanning wastes and 800-1,200 ppm for chrome-tanning wastes. Nearly 1,450m^3/h waste water containing sulphur compounds and mercury and reaching BOD levels of nearly 60 ppm are discharged continuously into the Karnaphuli River, causing a major localized water pollution problem in Chittagong (ESCAP, 1988). The river in this area (Figure 22) receives a large volume of paper and rayon mill wastes, including 0.35 t china clay and 4 t of cellulose fibre daily, besides such chemical effluents as mercury, acids, sulphate, alcohol etc. The mercury loss from the paper and rayon mills is reported to be to the tune of about 3,000 kg/year (Omar *et* a!., 1985). Mercury, acids, other chemicals, rock sulphate and phosphate from a chemical complex, a fertilizer plant and other industries, as well as lead from an oil refinery are also discharged directly into the Karnaphuli River, near Patenga.

Fig. 22. Enlarged view of the Karnaphuli River estuary showing location of the main sources of pollution on its banks.



Chromium from tanneries in Chittagong, cadmium from the city's dyeing, printing and paint industries, as well as arsenic compounds from the urea plant also enter the river and sea (see table alongside) Toxic effluents from the **DDT** plant at Barabkunda near Chittagong used to be drained into the Bay of Bengal until recently. The government, in fact, banned the production and use of DDT in February, 1992. The marine environment, however, has already accumulated substantial quantities of the toxic effluents from the plant.

Estimated amount of insoluble inorganics entering the water

insoluble inorganics	*Probable quantity discharged directly or indirectly into coastal waters in Chittagong*	*Conc. level in groundwater in Chittagong (ppm)*	*Conc. level in surface water and in Bay of Bengal (ppm)*	*Standard allowable concentration (ppm)*
Mercury	500 kgvear		0.05-0.27	001
Lead			0.5-21.8	0.025
Chromium			220	0.05
Arsenic compound			+ve	0.015
Cadmium			0.3.2.9	0.015
Si		I 9.12.12	—	
Al		0.53-2.32	—	—
Fe		0.97-3.42	2.62-5.6	0.3
Ca		3.20-25 2	5.2-23.2	—
Mg		00-70	6.57-10.36	125

Source: Department of Environment, Bangladesh (cited in ESCAP. 1988)

Although the industries in the Khulna region discharge huge quantities of untreated wastes into the Bhairab-Rupsa river system flowing into the Bay of Bengal, information regarding the pollution load in the river and the sea is very meagre. According to ESCAP (1988), however, a newsprint mill continuously discharges nearly 4,500 m^3/h of waste water containing high levels of suspended solids (300-500 mg/l) and sulphur compounds. It has also been estimated that suspended solids may amount to (70 x 50,000) kg/year. BOD data are not available, but it is assumed to stand at (0.05 x 50,000) kg/year for the factory's chemo-mechanical process.

29.4 Industrial pollution control measures

A systematic study on the overall impact of industrial pollutants on Bangladesh's aquatic life has not yet been carried out in the country. Nevertheless, it is obvious that huge amounts of toxic pollutants in its rivers and in the Bay of Bengal are threatening aquatic life, particularly fish. Many cases of localized but severe environmental problems, like fish kills, have been registered by the DOE, other institutions and by fisherfolk (Bhouyain, 1983).

Large-scale fish kills have been recorded in the Sitalakkhya and Meghna Rivers near two fertilizer factories. These fish mortalities are attributed to raw ammonia locally released into the water (IUCN, 1991a). The DOE has recored 200 ppm ammonia levels in the Sitalakkhya River, where fish mortalities have occurred. To maintain healthy water, levels should not exceed 2 ppm (Bhouyain, 1983). The harmful effects of the effluents from a urea factory in Chittagong on aquatic organisms, particularly plankton and fish, were studied by Hossain in 1992. He noted that if the high loads of ammonia, nitrite, nitrate, BOD and COD at the outfall in Karnaphuli River continued for any length of time, fish in this area might perish.

Until now, only a few industries have taken some pollution control initiatives for effluents treatment. They use simple neutralization and settling methods. Measures introduced in paper mills are only effluent dilution. The waste water from the pulp mills, containing wood fibre, neutral sulphites and waste alcohol from chemical plants, is mixed with 4,500 m^3 of turbine condenser cooling freshwater and is thrown into the Bhairab River during high and low tides in one instance. One urea factory has, however, taken limited steps to control ammonia discharges through lagooning (IUCN, 1991b). In the case of another factory on the Meghna River, while it claims to use modern ammonia control equipment, it also reportedly discharges highly ammonia-rich effluents during mechanical failures in the cleansing process. The latest addition to the fertilizer industry is a modern installation with a proper stream, but Hossain (1992), reports that the Karnaphuli estuary is, nevertheless, being polluted by its effluents.

It would seem that none of the treatment arrangements in these industries ensure adequate pollution control. Worse still, there are hundreds of other industries in the Chittagong and Khulna region that do not even have such poor arrangements; they discharge their untreated wastes directly into the Karnaphuli River, the Bhairab or the Bay of Bengal.

29.5 Municipal wastes

The cities and human settlements in the coastal areas of Bangladesh do not have domestic waste treatment facilities and, therefore, effluents either directly or indirectly find their way — untreated — into the rivers and, ultimately, into the Bay of Bengal. The two larger coastal cities, Chittagong and Khulna, are the greatest urban contaminators of the marine environment through municipal wastes, which are discharged into the Karnaphuli and Passur Rivers respectively. Although far from the coast, Dhaka, Bangladesh's capital, also makes a significant contribution in this regard. It produces huge amounts of domestic sewage and solid wastes which mainly enter the tidal river Buriganga flowing into the Bay of Bengal. Nationwide population pressure stretches the already inadequate sanitation facilities to their limit.

The problem is further exacerbated by the urban population explosion. In 1941, the urban population was 3.38 per cent of the total population, in 1981 it was 15.1 per cent of the population and numbered

13.5 million. It is expected that in the year 2000 it will be over 51 million (Rahman and Alam, 1985). According to the 1981 census, 45 per cent of the urban population live in Dhaka, Chittagong, Khulna and Rajshahi (Shirazi, 1991).

The polluting municipal wastes include raw and partially decomposed sewage, solid wastes, human excreta and remains of slaughtered animals. These contain such biodegradable items as kitchen waste, cartons, bones, the viscera of cattle and garbage from vegetable and fish markets, and non-biodegradable items like polythene bags, glass and tin containers. The results of chemical analysis of mixed refuse from Dhaka city are given in the table alongside.

Analysis of mixed refuse produced in Dhaka city

Constituents %	*Domestic refuse*	*Market waste*
Moisture content	45.30	53.60
Fixed residue	57.20	55.60
Carbon	22.60	25.70
Nitrogen	0.41	0.36
Phosphorus	0.05	–

Nole : Determination made on dry basis

Source: Ahmed (1985b)

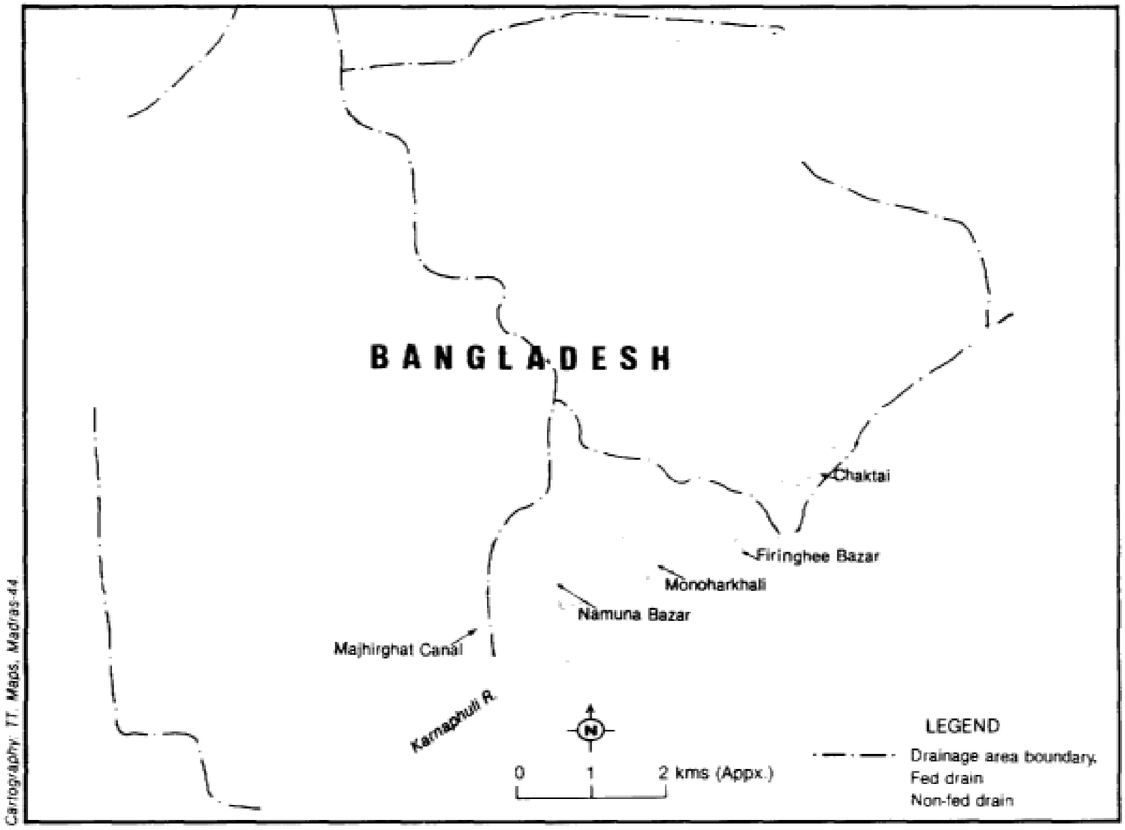
Garbage is managed by the city corporations in the four metropolises and sewage by the Water Supply and Sewerage Authority (WASA). Most of the sewage drains controlled by WASA are dug, open, earthen drains, irregularly cleared, except in Dhaka where there is a partially underground sewerage system and a limited sewage treatment facility. It is still common practice to dump excreta in drains and canals which flow into nearby rivers. Septic tank effluents are also dumped directly into rivers and canals, which thereby accumulate microbial pollution.

The municipal wastes from three cities are looked at a little more closely in the paragraphs that follow.

CHITTAGONG

Due to lack of proper waste collection and sanitation facilities, raw and partially decomposed sewage and solid wastes from all over the city find their way into the Karnaphuli River through five main canals, all open (see Figure 23). As the city has no underground sewerage pipeline or sewage treatment plant, its 473 miles of drains – mostly open – are connected to these five canals.

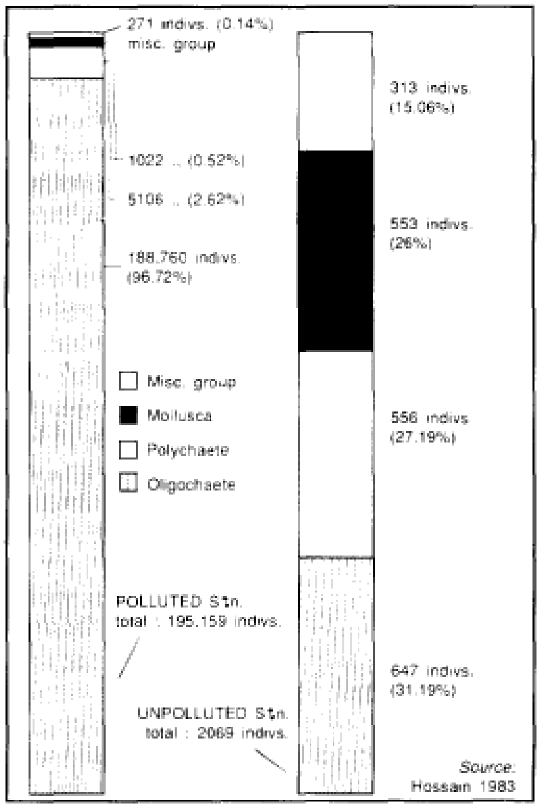
Fig 23 The Chittaqonq City Corporation drainage system, showing the five main sewerage canals



About 480 t of solid wastes are generated daily. adding to excreta of about 2.5 million people. The collected solid wastes are dumped in Halishahar and Firinghee Bazar, adjacent to the Karnaphuli River estuary, and directly enter the estuary, especially during the rainy season.

The city has about 50,000 sanitary latrines, 24,000 service latrines and three public toilets. The excreta collected by the municipal staff are stored in five large septic tanks for two months (Rahman and Chowdhury, 1988) and then discharged into the canals or the river. A large number of latrines are directly connected to the river. As a result, large quantities of *E. coli*, faecal *Streptococci* and other microbes are found in the river and estuary (Mohsin, 1979; Hakim *et al.*, 1981; Hossain, 1983). Hossain (1983), recorded as many as 18,000 coliforms/100 ml in the Karnaphuli River estuary near sewage disposal areas, which is very much higher than the standard safety levels (0/100 ml for drinking, <200/100 ml for bathing) recommended by the World Health Organisation (WHO, 1973). He also recorded an abundance of oligochaetes and other pollution-tolerant organisms (Figure 24) in sewage outfall areas, which clearly indicates the localized pollution in the estuary. The polluted stations held almost 200,000 individuals/rn3 while the unpolluted stations held only some 2000 individuals/rn3. Every day, a considerable amount of blood as well as the viscera of about four hundred slaughtered animals from the Firinghee Bazar and Dewan Hat slaughterhouses find their way into the Karnaphuli River (Rahman and Chowdhury, 1988).

Fig. 24. Annual (1982-83) abundance (indivs./m³) of macrobenthos under different taxonomic groups at two different areas of investigation in the Karnaphuli River estuary



A pollution study of the five canals was made by the Department of Environment's Chittagong Divisional Laboratory and revealed the results given in the table alongside.

D.O. and BOD in five canals of Chittagong metropolitan area

Name ofcanals	*DO. fmgi)*	*BOD (mg/l)*
Chaktai	0	180
Firinghee Bazar	0	24 - 264
Monoharkhali	1.1 -4.3	30- 184
Namuna Bazar	0.0- - 0.2	6 - 32
Majhirghat	0	60 - 280

Source DOE (Chittagong)

Pitch black waste water, with a virtually nil DO., high BOD and specific gravity, indicates the organic pollution and septic condition of the canals.

It is estimated that the total BOD load coming into the Karnaphuli River from Chittagong city is 3.5 t/day, and this may increase to over 5 t/day by the year 2000. The total load, including industrial sewage, reaching the Bay of Bengal is about 20 t/day (see table on page 96, top). Such loads can cause water pollution in the river and sea, particularly near drainage outfalls (ESCAP, 1988). It is noteworthy that the flow of the river varies from 11,200 m³/sec in the rainy season to as low as 113 m3/sec in the dry season. The latter is too low for the water to purify itself of all biodegradable wastes (ESCAP, 1988). As a consequence, pollution is more concentrated (less diluted) during the dry season. The poor aeration of a relatively stagnant water often fails to meet the biological oxygen demand of rapidly stabilizing waste. Deoxygenation beyond critical limits disrupts the balance between animal and plant life and causes changes in the physical, chemical and biological conditions of water. ESCAP (1988) reported that the fish catch in the Karnaphuli was diminishing year by year as a result of oxygen depletion due to this decomposition process.

Sewage from numerous cargo ships, tankers, fishing trawlers and other vessels in the Chittagong port area, and cargo sweepings dumped into the sea near the port, only add to the pollution of the city's waters.

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KHULNA

There are no sanitation and collection facilities for domestic waste in the Khulna city and Mongla port areas. The raw and decomposed sewage and human excreta from slum areas in Khulna and Mongla enter the Passur River and pollute it. Domestic and kitchen wastes from the city and from ships anchored in the port add to the degradation. The domestic waste load in the Khulna and Mongla port areas is estimated at approximately 2.2 t BOD/day (ESCAP, 1988).

DHAKA

Dhaka is the only city with an underground sewerage pipeline system connecting major parts of the city and leading to a sewage treatment plant at Pagla, a few kilometres from the city. This plant is being upgraded by the Japanese International Cooperation Agency (JICA), to increase its capacity. The World Bank plans a further increase in capacity (IUCN, 1991b). The present capacity, however, is 90,000 m^3/day, and this is not adequate for effective sewage treatment (Shiraji, 1991). It can only serve about 1.2 million people (Ahmed, 1985b), although the estimated population of Dhaka city is six million. The treatment method is also not based on sophisticated technology. As a result, the effluents from the treatment plant, containing high BOD and suspended solids, is discharged into Buriganga River. The average BOD of Dhaka city sewage is, in fact, around 180 mg/l (Ahmed, 1985b). The DOE monitoring also indicates zero D.O. and high BOD ranging between 50 and 150 mg/l in the Buriganga River (IUCN, 1991c).

The solid wastes produced daily in Dhaka varies from 1500 t in the dry season to 2000 t in the rainy season. These wastes are disposed of in open low-lying dumping sites, which funnel into the water systems, particularly during the rainy season.

The Buriganga River is a tidal river which flows by the side of the most densely populated part of the city. Waste is indiscriminately dumped in it by city dwellers and industries, and people liv ing on the river bank use fly latrines constructed on the river banks. As a result, the river is severely polluted. In the city, the human excreta pollution loads were estimated at 250 t/day in 1988, and this is expected to increase to 490 t /day by the year 2000 (Ahmed, 1988). Rahim et al. (1985) observed that the counts of faecal coliforms (FC) and faecal *Streptococci* (FS) in the Buriganga River ranged between 1.3×10^4 - 2.3×10^6 and 2.7×10^3/ - 3.1×10^5/100 ml respectively. The ratio of FC to FS, always above 4.0, indicates faecal pollution.

The strength of the river flow is considered sufficient to dilute the load through natural degradation, but in the dry season the dilution factor is reduced considerably and the capacity for self-purification is, thus, reduced. Ahmed (1985b) reported fish and other aquatic life mortality as a result of deoxygenation and the proliferation of toxic gases.

The faecal contamination of rivers, estuaries and the Bay of Bengal is considered one of the most pressing environmental challenges in Bangladesh, as it spreads various water-borne diseases to coastal inhabitants who use these polluted water for drinking, bathing and swimming. About 70 per cent of the total population of Bangladesh are reported to suffer from these diseases (WPCP, 1975). Ahmed (1979) claims that the rate of faecally-transmitted diseases in the country is the highest in the world.

29.6 Agricultural wastes

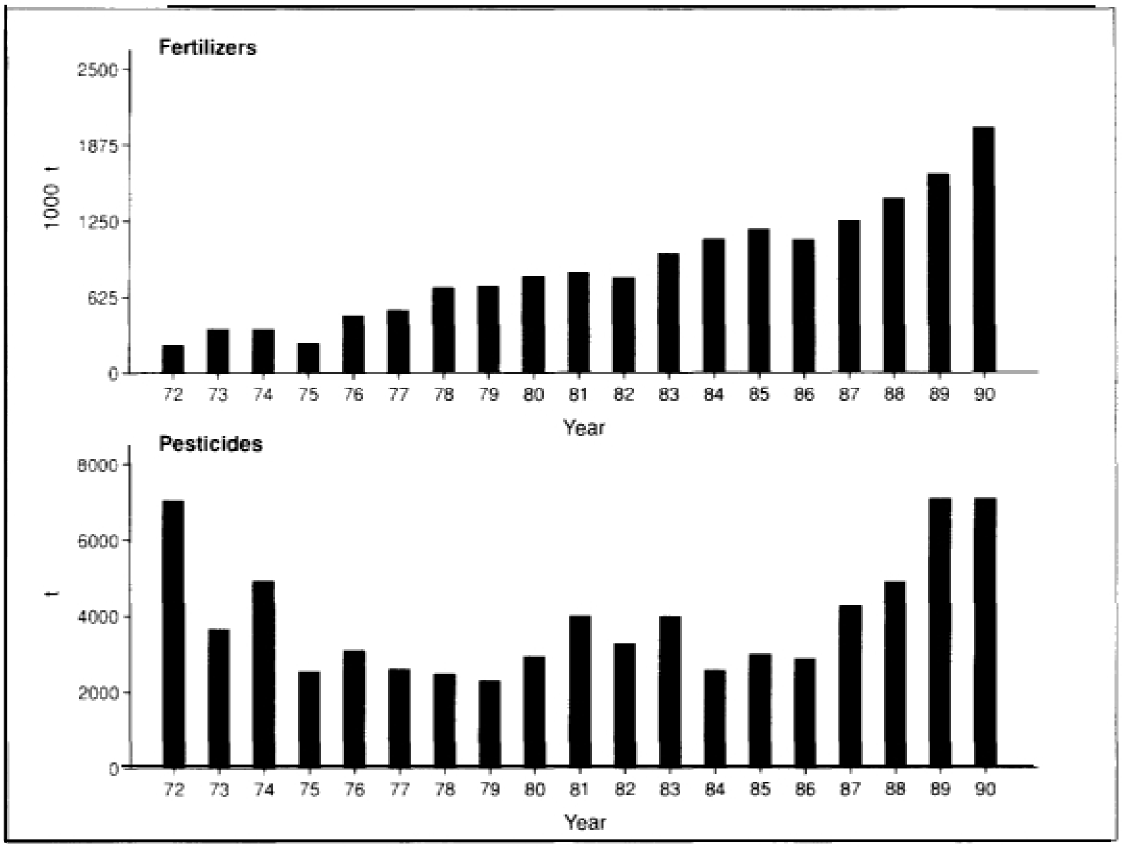
Bangladesh is an agricultural country and about two-thirds of the working population are engaged in agricultural production. Quite remarkable quantities of agrochemicals (pesticides and chemical fertilizers) are currently being used in Bangladesh throughout the year. Their use is practised without understanding the nature, behaviour and impact of many of these chemicals on the ecosystem.

Although pesticides are considered important to fulfil the ever-growing need for more food, their residues sadly have a deleterious impact on the environment. These chemicals come into contact with water every monsoon (May through September), as most of the agricultural lands are low-lying. The contaminated water finds its way into ponds, streams, rivers and, ultimately, into the Bay of Bengal. It is also thought that agrochemical pollutants are washed down from Nepal and India through shared rivers causing environmental damage in Bangladesh.

FERTILIZERS

Agrochemicals were first used on a significant scale in the agriculture and public health sectors *(e.g.* for malaria eradication) in the *1950s.* In the mid-1960s, high yielding varieties (HYVs) of rice were introduced, greatly increasing annually the use of chemical fertilizers and pesticides (Figure 25).

Fig. 25. Vearwise consumption of fertilizers and pesticides in Bangladesh.



Waste from fertilizer plants, as well as drainage and leachate from fertilized land, are the sources of nitrate and phosphate pollution, causing eutrophication in relatively stagnant rivers (Ahmed, *1985a).* The extent of nutrient pollution from leachate and drainage of agricultural land has not yet been evaluated through any systematic studies; nor is there any report of such pollution in the Bay of Bengal. However, according to the ESCAP (1988) report, the adverse effects of nitrate and phosphate pollution arising from the use of fertilizers may be considered insignificant in the face of the present need of increasing crop production.

PESTICIDES

Sarker (1992) states that there are *253* registered pesticides for agriculture and 85 for public health in the national market. Though the production and use of DDT is banned, it is still used in agriculture and mosquito control, even in dry fish preservation.

The DOE, with the help of Government's Plant Protection Department, has been trying to implement partial restriction on the use of insecticides in the country. Registration of eight harmful insecticides has so far been cancelled, and cancellation of a few more is under consideration.

Since pesticides are persistent chemicals, it is obvious that the offshore waters of Bangladesh receive their water-borne residues. But no systematic study has been carried out to assess the amount of residues in the run-off or in marine waters, and their impact on marine resources. However, it is assumed that 25 per cent of the total amount of pesticides used may reach the coastal water and cause pollution of seawater (ESCAP, 1988). On the basis of this assumption, an estimate of the pollution load in the Bay of Bengal, as a result of the use of pesticides all over the country, has been made by ESCAP (see table alongside).

During 1990-91, approximately 7200 t of pesticides were used in Bangladesh (Pesticide Association of Bangladesh, Pers. Commn.). Therefore, the pollution load in the Bay of Bengal, deriving from Bangladesh in the form of pesticide residues, may be as high as 1800 t/year.

Estimated amount of pesticides and other persistent organics used in agriculture in Bangladesh and probable pollution load in sea water

Persistent organics by type	*Sales of pesticides throughout the country, July 1984-June 1985* (t)	*Estimated amount received by coastal water through riser run-off* (t/yr)
Organomercurial fungicides	0.0	0.0
Halogenated hydrocarbons	40.6	10.5
Carbonates	891.8	223.0
Polychiorinated biphenyls	0.0	0.0
Organophosphorous	1991.3	498.1
Other toxic agrochemicals	74.3	18.6
DDT	1038.0	250.0
Total	4036.0	1000.2

Source: ESCAP, (1988)

Scientists world over agree that pesticides have numerous side-effects on both the environment and public health, and on fisheries in particular. Among the pesticides, organochiorides (OCs) are most toxic to fish and other aquatic organisms and among the OCs, dieldrin is about forty to fifty times as toxic as DDT. Aldrin is still more toxic and endrin is the most toxic of all, being about five times as poisonous as dieldrin. Most species of fish cannot survive in a concentration of insecticides greater than about one to ten ppb (Ahmed, 1985a). Both OC and OP (organophosphorus) insecticides can harm fish and other aquatic fauna in sublethal doses by damaging or destroying the organisms' physiology and food chain. In small concentrations, the OCs alter the physiology of fish reproduction (IUCN, 1991a). The OPs, however, are less toxic and more short-lived.

In Bangladesh, comprehensive studies on the effects of different insecticides and pesticides on various finfish species, shrimp etc. are yet to be undertaken.

Hossain, 1989, however, studied the contamination of different persistent ogranochlorine pollutants (DDT, DDE, DDD, heptachlor, lindane, dieldrin, aidrin, heptachlor-epoxide and PCBs) in three marine shrimp *(Penaeus indicus, Metapenaeus monoceros* and *Penaeus monodon)* and four finfish species *(Hilsa ilisha, Coilia dussumerii, Johnius bekzngerii* **and** *Pampus chinensis)* in the Bay of Bengal off the coast of Bangladesh. Results show that contamination by sum-DDT, heptachlor and lindane is higher in all the species than by dieldrin, aldrin and heptachlor-epoxide (see table below and overleaf top).

Comparison of the PCBs, pesticides and mercury levels in different marine samples from Bangladesh. Muscle nanogram/g dry weight (DW: dry weight; PCBs: as sum of congeners) (IU PAC nr, 28, 52, 101. 118, 153, 138, 189)

	Habitat	No. of samples	% DW	lipid DW	PCB	Sum. DDT	Lindane	Hepta-chlor	Hepta-chlor eposide	Aldrin	Dieldrin	Hg
Penaeus indicus (Shrimp)	Estuary	10	24.5	52.4	134	424	29	127	14	9	15	251
Meta-penaeus monoceros (Shrimp)	Estuary Coast	10	27.5	33.5	81	66	22	75	32	5	6	192
Pertaeus monodon (Shrimp)	Deep sea	10	50.5	35.6	16	68	6	26	3	2	0	67
Hilsa ilisha (Fish)	River & Estuary	10	39.5	254.3	20	307	65	394	ND	11	0	80
Coilia dussu-merii (Fish)	Coast & Open sea	10	18.0	50.3	113	138	31	90	15	24	0	178
Johnius belan-geru (Fish)	Coast & Open sea	10	280	36.0	327	84	29	105	6	35	6	96
Pam*pus chinensis* (Fish)	Open sea	10	22.0	330	00	68	19	36	9	11	6	201

ND = Not detected

Source: Hossain (1989)

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Comparison of the PCBs, pesticides and mercury levels in different marine samples from Bangladesh Muscle microgram/g lipid weight: (PCBs: as sum of congeners) (IUPAC nr, 28, 52, 101, 118, 153, 138, 189)

Species	Habitat	No. of samples	PCB	Sum-DDT	Lindane	Hepta chlor	Hepta chlor epoxide	Aldrin	Dieldrin	HG
Penaeus indicus (Shrimp)	Estuary	10	2.56	0.09	0.55	2.42	0.95	0.17	0.18	4.01
Metapenaeus monoceros (Shrimp)	Estuary Coastal	0	2.40	1.96	0.65	2.23	0.267	0.15	0.29	15.70
Penaeus monodon (Shrimp)	Deep sea	10	0.45	1.63	0.14	0.70	0.085	0.065	0.00	1.09
Hilsa ilisha (Fish)	Riser & Estuary	10	—	—	—	—	—			
Coilia dussumerii (Fish)	Coast & Open sea	10	0.79	1.21	0.25	1.55	0.00	0.043	0.00	0.3!
Johnius belangerii (Fish)	Coast & Open sea	6	2.25	2.74	0.62	3.77	0.06	0.047	0.00	3.54
Pampus chinensis (Fish)	Open sea	7	9.00	2.33	0.8!	2.9!	0.311	0.97	0.10	2.67

Source: Hossain (1989)

It was generally found that the estuarine species were more contaminated than the coast or open sea species. It would seem that the location could be the most important factor in explaining the differences in contamination, reflecting the inland origin of pollution.

The percentage distribution of DDT and its metabolites DDE and DDD in shrimp species (see table alongside) shows higher percentage (%) of DDT, with a mean value of 57 per cent compared to total DDT. The presence of such a high percentage of **DDT** in biota also indicates this substance is still used in the country and it enters the aquatic environment by inundation and other processes, possibly influencing the aquatic fauna (Hossain, 1989). Although he did not study the toxic effects on various species, it is known that accumulation of such organochlorine in fish as well as other organisms, through food chains, has a deleterious impact on their physiology and biological processes.

Comparison of the relative amount of DDT and its metabolites (DDE, DDD) in marine shrimp

Species	% DDT/ sum-DDT	**% DDE/** sum-DDT	**% DDD/** sum-DDT
Penaeus indicus (White Shrimp)	62	5	35
Metapenaeus/monoceros (Brown Shrimp)	34	46	23
Penaeus monodon (Tiger Shrimp)	74	4	20

Source: Hossain (1989)

A few studies on the toxic effects of pesticides on some freshwater fish species have been carried out in Bangladesh. Kabir and Begum (1978) observed harmful effects of Diazinon on *Heteropneustesfossilis.* Kabir and Ahmed (1979) observed that Paden(an organophosphorus chemical) affects the fish *Anabas testudineus* even within the recommended field dose. They also concluded that Furadan and Basudin (insecticides commonly used in Bangladesh), though apparently harmless in recommended dosages, can affect the fish if the doses are exceeded. Cymbush, commonly known as cypermethrin, has been found to be lethal to the Snakehead *(Channapunctata)* at concentrations above 0.2 ppm (Al-arabi *et al.*, in press). Significant histological changes in gills, liver, stomach, intestine, skin etc. in freshwater carp have been recorded by FRI, (1991), after use of Diazinon and Basudin. **FRI has suggested that** the use of these two pesticides be restricted and that of Dimecron be encouraged in paddy-cum-fish/shrimp farming, which is practised in the southern part of the country.

29.7 *Oil pollution*

Pollution by oil spills and oily substances is also a potential threat to the marine environment of the country. Localized oil pollution is said to he heavy in the vicinity of the Chittagong and Mongla (near Khulna) port areas, which are centres for tanker traffic and transshipment operations.

Apart from the port areas, pollution is caused by seagoing vessels that pass through the Passur River for a distance of about one hundred km *via* the Sundarbans to and from Mongla Port. There have also been persistent reports of oil slicks in the territorial waters of the country and the upper Bay of Bengal (ESCAP, 1988).

Chronic oil pollution results from crude oil transportation systems, ballastwater, bilgewater and oil slicks from mechanized vessels, workshops, refinery residue discharges and overflows. More than 50 per cent of the oil pollution in the marine environment derives from urban activities and through river runoffs. One of the world's two largest oil tanker routes, which passes through the southern Bay of Bengal to the Far East (ESCAP, 1988), also contributes to the oil pollution in the coastal and marine environment of Bangladesh. Besides port pollution levels continuously rising, accidental oil spillages from oil tankers cause probable damage to mangrove forests and other marine and coastal resources.

Nearly 1200 ships and forty to fifty tankers in Chittagong Port, and nearly 600 ships in Mongla Port are handled annually (Majumder, 1992). Approximately 1.2 million t of crude oil and 5 million of refined oil are handled in Chittagong. Due to draught restrictions in the harbour, large tankers of 100,000 DWT transfer the contents offshore to smaller tankers of 19,000 DWT, which, in turn, ship the oil in to storage tanks onshore. There are six petroleum product terminals in Chittagong, all of which are capable of loading into smaller tankers as well as accepting products from larger tankers (ESCAP, 1988). At all transfer points, spillage takes place. Oil discharges due to dripping from damaged flexible hoses, overfilled sumps and deteriorated packing in flanges all contribute to chronic oil pollution within the harbour.

Crude oil residue and other oily effluents from the oil refinery at Chittagong, as well as oil - water emulsion from the repairing and manufacturing industries situated near the coastal areas enter the Karnaphuli estuary. As a result, an oil slick settles on the surface water of the estuary around the port, turning the surface water black and making the grasses and objects in the intertidal zone black, sticky and tarry (Islam and Hossain, 1986). During a year-long observation, Paul, (1981), recorded 2.0-32.08 g/litre (mean 10.62 g/litre) of oil in the polluted parts of the Karnaphuli River estuary.

Transport of refined petroleum products from Chittagong Port to Mongla Port, to oil depots at Doulatpur, Khulna and in other parts of the country is carried out using a fleet of 32 inland water tankers of average capacity 1000 DWT. Oil spillage occurs regularly during oil transfer from these tankers to receiving stations. Fuel oil spillage and the discharge of oil and oily waste water (bilgewater) from foreign vessels have also frequently been reported in Mongla Port and the Passur River (ESCAP, 1988).

Ballast- and bilgewaters from tankers and other ships anchored in ports should only be emptied in special coastal installations where the oil can be separated and recycled. This is obligatory in many countries, but Chittagong and Mongla do not have such facilities and the ships directly discharge these waste oil - water mixtures into the waters of Bangladesh.

Shipbreaking units in Chittagong and Khulna are also responsible for this type of pollution. The bottom sludges of residual heavy oil in the oil tanker chambers, lubricants and engine oils from condemned tankers and ships constitute a considerable amount of oil spillage during washing and dismantling operations. This discharge has, in fact, been the cause of severe seawater pollution and has contributed towards the destruction of many amenities in the nearby beaches.

Owing to the lack of surveillance facilities, no assessment of the extent of port pollution has been possible, but a rough estimate of the amounts of oil and oily substances entering the sea in the Chittagong area is given in the table alongside.

Oil and oily substances in the Chittagong area

Oil and oil-emulsion source	*Estimated amount of discharge*
Chronic spillage of crude oil during transportation operations at Chittagong port	6,000 t /vear
Baltastwaters	Not known
Bilgewaters	11, 000 m³/year
Leakage, toss of fuel o/l from mechanized vessels dry docks, fish harbours, etc.	Not known
Oil emulsion from workshop	Not known
Crude oil residue, processed oil and washwater from refinery	50,000 t year
Refuse oil from shipbreaking activities at Fauzdarhat	400 kg year

Assuming 0.5 per cent transportation toss during crude oil trans/er at Chittagong port

Source: ESCAP (1988)

Moreover, numerous mechanized boats, river craft, fishing trawlers, passenger launches and steamers plying along the waterways of the country discharge waste oil, spillage and bilge washings.

Severe accidental oil spillage due to extreme natural calamities, tank leakages and other causes is a constant danger in Bangladesh. Bangladesh's 1991 cyclone is a case in point. With maximum wind velocity of 235-240 km/h and tidal surges six to ten metres high, eighteen vessels sank in the Chittagong port area and many other boats, trawlers, barges and other vessels sank in channels and coastal areas. Besides being a threat to safe navigation, these sunken vessels also threaten surrounding areas with spillage and contamination through toxic materials

(BCAS, 1991). In the last few years, two severe oil spillages occurred accidentally in the Bay of Bengal within Bangladeshi territorial waters. The m.t. *Filoti* deposited as much as 2200-3000 t of crude oil near Katub Island (Talukder, 1992: Majumder, 1992) in 1989, while the t.t. *Energy* discharged unknown quantities of oil in the same area in 1992. This caused an oil slick for about 64 kms along Khulna's mangrove area (Anon, 1992 a). Both incidents undoubtedly had a negative impact on the coastal mangrove forest and marine resources. It is estimated, that accidental oil spillage, oil slicks, ballast, bilgewater discharges and the like will increase four-fold by the year 2000 if adequate surveillance and control measures are not taken up immediately (ESCAP, 1988).

Oil pollution clearly damages the mangrove ecosystem as well as other coastal and marine resources. Spills cause defoliation and mortality to mangroves, river breeding grounds and nurseries of both marine fish and crustaceans in mangrove swamps. The pneumatophores (breathing roots) of the trees become covered by oil and tar resulting in defoliation and death. With the acceleration in port activities in Bangladesh and consequent increase of accidental oil spills, the mangrove ecosystem may be irreversibly damaged.

Oil pollution affects coastal and marine fisheries both quantitatively and qualitatively and reduces the productivity of fish stocks. Qualitative deterioration also reduces the nutritional value of fish. The thin layer of oil on the water surface hampers light penetration and air-sea gas interaction, affecting the multiplication of planktonic food organisms. Paul (1981), observed a greatly reduced phytoplankton population in the oil-polluted area of the Karnaphuli River estuary. This could effect physiology of marine fish living on planktonic organisms and interfere with growth and reproduction. Fish can also absorb oil directly with their feeding, resulting in the tainting of fish tissue. Also, the aromatic hydrocarbons present in crude oil are persistent and carcinogenic. Since they have a tendency to be biologically accumulated in fish tissues, they can pass in to organisms of higher trophic levels in the food chain.

There is no systematic study assessing the impacts of oil pollution on mangrove forest and marine fisheries, but fish mortalities due to oil spillage have occasionally been reported both in the press and by fishermen, particularly after the mt. *Filoti* and t.t. *Energy* incidents (Anon, 1992a; Anon 1992b; Majumder, 1992, Talukder, 1992). Fishermen have noticed the sudden decline of fish catches in the affected area, probably due to fish migration from the contaminated fishing ground.

It is reported, in fact, that, since 1976, Bangladesh has sustained a loss to its fishery of over US $ 100 million, owing to 1,440,000 m^3 of timber loss caused by the death of mangroves alone (ESCAP, 1988). Oil pollution is perhaps one of the factors responsible for this loss.

29.8 *Shipbreaking operations*

Shipbreaking operations in Bangladesh began in 1969 and have increased after 1980 to meet the growing demand for scrap as raw material for re-rolling mills and other purposes. There are, today, about 150 entrepreneurs engaged in this business (Islam and Hossain, 1986). They buy damaged stock and obsolete seagoing ships and oil tankers abroad and dismantle them on the seashore from Kumira to Fouzdarhat in Chittagong and near Mongla Port at Khulna. These operations pollute the coastal soil and water through the discharge of various refuse materials, metal fragments and oil from the scavenged ships.

According to Islam and Hossain (1986), rust from the scrap iron enters the soil and sea water. The possible effects of shipbreaking activities on the soil and seawater environment in the Chittagong coast are cited in the tables below. A concentration of ammonia toxic for marine organisms was

Physicochemical properties of beach soil (A) **and seawater (B) within and outside the shipbreaking area of the Chittagong coast**

A	Sampling stations 1A*	*2A*	*3A*	*4A*	*5B***	*6B*
Accumulation of metal fragments (cm depth)	.0	0.7	1.2	0.6	—	—
pH	8.4	8.!	8.3	8.4	7.4	7.3
EC (micromhos/cm)	324	296.0	360.0	302.0	500.0	508.0
Chloride (mg/l)	113.0	110.0	116.0	119.0	202.0	213.0
Iron (mg/l)	2.0	1.8	2.1	1.6	0.6	0.6
Ammonia (mg/l)	16.1	20.!	21.1	17.2	1.0	0.9

Note : *A Stations within shipbreaking area

**B : Stations outside shipbreaking area

Source for these two tables : Islam and flotsam, 1986

B	*Sampling Stations* IA*	2A	3A	4A	*5B***	*6B*
Turbidity (JTU)	720	690	708	723	475	470
Total solids *(mg/l)*	4195	3678	4186	4038	2335	2284
Total dissolved solids (mg/l)	1990	1860	1906	1982	1320	1288
pH	7.8	7.7	7.9	7.7	7.3	7.2
EC (micromhoscm)	1600	1860	1842	1710	3040	3036
Chloride (mg/l)	470	478	460	502	785	789
Iron (mg/l)	36.0	40.1	41.3	37.6	2.8	2.3
Ammonia (mg/l)	2.7	3.1	3.2	2.9	0.2	0.3
DO (mg/l)	4.10	3.7	3.8	3.90	6.2	6.4
BOD (mg/l)	7.6	7.8	7.9	7.00	4.3	4.1
Oil (mg/l)	10600	10340	10800	9280	—	—

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found in both beach soil and seawater with an increase in pH. The accumulation of metal fragments was found 1.2 cm deep in the soil of the affected area. Iron contents were high and thin layers of burned oil and other lubricants prevailed in both soil and water. Extensive human activities in the affected area accelerated the rate of seashore erosion and has resulted in higher seawater turbidity. Critical concentration of D.O. and higher BOD were also found with an abundance of floating materials (grease balls and oil films) in the seawater.

Pollution due to oil spillage, stranded metallic fragments, refuse materials, iron corrosion etc. have affected recreational beaches, clearly hindering tourism. We know that oil spillage may cause serious damage to fish by reducing the light intensity underneath an oil layer, inhibiting photosynthesis and reducing the exchange of oxygen and carbon dioxide across the air-sea interface, as well as by acute toxicity. The growth and abundance of marine organisms is also probably affected significantly by the high ammonia content.

The government has now marked specific areas for shipbreaking operations in Chittagong and Khulna

29.9 Plastic products

The ubiquitous use of nonbiodegradable plastic carrybags has become an environmental hazard in Bangladesh. This began in the 1980s and has increased dramatically in recent years. In Dhaka city alone there are nearly fifty plastic factories which produce about 7 to 7.5 million polythene bags daily (Ibrahim, 1992). After use, bags are discarded everywhere. Besides plastic bags, other plastic products like bottles, bowls, ropes, nets, PVC, packaging items, disposable injection syringes and other items are also widely used and not properly recycled.

Plastic products are nonbiodegradable and depositing them in urban canals and sewerage drains has caused a serious environmental problem — drain jamming. Passing through other drainage systems, they enter rivers and pass into sea waters. The DOE (1990), has stated that plastic is as harmful to marine organisms as oil spillage and toxic materials.

30. NATURAL DISASTERS

Bangladesh's physiography, morphology and other natural conditions have made her vulnerable to natural disasters and environmental hazards. Cyclonic storms and floods occur often, causing immense suffering and damage. For example, the economic loss caused by the 1991 cyclone was of the order of 60 billion Taka* and that of the 1988 flood about 50 billion (Pramanik, 1991).

Cyclonic storms, often accompanied by torrential rains and devastating tidal surges, cause havoc to lives and property in the cyclone path, usually in the offshore islands and coastal areas in Bangladesh. Loss of human and animal lives, inundation of land and ponds by saline water and the submersion of industrial and motorized equipment, all create an environmental hazard and cause a sudden change in the ecosystem, which takes a long time to recover.

The storms usually form in the southeast part of the Bay of Bengal, move in a northerly or northwesterly direction and often turn northeasterly or easterly towards the east coast of the country. The tropical cyclone forms during the pre-monsoon (March-May) and the post-monsoon (October-November) seasons, while the monsoon depression develops during the Southwest Monsoon season (June-September), (ESCAP, 1988). The tropical cyclones are the more dangerous, having wind speeds up to 240 kph. The most destructive element is the tidal surge which reaches 3-20 metres in height. Over 40 damaging cyclones have been reported in the Bangladesh coastal area from 1973 to April 1991.

Most freshwater ponds, canals and ditches etc. are inundated by saline water during cyclones, resulting in the loss of all freshwater fish. Decomposing human and animal carcasses cause air and water pollution. The rains also carry decomposed materials into pond and channel waters, which get so polluted that any sort of organism would find it hard to survive. In some swamps, marine shrimps ***(Penaeus monodon, P. indicus, Metapenaeus monoceros)*** and fish of the Gobidae family have been found after a cyclone (BCAS, 1991).

* US $ 1 = 30 Taka (appx.)

In the 1991 cyclone, thousands of fishermen lost their lives. Seventy per cent of the boats and nets in the country were lost and the calamity washed away shrimp culture ponds, prawn hatcheries, embankments and infrastructure of projects, totalling 3 billion Taka (BCAS, 1991).

Besides the devastating cyclones and tidal bores, the combination of monsoon rain and the enormous water run-off from the Himalayan drainage system, passing through the Ganges-Brahamaputra-Meghna river system, ravages central or northern Bangladesh, causing floods in parts of the coastal region. And environmental degradation follows such floods.

31. SILTATION

Siltation is one of the most striking oceanographic features of the northern Bay of Bengal. Sedimentary processes may, in fact, influence the estuarine and nearshore fishery ecology of the waters of Bangladesh.

Denudation of the Himalaya has resulted in the formation of the world's largest delta which is still active, growing at a rate of about seventy cms every thousand years (Curray and Moore, 1971; Biswash, 1978). The Ganges-Brahamaputra river system brings this sediment down and drains it into the Bay of Bengal. The Meghna system seems to filter the sediment while passing through the depressions *(haors)* of the Sylhet basin and, therefore, contributes less to the process. A total of six million m^3/s of water carrying an estimated 2,179 million t of sediment is carried down to the sea each year by the Ganges-Brahmaputra river system (Curay and Moore, 1971).

Other major sources of siltation in the region are due to the increased run-off during the rainy season as well as floods and the increased erosion of topsoil as a result of coastal inland vegetation depletion. Massive earthworks in coastal development projects and possibly also rapid horizontal expansion of other land-use practices (e.g. aquaculture), affect the natural siltation process of the inshore and estuarine habitats. Mass scale flattening and hill scarping in the Chittagong region, for instance, must have changed the sedimentary process of the area in the recent years.

The accretion-erosion process of islands like Hatia, Sandwip and Bhola indicate a strong sedimentary process in the vast Ganges-Brahamaputra-Meghna estuary, which constitutes about 12,800 km2 of in-shore fish habitat (West, 1973). Erosion in the islands has been increasing in the past few decades. Sandwip has lost over 72 km^2 between 1953 and 1982, as compared to 190 km^2 in the last two centuries. Hatia, which increased to about 1070 km^2 from 307 km^2 between 1779 and 1945, lost 700 km^2 of accreted land by 1979 (within a period of 34 years only) (Mirza and Shahjahan, 1987). Huge rates of accretion in the past indicate an extensive amount of deposit carried down by the rivers; likewise, increased erosion in recent years must be translated in terms of heightened sediment transfers out to sea.

A case study presents an average annual deposition of 192,244 m^3 of sediment in the Karnaphuli estuary during 1987-1990 (Sharif, 1992). During the southwest monsoon, the total suspended material in this river was found to vary from 0.09 g/l on the surface to 0.24 g/l at the bottom, with a maximum concentration of 1.43 g/l at selected stations (Quader, 1976). Other major rivers may portray a similar picture. Reduced navigability of inland and coastal watercourses, as well as drainage congestion, also feature in this scenario.

Siltation may have the following impacts on fisheries:

HABITAT DEGRADATION

Due to heavy siltation in the nearshore regions, a continual alteration in the habitat, especially to the bottom topography, occurs. Extensive erosion rates in Hatia, Sandwip, Bhola and Noakhali in the past few decades must have indeed transformed bottom conditions. This may, in turn, have substantial effects on the fish community, particularly demersal stocks.

TURBIDITY

Increased turbidity, as a result of higher erosion and upland load levels, has effected habitat productivity directly. Photosynthetic rates decrease with impaired sunlight penetration caused by increasing turbidity. The 'turbidite wedge' reaches far out to sea during the rainy season. Fine silt, when it clings to the gills of fish, may also affect their normal respiratory process.

As they approach the estuary, sediment particles trap different pollutants, and ‘flocculation’ causes them to settle onto the bed. The concentration of heavy metals, for instance, in the bed sediment of the Karnaphuli estuary was reported by Sikder (1991). Quader (1976), examined in the same area the long-term impact of silt, as a contaminant, on *Apocryptes* bato (Perciformes, Gobiidae). According to these reports, the demersal stock is most likely to be adversely affected.

32. CLIMATE CHANGE AND SEA LEVEL RISE

Over the past century there have been clear indications of climatic disruptions all over the globe due to the greenhouse effect. An anticipated sea level rise due to increasing temperatures is likely to destroy much of the world’s coastal area if no preventive measure is taken.

Information regarding the extent of sea level rise in Bangladesh is meagre. However, in a recent study, Mahmood *et al.* (unpublished), detected a trend of sea level increase of 5.18 mm/year in the southwestern Khulna region of the country. This is, however, attributed to a rapid rate of land subsidence. A follow-up study predicted a rise of 85 cm in this region by the year 2050 (Mahmood and Chowdhury, unpublished). The Woods Hole Oceanographic Institution’s (WHOI) prediction in 1986 of sea level figures (by 2050 and 2100) are shown alongside.

	Average scenario		Worst *scenario*	
	2050	2100	2050	2100
Total relative sea level rise (cm)	83	340	153	460
Absolute sea level rise (cm)	13	200	13	220
Land subsidence (cm)	70	70	140	240
Shoreline erosion (km)	1	2	1.5	3
Loss of habitable land (%)	1	26	16	34
Population displaced (%)	7	30	13	40
Reduction of mangrove areas (%)	50	75	79	95

Source : Woods Hole Oceanographic Institution, 1986

Various aspects of the greenhouse effect on, and sea level rise in, Bangladesh have been documented (Broadus *et al.,* 1986; ESCAP, 1988; Brammer, 1989; Commonwealth Secretariat, 1989; Milliman *et al.,* 1989; Nishat, 1989; Rahman and Huq, 1989; Rashid, 1989 and Broadus, in press).

Climatic change and future sea level rises only have indirect implications for the marine fisheries. These are discussed in the paragraphs that follow.

CHANGE IN CURRENT AND WATER MOVEMENT

As a result of sea level rise, water characteristics, like temperature and density etc., are likely to be affected, and atmospheric alterations, like shifts in circulatory pattern, are likely to occur. Waves will be stronger, the courses and speed of important world ocean currents will be altered. How pronounced thesechanges will be, however, is not yet clear. Bakun (1990) expects an intensification of coastal upwelling as a result of future climatic change, whereas, Gucinski *et al.* (1990) anticipates the reverse.

LOSS OF COASTAL/TIDAL MARSHES

In Bangladesh, the disappearance of tidal marshes and mangrove swamps will have adverse effects on the local fishery. WHOI (1986), predicted a 50-70 per cent mangrove forest depletion by 2050 and a 79-95 per cent depletion by 2100. It is well known that these tidally inundated lowlands and marshes serve as important breeding and nursery grounds for fish and shrimp, supplying invaluable nutrients.

CHANGE IN PRECIPITATION AND RUN-OFF

Heightened evaporation due to temperature rises will increase precipitation worldwide. The associated growth of run-off, sedimentation and salinity-decrease may, indeed, harm the coastal fishery of the Bay of Bengal.

33. EDUCATION AND RESEARCH

Education and research on the marine environment are inadequate in Bangladesh. This is due not only to the scarcity of higher educational institutions and research organizations, but also to poor facilities, lack of skilled manpower and an absence of forceful programmes in the existing institutions.

Until recently, resource exploitation and biota were the only focal points. Concern about the environment was practically nonexistent. With a global awareness of environmental matters growing, there is in Bangladesh an increasing national emphasis on environmentally sound development. Government, universities, research organizations and NGOs have all embarked on academic and research programmes to study environmental pollution and protection as well as examine environmental impact assessments and related issues.

But initiatives for coastal and marine environmental studies are few. The Institute of Marine Sciences (IMS), at the University of Chittagong, is the only place which awards a degree in marine sciences. The University of Khulna has recently established a department focusing on education and research in Marine Biology. The BUET (Bangladesh University of Engineering and Technology) provides limited courses in coastal engineering. The formation of a national institute primarily concerned with oceanographic research and marine environmental problems is still in the planning stage.

Because of a lack of sea-going facilities at the IMS, University of Chittagong, and because they happen to coincide with Bangladesh's current needs, Estuarine Ecology, Fisheries Biology and Coastal Aquaculture have been the major focus of both academic and research programmes there. Water pollution studies have been recently initiated, focusing mainly on the impact of industrial and domestic wastes on the water quality and the habitat. Some milestone studies have been undertaken on the following :

- Oil pollution from ships in and around Chittagong port.
- Heavy metal concentration in some commercially important shell and finfish in the Karnaphuli River Estuary.
- Monitoring of effluents discharged by the KPM and KRC and their effect on biota,. with special reference to plankton and fish in the Karnaphuli River.
- Deposition of iron in the shorebed at Faujdar Hat (Shipbreaking Zone).
- The sea level rise on the Bangladesh coast.

IMS has also conducted some interesting studies on environmental problems such as the irrational expansion of shrimp farming and shrimp seed collection in the coastal estuarine waters which threaten both the marine fisheries and the mangrove ecosystem (Mahmood, 1990a; Alam 1990; Mahmood, 1991b).

The chemistry of different types of wastes, their behaviour in water, toxicology and control measures are still virtually unknown. The DOE has four small laboratories, each equipped with a spectrophotometer, used for the analysis and monitoring of certain water qualities and for microbiological examinations. Until recently, there was no pesticide residue analysis laboratory in the country and, hence, no effort was made to study the nature and magnitude of environmental problems arising from pesticide residues in Bangladesh. In a newly developed pesticide laboratory at the Bangladesh Atomic Energy Commission (BAEC), identification and monitoring of the magnitude of toxic residues in food items, including fish, and in the environment, have been initiated. The laboratory uses the microanalytical procedures of gas chromatography (ECD and FPD Modes), high performance liquid chromatography and other relevant techniquess (Matin, 1992). This facility is currently being used by the DOE and other organizations for residue monitoring in water and fish. The International Centre for Diarrhoea1 Disease Research (ICDDRB), Bangladesh, has a laboratory equipped with several facilties to detect microbiological pollution and analyze the physicochemical properties of water.

3 3.1 *Current programmes*

Bangladesh's recurring floods and cyclones as well as worldwide concern about environmental issues have led to greater concern in Bangladesh for improving environmental management in the country. Government, international agencies, donors and NGOs have all undertaken or proposed a wide range of programmes and projects relating to the environment as a whole and on deforestation, health and sanitation, water management, flood control, urban problems, probable sea level rise and its impact, inland fisheries, coastal rehabilitation, institutional strengthening etc. in particular.

However, programmes aimed at coastal and marine environment protection are still few and far between. The DOE has, nevertheless, proposed for approval by government the following projects, either directly or indirectly related to the marine environment :

- Procurement of an environmental laboratory ship for environmental monitoring and surveillance of the coastal area of the country.
- A detailed environmental study (river basin study) and preparation of an action plan to clean the Buriganga, Sitalakkhya, Karnaphuli and Rupsa Rivers.
- A pilot study on residual biocides and their effect on aquatic flora and fauna.
- A Regional Environmental Development Plan (REDP) for Chittagong Metropolitan City.
- Development of the National Industrial Environmental Siting Plan and Guidelines.
- Development in Bangladesh of industrial pollution control technology.
- Technical assistance from government for industrial pollution control management.
- Technical assistance from government for control of toxic chemicals and hazardous waste and in implementing safety measures for their handling.

The UNEP has been active in addressing marine and coastal environment problems, and has been instrumental in mooting a South Asian Seas Action Plan, which is currently under consideration. The Economic and Special Commission for Asia and Pacific (ESCAP) has also produced a report entitled 'Coastal Environmental Management Plan for Bangladesh' (ESCAP, 1988).

Projects have been undertaken for coastal rehabilitation and mangrove replantation by the Asian Development Bank (ADB) and IDA respectively. A three-year ADB-funded technical assistance project entitled 'National Environmental Monitoring and Pollution Control Project' is underway. Under this project, national environmental planning, assessment and monitoring capacity are being enhanced through the institutional strengthening of the DOE. The ADB is also financing another project which will strengthen the DOE infrastructure and laboratory facilities, enabling assessment and monitoring of national marine pollution.

The Flood Action Plan (FAP) aims at flood control in Bangladesh and has evolved an approach of sustainable development to provide, through effective water management, a more secure environment for agriculture, fisheries and integrated rural and urban development. Under this programme, the ODA-UK has undertaken a study on the impact of the FAP on fisheries, including the migratory patterns of marine fish. The World Bank too has been taking greater interest in environmental matters, including flood control and its impact on fisheries and coastal deforestation.

34. CONCLUSIONS AND RECOMMENDATIONS

Despite a limited area – 144,045 km² – and a population over 110 million, Bangladesh has not hitherto paid adequate attention to environmental degradation and pollution which are, at present, affecting the coastal marine environment and its major protein resources. This has, however, now become a key policy issue and a major problem area in the country. Government has, as a result, adopted an environmental policy and action plan with a view to continuing Bangladesh's developmental process on a sustainable basis. In the light of this policy and action plan, as well as of suggestions made by environmental scientists, the following recommendations, addressing major environmental concerns, are made :

- Environmental Impact Assessment (EIA) of water development, flood control and irrigation projects should be devised immediately. And on the basis of this assessment, necessary measures should be taken to minimize engineering faults causing damage to the environment and the fisheries. In addition, the EIA should be made mandatory for all development projects.
- The migratory routes of all freshwater and salinewater fish and prawn species which require both habitats should be determined. While designing water regulating structures, e.g. regulators, dams and barrages, the migration and movement of fish and prawn

species should be taken into account. Using the migration and swimming habits of fish and prawn as hydraulic design criteria, design engineers should allow for fish and prawn migration without jeopardizing the primary objectives of water control. In achieving this, fisheries scientists and fish behaviour specialists should be invited to work closely with design engineers and planners.

- Fisheries studies should become an integral component of pre-feasibility and feasibility studies for any water resource development project. All costs for the studies should be reflected in the project formats.

- The coastal land areas most suitable for shrimp culture should be delineated, and only these areas be allowed salinewater intake for shrimp cultivation. Shrimp farming must not be allowed at the cost of mangrove forest destruction. Strong legal measures should be taken in this regard. Semi-intensive and intensive shrimp farming must be encouraged in order to limit the horizontal expansion of this practice, which, at present, is causing mangrove depletion. The remaining stretch of mangroves in the Chakaria Sundarbans must also be, at all cost, protected.

- A timely management step should be taken to regulate the estuarine capture fishery by imposing some restrictions. A survey of fish biomass and production in the estuaries and of the socioeconomic conditions of the fishermen is a prerequisite for doing so.

- Massive destruction of shrimp and fish post-larvae while collecting *P. monodon* seed should be stopped. For this, regulatory measures must be immediately imposed and awareness campaigns initiated among fisherfolk engaged in seed collection. In order to meet the demand for seed, more hatcheries need to be establised.

- Direct discharge of untreated toxic pollutants into rivers from industries, particularly in Chittagong and Khulna, should be stopped immediately. Major polluting industries like tanneries in Chittagong, and large plants, mills and chemical complexes in Chittagong, Barabkunda and Khulna should immediately instal primary and secondary treatment plants. Less-polluting industries should also instal inexpensive, primary waste-treatment plants like oxygen ponds. As suggested in the National Policy, all proposed industries should be compelled to examine and assess their probable environmental impact, and take appropriate mitigating measures before permission is given for them to begin operations.

  Sewage treatment plants to treat the municipal sewage of Chittagong and Khulna cities must be installed with immediate effect in order to improve the coastal environment.

- A marine water quality monitoring and surveillance programme should be initiated to detect the existing and potential pollution levels due to continuous accumulation of toxic and persistent agrochemicals, toxic metals, oil and oily substances as well as persistent toxic industrial effluents. For this, the existing laboratories at Chittagong and Khulna should be updated, with modern analytical equipment, sampling facilities and trained manpower.

- The proposed coastguard corps should be formed as soon as possible to watch over the coastal and marine environment and resources.

- The Chittagong and Mongla ports must install bilge- and ballastwater treatment plants to reduce discharges – accidental or otherwise.

- The proposed National Contingency Plan should be prepared and brought into operation to ensure protection against pollution caused by ship accidents in marine waters. Oil spillage-cleaning equipment should also be procured.

- Appropriate legislation for the protection of the marine environment and related ecosystems should be developed, promulgated and implemented as soon as possible. These should encompass all aspects – including coastal and marine pollution prevention and control, oil spillage cleaning and strict compensation, besides protection of the coastal environment. The draft Protection of Marine Environment of Bangladesh Act must be changed in light of the 1992 Environment Policy, and then speedily implemented. Existing laws relating to pollution should be updated and enforced. All mechanisms necessary for law enforcement need to be strengthened. Besides, Bangladesh has to take the necessary steps to enforce all international conventions and protocols relating to marine pollution, including MARPOL 73/78.

35. REFERENCES

AHMED, A. T. A. 1990. ***Studies on identity and abundance of mollusc and fauna of the Bay of Bengal.*** Final report of contract research project, BARC, Dhaka, Bangladesh. 77p.

AHMED, M.F. 1979. ***Environmental engineering research and training in waste management and utilization of new technology in Bangladesh.*** Paper presented at UNESCO seminar, Lahore, Pakistan, March 18-22. 20p.

__________ . 1985a. Modern agriculture and its impact on environmental degradation. ***Proceedings, SAARC Seminar on Protecting the Environment from Degradation,*** Dhaka, Bangladesh. pp. 42-49.

__________ 1985b. Waste disposal and degradation of water quality in and around Dhaka city. ***Proceedings, SAARC Seminar on Protecting the Environment from Degradation,*** Dhaka, Bangladesh. pp. 176-182.

__________ 1988. ***Environmental pollution in Dhaka: present and in the*** year 2000. Paper presented in a seminar on Dhaka 2000 Year. Dhaka, Bangladesh. June 2-3, 1988.

AHMED, M.K. 198 1. ***Behundinet fishery in the brackishwater area of Satkhira with emphasis on bionomics and mortalities of shrimps.*** Freshwater Fish. Res. Stn. Chandpur, Bangladesh. Res. Rept. no.3. 42p.

________ 1984. ***Behundinet fishery in the brackishwater area of Potuakhali with emphasis on bionomics and mortalities of shrimps.*** Freshwater Fish. Res. Stn. Chandpur, Bangladesh. Res. Rept. No. 8. 42p.

ALAM. M.M. ***1990. Study on colossal loss of shellfish andfinfish post-larvae for indiscriminate catch of*** Penaeus monodon ***post-larvae along the coastal wafers of Cox's Bazar and Teknaf.*** M.Sc. Thesis. Institute of Marine Sciences, University of Chittagong, Bangladesh.

AL-ARABI, S.A.M., ALAM, M.G.M. and MAZID, M.A. ***Toxic effect of Cymbush to the Snakehead,*** Channa punctata. Fisheries Research Institute, Bangladesh. (In print.).

ALI, A. 1979. ***Storm surges in the Bay of Bengal and some relatedproblems.*** Ph.D. Thesis (Unpubl.), University of Reading, Reading, UK. 227p.

____ 1980. Storm surges in Bangladesh. ***The Bangladesh Times,*** Dhaka, Sept. pp.25-26.

ALI, M.Y. 1989. Environment, conservation and fishery resources in Bangladesh. IN : Aguero, M., Huq, S., Rahman, A.K.A. and Ahmed, M.(eds.), ***Inlandfisheries management in Bangladesh.*** Department of Fisheries, BCAS. Dhaka, and ICLARM, Manila, Philippines, pp.36.52.

AMIN, N. AND MAHMOOD, N. 1979. Seasonal occurrence of post-larvae of penaeid shrimp ***Metapenaeus brevicornis*** (H. Milne Edwards) in the Karnaphuli estuary. ***Bangladesh J. Agr.*** 4(1):21-24.

ANON 1992a. Oil slick in the Bay of Bengal. ***The Daily Ittefaque*** (February 11, 1992), Dhaka

____ 1992b. ***The Dhaka Courier.*** Vol.8, No.29 (February 21-27 1992). Dhaka, Bangladesh.

ANWAR, J. 1988. Geology of the coastal area of Bangladesh: Recommendation for resource development and management. ***IN: Proceedings, National Workshop on Coastal Area Resource Development and Mangement,*** Part II. Organized by CARDMA (Coastal Area Resource Development and Management Association), Dhaka, Bangladesh. pp.3666.

BAKUN, A. 1990. Global climatic change and intensification of coastal ocean upwelling. Science, 247:198-201.

BASHIRULLAH, A.K.M., MAHMOOD, N. and MATIN. A.K.M.A. 1989. Aquaculture and coastal zone management in Bangladesh. ***Coastal Management.*** 17:119-127.

BCAS (BANGLADESH CENTRE FOR ADVANCED STUDIES). ***1991. Cyclone '91: An Environmental and Perceptional Study.*** (Haider, R., Rahman, A.A. and Huq.S., eds.). 91p.

BEGUM, M. and AHSANULLAH, M. 1986. ***Pelagic fish resources and present status of tuna and tuna-like fish in the continental shelf of the Bay of Bengal.*** Mimeo. 8p.

BENNETT, C.J. and ALAM, M.F. 1992. ***Processing, marketing, utilization and consumption of estuarine set bagnet catches.*** Paper presented at the Seminar on Estuarine SBN Fishery of Bangladesh. BOBP/FAO/DOF. Cox's Bazar, Bangladesh. January 1992. 16p.

BHOUYAIN, A.M. ***1979. Effect of industrialpollution on the biology of the River Karnaphuli.*** M.Phil. Thesis. Dept of Zoology, University of Chittagong, Bangladesh. 164p.

____________ 1983. Fresh and brackishwater pollution in Bangladesh. ***Marine Fisheries Information Bulletin.*** 1(3):32.

BISWASH, A.K. 1978. Environmental implications of water development for developing countries. *Marine Fisheries Information Bulletin. I(3):32.*

BRAMMER, H. 1989. Monitoring the evidence of the Greenhouse effect and its impact on Bangladesh. IN: Hansa *et al.* (eds.), *Proceedings, International conference on the greenhouse effect and coastal area of Bangladesh,* CARDMA, Dhaka. pp.38-47

BROADUS, J.M. (in press). Possible impacts of and adjustments to sea level rise: the cases of Bangladesh and Egypt. Forthcoming IN: Wigley, T.M.L. and Warrick, R. (eds.), *The effect of the climate change on the sea level, severe tropical storms and their associated impacts,* Climatic Research Unit, University of East Anglia, Norwich, UK. 20p.

BROADUS, J.M., MILLIMAN, J. EDWARDS, S., AUBREY, D. and GABLE, F. 1986. Rising sea level and damming of rivers : Possible effects in Egypt and Bangladesh. IN: Titus, J.G. (ed.), *Effect of changes in stratospheric ozone and global climate.* Vol.4 : Sea Level Rise, UNEP/EPA. pp.165189.

BOBP (Bay of Bengal Programme). 1990. *Shrimp seed collectors of Bangladesh.* BOBP/WP/63. Madras, October 1990.

BWDB. 1978. *Report on theprotection of the sea coast from Patenga to Kumira Chittagong.* Bangladesh Water Development Board, Design Directorate II, DA.

CHOWDHURY, *N. 1989. Consultancy report on environmentpollution.* Department of Environment and Forests, Dhaka, Bangladesh, 1989.

CHOWDHURY, Z.A. 1992. *Studies on the beach seine fishery of Bangladesh with emphasis on Cox's Bazar, Teknof coast.* Paper presented at the Seminar on Estuarine SBN fishery of Bangladesh. BOBP/FAO/DOF, Cox's Bazar, Bangladesh. January 1992. 22p.

COMMONWEALTH SECRETARIAT. 1989. *Climatic change* : meeting *the challenge.* Report by a Commonwealth Group of Experts. Commonwealth Secretariat, Marlborough House, Pall Mall, London, U.K. 116p.

CURRAY, J.R. and MOORE, D.G. 1971. Growth of the Bengal Deep-Sea Fan and denudation in the Himalayas. IN : Whitaker, J.H.M. (ed.), *Submarine canyons and deep* sea *funs,* Hutchinson & Ross, Inc., Pennsylvania, USA. pp. 236-245.

DAS, N.G. and DAS, S. 1980. Two calanoid copepods from the Karnaphully river estuary. *Chittogong Univ. Studies,* 11(4):41-47.

DAS. *S. 1977. Taxonomy of calanoid copepods of the Karnafuli estuary.* A postgraduate dissertation. Institute of Marine Sciences, University of Chittagong, Bangladesh 25p.

DOE (Directorate of Environment). *1990. Environment of Bangladesh and DOE.* Dhaka, Bangladesh 155p. (In Bangla).

ELIAS, *S.* 1983. *Zooplankton of the Matamuhuri River estuary with special reference to shrimp and finfish larvae.* A postgraduate dissertation. Institute of Marine Sciences, University of Chittagong, Bangladesh. 172p.

EPC. 1980. *Year book of environment pollution control.* Vol.1. July 1975 to March 1980. Environmental pollution control, Bangladesh. 257p.

EPWAPDA. 1960. *Coastalembankment project in East Pakistan : Khulna, Bakergonj, Noakali and Chittagong.* EPWAPDA, East Pakistan.

ESCAP. 1988. *Coastal environment mangement plan for Bangladesh.* Vol. 2. Bangkok, Thailand 149p.

EYSINK, W.D. 1983. *Basic considerations on the morphology and land accretion potentials in the estuary of the lower Meghna River.* LRP, Bangladesh Water Development Board. LRP Technical Report 15. 39p.

FAO. 1984. *Technical Cooperation Programme: Integrated Development of Bangladesh by FAO.* Based on the work of H.R. Rabanal. Rome, FAO, FO:TCP/BGD/2309:28p.

FRI (Fisheries Research Institute). 1991. *Toxicity of ricepesficides to fish and shrimp.* Progress report of research project at Riverine Station, FRI. Chandpur, Bangladesh. 8p.

FUNNECAARD, P. 1986. Shrimp seed, any to sell? Come to Satkhira, Bangladesh. IN: *Buy of Bengal News, No. 22* BOBP, Post Bag 1054, Madras, India. pp.2-6.

GUCINSKI, H., LACKEY, R.T. and SPENCE, B.C. 1990. Global climate change: Policy implications for fisheries. *Fisheries,* 15(6):33-38.

HAKIM, M.A., KHAN, Z.U.M. and RAHMAN, M.A. 1981. A note on the hetrotrophic bacterial population in intertidal sediments of the Karnafuli estuary. ***Mohasogor.*** Bulletin of the National Institute of Oceanography, India. 14(1):79-81.

HAIDER, S.M.B., and MAHMOOD, N. 1992. The coral genus ***Acropora*** (Scleractinia: Astrocoeniina:Acroporidae) in nearshore waters of the St. Martin's Island, Bangladesh. ***Bangladesh J. Zool. (In*** press).

HAQUE, M., ISLAM, M.A., AHMED, S.T. and HOQUE, S.M. 1979. Geology of the St. Martin's Island. *Bangladesh **J. Sci. Ind. Res.*** 2(B):17-27.

HAQUE. S.M.A. ***1983. Study on phytoplankton of the Matamuhuri estuary and fish ponds in the vicinity.*** A postgaduate dissertation. Institute of Marine Sciences, University of Chittagong, Bangladesh. 174p.

HOSSAIN, M.M. ***1983. Pollution as revealed by macrobenthic organisms in the Karnaphuli River estuary.*** A postgraduate dissertation. Institute of Marine Sciences, University of Chittagong. Bangladesh. 96p.

________________ ***1989. Contamination of some commercially important marine shrimp and fish species from Bangladesh by organochlorine pesticides, PCBs and total Mercury.*** Thesis, Vrije Universiteit, Brussel. 99p.

HOSSAIN, H.M., MAHMOOD, N. and BHOUYAIN, A.M. 1988. Some water quality characterstics of the Karnafully River estuary. ***Mohosagor*** 21(3):183-188.

HOSSAIN, M.T. ***1992. Study on the Environmental Impact Assessment (EIA) of the effluent dicharged by the Chittagong Urea Fertilizer Limited (CUFL) in the Karnofully River Estuary.*** Thesis, Institute of Marine Sciences, University of Chittagong, Bangladesh. 56p.

HOWLADER, MS. 1976. Taxonomic study on the penaeid shrimps of Bangladesh water. ***Bangladesh J.Sci. Ind. Res.*** X1(1-4):122-138.

HUQ, A.M. 1986. Preliminary studies on the angiospermic flora of Kutubdia Island in Bangladesh. ***J. Asiatic Soc. Bangladesh (SC.). 12 (l&2):59-70.***

HUQ, A.M. and KHAN, M.S. 1984. A preliminary taxonomic report on the angiospermic flora of Moheshkhali Island-I. ***Dhaka University Studies (B). 32(2)*** : 19-3 1.

HUQ, ***Q.M.*** 1987. ***Observation on landing of Tuna and Tuna-like fishes at the BFDC landing centre, Cox's Bazar,*** Nov. *86-Oct* '87. Mimeo. 4p.

___________ ***1992. Bottom longline fishery for Jewfish (Sciaenidae) in Bangladesh.*** Paper presented at the Seminar on Estuarine SBN fishery of Bangladesh. BOBP/FAO/DOF. Cox's Bazar. January 1992. 17p.

HUSSAIN, M.M. ***1971. The commercial fishes of the Bay of Bengal.*** Survey for development of Fisheries in East Pakistan. 60p.

________________ 1984. ***Commercial exploitation of marine fisheries resources of Bangladesh.*** Paper presented at the Training Seminar, Marine Fisheries Resources Survey, DOF, Bangladesh. 13p.

________________ 1992. ***Marine fishery resources of Bangladesh.*** Paper presented at the National Seminar on Marine Fisheries Development in Bangladesh, Bangladesh Fisheries Advisory Service Project/Ministry of Fisheries and Livestock, Dhaka, Bangladesh, March 11, 1982. 8p.

IBRAHIM, M. 1992. Plastic bags?. ***The Dainik Bangla, March 11, 1992.***

ISLAM, A.K.M.N. 1980. A marine angiosperm from St. Martin's Island. ***Bangladesh J. Bot. 9(2):*** 177-178

ISLAM, *M .M* .R. ***198*** 1 ***Seasonal variation of the phytoplankton of lotic (the Karnaphuli River estuary) and lentic wafer (Foy's Lake) environment.*** A postgraduate dissertation. Institute of Marine Sciences, University of Chittagong, Bangladesh. 72p.

ISLAM, M.S. 1982. ***Zooplankton communities of the Karnaphuli river estuary during Northeast monsoon with special reference to Chaetognaths.*** A postgraduate dissertation. Institute of Marine Sciences, University of Chittagong, Bangladesh. 61p.

____________ ***1992. Trammelnet fishery in Bangladesh.*** Paper presented at the Seminar on 'Estuarine SBN fishery of Bangladesh' BOBP/FAO/DOF, Cox's Bazar, January 1992. 13p.

ISLAM, K.R. and HOSSAIN, M.M. 1986. Effect of ship scrapping activities on the soil-sea environment in the coastal area of Chittagong, Bangladesh. ***Marine Pollution Bulletin,*** 17:462-463.

IUCN. 1991a. ***Towards sustainable development : Fisheries resource of Bangladesh.*** A background paper prepared for National Conservation Strategy of Bangladesh. Bangladesh Agricultural Research Council (BARC), Dhaka. 96p.

—— 1991b. ***Towards sustainable development: Industries of Bangladesh.*** A background paper prepared for National Conservation Strategy of Bangladesh. Bangladesh Agricultural Research Council (BARC), Dhaka. 96p.

1991c. ***Towards sustainable development: Issues of environmental pollution in Bangladesh.*** A background paper prepared for National Conservation Strategy of Bangladesh. Bangladesh Agricultural Research Council (BARC). Dhaka.

JAHAN, S.M.D. 1992. ***Socioeconomic study of set bagnet fisherfolk of Bangladesh.*** Paper presented at the Seminar on Estuarine SBN fishery of Bangladesh. BOBP/FAO/DOF, Cox's Bazar. January 1992. 14p.

JALAL, K.F. 1988. Towards a national strategy on coastal resource management in Bangladesh. ***IN: Proceedings. National Workshop on Coastal Area Resource Development and Management.*** Pt.II, pp.67.78.

JHINCRAN, V.G. ***1983. Fish and Fisheries of India.*** Hindustan Publishing Corporation (India), Delhi.

KABIR, S.M.H. and BEGUM. R. 1978. Toxicity of three organophosphorous insecticides to ***shringhi*** fish, ***Heeropnenstes fossilis*** (Bloch). ***Dhoko University Studies*** (B), XXVI(I):1 15-122.

KABIR, S.M.H. and AHMED, N. 1979. Histopathological changes in climbing perch ***Anabos testudineus*** (Bloch) (Anabantidae : Perciformes) due to three granular insecticides. ***Bangladesh J. Zool.*** 7(1):21-29.

KAMAL, D. 1992. ***Studies on the intertidal green mussel,*** Perna viridis ***L. inhabiting Moheshkali Channel, Bay of Bengal.*** M.Sc. Thesis. Institute of Marine Sciences, University of Chittagong, Bangladesh. 130 p.

KARIM, A. and KHAN, M.A.A. 1980. Phytosociological studies of mangrove forests of Chakaria Sundarbans. ***Bano Biggyan Patrika,*** 9(1-2):17-28.

KATEBI, M.N.A. and HABIB, G. 1988. Sundarbans and Forestry. IN: ***Proceedings, National Workshopon Coastal Area Resource Development and Management,*** Pt. II, pp.79-100.

KHAIR, A. 1988. Monitoring and control of toxic chemicals in chemical industries. IN: Proceedings, National Symposium on the Monitoring System of Chemical Industry in Bangladesh. Bose Study and Research, Dhaka University, January IO-February 4, 1988. p.151.

KHAIR, S.A. 1976. ***Biology of*** Schmackeria loolpes *(Gyrney, 1907), (Crustacea)* ***of the Kornaphuly river estuary.*** A postgraduate dissertation. Institute of Marine Sciences, University of Chittagong. 81p.

KHAN, M.G. 1983. ***Results from the 15th cruise (Dec.*** '83) ***of the*** r.v. Anusandhani ***IO the demersal fishing ground of the Bay of Bengal, Bangladesh.*** Marine Fisheries Research, Management and Development Project, Chittagong. 15p.

—— 1992. ***Life cycle and dynamics of the shrimp and fish population exploited by multigear fisheries in the coast of Bangladesh.*** Paper presented at the Seminar on Estuarine SBN fishery of Bangladesh. BOBP/FAO/DOF, Cox's Bazar, Bangladesh. January 1992. 14p.

KHAN, M.G. and HAQUE, K.A. 1988. Exploration and exploitation of marine fishery resources of Bangladesh. ***The Journal of NOAMI.*** 5(1&2): 1-4.

KHAN, M.S. and KARIM, A. 1982. Bangladesh : Utilization of the deltaic zone. IN: Chandra, H,S., Chia, L.S. and William, L.(eds.), ***Man, Land and Sea : Coastal Resource use and Management in Asia and Pacific.*** The Agricultural Development Council, Bangkok. pp.85-102.

LAMBOEUF, M. ***1987. Bangladesh — Demersal Fish Resources of the Continental shelf.*** FAO, Rome. 26p.

MAHMOOD, ***N.*** 1984. ***Studies in the tidal area of Bangladesh : A summary report on the hydrobiological survey during*** I982-'83. AO/UNDP/BGD/79/015:15pp. (manuscript).

—— 1986. Effect of shrimp farming and other impacts on mangroves of Bangladesh. Paper presented at the 3rd session of the IPFC woking party of experts on Inland Fisheries, Bangkok, Thailand, June 19-27, 1986. ***FAO Fish Report. No. 370.*** pp.46-66.

—— 1988. Coastal Fisheries and shrimp farming. IN: Hansa et ***al.,*** (eds.). ***Proceedings, National Workshop on Coastal Area Resource Development and Management,*** CARDMA, Part II.pp.114-122.

—— ***1989. Shrimp culture in Bangladesh: Problems and prospects therein.*** Paper presented at the Seminar on Maximum utilization of internal resources in the socioeconomic development of Bangladesh. Chittagong Chamber of Commerce and Industry, Bangladesh, May 17-18, 1989. 13p. (mimeo). (In Bangla).

<<

______________. 1990a. An assessment of the quantum of damage caused to zooplankton while Fishing *bagda* shrimp *Penaeus mondon* fry in Bangladesh estuaries. IN : *Proc. Seventh Nut.* Zool. Conf. Bangladesh. pp.87-94.

______________ 1990b. *Study on immigration of commercially important penaeid shrimp post-larvae in the estuarine area of Chakaria, Cox's Bazar, Bangladesh.* Ph.D. Thesis. Department of Zoology, University of Rajshahi. 133p.

______________ 1991b. *Shrimp farming: A potential threat to the mangroves of Bangladesh.* Paper presented at, the Symposium on Impacts of Climate Changes and Ecosystems and Species (ICCES). Amestoort, The Netherlands, December 2-6, 1991 15p.

MAHMOOD, N., AHMED, S.U. and LOESCH, H. 1985. Study on the distribution of Finfish larvae in the vicinity of brackishwater aquaculture ponds of Satkhira. *Proceedings, Second Intl. Warmwater Aquaculture Conf.,* Brigham Young University, Hawaii Campus, Honolulu. pp.l09-130.

MAHMOOD, N. and CHOWHURY, M.R. 1989. *An overview of the shrimp fishery in Bangladesh.* Paper presented at BCAS Workshop on The Environmental Aspects of Agricultural Development and Surface Water Systems. November 8-9, 1989. 52p.

MAHMOOD, N. and HAIDER, S.M.B. 1992. A note on corals of the St. Martin's Island, Bangladesh. *Chittagong Univ. Studies.* (In press).

MAHMOOD, N. and KHAN, M.G. 1980. *On the occurrence of post-larvae and juvenile penaeid prawn at Bakkhali estuary and adjacent coastal area of Cox's Bazar with notes on their utilization in aquaculture.* Final report. Research Programme U.G.C., Dhaka, Bangladesh. 26p.

______________ *1992. Offshore pelagic fishery resources of Bangladesh : Need for Assessment and exploitation.* Paper presented in the First Asia-Pacific Seminar on Sustainable Ocean Development and Management, July 27-30, 1992. AIT, Bangkok, Thailand. 9p.

MAHMOOD, N. and AHMED, M.K. 1976. Study on the hydrology of the Karnafuli estuary. *J. Asiatic Soc. Bangladesh* (Sc.). 2(1):89-99.

MAHMOOD, N., KABIR, M.H. and CHOWDHURY, S.R. (unpublished). *Variation in mean sea levei along the coast of Bangladesh.*

MAHMOOD. N. and CHOWDHURY, S.R. (unpublished). *Sea level rise in Bangladesh : A futuristic scenario.*

MAJUMDER, M.K. 1992. Coastal pollution: Question of life and death. *The Dhaka Courier,* Vol.8. no. 45, June 12, 1992.

MATIN. 1992. Pesticide usage and monitoring of residues in food and environment. *The Bangladesh Observer,* June 1 and 2, 1992.

MEAF (Ministry of Environment and Forest). 1991. *Bangladesh Country Report for* United Nations Conference on Environment and Development (UNCED). Brazil, 1992. MEAF, Govt. of Bangladesh. 114p.

1992. Environment Policy I992 and Action Plan. Government of the People's Republic of Bangladesh. 28p. (In Bengali).

MILLIMAN, J.D., BROADUS, J.M, and GABLE, F. 1989. Envionmental and economic implications of rising sea level and subsiding deltas : The Nile and Bengal examples. *Ambio,* Vol.18.

MIRZA, M.M.Q. and SHAHJAHAN, M. 1987. Erosion in the coastal area with special reference to Hatia, Sandwip and Bhola islands. *The Journal of NOAMI* Dhaka. 4(2):19-27.

MOHI, S.A. 1977. *Distribution of ichthyoplankton in the Karnaphuli River estuary in relation to salinity.* Postgraduate dissertation. Institute of Marine Sciences, University of Chittagong, Bangladesh. 53p.

MOHSIN, N.A. 1979. *Studies on the limnology of aperennial* khal *with reference to pollution by municipaland industrial effluents.* Thesis. Dept. of Zoology, University of Chittagong, Bangladesh. 146p.

MPO (Master Plan Organisation). 1985. *Draft Final Report, Vol. I. National Water Plan Project.* Ministry of Irrigation, Water Development and Flood Conrol, Government of Bangladesh, Dhaka. July 1985.

______________ *1986. Final Report. Vol.I,II and* III. December, 1986.

______________ 1987b. *Technical Report No.17 · Fisheries and flood control, drainage and irrigation development.* March 1987.

NISHAT, A. 1989. Greenhouse effect and Bangladesh : Hydrological settings and technical options. *Proceedings, International Conference on the Greenhouse Effect and Coastal Area of Bangladesh.* CARDMA, Dhaka. pp.77-80.

NURUZZAMAN, A.K.M. 1990. *Conflicts between agriculture andshrimp cultivation.* Paper presented at the seminar on Environmental and Policy Aspects of Shrimp Cultivation. Bangladesh Centre for Advanced Studies (BARC), Dhaka, August 28-29, 1990.

OMAR, K.I., RAHMAN, K. and AHMED, *N.* 1985. *Study of efflent management ofpollution control.* Report l. Karnaphuli Paper and Rayon Complex. BCIC, Chemical Engineering Department, BUET. Dhaka. 1985.

PATULLO, J.G. 1963. Seasonal changes in sea level. IN: Hill, M.N.(ed.), *The sea,* (II). Wiley, New York. pp.485- 496.

PAUL, *S.* 1981. *Effects of oil pollution uponplanktonic organisms in the Karnafuli River estuary.* A postgraduate dissertation, Institute of Marine Sciencs, University of Chittagong, Bangladesh. 81p.

PENN, J. W. *1983. An assessment of potential yields from the offshore demersal shrimp and finfish stocks in Bangladesh* waters (including comments on the trawl fishery). 1981/82/FAO/UNDP Fishery Advisory Project (Phase 2), Rome. FAO, FI:DP/BGD/81/034. Field document, 29p.

PRAMANIK, M.A.H. 1984. *Remote sensing application to accretion and erosion studies and effects on mangrove.* Paper presented at UNESCO/UNDP Training Seminar on Geology, Sedimintology. Erosion and Accretion in Mangrove Areas, Jan-Feb., 1984, Dhaka, Bangladesh. 14p.

____________________ 1991. Envionmental vulnerability in Bangladesh. *Proceedings of the ESCAP/UNDP Workshop on Regional Development Issues and Environment.* Dhaka, Bangladesh. November 18-21, 1991.

QUADER, *0.* 1976. *Pollution of the Karnaphuly estuary and its effect* on Apocryptes bato *Ham. and Buch. (Perciformes: Gobidae).* A postgraduate dissertation. IMS, University of Chittagong, Bangladesh. 70p.

QUADER, O., PRAMANIK, M.A.H., KHAN, F.A. and POLEYN, F.C. 1986. Mangrove ecosystem study of the Chakaria Sundarbans at Chittagong with special emphasis on shrimp ponds by remote sensing technique. IN: Nishoul, J.C.J (ed.), *Marine Interfaces Ecohydrodynamics.* Elsevier, Amsterdam, Oxford, N.Y., Tokyo. pp.645653.

QUAYUM, S.A. 1992. *Marine set bagnet fisheries of Bangladesh.* Paper presented at the Seminar on Estuarine SBN fishery of Bangladesh. BOBP/FAO/DOF, Cox's Bazar, January 1992. 20p.

RAHIM, Z., AZIZ, K.M.S. and ISLAM, M.S. 1985. Current environmental pollution by human faecal contamination. *Proceedings, SAARC Seminar on Protecting the Environment from Degradation.* Dhaka 1985. pp.232-237.

RAHMAN, A. and CHOWDHURY, N. 1988. Chittagong : The endangered port city. *The Weekly Bichitra, Vol.17, No.27.* (In Bangla).

RAHMAN, A.A. and HUQ, S. 1989. Greenhouse effect and Bangladesh: A conceptual framework. *Proceedings, International Conference on the Greenhouse Effect and Coastal Area of Bangladesh.* CARDMA, Dhaka. pp.23-27.

RAHMAN, G. and ALAM, N.L. 1985. Legal and industrial framework for the protection of environment from degradation in Bangladesh. Proceedings, *SAARC Seminar on Protecting the Environment from Degradation.* Dhaka 1985. pp.202-207.

RAHMAN, K., AHMED, N., JAMAN, J. and QU ADER, A.K.M.A. 1980. *Treatment and diposal of effluent at UFFL..* BCIC. Chemical Engineering Department, Buet, Dhaka, 1980.

RASHID, H.E. 1989. Greenhouse effect : Its implications for the agricultural sector in coastal areas of Bangladesh. *Proceedings, International Conference on the Greenhouse Effect and Coastal Area of Bangladesh.* CARDMA, Dhaka. pp.81-84.

SADA, M *.N, 199* 1. *Country status paper on marine fisheries, aquaculture resources and post-harvest technology practices in Bangladesh.* Presented at the training course conducted by Bureau of Fisheries and Aquaculture Resources, Quezon City, Manila, The Philippines. 17p.

SAENGER, P., HAGERL. E.J. and DAVIE, J.D.S. 1983. *Globalstatus of mangroveecosystems.* Commission on Ecology paper no.3.IUCN.

SAETRE, R. 1981. *Survey on marine fishery resources of Bangladesh.* Nov-Dec. 1979 and May 1980. Report on surveys with the r.v. *Dr. Fridtjof Nansen.* Institute of Marine Research, Bergen, Norway. 67p.

SAIKAT, S.Q. 1992. Impact of shrimp seed collection. *The Dhaka Courier,* Vol.9. Issue 2, August 14, 1992. p.7.

SALAM, A. 1976. *Algal flora of the Karnafuli estuary and ecological observations on changes in growth of some intertidal algae at Patenga coast.* A postgraduate dissertation. Institute of Marine Sciencs, University of Chittagong, Bangladesh, 228p.

SARKER, A.H. 1992. Pesticides and environment. *The Daily Sangbad,* April 18, 1992. (In Bengla).

SENGUPTA. R., ALI., M., BHUIYAN, A.L., HOSSAIN, M.M., SIVALINGAM, P.M., SUBASINGHE, S. and TIRMIZI, N.M. *1990. State of the marine environment in the South Asian Seas region.* UNEP Regional Seas Reports and Studies No.123. UNEP. 1990.

SHAHIDULLAH, M. 1986. Marine fisheries resources management in Bangladesh and current status of exploitation. *Marine Fisheries Bulletin* 3. Chittagong, Bangladesh. 26p.

SHARIF, M. *1992. Studies on the siltation rate of the Karnaphuli estuary of the Bay of Bengal.* A postgraduate dissertation, Institute of Marine Sciences, University of Chittagong, Bangladesh. 20p.

SHIRAZI, Z. 1991. Waste management and the environment. *The Bangladesh Observer.* October 30, 1991.

SIKDER, M.D.H. 1991. *Studies on sand and silt movement in Chittagong Harbour by radioactive tracer techniques.* Institute of Nuclear Science & Technology, Atomic Energy Research Establishment, Dhaka.

SMITH, W.G. 1982. *The tidal area study, an interim report.* FAO/UNDP/BGD/015: 27p. (manuscript).

SOBHAN, T. 1990. Shrimp exporters perspective (abstract). IN: *Proceedings, Seminar on Environmentaland Policy Aspects of Shrimp Cultivation.* BCAS at BARC campus, Dhaka, Bangladesh, August 28-29, 1990.

TALIJKDER, A.B.M.A. 1992. Source of pollution in the Bay of Bengal and its impact. *The Daily Purbakone,* May 12, 1992. (In Bangla).

UNEP. 1986. *Environmenialproblems of the marine and coastal area of Bangladesh : National report.* UNEP Regional Seas Report and Studies, No.75.

WEST, W.Q.B. 1973. *Fishery resources of the Upper Bay of Bengal.* IOFC/DEV/73/28. FAO, Rome. 44p.

WHO (World Health Organization). 1973. *Drinking water Standard.* WHO.

WHOI (Woods Hole Oceanographic Institution). 1986. *Sea level rise and river deltas : A battle of man, nature and rime.* Vol.18. No.2.

WPCP (Water Pollution Control Project). 1975. Year *Book.* Water Pollution Control Project, DPHE. Ministry of L.R., L.G., R.D. and Co-operatives. 505p.

ZAFAR, M. and MAHMOOD, N. 1989. Studies on the distribution of zooplankton communities in the Satkhira estuarine system. *Chittagong University Studies,* Pt. II(Sc.) 13(I): 115-122.

APPENDIX XIV

Institutions engaged in environmental research, monitoring and enforcement

GOVERNMENT/SEMI-GOVERNMENT

The Department of Environment (DOE) is the main governmental instituiion responsible for all environmental planning, management and monitoring, including the requirements of the marine sector. It also works as the technical arm of the newly formed Ministry of Environment and Forest. The Department, renamed and reconstituted as the 'Department of Environment' replaced what was known as the Department of Environment and Pollution Control (EPC) and was placed under the newly formed Ministry in August 1989. However, its manpower strength is as before and still works with a limited budget, a weak institutional basis and poor logistic support. The DOE is charged with greater responsibility and powers and has a broader working mandate. Although technical assistance projects funded by ADB are underway to strengthen the DOE, they have achieved only limited progress. The assistance is mainly directed to spearheading policies and monitoring industrial and urban pollution.

The main objective of EPC was pollution control. The new nomenclature has given a totally different dimension to the Department's role and, understandably, the main objective of the Department now is overall environmental protection and better management of the environment. Its major responsibilities include:

- Co-ordinating environmental assessment and monitoring;
- Undertaking certain assessment and monitoring tasks, such as on-site surveillance of development projects, follow-up and monitoring of developments to determine if environmental improvement measures are effective;
- Preparing reports for submission to pertinent planning and implementing agencies;
- Promoting environmental awareness through public information programmes;
- Controlling and monitoring industrial pollution; and
- Assisting the Ministry on technical issues

There are many other government agencies and institutional organizations dealing with coastal and marine affairs, and resource development and management involving environmental issues. They include the following:

- Department of Forests (Ministry of Environment and Forest) which overseas coastal forest development and management.

  Department of Fisheries (Ministry of Fisheries and Livestock) which overseas coastal and marine fisheries survey, development and management,
- Bangladesh Fisheries Development Corporation (Ministry of Fisheries and Livestock) which overseas capture fishing and marketing.
- Department of Science and Technology (Ministry of Education) which overseas marine affairs, including coastal zone management.

  Chittagong and Mongla Port Authorities and Directorate of Shipping (Ministry of Ports, Shipping and Inland Water Transport) which oversee marine shipping and port activities, including the monitoring and control of pollution in the port and marine waters of Bangladesh.

Although responsibilities for management of coastal forests, marine fisheries and other natural resources and marine affairs are mainly focused within the respective individual departments and ministries, as indicated above, overall coordination for environmental issues arising in these sectors is the responsibility of the DOE.

The Bangladesh Navy is engaged at present in establishing/maintaining Bangladesh's jurisdiction over areas within its maritime boundaries. It also offers protection to offshore fishing activities. In the newly adopted environmental policy of 1992 and the consequent Action Plan, the Navy has been entrusted with the surveillance and enforcement of pollution prevention and environmental protection in national marine waters.

Among research organizations, the Forest Research Institute and Fisheries Research institute participate in environmental research, but not in the marine environment. The Bangiadesh Agricultural Research Council (BARC), under the Ministry of Agriculture, is a key unit for co-ordinating agricultural and environmental research, including fisheries, but it has not so far undertaken any programme on impact assessment of toxic agrochemical residues on the marine environment and resources of Bangladesh. However, it should be mentioned that the Institute of Food and Radiation Biology of the Bangladesh Atomic Energy Commission has recently developed the required facilities to undertake pesticide-residue monitoring and research. This is a timely research approach to a serious environmental problem. The Bangladesh Space Research and Remote Sensing Organization (SPARRSO), under the administrative control of the Ministry of Defence, acts as the focal point for space research and remote sensing activities concerning natural hazards like cyclones, floods, drought etc. The study of the coastal systems in Bangladesh using space and remote sensing techniques has been one of the major activities of SPARRSO (Pramanik, 1984) from its inception.

UNIVERSITIES

None of the universities of Bangladesh offer courses or conduct research in the marine environment or the resources therein, except for the University of Chittagong. The Institute of Marine Science (IMS) under this University is the only one of its kind and has long been making a major contribution to the study of country's coastal and marine pollution and their impacts, despite its limited facilities and inadequate skilled manpower. Recently, a new university, namely University of Khulna with a department of Marine Biology has been established, but its activities are yet to be started.

Zoology and Botany departments of other general universities, the Bangladesh Agricultural University and a few departments of the Bangladesh University of Engineering and Technology undertake some environmental studies. But they have, till now, not engaged themselves in studies relating to marine environmental problems or fisheries.

NGOs

NGOs in Bangladesh are fast emerging as an effective 'Third Sector' in the development process, the other two sectors being the Government and the private sector. About 13,000 NGOs have been established to work in different development fields in the country (MEAF, 1991).

Though environment, conservation and sustainable development do not specifically appear in their policy documents or work programmes, most NGO activities have a direct bearing on the improvement of the environment, resource conservation and sustainable development. In general, their activities include environment developmental activities, public awareness and social impact assessment. The number of NGOs engaged in coastal environmental issues are very few. They are BCAS (Bangladesh Centre for Advanced Studies), IIESDM (International Institute for Environmental Studies and Disaster Management ASA (Association for Social Advancement), UBINIG etc., which mainly focus their work on raising public awareness and socioeconomic perspectives. In 1987, members of the then parliament from the coastal districts formed an environmental interest group, the Coastal Area Resource Development and Management Association (CARDMA) to work with the special parliamentary committee on coastal development. They made a good start, but with the change of Government, CARDMA is now virtually inactive, what usually happens in a developing country like ours!

Addresses of orgnnizations in the fields of environment and pollution in Bangladesh

Department of Environment (DOE), House No 2, Road No. 16A (new) Dhanmondi, Dhaka

University of Chittagong, Chittagong

Dhaka University, Dhaka

Rajshahi University, Rajshahi

Khulna University, Khulna

Bangladesh Agricultural University, Mymensingh

Bangladesh Centre for Advanced Studies (BCAS), House No. 620, Road No. 10A (new), Dhanmondi Residential Area, Dhaka

Fisheries Research Institute (FRI), Mymensingh - 3301

Coastal Area Resource Development and Management Association (CARDMA), 159 Gulshan Avenue, Dhaka

Bangladesh Agriculture Research Council, Farmgate, Dhaka

Approtech Consultants Ltd., House No. 30, Road No. I3A, Dhanmondi, Dhaka

Institute of Food Science and Technology, BCSIR, Dhaka

International Centre for Diarrhoea1 Disease Research, Bangladesh (ICDDRB), GPO Box 128, Dhaka 1000

Additional Secretary, In Charge of Prime Minister's, Secretariat, 43 Purana Paltan Lane, Dhaka

Addresses of NGOs engaged in environment activities

Association for Development Agency in Bangladesh (ADAB), 1/3 Block F, Lalmatia, Dhaka 1207

Association for Social Advancement (ASA), 5/12 Block - B, Humayun Road, Mohammadpur, Dhaka 1207

Bangladesh Environmental Lawyers' Association (BELA), 14 Lake Circus, Kalabagan, Dhaka

Bangladesh Centre for Advanced Studies (BCAS), House No. 62, Road No. 10A (New), Dhanmondi R.A., Dhaka 1207

Bangladesh Rural Advancement Committee (BRAC), 66 Mohakhali C.A., Dhaka 1212

CARITAS (Bangladesh), 2 Outer Circular Rod Santibg, Dhaka

Centre for Environmental Studies and Disaster Management (CESDM), Khulna University, Khulna

Centre for Environmntal Studies and Research (CESR), 68/1 Purana Paltan, GPO Box 3290, Dhaka 1000

Centre for Mass Education in Science (CMES), 37/C Asad Avenue, Mohammadpur, Dhaka 1207

Development Studies Centre, 24 Lake Circus, Kalabagan, Dhaka 1205

Forum of Environmental Journalists of Bangladesh (FEJB), National Press Club, 18 Topkhana Road, Dhaka

International Institute for Environmental Studies and Disaster Management (IIESDM), House No. 20, Road No. 6, Sectol, Uttara, Dhaka

International Union for Conservation of Nature and Natural Resources (IUCN), 35-B/1 lndeera Road, Dhaka 1215

Nari Pokkho, 195 Madhubazar, West Dhanmondi, Dhaka

Nature Conservation Movement (NACOM), 29/C-A North Kamalpur, Dhaka

Poush, 5/7 Sir Syed Road Block A, Mohammadpur, Dhaka

PROSHIKA-MUK, 5/2 lqbal Road, Mohammadpur, Dhaka

Rangpur Dinajpur Rural Services (RDRS), House No. 62, Road No. 7A, Dhanmondi, Dhaka

Shawnirvar Bangladesh, 109 Siddique Bazar, Dhaka

Society for Conservation of Nature (SCONE)

Unnayan Bikalpa Nitinirdharan Gobeshona (UBINIG), 5/3 Barabo, Mahanpur, Ring Road, Shamoli, Dhaka 1207

Worldview International Foundation, House No. 76A, Road No. 12A, Dhanmondi R.A., Dhaka

National Policy and Action Plan

NATIONAL POLICY

There is no policy focusing exclusively on the marine environment of Bangladesh. It has been addressed in the national policy, namely the Environment Policy (EP), 1992 (MFAE, 1992) adopted and published recently by the Government of Bangladesh as a significant component of an overall environmental strategy for multisectoral sustainable development. It has specifically identified environmentally desirable policy suggestions for major development sectors, including agriculture, industry, health and sanitation, energy and fuel, water and irrigation, forest, wildlife and biodiversity, fisheries, livestock, food, transport and communication, coastal and marine ecosystem, industry, housing and urbanization, population, public awareness, education and research etc. The major objectives of the policy are as follows:

- Maintenance of the ecological balance and overall progress of the country through preservation and development of the environment.
- Protection of the country against natural disasters.
- Identification and prevention of all types of activities related to pollution and degradation of the environment.
- Ensuring environmentally sound development in all sectors.
- Ensuring sustainable, long-term and environmentally congenial utilization of all resources.
- Participation as far as possible with all international initiatives related to the environment.

For preservation of the coastal and marine environment, the EP stresses the following:

- Ensuring environmentally sound preservation and development of coastal and marine ecosystems and resources therein.
- Protection of all domestic and foreign activities causing pollution in coastal and marine areas.
- Strengthening research for the protection and development of the coastal and marine environment and resources.
- Keeping the fish catch from coastal and marine waters at the maximum sustainable level.

There are many other policy suggestions in the EP which are relevant to marine environmental issues, e.g. ensuring the congenial environment for fisheries development, preservation of mangrove and other ecosystems etc. Re-assessment of water development, flood control and irrigation projects having harmful impacts on fisheries, and doing EIA (Environmental Impact Assessments) before taking up new projects have been stressed.

The EP recommends that all water bodies in Bangladesh be free from pollution and that industries take up pollution control measures gradually. It suggests a gradual ban on the establishment of any new industry or the operation of any existing one whose produce is hazardous to the environment. Natural pest control, instead of using chemical pesticides, and the use of manure and agricultural wastes as fertilizers have also been suggested. In respect of an institutional framewok, the Ministry of Environment and Forest (MEAF) is responsible for putting it in effect and conducting the inter-ministerial and inter-departmental co-ordination for this. The EP also suggests formation of a National Environmental Committee with the Prime Minister in the chair for overall direction of the implementation of the EP.

Another industrial policy enunciated in 1991 as important objectives mentions maintenance of environmental balance in industrialization and prevention of environmental pollution. The policy emphasizes the need to develop industrial growth centres in appropriate locations to ensure environmentally-conducive industrialization. Existing industries will be required to adopt anti-pollution measures within the timeframe to be specified by the government.

It is very significant that a national environmental policy has been formulated in Bangladesh where any industry, no matter how dangerous or how harmful to others, any ship, no matter how careless or how dirty it is, or any township can freely dump wastes into the waters. This situation has not only been due to the lack of policies, but also due to financial, technical, institutional, administrative and legislative weaknesses and gaps.

Environmental Quality Standards (EQS) for Bangladesh have been drafted, but are yet to be adopted. The scope of DOE's mandatories and DOE's administrative rights are ambiguous and undefined. It is not yet of adequate strength to obtain the needed data, or provide the types of good judgement necessary to perform the job with objectivity. Often, industries refuse DOE personnel access to their plants unannounced. Sewage and municipal waste management from the water pollution control standpoint is not addressed in the EP. Legislative lacunae, ineffectiveness and gaps are still major problems in the country. The Water Supply and Sewerage Authority Ordinance, 1963 establishes executive responsibilities for WASA authorities in Bangladesh. But there is no explicit mechanism for prosecuting WASA for failing to carry through with the assigned responsibilities. Therefore, gradual strengthening of all mechanisms through integrated efforts, actions and motivation is of prime importance if it is intended to go ahead with implementation of these policies.

ACTION PLAN

To achieve the aims and objectives of the Environmental Policy and with a view to implementing different policy suggestions, an Environmental Action Plan has also been adopted within the framework of the EP. The action plan proposes specific and issue-oriented mitigatory steps to address major environmental problems, with an indication of authorities responsible for the implementation. The action plan adopted in respect of coastal and marine environmental problems is furnished below:

Action	*Implementing authorities*
A special cell is to be formed in the Ministry of Environment and Forest with a view to monitor and coordinate the programmes for coastal and marine environmental protection and development.	a) Ministry of Environment and Forest. b) Directorate of Forest. c) Directorate of Environment. d) Forest Research Institute
The newly accreted lands in the coastal areas are to be handed over to the Directorate of Forest on priority basis for conservation and plantation aimed at making them stable.	a) Ministry of Land. b) Directorate of Forest.
The Bangladesh Navy to keep an eye on the territorial waters of the country to prevent pollution and unauthorized entry into the country's EEZ and territorial waters.	a) Ministry of Defence. b) Bangladesh Navy. c) Ministry of Shipping. d) Department of Shipping.
A local and National Contingency Plan with a funding system, for the protection of the marine environment from pollution caused by ship accidents, and this programme to be co-ordinated on a regional basis.	a) Ministry of Shipping. b) Ministry of Defence. c) Bangladesh Navy. d) Department of Shipping.
An appropriate arrangement to be made by the Chittagong and Mongla Port Authorities for removal of accumulated refuse from ships and also for environmentally safe discharge of oil and oily substances from the ships.	a) Ministry of Shipping.
A special cell to be formed in the Ministry of Water Transport to determine the nature and property of wastes, to assess harmful impacts on the environment and to give permission prior to discharge of wastes in seawater.	a) Ministry of Shipping. b) Directorate of Environment.
For safety of all types of coastal resources and for assistance in environmental management activities, an integrated 'Coast Guard' system to be developed urgently by the Ministry of Shipping.	a) Ministry of Shipping.
Appropriate arrangement to be made for the prevention of pollution in the territorial waters, conservation of coastal and marine environment, observation and conservation of newly accreted lands in the coastal area and rational utilization of all types of coastal resources.	a) Ministry of Defence. b) Bangladesh Navy. c) Ministry of Shipping. d) Mercantile Marine Department. e) Directorate of Forest. f) SPARRSO.

Like the Environmental Policy, the action plan also suggests different steps for implementation in order to mitigate environmental problems arising from agrochemicals and industrial wastes. The production, import and use of persistent insecticides and pesticides (e.g. DDT, chlorinated hydrocarbons etc.) are proposed to be banned as early as possible through a gradual control, and an integrated pesticide management measure is to be introduced. Pollution control measures are to be taken up by all the existing industries identified as polluters and they must also do EIA studies. The plan also suggests taking necessary steps for environmentally sound exploitation of shrimp seeds and shrimp farming, and delineation of shrimp farming zones in the coastal area.

APPENDIX XV

Legislation against threats to the marine environment

National environmental legislation provides guidelines relating to the control of environmental pollution, conservation of natural resources and the protection of environmental health. About 45 laws in different areas, including coastal and marine environment and resources, have a bearing on environmental issues (IUCN, 199ld). But specific standards and enforcement mechanisms are lacking. In fact, there is yet no appropriate legislation for the protection of the marine environment and the related ecosystems of the country. As for other areas, the existing laws in this regard are also inadequate, contain glaring inconsistencies and are neither enforced nor enforceable in Bangladesh due to institutional, technical, strategic and financial constraints. Today, most of the laws are dated, inept and incoherent.

The sad legislative situation in respect of marine pollution can be gauged from the fact that, in 1989, Bangladesh failed to even file a case against a super oil tanker m.t. Filoti, after it was responsible for spilling about 3000 t of crude oil in national waters. Bangladesh is still not a signatory to the Marine Convention of 1973, under which foreign ships can he sued for damage claims upto US $ 80 million for oil spill or dumping wastes (Anon, 1992b). To become a signatory to the Convention, ports, for instance, should have reception facilities for the treatment of ballast- and bilgewaters and other wastes from foreign ships, the country should have sufficient and competent coast guards to determine the exact nature of the accidents at sea. With coast guard patrolling, other law enforcing agencies and punitive legal action all nonexistent, foreign ships discharge bilge- and ballastwaters and hazardous wastes at will, considering the Bay of Bengal as the safest dumping ground in the world. In 1988-89. a ship, the ***Falicia,*** carrying hazardous wastes, dumped its cargo in the Bay while travelling from Colombo to Singapore (Anon, 1992b). Bangladesh was not even in a position to determine if the wastes were dumped in its territorial waters or not.

The present laws, which directly or indirectly relate to coastal and marine environmental protection and resource development, are, no matter how inadequate they be, the following:

Territorial Waters and Maritime Zone Act, 1974

It was adopted for the management of maritime activities within territorial waters, with limits to be determined by the Government. The act provides for the conservation, use and exploitation of marine resources, as well as for the control of marine pollution. According to its provisions, this act enables the Government to prevent and control marine pollution and also aims to preserve the quality and ecological balance in the marine environment in the high seas adjacent to territorial waters. To this end, conservation zones may be established to protect marine resources from indiscriminate exploitation, depletion or destruction.

Territorial Waters and Maritime Zones Rules, 1977

The rules adopted in 1977, as an outcome of the Territorial Waters and Maritime Zones Act, 1974, provide for the regulation of the conduct of seabed and shipping activities within the territorial waters and economic zones of Bangladesh. They are meant to provide protection against serious marine pollution infringements, but penalties under them are nominal, the maximum penalty, for instance, being only I ,000 Taka. This is no deterrent to vessels discharging pollutants into the marine environment. In addition, there are no specific provisions under these rules for clearing oil spills within territorial waters and national maritime zones, or for exacting compensation for marine pollution (IUCN, 199ld).

Environmental Pollution Control Ordinance, 1977

This ordinance deals with the control, prevention and abatement of all types of environmental pollution, but does not make specific reference to marine environment pollution or to shipping operations. But the ordinance offers protection against pollution sources that endanger the marine environment, (ESCAP, 1988). The maximum fine the ordinance carries, however, is only 5,000 Taka.

This legislation is intended to regulate industrial and domestic wastewater discharges at the source. The law's mainstay is a mandatory pollution control system; every establishment discharging wastewater must have such a system. It does not, however, provide for any administrative mechanisms, powers and standards to ensure effective implementation. Besides the inadequate penalty for offences committed under this law, it also does not specify the impact of the agrochemicals residues on the environment (IUCN, 199ld). Further, it does not require environmental impact assessment for development projects or environmentally sound siting of industries, urban centres, etc.

Marine Fisheries Ordinance, 1983

The ordinance provides for the management, conservation and development of marine fisheries. It requires licensing of all fishing vessels, domestic and foreign. To use or attempt to use any explosives, poison or other noxious substances for the purpose of killing, stunning, disabling or catching fish is prohibited under this ordinance.

East Bengal Protection and Conservation of Fish Act, 1950

This act protects and conserves fish in national inland waters, including coastal territorial waters. It regulates the construction of temporary or permanent dams, bunds, embankments and other structures which may cause damage to fish. The penalties

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under this act, which range from 500 Taka or six months jail, are, however, inadequate. Since the officers of the Directorate of Fisheries do not have any magisterial powers enabling them to enforce the legislation, the effectiveness of the act is questionable.

Bangladesh Merchant Shipping (Amendment) Ordinance, 1988 and Bangladesh Inland Shipping (Amendment) Ordinance, 1989

Both ordinances regulate shipping, but not the pollution control measures used by ships.

Petroleum Act, 1934

This was promulgated to regulate petroleum exploitation in the offshore areas so as not to interfere with navigation, fishing and conservation of marine and seabed resources. Aspects connected with ecology and environment are also provided for under the act. It needs, however, to be ratified to meet today's challenges.

Pesticides Ordinance, 1971

The act, as amended by the Agricultural Pesticides (Amendment) Act 1980 and the Agricultural Pesticides (Amendment) Ordinance 1983, provides for the regulation of import, manufacture, formulation, sale, distribution and use of pesticides in Bangladesh in order to safeguard public health and protect animals or vegetation. It does not, however, incorporate the 'polluter pays' principle for damages arising out of the use of agrochemicals. It also does not have provisions for the control of illegal/smuggled pesticides.

Other laws relating to the land-based sources of marine pollution are:

- The Water Supply and Sewerage Authority Ordinance, 1963, and
- The Factories Act, 1965.

Draft Legislation

Protection of the Marine Environment of Bangladesh Act

This is expected to be an appropriate act for the prevention and control of marine pollution in the Bangladesh environment. The act was drafted in 1984 and redrafted in 1990 by the Shipping Department. It is yet to be adopted by the government, because the draft requires further examination in the light of the new Environment Policy enunciated in 1992 (Majumder, 1992). The draft act includes:

- Provisions on oil and pollutant discharge from ships, offshore installations and seabed exploration and exploitation.
- Provisions for pollution prevention and pollution control equipment on ships and offshore installations.
- Provisions for the transfer of oil or pollutants at sea.
- Provisions for the installation of waste reception facilities in ports and harbours.
- Appropriate enforcement machinery, including inspection, and penalties for violations.

Environment Protection Act

This draft act establishes the basis for an industrial waste permit system and assigns authority to the DOE to enter the premises, inspect and close, if necessary, any industry. A clause relating to Environmental Impact Assessment (EIA) is also contained in the ordinance.

International Conventions

International Convention for the Prevention of Pollution of the Sea by Oil, (1954). (OILPOL)

Bangladesh is party to this convention through accession and the convention has been in force in Bangladeshi waters from December. 1981.

The original convention, however, has long been superceded by another convention called the International Convention for the Prevention of Pollution from Ships, 1973, as by modified the 1978 protocols (MARPOL 73/78).

International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (1969).

Bangladesh is party to this convention through accession and the convention has come into force in the country from February, 1982.

International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 thereto (MARPOL 73/78).

Although this convention has been accepted by the major maritime nations and has come into force internationally, Bangladesh has not yet ratified it.

International Convention on Civil Liability for Oil Pollution Damage, 1969 (CLC).

This is another convention that has been implemented internationally, but which has still not been ratified by Bangladesh. The necessary legislation, however, has been prepared and will soon be incorporated into the revised Merchant Shipping Ordinance. This will eventually pave the way for the convention's ratification.

1984 Protocol to amend the International Convention on Civil Liability for Oil Pollution Damage, 1971.

The status of this convention is the same as that of the CLC, 1969.

International Convention for the Establishment of an International Fund for Compensation for Oil Pollution Damage.

Bangladesh has not yet ratified the convention and, therefore, cannot claim any damage compensation above the stated limited liability from the polluter of national waters. Neither can Bangladesh be a member of any club fighting against maritime pollution and working to ensure compensation.

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APPENDIX XVI

Other publications on the marine environment

BBS (BANGLADESH BUREAU OF STATISTICS). 1989. Statistical *Year* Book of ***Bangladesh.*** Ministry of Planning, Government of the People's Republic of Bangladesh.

HUSSAIN, A., MAHMOOD, N. and HOQ, M.A. 1977. Study on sediment samples of the Bay of Bengal off the coast of Bangladesh. The ***Oriental Geographer.*** XXI(1&2):79-84.

MAHMOOD, N. and KHAN, Y.S.A. 1976. Preliminary observation of the hydrological conditions of the Bay of Bengal off the coast of Bangladesh. ***J. Asiatic Soc. Bangladesh. (Sc.).*** I (2): 117-122.

MAHMOOD, *N.* 199la. ***Potentials and strategies of brackishwater aquaculture development in Bungludesh.*** Paper presented at the Workshop on Inland Aquacultue Development Strategies for Bangladesh, BARC/ICLARM, September 29, 1990, Dhaka. 12p.

MONDAL, A.H. 1978. Offshore coastal areas of Bangladesh. ***The Bangladesh Observer,*** May 9-10, 1978.

MPO (Master Plan Orgnization). ***1984. Second Interim Report Vol. VIII · Fisheries.*** Master Plan Organization for National Water Planning. Ministry of Irrigation, Water Development and Flood Control, Government of Bangladesh, Dhaka.

1987a. ***Technical Report No.16 · Openwater capture fishery resources.*** March 1987.

1987c. ***Technical Report No. 18 · Coastal shrimp aquaculture resources.*** March 1987.

1987d. ***Technical Report No.19 · Coastal water culture fishery resources.*** March 1987

1990. Fourth Five Yeur Plan Project Portfolio · Vol.I · National Water Plan Project · Phase II (in association with UNDP and World Bank), Dhaka, Bangladesh.

NEMCP/DOE (National Environmental Monitoring and Control Project). 1988-89. Progress Report.

NISHAT, A. 1988. Review of present activities and state of art of the coastal areas of Bangladesh. ***Proceedings, the National Workshop on Coastal Area Resources Development and Management (Port*** II). CARDMA, Dhaka, October 3-4, 1988. pp.23-35.

PRAMANIK, M.A.H. 1983. ***Remote sensing application to coastal morphological investigations in Bangladesh.*** Ph.D. thesis, Jahangirnagar University, Savar, Dhaka. 227p.

________________ 1984. Methodologies and techniques of studying coastal systems — SPARRSO case studies. ***Proceedings, National Workshop on Coastal Area Resources Development and*** Munugement (Part II). CARDMA, Dhaka, October 3-4, 1988. pp.122-138.

SATTAR, M.A. 1985. Use of pesticides in Bangladesh and protection of Environment. ***Proceedings, SAARC Seminar on Protecting the Environment from Degradation.*** Dhaka, Bangladesh. pp.58-68.

SCOTT, D.A. ***1989. A directory of Asian Wetlands. IUCN.***

SHAHJAHAN, M. 1991. Mitigation of damages due to cyclone disaster in Bangladesh. ***ADAB*** News (special issue on cyclone), April-June 1991. pp. 14-16.

STEWART, R.W., KJERFVE, B., MILLIMAN, J. and DWIVEDI, S.N., ***1990. Relative sea level change: A critical*** evaluation. Report of the UNESCO (COMAR) Working Group on Mean Sea Level Rise and its influence on the Coastal Zone. UNESCO/IOC/COMAR. UNESCO Reports in Marine Science, No.54.

STOKER, H.S. and SEAGER, S.L. 1972. ***Environmental Chemistry : Air and water pollution.*** Scott, Foresman and Company, Chicago.

WIGLEY, T.M.L. and SANTER, B.D. 1989. Future climate of the Caribbean Basin. IN : Maul, G.A. (ed.) ***Implications of climate change in the wider Caribbean region.***

APPENDIX XVII

Public awareness

All effective conservation efforts must rally people and ensure their participation in environmental restoration and conservation. Some restrictions imposed on people makes society aware of the dangers of environmental imbalances and the need to conserve the ecosystem.

Unlike developed countries, which have adequate funds and high literacy rates, public awareness-building and mass education are difficult in a country like Bangladesh. Even so, the media, the DOE (Department of Environment), NGOs and other agencies are today actively involved in meeting this challenge.

The national media is an effective tool for improving awareness of various environmental aspects. Among the leading Bangla and English dailies, for instance, *Ittefaq, Inqilaab, Azker Kagaz, Bhorer Kagaz, Dainik Bangla, Sangbad, Bangladesh Observer, The* New *Nation* etc. all focus on relevant environmental issues. Among the Chittagong-based local dailies, ***PurbaKone*** and ***Azadi*** are conscious of these issues. Commentaries on environmental aspects are often also seen in the ***Dhaka Courier.*** A milestone in this connection has been set by a weekly, *Bichitra,* which issues a multicoloured environmental supplement.

Moreover, environmental journalists in Bangladesh have recently formed the 'Forum of Environmenta! Journalists of Bangladesh' (FEJB). Its main objective is to make people environmentally conscious in their day-to-day living.

The Department of Environment (DOE) has also recently begun to pay attention to developing public awareness. It has published a booklet entitled ***Environment of Bangladesh and the Department of Environment*** (in Bangla - I55 pages)', covering various environmental issues relating to Bangladesh and the role the DOE plays in them. The booklet is distributed free. Appropriate radio broadcasts have also had a positive impact.

Various NGOs and other entrepreneurs are engaged in environmental activities. The Centre for Mass Education in Science (CMES) is one of the leading NGOs devoted to public awareness and mass education development. Unfortunately, there are no associations which pay exclusive attention to the marine or coastal environment.

APPENDIX XVIII

Abbreviations

ASA	Association for Social Advancement
BAEC	Bangladesh Atomic Energy Commission
BARC	Bangladesh Agricultural Research Council
BBS	Bangladesh Bureau of Statistics
BCAS	Bangladesh Centre for Advanced Studies
BCSIR	Bangladesh Council of Scientific and Industrial Research
BFRI	Bangladesh Forest Research Institute
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
CARDMA	Coastal Area Resource Development and Management Association
CMES	Centre for Mass Education in Science
DOE	Department of Environment
DOF	Directorate of Fisheries
EP	Environmental Policy
EPC	Department of Environment and Pollution Control
EPWAPDB	East Pakistan Water and Power Development Board
ESCAP	Economic and Social Commission for Asia and Pacific
FAP	Flood Action Plan
FEJB	Forum of Environment Journalists of Bangladesh
FRI	Fisheries Research Institute
ICDDR, B	International Centre for Diarrhoea1 Disease Research, Bangladesh
IIESDM	International Institute for Enironmental Studies and Disaster Managements
IMS	Institute of Marine Sciences
IUCN	International Union for Conservation of Nature
MEAF	Ministry of Environment and Forest
MPO	Master Plan Organization
PAB	Pesticide Association of Bangladesh
SPARRSO	Space Research and Remote Sensing Organization
UNEP	United Nations Environment Programme
WPCP	Water Pollution Control Project

Fishermen dry their nets allalong the beaches of the Indian East Coast where traditional craft, like the kattumaram, *occupy much of the rest of the space.*

The Indian East Coast

Based on
A Desk Review
by
The Central Inland Capture Fisheries Research Institute,
Barrackpore, West Bengal

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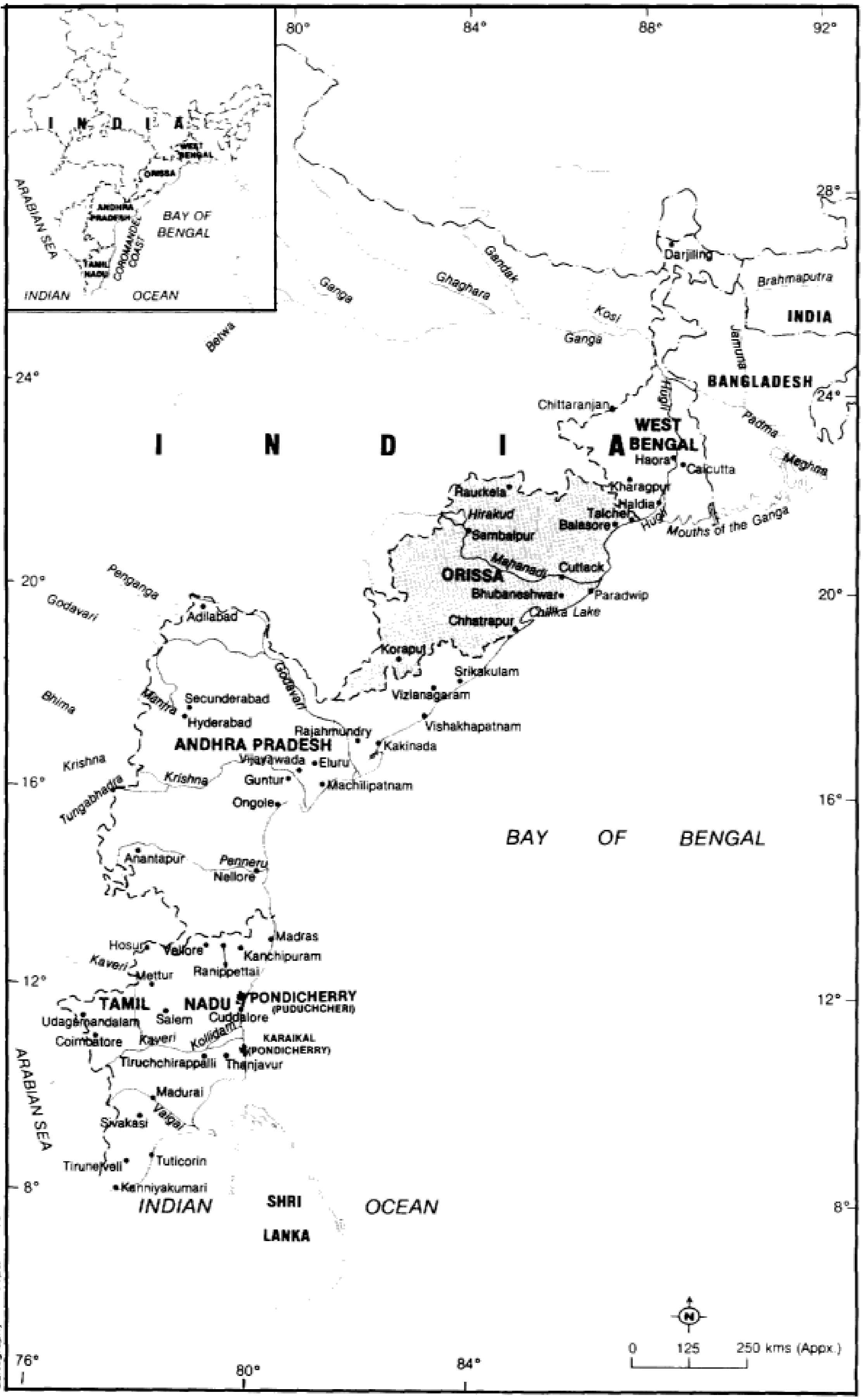
Fig. 26.Map showing the states, major rivers and important Cities of the Indian east coast



Cartography: T.T. Maps, Madras-44.

36. *THE COAST*

The east coast of India, extending from the international border of India and Bangladesh in the northeast to Kanniyakumari in the south, is *2,545* km long, covers 21 districts in the states of West Bengal, Orissa, Andhra Pradesh and Tamil Nadu and has a population of approximately 128 million. Five major and five minor ports are situated along the coast, handling a billion tonnes of goods every year. The beaches, like those at Digha, Pun, Gopalpur, Waltair, Madras and Covelong, attract tourists from all over the world, as do the scores of well-known centres of historical and religious significance along the western and northern edges of the Bay of Bengal.

The Bay of Bengal is one of the two northern embayments of the Indian Ocean, flanked by the Indian peninsular and Shri Lanka in the west and the Andaman and Nicobar Islands and Myanmar in the east. It is over 2 million km^2 in extent and acts as the recipient of two mighty rivers of the subcontintent, *viz,* the Ganga and the Brahmaputra. The other major Indian rivers that drain into the Bay of Bengal are the Mahanadi in the north, the Godavani and Krishna in the central region and the Kaveri in the south. There are also a number of minor rivers flowing through the various geological formations of the Indian subcontinent and draining into the Bay. Four states and one Union Territory (U.T.), *viz.* West Bengal (157 km), Orissa (476 km), Andhra Pradesh (974 km) and Tamil Nadu and Pondicherry U.T. (938 km) share the eastern coastline and cover continental shelf areas of 20,000, 25,000, 31,000 and 35,000 km^2, respectively (see Figure 26 on previous page). The total area of the EEZ (Exclusive Economic Zone) of India in the Bay of Bengal is *515,500* km2.

The climate of the region is subtropical to tropical and is characterized by high temperatures and medium rainfall. Virtually all the rain falls during the Southwest Monsoon (June to September), causing a drastic fall in salinity in the Bay of Bengal. Further meteorological data are given in the table below.

Meteorological parameters of the coastal states of the Bay of Bengal

	West Bengal		Orissa	Andhra Pradesh	Tamil Nadu
	Kakdwip coast	**Contai-Digha coast**			
Salinity *(ppt)*	15-27	20-30	18-35	18-33	31
Temp (°C)	25-35	22-37	10-43	20-30	27-30
Relative humidity (%)	80-92	Upto 70	61-81	60-75	—
Total rain fall (mm/year)	1722	2000	995-1914	1000-1500	900
Wind velocity (km/hr)	—	3.0-16.6	7.7-17.7 (70-120 in stormy weather)	—	5-10(100-200 in stormy weather)

The average values of salinity in the Bay of Bengal are rather low and range between 30 and 34 ppt (parts per thousand). The low salinity is mainly due to the diluting effects of the river systems of the subcontinent, discharging an estimated at 71,645 km3 of water into the bay. The discharge and drainage area and the total suspended and chemical load entering the Bay of Bengal from the six major east coast rivers are given in the table below.

Discharge and drainage area. Total suspended and chemical load entering the Bay of Bengal from six major Indian rivers

River	*Discharge (km^3/y)*	*Drainage area (km^2)x10^3*	*Load yr)*		
			Chemical	*Sediment*	*Total*
Ganga	493	750	84	329	413
Brahmaputra	510	580	51	597	648
Krishna	30	251	0.4	4	14.4
Godavari	90	310	17	170	187
Kaveri	21	88	3.5	0.04	3.54
Mahanadi	67	42	9.6	I.9	11.5

Source: Chakrapani and Subramanian (1990)

Due to the substantial discharge of water into the bay, it can be classified as an estuary. Besides, there is an annual addition of freshwater, approximately 3000 km^3, from precipitation and runoff.

The annual surface temperature varies within a narrow range of 27 to 29°C. In general, the shelf waters along the bay are nearly isothermal. The termocline, whenever found, is usually below 50-55 m and, in some cases, even below 100 to 125 m.

While circulation of water in the Bay of Bengal is, as a rule, much influenced by the monsoon winds, coastal configuration governs the water movements nearer the shores. The surface drift on the east coast during February to July is in a northeasterly direction and this turns southwesterly from September to December in the northern and southern parts of the coast. Occurrence of upwelling in the bay is less frequent and, consequently, nutrients are not present in high concentrations in the water.

The coast is endowed with extensive areas of estuaries, brackishwater lagoons, mangroves, coral reefs and seaweed beds. These coastal habitats are dynamic, rich in species and individuals and have a high production. Hence, they have great ecological, social and economic significance. These areas are important for the marine fisheries, serving as they do as nurseries for many species of fish and shellfish.

The coastal habitats are threatened by domestic, agricultural and industrial pollution as well as deforestation. Increasing transport of goods along the rivers also causes problems in the marine habitats, which are often sensitive to siltation and reduced light penetration. It is evident that many coastal areas need a higher degree of protection than they get today.

Several surveys of mangroves have been made on this coast. Some are shown in the table set alongside. Detailed information regarding the marine habitats is presented in the respective chapters on the states.

Various survey estimates of the mangrove forests of the Indian east coast and the Andaman and Nicobar Islands

Area	*Sidhu 1963 (km²)*	*Blasco 1977 (km²)*	*Govt. of India 1987 (km²)*
Tamil Nadu	26	5	150
Andhra Pradesh	184	100	200
Orissa	120	50	150
West Bengal	4189	2000	4200
Andaman and Nicobar Islands	1152	1000	1190
Tolal	5671	3165	5890

A brief profile of the four states is given in Appendix XX.

37. *LIVING AQUA TIC RESOURCES IN THE BA Y OF BENGAL*

During the Southwest Monsoon months, the seawaters by the Bay of Bengal coast attain optimum conditions for the growth of phytoplankton, due to upwelling which brings nutrients to the surface. A fall in temperature (from 3 1-32°C to 23-25°C) and salinity (from 30 to 21 ppt) also occurs during this period. Integral mean concentrations (IMC) of chlorophyll-a and phaeopigments increase from inshore to offshore. For POC (particulate organic carbon), however, the integral mean concentrations decrease (see table below).

Mean concentrations of chlorophyll-a, phaeopigments and POC in the Bay of Bengal

Parameter	*Inshore*	*Offshore*	*Entire area*
Chl.a			
Surface (mg/m³)	0.58 (0.020 . 5.717)	0.27 (0.007 - 2.159)	0.397
Column (mg/m²)	12.465 (1.108-50.545)	10.739 (1.280-28.448)	11.45
IMC (mg/m³)	0.61	0.261	0.402
Phaeopigments			
Surface (mg/m³)	0.098 (0 . 0.444)	0.083 (0 - 0.598)	0.09
Column (mg/m²)	3.726 (0.191 - 10,964)	4.850 (0.446 - 18.538)	4.396
IMC (mg/m³)	0.14	0.105	0.119
Poc			
Surface (mg/m³)	442	375	402
Column (g/m²)	11.524 (1.233 -33.534)	17.856 (2.574 - 46.101)	15.256
IMC (mg/m³)	404	344	372

(After Rudhakrishnan *et al*, 1982)

(Range is parentheses. Integral mean concentration (IMC) = 1/2 di $(d_i - d_{i-1}(a_{i-i} + a_i)$ where 'd' is the depth at which the concentrations 'a')

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The particulate organic carbon values are comparatively high because of higher surface primary production. The average rate of carbon synthesis of surface water for the Exclusive Economic Zone of the east coast is 15 mg $C/m^3/day$, which is equivalent to almost 160 g C per m^2 and year. Recent figures of the rate of carbon synthesis in the northern Baltic proper in Europe amounted to 200 g C per m^2 and year (Swedish Environmental Protection Agency, report number 3989, in Swedish). In spite of lower temperatures and a shorter vegetation period, the production in the Baltic proper is very high due to the large input of nutrients from human sources.

Benthic biomass distribution is shown in Figures 27 a and 27 b below.

Fig. 27 a. Distribution of macrobenthic biomass

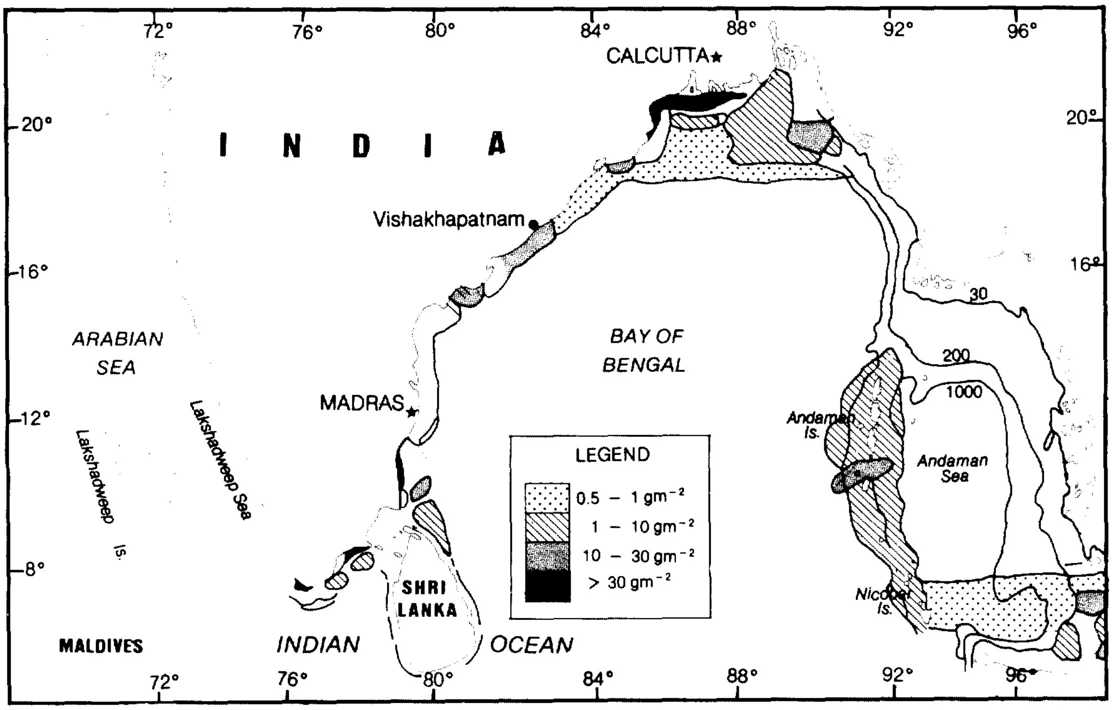
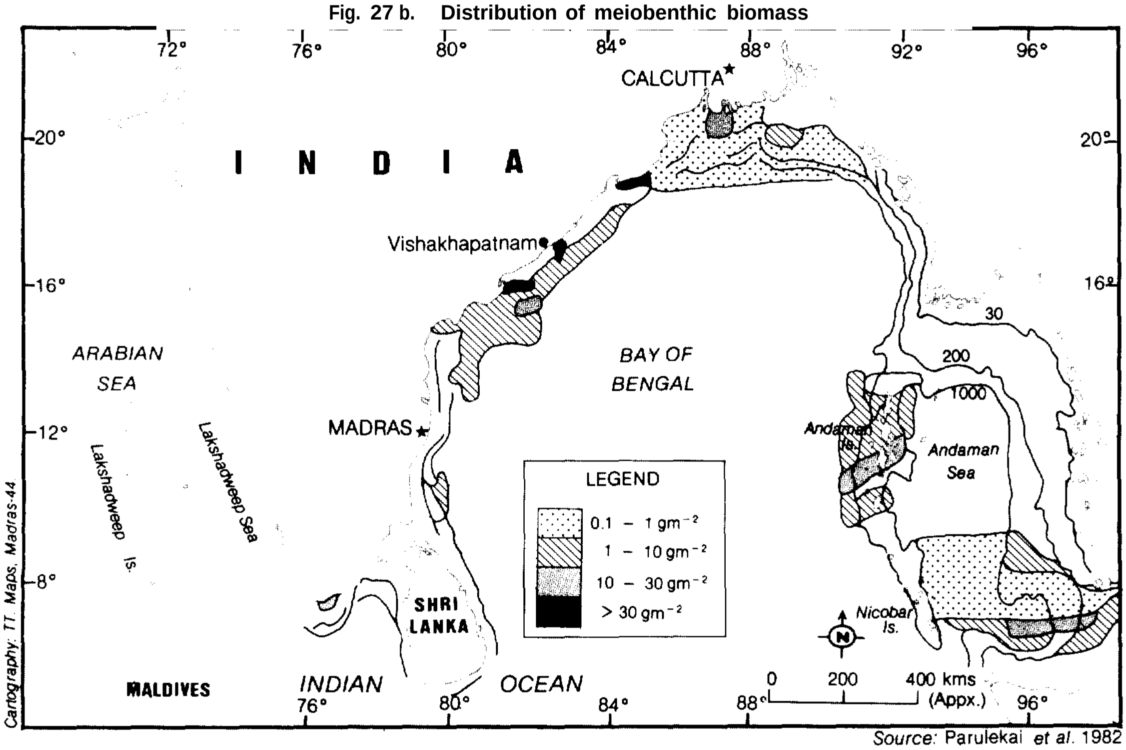


Fig. 27 b. Distribution of meiobenthic biomass



Source: Parulekai *et al.* 1982

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The Bay of Bengal supports a rich marine fishery, which chiefly consists of fish and crustaceans, besides other biological resources like molluscs, corals, sponges, echinoderms and seaweeds. An average of almost 200,000 *t* of pelagic fish and some 270,000 t of demersal fish and shrimp are landed annually (see table alongside).

The major groups are silverbellies, anchovies, other sardines, catfish, elasmobranchs, croakers, ribbonfish, pomfrets, H*ilsa*, shad, carangids, perch, Bombay Duck and shrimp. Fisheries statistics are given in the table below.

Statewise marine fish catch (in t) from the Bay of Bengal during 1987-1990

Stare or territories	*1987-88*	*1989*	*1990*
West Bengal	61,800	96,900 (13,400)	123,000(17,000)
Orissa	57,000	82,455 (4557)	52,832(2750)
Andhra Pradesh	139,399	124,944 (18,162)	135,121 (17,979)
Tamil Nadu	219,000	293,129 (11,734)	306,733 (19,402)
Pondicherry	20,241	32,187 (2686)	35,26! (3571)
Andamans	10,951	15,036 (213)	13,770 (240)

Note Marine fish landings for West Bengal include landings at Digha and Sankarpur

Source: Fishing Chimes, 11(3): 63 (June, 1991)

Figures in brackets indicate catches of marine shrimp (Out of total)

Fisheries **statistics along the Bay of Bengal coast**

State	*No. offishing villages*	*No. of landing centres*	*Area of brackish water bodies (ha)*	*Marine fishermen*	*Potential brackish water aquaculture area (ha)*	*Area under brackishwater farming (ha)*
West Bengal	652	47	210,000	404,000	300,000	30,000
Orissa	329	62	574,000	521,439	15,330	1500
Andhra Pradesh	409	379	64,000	605,796	17,000	1000
Tami! Nadu	442	343	56,000	520,903	80,000	100
Pondicherry	45	28	negligible	27,865	480	—
Andatmans	43	54	115,000	2225	37,900	—

Source: Govt. of India (1988).

In certain areas, especially West Bengal, there seems to be a potential for increased fishing efforts. (See table below on benthic biomass, annual production, exploited and potential yield from the continental shelf.)

Benthic biomass, annual production, exploited and potential yield from continental shelf

Region	*Mean biomass (g/m^2)*	*Annual carbon production mean ($g\ C/m^2 yr$)*	*Annual biomass prod. (tons/yr)*	*Potential yield (kg/ha)*	*Exploited catch (kg/ha)*
Tamil Nadu	1191	2.139	$0.8x10^6$	238	159
Pondicherry	1.13	0.352	$8.3x10^3$	22	58
Andhra Pradesh	3.42	1.066	$0.2x10^6$	68	152
Orissa	7.34	1.760	$0.3x10^6$	147	52
West Bengal	45.49	11.853	$2x10^6$	909	35
Andamans	7.62	1.273	$0,2x10^6$	158	3

Source : Parulekat *et al*, 1982.

38. MARINE *POLLUTION IN THE BA V OF BENGAL*

The exponential growth of population, the rapid pace of industrialization and urbanization, and the increasing use of fertilizers and pesticides in agriculture are mainly responsible for pollution along the Bay of Bengal coast. The main sources of pollutants are

- Domestic wastes
- Industrial wastes from textile mills, chemical plants and pharmaceutical, plastic, detergent, food processing, jute and tyre factories etc.
- Pesticides and insecticides used in agriculture and healthcare, including chlorinated hydrocarbons like DDT, BHC, Endrin and Dieldrin and organophosphates such as Malathion, Parathion, Diazinon etc.
- Petrochemical substances, from oil exploration, refineries, oil tankers, ships, fishing vessels etc.
- Radioactive wastes, from nuclear power stations.
- Heated effluents discharged from thermal (coal-based) power stations.

38.1 *Heavy metals*

Industrial activities are the main cause of heavy metal pollution. River runoff is the natural source of metals in ocean waters. Some metals are toxic in nature, *e.g.* cadmium, mercury and arsenic. Since sediments act as reservoirs of metals, the river mouth sediments of the Ganga, Kaveri, Krishna, Godavari and Mahanadi show a sudden increase of metal concentrations, compared to inter-riverine coastal sediments. The quantity of heavy metals, such as zinc, copper, nickel, chromium, mercury, cadmium, cobalt, lead and arsenic, discharged into the Bay are considerable. Some figures of heavy metals in sediments and in fish are shown in the tables below. It should be pointed out that the concentrations of metals in sediments do not necessarily correspond to the concentrations, in the water. When analyzing sediment concentrations it is important to know the water content and the organic content of the sediment samples.

Heavy metals in sediments of various estuaries of India's east coast and in the Bay of Bengal (in ppm)

Source of sediments	*Manganese*	*Nickel*	*Copper*	*Zinc*	*Chromium*	*Lead*	*Cadmium*
1. Kaveri estuary							
a, bed	1310	379	33	75	229	38	1.8
b. sediment	1968	379	55	347	246	38	3.4
2. Ganges estuary	732	49	44	151	98	32	—
3. Krishna estuary	6978	149	69	1482	174	4*	
4. Godavani estuary	1294	91	119	—	128	5*	
5. Narmada estuary	077	81	136	140	—	—	—
6. Tapi estuary	1125	70	128	125	—	—	—
7. Southeast coast of Indta	337	—	17	62	138	53	2.7
8. Bay of Bengal	529	64	26	—	84	—	—
For comparison							
9. Baltic Sea, Europe (average pee-industrial sediments)	600	41	46	115	51	19	0.3

Sources : (1) Subramanian *et al.,* 1989; (2) Subramanian *et al.,* 1988; (3) Ramesh and Subramanian. 1988; (4) Biksharn and Subramani, 1988; (5) Subramanian *et al.,* 1985: (6) Borole*etal.,* 1982; (7) Subrarnanian and Mohanachandran, 1990; (8) Sarin *et al., 1979.*
* Subrarnanian *et al.,* 1985.

Ranges and average concentrations of some toxic heavy metals (ppm wet weight) in different body parts of fish from the northern Indian Ocean

Body parts	*Mercury*		*Cadmium*		*Lead*	
	Ranges	*Average*	*Range*	*Average*	*Range*	*Average*
Muscle	ND-0.36	0.07	ND-3.24	0.59	ND-3.43	1.11
Liver	ND0.04	0.01	1.2-87.3	20.18	1.17-62	3.80
Gill	ND-0.03	0.016	ND-0.7	60.42	1-7.0	3.14
Heart	ND-0.08	0.026	ND-1.91	0.54	1-3.4	.36
Kidney	ND-0.04	0.015	0.38-36.69	9.00	l-69.46	8.61
Gonads	ND-0.03	0.015	ND-8.06	1.25	1-4.76	.36

ND. — Nondetectable

Source : Kureishy, 1985

Samples of herring *(Clupea harengus)* liver (for Hg muscle) collected from the southern Baltic Sea during 1980-1988 showed the following, very approximate concentrations (wet weight): 0.02 ppm mercury, 0.03 ppm cadmium and 0.07 ppm lead (HELCOM,l990). When comparing the metal concentrations in fish tissue, it is essential to know the size/age and species of fish. The herring, a small and shortlived species, naturally have lower concentrations of metals than larger, more long-lived species such as tuna. However, the concentrations of cadmium and lead indicated in the table above seem remarkably high, despite the fact that information regarding species, sampling, analyses etc, is not available. The WHO-limit for mercury in fish meat used for human consumption is 0.5 ppm (wet weight). Since bioaccumulation of metals occurs, high concentrations in sediments and water should be taken as a serious warning. The Tamil Nadu section of this survey contains further complementary information on heavy metals.

38.2 Pesticides and insecticides

About 78,000 t of pesticides and insecticides are used in India every year at present, of which approximately one third is by Andhra Pradesh. It is estimated that about 25 per cent of these substances finally reach the sea (Qasim and Sengupta, 1992) and 0.1 per cent of the total quantity used is bioaccumulated in marine biota.

The major cause of pesticide hazard is faulty application and negligence on the part of the farmer in adopting simple precautionary measures. Added to this is a lack of knowledge about proper dosage.

Kannan et *al.* (1992) have studied the persistence of organochlorine residues in foodstuffs and their implications on human dietary exposure. There has been a high level of food contamination with HCH, DDT, Aldrin and Dieldrin throughout India. Dairy produce and livestock meat are the products most contaminated. Concentrations of organochlorine compounds in a few dairy products were above the maximum residue limits set by the FAO/WHO as well as by the Indian Ministry of Health. The average daily intake of HCH and DDT was estimated to be 115 and 48 micrograms/person respectively: this is higher than quantities observed in most developed nations. The dietary intakes of Aldrin and Dieldrin also exceeded the acceptable daily intake recommended by the FAO/WHO.

Pesticide residues are also found in shrimps, bivalves, gastropods, molluscs and fish. Commercially valuable fish are often contaminated by pesticides. Big shipments of contaminated shrimps have, in fact, been returned from Japan and Europe. The concentration (in micrograms/gram wet weight) of persistent organochlorine residues in mussels ***(Perna verdis)*** at different places along the Indian coast are tabulated below.

Concentration in (micrograms/gram wet weight) of persistent organochlorine residues in mussels (Perna verdis) from the Indian coasts

Sampling location	*Sampling date*	*Fat %*	*HCHs*				*DDTs*					
			αE-HCH	β–HCH	d-HCH	E-HCH	opDDE	ppDDD	opDDT	ppDDT	EDDT	PCBs
Ennore estuary mouth, Madras	21.8.1988	0.33	1.40	3.80	0.50	5.70	3.80	6.20	<0.50	5.80	16.00	7.10
Kasimedu-Royapuram Fishing Harbour, Madras	30.8.1988	0 41	1.90	1.70	0.70	4.30	17.00	11.00	co.50	5.10	33.00	5.80
Pondicherry Harbour	21.8.1988	0.60	5.20	2.30	1.10	8.60	4.20	4.90	<0.50	6.50	16.00	1.80
Cuddalore Habour	21.8.1988	0.32	2.20	0.50	2.50	5.20	2.30	1.40	<0.50	1.50	5.20	<1.00
Vellar Estuary, Porto Novo	17.2.1989	I.80	6.00	8.40	I.20	16.00	2.00	0.90	0.59	1.00	4.50	2 00
Nagapattinam Harbour	28.8.1988	0.29	3.40	3.20	0.80	1.40	1.10	0.70	40.50	0.90	2.80	2.00
Calicut	1.12.1988	3.80	3.30	1.40	0.90	5.60	2.50	3.00	9.20	co.50	6.00	5.70
Suratkal	6.5.1989	3.50	6.00	1.70	2.00	9.70	12.00	25.00	2.30	<0.50	39.00	4.20
Goa Harbour	25.2.1989	2.10	3.20	I.00	0'0	4.90	4.10	11.00	5.60	16.00	37.00	4.00

Source : Ramesh et al., 1990

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If a comparision is made with the consumption of pesticides from different places in the world, the Indian figures are comparatively low (see table below left). The second table below shows some pesticide concentrations in paddy fields in different countries. The pesticides now used in Western countries are, however, in general more easily degradable and, hence, more harmless. The use of persistent chlorinated pesticides has been banned in most Western countries, but their use persists in developing countries like India, due to their low cost, easy availability, long-lasting effects and easy usage.

Pesticide consumption in Orissa as compared to other countries and states of India

Name of the country or state in India	*Year*	*Pesticides consumed (g/ha)*
Japan	1973.74	10,790
Europe	1973-74	1890
U.S.A.	1973-74	1490
Africa	1973.74	127
India	1987-88	538
Haryana	1983	500
Punjab	1983	600
Andhra Pradesh	1983	700
Assam	1983	100
Orissa	1988-89	290

Source: Mitra. 1990

Mean concentration of HCH and DDT in paddy soils from various countries

Locallity	*Survey year*	*Concentration* HCH	*(ng/g)* DDT
Japan	1974	34.0	not analyzed
USA	1972	not analyzed	80.0
Indonesia	1982	8.9	1.2
Taiwan	1981	1.9	12.0
Malaysia	1981	5.3	5.3
S. India	1988-89	18.0	2.7
Vellar watershed (TN)	1988	120.0	1.9

Source; Ramesh et *al.* (1991)

APPENDIX XIX

Institutions engaged in environmental research, monitoring and enforcement

The following organizations are engaged in studies of the marine environment in India :

Dept. of Agricultural Engineering, Indian Institute of Technology, Kharagpur 721 302, West Bengal.

Dept. of Marin Science, Calcutta University, 35 B C Road, Calcutta 700 019, West Bengal.

Centre for Environmental Studies, Dept. of Civil Engineering, Jadavpur University, Calcutta 700 032, West Bengal.

Dept. of Chemistry, Vishvabharati, Santiniketan 731 235, West Bengal.

School of Basic Medical Sciences, Mahatma Gandhi University, Gandhinagar, Kottayam 686 008, Kerala.

Centre for Earth Science Studies, P B No. 7250, Akkulam, Thiruvananthapuram 695 031, Kerala.

Central Salt and Marine Chemical Research Institute, Bhavnagar 364 002, Gujarat.

Dept. of Geology, Aligarh Muslim University, Aligarh, Uttar Pradesh.

Port Trust, Calcutta, West Bengal.

Central Soil Salinity Research Institute, Canning, West Bengal.

Zoological Survey of India, Calcutta.

Central Institute of Brackishwater Aquaculture, Kakdwip, West Bengal.

Sundarbans Development Board, Govt. of West Bengal, Calcutta, West Bengal.

River Research Institute, Mohanpur, Nadia, West Bengal.

Dept. of Forest, Govt. of West Bengal, Alipur, West Bengal.

Central Water Pollution Control Board, Salt Lake, Calcutta, West Bengal

Dept. of State Fisheries, West Bengal, 8 Lindsay Street, Calcutta.

APPENDIX XX

Profiles of major Indian states on the Bay of Bengal coast

WEST BENGAL

Length of coastline	157 km
District (population in millions)	24 Parganas, North and South (10.7); Calcutta (4.4); and Midnapore (8.4).
Drainage systems	1. Hugli estuary (Haldia, Rupnarayan and Damodar). 2. Rasulpur (Other estuaries are not much polluted).
Major industries	Pulp and paper, textile, chemicals, pharmaceuticals, plastic, food, leather, jute, tyre, fertilizer, oil refineries. distilleries etc.
Ecologically sensitive areas	1. Tiger reserve project. 2. Crocodile breeding and rearing project. 3. Sajinakhali bird sanctuary. 4. Mangrove forest of Sundarbans.
Places of special interest	1. Beaches of Digha, Bakkhali and Sagar Island. 2. Pilgrim centre at Sagar Island.
Major ports	Calcutta and Haldia
Fishing activities	1. No. of fishing villages — 652 2. Marine fishermen — 404,000 3. Fish landing centres — 47 4. Area under brackishwater farming (ha) — 30,000 5. No. of craft Traditional — 4601 Mechanized — 1582 6. Fishing harbours — Sankarpur and Raichawk.

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ORISSA

Length of coastline

476 km

Districts (population in millions)

Balasore (2.3), Cuttack (4.6), Puri (2.9) and Ganjam (2.7).

Drainage systems

1. Subarnarekha
2. Jamir
3. Burnabaiang
4. Baitarani (Dhamara)
5. Brahmani (Maipura)
6. Mahanadi
7. Baranel
8. Devi
9. Bhargavi and Daya
10. Rusikulya

Major industries

Chemical, pharmaceutical, leather, rubber, plastic, metal products, food products, textile. electrical machinery etc.

Ecologically sensitive areas

1. Chilika, the largest brackishwater lake in Asia
2. Bhitarkanika Wild Life Sanctuary.
3. Mangrove forests of Brahmani and Baitarani delta.
4. Bird sanctuary of Nalbasa Island.
5. Danghmal crocodile project.
6. Satbhya turtle rookery.

Places of special interest

1. The beaches of Astarange, Konarak, Puri, Aryapalli and Gopalpur.
2. Sun Temple at Konarak and the Lord Jagannath Temple at Puri.
3. Pilgrimage centres of Aredi on the river bank of Baitarani.
4. Dhamara tourist resort.
5. Baliapal Agni Rocket Launching Station.

Major ports

Paradwip and Aryapalli near Gopalpur.

Fishing activities

1. No. of fishing villages	—	329
2. Marine fishermen	—	521,439
3. Fish landing centres	—	62
4. Area under brackishwater farming (ha)		1500
5. No. of craft		
Traditional	–	10,579
Mechanized	—	674
6. Fishing harbour	—	Dhamara

ANDHRA PRADESH

Length of coastline	476 km
Districts (population in millions)	Srikakulam (2.0), Vishakhapatnam (2.6). East Godavari (3.8). West Godavari (2.9). Krishna (3.0), Guntur (3.4) and Prakasam (2.3).
Drainage systems	1. Navpada 2. Vamsdhra 3. Nagavai 4. Peddagedda 5. Kandivalasa 6. Nelhmaria 7. Gosiani 8. Narayagida 9. Sarada 10. Varaha 11. Tandava 12. Eluru 13. Godavari 14. Krishna 15. Gundlakamma 16. Musi 17. Palleru 18. Manneru 19. Penneru 20. Upputeru 21. Swarnamukhi 22. Kalangi through Pulicat Lake.
Major industries	Paper and pulp. textile, chemical, pharmaceutical, tanneries, fertilizers, rubber, electrical products, battery, salt production centres at Ramchandrapuram, Machilipatnam and Tekkali.
Ecologically sensitive areas	1. Mangrove forest areas at Nizampatnam, Pandipora, Machilipatnam and Coringa Island.
Places of special interest	1. Sriharikota Satellite Launching Station. 2. Pilgrim centres at Kollapatnam and Antarvedi.
Major ports	Vishakhapatnam, Kakinada, Machilipatnam, Bheemunipatnam, Narsapur, Krishnapatnam, Vadarevu and Kalingapatnam.
Fishing activities	1. No. of fishing villages — 409 2. Marine fishermen — 606,796 3. Fish landing centres — 379 4. Area under brackishwater farming (ha) — 1000 5. No. of craft Traditional — 57,458 Mechanized — 1009 6. Fishing harbours — Vishakhapatnam, Kakinada, Nizampatnam and Bharanapada.

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TAMIL NADU

Length of coastline	938 km
Districts (population in millions)	Madras (3.3). South Arcot (4.2), Chidambaram (1.4), Thanjavur (4.0). Pudukkottai (1.2), Ramanathapuram (1.0) and Kanniyakumari (1.4).
Drainage systems	1. Arni 2. Cooum 3. Adyar 4. Palar 5. Ponnaiyar 6. Chunnambar 7. Uppar 8. Pannaiyar 9. Godilam 10. Vellar 11. Kollidam (Coleroon) 12. Kaveri 13. Varshalee 14. Manimuttar 15. Vaigai 16. Vaippar 17. Chittar
Major industries	Paper and pulp, wood products, food products, transport equipment, tannery, metal products, fertilizers, chemical, engineering, thermal power, salt production centres at Vedaranniyam, Marakkanam and Tuticorin.
Ecologically sensitive areas	1. Mangrove forest area at Pichavaram near Parangipettai (Porto Novo). 2. Bird sanctuary and wild life and forest conservation zone near Point Calimere. 3. Oyster beds near Point Calimere. 4. Coral reef near Mandapam. 5. Shell fishing area within Tuticorin harbour. 6. Sanctuary for coastal fauna at Kurusadai Island. 7, Sponge beds at Manoli and Putti Islands. 8. Windowpane shell fisheries at Point Calimere.
Places of special interest	1. Beaches in Madras, Kovalam and Pondicherry. 2. Atomic power station at Kalpakkam. 3. Offshore oil exploitation near Madras and Kaveri delta, Palk Bay. 4. Shrines'at Mamallapuram. Rameshwaram, Tiruchendur and Kanniyakumari.
Major ports	Madras, Tuticorin, Cuddalore and Nagapattinam
Fishing activity	1. No. of fishing villages — 449 2. Marine fishermen — 520,903 3. Fish landing centres — 343 4. Area under brackishwater farming (ha) 100 5. No. of craft Traditional — 39,367 Mechanized — 2514 6. Fishing harbours Cuddalore, Tuticorin, Madras, Nagapattinam and Pazhaiyar.

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The backwaters of West Bengal, where fishing is a way of life.

West Bengal, Indian East Coast

Summary of impressions from a visit to West Bengal in April 1992 by Dr Staffan Holmgren, BOBP. and of the discussions he had with the staff of the Central Inland Capture Fisheries Research Institute, Barrackpore, West Bengal.

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39. THE GANGA AND THE HUGLI ESTUARY*

39.1 *Estuarine fisheries in West Bengal*

Of the 172 species of fish recorded in the Hugli-Matlah estuarine system, 73 are from the upper freshwater zone and 99 from the more saline marine zone. The fisheries of the system have been reported upon by Gupta (1970), De (1910), Naidu (1952), Jhingran and Gopalakrishnan (1971), Dutta et al. (1971) and others. The table alongside shows landings of important species from the Hugli-Matlah estuarine system during 1990-9 1.

Specieswise landing from Hugli-Matlah estuarine system during 1990-91 (in t)

Tenualosa ihsha	1622.9
Setipinna spp.	3293.7
Trichiurus spp.	29966
Harpodon nehereus	4932.8
Pama pama	3756.1
Sillaginopsis panijus	23.3
Tachysurus jella	597.7
Polynemous paradaeus	188.9
Coilia spp.	801.8
Tenualosa toli	49.2
Ilisha elongata	447.4
Elutheronema tetradactylum	14.6
Otolithoides biauratus	303.6
Pangasius pangasius	11.1
Lza parsia	20.4
Lores calcarifer	6.2
Pampus argenteus	452.5
Shrimp	2419.3
Miscellaneous	7733.2

39.2 Pollution in the estuary

The conditions in the Ganga in general and especially in the Hugli estuary are quite bad. The Hugli estuary is probably one of the most polluted estuaries in the world, with serious damage to fish and aquatic fauna and flora. In parts of the Ganga and Yamuna, sewage discharges cause anoxic conditions that result in no fish or zooplankton being present from January to August and a reappearance of the rotifer *Keratella* in September.

In 1981, there were 317 major industrial units operating along the banks of the Ganga and only 30 per cent of them followed some type of pollution control measures. Mixed discharges of industrial and domestic effluents were common. There were 96 factories from Nabadwip Island to the bar mouth discharging the impressive amount of almost half a billion litres of untreated wastes every day. Almost everything producing hazardous wastes are there: pulp and paper mills, pesticide manufacturing plants, chloralkali plants, distilleries, yeast, rayon, cotton, thermal power plants, and vegetable oil and soap, fertilizer, antibiotic factories etc.

In 1960, a rather comprehensive study was made of the environmental conditions in the Ganga and the Hugli estuary. A similar study was made in 1988 and it showed a clear deterioration in the Ganga. Chloride concentrations and alkalinity had increased, while oxygen had decreased. The nutrients had increased significantly. Surprisingly, there were no significant changes in the chemical parameters in the Hugli estuary during the period. The regular flushing by tidal water had evidently taken all wastes out to the sea and the estuary itself had not changed significantly.

A look at the statistics for fish catches was still more intriguing. In the Ganga, the catches had fallen from 50.3 kg/ha/year in 1960 to less than 20 kg in 1988. Of the 600 species found in the

* The figures regarding the environmental status of the river Ganga and the Hugli estuary are from the Central Inland Capture Fisheries Research Institute.

Ganga, 100 were endangered. In the estuary, the catches had increased: 1960: 7.5 t, 1970: 14.6 t and 1980: 24 t. Most of the increase was from the outer zone of the estuary. Scientific measures of the primary production showed that it was a real increased production and not increased fishing effort. If average primary production is set at 1 in the Ganga, it is 0.5 in the inner and middle zones and 2 in the outer zone. While there is damage in the inner zones due to pollution, the increased loads of nutrients in the outer zone have evidently been beneficial to fish production. In the estuary, almost 200 kg of fish is harvested/ha and year and this could be increased seven times without endangering the stocks (see Figure 28).

If chemical analyses are compared between 1960 and 1988, the following trends can be identified: pH decreased a little in the upper zone, but was surprisingly stable in the rest of the river; chloride and alkalinity increased due to sewage discharge and irrigation; oxygen concentrations were lower in areas with sewage and industrial discharges (Kanpur and Allahabad) and nutrients have increased somewhat, but not alarmingly. Conditions in the estuary have not changed significantly due to rapid changes, because of tidal damming up at high tide, flushing out at low tide. Also, freshwater discharge from Farakka has a remarkable ameliorating effect on pollution in the river/estuary. The industrial discharges are brought further out to sea. This method of diluting the pollutants is not a satisfactory method of combating pollution, the problems being just transferred to the sea instead. Riverine and estuarine plankton composition has changed significantly during the period with decreasing diversity indicating pollution. Bottom fauna has increased remarkably almost everywhere.

The N-content of fertilizers used in the Ganga area is about 900,000 t, P=200,000 t and K= 100,000 t. Ten to fifteen per cent of this will eventually end up in the sea.

About 3000 t of pesticides are used. The residues of DDT and BHC-Y in fish were highest in the industrial area of the tidal stretch of the river as compared with the estuary and river. Molluscs had the highest concentration of DDT: 65-150 ppb. Fish had 31-460 ppb, plankton 40-90 and sediments 20-70 ppb. The biomagnification, as compared with ambient water was almost 20,000 times for molluscs, 10,000 times for fish, 5000 times for gastropods and 2500 times for plankton. Analyses of fish in the Hugli estuary revealed that most fish had DDT residues. Large Hilsa had surprisingly low values. Less than lethal effects that DDT and BHC have had on fish are decline in growth, blood Hb and liver damage.

Heavy metals are found in fish in the Hugli estuary (see table alongside). Zinc in fish kidney up to 300 ppm has been recorded as well as high levels of copper, chromium, cadmium, lead and mercury. One fish at Delhi had 1.4 mg mercury/kg. In general, however, most values for heavy metals, as well as DDT in biota, were one or two orders of magnitude lower than what is found in Europe. But due to the stable and bioaccumulative nature of these substances, the concentrations found should be seriously considered.

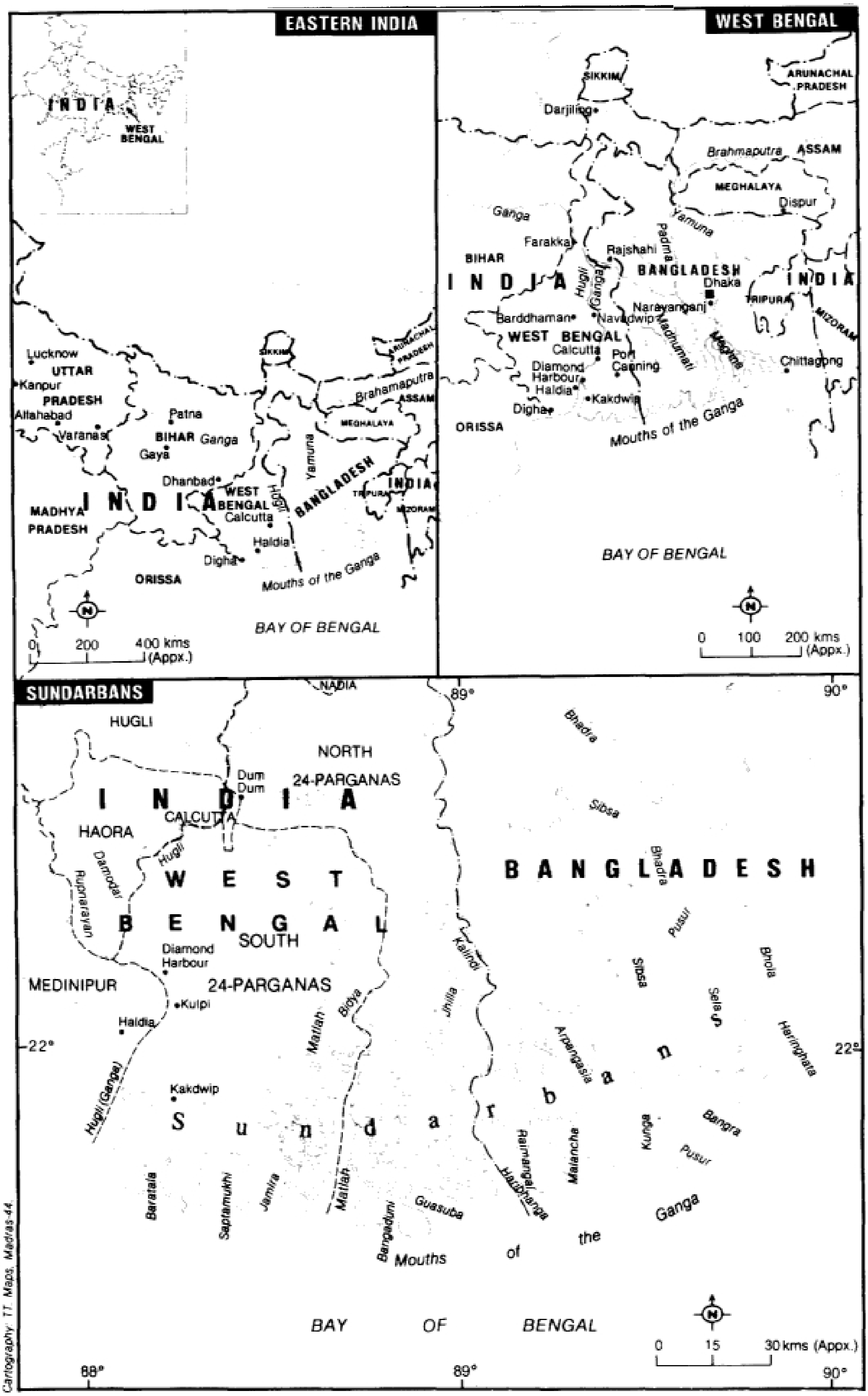
Mean composition of the sediments of the Ganga and Hugli (values in ppm)

Metals	Hugli estuary		Ganga	
	Bed	Suspended	Bed	Suspended
Chromium	61	98	52	264
Manganese	553	732	400	3450
Iron	31,036	42,111	21,600	99,000
Cobalt	36	53	22	223
Nickel	32	49	20	137
Copper	26	44	21	252
Zinc	71	151	46	1836

39.3 Fish ponds

Almost all the municipal waste of Calcutta passes through one or two systems of fish ponds before it is released into the Hugh River. The Mudiali Fishermen's Cooperative is one of the

Fig. 28. West Bengal and the Sundarbans



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eighty cooperatives that have succeeded in using wastewater, in this case even industrial wastewater. By having the wastewater pass an ingenious system of ditches with dense vegetation of water hyacinths, *Eichhornia,* and *Valesneria,* they are able to use the treated water to produce 5-7 t of fish, without any addition of feed or fertilizers. By refining the method, they claim they can produce 15-20 t of fish/ha. They also use the treated waste water to irrigate and fertihze gardens and orchards. The income from the fish ponds, together with vegetables and fruit, can support about 2000-3000 people on 65 ha. The area had earlier been wasteland, belonging to the Port Authority, which had used it for waste disposal.

Most cooperatives and private enterprise fish ponds take their waste water from the main canal that has virtually only municipal waste. The industrial waste is usually led into a separate storm drainage canal. All values for mercury and pesticide residues in the flesh of fish grown in the ponds, as well as bacterial contents, were found to be well below WHO recommendations.

40. MANGROVES

40.1 *Mangroves*

The total area of mangroves in India is estimated at 6740 km^2. The east coast is endowed with the world's largest mangrove forest, the Gangetic Sundarbans in West Bengal (see Figure 28 on p. 151).

The Sundarban mangroves are of the deltaic type and show luxuriant and gregarious growth in the rich alluvial deposits at the mouth of the Ganga-Brahmaputra river system. As the freshwater discharge in this mangrove area is on the decline, the denudation process has started with the rise in the salinity of the region.

In the 4264 km^2 of the Sundarbans, mangroves like *Ceriops tagal, Excoecaria agallocha, Heritiera fomes, Sonneration apatala, Nypa fruteams* etc. are found. But more abundant are *Avicennia marina, A. alba, A. officinalis* and *Phoenix paludosa.* The Sundarbans is endowed with 30 of the 53 species of true mangroves in the world. Besides these, there are a good number of mangrove associates and obligatory mangroves. Weed flora, non-littoral plants and aquatic flora are also available.

Ghosh (1989) has provided fairiy good details about the living natural resources of the Sundarbans, which include benthic fauna and other species dependent on them. The region is rich in living natural resources. At least 70 species of common mangrove vegetation (including 30 tree, 20 shrub and 20 herb species) have been recorded from the Sundarbans delta. Besides the dominant flora, at least 16 species of algae, 33 species of phytoplankton and 184 species of fungal flora, including new species, have been documented in the mangrove swamps of this zone (Anon, 1987). These indicate the extent of available biomass and dynamics of the ecosystem. The components of the food-chain in an active cycle support a wide array of fauna.

At present, the undermentioned organizations, besides the West Bengal Forest Department, are working on the mangroves in West Bengal.

Central Inland Capture Fisheries Research Institute, Barrackpore.

Calcutta University, Calcutta.

Central Soil Salinity Research Institute, Canning.

Bidhan Chandra Krishi Viswavidayalaya, Mohanpur.

Botanical Survey of India, Calcutta

APPENDIX XXI

Other publications on the marine environment

ANON. Formation of the barrier spit and other sand ridges near Chilika Lake in the east coast of India. *Mar.* Geog. 9: 101-l 16.

BUTLER, E. l. 1972. Chemical survey of Tamar Estuary, properties of the water. J. Mar. *Biol. Assn. 52,* 681-699.

CHACKO, P. I. 1953. On the plankton of three freshwater ponds in Madras city, India. *Proc. Indo-Pacific Fish Council* (UNESCO) 1954. 103-7.

GANAPATHI, P.N. and RAO, T.S.S. 1959. Some remarks on the hydrography and biology of the Bay of Bengal. *J. Mar. Biol. Assn. India. I: 224-227.*

DHAL, A. L. 1984. Oceania's most pressing environmental concerns. *Ambio.* 13: 297-301.

GOUDA, R. and PANIGRAHY, R.C. 1992. Seasonal distribution and behaviour of silicate in Rushikulya estuary, east coast of India. *Ind. J. Mar. Sci.* 21: 111-115.

HOLEMAN, J.N. 1968. The sediment yield of major rivers of the world. *Water Resources Research. 4:787-797.*

KUREISHY, T.W. et al. 1978. DDT contamination in zooplankton from the Arabian Sea. *Ind. J. Mar. Sci. 7: 54-55.*

KUREISHY, T.W. and GEORGE, M.O. 1978. DDT contamination in zooplankton from Arabian Sea. *Ind. J. Mar. Sci.* 7, 54-55.

PARULIKAR. 1977. Toxicity tests of oil dispersants on some marine animals. *Mahasagar,* Bull. of NIO, India. 10 (3 and 4). 109-115.

PANIGRAHY, R.C. and GOUDA, R. 1990. Occurrence of bloom of the diatom *Asterionella glacialis* (Castracane) in the Rushikulya estuary, east coast of India. *Mahasagar J.* Oceanogr. Limnol. 23: 179-182.

QASIM and SENGUPTA. 1988. Pollution of the seas around India. *Proc. Ind. Acad. Sci.* (Anim. Sci). 97 : 117-131.

RAMAN et. al. 1975. Studies on the hydrobiology and benthic ecology of Pulicat Lake. *Bull. Dept. Mar. Sci.* Univ. Cochin. VII: 855-884.

RAY, S.B. 1984. Suspended matter, major cations and dissolved silicon in the estuarine waters of the Mahanadi River. *Ind. J. Hydrols. 69:* 183-196.

RODRIGUEZ, A. 1981. Marine and coastal environmental stress in the wider Caribbean region. *Ambio. 283-294.*

SLJBBARAJU, R.C. and KRISHNAMURTHY, K. 1972. Ecology aspects of plankton production. Mar. *Biol.* 14: 25-31.

SUBBA RAO, D.V. 1969. *Asterionella japonica* bloom and discolouration off Waltair, Bay of Begal. *J. Limnol. Oceanogr.* 14: 32-34.

SAUZGIRI, et. al. 1979. Total mercury concentrations in waters of the Laccadive Sea. *Ind. J. Mar. Sci. (4) 2.*

SAHA, G.H. er. al. 1971. Studies on the seasonal and diurnal variations in physico-chemical and biological conditions of a perennial freshwater pond. *J. Inland Fish. Soc. 1971.* 1: 79-102.

A fishing village on the shore near Pentakota in Orissa.

Orissa, Indian East Coast

Based on reports by
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41. *MARINE HABITATS OF ORISSA*

41.1 *Chilika Lake*

Chilika Lake, the largest brackishwater lake in Asia, is also one of the best studied coastal lagoons in the tropics. It is connected to the Bay of Bengal by a long (35 km) and narrow channel. Chilika Lake covers an area of approximately 790 km^2 (1989). During the monsoon season, the area swells several hundreds square kilometres due to a larger inflow of freshwater. The salinity varies from traces to 36 ppt (parts per thousand). In 1987, the maximum depth was 3.4 m. Further environmental characteristics are given in the table below:

Environmental characteristics of the Chilika Lake

Physico-chemical Properties	
Temperature (°C)	
Surface water	: 17.5 32.0
Salinity ppt	
Range	: Traces 36.0
pH	
Range	: 7.6 10.0
Dissolved oxygen (mg/litre)	: 1.3 · 13.4
Transparency (Secchi disc depth in m.)	: Minimum – 0.32 Maximum – 1.40
Nutrients (mg/litre)	
Nitrate	: Traces 0.19
Phosphate	: Traces 0.18
Silicate	: 0.10. 0.60
Trace elements (ppm)	
Copper	: 0.02 0.04
Zinc	: 0.025 0.19
Iron	: 0.12 0.32
Sediments	
Carbonate contents (%)	: 1.6-3.8
Trace metals (ppm) in sediments	
Copper	: 5 · 66 (37)°
Nickel	: 150- 270 (195)°
Chromium	30- 270 (188)°
Lead	**: 72 · 122 (91)°**
Phytoplankton	
Phytoplankton densuy	
Mishra *et al.* (1988)	: $2.10^3 \cdot 3.10^6$
Panigrahy (1985)	: cells/litre (appx.)
Relative species abundance (%)	
Diatoms	: 70%
Blue-green algae	: 25%
Dinoflagellates	: 3%
Green algae	: 2%
Phytoplankton pigment (mg/m^3)	
Total Chlorophyll ND 67.05	: 67.05
Chlorophyll a ND	: 13.38
Chlorophyll b ND	: 18.60
Chlorophyll c ND	: 59.03
Primary productivity	: 7.70 mg $C/m^3/h$
Zooplankton and secondary productivity	
Plankton volume (ml/litre)	: 0.03 0.27
Faunistic composnion	: 170 species (26 groups)
Relative abundance of dominant groups (4)	
Copepoda	: 43.0- 70.0
Veligers	: 5.0. 30.0
Naupli	: 16.0 · 18.0
Protozoans	: 7
Rotifers	: 4
Polychaetes	: 2
Mysids	: 1.5
Biomass (gm/m)	**: 0.32 · 3.30**
Macrophytes	
Dominant species	: *Potamogeton pectinatus* *Halophila ovata* *Najas gramineae* *N. falcioulata* *Rupia maritima* *Eichornia crassipes* *Scirpus articulatus* *Gracilaria verucosa*
Area covered by macrophytes (km^2)	: 1973 20 1977 · 60 **1982- 100** **1985 -200** 1991-440
Zoobenthos	
Total no. of species	**: 62**
Dominant groups	: Foraminifera Nematoda Polychaeta Copepoda Ostracoda Isopoda Amphipoda Gastropoda Bivalvia
Biomass (gm/m^2)	: Northern sector 11.1 Central sector 18.3 Outer channel area 13.8 Southern sector · 11.1
Average annual production (gm/m^2)	**: 13 5 · 16.5**
Fisheries	
Fish catch (tonnes) 1986-87 to 1991-92	: Min 4185.0 Max 8815.7 Avg. · 6034.2
Rate of fish production (kg/ha)	: **65 122**
Faunistic composition	: Icthyofauna · 166 species Prawns 21 species Crabs 5 species
Birds & mammals	
No of species of birds	: 151 (26 families) Migratory % Resident 55
Mammals	: Dolphin (*Coryphaena* sp.) Sea cow (*Dugong dugong*)

* Average value

Source: Asthana (1978); Banerjee & Raya Choudhury (1966); Jhingran & Natarajan (1966, 1969); Misra et al (1988); Mohanty (1981); Mohapatro et al (1988); Patnaik (1973); Patnaik (1988); Patnaik & Sarkar (1976); Panda (1988); Panigrahy (1985); Raman et al. (1990); Sarma (1988).

Chilika Lake is at present showing many symptoms of environmental degradation. A constant inflow of silt, 13 million t per year, due to soil erosion in the catchment area, is choking the lake mouth. Satellite images indicate that an area of 46 km^2 has been silted up and this area is now heavily infested with weeds and grasses. The shrinkage has been calculated at 1.5 km^2 per year. Due to the decrease in salinity and the excess nutrients (from the silt), weeds have spread over approximately one-fourth of the lake.

The drop in salinity (due to choking of the mouth) has also led to decreasing production of fish and prawn (see table alongside). However, if fish landings from 1930 to 1990 are considered (see second table on right), the picture is different. Recognizable changes have also occurred in the ranking order of different groups of fish and prawn catch (see third table on right).

There are conflicting opinions regarding changes in fish catches and species composition [(Jhingran and Natarajan (1966, 1969); Kowtal(l967); Misra (1988); Mishra and Satapathy (1992)]. The reason for this is probably because there are two opposite processes going on; on the one hand, the increasing inflow of nutrients causes increased production, while, on the other, siltation and reduced salinity cause diminished fish production.

Ranking of ten different catches in Chilika Lake

Groups	Periods of assessmenf				
	1949I50 1954-55	1957/58 1965-66	1981-82	1986-90	1990-92
Prawn	I	l	3	3	2
Mullets	3	2	4	6	5
Clupeids	4	4	1	I	4
Perch	5	5	5	4	6
Catfish	6	3	6	5	3
Threadfins	7	6	7	7	7
Scianids	8	7	9	*	*
Beloni-forms	9	9	8	8	8
Elasmo-branchs	10	10	10	*	*
Miscel-laneous	2	8	2	2	I

* included in 'miscellaneous'

Five-yearly trends of fish landings in Chilika Lake from 1930 to 1990

Year	Fish landings (t)
1930-34	1452
1935-39	1738
1940-44	1755
1945-49	3078
1950-54	4821
1955-59	5616
1960-64	3681
1965-69	3160
1971-75	6152
1976-80	5696
1981-85	6811
1986-90	7740

41.2 *Mangroves*

A recent study made by the Forest Survey of India indicates that the mangrove area in Orissa is more than 195 km^2 in extent, of which 174 km^2 are in Cuttack District and 21 km^2 in Balasore District. (Personal communication of Harbola, 1992). The mangrove forests are mainly located in the Bhitarkanika area in Cuttack District and the Mahanadi delta between the Cuttack and Puri Districts.

One estimate puts the degradation of mangrove forests in Orissa at 20 km^2 over ten years (Samal *et al.,* 1988). Both Bhitarkanika and Mahanadi delta mangroves are now degraded due to conversion of mangroves into paddy fields and aquaculture ponds.

42. FISHERIES

There are 329 marine fishing villages in Orissa, with over 20,800 fisherfolk households and a population of 126,000 fishermen, of whom 30,700 are actively engaged in fishing.

The total marine fish catch of the state was 55,000 t in 1985-86 and increased to 80,000 t in 1990-91. This growth was possible due to country craft motorization and infrastructure development such as harbours, jetties etc.

Orissa's total marine product exports was 2842 t (Rs. 1,600 million) in 1981-82. This increased to 3841 t (Rs. 5,400 million), in 1990-91.

Annual production of fish and prawns

Year	Production of fish and prawns (t)
1985-86	8590
1986-87	8872
1987-88	8104
1988-89	6128
1989-90	6670
1990-91	4273

The estimated harvestable potential of marine fish upto 100 m depth is 125,000 t. Based on the MSY estimates made by the Fishery Survey of India (1990), and the current production, it is estimated that an additional yield of 30,000 t of fish and crustaceans per annum can be harvested from the continental shelf along the Orissa coast.

The total estimated area suitable for brackishwater fish/prawn culture in Orissa is 32,000 ha, out of which approximately 29,000 ha have been surveyed and found suitable. Development has taken place in around 9,000 ha. Fish and prawn production from aquaculture is shown in the table alongside.

Total shrimp/fish production from brackishwater aquaculture in Orissa (198586 to 1990-91)

Year	Production (t)
1985-86	20s
1986-87	904
1987-88	1075
1988-89	1860
1989-90	2900
1990-91	2564

43. MARINE POLLUTION

43.1 Domestic wastes

Most urban areas have some disposal system and, therefore, a sizeable part of urban waste water find its way to the natural drainage channels. In rural areas, however, there are no organized systems of water supply and drainage. Most sewage is, therefore, totally absorbed by the soil.

The pollution load of the Mahanadi River in terms of BOD and COD load from domestic and livestock sources is estimated at 217,000 and 251,500 t/year respectively. Water quality parameters upstream and downstream of Cuttack are presented in the table below. The figures give an indication of the extent of pollution in this river due to domestic waste. The domestic pollution rates in other Orissa rivers has not been assessed.

Water quality parameters at Cuttack

Parameter	Upstream Cuttack U/S		Downstream Cuttack D/S	
	Range	Average	Range	A verage
pH	7.2-8.7	7.4	7.0-8.7	7.9
DO	5-8.8	6.7	5.0-8.8	6.4
BOD	1.0-5.8	3.4	2.0-12.4	4.8
COD	1.626.0	11.3	4.8-30.0	18.2
TC (MPN/100ml)	28-l 10.0	353.0	75-4600	1646
FC (MPN/100ml)	15-1 100	209.0	75-2400	430
Conductivity (m mhos/m)	15.5-43.0	26.3	14.6-60	29.3
Chloride	4.6-66.8	14.9	9.4-33.8	18.0
Sulphate	20.0-140.0	49.8	5-280.0	84.3
Calcium	32.0-70.0	53.15	36.0-90.0	67.1
Magnesium	8.0-50.0	32.8	8.0-70.0	39.7
Total hardness	40.0-120.0	84.9	56.0-160.0	103.8
Alkalinity	72-230.0	121.0	90.0-290.0	141.6
Sodium	5.0-48.0	19.6	4.0-46.0	23.3
Turbidity (NTU)	4.0-450.0	93.0	7.0660	127.0
Temp (°C)	25.0-33.0	26.3	24.0-33.0	28.4

Note : Values of parameter, if not otherwise stated, are in mg/litre

43.2 *Industries*

The table below lists the major industries in the coastal districts of Orissa. Pollution points and points of metal contamination are shown in Figures 29 and 30 on the facing page.

The Brahmani River at Raurkela and in the Talcher Nalco region and the Mahanadi at Brajrajnagar and the Rusikulya estuary near Gopalpur are the most polluted areas of the state. There are reports of fish kills, fall in catches (particularly CPUE) and even in diminished fish quality. Fish caught from the affected areas do not fetch good prices. The entire Orissa coast, particularly at Gopalpur, and the stretch of the Mahanadi river near Brajrajnagar are polluted due to heavy metal deposits,

Distribution of different types of industries in the coastal districts of Orissa.

Type or Industry	Total in the state	Distribution in the coastal districts			
		Ganjam	Puri	Cuttack	Balasore
Giant Industries (Investment more than Rs. 2000 crores)	2	Nil	Nil	Nil	Nil
Major/Large Industries (investment more than Rs. 25 crores)	27	1. Ganjam: *Products:* NaOH, HC1, H_2SO_4 Cl_2 SO_2. 2. Ganjam *Producrr* Synthetic Rutile, Ilmenite & Thorium	I .* Chandaka Industrial Complex. *Products:* Piping & Fittings, Condenser Tubes. 2. Panipoilia. *Producr:* Sugar 3.* Bhubaneshwar. *Producr.* Repairing of Railway coaches.	1. Choudwar. *Producrr* High carbon Ferrochrome/ Chargechrome. 2. Choudwar. *Producrs:* Textiles & yarn. 3. Paradwip. *Producr.* Diammonium phosphate. 4. Choudwar. *Products:* Different types of paper.	1. Chhanpur, *Products :* Tyres & Tubes. 2. Randia. *Product* Chargechrome. 3. Balgopalpur. *Producrs:* Silicon metal, High Ferro-silicon & Silico manganese.
Large Industries (Investment Rs. 5 crores- Rs. 25 crores)	58	1. Aska: *Products:* Sugar, Rectified spirit & Carbon-dioxide. 2. Aska. *Products:* Fine cotton yarn & synthetic yarn.	1.* Bhubaneshwar. *Products:* Microprocessor based computers. 2.* Bhubaneshwar. *Products:* Printed circuit boards. 3.* *Producrs:* Stainless steel watch cases. 4.* Bhubaneshwar. *Producrs:* Television sets (B.W. Portable and Colour). 5. Bhubaneshwar, *Products:* Hard Perrite. 6. Bhubaneshwar. *Producrs.* Refined Oil (Groundnut, Mustard) 7.* Bhubaneshwar, *Products:* EPABX Push Button Telephone. 8. Khurda. *Producrs:* Textiles and yarn. 9.* Bhubaneshwar. *Products:* Radio communication equipment. 10.* Bhubaneshwar. *Products* Repair and maintenance of professional electronic equipment.	1. Kendrapada. *Products* Grey cloth. 2. Chhatia. *Producrs:* Grey cloth. 3. Paradwip. *Products:* Beer. 4. Jaipur. *Products:* High carbon ferrochrome products. 5. Dhanamandal. *Products:* Jute fabrics and Bags, Tarpaulin canvas, Hycee light weight cement packing items, various types of twine. 6. Bhagalpur, *Products:* Cotton and viscose yam. 7. Baranga. *Products:* Sanitary wares, refractory and SW pipes. 8. Sunapal. *Products:* Sugar.	1. Balgopalpur. Products: Multi wall papers sacks. 2. Balasore, *Producrs:* HDPE woven sacks. 3. Balagopalpur. *Producrs:* Writing and printing paper. 4. Somanathpur. *Products:* Sanitaryware, such as Indian water closets. 5. Gopinath: *Producrs:* Textiles and yarn. 6. Somanathpur. *Products:* Granite, Tiles, Monuments for 100% export surface plates. 7. Ganeswearpur. Products: Aluminium extrusions. 8. Somanathpur. Producrs: Rubber prophylactics. 9. Tigiria. *Products:* Textiles and yarn. 10. Tirtol. *Products:* Textiles and yarn.
Medium Industries (Investment Rs. 1 crore . 5 crores)	103	3	33	21	24

Source : Industries Department, Government of Orissa. * Non-polluting industries.

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Fig. 29. Map of Orissa showing pollution points

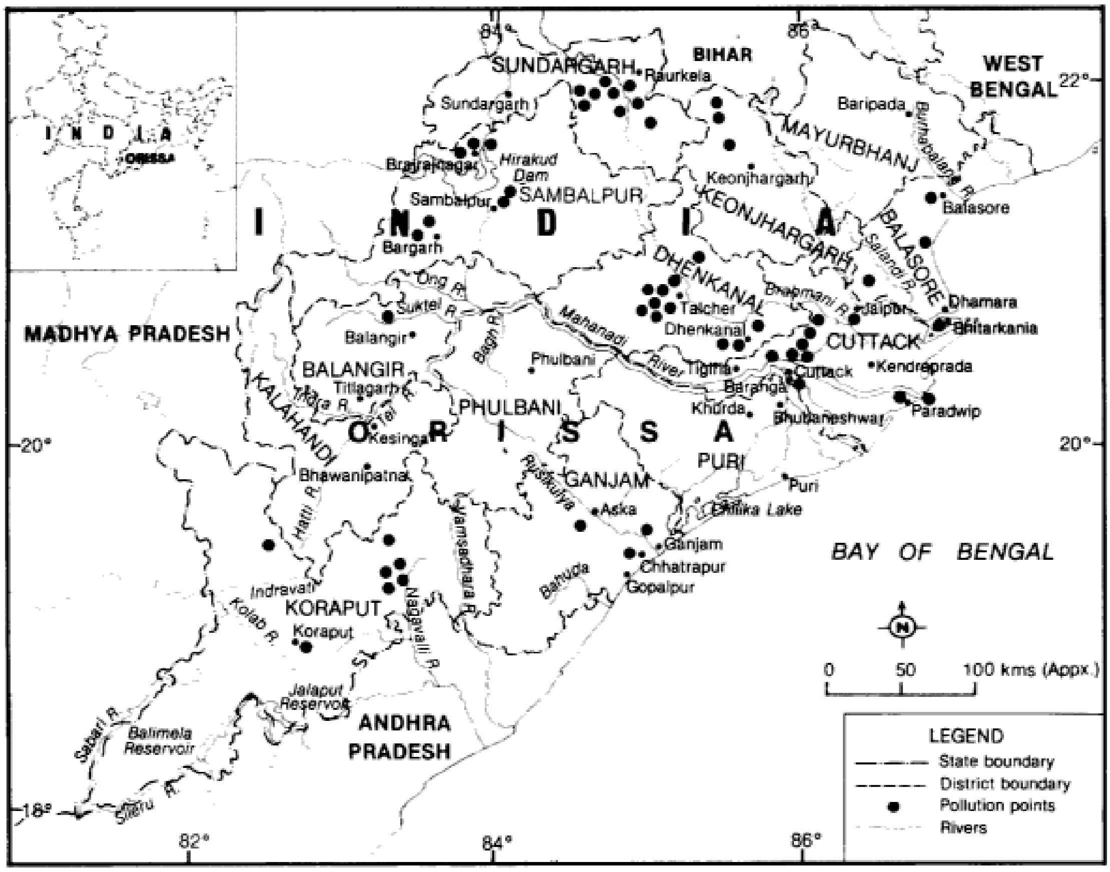
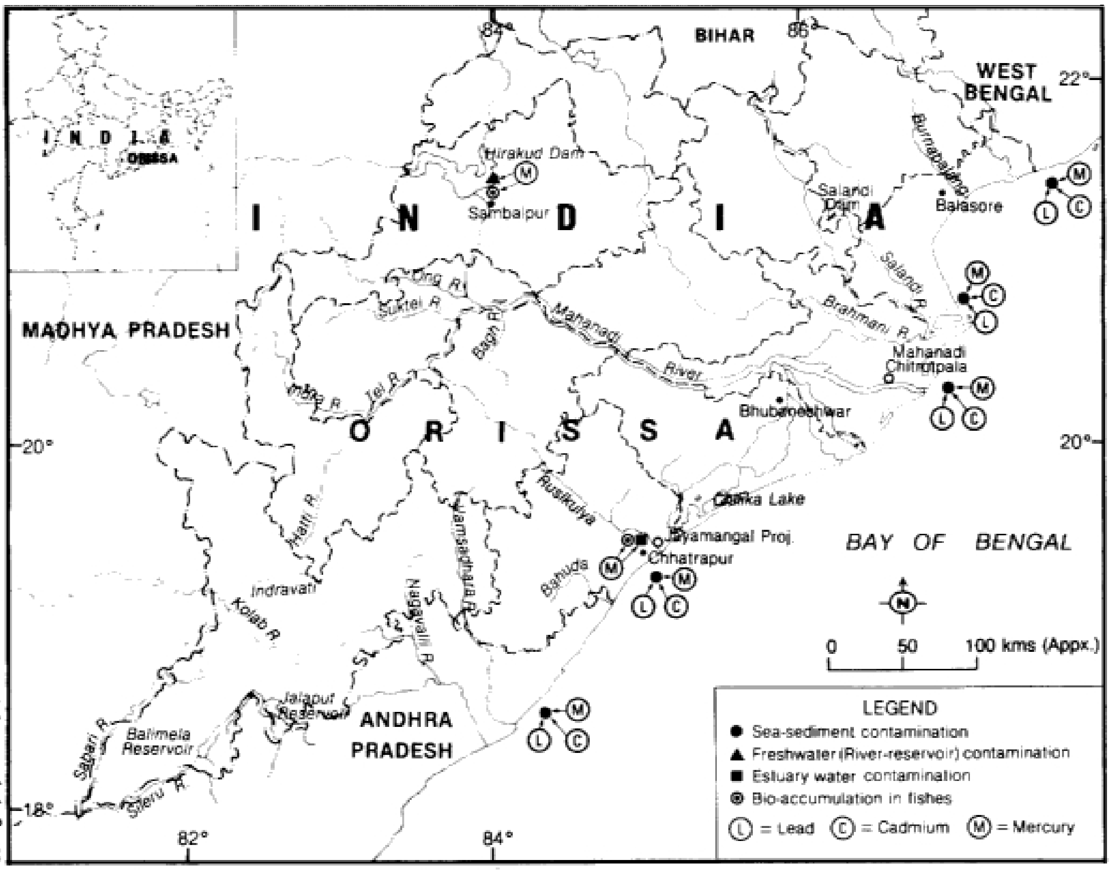


Fig. 30. Map of Orissa showing pollution points of metal contamination



Cartography, TT. Maps, Madras-44.

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which are bioaccumulative. Fish samples have been found to contain substantially high levels of mercury. There is total extinction of all forms of aquatic life in certain sections of rivers like the Nandira and Ib, due to such pollution. Pollution has also reportedly been the cause of the loss of the *Hilsa* fishery in the Rusikulya River and the freshwater prawn fishery in the entire stretch of the Brahmani river.

A study of the Orissa coast was carried out in 1990-91 to detect changes in the biochemical regime of the marine system brought about by coastal pollution. Five transects, namely Kalingpatanam, Gopalpur, Paradwip, Dhamara and Dyhiaha, were fixed for the study. Each transect included a number of stations, starting from river estuaries nearer the coast and going deep into the sea, up to a distance of 5.7 km. Only a few series are available, but in the near future, similar series of samples are to be taken all along the Indian coast. (Source: *Report on Marine Pollution Monitoring Studies.* Department of Ocean Development Unit for Coastal Ocean Monitoring and Predictive System (COMAPS), Regional Research Laboratory, Bhubaneshwar). Some of the values of mercury, cadmium and lead in the sediments were surprisingly high, but could not be related to specific pollution sources.

The mercury concentration in the Gopalpur transect near the Rusikulya estuary was the highest. Due to this, there are enhanced levels of mercury in the planktonic organisms as well. This is due to the effect of effluents discharged from a chemical plant in Ganjam. Shaw et *al.* (1989) found a heavy mercury contamination of 1.85 mg/l in effluent from this factory which is much higher then the permissible limit of 0.01 mg/l prescribed by the Central Pollution Control Board.

A study was made on the geographical distribution of mercury around the chlor-alkali plant of this factory (Shaw *et al.,* 1988). The concentration of mercury was found highest in the samples collected from the solid waste deposit area. Mercury levels decreased with the increase in the distance from the factory. Mercury concentration in samples collected from the solid waste deposit area was as high as 640 (+ 33 mg/kg). Mercury concentration in fish flesh from the Rusikulya estuary was also studied (Shaw *et al.,1985).* It was found that the concentration was as high as 2.18 (+ 0.03 mg/kg in fish muscle: 2.1 (+0.12 mg/kg) in fish liver and 1.89 (+ 0.19 mg/kg) in fish brain.

Presence of mercury in the Ib section of the Hirakud reservoir, around Brajrajnagar, has also been reported. Das *et al.* (1985) carried out detailed water sediment analyses and fish sampling, both upstream and downstream, as well as at the effluent discharge point (see table alongside). The bioaccumuiation of heavy metals in fish detected from this region is more than twice the limit prescribed by the WHO.

Water sediment analyses and fish sampling in the Ih River

	Water	*Sediment*	*Magnification*
Upstream	Nil	Nil	Nil
Lagoon	0.0075	0.4275-2.16	57-288
Discharge point	0.005	0.4-1 2	80-240
Downstream	0.0025	1.2-1.92	480-768
Plants (one species)			
Upstream: Nil; Downstream: Nil; Lagoon: 0.125			
Fish			
Downstream			
– *Amblypkaryngodon* sp. *(mahuradi)*		0.95	(380)
– *Mastaceinbellus pancalus (todi)*		1.075	(429)
– *Ckanna punctatus (gadisa)*		1.1	(440)
– *Ckanda range (patpania)*		1.25	(480)
– *Wallago attu (balia)*		1.33	(532)
Upstream			
– *Mustus keletius (kantia)*		0.475	(190)
– *Puntius sophore (kerandi)*		*0.60*	(240)
Different tissues of *Wallago attu*			
– *ovary*		0.87	(348)
– Heart		0.968	(387)
– Liver		1.38	(552)
– Alimentary canal			

Note : Study month: Feb-March, 1985; Mercury concn. ppm dry weight n = 3; Names in parentheses are local names; Values in parentheses refer to magnification'from downstream water.

Source : Das et *al.* (1986). Pollution load in the Mahanadi River System, IE *Journal* Vol. XII

43.3 *Treatment of waste water*

In certain cases, waste water is diverted into marshes or other detention basins. By physical detention, diversion, filtration and other chemical treatment, the harmful substances are broken down into simpler harmless substances, reducing the intensity of pollution. This is a simple form of what may be called the Effluent Treatment System.

A survey was conducted by the Orissa State Prevention and Control of Pollution Board in 1991-92, and it discovered that out of 66 large and medium scale industries causing pollution, 37 have installed full-fledged effluent treatment ponds (ETP), 21 were in the process of installation, while installation of ETP in 8 others was still in the planning stage.

In 1992, Sirajuddin Khan visited twenty polluting industries in the state. His experiences from this survey are presented below.

Out of twenty industries visited, two had practically no ETP system and directly discharged their effluents into the water courses. The other 18 had regular ETP systems. Some of these were of the diversion and retention types. Here, the waste liquid was diverted into adjoining marshes or into retention basins, where, by natural processes, it was broken down.

Most managements readily showed Khan round their ETP and sewage treatment pond (STP) systems and provided information. Only one refused to show its ETP system or furnish any information. The following are some impressions of the effectiveness of the state's effluent treatment systems.

Almost all the industries using D.M. plants had an acid-alkali neutralization pit with a pH monitoring system. Other industries had very good effluent treatment plants in the area for their liquid wastes. Some recently established industries had most modern ETP systems.

Some of the older industries plan to adopt modern production technology and effluent treatment in order to avoid hazardous wastes like mercury. A substitute for mercury cell processes by membrane cell technology is, in fact, envisaged.

Several industrial units were conscious of the reduced use of waste water in pollution abatement. Large volumes of waste water are, in fact, recycled in the production process, as well as in effluent and sewage treatment processes. Effluents are also utilized in quenching boiler ash and making ash slurry.

Many of the industries had effluent quality control units with well-equipped laboratories and qualified technical staff to monitor the quality of the treated effluents. They maintained meticulous records of every analysis, and their reports (which are not always in agreement with the periodic monitoring reports of the State Pollution Board) show that all parameters of treated effluents are within the permissible limits.

Many industries have, besides the usual ETP systems, provision for emergency draining outlets for factory effluents, which flow directly into the water course. These, the managements said, are used when the ETP is under maintenance. During Khan's visit, many of the ETPs were out of order or under maintenance.

The most significant point that emerged during the survey and inspection of effluent points is that even if effluents are treated and all prescribed parameters followed, the treated effluent thereby being considered harmless for domestic use, it may still remain harmful for aquatic organisms. For instance, ash slurry, coal dust and other inert suspended materials are not toxic to fish, but they destroy fish by choking their gills, damage the spawning and nursing grounds and retard plankton production. Some chemical pollutants cause fish kills, while others get absorbed in the body, disturbing the metabolism, damaging the nervous system and destroying the flesh and the keeping quality of captured fish. Mercury, for example, at the prescribed limit of 0.01 mg/litre, is probably harmless to fish, but since mercury is bioaccumulative and tends to get deposited in fish muscles, liver and brain, it is, ultimately, a threat. The survey revealed that both the public as well as the industrial community have become more environmentally conscious. Industrial groups are now more eager to take pollution control measures and invest money in elaborate effluent treatment systems. The private sector industries are more concerned about environment conservation than public sector units.

43.4 Agriculture

Orissa, a predominantly agrarian state, had a population growth rate of 19.5 per cent in 1981-1991. There is, therefore, pressure on farming activity to increase production. During 1991-1992, 8,490,300 ha were under cultivation (*Statistical Abstracts,* 1991). About 30 per cent of this land was for high yielding varieties, HYV, which, for successful yields, require large amounts of fertilizers, pesticides and insecticides. The consumption of chemical fertilizers is shown in the table above.

Consumption of chemical fertilizers in Orissa

Year	Quantity of consumption ('000 t)			
	Nitrogen	Phosphate	Potassium	Total
1984-85	70	27	16	113
1985-86	87	33	20	140
1986-87	91	38	24	153
1987-88	88	39	25	152
1988-89	123	48	31	202

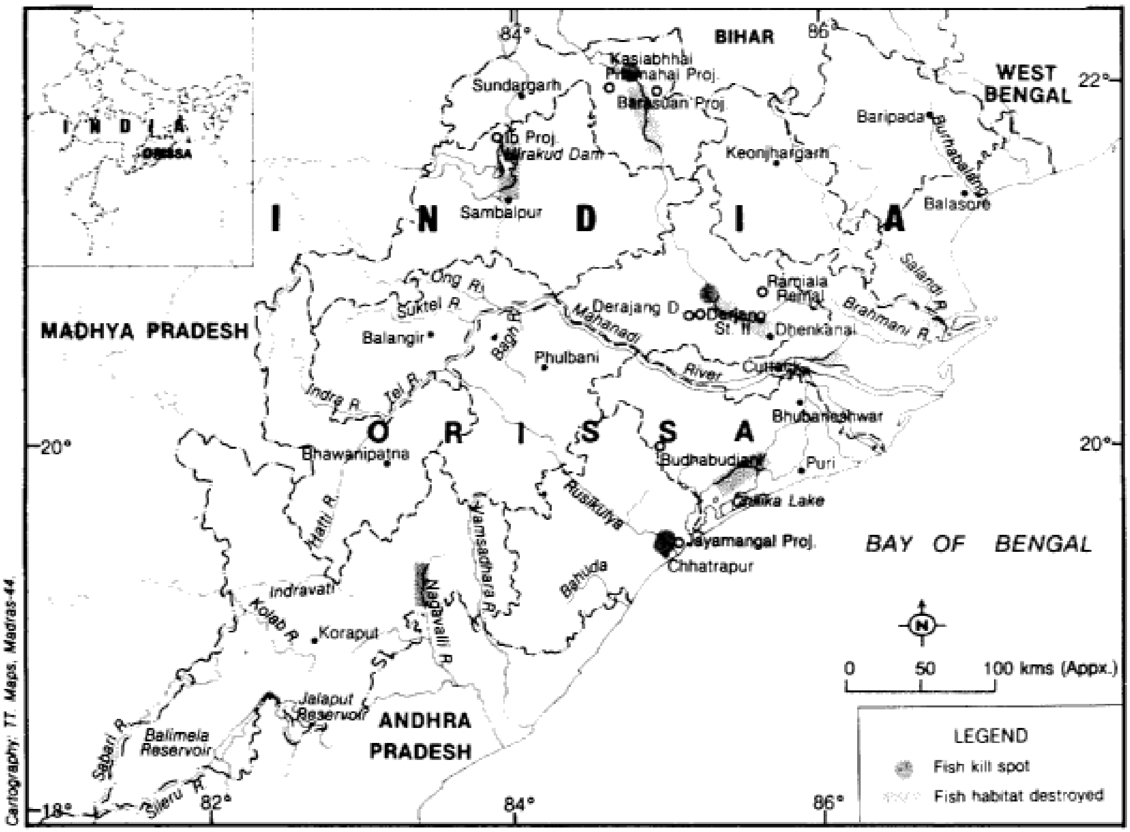
(Source : Statistical Abstract, 1991)

44. EFFECTS OF POLLUTION

Detrimental effects of pollution have not been recorded in a major way in coastal areas. However, river pollution is much more evident. Since river water finally reaches the sea, and since many fish spend a part of their lives at sea and a part in the rivers, river pollution is also relevant when discussing the marine environment. Among the observed effects are :

- **Biovacuum zones:** A total destruction of all forms of life, as in parts of the Nandira and Ib Rivers, near Brajrajnagar has been reported.
- **Reduction of fish catch and quality quantum:** This has been noted in the Brahmani, Mahanadi and Rusikulya Rivers.
- **Path-blockages for fish migration**
- **Effects on plankton:** Plankton occurring in the unpolluted zone of Nandira River has diminished with the proportionate increase in pollution load (Tripathy *et al., 1990).*
- **Depletion of fishery:** The *Hilsa ilisha* and mullet fisheries have been totally destroyed in the Rusikulya estuary. (Commentaries on water, air pollution and environment protection laws, 1990).
- **Bioaccumulation of heavy metals in fish:** Reported from the Rusikulya estuary and Ib River.
- **Destruction of spawn collection grounds in rivers:** Riverine spawn collection was a thriving industry which attracted a large number of collectors. Spawn collection has now been completely wiped out from the Brahmani River and, to a certain extent, from the Mahanadi River.
- **Freshwater prawn fishery destroyed:** The fishery for *Macrobrachium malcolmsonii* has been destroyed in the Brahamani River (fishermen's report)

Fig. 31. Map of Orissa showing identified area of fishkills and habitat destruction



- **Fish kills** : These have been reported from the Nandira section (Brahmani), lb zone (Hirakud reservoir) and Rusikulya estuary. Fish kills are also regularly reported each year from the Raurkela and Taicher regions (Brahmani). Figure 31 shows fish kill spots and areas where the fish habitats have been destroyed.
- **Effect of general water quality:** Surface drinking and irrigation water has been destroyed, in some areas, as in the Nandira River, for instance.

45. USE OF INDUSTRIAL/DOMESTIC WASTES

If the cost of effluent treatment could be partly recovered, it would provide an inducement to industries to go in for proper effluent management. At least some industries in Orissa have the potential for this. Examples are

- Use of rice mill effluent in pond fertilization. A rice mill diverts its waste water tanker to a Sambalpur fish farm. The results are very positive: the cost of pond fertilization is reduced without any environmental repercussions.
- Use of sewage and domestic waste. Sewage from city municipalities is used for fish culture in many places, *e.g.* in West Bengal, which has 130 sewage-fed farms, and in Tamil Nadu.
- Use of pulp and paper mill effluents for irrigation. A paper mill in Orissa has tested irrigation of crops like sugarcane and paddy with paper mill effluents. No adverse effects were reported (Reddy, 1981).
- Use of paper mill sludge. This can be utilized as liming material in agricultural lands and fish ponds.
- Use of sludge from chemical plants. It can be used as binding material in cement manufacturing.
- Use of sludge from sewage. Successful trials have been carried out using sludge as fertilizer at the Berhampur state fish farm.
- Use of fly ash from thermal plants. This can be utilized in brick and cement manufacture etc.

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46. REFERENCES

ASTHANA, V. 1978. Limnological studies of lake Chilka, Orissa. *Indian programme on man and the biosphere project.* Report No. 112, Department of Science and Technology, Govt. of India, New Delhi.

BANERJEE, A.C. and RAY CHOUDHURY, N.C. 1966. Observation on some physico-chemical features of the Chilka Lake. *Indian J. Fish., 13: 395- 429.*

BAY OF BENGAL PROGRAMME. 1993. *The Impact of rhe Environment on the Fisheries of Orissa.* BOBP, (BOBP/REP/67). (Madras, 1993).

DAS, R.C. et *al.* 1986. Pollution load in the Mahanadi River system. *I.E. Journal.* Vol. XII.

DAS, M.C., MISHRA, P.C. CHOUDHURY, K. and DAS, R.C. 1985. Bioaccumulation of mercury in River lb. Reprint. *Ecology and Pollution of Indian Rivers.* pp. 287-299.

HARBOLA. 1992. Mangrove Forests of Orissa. (Personal Communication).

JHINGRAN, V.G. and NATARAJAN, A.V. 1969. A study of the fisheries and fish populations of the Chilka Lakeduring the period 1957-65. *J. Inl. Fish. Soc. Ind., I:* 49-126.

__________ 1966. Final report on the fisheries of the Chilka Lake (1957-65). *Bull. Cent. Inl. Fish. Res.* Inst.. Barrackpore.

KOWTAL, G.V. 1967. Occurrence and distribution of pelagic fish eggs and larvae in the Chilka Lake during the years 1964 and 1965. *Ind. J. Fish.* 14: 198-214.

MISHRA, S.K. and SATAPATHY, D. 1992. Impact of habitat destruction on fishery of Chilka lagoon in the east coast of India. *Proc. Natl. Sem. Endangered Fish. India.* Allahabad. (Abstract).

MISRA, P.M. 1988. Physico-chemical and biological properties of the Chilka Lake with reference to fisheries development *Proc. Natl. Sem. Recent Treds in Fish. Biol. : 45-50.*

MISRA, P.M., SAHU, B.K., PANIGRAPHY, R.C., TRIPATHY, S.K. PADHY, A., PANDA, D., PATNAIK, D.K. and PATRO, S.K. 1988. *Studies on the hydrobiological features of Chilka Lake, Orissa.* Final Report. Dept. of Env. and Forests, Govt. of India : 45 p.

MOHANTY, P.R. 1981. Studies on the *Grucilaria verrucosa* (hudson) papenfuss of Chilka Lake. Ph. D. Thesis, Berhampur University, Berhampur: 102 p.

MOHAPATRO, P., SINGH SAMANT, N.C.M, MOHANTY, D.C. and BHATTA, K.S. 1988. A study of physicochemical observation of three stations in Chilka lagoon during the year *1985-87. Proc. Natl. Sem. Conserv., Mgmnt. Chilka.* Dept. of Sci., Tech. and Env., Govt. of Orissa, Bhubaneshwar. (Abstract).

PANDA, D. 1988. *Studies of texture and organic carbon in thesediments of the Chilka Loke.* M. Phil., Thesis., Berhampur University, Berhampur: 40 p.

PANIGRAPHY, R.C. 1985. Phytoplankton and primary productivity in Chilka Lake. Ph. D. Thesis, Berhampur University: 140 pp.

PATNAIK, D.K. 1988. Distribution of nutrients in surficial sediments of the Chilka Lake. M. Phil. Thesis, Berhampur University: 42 pp.

PATNAIK, S. 1973. Observations on the seasonal fluctuations of plankton in the Chilka Lake. *Ind. J. Fish. 20: 43-55.*

PATNAIK, S and SARKAR, S.K. 1976. Observations on the distribution of phytoplankton in Chilka Lake. J. *Ind. Fish. Soc. India., 8: 38-48.*

REDDY, M.R. 1981. Paper mills effluent for sugarcane irrigation. *IA WPC TECH. Annual* VII. 129-146.

RAMAN, A.V., SATYANARAYANA, CH. ADISESHAAI, K. and PHANI PRAKASH, K. 1990. Phytoplankton characteristics of Chilka Lake, a brackishwaster lagoon along east coast of India. *Ind. J. Mar. Sci.,* 19: 274-277.

SARMA, A.L.N. 1988. Invertebrate community ecology in the context of conservation and development of Chilka Lake (Bay of Bengal). *Natl. Sem. Consv. Mgmnt. Chilka.* Dept. of Sci., Tech. and Env., Govt. of Orissa, Bhubaneshwar. (Abstract).

SHAW, B.P. 1985. Residual mercury concentration in brain, liver and muscle of contaminated fish collected from an estuary near a caustic chloride industry. Curr. *Sci, 54:* 810-812.

SHAW, B.P., SAHU, A. and PANIGRAHY, A.K. 1988. Mercury in bed sediments of the Rusikulya River estuary. J. *Env. Biof. IO: 59-64.*

__________ 1989. Mercury in the Rusikulya River estuary. *Mar. Pollu. Bull.* 19: 233-234.

SAMAL, *et al. 1988. Management strategy for Bhitara Kanika mangrove forests.* Indo-U.S. Workshop, New Delhi.

TRIPATHY, SK., PANIGRAPHY, R.C., GOUDA, R. and PANDA, D. 1990. Distribution of calcium and magnesium in Rusikulya estuary, east coast of India. *Ind. J. Mar. Sci., 19: 212-214.*

APPENDIX XXII

Institutions engaged in environmental research, monitoring and enforcement

GOVERNMENT

Stale Prevention and Control of Pollution Board, Orissa (SPCP), A/118 Nilakantha Nagar. Unit-VIII, Bhubaneshwar - 751 012.

This is the organization most actively involved in the study of pollution in Orissa. It has a wealth of information on aquatic pollution. The SPCP Board was established in 1983 to enforce the provisions of the Water (Prevention and Control of Pollution) Act, 1974, and Air (Prevention and Control of Pollution) Act, 1981. Subsequently, the Board was entrusted with the responsibility of enforcing certain environmental provisions which come under the Pollution Act, 1986.

Regional Research Laboratory (Council of Scientific and Industrial Research), Bhubaneshwar 751 013.

This laboratory of the Council of Scientific and Industrial Research (CSIR), Government of India, devotes itself to aspects of research connected and concerned with technological problems of industrial development. It has undertaken marine pollution monitoring along the Orissa coast as a Department of Ocean Development (DOD) unit for Coastal Ocean Monitoring and Predictive Systems(COMAPS). Its aim is to study various pollution parameters along the Orissa coast, from Digha in the north to Kalingapatnam in the south.

Orissa Remote Sensing Application Centre (ORSAC), Bhubaneshwar.

The Oceanic Remote Sensing Centre for the east coast, which preceded ORSAC, was set up in Bhubaneshwar in 1987-88 with DOD assistance. In 1991-92, it was taken over by the State Government and ORSAC formed. ORSAC carries out studies on different environment aspects in coastal/oceanic waters. It has worked on aspects of environment degradation relating to Chilika Lake, mangroves and coastal waters.

Department of Fisheries, Government of Orissa, Dry Dock, Jobra, Cuttack 753 007.

The state Fisheries Department is basically concerned with the development of fisheries resources for the socioeconomic upliftment of the people of the state. It covers freshwater, inland, brackishwater and marine fisheries. The Department is not directly concerned with study of environmental pollution and degradation. However, it takes up local production-related problems for study and has, therefore, indirectly worked on a few aspects of pollution, including the use of industrial and sewage wastes.

Chief Conservator of Forests (Wild Life). Orissa, BBSR.

The Wild Life Department, an offshoot of the Forest Department, is concerned with the preservation of wild animals and the enforcement of the Wild Life Protection Act. Certain sections of Chilika Lake have been declared bird sanctuaries under the Act. Furthermore, selected marine and estuarine animals, like crocodiles and turtles, are also covered under the Wild Life Protection Act. Estuarine and coastal water pollution, which affects these animals, are also brought under this legislation.

OTHERS

- Central Rice Research Institute, Bidyadharpur, Cuttack District 753 006
- Central Institute of Freshwater Aquaculture, Kausalyagang, Bhubaneshwar, Puri District 751 002

UNIVERSITIES

A number of universities have been working on fisheries-related pollution studies. These include the following:

- Utkal University, Vani Vihar, Bhubaneshwar, Puri District.
- Berhampur University, Bhanja Bihar, Berhampur, Ganjam, District 760 007. (Department of Marine Science).
- Sambalpur University, Jyoti Vihar, Burla, Sambalpur District
- Orissa University of Agriculture and Technology, Bhubaneshwar, Puri District.

APPENDIX XXIII

Legislation against threats to the marine environment

The Union Government's first Act on environment protection, called the Water (Prevention and Control of Pollution) Act, 1974, was adopted by the Orissa State Assembly in April 1983. The second Act, namely the Air (Prevention and Control of Pollution) Act, 1981, since amended, was adopted by the State at the same time. The Environment (Protection) Act, 1986, has also been adopted by Orissa State (Source: SPCP Board).

The consolidated Orissa Forest Act, 1972, which received the assent of the President of India in 1972 provides for environmental protection against degradation and pollution, particularly in forest areas and includes mangroves. (Source: Orissa Forest Manual).

The Orissa Forest Act, 1972. makes ample provision for protection against such types of environment degradation as tree-felling and shifting cultivation, which cause both soil erosion and water degradation.

Apart from the protection of reserved forests, the Orissa Forest Act provides for control of forest and land which are not Government property or in which the authorities have a joint interest. Section 39 of the Act provides as follows:

The State Government may notify, regulate or prohibit the following in any forest or waste land:

a. the breaking-up or clearing of land for cultivation;

b. cattle pasturing; or

c. setting fire to or clearing of the vegetation, when it appears necessary for any of the following purposes, namely:

   i. for protection against storms, winds, rolling stones, floods, avalanches;

   ii. for the preservation of soil on the ridges and slopes and in the valleys or hilly tracts, the prevention of landslips or of the formation of ravines and torrents, or the protection of land against erosion or sand deposits, stones or gravel;

   iii. for the maintenance of water-supplies in springs, rivers, tanks, reservoirs and irrigation projects;

   iv. for the protection of roads, bridges, railways and other communication infrastructure;

   v. for the preservation of public health and places of worship. (Source: Orissa Forest Act, 1972).

A traditional nava *coming in to beach on the Andhra Pradesh coast.*

Andhra Pradesh, Indian East Coast

by

V Sree Krishna
Consultant-Environment/BOBP

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Marine Habitats

- Mangroves
- Algae

Fisheries

Marine Pollution

- Industries
- Agriculture
- Exploitation of natural resources

References

Appendices

- Institutions engaged in environmental research, monitoring and enforcement
- Legislation against threats to the marine environment.
- Other publications on the marine environment.

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47. MARINE HABITATS

47.1 Mangroves

The total mangrove area in India has been estimated at 6740 km^2. Of this, Andhra Pradesh has about 9 per cent, an area of 582 km^2.

The greater part of the mangrove forests in Andhra Pradesh are in rhe Krishna and Godavari River estuaries (see Figure 32 on next page). To protect these unique forests, the Andhra Pradesh Government has formed two sanctuaries. The Coringa Wildlife Sanctuary in East Godavari District, was established in 1978, while the Krishna Sanctuary in Nagayalanka, Vijayawada, was inaugurated more recently.

The mangroves of Andhra Pradesh are mainly Auicennia. A clear felling system is being practised, on a 25-year rotation basis in Coringa, and every 15 years in Kandikuppu (both in East Godavari). The Krishna mangroves are also managed on a 25-year rotation felling system.

Before the abolition of private estates came into force, and the subsequent grouping of the region's mangroves into forest blocks (see table alongside), most of the mangrove areas in East Godavari were under the control of private estate owners, who heavily exploited them. The mangrove areas were further degraded by indiscriminate felling and grazing.

In 1977, a severe tidal wave in Divi Taluq destroyed the mature mangrove forests in the Krishna estuary. However, the area has been well protected since and there is profuse regeneration. At present, these areas have a healthy young mangrove crop, which is no longer endangered by any sort of mangrove-related exploitation.

Brackishwater farming has become very popular among private entrepreneurs in Andhra Pradesh, and around 50 per cent of the developed area has been a consequence of clearing mangroves for the construction of ponds. The World Bank is supporting the development of brackishwater aquaculture in the state. To minimize the negative effects of the mangrove felling on the ecosystem, extensive environmental studies have been carried out. Further, to receive support from the World Bank, mangrove afforestation is a prerequisite.

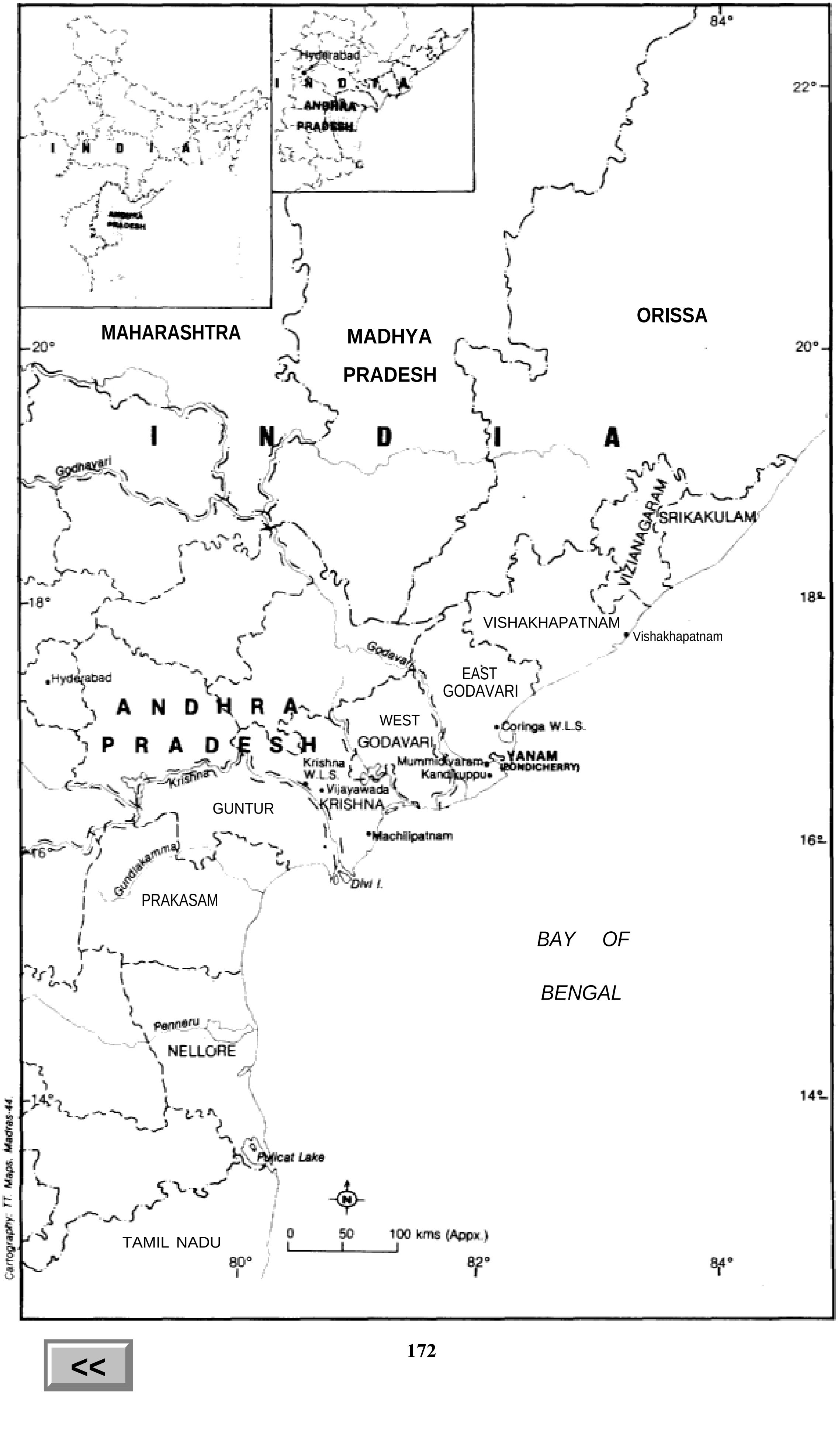
Mangrove afforestation on the seaward side of saline embankments would provide greater long-term stability than the more common

Areas notified as mangrove forest blocks

District	Name of rho forest block	Area in ha
East Godavari		
Kakinada Tq.	Kegita R.F.	467
	Coringa R F.	4242
	Coringa Exr. R.F	19,467
	Kothapalem R.F.	51
Mummidivaram Tq.	Masonithippa R.F.	1090
	Balusuthippa R.F.	415
	Muori R.F.	147
	Rathukalva R.F.	2043
	Kandikuppu R.F.	3802
	Mattatippa R.F.	445
	Kothapalem Ext. R.F	61
	Bhairavapalem R.F.	971
		33,261
Krishna	Nachugunta R.F.	6065
	Nachugunta-II R.F.	875
	Sorlagondi R.F.	2508
	Sorlagondi Ext. R.F.	2691
	Yelichitla Dibba R.F.	3714
	Yelichitla Dibba Ext. R.F.	610
		16,463

Source : Andhra Pradesh Shore Areas Dev. Authority Report, 1988

Fig. 32. Marine habitats of mangroves and algae in Andhra Pradesh



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engineering solutions, such as brick or stone pitching (World Bank project preparation report in West Bengal, Orissa and Andhra Pradesh, 1991 EIA). It has been suggested that the perimeter cyclone embankments of the prawn farms in Andhra Pradesh be afforested with ***Excocaria agallocha*** and ***Ceriops decandra*** on the upper (less frequently inundated) reaches and with ***Brugueria gymnorhiza*** or ***Avicennia marina*** on the lower reaches of the dykes. Seedlings can be either purchased from the Forest Department nurseries or collected from the wild. An initial planting density of 6000 seedlings per hectare is suggested at a cost of 2,400 Rs./ha. Labour would cost a further 6,800 Rs./ha, resulting in a total afforestation cost of 9,200 Rs./ha.

Other mangrove areas, known to have existed earlier, namely Upputeruin in West Godavari District near Machilipatnam, were opened up for various purposes by the Andhra Pradesh Government in the early 1960's and are, thus, no longer under mangrove acreage. Some former mangrove areas that no longer contain any mangroves due to sand-bar formation have been brought under casuarina.

47.2 Algae

Surveys made by the National Institute of Oceanography show that there are 522 species of marine algae along the Indian coast, of which eighty are found in Andhra Pradesh. These include 43 Rhodophytes, rich in iron and manganese.

Detailed surveys have shown that two commercially important genera, namely ***Gelidium*** and ***Gracilaria,*** are found in the Pulicat Lake and off the coast of Vishakhapatnam.

48. FISHERIES

Exploratory surveys at different depth levels estimate fish stocks at approximately 300,000 t in Andhra Pradesh.

Against this estimated availability of fishery resources, the current level of exploitation is less than 50 per cent in the case of all varieties of fish, except for crustaceans, where it is about 80 per cent.

Andhra Pradesh is one of the leading fish producing states of India and is especially strong in culture fisheries. The state is endowed with vast resources of inland, brackishwater and marine fisheries. It produces 140,000 t of freshwater fish and 120,000 t of marine fish per year, out of which nearly 20,000 t is shrimp.

Fish culture has been popular with fish farmers in the coastal districts from 1980 onwards. The production averages seven tonnes per hectare per crop, with a net profit of 25,000 Rs*/year, against Rs. 10,000 in agriculture. Some progressive farmers and entrepreneurs have produced as much as twelve tonnes per hectare, thus reaping profits of up to Rs. 50,000.

Of late, brackishwater prawn culture has gathered momentum. About 10,000 ha are already under extensive culture, producing 400-500 kg/ha/crop. There is potential to produce upto 2-3 t/ha/crop, which would mean returns of about 150,000 Rs/ha/crop. The Andhra Pradesh Government leases brackishwater lands to farmers and entrepreneurs on a 15-year lease. Approximately 17,000 ha more are to be leased shortly.

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* US $ I = IRs. 32 appx.

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49. MARINE POLLUTION

49.1 Industries

The location of the main industries in the coastal districts of Andhra Pradesh are shown in Figure 33 (facing page).

Over 30 per cent of all industries (large and medium) in Andhra Pradesh are located in the nine coastal districts (see tables below and Figure 33 on facing page).

Categorywise large and medium industries in Andhra Pradesh

Sl. No.	Category *of industries*	*No. of units*	Capital investment *(Rs. '00,000)*	*Employmenr number*	*Per* capita investment *on employment (Rs. '00,000)*	Units in *coastal districts*
1.	Food & Agro processing industries	139	65787	43071	1.52	19
2.	Leather Industries	6	534	883	0.60	1
3.	Chemical & allied industries	113	86969	29234	2.97	26
4.	Drugs & Pharmaceutical industries	29	9173	2474	3.70	3
5.	Paper, pulp & other forest-based industries	29	32055	17058	1.87	16
6.	Textile industries	75	29281	37213	0.78	19
	Jute-based industries	11	3249	17596	0.18	II
0.	Cement industries	34	133043	12666	10.50	7
9.	Mineral-based ceramic industries (other than cement)	27	45392	176591	0.25	2
10.	Engineering industries	127	139428	69051	2.01	21
II.	Electrical industries	20	195679	19417	10.07	6
12.	Electronic industries	22	12494	12366	1.01	2
		632	753090	437684	1.72	193

Categorywise distribution of large and medium industries in the coastal districts of Andhra Pradesh

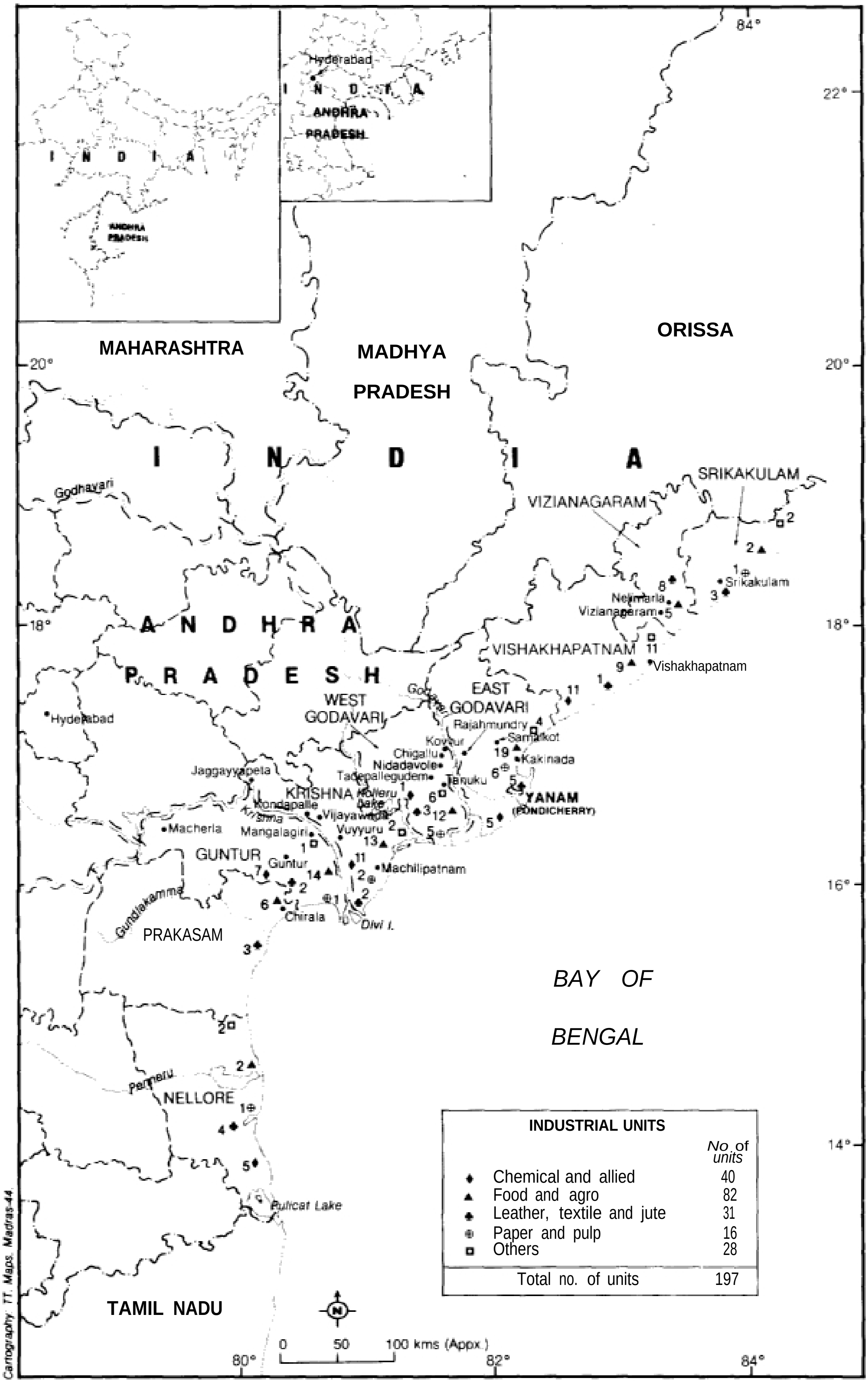
District	Food & Agro	Leather	Chemical & Allied products	Drugs/ Pharma-ceuticals	Paper & pulp	Textile	Jute	Cement	Mineral based	Engng.	Electrical	Electronic	Total no. of units
Srikakulam	2		2		1	-	3	-	-	-	-	–	8
Vizianagaram	5	1	–		–	1	6	-	-	-	–	–	13
Vishakhapatnam	8	–	11		–	–	1	1	–	1	3	–	31
East Godawari	16	–	3	2	6	5	-	-	–	4	1	–	37
West Godavari	12	–	6		5	2	I	–	–	I	–	–	27
Krishna	13	–	2	–	2	2	–	2	1	5	–	1	28
Guntur	14	–	1	–	I	2	–	4	–	3	–	–	25
Prakasam		–	–		–	3	-	-	–	–	–		10
Nellore	2	–	1	1	1	4	–	–	I	I	2	I	14
Total	79	1	26	3	16	19	11	7	2	21	6	2	193

Of the industries established in the coastal districts, around half are in the central zone and a quarter each are in the northern and southern parts of the state (see Figure 33 on facing page). The Godavari, Krishna and Gondalakama River estuarine marine ecosystems are, consequently, more affected by industrial pollution than the coastal areas of north and south Andhra Pradesh.

VISHAKHAPATNAM DISTRICT

Among the three coastal districts in the north, the present status of marine environmental pollution is most alarming in Vishakhapatnam, where alone there are 31 medium and large industries concentrated.

Fig. 33. Industries in Andhra Pradesh coastal districts



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Among the food and agriculture industries in this district, except for two sugar mills the rest are in marine products processing. Organic pollution is the potential environmental threat this group of industries poses.

There are eleven chemical and allied industries also causing pollution. The majority of the pollutants are heavy metals, such as cadmium, copper, lead, mercury, nickel, zinc and iron ore, and are from the steel, fertilizer and metal alloy industries. The fertilizer industries also contribute ammonia and sulphur pollution.

Since Vishakhapatnam District possesses a major fishing harbour and port, where oil transportation etc. are inevitable, high concentrations of hydrocarbons are found contaminating the surrounding marine environment.

There are no paper and pulp industries in the district, but there is a jute mill of 33,439 t capacity.

High sulphur concentrations have been registered in the sea outside Vishakhapatnam due to the siting in the district of a large zinc plant, other industrial plants, as well as an oil refinery.

The shipyard here, among the world's biggest, also contaminates the marine ecosystem due to regular vessel movements, draining of waste oil, the painting of vessels etc.

The Port authorities in Vishakhapatnam have, however, established an environmental wing which monitors the environmental impact. By using oil skimmers, oil is removed from seawater.

SRIKAKULAM DISTRICT

This district, like the other northern district of Andhra Pradesh, Vizianagaram, is fortunately still in a healthy environmental state. But a recently established alkali-based chemical industry will, no doubt, cause some marine environmental pollution.

A paper mill established in 1983 has also been polluting the area's marine environment with chlorinated organic compounds.

VIZIANAGARAM DISTRICT

There are no chemical industries in this district and the only threat to the marine environment here is a major tannery established in 1977 and which produces finished leathers.

Of the food and agro-based industries in the district, two are sugar mills; the others produce vegetable oils.

EAST GODAVARI DISTRICT

Two major fertilizer factories, one established in 1990 with a capacity of 1,000,000 tpa and the other in 1988 with a capacity of 300,000 tpa, use hydrogen from petroleum and nitrogen from natural gas to produce di-ammonium phosphate.

The effluent treatment ponds of these two units are scheduled to be located near residential areas in Kakinada town. A recommendation has been made that fish and crustaceans be introduced into the treated effluents as bio-indicators and observed for periods of at least 76 hours. If the indications are favourable, the treated effluents are to be discharged through pipelines into the deeper sea, instead of into the shallow waters of Kakinada Bay.

Pulp and paper mills in the district release chlorinated hydrocarbon effluents into the Godavari River.

A natural gas project is under consideration on the east Godavari shoreline. This might cause thermal pollution.

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WEST GODAVARI DISTRICT

Among the six chemical industries, only three are hazardous — one established in 1964 and producing superphosphate and sulphuric acid, another established in 1978, and producing hydrazine and hydrate, and a third established in 1982 and producing liquid BHC, BHCWDP, BHC-dust and liquid pesticide formulations.

The first is at Nidadavole, 10 km from the Godavari River, the other two are in Koovur on the Godavari's banks. The latter are about 80-100 km from the Bay of Bengal. Their effluents are, therefore, further degraded when they reach the sea. No damage to marine life has been documented.

The Godavari River, the largest of the peninsular rivers, provides raw water to a major paper mill in the district, located about 200 km from the Bay of Bengal. The processing of paper and boards produces enormous quantities of factory waste here.

Investigations into metal pollution in the Godavari River here reveal that at the discharge point, and upto about 1 km downstream, iron, manganese and zinc are in high concentrations. Upstream from the factory, the metal concentrations are below the detection limits of the analysis method.

A considerable drop in pH values and an appreciable increase in organic matter, hardness and calcium levels have been noticed after the entry of wastes into the river. Diatoms were more diversified in unaffected water, whereas Cyanophyceae were more prevalent both qualitatively and quantitatively in the polluted areas.

Iron was the most dominant heavy metal (see table below), while zinc and manganese occupied second and third positions in order of dominance. Cadmium was recorded in very low concentrations, with a maximum of 0.5 micrograms/l in the effluents.

Two-year averages of various heavy metals and physieochemical factors in the Godavari River

Name of factor	*Station II*	*Station III*	*Effluents*
Cd microgram/litre	0.25 ± 0.13	0.21 ± 0.53	2.80 ± 1.58
Cr microgram/litre	47.91 ± 18.87	34.16 ± 18.86	65.83 ± 37.52
Pb microgram/litre	29.58 ± 12.67	13.12 ± 8.57	44.58 ± 18.64
Co microgram/litre	15.00 ± 8.84	8.75 ± 9.91	26.25 ± 10.95
Ni microgram/litre	28.73 ± 9.41	19.58 ± 7.50	47.50 ± 11.13
Zn microgram/litre	233.41 ± 363.17	198.75 ± 313.16	395.83 ± 539.22
Cu microgram/litre	37.50 ± 17.75	26.25 ± 17.89	66.30 ± 39.06
hln microgram/litre	157.91 ± III.74	78.33 ± 96.39	282.50 ± 119.71
Fe microgram/litre	388.33 ± 137.54	272.50 ± 133.32	579.16 ± 212.60
pH	7.65 ± 0.21	7.90 ± 0.18	6.90 ± 0.10
CO3 mg/litre	3.26 ± 4.57	11.70 ± 6.60	3.15 ± 5.94
Organic mg/litre matter	16.68 ± 14.31	7.12 ± 6.80	57.79 ± 26.87
Hardness mg/litre	2ao.w ± 86.80	179.30 ± 43.60	523.30 ± 150.20
Ca mg/litre	59.50 ± 21.90	33.70 ± 12.40	131.80 ± 44.20
Mg mg/litre	32.70 ± 16.10	21.50 ± 15.00	47.20 ± 30.60

GUNTUR DISTRICT

The Central Government's zinc factory established in 1971 has been exploring for lead in the Bandalamothu areas. The ore mining operations have been causing significant marine environment pollution due to the runoff of certain heavy metals, such as lead and zinc. Since mining has been going on for twenty years, lead and zinc have accumulated and constitute a potential threat to the environment.

PRAKASAM AND NELLORE DISTRICTS

These southern districts are free from hazardous contamination.

49.2 Agriculture

About 250,000 t of pesticides were produced in India in the period 1976-80. Today, about 78,000 t of insecticides and pesticides are used in India every year. Andhra Pradesh alone uses some 26,000 t of these pesticides each year (EIA, 1991). With increased food production the need of the hour, pesticides application in Andhra Pradesh will only further increase.

The pesticides used in Andhra Pradesh are mainly DDT, CHC, chlordane, heptachlor toxaphene, aldrin, dieldrin and endrin. These are all toxic to fish and other biological communities.

The Godavari, Krishna and Gondalakama River estuarine marine ecosystems are highly affected by pesticide contamination. Such contamination is comparatively less in the coastal areas north and south of this part of the Andhra Pradesh coast.

It is documented that mangroves accumulate pesticide residues. A proposed estuarine wetland management project, where mangrove species are to be planted in and around the low-lying, run-off areas affected by pesticide contamination, is therefore proposed.

The speed of pesticide and insecticide degradation, and the role of possible micro-organisms within the coastal marine environment are being investigated by the National Environmental Engineering Research Institute (NEERI) in Andhra Pradesh.

Studies on species versus community reactions are also essential to curb the insecticide and pesticide pollution problem.

The 'Phycological aspects of different river ecology' are being studied in freshwater rivers, which are the carriers of insecticides and pesticides, by several pollution-controlling organizations and research institutions in Andhra Pradesh, such as Osmania University, Andhra University and Nagarjuna University.

The Kolleru Lake, situated between the Godavari and Krishna estuaries, is a freshwater lake which receives occasional intrusions of saltwater. The intensive use of pesticides and nutrients in the drainage area and a diminished inflow of freshwater due to aquaculture constructions are probable causes for damage to the lake's fisheries. The lake has become eutrophicated with weeds and algal flora growing in an uncontrollable manner. Even its air-breathing fish stocks have been reduced. This lake is a potential subject for study to assess the amount of pesticide biomagnification in the foodweb.

49.3 Exploitation of natural resources

'Oil and natural gas findings in Andhra's shore areas have opened up wide industrial opportunities. The surveys so far carried out indicate a high potential for oil and natural gas reserves.

The total area available for exploration and exploitation of hydrocarbons in the Krishna-Godavari basin is of the order of 15,000 km^2 on land and 21,000 km^2 in the sea, upto a depth of 200 metres. The gas composition indicates a high methane content. Environmental Impact Assessments need, however, to be conducted if this resource is to be exploited.

Exploration of chromite deposits at Kondapalle (Krishna District), bauxite deposits in Vishakhapatnam, Vizianagaram and Srikakulam Districts, mica pegmatite deposits in Nellore District and graphite mining in Vizianagaram District also have the potential to endanger the environment.

50. *REFERENCES*

Masterplan for the Andhra Pradesh Shore Areas Development Authority. Vol. 1, 1988, Finance and Planning Dept., Govt. of Andhra Pradesh.

Masterplan for the Andhra Pradesh Shore Areas Development Authority. Vol. 2, 1988, Finance and Planning Dept., Govt. of Andhra Pradesh.

World Bank appraisal of shrimpfarming in West Bengal, Orissa and Andhra Pradesh, 1991. Environmental Impact Assessment of Aquaculture Development. Final report for the environmental assessment of the World Bank-supported inland fisheries and brackishwater aquaculture projects for West Bengal, Orissa and Andhra Pradesh. Prepared by Mark Hardin. ***et al.***

APPENDIX XXIV

Institutions engaged in environmental research, monitoring and enforcement

GOVERNMENT

Aadhra Pradesh Government Fisheries Department,
Commissionerate of Andhra Pradesh Fisheries, Tank Bund Road, Hyderabad

Andhra Pradesh Fisheries Training Institute,
Kakinada, East Godavari District, Andhra Pradesh.

Andhra Pradesh Training Institute,
Machilipatnam. Krishna District, Andhra Pradesh.

Andhra Pradesh Pollution Control Board,
Hyderabad, Andhra Pradesh

Andhra Pradesh Shore Areas Development Authority,
Hyderabad, Andhra Pradesh.

Control Institute of Fisheries Education (CIFE),
Beach Road, Kakinada, East Godavari District, Andhra Pradesh

Central Institute of Fisheries Technology (GIFT),
Kakinada, East Godavari District, Andhra Pradesh.

Central Marine Fisheries Institute (CMFRI),
Kakinada. East Godavari District, Andhra Pradesh.

Commissionerate of Industries,
Andhra Pradesh, Hyderabad, Andhra Pradesh.

Director of Ports,
Kakinada, Andhra Pradesh.

- Fishing harbour, Kakinada
- Fishing harbour, Vishakhapatnam
- Fishing harbour, Nizampatnam
- Fishing harbour, Krishnapatnam
- Fishing harbour, Machilipatnam

Department of Forest,
Hyderabad, Andhra Pradesh.

Department of Salt,
Office of the Assistant Commissioner of Salt, Kakinada, East Godavari District, Andhra Pradesh

Fisheries Survey of India (FSI),
Vishakhapatnam, Andhra Pradesh.

National Environmental Engineering Research Institute (NEERI),
Hyderabad, Andhra Pradesh.

National Remote Sensing Agency (NRSA).
Hyderabad. Andhra Pradesh.

Zoological Survey of India (ZSI),
Madras, Tamil Nadu.

UNIVERSITIES

Andhra Pradesh Agriculture University,
Beach Road, Kakinada. East Godavari District, Andhra Pradesh

Andhra University,
Waltair. Vishakhapatnam

- Department of Marine Biology
- Department of Zoology (School of Life Sciences)
- Department of Environmental Sciences

Nagarjuna University,
Department of Life Sciences, Guntur, Andhra Pradesh.

Osmania University,
Hyderabad, Andhra Pradesh.

- Department of Zoology
- Department of Botany

APPENDIX XXV

Legislation against threats to the marine environment

C.F.V.S. Coastal Zone Management Act, 1972. Sect. 304 (a).

Art 48 A (Part IV), Constitution of India.

Art 51 A (g) (part IV-A), which runs as :

'It shah be the duty of every citizen of India, to protect and improve the natural environment including forests, lakes, rivers and wild life, and to have compassion for living creatures.'

By virtue of Art 31 A.

The three lists (Seventh Schedule, Art 246) are :

I. Union List - Entries 52, 53. 54, 55, 57

IL State List - Entries 6, 7, 14, 18, 21, 24, 25

III. Concurrent List - Entries 17A, 17B, 20

Entries Nos. 6 and 7 of the State List.

Section 19 of the Water (Prevention and Control of Pollution) Act 1974.

Section 33

APPENDIX XXVI

Other publications on the marine environment

Aquatic Environment Monitoring Report - No. 27.

Directory of Large and Medium Industries in Andhra Pradesh, 1990. Published by The All India Manufacturers' Organization. Andhra Pradesh State Board, 6-3-540/8. 1st Floor, Punjagutta Road, Hyderabad 500 482. Andhra Pradesh.

Masterplan for Kolleru Luke Development. An integrated ecological approach. Office of the Kolleru Lake Development, Kaikalur 1987.

NATARAJAN, R. ***et.*** al. 1991. Coastal Zone Management Ocean Data Centre, Anna University, Madras 600 025.

SUDHAKAR, ***G. et. al.*** 1991. ***Metalpollution and its impact on algae in flowing waters in India.*** Dept. of Botany, Osmania University, Hyderabad, Andhra Pradesh.

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Polluted fish landing sire in the Royapuram fishing harbour, Modras.

Tamil Nadu and Pondicherry, Indian East Coast

by

I. Joseph A. Jerald

Consultant-Environment/BOBP

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Marine Habitats

- Mangroves
- Coral reefs
- Seagrass beds and seaweeds

Marine Fauna

- Fisheries
- Aquaculture
- Molluscs

Fish Kills

Marine Pollution

- Domestic wastes
- Industries
- Energy production
- Oil pollution
- Agriculture

References

Appendices

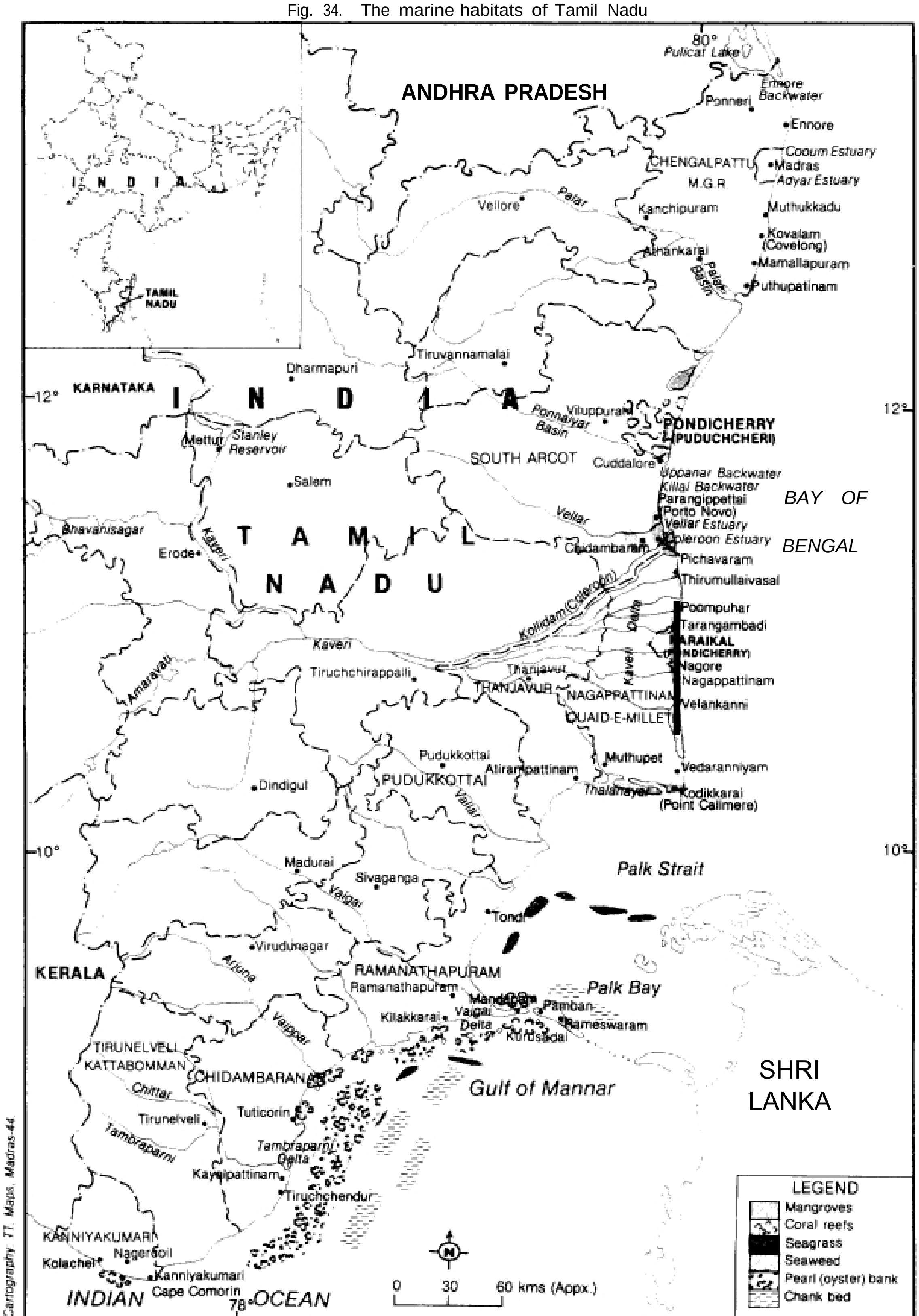
- Institutions engaged in environmental research, monitoring and enforcement
- Legislation against threats to the marine environment
- Other publications on the marine environment

51. *MARINE HABITATS*

51.1 *Mangroves*

Mangroves flourish in the Pennar and Kaveri deltas of Tamil Nadu as well as further south in the Tuticorin and Rameswaram areas. Productive forests are found at Pichavaram and Kodikkarai (Point Calimere) (Muthupet, Chatram, Puthupatinam and Talanayar) (see Figure 34).

Fig. 34. The marine habitats of Tamil Nadu



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The lush mangroves forests are protected by the Forest Department as Reserve Forests. The total area under mangroves in Tamil Nadu is about 225 km^2, about 3 per cent of India's mangrove forest area.

One of the largest and most unspoiled mangrove forests in Tamil Nadu is in Pichavaram in South Arcot District. This forest has 110 km^2 of mangroves, including 14 km^2 that is deemed Reserve Forest. This forest is spread over 51 islets separated by a complex network of creeks and channels (Nagarajan, 1990). A long sand bar separates the whole area from the open sea. The Kollidam (Coleroon) River, emptying into the south end of the lagoon, provides the bulk of the fresh water and sediments inflow. But since this river is used for irrigation, it deprives the mangroves of freshwater supply at critical stages. This results in salinity increase.

Most of the other mangroves in Tamil Nadu have been degraded and are close to extinction. In a few areas, the coastline is fringed by Cusuarina *aquisetifolia* and dune vegetation.

5 1.2. *Coral reefs*

Coral formation in Tamil Nadu is mainly confined to the Gulf of Mannar and Palk Bay. Some patchy growth is also found at Enayam, on the west coast of Kanniyakumari District (see Figure 34 on p. 185). A Marine National Park has been established off both sides of the Mandapam Peninsula along the southern coast of Tamil Nadu, to protect the coral reefs in the Gulf of Mannar and Palk Bay that are facing severe ecological threats.

The Gulf of Mannar reefs extend from the Rameswaram archipelago to Tuticorin in a NE-SW direction over a distance of 140 km. The formation is estimated to be 100 km^2 in extent (Wafar, 1986). The reefs are discontinuous and are mainly found around twenty small islands, at a maximum depth of about six metres (Wells, 1988). These are small fringing reefs, built on the shallow shores of islands that were separated from the mainland in the past by wide subsidence.

The reefs of the Palk Bay, about 30 km in length, stretch in an east-west direction along the Mandapam Peninsula and the shore of Rameswaram island. They are found 200-600 m from the shore in broken patches.

The outer side of the reef harbours ramose corals, while the inner side has massive corals with large polyps. Sedimentation on the shoreward side influences the distribution of corals. The reefs were once mined and, in 1964, were subjected to a cyclonic tidal wave which killed and uprooted many ramose corals. Recolonisation is presently underway, albeit slowly, since the reef is not flourishing.

Pillai (1971) has pointed out that the inshore waters of the Palk Bay become very turbid during the Northeast Monsoon, due to sedimentation. This causes mortality to the coral colonies on the inner side of the reef, where only the species with large polyps survive.

Ninetyfour species, belonging to 37 genera, have been recorded in the Gulf of Mannar and the Palk Bay (Pillai, 1971). The notable feature of the coral in this area is that many common genera found in other parts of the lndo-Pacific are **not** found here. The genera *Pocillopora, Arcopora, Montipora, Porites* and *Leptastrea* are the commonest here. The species of the genera *Montipora* and *Arcopora* have a well-diversified propagation, while Favia spp. and *Favites* spp. are moderately fertile.

Scleractinian corals contain calcium carbonate, which is the raw material for many industries. Corals have been used in Tamil Nadu from earliest times in the preparation of lime and mortar for house building. The establishment of a calcium carbide factory in Tirunelveli District (south Tamil Nadu) paved the way for large-scale quarrying of coral from this area. In the late Sixties, it was estimated that about 500 people were engaged in the Mandapam area collecting coral. It has been reported that 250-300 m^3 of reef was brought ashore daily (Pillai, 1973). According to Venkataramanujam *et* al. (1981), nearly 15,000 t of coral are annually removed from the reefs around Tuticorin, in addition to about 10,000 t of dead shingle *(challi)* washed ashore. Thomas and George (1987) have reported that intensive removal of corals near Tuticorin and in the Gulf of Mannar have greatly reduced the productive coral habitats of Tamil Nadu. Exploitation of corals have totally destroyed reefs in many sites and their recolonization is a remote possibility, since no reef framework is left, as in the case in Manauli Island off Mandapam. Studies of Mandapam reef in the Palk Bay have, however, shown that the fast growing genus, ***Acropora,*** could establish itself on hard rocks. This appears to make reasonable recolonization possible in 10-15 years.

Any plan of action on coral conservation and reef resources should emphasize the necessity of limiting man-made reef destruction. If no action is taken soon, one of the most valuable and useful marine resources of Tamil Nadu will be completely exterminated (Thomas and George, 1987). Fortunately, there is increasing concern in the state for reef protection.

Concrete well rings, with coconut fronds, are being used as fish aggregating devices by some fisherfolk villages 20 to 25 kms south of Madras. These artificial reefs become encrusted with heavy growth of algal mats, barnacles, green mussels and other bivalves, tubicular polychaetes and bryozoans and become something like 'submarine gardens or parks' in areas where such natural ecosystems have been destroyed by continuous bottom-trawling. These artificial reefs also help to rehabilitate fish that have been denied natural breeding sites in coastal waters due to various pollution hazards.

5 1.3 *Seagram beds and seaweeds*

SEAGRASS

Little information is available on the extent of seagrass beds along the Tamil Nadu coast.

Studies of the environmental impacts on seagrass beds in the Gulf of Mannar have been made by Rajeswari and Kamala (1987). They reported six genera and eleven species.

Recent studies, indicate that the islands in the Gulf of Mannar are extremely rich in seagrass (see Figure 34 on p. 185). Salm (1975), however, has claimed that there used to be large seagrass beds in the Gulf of Mannar, which supported large dugong (seacow) herds that have now almost entirely disappeared. He adds that the most extensive areas of seagrass beds are, possibly, in the Palk Straits.

Twelve seagrass species are found in this region: ***Halodule uninervis, H. pinifolia, Cymodocea rotundata, C. serrulata, C. syringodium, C. isoetifolium, Enhalus acoroides, Thalassia hemprichii, Halophila ovalis, H. ovata, H. decipiens, H. stipulacea,*** and ***H. becarii.*** This includes two new records, namely ***Halophila decipiens*** and ***H. becarii.***

Although no estimates have been made for the South Asian seas, estimates elsewhere suggest that the economic value to be obtained from seagrass beds can reach approximately $ 3,500 per ha (Thorhaug, 1983).

Partly because of the relatively inconspicuous nature of this habitat, impacts on seagrass beds have been much less well-documented than have those of other major marine ecosystems. Very little, in fact, is known about the environmental status of the seagrass beds. It is nevertheless possible that eutrophication and sedimentation have caused damage, since seagrasses are extremely sensitive to reduced light penetration.

Aside from this, mechanical substrate turbulence is the most disturbance caused by humans to seagrass beds.

The Indian Marine Biological Association has emphasised the need for seagrass bed protection, to which little attention has been paid in the past. Coastal activities, such as boat construction, human settlement and wastewater disposal should be prohibited in the vicinity of seagrass beds, it has been recommended.

SEAWEED

The economic importance of seaweeds in this region, their mode of exploitation, research on various aspects of their culture, as well as uses, are still in an explorative stage (Krishnamurthy, 1991). Nevertheless, seaweed has been exploited along the Tamil Nadu coast since 1952. It has been reported that the coastal seaweed resources have been diminishing over the years, and conservation, particularly of *Gelidiella acerosa,* has been advocated. Krishnamurthy (1986) has stated that, as yet, no successful effort at large-scale seaweed cultivation has been undertaken off Tamil Nadu coast.

Estimated standing seaweed stocks are listed alongside.

Seaweeds of the Tamil Nadu coast (estimated standing crop)

Flora	Wet weight (t)
Agrophytes	
Gelidiella acerosa	74
Gracilaria edulis	345
Gracilaria spp.	629
Carrangeenophy tes	
Hypnea must informes	293
Hypnea spp	505
Alginophytes	
Sargassum spp	9381
Turbinaria spp	740

Source: Survey of 1971-75

52. MARINE FAUNA

52.1 Fisheries

Tamil Nadu has a coastal fisherfolk population of 470,000, who form almost one per cent of the state's total population. The state has one major fishing harbour, Madras, and one minor one, Tuticorin. These are landing centres with berth facilities at Mallipatnam, Kodikkarai (Point Calimere), Cuddalore and Rameswaram. However, localized small-scale fishing activities are prevalent all along the coast.

Tamil Nadu has 4000 mechanized vessels (1986), more than 80 per cent of which are of 30-32-feet length, resulting in crowding at 0- 30 fathom depth range. The state is fourth in marine production in India. The annual production during 1990-91 was 289,000 t, accounting for 17 per cent of the country's total marine production (Department of Fisheries, Government of Tamil Nadu).

The exploitation of inshore species in Tamil Nadu is primarily artisanal or small-scale, utilizing a wide range of gear types and craft.

An acoustic survey, both off Cape Comorin and in the Gulf of Mannar, gives an estimated average standing stock of 624,000 t, composed mainly of pelagic species. Of this, the *Stolephorus* (Anchovies) stock was estimated to be 82 per cent.

Among the coastal pelagic resources, the Clupeoids, Scombroids and Carangids are the dominant groups in Tamil Nadu. In the Clupeoids group, *Sardinella* and ***Stolephorus*** are the major species and among the Scombroids, *Rastrelliger* are significant. Tuna and tuna-like fish, as well as the Spanish Mackerel, are the most exploited fish in Tamil Nadu. Tuna catches show highly seasonal fluctuations; peak catches of both Little Eastern and Frigate Tuna are recorded in July-September (Skillman 1982).

52.2 Aquaculture

Shrimp farming is the dominant aquaculture practice in Tamil Nadu. Of the 56,000 ha of estimated brackishwater area in the state, about 176 ha are currently under culture, and a production of over 88 t of shrimp has been reached. The Government has identified 15,000 ha more for brackishwater culture.

Many private firms have recently gone into aquaculture and have touched yields of up to 500-2000 kg/ha/crop. Smaller farmers have usually achieved 500 kg/ha/crop in 4-5 month culture periods.

In the coastal villages of South Arcot and Quaid-e-Milleth Districts, several shrimp farms have been started by private sector concerns. Some of these projects have lacked ecological planning and have destroyed mangrove forests and swampy lagoons during indiscriminate pond construction.

5 2.3 Molluscs

The pearl banks and chank beds off Tuticorin in the Gulf of Mannar (see Figure 34 on p. 185) have been renowned from the earliest times (Rajendran et *al.* 1988). The prevailing two monsoons and other climatic conditions, together with the hydrological situation in the Gulf, have favoured production of pearl oysters and chanks. The traditional pearl fishery continued till the early Eighties, when the banks were found to be exhausted. The Central Marine Fisheries Research Institute (CMFRI), in an attempt to tackle the problem, has launched a pearl culture project. Techniques for the production of a free and spherical cultured pearl oyster, ***Pinctada fucata,*** were developed in India in 1973. A multiple nuclei implantation technique and reuse of the oysters for a second crop have further improved production rates. Tamil Nadu Pearls Limited, with a laboratory for nucleus implantation at Mandapam and another for collection of oysters at Tuticorin, started a farm at Kurusadai Island.

Tuticorin, once called 'The Pearl City', has been rapidly industrialized during the last two decades. Since then, pearl production has diminished substantially. The sacred chank, Xancus pyrum, found since ancient times, has also become very scarce. Apart from industrial pollution, silt and mud carried by the Tambraparni River have been detrimental to the natural habitats of pearls and chanks in this Gulf.

Oysters and clams are distributed in estuaries, backwaters and bays along the coast. They are highly nutritious and provide a cheap protein source for the rural coastal population. These shellfish are collected during low tides and are a subsistence fishery.

Several species of oysters flourish along the Tamil Nadu coast. Among them, the backwater oyster, ***Crassostrea madrasensis,*** dominates. C. *crista galli* and the rock oyster, ***Saccostrea*** *cucullata,* also occur, albeit in smaller quantities. The commercially important clams are ***Meretrix meretrix, M. casta, Katelysia opima*** and ***Anadara rhombea.***

Available information on the standing stock of oysters (mostly C. ***madrasensis)*** is summarized below.

Oyster resources of the Tamil Nadu coast

Area	Extent of bed in ha	Shell on biomass (t)	Reference
Pulicat Lake	9	1321	Thangavelu & Sanjeevaraj (1988)
Ennore	45	18616	Sarvesan et *al. (1988)*
Muttukkadu backwaters	4	5450	d o
Athankarai	14	389	Rao et al., (1987)
Thirumullaivasal	25	75	Muthiah & C T Rajan (pers communication)
Tarangambadi (Tranquebar)	0.6	26	d o
Nagore	0.5	3	d o
Karangod	0.5	40	d o
Muthupet	1500	16740	M.E. Rajapandian (pers communication)
Total	1598.6	42660	

Bivalve wild stocks are vulnerable to overfishing. In order to overcome this situation, techniques for farming C. ***madrasensis*** have been developed at the Tuticorin Research Centre of CMFRI (Nayar, 1987). Technology for mass production of oyster spat has also been developed by the CMFRI at Tuticorin (Nayar et ***al.,*** 1988). The Centre has, in addition, developed a hatchery technology suitable for mass production of clam seeds.

53. FZSH KILLS

Mortality of fish and aquatic organisms due to pollution has been observed in the inshore waters of Kayalpatnam, 30 km south of Tuticorin, as well as in adjacent areas, since the early Eighties. The lagoons in this area extend a distance of three km before joining the sea. The lagoon mouth remains closed for most of the year, except during the peak of the Northeast Monsoon, when it opens, discharging the polluted water into the sea.

Two major chemical works at Shahupuram, near Kayalpatnam, are the main polluters. Pollutants from them include organic compounds, chlorinated hydrocarbons and mercury. The sudden release of polluted water when the lagoon mouth opens, usually in November, is believed to be the cause of the mass mortality of fish and aquatic organisms in inshore waters (Kasim et *al.,* 1991). The duration of such kills is, however, only a day or two.

Fish kills have also occurred at nearby Tiruchendur. Most of the dead organisms were found close to the lagoon by one of the chemical works, they were less towards Tiruchendur town. About twenty different groups of marine organisms, comprising fish, crab, starfish, molluscs and others, were found affected by the polluted water. Most severely affected were mullets, catfish and eels. Chemical analyses of the water revealed that the pH was less than 3.5 near the lagoon.

Similar instances of fish kills have been reported in the Kaveri riverine stretch near Mettur in Tamil Nadu. Effluents from chemical industries here were attributed as the cause for mass fish and aquatic organism mortality.

Phytoplankton blooms have been reported in the Pamban area near the Kurusadai Islands in the Gulf of Mannar since the early Forties. They have caused mass mortality of marine organisms. Studies have been carried out on the *Trichodesmium erythaeum* bloom in the waters around the Kurusadai islands. In September 1972, were the occurrence of a bloom that lasted for seven days, over an area of about 7 km^2, was recorded. There was, however, unlike in previous cases, no mortality of fish or other organisms. The phosphate content decreased with the advance of the bloom and, finally, disappeared during the last days of bloom proliferation. Nitrate was not traceable. Phosphate loss and lack of its replenishment might have acted as a deterrent to the bloom flourishing.

In 1970, Porto Novo waters experienced the *T. erythaeum* bloom.

Studies on microbial pollution in Tamil Nadu's coastal waters have been carried out in a few universities. In recent years, fish and shellfish from coastal areas have been blacklisted as notorious transmitters of food-borne diseases, and there are reports of fish infection by bacteria in Tamil Nadu. A survey conducted near the Parangipettai (Porto Novo) coast recorded several instances of fin rot diseases (Lakshmanaperumalsamy *et al.,* 1984). Occurrence of bone tumour (in a catfish, *Tachysurus* spp.), fin necrosis accompanied by external haemorrhage, ulceration and loss of scales symptoms were also quite common due to bacterial infections.

54. MARINE POLLUTZON

54.1 Domestic wastes

Domestic wastes from many coastal cities in Tamil Nadu are directly discharged into the coastal waters (see table on facing page, top) while in others they are carried to the sea through waterways such as rivers, streams and other freshwater systems.

Sewage production and BOD load from coastal towns in Tamil Nadu

Name of lown	Status	Population 1981	Sewage production ı 10 l/d	BOD 10 kg day***
1. Madras	Class I	3,276,622	195.0	983
2. Cuddalore	Class I	127.625	7.5	38
3. Tuticorin	Class I	192,949	II.5	57
4. Chidambaram	Class II	55,920	3.4	16
5. Nagapattinam	Class II	82,626	5.0	24
6. Tiruchendur	Class II	24,233	1.5	7.2
7. Rameswaram	Class III	27,928	0.8	8.4
8. Kolachel	Class III	23.124	0.7	6.9
9. Parangipettai (Porto Novo)	Class III	20.100	0.6	6.0
10. Vedaranyam	Class III	26,573	0.8	7.9
11. Atiramapattinam	Class III	21,179	0.7	6.3
12. Kilakkarai	Class III	27,842	0.9	8.3
13. Mandapam (Pamban)	Class IV	14,806	0.45	4.4
14. Kanniyakumari	Class IV	14,087	0.45	4.4
15. Tondi	Class IV	11,148	0.35	3 5
16. Ponneri	Class IV	16,021	0.50	4.8
17. Tarangambadi (Tranquebar)	Class IV	18,607	0.55	5.5
18. Thirumullaivasal	Class IV	10,326	0.30	3.1

* at the rate of 60 l/day for Class I & II and 30 l/day for Class III & IV cities

** at the rate of 0.3 kg/day person

The major cities situated on the coast are Madras, Cuddalore, Pondicherry and Tuticorin. More than 500 fishing villages and small towns are also found there. The estimated population of these coastal cities stands at roughly six million. The domestic wastes discharged into the sea from the urban and rural areas are untreated. In Madras City alone, there are more than three million people living on the coast. Much sewage is washed into the Cooum and Adyar rivers and the Buckingham Canal in Madras city. The standards set (7968 of 1976) by the Indian Standards Institute (ISI) for different pollutants in the effluents discharged into the sea are presented in the table below together with, as a comparison, the values recorded from the waters of the River Cooum, at the discharge points by Napier Bridge. The data clearly shows the high pollutant load being added to coastal waters. Sewage pollution is more severe in Madras compared to other places (Ramachandran, 1990).

Effluent water quality (UNEP, Ecology 2(8):13)

Pollution parameters	ISI Standard	Minimum national standard proposed	Reference effluent*	River Cooum
TSS (mg/l)	100	20	30	6343**
Oil grease (mg/l)	20	10	1.4	–
BOD_5 (mg/l)	100	15	30	176**
COD (mg/l)	250	NS	6.2	351**
Phenols (mg/l)	5	I	–	10**
Sulphide (mg/l)	5	I	–	120***
pH	5.5-9	6-8.5	7	7.3'

Source : * Srandard proposed by UNEP

** Somasundaram et *al., (1987)*

*** Rarichandran (1987)

According to Ramasubramaniyan et *al.* (1991), the pollution in the Madras coastal waters is mainly due to sewage inflow into the Cooum River.

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There are several reports available on the distribution of human pathogens, bacteria water indicators as well as sediment, phytoplankton and fauna1 samples along the Tamil Nadu coast. The seasonal incidence of *Escherichia coli* in environmental samples (water, plankton and sediments) in 1981-82, and in sea foods in 1982-83, were monitored at the Vellar estuarine region in Parangipettai (Natarajan and Ramesh, 1987). High *E. coli* counts in water (1.7 x 10^3/100 ml), plankton (3.6 x 10^4/g) and sediments (7.0 x 10^3/g), were recorded during monsoon and post-monsoon periods, while low values were recorded during the summer.

The incidence of three new serotypes of *Salmonella, viz. S. irumu, S. Panama* and S. *lexington,* was recorded for the first time in India in environmental samples taken in the Pichavaram mangroves and in the Vellar estuary (Ramamurthy *et al., 1985).*

Sewage sludge has caused extensive contamination of the Vellar estuarine water by enteropathogenic gram negative, motile *E. coli* bacterium and faecal coliform. Water, sediments, plankton, finfish and shellfish in the different zones of the estuary were also affected (Sivakumar *et al.,* 1986). The contamination is reported to have caused gastroenteritis and urinary infection, particularly in children. The presence of the faecal coliforms in aquatic systems, fishing products (see table below) and other sources in this area is considered an index of poor sanitary quality as well as an indicator of pollution.

Incidence of total coliform and faecal coliform associated with a few marine organisms

Collection area in Parangipettai	Group examined	No. of specimens examined	No. and per cent of samples positive			
			Total (No.)	Coliform (%)	Faecal (No.)	Coliform (%)
Vellar estuary	Fish	62	58	93.55	30	48.39
	Shrimp	12	12	100	10	83.33
	Crab	6	3	50	3	50
	Molluses	14	14	100	8	57.14
	Total	94	87	92.55	51	57.45
Landing site	Fish	50	50	100	40	80
	Shrtmp	50	50	100	44	88
	Crab	24	24	100	16	66.67
	Total	124	124	100	100	80.65

A report on the bacterial flora examination by the State Fisheries Board in the Eighties revealed that the total bacterial count of natural bed oysters ranged from 14.8 x 10^2/g to 11.6 x 10^3/g in the sediment, and the total bacterial count of the surrounding seawater ranged from 4.5 x 10^2/ml to 9.8 x 10^3/ml. Faecal coliforms of natural bed oysters ranged from 0 to 39/100 g in the sediment, and that of natural seawater from 0 to 28/100 ml.

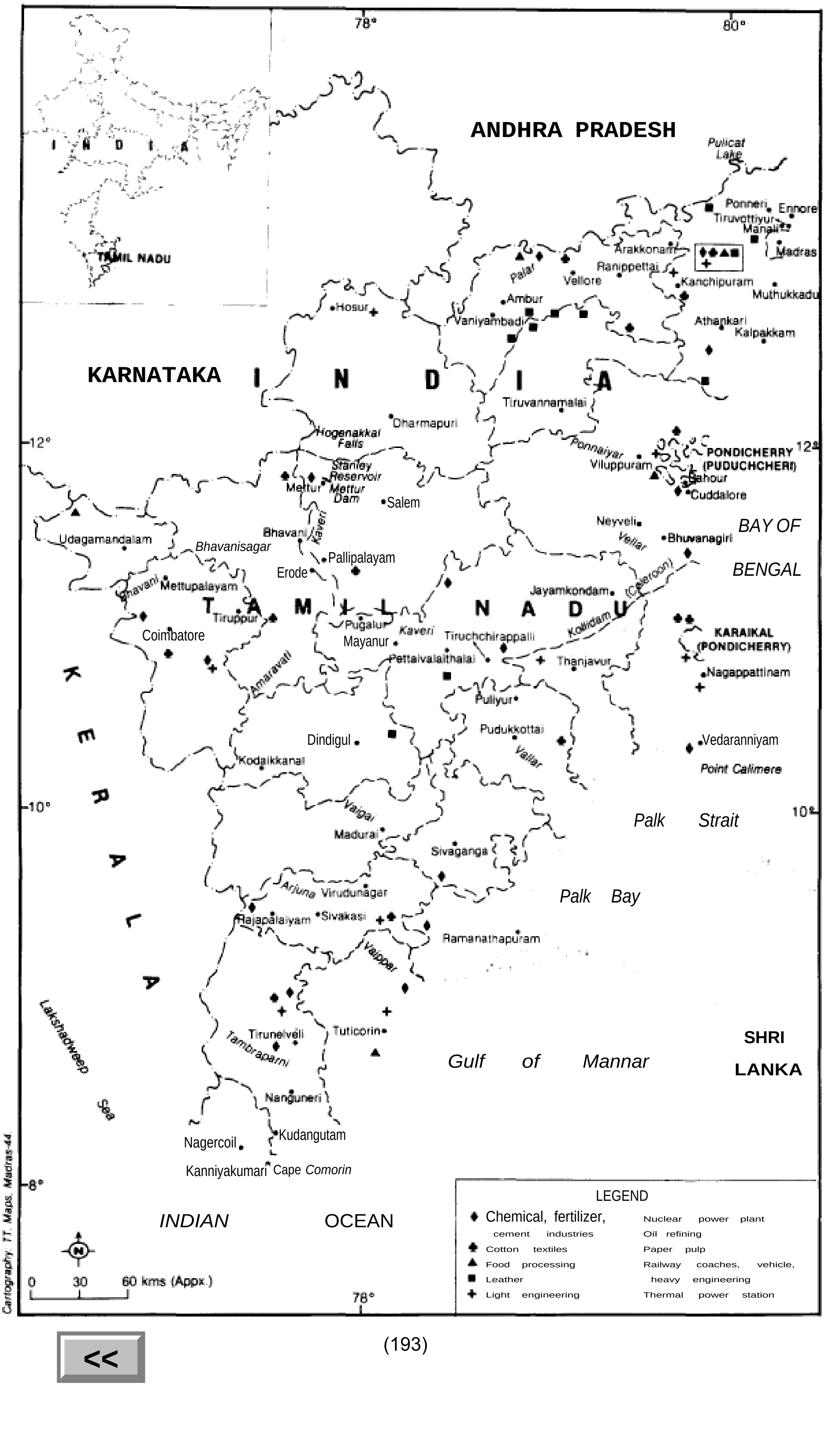
Lakshmanaperumalsamy and Purushothaman (1982) reported heterotrophic bacteria being more abundant with seaweeds than in the seawater. The common genera encountered by them were *Bacillus, Corynebacterium, Vibrio, Alcaligenes and Pseudomonas.* The bacteria present on the surface of *Enteromorpha intestinalis* cells and in the seawater were found to produce the growth hormone Indole acetic acid (IAA) in media supplemented with l- tryptophan (Chandramohan, 1971).

Mycoflora is affected to a very large extent by sewage. Reports on the ecology of higher fungi in marine and brackishwater soils environments are scanty. However, it has been recorded that 86 species of fungi, a majority belonging to fungi imperfecti, and 22 species of marine lignicolus fungi exist. Very recently, Prabhu *et al.* (1991) made a study for two years on mycoflora in seawater and sediments along the Madras coast. Their report identified 26 species of fungi belonging to 14 genera.

54.2 Industries

There are about 12,150 industries in the State of Tamil Nadu and the Union Territory of Pondicherry. Of these, 5650 are situated in the coastal zone and 2500 not far from the coast (see Figure 35 on facing page).

Fig. 35. Map showing the towns, industries and rivers of Tamil Nadu



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The major congregation of industries is in Madras. About 1500 industries are located in the city alone. The types of industries in Madras are :

Electricity, gas and water (35%)

Rubber, plastics, petroleum and coal products (9.5%)

Machine tools (9.3%)

Paper and pulp products (5.5%)

Metal products (5.1 %)

Others (35.6%)

Source: (Industrial Profile of Tamil Nadu, 1985) — Department of Statistics, Government of Tamil Nadu).

Quantity of water used in some industries

Industry	*Quantity of water*	*Purpose used*
Thermal power	100- 150 m^3, hr per MW	Cooling
Pulp and paper mills	63-112m^3/t 270m^3/t pulp	Processing of board
Oil refining	350m^3/t crude oil	Processing
Tannery	72m^3/t hides	Processing
Textiles	0.12-0. 19m^3/m 10-20m^3/100 kg goods	Bleaching Dyeing

Major sources of metal pollutants

Pollutant source	*Major Pollutants*
Chlor-alkali factories	Mercury
Industrial coolant water discharge and corrosion of pipelines	Copper
Dust and rain (atmospheric fall-out, petroleum burning)	Lead
Plating and galvanizing (machine tools and metal products)	Zinc, cadmium and chromium
Municipal waste water	Cadmium and copper
Combustion of coal (power plants – flyash)	Copper, lead and zinc
Combustion of oil (power generators)	Nickel
Dredging and dumping of sediments from harbours	Zinc, lead and copper
Antifouling paints	Copper and mercury

HEAVY METALS

Virtually all industrial processes involving water are potential sources of metallic contamination in estuaries and coastal water. The quantity of water used in the various major industries on the coast are given in the table alongside (top). The various sources of metal pollutants and the principal metals associated with these sources are presented in the second table alongside. The heavy metals commonly found in Tamil Nadu coastal waters are cadmium, copper, lead, mercury, nickel and zinc.

The metal levels in the offshore and coastal waters of various regions of Tamil Nadu, as well as concentrations recorded from the Cooum River (as a representative of discharged wastes), together with WHO standards and the average values recorded from surface waters of the Bay of Bengal and the Arabian Sea, are shown in the table below.

Heavy metals in the coastal waters of Tamil Nadu (microgram/litre)

Pollutant (1)	*Point Caiimere* (2)	*Porro Novo* (3)	*Madras* (4)	*River Coounr* (5)	*U'HO* Stds (6)	Bay of *Bengal* (7)	Arabian Sea (8)	*Ojjshore waters* *Madras* (9)	*Tuticorin* (10)
Cadmium	0.1-0.06	0.2-0.5	14	0.98	2	0.3-2.9	0.2-3.5	0.10-0.8	0.4-2.0
Copper	2-8	0.5-9 9	6-170	4.32	3	1.2-17.5	2.5-22.5	3.00-3.2	4.0-5.0
Lead	I s-2.5	1.5-3.0	7-42	1.38	1	0.5-21.8	4.0-12.5	5.00-6.00	2.0-7.8
Mercury	—	0 4	I-I.2	0.009	0.01	0.05.0.3	0.03-2.0	0.03-0.06	0.1-0.12
Nickel	0.7-2.0	0 8-2.4	5-17	5 62	–	0.8-30.3	1.0-16.3	–	–
Zinc	22-40	4.98	15-290	17.6	5	1.9-174	2.9-42.4	–	

Sources : I-Natarajan (1987); 2-Various sources; 3-Daniel (1984);
4 & 5-Somasundaram et al. (1987); 6-8 Qasim & Sengupta (1983);
9, 10-Nanonal Institute of Oceanography, Goa.

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The metal concentrations in natural unpolluted seawater, freshwater, Indian rainwater and rainwater in Northern Europe are presented in the table below. The data in this table and in the table at the bottom of the previous page indicate that:

- The coastal waters of Tamil Nadu are polluted with the metals mentioned.
- The concentrations of heavy metals in offshore waters are remarkably high.
- The precipitation in India contains significantly less metals than snow and rain in Northern Europe.

Heavy metals in natural waters (microgram/litre)

Metals	Natural seawater (a)	Fresh water (b)	Raomwater (India) (c)	Rainwater (N. Europe) (d)
Cadmium	0.015-0.118	0.07	NA	NA
Copper	0.892-0.240	1.80	6.R	24
Lead	0.001-0.015	0.20	21.5	25
Mercury	0.01 1-0.033	0.01	NA	0.03
Nickel	0.228-0.693	0.30	01	8
Zinc	0.007-0.640	IO	13.3	70

Source : a,b & d · Bryan (1984); c Fondckar and Topgi (1979)

The heavy metal concentrations (microgram/g dry weight), in coastal sediments in Madras, Parangipettai (Porto Novo) and Kodikkarai (Point Calimere) are shown in the table below. Surprisingly high values were recorded at Kodikkarai and Parangipettai compared to the badly polluted seas near Madras. An explanation for this aberration lies in the high organic content in the sediment samples from Kodikkarai and Parangipettai and the sandy sediment from the Madras samples.

Heavy metals in coastal sediments of Tamil Nadu (microgram/g dry wt.)

Metal	Madras ('82- '83) (a)	Porto Novo ('81-'84) (b)	Point Calimere ('86) (c)
Cadmium	0.3-I .45	10-15.0	E-12.0
Copper	0.16-25.2	29-680	40-80.0
Lead	0.09-80.7	7-12.5	7.8-12.5
Nickel	4.70-13.4	7.5-17.0	10-16.0
Zinc	6.60-50.0	3.5-12.0	432-I 142

Source : a-Daniel (1984); b-various sources; c-Nararajan and Ramesh (1987)

The sediments along the coast and continental shelf north of Madras have a high concentration of organic carbon and trace metals such as iron, copper, manganese, zinc and mercury (Ramasubramaniyan et *al.,* 1991; Prabhu et *al.,* 1991).

The heavy metal concentration in the body of various biota collected in Madras, Porto Novo and Point Calimere are given in the table below. The essential metals – copper and zinc – showed higher concentrations than such non-essential metals as cadmium, lead, mercury and nickel. The biota analyzed included phytoplankton, zooplankton, molluscs and fish. The Madras biota showed higher values than in the other places due to the high pollutant levels of ambient water.

Heavy metals in marine biota of Tamil Nadu (microgram/g dry wt.)

Metal	Madras (a)	Porto Novo (b)	Point Colimere (c)
Cadmium	2.0-7.5	0.2-0.25	0.02-0.025
Copper	78-530	2-330	0.05-0.15
Lead	0.18-25	0.01-0.03	0.02-0.025
Mercury	0.08-0.9	0.13-0.82	–
Nickel	0.10-22	0.10-0.30	0.01-0.02
Zinc	5-1200	4-1200	1-14

Rajendran et al. (1988) have reported a higher concentration of iron in oyster Crassostrea ***madrasensis*** (Preston) in the Cuddalore backwaters. Occurrence of trace metals was also noted in the soft tissues of bivalve, gastropods and crustaceans found in the Kalpakkam coastal waters of Tamil Nadu.

According to Daniel (1984), cadmium, lead, copper, nickel and zinc are the main metal pollutants of the Tamil Nadu coast. He has observed that ***Halalimus*** and ***Fredericia*** (Oligochaete) tolerate high organic pollution, ***Oithona rigidac*** and ***Centropages orsini*** tolerate oil pollution, ***Charybdis cruciata*** withstand zinc and cadmium, ***Sepia aculiate*** tolerate copper and ***Paphia*** spp. tolerate nickel.

Mercury concentrations in water, sediments and biota from the Madras coast have also been investigated. He observes that the concentration in the tissues of marine animals was below the FDA guideline of 1.0 mg/kg (1000 ng/g) wet weight. However, he noted that the mercury level exceeded permissible limits in the gills, muscle and skin of the shark, ***Nemipterus javanicus,*** and the whole prawn ***Penaeus indicus.*** Furthermore, he noted that mercury concentrations increased in both water and biological samples along the Madras coast. This is advance warning of increasing mercury pollution.

However, considering the high concentrations of heavy metals in water and sediments, the residues in the biota are surprisingly low.

CHEMICAL INDUSTRIES

Effluents of protein products from a factory in Udagamandalam (Ooty), in western Tamil Nadu, contained high levels of suspended solids and dissolved solids. The dissolved oxygen was very low, as a result of high BOD and COD values. The effluents also contained high amounts of chloride, sulphate, phosphate and toxic levels of nitrates, nitrites and ammonia. Bioassay experiments revealed that the effluents were harmful to the fish in the mountain streams of the area. There was, in fact, a 25-30 per cent reduction of crop seed germination grown on the effluents (Oblisami and Rajannan, 1990).

The effluents from a bleaching company in Mettupalayam, also in western Tamil Nadu, were dull blue in colour and had high amounts of suspended and dissolved solids, with consequent high BOD and COD values. Dissolved oxygen was low and a high concentration of phenols was also reported.

A distillery in Appakudal let out dark brown, alcohol-smelling effluents. The effective concentration of suspended and dissolved solids, as well as BOD and COD, were high. The effluent pH was acidic (5.0), while the DO content was zero. High quantities of chloride (2200 to 7500 mg/l), and ammonia to an extent of 3.3 mg/l, were recorded in the distillery effluents. The effluents also contained organic acids such as propionic acid and buturic acid. Bioassay of fish fingerlings in the distillery effluents revealed that the effluents were highly harmful to the fish (Oblisami and Rajannan, 1990).

The seafood processing plant in Tuticorin discharges water with high concentration of H_2S (>2mg/l), BOD_5 (>30 mg/l), COD (> 100 mg/l) and low pH (6.5). The effluents were mostly untreated or, at best, partially treated.

TANNING INDUSTRY

The leather industry is the fourth largest commercial activity in India. About 80 per cent of the total leather production for export comes from Tamil Nadu, where there are 2200 tanneries, mostly small- and medium-sized and many close to the coast.

Tannery effluents possess a high concentration of dyes and bleach liquors as well as chromium, all of which are very toxic. Tannery wastes also have very high organic contents. The environmental problems connected with tanneries are, in fact, so difficult to handle that there are now practically no such activities in developed countries. As a result, the majority of tanneries are to be found in the poorer countries where environmental laws are lenient or nonexistent.

Oblisami and Rajannan (1990) reported that the effluents from a wattle extracting plant in Mettupalayam were mostly acidic and contained high levels of dissolved solids, sulphate, chloride and tannins (600 to 2000 ppm). The effluents BOD and COD were also high. Irrigation crops with this effluent were found to have adverse effects on seed germination.

Bowonder and Ramana (1986) have recorded groundwater depletion and pollution by small-scale tanneries in the North Arcot District, Tamil Nadu. According to them, the magnitude of the problem worsens due to the interactive effects of population growth, urban development, increased groundwater extraction, depletion of forest cover and the increase in the number of tanneries.

Oceanographic studies of the impact of tannery waste off the Tamil Nadu coast have been carried out by the National Institute of Oceanography, Goa. They showed pollution from tanneries all along the coastal stretch from Madras to Vedaranniyam. The ill-effects of tannery effluents, leading to fish kills in the Palar River, have been mentioned in the press (Narayanamurthy, 1987; *The Hindu,* 1991).

Since the impacts of tannery wastes have increased alarmingly, the Government has requested the Central Leather Research Institute (CLRI), Madras, to find remedies for the crises. The Institute has been carrying out studies on the control of pollution arising from tanning industries and has also been offering industrial consultancy services on pollution control programmes. It has designed, erected, put into operation and maintained a full-scale demonstration effluent treatment plant in Ranipettai since 1977 in a collaborative venture with the industry. Since then, it has designed several effluent treatment systems for various factories in Madras, Ranipettai and Vaniyambadi.

More recently, the CLRI has established a common effluent treatment plant at Vaniyambadi, near Ambur in North Arcot District, for a group of 79 major tanneries. The project is the first of its kind in the state. The plant will collect and treat 2.0 million litres of effluent discharge per day. The cost of the project is estimated at Rs. 2.5 million. The feasibility report furnished by CLRI was approved by the Central Pollution Control Board and Department of Environment, which provided financial assistance to the tune of Rs. 2.5 million. The project was implemented by the Tamil Nadu Leather Development Corporation and the tanning industry (CLRI report).

54.3 Energy production

The per capita consumption of power in Tamil Nadu is estimated to be 280 kwh (1989-90). The State depends primarily on thermal generation (73 per cent) for its energy requirements. The major contribution is from coal-fired and lignite-based thermal stations. Some nuclear power (8 per cent) and hydro-generation (19 per cent), particularly in years of abundant rainfall (Belliappa, 1992), supply the rest of the state's requirement.

The annual coal requirement to meet the present thermal power needs of Tamil Nadu is approximately seven million tonnes. Tamil Nadu is fortunate to have a large lignite reserve, as well as high quality black coal (see table below).

Coal reserves in Tamil Nadu

Name of area	Geological reserve (t)	Minable reserve (t)	Area $(km)^2$
South Arcot (TN)	3300	2100	485
Jayamkondam area in Tiruchi Dr (TN)	1150 appx.	650	120
Bahur area (partly in TN & Pondicherry)	585	Not assessed	52

About eleven million tonnes of lignite is mined a year. The extraction and utilization of lignite for power generation has been entrusted to a public-sector company in Neyveli. Lignite is extracted by open cut mining where the surface over-burden is removed and the lignite is extracted. The Neyveli belt is, therefore, subjected to the environmental consequences of open-cast mining as well as the problems associated with thermal power generation. The peculiar feature of Neyveli, however, is the high water table, which needs constant freshwater pumping to enable extraction of the lignite. Roughly $135 m^3$ of water per minute is required to be pumped out. The constant pumping of such large quantities of water into the surrounding areas exposes them to the risk of water-logging, resulting in soil chemistry changes.

The Jayamkondam area is a virgin site, but it is planned to set up a major power plant here to utilize the lignite available. The problems associated with the mining and utilization in this area are likely to be no different from those faced at Neyveli. The water availability, however, may not be as copious as at Neyveli.

The most important environmental effects caused by electrical power plants are due to thermal and residual chlorine effluents. While fish might survive at a lower temperature, the sharpness of the lethal maximum temperature is such that even the slightest change can cause mortality (Kutty et *al.,* 1986).

Tropical aquatic organisms are more prone to thermal effects because they normally live in a temperature regime which is close to the upper tolerance limit. Temperature may also exert synergistic effects with mechanical stresses as well as chlorine residuals and trace metals present in the effluent waters (Satpathy et *al.,* 1990). Temperature elevation, due to effluent discharges from the power plants in Madras (Kalpakkam and Ennore), has been observed in an area of several square kilometres. The condenser cooling system at Kalpakkam, for instance, uses seawater at the rate of 35 m^3/s, which is then discharged at high temperatures. The rise at the outfall, as compared to the intake, is found to range between 8 and 10°C. Ecological changes included a marginal decrease in dissolved oxygen, pH, and primary productivity (Durairaj, 1990). The movement of the thermal plume on the coast has not, led to fish kills, but significant changes in sedentary fauna and flora have been recorded in the condenser outfall area (Suresh et *al.,* 1990). The influence of thermal effluents on the phytoplankton ecology of the mangrove estuaries of Tuticorin on the Tamil Nadu coast was studied by Santhanam (1990). He has attributed the cause for poor species' diversity to the impact of direct mixing of thermal effluents. Another study recorded a 60 per cent zooplankton mortality due to entrainment.

On the sandy shores, where the impact of the thermal plume is observed, *Emerita asiatica* seemed to be the first order impact organisms. There was also a marked reduction of biota upto a few kilometres on the adjacent shores. When the ambient temperature ranged between 37.0 and 37.6°C, almost all the macro-epifauna and epi-flora perished, except for Periwinkles and Cthamalid Barnacles.

Chlorine is applied to the seawater at the rate of 25 kg per hour at the cooling water intake about 400 metres from the shore. (This is being practised at Kalpakkam Nuclear Power Plant, about 60 km south of Madras.) Chlorine is used to kill the growth of marine organisms, which build up on the walls of the power plant cooling systems. The excess chlorine has caused physical damage to the cells of the phytoplankton, leading to a reduction in photosynthetic efficiency as well as a decrease in primary organic productivity (Ahamed ef *al.,* 1990). In addition to these ill-effects, chlorine added to the seawater also transforms its chemistry, forming a complicated Trihalomethane (THM) compound that is potentially a carcinogenic agent. Excess chlorine with ammonia derivatives form compounds such as chloramines and bromamines, which are more persistent than free halogen and hence, potentially more toxic. Some of them are biomagnified and concentrations should, therefore, be checked in commercially important fish and crustaceans.

The increase in usage of nuclear energy for the production of power has increased the amount of radioactive wastes (Rangarajan et *al.,* 1991). The Madras Atomic Power Station (MAPS) is a clear example of this (see table below and on facing page, top).

Radioactivity of Tritium in MAPS effluents (T Bq)

1985		1986		1987		1988	
L.d.*	A.d.**	L.d.	A.d.	L.d	A.d.	L.d.	A.d.
0.015	18	0.27	41	0.057	54	0.089	373

Source : Rangarajan et al., 1991

* Liquid discharge ** Atmospheric discharge

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During the power plant operations, tritium is routinely released into the environment from the reactors, through atmospheric and liquid discharge routes. On release into the environment, tritium (t ½ = 12.3 years), being an isotope of hydrogen, assimilates readily with the water component of the atmospheric, aquatic and biological systems. Although tritium occurs in nature – formed by the action of cosmic rays on the earth's atmosphere – nuclear installations are, by far, the greatest source of tritium in the environment. The nuclear industry insists that such releases pose no risk to the public, but there is mounting evidence linking tritium emissions with birth defects and cancers (Gardner, 1990).

Yearwise increase in generation of radioactive wastes

Year	Atmospheric discharge (A.d) (T Bq)	Liquid discharge (L. d) (T Bq)
1989	1147 6	922
1990	829.5	141.1

Though scientific reports (Rangarajan et *al.,* 1991) reveal that tritium levels in the waters of habitats adjacent to MAPS are low (3 1 - 240 Bq/l), the media has been regularly highlighting the hazardous effects of these plants to the public. If the proposal to establish a nuclear power plant at Kudangulam, near Tirunelveli, materializes, the threat due to radioactive pollution could be even more severe,

54.4 Oil pollution

Activities responsible for oil pollution of the marine environment in Tamil Nadu include oil exploration, oil refining, oil transport, oil spills and leakages from ships and fishing trawlers as well as from petrochemical industries. The places where such activities take place and their magnitude are presented in the table alongside.

Activities related to marine oil pollution in Tamil Nadu

Activity	Area	*Other details*
Oil exploration (Drilling wastes. production wastes and sanitary wastes)	Kareri Delta, Palk Bay	Offshore and nearshore
Oil production (same as above plus free emulsion tank bottom sludge etc.)	Koilkalappat Narimanam Bhuvanagiri	25,000 t 30.000 bbl/d*
Oil transport (ship wastes, tank washings, spills etc.)	Madras and Tuticorin	3 x 10^6 t/y
Oil refining [oil from leaks, spills, effluents tanks draw off etc.)	Madras	5 x Id t/y
Petrochemicals productton (by-products productron and industrial wastes).	Madras Gulf of Mannar	75,000-100,000t/y

* billion barrels per day

The southern Bay of Bengal, the Gulf of Mannar region, forms a part of one of the two major tanker routes (Qasim and Sengupta, 1983). The range of concentration dissolved petroleum hydrocarbons in the Bay of Bengal and the Arabian Sea are 0 to 28.2 and 0 to 42.8 microgram/kg, the average being 4.6 and 15.8 microgram/kg respectively. The particulate petroleum residues range from 0 to 69.8 mg/m^2 in the Bay of Bengal and from 0.3 to 112.2 mg/m^2 in the Arabian Sea (UNEP, 1985).

The dissolved PHC in the Pichavaram mangrove waters (Parangipettai) ranged from 5 to 15 microgram/litre and in Kodikkarai (Point Calimere) from 8 to 20 microgram/litre (Natarajan and Ramesh, 1987). In the Madras area, values ranging from 4 microgram/litre to as high as 108 microgram/litre in water and from 1.5 to 3.5 microgram/g dry weight of sediments were reported. The values recorded along the Tamil Nadu coast are slightly less than those recorded in other parts of the world. Thus, at present levels, they do not pose any threat to marine life. Intensification of oil exploration during the next five years in the Godavari basin and the Palk Straits area should, however, cause concern. Continuous monitoring of both areas, to establish a scientific database and to assess the environmental impact and degradation is essential.

54.5 Agriculture

Tamil Nadu has a total cropping area of 7.1 million ha, of which about 2.65 million ha are irrigated. The most commonly used pesticides are HCH, malathion, parathion, monocrotophos and sevin (cabaryl). About 8,000 t of solid and 500,000 litres of liquid pesticides are used in agriculture. (Agro Stat., Dept. of Agriculture, Govt. of Tamil Nadu). In addition, DDT is still used in significant amounts for sanitation purposes.

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Pesticides recorded in Tamil Nadu coastal waters include DDT, lindane (r-HCH), endosulfan and heptachlor. The concentration of these pesticides in the coastal waters and sediments from Madras and Parangipettai are presented in the table alongside.

Pesticides in coastal waters (microgram/litre) and sediments (microgram/g dry weight) of Tamil Nadu

Pesticides	*WATER*		*SEDIMENTS*	
	Madras (a)	*Parangipettai (b)*	*Madras (a)*	*Parangipettai (b)*
DDT	9 224	5.2	0.04 3.05	10 44
Lindane	6 761	0.9	003 10'1	I 96
Endosulfan	2 578	0.1	0.00: 519.2	I 33
Heptachlor	6 690	–	0.001 18 37	–

Sources a – Daniel (1984) b - - Rajendran (1984)

The Madras waters had higher values than the Parangipettai waters. But higher values have been recorded in Parangipettai sediments, than in Madras. The bioaccumulation of these pesticides in marine organisms is expected to be considerable.

Analysis of pesticide residues in marine fish revealed that the highest concentrations were found in Black Pomfret followed by tuna, vala and mackerel. However, their concentration was well below the level stated by FDA to be a potential hazard to human health. Yet, pesticide residue in fish should be viewed seriously, as ongoing bioaccumulation can lead to future health hazards for consumers.

Studies carried out by Ramesh et *al.* (1990), on the persistent organochlorine residues in green mussels ***(Perna viridis)*** from the coastal waters of South India, revealed that the concentrations of HCH and DDT ranged from 3 to 33 ng/g on wet weight basis. On the other hand, PCB levels were apparently lower, varying from 1 .0 to 7.1 ng/g wet weight. The residue pattern of organochlorine in mussels is, in the main similar to those in Indian human samples.

The coastal marine pollution of HCH in India ranks with the worst contaminated areas in the world. Ramesh et ***al.*** (1991) have studied the distribution and behaviour of persistent organochlorine insecticides (HCH and DDT), in paddy soil and in the sediments of the Vellar watershed and the Pichavaram mangroves near Parangipettai in Tamil Nadu. Their study indicated that the relative flux of residues in the aquatic environment in tropical watersheds is smaller than the amount volatilised in the atmosphere. The sandbar built between the Vellar and Kollidam (Coleroon) estuaries seems to act as effective traps for heavy metals and pesticides, preventing their entry into the coastal waters (Rajendran,l984).

The pesticide concentrations recorded in different marine biota are presented in the table alongside.

Pesticides in marine biota of Tamil Nadu (microgram/kg)

Organism	*Total DDT*	*Lindane*	*Endosulfan*
Plankton	8.11	1.72	0.20
Crassostrea madrasenis	3.37	0.96	0.39
Meretrix meretri	2.87	0.90	0.37
Katalysia opimo	3.06	0.78	0.40
Mugil cephalus	3.65	1.02	0.37
Therapon jarbusa	3.73	1.12	0.45
Mystus gulio	3.43	0.73	0.36
Siganus java	2.68	1.30	0.48

Source : Rajendran (1984)

Among the pesticides, lindane levels are high in water, endosulfan in sediments and DDT in biota. Among the biota, the highest concen-(rations were recorded in plankton. Special studies of biomagnification of pesticides in tropical habitats are needed.

Pesticides and heavy metals show high concentrations during the monsoon season in surface waters, indicating increased inputs from river run-offs and increased land drainage. The sediments show high concentrations during post-monsoon and summer months, through the settling of particulate matter by precipitation and flocculation. During summer, the petroleum hydrocarbons record maximum values due to the absence of freshwater flow and the stagnant conditions. The minimum values occur during the monsoon months, when dilution, because of flooding, takes place.

Bad land management in agriculture and forestry has led to an excessive loss of fertile soils. The increased transports of sediments have also caused damage to fisheries. Siltation prevents the natural exchange of water between estuaries and the sea, thereby affecting the salinity levels. This, in turn, affects marine fish and shrimp reproduction negatively.

55. REFERENCES

AHAMED, M.S., SURESH, K., DURAIRAJ, G. and NAIR, K.V.K. 1990. Observations on the cooling water chlorination and productivity of entrained phytoplankton at Kalpakkam, east coast of India. *IN: BARC* Proc. Bombay. pp 241 243.

BOWONDER, B. and RAMANA, K.V. *1986. Environmental degradation and economic development.* A case study of a marginally productive area. Department of Environment, New Delhi. pp. l-36.

BELLIAPPA, P.M. 1992. Coal and the clean environment with special reference to the State of Tamil Nadu, India. Proc. *Intl. conf. on environmentally sound coal technologies: Policy issues and tech. options.* Madras, India. Jan. 15-18.1992 PP.9.

BRYAN, G.W. 1984. Pollution due to heavy metals and their compounds. IN: *Marine Ecology,* Ed. 0. Kinne. John Wiley & Sons, New York, Vol. V. part 3. 1289-1432.

CHANDRAMOHAN, D. 1971. lndole acetic acid synthesis in the sea. Proc. *Ind. Acad. Sci. (Plant Sri.)* 73:105-109.

DANIEL, A. 1984. The effect of pollution on some organisms in the zooplankton, benthos and nekton, contributing to the food chain in the marine environment. *Completedprojects under environmental research programme: Objectives and salient findings.* ENVIS. Govt of India. Project 36/ERC. pp.58-59.

DURAIRAJ, G. 1990. Thermal ecology in the vicinity of a power plant cooling water outfall in coastal waters. *IN: BARC. Proc.* Bombay. pp. 272 · 279.

FONDEKAR, S.P. and TOPGI, R.S. 1979. Trace analysis of pollutants in rain water at Goa. *Mahasagar.* (Bull. Natl. lnst Oceanog.), 12:49-5 l.

GARDNER, M. 1990. Results of a case-control study of leukemia and lymphoma among young people near Sellafield nuclear plant in West Cumbria. *British Med. J. 300.* pp.423-429.

KASIM, M.H., BALASUBRAMANIAN, T.S., RAJA PACKIYAM, S. and RANGASAMY, V.S. 1991. Fish mortality due to pollution by industrial effluents in inshore waters of Kayalpatnam. Mar. *Fish. Inf. Ser.* No 113, July-Sept. 1991. pp 26-28.

KRISHNAMURTHY. V. 1986. ‘Seaweed cultivation — A Review’. IN: Ed. V. Krishnamurthy. *Mar. Biol. and Mariculture.* Mem. Salem Inst. Exp. Biol. No 2:112-125.

________________ . 1991. Seaweed Resources, IN: Ed. R. Natarajan *et al. Coastal Zone Management in Tomil Nadu. India.* pp.215-221.

KUTTY,M.N., KASIM, H.M., SANTHANAM, R. and SUKUMARAN, N. 1986. Thermal pollution of coastal waters and its effect on fish survival. *IN: Proc. Symp. Coastal Aquaculture, 4:1367-1376.*

LAKSHMANAPERUMALSAMY, P. and PURUSHOTHAMAN, A. 1982. Heterotrophic bacteria associated with seaweed. *Proc. Ind. Acad. Sci. (Plant Sci.)* 91:487-493.

LAKSHMANAPERUMALSAMY, P., CHANDRAMOHAN, D. and NATARAJAN, R. 1984. Fin rot and other diseases in marine fishes. *Proc. hd. Acad Sci.* (Animal Sci), 93:107-l 14.

NARAYANAMURTHY. 1987. Murder by poisoning: Death of the Palar. *IN: Thefightfor survival- People's action for environment.* Ed. Agarwal et al., Centre of SC. & Envt. Pub. pp. 89-101.

NATARAJAN, R. and RAMESH, S. 1987. *Assessment of water quality along Tamil Nadu coast.* Final Report. Central Board for Prevention and Control of Water Pollution, New Delhi, Sponsored research project. (Mimeograph).

________________________ 1987. Ecology of the human pathogen E. *Co/i* in Porto Novo coastal environs. Contribution IO Murine Sciences, Dr. S.Z. Quasim's sixtieth birthday felicitation volume. pp.67-84.

NAGARAJAN, R. *1990. Factors influencing Wader (Ciconiformes and Charadriiformes) populations in the wetlands of Pichovarum. Tomil Nadu, S. India.* M.Phil thesis, Bharathidasan Univ., Thiruchirappalli, 62p.

NAYAR, K.N. 1987. Technology of *oyster* farming. *Bull. Cent. Mar. Fish. Res. Inst. 38:59-62.*

NAYAR, K.N.. MAHADEVAN, S., RAO, K.S., SIVALINGAM, D. and RAMADHASS, K. 1988. Exploitation of molluscan shell deposits in Vaigai estuary at Athankarai. Bull. Cent. Mar. *Fish. Res. Inst., 42:35-39.*

OBLISAMI, G. and RAJANNAN, G. 1990. Impact of industrial pollution on the microbiology of Bhavani river and environs. *IN: Environmental Research* Executive Summaries of Completed Projects, Vol. 1. Ministry of Environment & Forests, Government of India. pp 112-l 13.

PRABHU, S.K., SUBRAMANIAN, B. and MAHADEVAN, A. 1991. Occurrence and distribution of heterotrophic bacteria off Madras coast, Bay of Bengal. *Ind. J. of Mar. Sci.* Vol. 20., June 1991, pp. 130-133.

PILLAI, C.S.G. 1971. Distribution of corals on a reef at Mandapam (Palk Bay), S.India. *Mur. Biol. Assn. India I 1(1&2):* 62-72.

__________ 1973. Coral resources of India with special reference to Palk Bay of Gulf of Mannar. *Proc. Symp. Living Rex of Ind.* (CMFRI. 700-705.

QASIM, S.Z. and SENGUPTA, R. 1983. Marine pollution studies in India. IN: *Water Pollution and Management Review.* ED. C.K. Varshney. South Asian Publishers Pvt. Ltd., New Delhi 139-159.

RAJENDRAN, *N. 1984. Organochlorine pesticide residues in Vellar estuary.* Ph.D. thesis. Annamalai Univ., Tamil Nadu. unpublished, 317 p.

RAJENDRAN, N., TAGORE. J. and KASINATHAN, R. 1988. Heavy metal concentrations in Oyster, *Crassostrea madrasensis* (Preston), of Cuddalore backwaters, southeast coast of India. *Ind.* J. *Mar* Sci. Vol 17. June IYR8. pp. 174-175.

RAJENDRAN, N., MAHALINGAM, R. and GOPINATH, K. 1987. Ecological conservation of seagrass beds in the Gulf of Mannar, India. *Envt. Conservation* pp. 265-268.

RAMACHANDRAN, S. 1990. Marine Pollution in Tamil Nadu — A status report. *Proc. Intl. Symp. Mar. Pollution,* 1990 pp. 143-160.

RAMAMURTHY.T., RAMESH, S. and NATARAJAN, R. 1985. Incidence of three new *Salmonella* serotypes — *S. irumu, S. panama* and *S. lexington* from the southeast coast of India (Porto Novo) *Ind. J. Med. Res. 81:558-560.*

RAMASUBRAMANIYAN, R., VALSARAJ, C.P. and RAO, V.N.R. 1991. Sewage pollution in the coastal waters of Madras, east coast of Ind. *Ind. J. Mar. Sci.* Vol 20, Dec 1991. pp.259-262.

RANGARAJAN, PARAMESWARAN, VS., AMALRAJ, R.V., KRISHNA, L.V.. SUNDARAJAN, A.R., NAIR. K.V.K. and IYENGAR, M.A.R. 1991. Impact of a coastal nuclear power plant: The Kalpakkam experience. IN: Ed. R Natarajan *et al., Coastal Zone Management in Tarnil Nadu.* 1991. pp 294-302.

RAMESH, A., TANABE, S., SUBRAMANIAN, A.N., MOHAN, D., VENUGOPALAN, V.K. and TATSUKAWA. R. 1990. Persistent organochlorine residues in Green Mussels from coastal waters of South India. *Mar. Poll. Bull.* Vol 21, N o 12., pp.587-590.

RAMESH, A., TANABE, S., MURASE, S., SUBRAMANIYAN, A.N. and TATSUKAWA, R. 1991. Distribution and behaviour of persistent organochlorine insecticides in paddy soils and sediments in the tropical environment: A case study in South India. *Environmental Pollution. 74:* pp. 293-307.

RAVICHANDRAN, S. 1987. Water quality studies in Buckingham Canal (Madras, India) — A discriminant analysis. *Hydrobiologia 154,* 121-126.

SALM, R.V. *1975. Sri Lanka, Southeast and Western India, Pakistan. Promotion of the establishment of marine parks and reserves in the northern Indian Ocean including the Red Sea and Persian* Gulf. IUCN Publ. New series. pp. 124-128.

SANTHANAM, R. *1990. Influence of thermal effluents on the phytoplankton ecology of mangrove estuaries of Tuticorin. southeast coast of India.* IN: Intl. Symp. on the ecology of mangroves and related ecosystems. Sept. 1990. Mombasa, Kenya. Sessions: Pollution of coastal systems.

SATPATHY, K.K., VENUGOPALAN, V.P., NAIR, K.V.K. and MATHUR, P.K. 1990. Environmental and operational problems and their assessment at power plant sites: The Kalpakkam experience. *Proc. of a Natl. Symp. on Envt: Scientific approach to Environmental issues.* BARC, Bombay, Feb 3-5, 1992. pp. 8-10.

SIVAKUMAR, V., THANGARAJ, G.S., CHANDRAN, R., LAKSHMANAPERUMALSAMY, P. and RAMAMURTHY, K. 1986. Studies on faecal coliform in an estuarine environment of Porto *Novo. Proc. Symp. Coastal Aqua., 1986.* 4:1330-1338.

SKILLMAN, R.A. 1982. *Tuna fisheries statistics for the Indian Ocean and Indo-Pacific.* Tuna Dev. & Manag. Prog., Colombo. Sri Lanka. I.P.T.P/82/WP/1.

SURESH, K.. SHAFIQ AHAMED. M. and DURAIRAJ, G. 1990. The impact of heated effluents from a power plant on the macrofauna and meiofauna of a sandy shore. IN *BARC Proc.* Bombay pp.21-24.

SOMASUNDARAM. M.V., RAVICHANDRAN, G. and RAMASAMY, A. 1987. Pollution in Coovum estuary and adjoining *wells. IN: Proc.Natl. Sent. on Estuarine Management,* Govt. of Kerala, Trivandrum. (In press).

THE HINDU. Survey of the Environment. 1991. I. Tamil Nadu-Facing threat on several fronts. 2. Pondicherry · In the effluent territory. Reports by N. Kalyanasundaram and S. Natarajan. p.72.

THORHAUG. A. 1983. Healing Carribean Coastlines. *Siren* 22.21-26. (Original not referred)

THOMAS, P.A. and GEORGE, R.M. 1987. Gorgonid resources of India. *Mar. Fish Info. Serv.* T & E Ser. 74: 1-3.

UNEP. 1985. IUCN/UNEP:Management and conservation of renewable marine resources in the South Asian Seas region. *UNEP Regional Seas Reports and Studies* No 62. UNEP, 1985.

VENKATARAMANUJAM, R., SANTHANAM, R. and SUKUMARAN, N. 1981. Coral resources of Tuticorin (South India). *Proc. 4th Intl. Symp. Coral Reefs,* Manila, I :259-262.

WAFAR, M.V.M. 1986. Corals and coral reefs of India. *Proc. Ind. Acad.* Sri., (Anim/plant): Suppl. 19-43.

WELLS, S.M. *1988. Coral reefs of the world. India.* IUCN 79-94.

APPENDIX XXVII

Institutions engaged in environmental research, monitoring and enforcement

GOVERNMENT ORGANIZATIONS

Tamil Nndu State Pollution Control Board (TNPCB)

This is the main governmental institution responsible for environmental planning, management and monitoring of the water, soil and air media.

All industries in the state function with permission from the Board, and their effluents and waste disposals are periodically monitored by it. Furthermore, the establishment of a new industry needs prior permission, which is granted only when the proposed industry instals treatment plants. The Board has been empowered to take action on suspected ill-effects due to factory effluents. The main objective of the TNPCB is pollution control.

Department of Environment (DOE)

The Department of Environment, Forests and Wildlife, New Delhi, is the second biggest governmental organization engaged in environmental research in Tamil Nadu. The DOE also sponsors scientific projects in different universities, research institutions and post-graduate colleges.

Council for Scientific and Industrial Research: (CSIR)

This quasigovernmental organization is involved in environmental research. The Council has regional laboratories in different states and carries out research in environmental and multidisciplinary scientific fields. The CSIR also conducts competitive exams nationwide for postgraduate students and funds scientific projects.

Indian Council of Agricultural Research (ICAR) **and Indian Council of Medical Research** (ICMR)

ICAR and ICMR are quasigovernment research bodies involved in research activities of a multidisciplinary nature. Higher studies and research pertaining to fisheries are usually sponsored by ICAR.

OTHER SCIENTIFIC ORGANIZATIONS

There are several other departments attached to Central Government Ministries, such as the Department of Science and Technology (DST), Dept. of Atomic Energy (DAE), Dept. of Biotechnology (DBT), Dept. of Ocean Development (DOD), Defence Research Agency and others which are actively involved in sponsoring and co-ordinating environmental work in Tamil Nadu.

Research organizations, such as the Forest Research Institute, Wildlife Institute of India, Indian Institute of Technology, and the Fisheries Research Institutes (Central and State), also participate in environmental research studies. The Central Marine Fisheries Research Institute (CMFRI), Central Institute of Brackishwater Aquaculture (CIBA), Central Inland Capture Fisheries Research Institute (CICFRI) concentrate on environmental studies in addition to aquaculture practices. The Zoological Survey of India (ZSI) has a separate block on marine biology; it is also involved in environment monitoring and management studies.

The National Environment Engineering Research Institute (NEERI) and Central Electrochemical Research Institute (CECRI) are also Central Government affiliated bodies effectively involved in environmental research activities. A research wing of the Department of Ocean Development, in collaboration with CECRI, has recently initiated efforts to collect ocean data in Madras at the CSIR complex. The Central Leather Research lnstiture (CLRI) in Madras extends consultancy services in environmental monitoring in addition to its involvement in scientific activities to bring down pollution in ianneries, the major industry of Tamil Nadu. The Central Rice Research Institute, in Thanjavur District, and the Indira Gandhi Centre for Atomic Research (IGCAR), in Kalpakkam, are also Research institutions where environment-oriented research work is going on.

The National Institute of Oceanography in Goa (NIO) is engaged in oceanographic and environmental studies along the Tamil Nadu coast.

UNIVERSITIES

Almost all the universities in Tamil Nadu offer courses and conduct research work in the field of environment. Most of the postgraduate institutions and autonomous colleges that have partial affiliation with the University Grants Commission (UGC) are also involved in environment activities. The Anna University, Madras, has a separate department, 'Centre for Environment Studies', where an M.Tech course on pollution studies is offered. The Water Resources Department of the same university has a 'Ocean Data Centre' which was recently started in collaboration with the NIO, Goa. The Remote Sensing Centre of the same university carries out studies on coastal mapping in Tamil Nadu. The Centre for Advanced Study in Marine Biology, Annamalai University, in Parangipettai, a major centre for higher learning on marine studies. In addition, the 'School of Ecology' at the Central Pondicherry University offers courses in ecological studies.

NONGOVERNMENTAL ORGANIZATIONS

The Madras Science Foundation, the SPIC Science Foundation, the C.P. Ramaswami Iyer Research Foundation and a few other private institutions are nongovernmental bodies where environmental research and awarenesss campaign programmes are routinely carried out in Tamil Nadu and Pondicherry.

APPENDIX XXVIII

Legislation against threats to the marine environment

FISHERIES

The Indian Fisheries Act was passed in 1897. The Indian Fisheries Tamil Nadu Amendment Act, passed in 1927. was again amended in 1980. The objectives of these legislations are :

- To prohibit the use of dynamite and poison in all waters within its jurisdiction.
- The prohibition or regulation of the use of fixed engines for the capture of fish, and the construction of weirs.
- The prohibition or regulation of the use of nets with a mesh below a minimum size.
- The prohibition or regulation of the capture or sale of all or any kind of fish during any closed season.
- The total closure of any water for a period not exceeding two years.
- To provide suitable penalties for breach of the law and of the rules they cover.
- Vesting the Government with the exclusive privilege over chanks and chank fisheries.

In 1981, the Maritime Zones of India (Regulation of Fishing by Foreign Vessels) Act was passed.

TANKER SAFETY

The regulation of tanker traffic in coastal waters is as complex as any coastal water use management issue and, perhaps, typifies, better than most issues, the potential disparity between a relatively narrow-focus central regulatory programme and a state's effort at comprehensive coastal water planning as part of its coastal zone management programme.

ENVIRONMENTAL PROTECTION

It is important to note at the outset that environmental legislation in India carries constitutional authority too. The directive principles of state policy requires that the state should protect and improve the environment. A corresponding duty has been imposed on every citizen. The law made for the protection of the environment also enjoys immunity from judicial scrutiny. The Constitution prescribes division of legislative powers between the Union Parliament and the State Legislatures.

TAMIL NADU (POLLUTION CONTROL) ACTS

The Tamil Nadu Pollution Control Board enforces the following regulatory enactments on environment and pollution control:

i) Water (Prevention and Control of Pollution) Act, 1974, amended in 1988.

ii) Air (Prevention and Control of Pollution) Cess Act, 1981, as amended in 1987.

iii) Water (Prevention and Control of Pollution) Act, 1977,

iv) Environment (Protection) Act, 1986.

SITING NEW INDUSTRIES

Guidelines have been evolved for siting new industries, prescribing the distance from sensitive areas and restricting certain industries within one kilometre from specified water sources.

Areas to be avoided in siting industries are:

- Ecologically and/or otherwise sensitive areas: at least 25 km, depending on the geoclimatic conditions.
- Coastal areas at least 500 m from high tide limit.
- Floodplain of the river-line system; at least 500 m from floodplain or modified floodplain effected by dam in the substream or by flood control system.
- Transport/communication system at least 500 m from highway and railway.

Note : Ecological and/or otherwise sensitive areas include religious and historic places, archaeological monuments, scenic areas, hill resorts, beach resorts, health resorts, coastal species, estuaries rich in mangroves, breeding grounds of specific species, gulf areas, biosphere reserves, national parks and sanctuaries, natural lakes, swamps, seismic zones, tribal settlements, areas of scientific and geological interest, defence installations, border areas (international) and airports.

APPENDIX XXIX

Other publications on the marine environment

AMANULLAH. 1992. Epizootic Ulcerative Syndrome in fish of Cauvery river at Trichy. (Persona1 communication).

AYYAKANNU, K. 1990. The Coleroon estuary and adjoining seaboard (South India). A holistic study of benthic ecology *Environmental Research.* Executive summaries of completed projects. Vol. I Ministry of Envt. and Forests, New Delhi. 35p.

BARBIER, M.D., JOLY, A.S. and TOURRES, D. 1973. Hydrocarbons from sea water. *Deep sea research 20:305-314.*

BAY OF BENGAL PROGRAMME. *Penculture of shrimp in the backwaters of Killai,* T.N. BOBP/WP/35.

CHACKO. P.I., ABRAHAM, J.G. and ANDAL, R. 1953. *Report on the survey of flora, fauna and fisheries of Pulicat Lake, Madras State, India.* (1951-52). Contribution from the Freshwater Fisheries Biological Station, Madras No. 8. 20p.

EDWARD, P.J.K. and AYYAKANNU, K. 1991. Temporal variation in annual production of *Tellina nobilis* and *Tellina cuspis* in a tropical estuarine environment. *Mahasagar.* Vol 24. No 1 (June) 1991. pp. 22-29.

EVANGELINE, T. 1975. Hydrobiology of the estuaries and backwaters of Ramanathapuram District, T.N. IN: R. Natarajan (Ed), *Proc. Symp. Estuarine. Biol.,* Annamalai Univ. pp. 193-21 1, Hindustan Pub. Corpn. (India), Delhi 110007.

FRANKLIN, GURUSWAMY, T.V. and NATARAJAN, T. 1991. Coastal survey by remote sensing. *Coastal Zone Management in Tamil Nadu, India.* Ed. R. Natarajan *et al.* pp 62-65.

GANAPATHY, R. and SAKTHIVEL, M. 1991. Prawn farming. *Coastal Zone Management of Tamil Nadu. India.* Ed. R. Nata:ajan *et al.* pp 186-191.

JAMES, P.S.B.R. and NAJMUDDIN, M. 1986. Recent observations on physio-chemical characteristics of the lagoon along the Palk Bay at Mandapam with a note on the possibility of its utilization for large scale fish culture. IN: *Proc. Symp. Coast. Aqua.,* 1986.4 : 1039-1046.

JAYABALAN, *N. 1980. Studies on Silver Bellies (Pisces: Leiognatidae) and their associated bioluminescent bacteria in Porto Novo waters.* Ph.D. thesis, Annamalai Univ., Annamalainagar.

JEBANESAN. A. *1989. Hydrobiological study of the river Cooum in Madras, South India, with special reference to aquatic Hemiprerams.* Ph.D. thesis, Loyola College, Madras.

JEGADEESAN, P. *1986. Studies on environmental inventory of the marine zone of Coleroon estuary and inshore waters of Pazhayaru, southeast coast of India.* Ph.D. thesis. CAS in Marine Biol., Annamalai Univ., Annamalainagar. 277p.

JERALD, J. A. 1992. *Integrated environmental research programme on River Cauvery.* Final report to the Ministry of Environment & Forests. New Delhi Univ. VI.B. 23 p.

JHINGRAN, V.G. 1985. Cauvery and other estuaries on the east coast. Estuarine fisheries. *IN: Fish and fisheries of India.* Ed. V.G. Jhingran. Revised & Enlarged 2nd Ed. p. 222.

________________ 1985. Pulicat lake. Estuarine fisheries. *IN: Fish and fisheries of India.* Revised & enlarged 2nd edn. Ed. V.G. Jhingran. pp. 236-241.

________________ 1985. The Vellar estuary and Killai backwaters. Estuarine Fisheries. IN: *Fish and Fisheries of India.* Ed. V.G. Jhingran. Revised & Enlarged 2nd edn. pp. 224-225.

________________ 1985. The Adyar estuary fisheries. *IN: Fish and Fisheries in India.* Ed. V.G. Jhingran. Revised & enlarged 2nd edn. pp 222-224.

JOHNSTON, R. 1984. Oil pollution and its management. IN. Ed. 0. Kinne *Marine Ecology,* Vol.V. Part 3. John Wiley & Sons. New York. pp. 1433-1582.

KALAYANASUNDARAM, N. 1991. Tamil Nadu facing threat on several fronts. Environmental Hotspots. *The Hindu, Survey of the Environment 1991.* pp. 72.

KANNAN, K. S., TANABEE, RAMESH, A., SUBRAMANYAM, A.N., and TATSUKAWA, R. 1992. Persistent organo-chlorine residues in foodstuffs from India and their implications on human dietary exposure, J. Agric. ***Food* Chem.** 40:518-524.

KRISHNAMURTHY, K. and JAYASEELAN, M.J.P. 1986. Prospects of aquaculture in a mangrove ecosystem. Proc,. ***Symp. Coast. Aqua. 4:1059-1067.***

KRISHNAMURTHY, K. and SUNDARARAJ, V. 1974. Studies on phytoplankton pigments in Porto Novo waters (India). II. Backwaters. J. ***Exp. Mar Biol. Ecol.,*** Vol. 14.. pp. 285-294.

KRISHNAN, P. and SAMPATH, Y. 1976. A survey of Pulicat lake and its fisheries. ***Madras*** J. ***of Fish.*** Pub. of Director of Fisheries, Tamil Nadu Vol. VII. pp. 89-91.

LAKSHMI, K.K. 1990. Seagrass ecosystem of Coromandel Coast. Envt. ***Res.,*** Govt. of India. 1990. p 83

LAW, R.J. 1981. Hydrocarbon concentration in water and sediments from U.K. marine water. Determination by fluorescence spectrophotometry. ***Mar Poll. Bull 12(5), 153-157.***

MANISERI, M.K. 1982. On the fishery of juveniles of ***Penaeus semisulcatus*** along the Tirunelveli coast, Tamil Nadu. ***Ind. J. Fish. 29:20-28.***

MARTIN, A. 198 ***I. Studies on vibrio parahaemolyticus and allied vibrios from the Pitchavaram mangrove-Killai backwater complex interconnecting the Vettar and*** Coleroon ***estuarine system.*** Ph.D thesis, Annamalai Univ., Annamalainagar.

MURUGAN. A. and AYYAKANNU, K. (1991). Ecology of Uppanar backwater, Cuddalore: I. Physico-chemical parameters. ***Mahasagar.*** Vol 24. No I June 1991. pp. 31-38.

MURUGAN, A. 1991. Ecology of benthic macrofauna in Cuddalore- Uppanar backwater. Southeast coast of India. ***Ind. J. Mar. Scs.*** Vol 20. Sept 1991 pp. 200-203.

NARASIMHAN, K.A. 1988. Recent advances in the hatchery production of seed of some commercial bivalves in India. ***Ind. Fish. Assn., 18:21-25.***

PERUMAL, P. 1991. Humic acids, photosysthetic pigments and physiochemical features of Vellar Estuary. ***J. Ecotoxicol. Environ. Monit.*** 1 (3) 192-197 pp.

PRABHU, S.K., SUBRAMANIAN, B. and MAHADEVAN, A. 1991. Mycoflora of sediment and waters of the Madras coast, Bay of Bengal. ***Ind. J. of Marine Sci.*** Vol 20., Sept. 1991, pp 226-228.

PRASADAM, R.D. and KADIR, P.M.A. 1988. Experimental pen and cage culture of grey mullets in the Pulicat lake. IN: M. Ed. Mohan Joseph. ***The first Indian Fisheries Forum.*** Proc. Asian Fish. Soc. Indian Branch, Mangalore. pp. 143-145.

QUART, A. 1992. Life and death in the Mangroves. 'Outlook', ***Bangkok*** Post, section three Vol XLVII No 238. Aug. 1992.

RAJAMANI ***et al.*** CLRI activities in environmental pollution control (tannery waste treatment, disposal and utilization) ***CLRI Report: Environmental Technology Area.*** CLRI, Adyar, Madras. pp. I-IO.

RAO, K.S., SIVALINGAM, D., NAIR, P.N.R. and UNNITHAN, K.A. 1987. Oyster resources of Athankarai estuary, southeast coast of India. ***Bull. Cent. Mar. Res. Inst.*** 38:17-29.

RAO, P.S. 1991. Quaternary Geology. IN: Ed. R. Natarajan ***et al. Coastal Zone Management in Tamil Nadu. India. 1991*** p 31.

RAMESH, A. ***1986. Ecophysiologicalstudies of luminous bacteria of vellar estuary.*** Ph.D. thesis, Annamalai University, Annamalainagar.

RAY, ***1991. A Mangrove ecosystem in India.*** A keynote address in Nat. Sem. on Consv. and management of mangrove ecosystem, organised by Bidham Chandra Krishi Visva Vidhyalaya, Kalyani. Dec. 1991 pp. I-9.

RAY, P.K., PRASAD, A.K. and NANDAN, R. 1985. Pesticides — Major Environmental Problem. ***Sci. and Culture*** 5 1:363-37 1.

SANTHANAM, R., KRISHNAMURTHY, K. and SUBBARAJU, R.C. 1975. Zooplankton of Porto Novo, S.India. ***Bull. Dept. Mar.*** Sri Univ. Cochin, 1975, V11.4. pp 899-91.

SARVESAN, R., THANGAVELU, R., SREENIVASAN, P.V., SUNDARAM, K.S. and POOVANNAN, P. 1988. Edible oyster resources of Ennore estuary and Muttukadu backwaters, Madras. *Bull. Cent. Mar. Fish. Res. Inst., 42:50-57.*

SATHIYAMURTHY, K., LATHA. K. and PURUSHOTHAMAN, A. 1991. Studies on Cu-tolerant bacteria in the Vellar estuary, southeast coast of India. Ind. *J. Mar Sci:.* Vol 20, Sept 1991 pp. 229-231.

SATPATHY, K.K.. VENUGOPALAN, V.P.. NAIR, K.V.K. and MATHUR, P.K. 1990. Environmental and operational problems and their assessment at power plant sites: The Kalpakkam experience. Proc. of *a Natl. Symp. on Envt:* Scientific *approach* to environmental issues. BARC, Bombay. Feb 3-5, 1992, pp. 8-10.

SELVAM, V.. MOHAN, R., RAMASUBRAMANIAM, R. and AZARIAH, J. 1991. Plant communitiesand soil properties of three mangrove stands of Madras coast. *Ind. J.* of *Mar Sci.* Vol 20. Mar 1991. pp. 67-69.

SENGUPTA. R. and QASIM, *S.Z. 1985. The Indian Ocean – An environmental overview realities and prospects.* R.C. Sharma Rajesh. Pub., New Delhi.

SIVASWAMY. S.N. 1990. Plankton in relation to coastal pollution at Ennore. Madras coast. *Ind. J. of Mar. Sci.* Vol. 19. June 1990 pp. 115-119.

SREENIVASAN. A. 1990. Limnological survey of Cauvery river system with particular reference to pollution indicators. *Environmental Research.* Executive summaries of completed projects. Vol.1. Ministry of Envt. and Forests. New Delhi. 43 p.

SUNDARARAJAN, D. and SAMBANDAM, K.P. 1987. Preliminary account on hydrobiology and fisheries of Coleroon Estuary. *Indian J.* Mar. Sci., Vol. IX. 1987. pp. 38-42.

TAMPI, P.R.S. 1969. Productivity of saline lagoon near Mandapam, India. *Proc. Intl. Symp. on coastal lagoons,* UNAM-UNESCO. Nov. 28-30 1967). Mexico, D.F. pp. 485-494.

THANGAVELU, R. and SANJEEVARAJ, P.J. 1988. Distribution of molluscan fauna in the Pulicat Lake. *Bull. Cent, Mar. Fish. Res. Inst. 52:58-67.*

THANGARAJ, *G.S.* 1984. *Ecobiology of rhe marine zone of rhe Vellar Estuary.* Ph.D. thesis. CAS in Marine Biol., Annamalai University, Annamalainagar. 192 p.

WOLSTENCROFT, A.J., HUSSAIN, S.A. and VARSHNEY, C.K. *1989. A Directory of Asian Wetlands.* IUCN pp. 367-505.

A fish landing site in Doddanduwa, a typical Shri Lankan fishing village.

Shri Lanka

by

Hemantha Dassanayake

National Aquatic Resources Agency
Crow Island, Colombo 15, Shri Lanka

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56. GENERAL *FACTS*

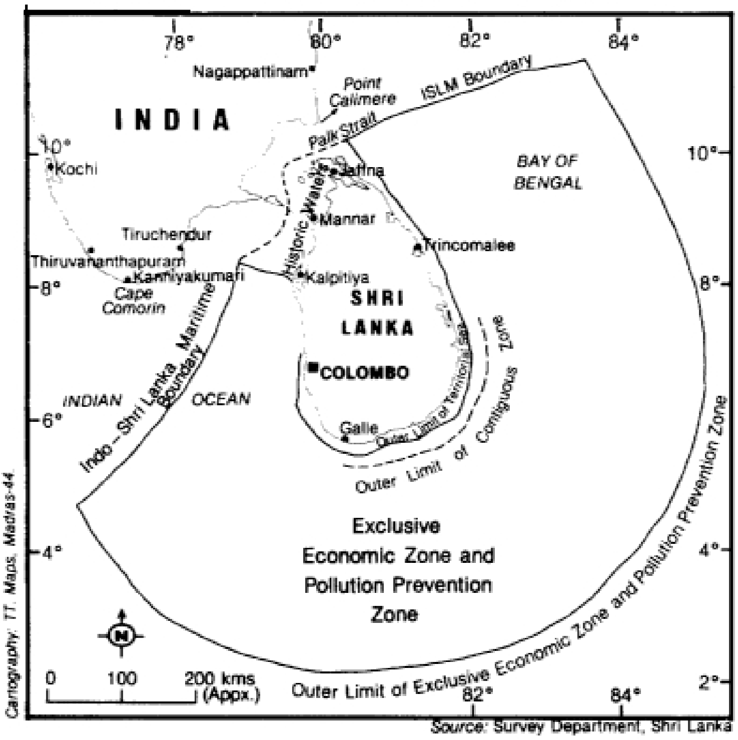
The marine fishery is very important to Shri Lanka. According to the 1988 census, 65 per cent of the animal protein consumed in Shri Lanka is from fish. The fisheries industry employs 96,000 persons, partly employs ten thousand and gives indirect employment to a further five thousand people. Nearly two per cent of Shri Lanka's Gross Domestic Product **(GDP),** conies from the fisheries sector (1988). Coastal fisheries supply over 90 per cent of the total marine fish production.

Urbanization and industrialization have caused several undesirable effects on the marine environment, such as pollution, over-exploitation of resources and habitat degradation. These are studied in this paper.

56.1 Location and territory

Shri Lanka is an Indian Ocean island situated between latitudes 5°51 and 9° 51 N and longitudes 79° 41 and 81° 51E. The country has a 1760 km-long coastline that is serrated by a number of estuaries, lagoons and river basins. Shri Lanka's land area is 65,610 km^2. Its maritime boundaries are as follows (Figure 36):

Fig. 36. Territory of Shri Lanka (including Maritime Zone)



Source: Survey Department, Shri Lanka

- **The terrilorial sea,** extending to a distance of twelve nautical miles from the coast of the main island.
- **The contiguous zone,** which extends a further twelve nautical miles from the outer limits of the territorial sea.
- **The Exclusive Economic Zone (EEZ),** which extends 200 nautical miles from the coasts (and includes the territorial and the contiguous zones).
- **The Internal Waters,** for which a demarcation is necessary in the Gulf of Mannar and the Palk Strait, where the above zones overlap with India's nautical zones.

Shri Lanka has three morphological zones, peneplains or erosional levels

- The first coastal peneplain is from sea level to 120 m.
- The second peneplain is from 300 m to 760 m.
- The third peneplain is from 900 m to 2440 m.

The second and third peneptains, called the Central Highlands, are only about one-fourth the country's total land area.

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56.2 Climate

There are four seasons during the year :

- The Southwest Monsoon period (May to September): During this period, there is heavy rainfall, but it is normally confined to the southwestern region.
- The Inter-Monsoon period (October to November): The Inter Tropical Convergent Zone (ITCZ) lies in the latitudes of Shri Lanka. Convectional thunderstorms in the afternoons are common during this period and low pressure zones originating from the Bay of Bengal sometimes develop into cyclonic storms.
- The Northeast Monsoon period (December to February): Heavy rains occur in the north, east and northeast slopes of the central hills.
- The Inter-Monsoon period (March to April): Again, as the island lies within the ITCZ, convectional afternoon thundershowers occur. But the depressional activity is low compared to the October-November Inter-Monsoon period.

Based on the mean annual rainfall, three major climatic zones are identified :

Zone	*Mean annual rainfall*
Dry Zone	1900 mm
Intermediate Zone	1900 - 2500 mm
Wet Zone	2500 - 5500 mm

The Mannar, Kalpitiya and Yala areas experience the lowest rainfall, that is, less than 1000 m. The highest rainfall is in the Watawala-Ginigathena area of the central massif region.

Drastic seasonal temperature changes are not experienced in Shri Lanka. Temperature variations due to elevation are more usual. The mean annual temperature in the coastal plain is 26 - 28°C and in highlands it is 15 - 19°C. The temperature in Nuwara Eliya, however, sometimes falls to 0°C. In the east and the northeast regions, temperatures sometimes rise as high as 37°C.

56.3 Oceanography

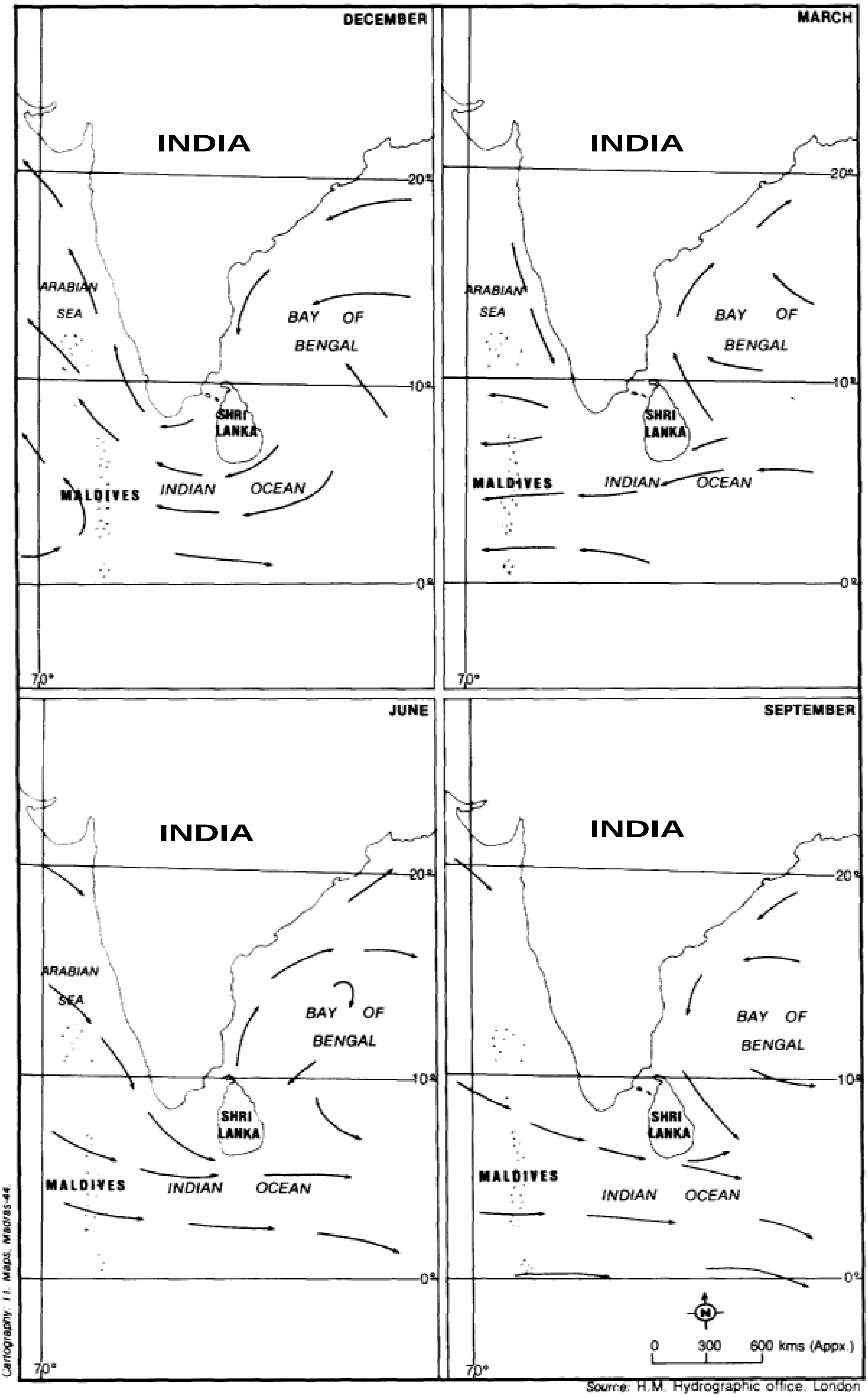
The continental shelf of Shri Lanka is about 28,000 km^2 in extent. The shelf is narrowest (6 km) in south Shri Lanka and widens towards the north. In the northwest (beyond Kalpitiya), it joins up with India's continental shelf.

The highest waves occur during the Southwest Monsoon when the effective fetch is about 800 km (between Maldives and Shri Lanka). During the Northeast Monsoon, the wind blows across the Bay of Bengal. The energy of the waves is relatively low during this period, as well as during the inter-monsoonal periods.

Currents coming from the Bay of Bengal, the Arabian Sea and the equatorial region meet in the area where Shri Lanka is situated. Figure 37 (on facing page) shows the current patterns around the island during the year. The strongest current hits the southern coastline during October-January.

Tidal cycle periods last for approximately twelve hours. The maximum tidal range is 75 cm in spring tide and 25 cm in neap tide. The amplitude of the tide is highest in the Colombo area and lowest around Delft (off Jaffna) and Trincomalee.

Fig. 37 Surface currents around Shri Lanka



Source: H.M. Hydrographic office, London

56.4 *Population*

Shri Lanka's population was estimated to be 16.6 million at the end of 1986. Fortysix per cent, of the country 's population lives in the coastal districts. With an annual increase of 1.6 per cent, the population is expected to grow to 20.6 millions by the year 2000.

57. ***MARINE HABITATS***

57.1 *Mangroves*

Mangroves are found all along the sheltered coasts of Shri Lanka. An estimate of the present mangrove areas in the island, excluding the disturbed northern part of the island, has been made using remote sensing and reveals the extent tabulated alongside.

District	*Extent (ha)*
Colombo	9
Gampaha	723
Puttalam	2970
Tnncomalee	1070
Batticaloa	1520
Amparai	53
Iota]	6345

A rough estimate of Shri Lanka's total mangrove area would be 10,000-13,000 ha.

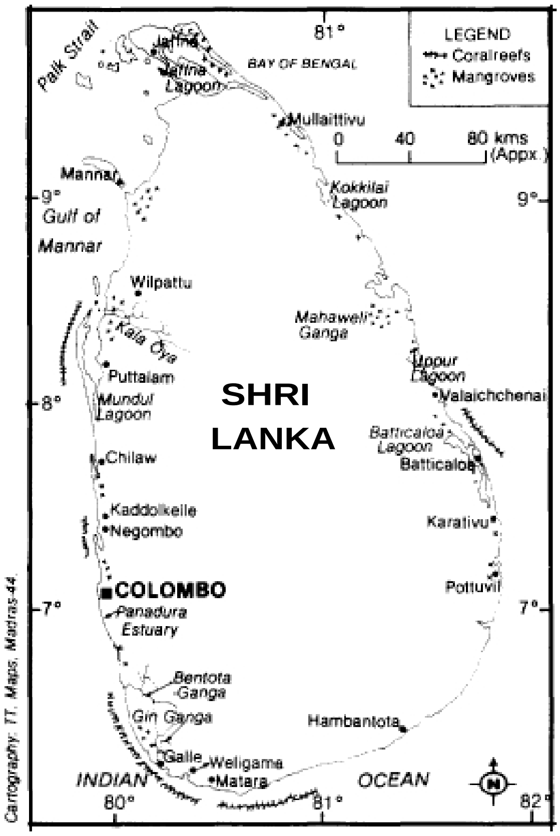
M. D. Amarasingha (1988) found 21 free mangrove species and 17 mangrove-associated species in the island.

Many present activities threaten the future of the mangrove habitats (see Figure 38). Protection of specific mangrove areas is, therefore, necessary. Traditional uses of mangrove can, however, be allowed up to a certain extent. Only degraded mangrove habitats should be used for development activities.

The mangroves situated within the authority of the Coast Conservation Department are legally protected. Mangroves found in the wildlife reserves, *e.g.* Wilpattu and Kokkilai Lagoon, come under the Wildlife Conservation Department. Mãngroves on government land are managed by the Chief Government representative (the Government Agent, GA) of the particular area. The GA has the authority to release the lands for various activities.

The National Mangrove Committee of the National Resource, Energy and Science Authority of Shri Lanka includes several conservation-oriented state orgnizations. The objectives of the committee are to co-ordinate the research and management of Shri Lanka's mangrove resources. As a result of proposals made by the National Aquatic Resource Agency (NARA), Kaddolkelle (Negombo), area has been identified as a mangrove reserve.

Fig. 38. **Location of coral reefs and mangroves of Shri Lanka**



57.2 *Coral reefs*

Coral reefs are located in relatively undisturbed shallow areas which do not receive large river discharges of freshwater. Figure 39 (on facing page) shows the condition of the coral reefs.

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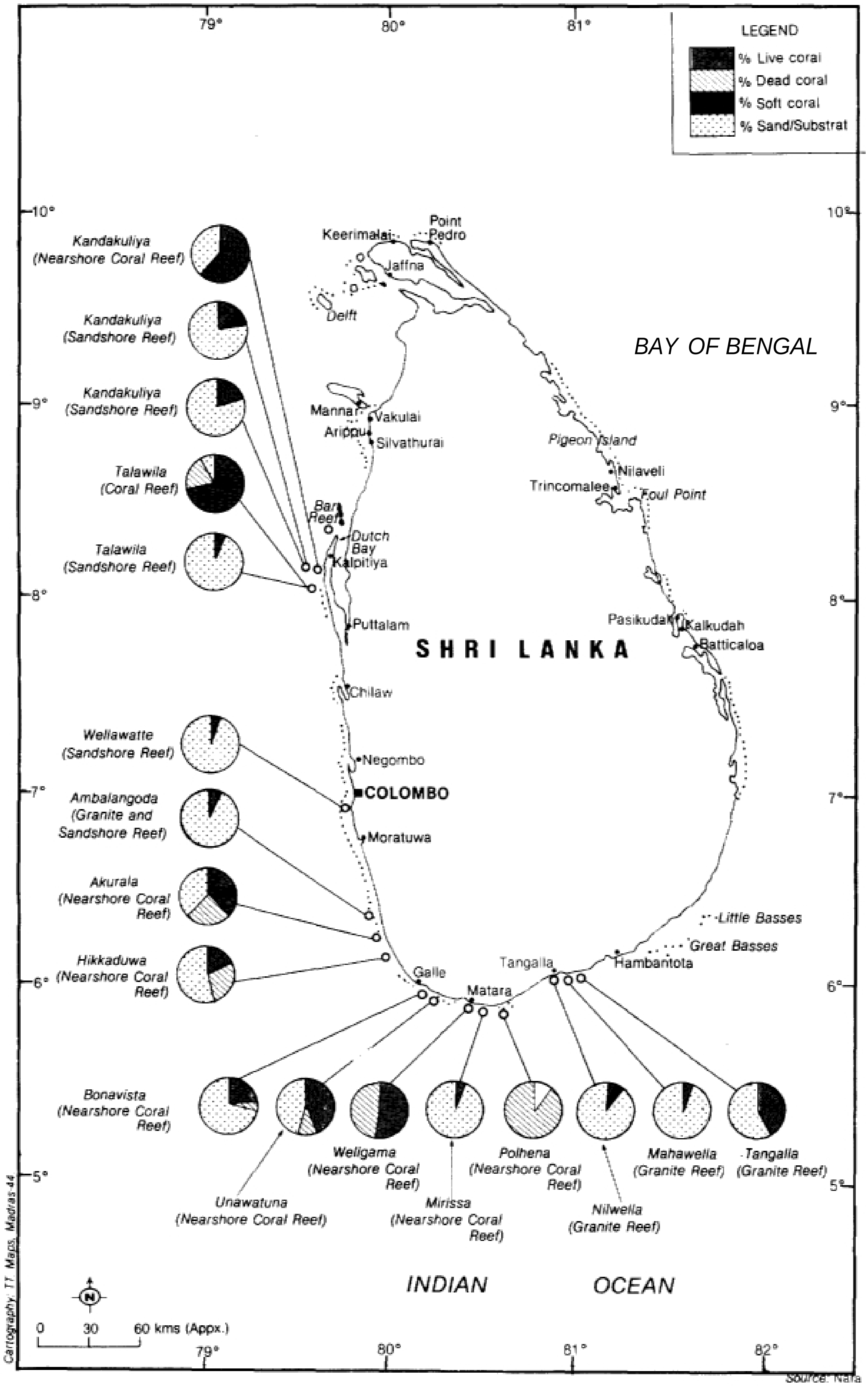
Fig. 39. Condition of the coral reefs of Shri Lanka



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The total extent of the coral reefs has still not been estimated. However, some available figures are given alongside.

Area	Extent
Trincomalee	2 km^2
Hikkaduwa reef	1.6 kin^2
Sallidnor	1km^2

The available information on the linear extent of the coral reefs is as follows:

District	Reel	Linear extent (Km)
Mannar	Vakulai	4
	Arippu	
	Silvathurai	2
Jaifna	Point Pedro-Keerimalai	0
Trincomalee	Foul Point	6
	Coral Point	2
Mullaitivu u	Nilaveli	1-2
	Pigeon Island	2-3
Battioaloa	Thennadi Bat	8
	Palavi Point	
	Palavi Bat	
	Elephant Point	4
	Vandeloos Bay	
	Pasikudah	
	Kalkudah	

One hundred and seventyone (171) coral species, belonging to *65* genera, have been recorded in Shri Lanka.

Coral reefs help to prevent coastal erosion. They are also valuable for scientific and educational purposes, as well as for tourism and recreation.

Corals are extracted and used for construction and lime extraction, as well as for ornamental purposes. Such fishery activities as angling, dynamiting, spear-fishing and, anchoring of fishing boats, apart from pollution due to land-based activities, all threaten the reefs.

Hikkaduwa and Bar Reef have been declared Marine Sanctuaries by the Department of Wildlife Conservation, while the Polhena Reef has been identified as a suitable site for a marine park. A Hikkaduwa Reef management plan is, in fact, being formulated under the Coastal Reef Management Project (CRMP), funded by USAID. A Bar Reef Management Plan is being developed by NARA, with the assistance of SAREC.

To prevent the coral reefs from further depletion, a comprehensive management plan must be formulated. Furthermore, legal provisions already available for regulation/prevention of destructive activities should be strictly enforced.

57.3 Seagrass beds

Seagrass beds are found in the open sea as well as in river basins, estuaries and lagoons. From Jaffna Lagoon to Dutch Bay, from Mannar to Rameswaram island in India, the seagrass beds are extensive. In the southwestern part of the island, smaller seagrass beds are found on the leeward side of the coral reefs. Seagrass bed areas in Shri Lanka have not, however, been precisely determined, but twelve species of seagrass, belonging to nine genera, have been identified.

Seagrasses are very sensitive to turbid water caused by pollution and sediments. Bottom trawling and dragnetting also cause damage to seagrass bed communities. The collection of Polychaet worms (feed for brood shrimp) also affects the seagrass beds negatively. The beds are also the only habitats for the endangered *seacow/Dugong dugong.*

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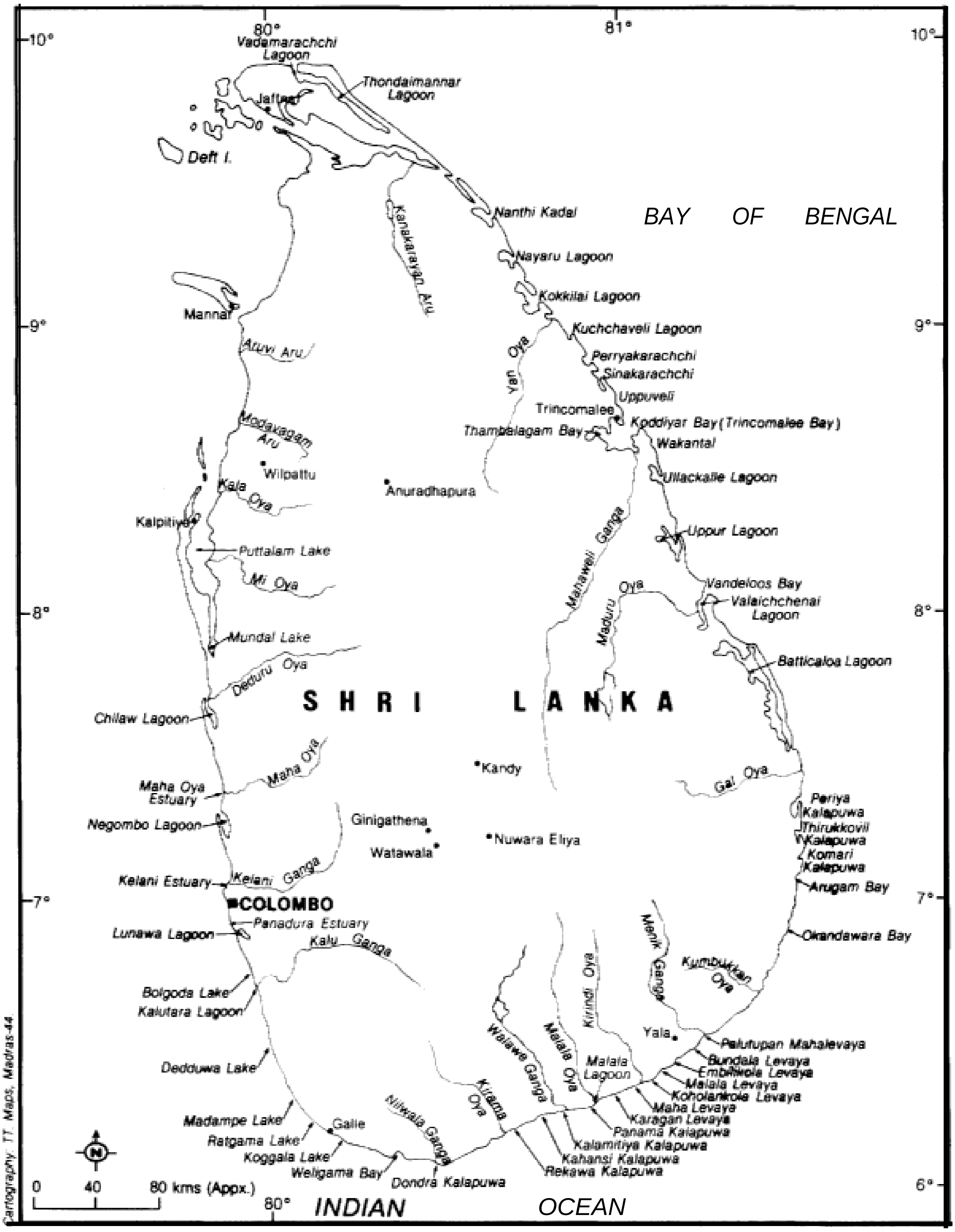
57.4 Estuaries and lagoons

Semi-enclosed brackishwater coastal waterbodies having a permanent free connection with the sea are termed estuaries in this report. Coastal waterbodies separated, or temporarily connected to the sea, are called lagoons. Two types of estuaries are found in Shri Lanka: the basin and the riv erine types.

Estuaries and lagoons are distributed all along the national coastline (see Figure 40). There are some 45 basin estuaries and 40 lagoons in Shri Lanka. Their total area is estimated at 40,000 ha. The major urban centres on the coast are all associated with estuaries.

Fig. 40. River basins, estuaries and lagoons in Shri Lanka



Puttalam estuary is one of the principal estuarine systems in Shri Lanka. It sustains a thriving commercial fishery, which gives a livelihood to a large number of people engaged in fishery-related activities.

The estuaries and lagoons are used as harbours, waste disposal sites and for recreation, education, sandmining and aquaculture purposes. They also serve as fishing grounds.

Waste disposal, aquaculture and mechanized fishing boats are the major causes for the degradation of the estuary (e.g. Kelani) and lagoon (e.g. Lunawa) environments.

Decreases in salinity due to the discharge of freshwater diverted from irrigation work has been responsible for the depletion of fish and shrimp catches in the Kalamitiya and Rekawa lagoons.

According to the definition of ‘coastal zone’ in the Coastal Zone Management Plan (1986), parts of the estuaries and lagoons come under the Coast Conservation Department’s jurisdiction. The destructive activities can, therefore, be regulated up to a certain extent.

58. LAND-BASED ACTIVITIES AFFECTING THE MARINE ENVIRONMENT

58.1 *Domestic wastes*

Densely populated human settlements are the primary cause of organic pollution of both inland and marine waters. Lack of waste water treatment facilities, is a common problem. Properly planned sewage systems have not yet been devised in Shri Lanka, except in the Colombo Municipality area.

In Colombo, sewage is screened for larger particles and floaing matter, then pumped directly into the ocean without treatment. The Colombo sewerage system consists of two ocean outfalls located in Wellawatte (southern outfall), and Modera (northern outfall), (Figure 41, see facing page). The Dehiwela, Mt. Lavinia (Galkissa) and Kolonnawa sewerage systems are planned to be connected to the Colombo ocean outfall system.

The Shri Lanka Sewerage Project Report (1981) proposes the construction of ocean outfalls for the diposal of waste from the Galle and Negombo Municipalities.

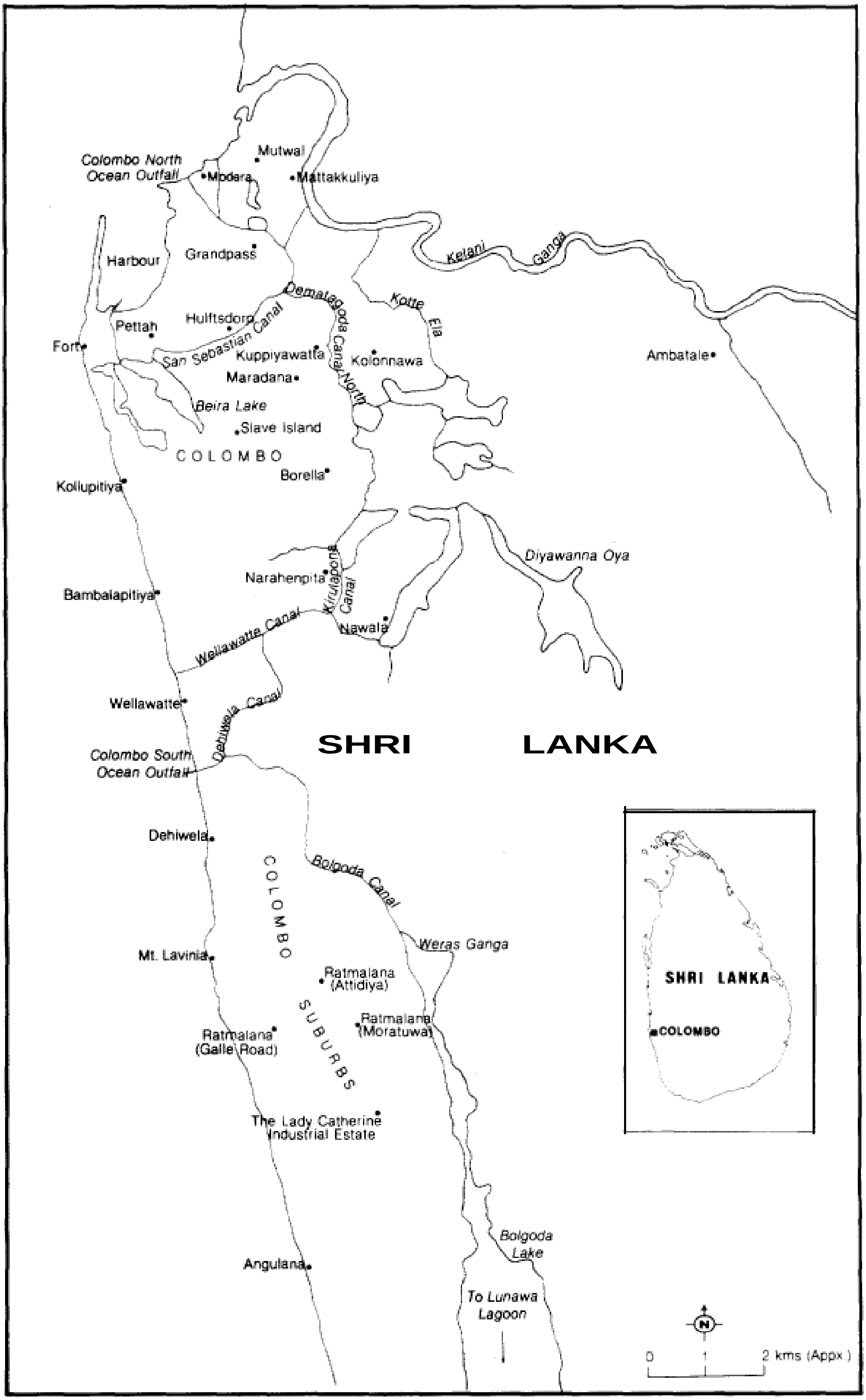
The details of the Colombo South (Wellawatte) and North (Modera) ocean outfalls are given in the table alongside.

	Wellawatte (Colombo South)	Modpro *(Colombo North)*
Commissioned	April 1986	December 1986
Placed in service	December 1986	January 1987
Length of outfall	1273 m	1860 m
Discharge capacity	2.4 m^3	2.9 m^3
Discharge volume 1990	43,908 m3/day	51,943 m^3/day

58.2 Industrial wastes

There are approximately 60,000 industrial establishments in Shri Lanka, ranging from large-scale industries to repair shops and small mining and quarrying operations. Most of the industries are in the Greater Colombo area (Figure 41, see facing page). In 1989, an industrial pollution survey was made, covering almost eight thousand units. Of these, three thousand were considered non-polluting, while the rest had polluting potential. Of the latter, three hundred were high-level polluters.

Fig. 41. Industrial establishments in the city of Colombo and suburbs



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In 1989, a strategy for the industrialization of Shri Lanka was published by the Government. The document envisioned making Shri Lanka a Newly Industrialized Country (NIC) in six years.

All new industries, it recommended, should be situated in specially designated Industrial Zones that would be provided with the basic infrastructure facilities needed to sustain industrial development. The facilities suggested were adequate supply of potable water, waste water disposal, energy, transport, solid waste management etc. Some of the areas zoned for industrial activities in the past — such as Ratmalana, Moratuwa- Lunawa and Ekala, for instance have, unfortunately, not been provided with this basic infrastructure.

The estimated waste loads from the industrial areas in Colombo city are given alongside.

Location	*Estimated waste load kg BOD/day*
Wellawatte	64
Narahenpita	368
Nawala	Very small
Kolonnawa	114
Hulftsdorp	1000kg COD/day
Grandpass	1922
Kuppiyawasta	105
Pettah	9.5
Mattakkuliya	543.5
Harbour	**96**
Slave Island	5

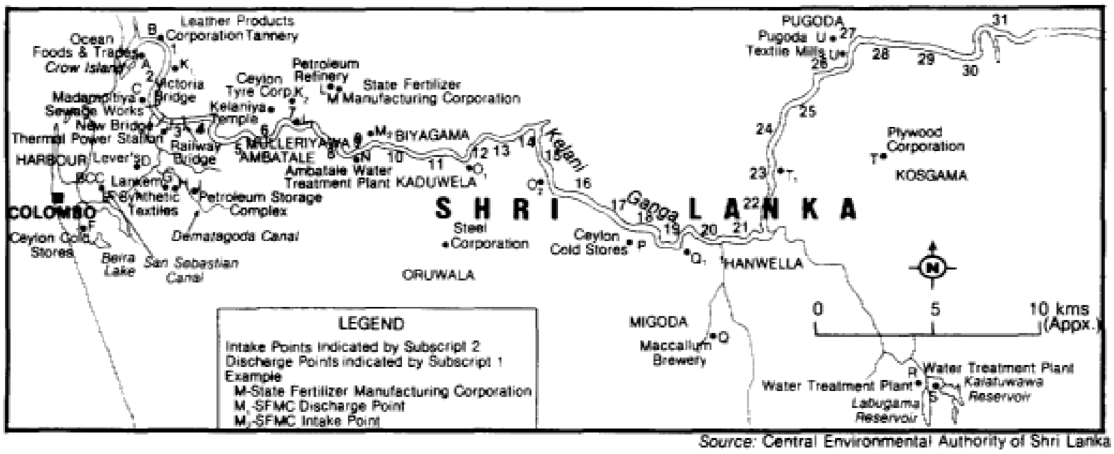
Source: Water pollution survey report, **CEA.**

Industrial enterprises are generally situated within or in close proximity to urban areas. In Colombo, the establishment of industries has been regulated only recently. Most industries and industrial estates started prior to the establishment of the Greater Colombo Economic Commission (GCEC) were not, in fact, provided with waste treatment facilities (see Figure 41 on p. 219).

The table on page 222 shows the Shri Lanka standards for industrial effluents.

Industries located along the Kelani River are indicated in Figure 42.

Fig.42 Major trade discharges in the Kelani Gangs catchment area



Cartography: TT. Maps, Madras-44.

Source: Central Environmental Authority of Shri Lanka

EXPORT PROCESSING ZONES

Three export processing zones have been established under the GCEC. The zones are located in Katunayake, Biyagama and Koggala (Figure 43, see facing page).

In the case of Katunayake, textile factories account for nearly fifty per cent of the total industries. In Biyagama, only 25 per cent are textile factories.

Other types of industries in the **EPZ** are metal-based, rubber products, electronic and electric appliances, ceramic products and tobacco processing.

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The average waste water loads and waste water disposal sites of the three EPZs.

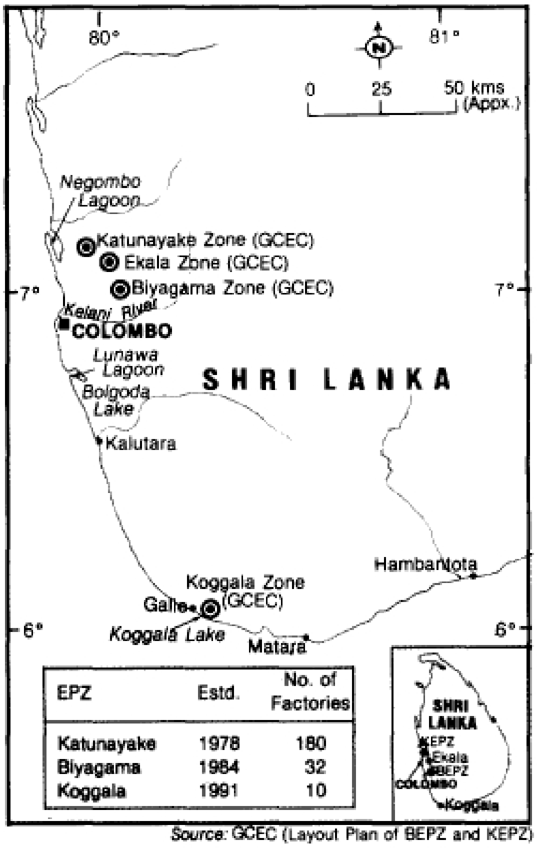
Zone	*Waste water* load (m^3/day)	*Waste water disposal site*
Katunayake	6300	Dasdugam Oya which floss Into Negombo Estuary
Biyagama	4437	Kelani Riser
Koggala	–	Proposed to be discharged into sea by ocean out fall

Both the Katunayake and Biyagama Export Processing Zones (KEPZ and BEPZ) are provided with central waste water treatment facilities. All effluents discharged from the enterprises in each zone are collected through a network of sewer connections into a central treatment facility. The process adopted is very similar in both zones.

The central treatment plant at the **KEPZ** has been designed for a loading rate of 3000 m^3/day and has a peak loading rate of 9000 m^3/day. The central treatment plant at the BEPZ has been designed for dry weather; 3400 m^3/day with a peak flow rate of 10,200 m^3/day.

Treatment processes include the following

Fig. 43. Location of Export Processinq Zones



Cartography: TT. Maps. Madras-44

Source: GCEC (Layout Plan of BEPZ and KEPZ)

Pre-treatment

SCREENING – **Bar screen**
– Coarse screen
– Fine screen

GRIT REMOVAL – Two parallel grit removal chambers for alternate use

Biological treatment

AERATED LAGOONS – Four rectangular lagoons at KEPZ, each of 7000 m^3 capacity
Two rectangular lagoons at BEPZ, each of 10,500 m^3 capacity.

Sludge setling

SETTLING TANKS – Four at KEPZ, one adjacent to each of the aerated lagoons (horizontal flow type). Scum is removed manually.

– Two at **BEPZ,** hopper bottom type circular tanks. Settled sludge is pushed into a hopper in the middle of the tank by a rotation scraper. Scum is also removed from the surface by a mechanical device.

Sludge removal

Sludge sediments in the settling tanks are, from time to time, removed by gravity flow and let into drying beds set up for this purpose. Water content in the sludge is removed partly by evaporation and partly by drainage. The drained water is then pumped back into the treatment plant.

Effluent polishing

At the BEPZ, a reservoir has been constructed to collect and treat the final effluents. This reservoir provides for an additional retention time of ninety days, during which time the remaining organic and inorganic material is further decomposed by microorganisms. During the rainy season, effluents stored in the reservoir get diluted by rainwater and spill over the spill structure provided in the dam. This water flows into the Kelani River along a natural water course. An additional pump

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house, however, has been provided to pump the effluents stored in the reservoir during dry weather. These effluents are channelled into the Kelani River through a pipeline constructed to dilute them, for an emergency.

At KEPZ, there is no provision for effluent polishing. The treated water is discharged into the Dandugam Oya.

EKALA INDUSTRIAL ZONE

The Ekala industrial zone consists of textile, battery-manufacturing, asbestos and food-canning factories. Adequate waste treatment facilities are not available in most of the factories, The waste water is discharged into open lands, roadside drains and, finally, into the Ja-Ela Oya which flows into the Negombo estuary.

Disposal of solid waste is carried out by private contractors. There is no supervision of their work and serious environmental damage from the disposal of solid waste, containing batteries waste as well as waste from tanneries, may occur.

POLLUTING-TYPE INDUSTRIES

The distribution of polluting-type industries in the coastal districts of Shri Lanka is given on a district basis in the table alongside *(Source.'* CEA).

District	No. of polluting type industries
Colombo	173
Gampaha	48
Puttalam	10
Jaffna	1
Trincomalee	1
Baticaloa	**I**
Amparai	3
Monaragala	1
Hambantota	3
Matara	18
Galle	17
Kalutara	55
Total	**331**

SMALLER INDUSTRIES

Smaller polluting industries are the desiccated coconut and copra industries, coconut fibre and batik units as well as licenced and illicit distilleries.

Waste water from desiccated coconut milk, for example, contains high values of BOD. Coconut husk retting is a microbial fermentation process carried out in the South. Effluents from batik industries include textile dyes, oil and organic components.

The distilleries are located in Seeduwa, Wadduwa, Paiyagala, Maggona, Beruwala and Aluthgama. These effluents contain sulphur, organic compounds, copper and tin.

STANDARDS FOR INDUSTRIAL WASTE WATER DISCHARGE

Required standards for industrial waste water discharged into marine coastal areas of Shri Lanka are given alongside

Shri Lanka Standard 721 : 1985

	Parameters	Values not to be exceeded
1.	Biochemical Oxygen Demand (BOO) (mg/l) (5 days at 20℃)	00
2.	Total suspended solids	
	a. for process waste waters (mg/l)	100
	b. for cooling water effluent	Total suspended matter content of influent cooltng water plus 10%
3.	Particle sine of	
	a. floatable solids	3mm
	h. settleable solids	850 microns
4.	Temperature	45℃
5.	pH value	Between 6 and 8.5
6.	Oils and grease (mg/l)	20
7.	Ammoniacal Nitrogen (as N) mg/l)	50
8.	Residual chlorine (mg/l)	
9.	Fluorides (as F) (mg/l)	15
10.	Cyanides (as CN) (mg/l)	0.2
11.	Phenolic compounds (as C6H5 H) (mg/l)	
12.	Sulphides (as S) (mg/l)	
13.	Arsenic (as As) (mg/l)	0.2
14.	Selenium (as Se) (mg/l)	0.05
IS.	Pesticides	
	a. Organophosphorouscompounds(as P) I (mg l)	
	b. Chlorinated hydrocarbons (as Cl) (mg/l)	0.02
16.	Copper (as Cu) (mg/l)	3.0
17.	Lead (as Pb) (mg/l)	1.0
18.	Chromium (as Cr) (mg/l)	1.0
19.	Cadmium (as Cd) (mg/l)	2.0
20.	Mercury (as Hg) (mg/l)	0,01
21.	Nickel (as Ni) (mg/l)	5.0
22.	Zinc (as Zn) (mg/l)	5.0
23.	Radioactivity	
	a. Alpha emitters (microcuries/ml)	10
	b. Beta emitters (microcuries/ml)	10
24.	Colour and odour	No visible colour or unpleasant odour
25.	Chemical Oxygen Demand (mg/l)	250

58.3 Agriculture

Pesticides are used extensively in agriculture. However the use of the more persistent type of organochlorine pesticides is banned, or restricted, in Shri Lanka. Information on the levels of pesticide residues in water and organisms is not available.

The following pesticides are prohibited for import and use in Shri Lanka: Arsenates and Arsenites, Chlorodimeform, DBCP, DDT, EDB, Endrin, Heptachlor, Leptophos, Parathion and Methyl Parathion, Thallium Sulphate, 2 4 5 1.

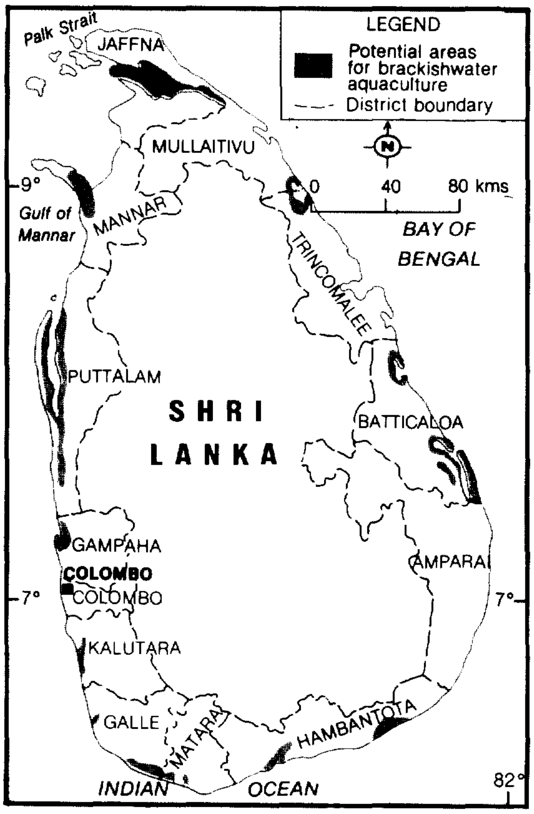
It is reported that the use of fertilizers has caused the eutrophication of dry zone reservoirs.

58.4 Aquaculture

The development of pond aquaculture has been encouraged by the Ministry of Fisheries during the last decade by initiating various incentive schemes. The construction of ponds has been subsidized and shrimp farmers have been given long-term land leases at nominal fees.

Successful pond aquaculture is, above all, a matter of appropriate site selection. Unfortunately, this has not always been taken into consideration in Shri Lanka. In 1987, for instance, it was found that 82 per cent of the small ponds constructed under the subsidy scheme in the Negombo area were non-functional. The potential areas for coastal aquaculture are shown in Figure 44.

Fig. 44. Potential areas for coastal aquaculture development



Cartography: TT. Maps, Madras-44.

The share of cultured and captured shrimps is shown in the table below

Year	Shrimp production from capture fishery	Shrimp production front brackish safer culture		Shrimp exports	
	Qty (t)	Qty (t)	Value (Rs. 10^6)	Qty (t)	Value (Rs, 10^6)
1981	4081	10*	1.5	2600	na.
985	4192	50	8.5	1648	303.3
986	4311	200	40.0	1973	427.9
1987	4461	375	88.0	1231	339.1
1988	4635	500	200.7	1826	526.8
989	4704	600	na.	2598	767.2
1990	4469	500	na.	1855	472.8
1991	5176	na.	n.a.	943	454.0
1992	6470	na.	n.a.	1246	613.1

Most of the shrimp culture sites are located in the northwestern coastal belt of the island. The impact of this development activity is

- Increased concentration of nutrients.
- Production of toxic metabolites like ammonia, hydrogen sulphides.
- Increase in suspended solids.
- Land salinization.
- Soil and water acidification.
- Natural wetlands siltation.
- Changes in coastal land use. (Jayasinghe 1992)

58.5 *Activities causing siltation*

The reclamation of coastal flats and flood plains was previously common practice in Shri Lanka. These activities, causing unexpected floods and having a negative impact on the stability of the water bodies, have now been suspended by the Government.

Heavy siltation is caused by the clearing of forests and encroachment of river banks. Most of the estuaries and lagoons are, in fact, very shallow due to the high sedimentation.

Another result of sedimentation is the formation of sand bars across the sea outlets of the coastal water bodies. This reduces water exchange with the sea. An accumalation of pollutants occurred in Lunawa Lagoon during sand bar formation.

In addition, shrimp and fish recruitment is restricted due to these sand bars.

Extraction of sand from the lower reaches of river beds during the dry season causes seawater intrusion. In the flood season, trapping of bed load materials occurs in places where the sand has been extracted. The loss of sediments affects coastal sand replenishment. However, this activity is now regulated and coastal sand mining is prohibited under the Coast Conservation Act.

58.6 *Tourism*

Most of the tourist resort areas are distributed along the coastal zone of the island. Among the six tourist development regions, four are situated in the coastal belt, *i.e* Colombo and Greater Colombo Economic region, the southern coastline, the eastern coastline and the northern resort area.

The construction of hotels and resorts, without paying due regard to coastal dynamics and behaviour of the ecosystems, has caused occasional erosion of beaches. These hotels have also cleared natural vegetation in some areas. There has also been discharge of sewage and wastewater into water bodies without proper treatment.

59. *MARITIME ACTIVITIES AFFECTING THE MARINE ENVIRONMENT*

59.1 *Seabed exploration*

Oil exploration in the Pasale area was not successful. A pre-feasibility study for extracting monazite from the sea off Beruwala will, however, be started in the first half of 1993 with financial assistance from a UNDP Revolving Fund.

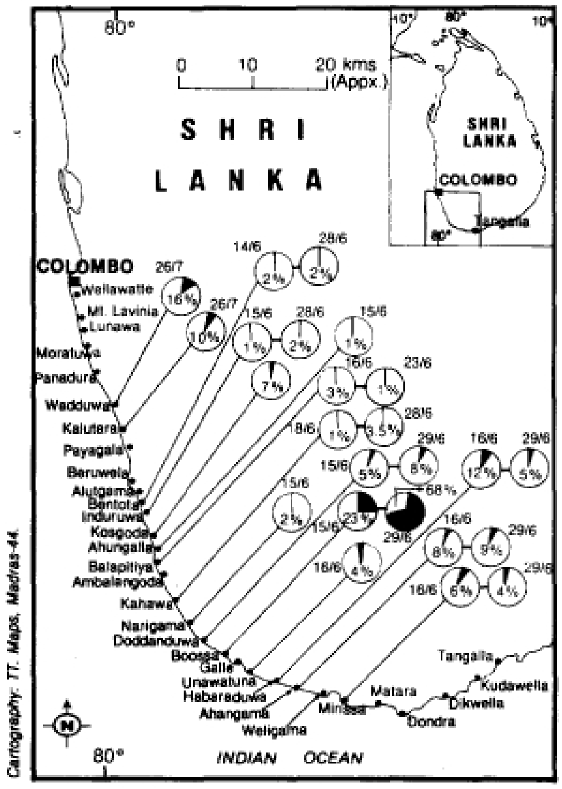
The mining of coral causes severe coastal erosion, as protection against wave actions is diminished. Coral mining in the coastal zone has been prohibited.

59.2 *Shipping*

Maritime traffic around Shri Lanka is very heavy due to the international shipping routes south of Shri Lanka. The majority of the vessels transport oil from the Gulf to the Far East and Australasia. In addition, large vessels enter Shri Lankan waters to load and unload cargo and bring in petroleum.

Major environmental contaminants from the ships are oil and waste discharges. The southern coast is polluted with tar balls formed from the coagulation of petroleum hydrocarbons (Wickremaratne and Pereira 1986) (see Figure *45).*

Fig. 45. Tar concentrations on southwestern Shri Lanka beaches expressed as a percentage of highest reported world value (Oman) 100% = 2325 **g/metre shoreline**



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59.3 *Fishery harbours*

Purification of bilge water and discharges of spent oil cause pollution in fishery harbours and landing sites. Beach and harbour pollution is also caused by the diposal of fish garbage (Namaratne and Dassanayake 1991).

60. FISH MORTALITIES

Mortalities of marine fish have not, so far, been recorded in Shri Lanka. Disease is the cause of most fish kills occurring in inland waters. Lack of oxygen, environmental stress due to industrial effluents or an excessive load of ammonia in combination with a high pH are other reasons. A summary of the recorded fish mortalities is given below :

Place	Reason	Year
Walawe Canga	Effluent discharge of paper mill	1978
Kelani River	Effluent from fertilizer corporation	Ocr. 1984
Kandy Lake	Oxygen depletion	Apr. 1986
Beira Lake	Blue-green algal bloom/Oxygen depletion	Jul. 1987
Beira Lake	Oxygen depletion/Blue-green algal bloom	Nov. 1988
Widespread (Kelani River, Dandugam Oya, Kotmale and Victoria Reservoirs etc)	EUS (Fish disease)	Jan. 1988
Smharaja MAB reserve	EUS	Jun. 1988
Kantale Reservoir	EUS	Jan. 1989
Beira Lake	Algal bloom	Jan 1990
Kalamatiyankulam reservoir	EUS	Feb. 1990
Maduru Oya reservoir	Oxygen deplerton/Algal bloom	Oct 1991
Anuradhapura reservoirs (Tissa Wewa, Nuwara Wewa)	Oxygen depletion	Jan. 1991
Kalamatiyankulam reservoir	EUS	Jan. 1991
Nilwala River	Input of agrochemicals and ammonia	May 1992

61. *RESEARCH*

The information gathered from marine fishery research in Shri Lanka does not provide a complete picture on the effect of pollution on resources. Systematic studies have not been carried out on toxic pollutants, such as heavy metals in marine waters. However, a considerable amount of scientific information is available.

In the present study, the situation in lagoons, estuaries, lower reaches of rivers and other coastal water bodies which have sea outlets were taken into consideration.

61.1 *Marine waters*

Information regarding the nearshore waters was gathered by the Fishery Resources Survey in 1978, 1979 and 1980. The resource potential of Shri Lankan waters was estimated by using acoustic methods, and the findings were supported by fishing trials and productivity studies. The results of the surveys showed considerable variation in biomass. These variations could be due to the seasonal migration of fish, changes in currents, productivity levels and physiochemical factors. It was estimated that the annual sustainable yield in the coastal sector is about 250,000 t (1978 survey).

Productivity, plankton and physiochemical data were collected in the surveys carried out by NARA in December 1985-November 1986, March 1987 and May 1987. Sampling was carried out from selected stations between Chilaw and Hambantota. Nutrient and productivity levels were generally found within tolerable ranges. In some stations, blue-green algae, Micocystis and *Oscillatoria,* were found in abundance and indicated eutrophication. Dinoflagellates were also found at some stations. No toxic red tides, however, have been reported from Shri Lanka's marine waters. The relationship between the physiochemical characteristics and productivity levels has not been evaluated.

Dassanayake (1989) summarized the significance of the marine environment, possible causes for degradation and preventive measures taken. Land-based sources of marine pollution in Shri Lanka were reviewed by Costa (1990); sewage as well as industrial and agricultural effluents were the major sources. A systematic collection and analysis of data on marine pollution is urgently needed.

61.2 Coastal waters

Incidence of tar balls on the southern coast of Shri Lanka was investigated and quantified by Wickremaratne and Pereira (1986). A seasonality in the abundance of tar balls was observed, with a peak during the Southwest Monsoon. The phenomenon was attributed to the currents and their circulation pattern in the area. Bilge water and oily waste discharges from oil tankers, on the international shipping routes south of Shri Lanka, probably caused this pollution.

NARA (1990) recorded a case of oil pollution along the southern coastline of Shri Lanka, from Ambalangoda to Doddanduwa. The oil slick was distributed over a fairly long stretch along the beach. It came from a ship anchored in Shri Lankan territorial waters. No effects on the coastal resources were, however, observed.

Investigations were made on the presence of floating oil in the south jetty of Colombo Harbour (NARA 1988). The cause for the oil spill was identified as oil leakage from the bunkering terminal of the Ceylon Petroleum Corporation.

A number of publications are available on the pollution aspects of inland water bodies and river systems. Some of the water bodies are situated in close vicinity to the sea and they are either temporarily or permanently connected with the sea. Therefore, pollutants received by them will eventually reach the sea.

A comparative study carried out on three estuary systems by Dassanayake *et al.* (1986) showed that levels of pollution were different in the three systems. The Kelani estuary was the most polluted, while the Maha Oya estuary was less polluted. The Panadura, however, is moderately polluted. At the time of the study, part of the Colombo sewerage system was directed into the Kelani River and pollution from raw sewage disposal was evident. In addition, large amounts of industrial discharges were channelled into the Kelani River. Industrial enterprises at Ratmalana discharge their effluents into Bolgoda Lake and they finally end up in the Panadura estuary. The fairly high levels of pollutants found in this estuary could be due to the effect of these discharges as well as to the various human activities in the surroundings.

The levels and distribution of heavy metals in the Negombo lagoon was studied by Niwaz and Guruge (1990). It was found that the concentrations of zinc, chromium, cobalt, nitrogen, manganese, and iron were higher during the rainy seasons. Lead (Pb) concentrations were found to be higher in fishing boat anchorages. The concentration of metals was higher in suspended sediments, collected by sediment traps, than in bottom sediments.

NARA in 1984 recorded a sudden fish mortality in the Kelani River due to high levels of ammonia. The reason for this was ammonia leakage from the Fertilizer Manufacture Corporation.

Dassanayake et al. (1985) recorded levels of heavy metals and sediments in Kelani River water. The abundance of metals had an industrial origin. As water from the Kelani River is used for drinking purposes, the need for regular monitoring of the water quality of the Kelani River was advocated.

The Kelani River pollution survey, carried out by the Central Envionmental Authority (1985), inspected all the factories which were located in close proximity to the river.

The Lunawa lagoon is characterized as highly polluted, with industrial effluents discharged from the industries in Ratmalana/Moratuwa. Jayakody (1988) showed that fishery activities in the lagoon have collapsed due to high pollutant levels in the water. The formation of sand bars across the lagoon's sea outlet has also exacerbated the situation. Most of the edible fish had disappeared. A recent report by the National Building Research Organisation (NBRO) (1989) concluded that the northern part of the lagoon was more polluted than the southern end. This observation confirmed that the pollutant sources were the industries located in the northern part of the lagoon.

The impact from the industrial and agricultural discharges in the Nilwala River was studied by de Silva et *al.* (1988). The physico-chemical parameters clearly reflected the influence of rainfall and agricultural activity within the catchment area.

Water pollution of the Walawe Ganga from the paper mill at Embilipitiya was discussed by Mathes (1991). The hazard was caused by a black caustic liquid containing high amounts of lignin and silicon which are derived from the paddy straw used in the paper production.

A water pollution survey was carried out by the Central Environmental Authority with an ultra light aircraft (CEA Water Pollution Survey report 1986 and Phase II report 1987). Colombo city was covered in Phase I and the south of Colombo (Ratmalana and Moratuwa) area was studied in Phase II. Pollution and polluted water bodies were identified by aerial photographs and confirmed by field surveys. The Lady Catherine Industrial Estate and the Lunawa lagoon (the most polluted lagoon in Shri Lanka) were proposed as suitable areas for a pilot project.

Pollution levels in the Tangalla fishery harbour were studied by Jayaweera et *al.* (1987). Effluents from the local prison and hospital, as well as water discharge from bathrooms in the harbour and fish offal were the sources of contamination. Faecal coliform bacterial counts were high in the harbour water.

Environmental and post-harvest handling aspects of fish in fishery harbours were dicussed by Namaratne and Dassanayake (1991). Pollution was observed in all three harbours investigated (Tangalla, Galle and Beruwala). The worst conditions were found in Beruwala. The dangers of the fish being contaminated due to local environmental conditions were stressed and appropriate remedies recommended.

A detailed study on the status of Colombo's Beira Lake, which has two sea outlets, was carried out by NARA (1985). It was concluded that the degradation of Beira Lake started back in the early 1900's because of increasing waste discharged into it. Due to its low flushing rate, nutrients remained, leading to eutrophy. Extensive blooms of the genus *Microcystis* dominated in the lake, depleting the oxygen and causing regular fish kills. Short-term and long-term actions for the development of Beira Lake were proposed in the document.

NBRO (1989) monitored the stream water inlet to the Beira Lake and summarized the information to be integrated into NARA's proposed management plan (1985) being considered by the steering committee for the Beira Lake rehabilitation.

A study on the pollution levels in Cilia Lake, a coastal water body near Beruwala, revealed that the lake was polluted with organic pollutants from the densely populated surroundings (NARA 1989).

Niwaz and Samarakoon (1990) found that the variation in nutrient levels in Negombo lagoon was influenced by rainfall. The study discovered that the inflow of nutrients came mainly from land drainage and from resuspension of estuarine sediments.

A study of plankton in Koddiyar (Trincomalee) Bay by Wanninayake and Indrasena (1986) recorded that diatoms often formed blooms. In addition to the Bacillariophyceae, Chlorophyta, Cyanophyta and Dinophyceae were also common. Dominating dinofl agellates belonged to the genera Peridium and *Ceratium.* The blooms were innocuous and did not present any environmental risk.

A study carried out by Perera (1987) described the productivity status of the Bolgoda Lake which receives industrial discharges from the surrounding factories. No negative effects of the pollutants from the industries were detected. The lake catchment area is fairly large and it discharges into the sea through the Panadura estuary.

Jayakody and Jayasinghe (1992) studied the impacts irrigation works had on fishery resources in some lagoons in southern Shri Lanka. In the Malala lagoon (Jayakody and Jayasinghe 1992), the excess fresh water released by the Lunugamwehera Tank entered it and reduced its salinity level. This caused a drastic reduction in shrimp catches. The formation of sand bars across the sea mouth prevented the recruitment of fish and crustaceans into the lagoon. Diversion of excess freshwater was not feasible due to excessive costs. To recuperate losses, aquaculture promotion seemed appropriate, and suitable species were identified.

The situation in the Rekawa lagoon (Jayakody and Jayasinghe 1992b) was quite similar to that of the Malala lagoon. Heavy loads of fresh water from the Kirama Oya drained into the Rekawa lagoon. In addition, drainage blockages caused by the construction of a bridge worsened the resource improverishment. Illegal fishing methods *(eri weta)* were also identified as factors responsible for the depletion of fishery resources.

The bacterial flora in edible molluscs such as clams, mussels and cockles, collected from the southwest coast of Shri Lanka were studied by Jayaweera and Chinivasagam (in prep.). Results reveal that the majority of samples conform to international standards, but those from Negombo to Beruwala showed comparatively higher levels of bacteria than those from Negombo to Puttalam. The higher contamination from Negombo to Beruwala would appear due to the greater land-based activities on this stretch.

The impact of shrimp culture projects that used different culture methods was discussed. The problems that occurred in shrimp culture, namely poor growth, high mortality, and frequent disease outbreaks, were linked with the poor quality of the water source, the Dutch Canal. The same waterbody is a recipient of farm effluents.

The impact of shrimp culture development was also studied by Jayasinghe and de Silva (1990). Some changes were found in the northwestern coastal area. The decrease of habitats like mangroves, salt marshes etc. was recorded, and could help explain the gradual depletion of finfish and crustaceans.

Existing literature on the fishery resources suggests that, in most cases, the decline of the fish catches and decrease of catch per unit effort (CPUE) are due to over-exploitation. The depletion of lobsters in southern Shri Lanka (Jayakody 1991), the decrease of ***Amblygastersirm*** in the Negombo coastal waters (Karunasinghe and Wijeratne 1991) and the decline of fisheries in Chilaw (Jayakody 1988) are all well documented. It is well known that the national lobster fishery suffers from over-fishing. Jayakody (1991) suggested a closed season, restricting the harvest of lobsters in identified locations, so as to allow resource regeneration.

The observed fluctuations in the yield of pelagic fish could, however, be due to their migratory pattern (Dayaratne 1988, Maldeniya and Joseph 1988).

Natural oceanographic characteristics also have a great impact on the availability of fish. The narrowness of the continental shelf, for instance, affects demersal fish besides lack of upwelling for the mixing of nutrients with upper layers (Joseph 1984).

62. CONCLUSIONS

Information on marine environmental research in Shri Lanka is extremely scarce, and research carried out to date, in nearshore waters, has not been aimed at studying the pollution hazards in fisheries.

Pollution problems afflicting coastal and inland waters are widespread in Shri Lanka. Lunawa lagoon, Walawe Ganga, Valachchenai lagoon represent classic examples of the impact organic waste, rich in nutrients, has on fish, causing regular kills. Oil pollution has frequently also affected environmental and resource stability.

The most significant negative impact, faced by the marine environment, however, comes from industrial pollution; proper measures must clearly be taken to curb the degradation of the marine ecosystem.

It has been shown that fish catches and catch per unit effort fluctuate in Shri Lanka waters. This is probably due to migratory behaviour, but environmental degradation and over-fishing may also have an impact.

Facilities for carrying out marine pollution research are available in most of the research institutes. Lack of trained persons and adequate funds is the problem.

The legal provisions for the regulation of marine pollution are adequate, if properly implemented.

Immediate pollution effects on critical habitats can be controlled, to a certain extent, through law enforcement and awareness programmes. The nongovernmental organizations and mass media are, to this end, vital in creating greater public awareness.

Systematic marine environmental studies should be given priority for a better understanding of the long-term ecosystem changes. A strategy for the conservation of resources should also be formulated, based on these studies.

63. REFERENCES

AMARASINGHA, M.D. 1988. *Socio-economic status of human communities of selected mangrove areas on the west coast of Shri Lanka.* UNESCO Occ. Pap.No.3. UNESCO, UNDP.

CENTRAL ENVIRONMENTAL AUTHORITY. 1985. Industrial pollution in the Kelani River, Colombo, Shri Lanka.

________________ 1986. *Wafer pollution survey with an ultra light air-craft Phase I,* Colombo, Shri Lanka.

COASTAL ZONE MANAGEMENT PLAN. 1986. Coast Conservation Department, Colombo, Shri Lanka

COSTA, H.H. 1990. Land-based sources of marine pollution in Shri Lanka. *Proc. of the Symp. on Ecology and Landscape Management in Shri Lanka: Conflict* or compromise? NARESA, Colombo, Shri Lanka.

DASSANAYAKE, C.B., WEERASOORIYA, S.V.R. and SENARATNE, A. 1985. The heavy metal pollution of the Kelani River in Shri Lanka. *Aqua. No. (2).* U.K.

DASSANAYAKE,N.H., PEREIRA, RAVI and DE ALWIS, P. 1986. *Estuarine studies, variations ofsomephysico-chemical and microbrologicol parameters in three selected systems. (Maha Oyo, Kelani and Ponodura).* NARA, Colombo, Shri Lanka.

DASSANAYAKE, H. 1989. *Marine environmentalprotection of Shri Lanka.* Country paper presented in an Intl. Trng. Course on Mar. Enclosure Ecosystem Experiments. Xiamen, P.R. China.

DAYARATNE, N.M.P.J. 1988. *High/y migratory living resources of Indian* Ocean. Presented at the Third Standing Committee of IOMAC, Colombo, Shri Lanka.

DE SILVA, M.P., KARUNATHILXKE, R. and THIEMANN, W. 1988. Study of some physico-chemical properties of Nilwala River waters in southern Shri Lanka with special reference to effluent resulting from anthropogenic activities. J. *Env. Science Health.* Part A, Vol. 423 No. (4).

JAYAKODY, D.S. 1988a. *Causes for the decline in fishery* in *Chilaw.* NARA, Colombo, Shri Lanka

________________ 1988b. *Causes for the depletion of fish in Lunawa Lagoon.* NARA, Colombo, Shri Lanka

________________ 1991. *Fishery, population dynamics and breeding biology of* Panulli homarus (L) on *the south coast of Shri Lanka.* Ph.D thesis submitted University of Sterling, U.K.

JAYAKODY, D.S. and JAYASINGHE, J.M.P.K. 1992a. *Report on the development potential of Malala lagoon.* NARA. Colombo, Shri Lanka.

____________________ 1992b. *Report on the development of Rekawa lagoon.* NARA, Colombo. Shri Lanka.

JAYASINGHE, J.M.P.K. *1992. Environmentalassessment and management of aquaculture development.* TCP/RAS/2253. Report of the Planning Workshop. Bangkok, Thailand.

JAYASINGHE, J.M.P.K. and DE SILVA, J. 1990. The impact of prawn culture development on the present land use pattern in the coastal areas of Shri Lanka. *Proc. of the Symp. on Ecology and Landscape Management: Conflict or compromise.* NARESA, Colombo. Shri Lanka.

JAYAWEERA, V., DE SILVA, SlSlRA and GODAKANDA, J.C. 1987. *Quality offish at landing sites along thesouthern coast of Shri Lanka.* NARA, Colombo, Shri Lanka.

JAYAWEERA, V. and CHINIVASAGAM, N. (in prep). *Bacteriological parameters of clams, mussels and cockles from the southwest coast of Shri Lanka.* NARA, Colombo, Shri Lanka.

JOSEPH, L. 1984. *200 miles exclusive economic zone and fishery development in Shri Lanka.* NARA, Vol.31 Colombo, Shri Lanka.

KARUNASINGHE, W.P.N. and WIJERATNE, M.J.S. 1991. Exploitation of *Amblygastersirm* stocks in the coastal waters of Negombo. *Proc. of the SLAAS 45th Ann. Session.* Colombo, Shri Lanka.

MALDENIYA, R. and JOSEPH, B.D.L. 1988. *Recruitment and migratory behaviour of yellow fin tuna,* Thunnus albacarus *from the western and southern coast of Shri Lanka.* IPTP/88/WP/17.

MATHES, A.P. 1991. Water pollution of Walawe Ganga due to the effluent discharge of Embilipitiya Paper Mill. *Proc. of the Workshop on Aquatic Resources of Shri Lanka.* NARA,, Colombo.

NARA. 1985. *Preliminary study of Beira Lake.* NARA, Colombo, Shri Lanka.

______ 1986a. *Report of the* Samudra Maru *Cruise* I, 1986. NARA, Colombo, Shri Lanka.

______ . 1986b. *Report of the* Samudra Maru *Cruise VII,* 1986. NARA, Colombo, Shri Lanka.

______ 1987a. *Report of the* Samudra Maru *Cruise* XII, 1987. NARA, Colombo.

______ . 1987b. *Report of the* Samudra Maru *Cruise* XVI, 1987. NARA, Colombo.

______ 1988. *Investigations on a spillage of oil at the bunkering terminals in the South Jetty of the port of Colombo. NARA, Colombo.*

______ 1989. *Report on the pollution status of Cilia Lake.* NARA, Colombo.

______ *1990. Preliminary report on the inspection of deposition of oil on the stretch of beach from Ambalangoda IO Doddanduwa.* NARA. Colombo.

NAMARATNE, S.Y. and DASSANAYAKE, H. 1991. *Present conditions of three selectedfishery harbours in Shri Lanka, Tangalla, Galle and Beruwala.* Report submitted to BOBP, 1991.

NATIONAL BUILDING RESEARCH ORGANIZATION. 1989a. *Effluent monitoring of majorstorm water entering Beira. Lake.* Colombo, Shri Lanka.

____________________ 1989b. *Water quality monitoring data, Lunawa Lagoon.* Colombo, Shri Lanka.

NIWAZ. J.M. and GURUGE, KS. 1990. Status of heavy metal abundance in the Negombo lagoon. *Proc. of the 46th Ann. Sessions SLAAS.* Colombo, Shri Lanka.

NIWAZ, J.M. and SAMARAKOON. R. 1990. Nutrient distribution in the Negombo Lagoon. *Proc. of the 46th Ann. Sessions of SLAAS.* Colombo, Shri Lanka.

PERERA, W.V.J. 1987. *Productivity of the Bolgoda lagoon system of Shri Lanka.* M.Phil thesis submitted to the University of Sri Jayawardenapura, Nugegoda, Shri Lanka.

WANNINAYAKE, T.B. and INDRASENA, W.M. 1986. The composition distribution and seasonal fluctuation of phytoplankton and zooplankton in the Trincomalee Bay. *Proc. of the 42nd Ann. sessions of SLAAS.* Colombo, Shri Lanka.

WICKREMARATNE, S.W. and PEREIRA R.P. 1986. Observation on the deposition of tarballs on beaches of Shri Lanka. *Proc. of the 41st Ann. Sessions of SLAAS.* Colombo, Shri Lanka.

APPENDIX XXX

Institutions engaged in environmental research, monitoring and enforcement

GOVERNMENT

Central Environmental Authority (CEA)

The CEA laboratory is capable of monitoring general water quality parameters, noise levels and air quality.

National Aquatic Resources Agency (NARA)

Being a multidisciplinary organization, NARA consists of five research divisions engaged in studies on Oceanography, Marine Biology Resources, Inland Aquatic Resources, Hydrography, Post-harvest Technology and Environmental studies. The NARA environmental laboratory monitors general water quality parameters, pesticides, heavy metals and microbiological water analyses. The testing of soil quality can also be carried out in the Inland Aquatic Resource Division's laboratory.

Ceylon Institute of Industrial and Scientific Research (CISIR)

The CISIR laboratories are well equipped with the necessary instruments for carrying out analyses of chemical water quality industrial pesticides and heavy metals, as well as testing air quality and noise levels.

National Building Research Organization (NBRO)

The Environmental Division laboratory has the facilities to study the chemical qualities of water as well as air quality parameters.

Institute of Fundamental Studies (IFS)

Facilities for pesticide, heavy metal and soil/sediment analyses

National Water Supply and Drainage Board (NWSDB)

Facilities to monitor chemical and microbiological parameters

Water Resource Board

General water quality parameters.

Division of Occupational Hygiene, Labour Department.

Facilities available for measuring general water quality parameters, air quality and noise levels

Geological Survey Department

Water quality and soil quality testing.

Greater Colombo Economic Commission

Its laboratory monitors industrial effluents in the Export Processing Zones.

UNIVERSITIES

University of Colombo
Kumaratunga Munidasa Mawatha, Colombo 3, Shri Lanka

The Department of Chemistry's does chemical analyses of water, including heavy metals testing. The Departments of Botany and Zoology undertake biological and microbiological studies of water.

University of Kelaniya
Kelaniya, Shri Lanka.

Physico-chemical tests of water are undertaken by the Chemistry Departments. Biological analysis of water and benthos can be carried out in the of Botany and Zoology laboratories. Microbiological analyses are underway at the Department of Microbiology.

University of Peradeniya
Peradeniya, Shri Lanka.

Chemical quality of water and sediment can be analysed in the Department of Geology. Chemical water analyses can be carried out in the Chemistry Department laboratory and biological and microbiological studies in the laboratories of the Botany and Zoology Departments.

University of Ruhuna
Galle, Shri Lanka.

Studies related IO fisheries are carried out by the Department of Fishery Biology. Chemical analysis is undertaken in the Chemistry Department. The Department of Zoology and Botany is equipped to carry out biological environment examinations.

University of Sri Jayawardenapura
Gangodawila. Nugegoda, Shri Lanka.

Physico-chemical water tests can be undertaken in the Chemistry Department. Biological analysis of water and benthos testing is done in the Departments of Botany and Zoology.

Eastern University
Venchaladi. Shri Lanka

The Chemistry Department is equipped for chemical, water and heavy metal analyses. The Departments of Botany and Zoology can undertake biological and microbiological wafer studies.

Northern University
Jaffna. Shri Lanka.

Chemical water testing is done in rhe Chemistry Deparrmenr. Biological analysis of water and benthos can be carried out in the Botany and Zoology laboratories.

NONGOVERNMENTAL ORGANIZATIONS (NGOs)

Earlier, most NGOs were mainly interested in wildlife conservation. Today, they play an important role in mobilizing the general public on environmental issues and creating awareness among them. Some of the successful campaigns carried out in the recent past have been the move to stop logging the virgin rain forest 'Sinharaja' and the cessation of the construction of thermal power (coal) plants in Trincomalee and Mewella.

It has been recorded that there are 80 nongovernmental organizations in Shri Lanka today. Among rhem are these national-level NGOs'.

Environmental Foundation Ltd.
No. 29 Siripa Road,
Colombo 05.

Wildlife and Nature Protection Society
Chaitya Road,
Fort, Colombo 01.

March for Conservation
Zoological Depr , Colombo campus,
University of Ceylon,
Munidasa Kumaranathunga Mw "
Colombo 03.

Shri Lanka Environmental Congress,
145/18, Dutugemunu Veediya,
Kohuwela, Nugegoda.

Parisarikayo
News Section,
Shri Lanka Broadcasting Corpn..
Torrington Square,
Colombo 07.

Ceylon Bird Club,
A. Baur & Co.,
Colombo 01.

Vidya Mandiraya.
Vidya Mw.,
Colombo 07.

Ruk Raka Ganno,
C/o Vidya Mandiraya,
Vidya Mw ,
Colombo 07.

G 2/5 (Anderson Flats)
215 Udyana Rd.,
Colombo 05.

Lanka National Sarvodaya Sramadana Association,
Rawathawatte Road,
Moratuwa.

Organisaation for the Safeguard of Life and Environment,
No. 15 Eliot Place,
Colombo 08.

APPENDIX XXXI

Legislation against threats to the marine environment

Legislation on the marine environment can be classified into three categories:

- fisheries and marine life,
- coast conservation and
- pollution control

The following is a list of laws and regulations covering the marine environment:

- Fisheries Ordinance No. 23
- Pearl Fisheries Ordinance
- Whaling Ordinance No. 2 of 1936.
- Chank Fishery Ordinance No. 8 of 1953.
- Foreign Fishing Regulation Act. No.59 of 1979.
- National Aquatic Resources Research and Development Agency Act No. 54 of 1981.
- State Land Ordinance No. 8 of 1947.
- Coast Conservation Act No. 57 of 1981.
- Maritime Zone Law No. 22 of 1976.
- Shri Lanka Ports Authority Act No. 1979.
- Water Resources Board Act No. 29 of 1963.
- National Environmental Act. No. 47 of 1981 and Amendment Act No. 56 of 1988.
- Control of Pesticide Act No. 33 of 1980.
- Malathion Control Act No. 22 of 1985.
- Custom Ordinance No. 17 of 1965.
- Marine Pollution Prevention Act No. 59 of 1981.

Institutional responsibility

According to the laws and regulations listed above, most environment-related events come under the purview of the Central Environmental Authority (CEA). The CEA has developed guidelines for the disposal of asbestos wastes, battery wastes, empty bulk containers from pesticide companies etc. Action is being initiated to locate industries neighbouring each other which could need waste treatment. A common treatment plant would mean lower costs for each individual industry compared to individual waste treatment.

Municipalities and Town Councils etc. are responsible for the transportation of waste discharges. However, the waste discharge quality should conform to the environmental standards laid down by the CEA.

The transportation, manufacture, formulation packing, distribution and selling of pesticides are regulated by the Registrar of Pesticides.

The National Aquatic Resources Agency (NARA) is responsible for carrying out fish mortality investigations, monitoring the destruction of other aquatic resources and is empowered to recommend remedial actions.

The critical habitats within the National Parks and Marine Parks come under the purview of the Department of Wildlife Conservation.

APPENDIX XXXII

Other publications on the marine environment

ABEYWICKRAXI.4. B.A. 1986. History of the manproves and seagrass studies in Shri Lanka Proc. of *the wkshp. on Research Needs* for *Aquatic Ecosystems.* NARA. Colombo, Shri Lanka.

AMARASINGHA, M.D. *1989. Structural and functional properties of the mangrove system in Puttalam Lagoon.* M.Phil thesis submitted to the University of Peradeniya.

ARUDPRAGASAM, K.D. 1975. The lagoons and coastal waters of Sri Lanka. *Proc. of Shri Lanka Assn. Ad of* Sci. 31(1 1). Colombo. Shri Lanka.

ARUMUGAM, S. 1969. U'ater *resources* of Ceylon and *utilization und* development. Water Resources Board, Colombo, Shri Lanka.

CENTRAL ENVIRONMENTAL AUTHORITY. 1987. *Water pollution survey with an ultra light aircraft Phase* IIColombo. Shri Lanka.

____________________ *1987 b. Handbook on environmental impact assessment.* Colombo. Shri Lanka.

DE SILVA J.A. and PINTO I 1987. A preliminary survey of estuarine benthos fauna in four coastal bodies in the west coast of Shri Lanka. *Proc. of the 44th An. Sessions SLAAS.* Colombo, Shri Lanka.

DE SILVA, N.W.R.N. *1987. Effects of the tourist industry on coral reefs at Hikkaduwa.* Report submitted to IDRC

DE SIL VA, S.S. 1984. Coastal Lagoons. IN: *Ecology und Biogeogruphy in Shri Lanka.* C.H. Fernando Ed. Dr. W.Junk. Hague, The Netherlands.

ELLEPOLA. RAMANI. 1991. *Hazardous Waste management* Presented at the Wkshp. on Opportunities and Constraints for Industrial Pollution Control in Shri Lanka. Central Environmental Authority. Colombo, Shri Lanka.

FRIDTJOF NANSEN SURVEY REPORT. 1980. *A survey of the coastal fish resources of Shri Lanka* Report No. (I, 2 & 3). NARA, Colombo, Shri Lanka.

FRIDRICH-EBERT-STIFTUNG. *1989. Pesticides in Shri Lanka.* Colombo, Shri Lanka.

JAYASURIYA, P.M.A. 1991. The species composition, abundance and the distribution of seagrasss communities in Puttalam Lagoon. *Vidyodaya* J. of *Sci.* VI 3, No 2, Shri Lanka.

NATIONAL CONSERVATION STRATEGY. 1988. Central Environmental Authority, Colombo, Shri Lanka

NATURAL RESOURCES OF SHRI LANKA. *1991. Conditions and trends* (1991). NARESA, Colombo, Shri Lanka

NORAD, CEA. 1989. *Environmental study of Shri Lanka.* Colombo, Shri Lanka

PUNCHIHEM'A, N.N. and PINTO, L. 1987. Periodicity in the occurrence of edible sea crab *Portunas pelagicus* (Lin.) in the seagrass of the Negombo lagoon. *Proc. of the 43rd Ann. Sessions of SLAAS,* Colombo, Shri Lanka.

RAJASURIYA, A. 1990. Coral reefs in Shri Lanka and present trend in their management. *Proc. of the Int. Sem. on Protection of Sensitive Sea Areas.* Malmo, Sweden.

RAJASURIYA, DE SILVA. N.W.R.N., 1988. Stony corals of the western, southwestern and southern coasts of Shri Lanka *Proc. of the 6th* Int. *Coral Reef Symp.* Australia, 1988.

SAMARAKOON, JAYAMPATHI and PINTO L. *Synthesis report for information on critical habitats in the coastal zone.* CCD/USAID/URI. Colombo. Shri Lanka.

SEWAN, B. 1981. *The coastal geomorphology of Shri Lanka.* Dept. of Geography, University of New England, Armidale, New South Wales. Research Series in Applied Geography.

UNEP. 1986. *Environmental problems of the marine and coastal ureas of Shri Lanka: National Report.* UNEP Regional Seas Reports and Studies No. 74 UNEP. 1986.

WIJEDASA, K.H.J. and ILAPPERUMA. *W.G.* 1986. *Survey of environmental registitution and institution in the SACEP countries: Shri Lanka.* Central Environmental Authority, Colombo, Shri Lanka.

APPENDIX XXXIII

Ongoing research projects

Assessment of the effects of coconut husk retting on the coral reef in southern Shri Lanka.

This project is being carried out by the NARA coral reef research programme with financial assistance from SAREC.

The husk-retting pits are polluted with organic substances and, possibly, tannins and polyphenolic compounds. During the high tide, the pits are flooded with tidal water which mixes with polluted water. Due to the chemical nature and high turbidity of the water, the coral polyps may be affected. The phenolic compounds can also taint the fish flesh and make it unfit for human consumption.

Study of Koggala Lake

The project is being executed by the environmental study unit of NARA. Shri Lanka's Third Export Processing Zone was established in close proximity the Koggala Lake (a lagoon situated in the Southern Province). Even though the industrial estate will be provided with waste treatment facilities, the amount of pollutants in Koggala Lake may be enhanced. The present study was initiated with the objectives of collecting baseline data on the environmental conditions for future use. Funds for this project have been provided by NORAD.

NARA/SAREC Coastal Ecosystem Research Programme.

A multidisciplinary programme was initiated by NARA with financial assistance from SAREC. The Programme's objective is to prepare a comprehensive management plan for the area. The marine biological resources, aquaculture, oceanography and environmental study divisions are involved in the programme. Fishery status in the estuary and sea, as well as productivity levels in the lagoon, are being studied by the Marine Biological Resources Division. The Inland Aquatic Resources Division is carrying out studies on the impact of aquaculture development in the area. The oceanography characteristics of the estuary are being studied by the Oceanography Division. The nutrient aspects of the estuary are being studied by the Environmental Study Unit.

Study of the two important river systems in Shri Lanka with respect to pollutant transport to the coastal region.

The Kelani and Kalu Ganga were selected for the study. The Kelani is more polluted with industrial and organic pollutants than the Kalu Ganga. Levels of accumulated pesticides in fish and mussels are also being studied. This work is funded by SAREC.

Coral Reef Research Project

This programme is being conducted by the NARA coral reef research programme with SAREC financial assistance

The objective of the study is to develop a comprehensive management plan for the area under study. The research carried out in the Northwestern Province, in Kalpitiya peninsula, has led to the eastablishment of a marine sanctuary at Bar Reef.

Study on the litter decomposition and nutrient transformation in the mangrove ecosystem in the Negombo area.

This study is being conducted by the Inland Aquatic Resource Division of NARA. Mangroves are considered an important, source of detritus in lagoons and estuaries. The present study was initiated with the objective of determining the mangroves, contribution to lagoon productivity.

Accumulation of chromium in water, soil and body tissues of fish and prawns due to industrial pollution in the Kelani River.

This study aims to determine the chromium contamination of soil, water and fish/prawn tissues in the Kelani River.

Study of the water quality and pollution levels in the Hamilton Canal, a man-made coastal water body.

The compilation of water quality data is being carried out to ascertain whether it is feasible to develop the Muthurajwela Marsh bordered by the canal to the west. The coastal waterbody links the Negombo Estuary with the Kelani River. Threats posed by pollutants being transported along the canal into the Negombo Lagoon are, also, being taken into consideration.

Monitoring of heavy metal pollutants and organohalogens in a lagoon and their effects on edible lagoon animals.

The project is still in the preliminary stage. The study area will be Gananduwa and Dondra lagoons in southern Shri Lanka. This project is being carried out by the Department of Chemistry, University of Ruhuna.

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Coral used for all building purposes in the Maldives.

The Maldives

by

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64. *INTRODUCTION*

With a territorial area of 90,000 km^2 and only about 300 km2 dry land (see Figure 46), the Maldives has traditionally exploited the sea. Its tuna fishery has long been the dominant fishery. However, considerable efforts are being made to diversify fisheries activities. As a result, nontraditional fisheries, such as lobster, sea cucumber and giant clam fisheries, have come into being, while the long-existing small-scale reef fishery has expanded.

Income originating from the sea has further increased with the introduction of tourism. Today, tourism is a major source of national income.

Even as the global environment crisis gains momentum, the Maldives too faces its own environmental challenges. Urbanization has deprived the islands of vegetation, and intensive groundwater use in urban centres has impoverished water, making it saline. Harbour construction and land reclamation have disrupted delicate marine ecosystems. And sewage and solid waste dumped into the water, as well as coral- and sand-mining, have further complicated the environmental situation.

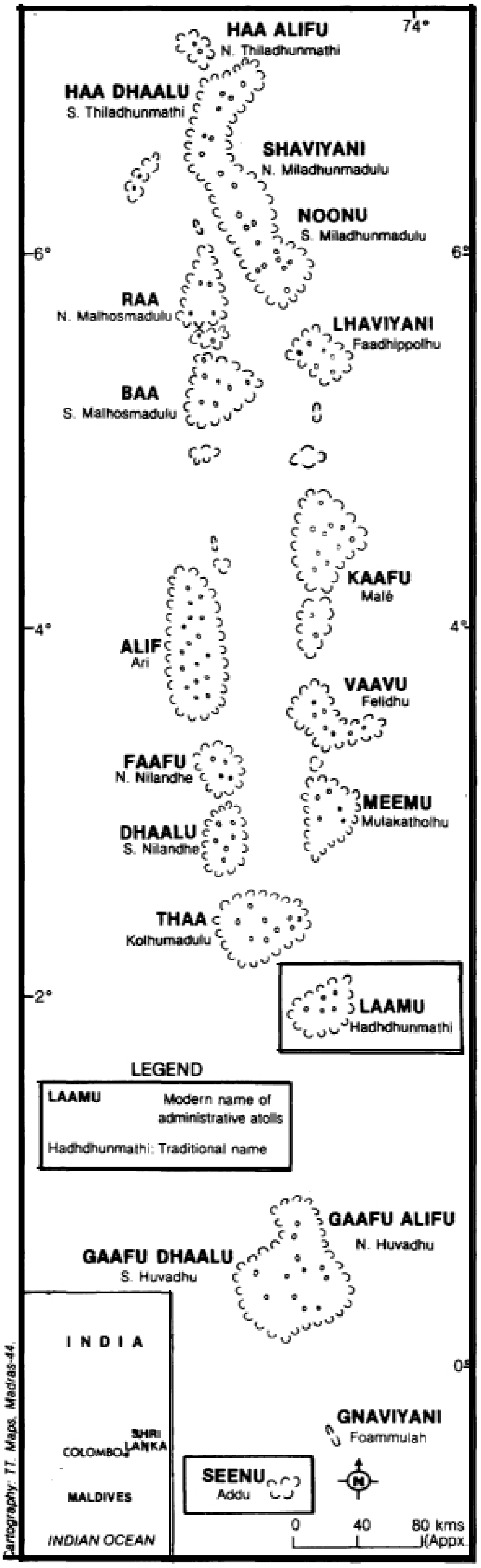
It is obvious that if the Maldives is to regularly reap the maximum benefit from fisheries and tourism, its seas must be kept healthy and unstressed. Rational use of marine resources, without threatening the environment, is clearly the ideal goal. Preventing, or reducing, damage to fish and fishery resources through sounder environmental management will improve the livelihood of the fisherfolk.

When considering various environmental threats affecting fisheries in the Maldives, it should be noted that all these effects are not quantifiable at this stage. Nevertheless, it must be emphasized that most environmental threats affecting fisheries in the Maldives are not due to pollution.

65. *THE SURVEY*

The Marine Research Section (MRS) of the Ministry of Fisheries and Agriculture (MOFA), with the Environmental Research Unit of the Ministry of Planning and Environment and the Maldives Water and Sanitation Authority, carried out a survey to assess potential environmental threats to marine fisheries in the country. Information was gathered mainly by reviewing existing reports and data, and by

Fig. 46. Map of Maldives showing the sites visited



interviewing fishermen and government authorities. In addition, field observations were carried out and water quality tested at some sites. Two field trips were made, one to Seenu Atoll and another to Laamu Atoll (see Figure 46 on p. 239 for site location), both priority areas for development activities.

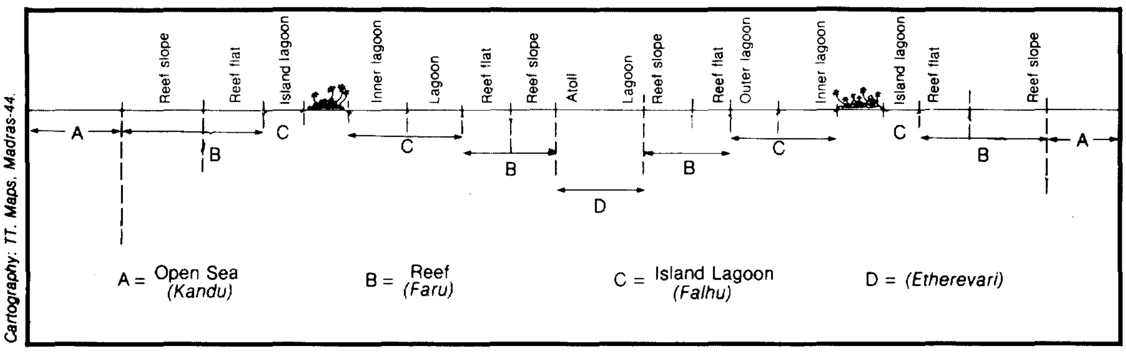
66. *THE MARINE ENVIRONMENT AND EXPLOITATION OF ITS RESOURCES*

The Maldives is an archipelago of coral islands stretching between latitudes 041 48" S and 7 06' 30' N. More than 98 per cent of Maldivian territory is sea. The scattered coral reefs and 1190 islands depend on the marine environment for their existence.

66.1 *Zoning*

A typical Maldivian coral island has a sandy lagoon situated in between the island and its house-reef. Beyond the reef stretches the deep atoll lagoon. Between the atolls are deep open seas or channels. Based on these features, Maldivian fishermen traditionally divide the marine environment into sandy lagoon *(Faihu),* reef *(Faru),* atoll lagoon *(Etherevari)* and open sea or channels *(Kandu)* (see Figure 47),

Fig. 47. Traditional zoning of waters of Maldives



This zoning may be arbitrary from an ecological viewpoint, but it is convenient to use in a survey of this nature. In the first place, all exploited marine resources, living or otherwise that are exploited in the Maldives, can be attributed to these zones. Secondly, the zones also indicate areas which are under varying degrees of anthropogenic influence.

The sandy lagoon and the reef, for instance, being shallower and closer to the islands, are more accessible to the people than the atoll lagoon and open sea. As a result, the living and nonliving resources *(e.g.* fish, corals, sand etc.) of these two zones are more intensively exploited and the zones themselves are modified by activities such as harbour construction, land reclamation and coral and sand mining.

Besides, ecological conditions in these zones are also different. Tidal fluctuations and their consequences, such as change in hydrostatic pressure, can be felt in the sandy lagoon and the shallow reef areas, whereas all these changes have negligible effects in the atoll lagoon and in the open sea.

Flora and fauna, and their relative abundance, in these zones also vary. The sandy lagoon is inhabited by burrowing organisms that can withstand tidal fluctuations and sand displacements. The abundance of organisms is high. though the number of species is low. In some sandy lagoons, however, the dominant seaweeds and seagrasses grow so abundantly that they invade the adjacent shallow coral reef areas.

Reef life is very diversified. The reef is rich in species and number of organisms. Fish, lobsters, sea cucumbers, giant clams and many other organisms find their home in the reef, while the reef corals themselves are very diversified.

The atoll lagoon and open sea are zones with diversified species.