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

BAY OF BENGAL PROGRAMME **BOBP/REP/67**

An environmental assessment of the Bay of Bengal region

by

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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).

This document is a report and has not been cleared by the governments concerned or the FAO.

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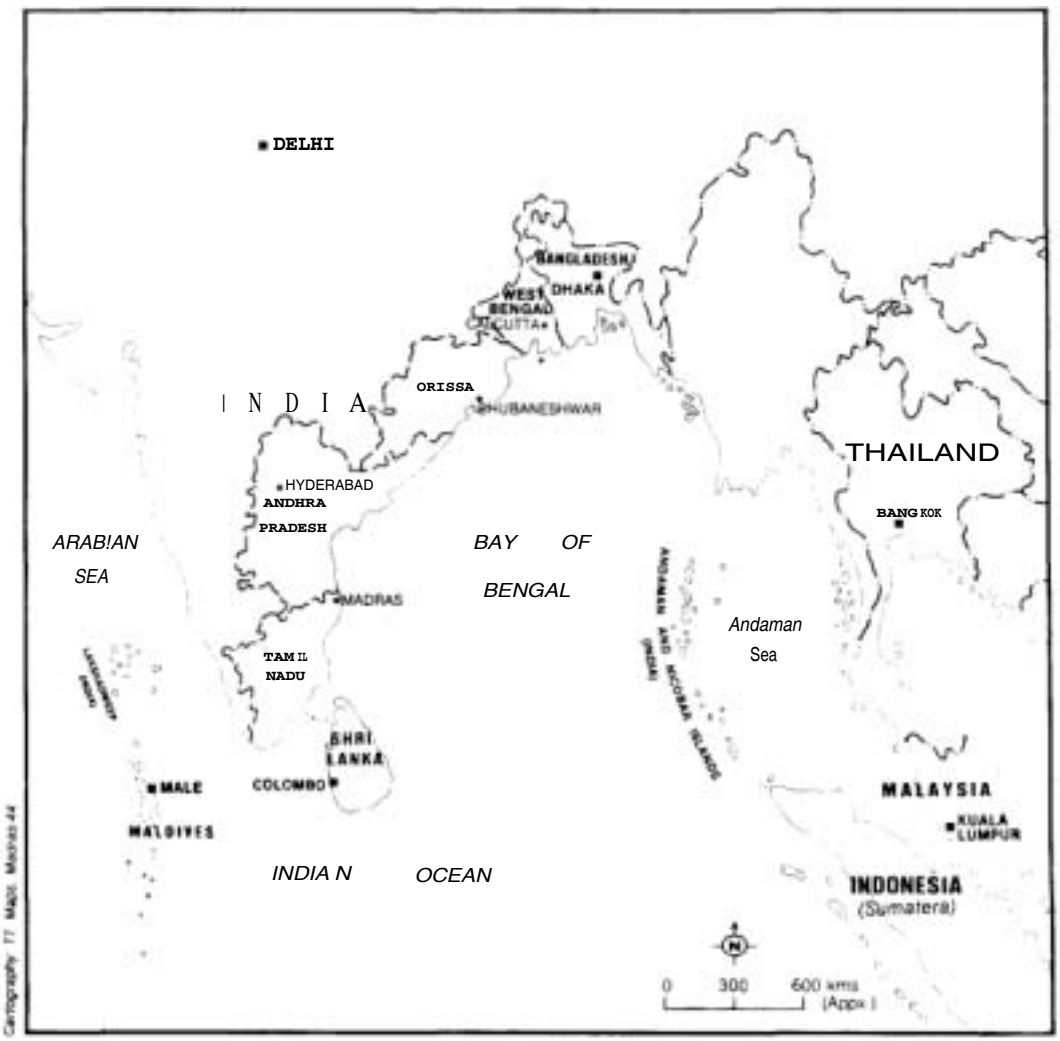
Contents

List of abbreviations

ADB	=	Asian Development Bank
ADI	=	Acceptable Daily Intake
AS	=	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
co	=	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
oc	=	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

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



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.

– 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

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.
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.	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.
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.
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.	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.

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.

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.)