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PREFACE

The better understanding of the changing problems facing the marine environment is a continuing goal of UNEP's ocean programme, as it provides the necessary scientific background for shaping UNEP's policy towards the protection of the oceans.

The main sources of factual information used in the assessment of the state of the marine environment are data published in open scientific literature, data available in various reports published as "grey literature" and data generated through numerous research and monitoring programmes sponsored by UNEP and other organizations.

Several procedures are used to evaluate critically the large amount of available data and to prepare consolidated site-specific or contaminant-specific reviews.

GESAMP, the IMO/FAO/Unesco/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on Scientific Aspects of Marine Pollution, is charged by its sponsoring bodies with preparation of global reviews. Reviews dealing with several contaminants have been already published by GESAMP and others are being prepared for publication. The first global review on the state of the marine environment was also published by GESAMP in 1982, and the second global review was published in 1990 [1/].

In parallel with the preparation of global assessments, the preparation of a series of regional assessments, following the general format of the second global review by GESAMP, was initiated by UNEP in 1986, with co-operation of the Food and Agriculture Organization of the United Nations (FAO) and the Intergovernmental Oceanographic Commission of Unesco (IOC). Fifteen task teams of scientists were set up, involving primarily experts from the relevant regions, to prepare the regional reports under the joint overall co-ordination of UNEP, FAO and IOC, and with the collaboration of a number of other organizations.

The present document is the product of the Task Team for the South Asian Seas Region. The final text of the report was prepared by R. Sen Gupta, as Rapporteur of the Task Team for the South Asian Seas Region, with collaboration of M. Ali, A.L. Bhuiyan, M.M. Hossain, P.M. Sivalingam, S. Subasinghe and N.M. Tirmizi, whose contributions are gratefully acknowledged.

The report was edited and prepared for publication by Philip Tortell of Environmental Management Limited, New Zealand.

[1/] Publications of GESAMP are available from the organizations sponsoring GESAMP.

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1. INTRODUCTION

The South Asian Seas region consists of India, Bangladesh, Pakistan, Maldives, Sri Lanka, Burma and western coasts of Thailand and Malaysia (Figure 1).

The total land area covered by these countries is 5.341 million km^2, having a population of 950 million with a mean of 178 persons per km^2. The population density varies from 26 per km^2, in Sri Lanka to 591 per km^2, in the Maldives. The average growth of population is around 2% per year. It can be assumed, at least at a first approximation, that 25% of the population of these countries is directly or indirectly dependent on the sea for its living. This would mean that roughly about 240 million people will be dependent on the bounties of the sea for their livelihood.

No accurate information is available about the total length of coastline in all the countries. The available information indicates that Pakistan, Bangladesh, Sri Lanka and India have coastlines of 825 km, 768 km, 1,700 km and 7,500 km respectively, making a total of 10,793 km, excepting Maldives. All these countries have wide Exclusive Economic Zones (EEZ), the extent of most have not yet been finally ascertained. Pakistan is estimated to have an EEZ of 196,600 sq.km., which is about 25% of its land area, India has 2.015 million sq.km., which is 61% of the land area, Sri Lanka has 1.2 million sq.km., which is nearly 20 times the land area and Maldives has 90,000 sq.km. (Sen Gupta, 1987; Bhuiyan & Hossain, 1987; Sivalingam, 1987; Subasinghe, 1987; and Tirmizi, 1987).

These countries lie in the equatorial and tropical tidal regions and are influenced mainly by semi-diurnal tides sometimes with large amplitude. All the countries are blessed with perennial rivers. It has been estimated that the total river runoff to the Bay of Bengal and the Arabian Sea is about 3,000 km^3 per year adding 1,600 million tonnes of sediments every year (Sen Gupta & Qasim, 1985). These two marine areas occupy 3% of the world oceans but receive 9% of the global runoff. This means that this region receives three times more river runoff per unit area when compared to the rest of the world (Sen Gupta & Naqvi, 1984).

All the countries in this region are mainly dependent on agriculture for their economy. However, some of the specific economic activities of the countries are: Maldives - fishing and tourism; Pakistan - fishing, oil exploration, agriculture, industries and tourism; Bangladesh - fishing, agriculture, industries; Sri Lanka - fishing, agriculture, industries; Malaysia - fishing, agriculture, industries, tourism, oil exploration and mining; India - fishing, agriculture, industries, tourism, oil exploration. The coastal regions of all the countries are being gradually subjected to urban development.

Marine environmental research is at various stages of development in most of the countries and there is hardly any on-going pollution monitoring programme. It has, however, been stated that "Research in marine pollution has attained significant status in India and a substantial amount of data have been collected in different fields" (UNEP, 1986).

Data and information for this report have been collated from members of the Task Team. The final draft was reviewed at the second meeting of national focal points on the development of an action plan for the protection and management of the South Asian Seas region, Bangkok, 7-11 December 1987 and has been revised accordingly.

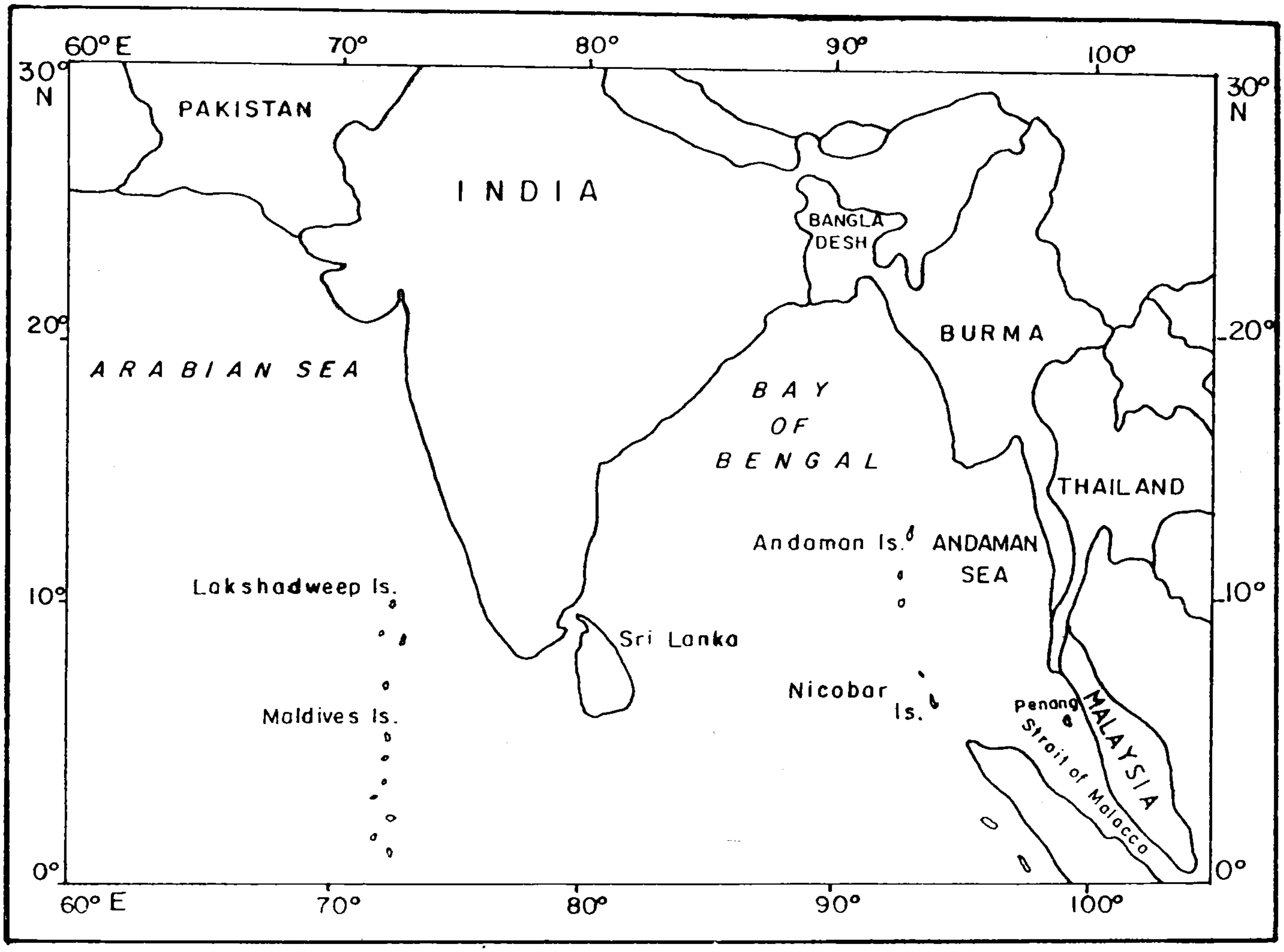

Fig 1 . The South Asian Seas Region

2. CHARACTERISTICS OF THE REGION

In relation to the equator, the Indian Ocean has an asymmetric shape largely due to the presence of the Asian continent. The result is that this ocean gets separated from the deep-reaching vertical convection areas of the northern hemisphere. Such an asymmetric configuration leads to a weak circulation and poor renewal at depths of the Northern Indian Ocean (Dietrich, 1973). The Indian Ocean can, broadly speaking, be divided into three regions on the basis of their distinct circulation systems (i) the seasonally changing monsoon gyre; (ii) the southern hemisphere subtropical anticyclonic gyre; and (iii) the Antarctic waters with the circumpolar current (Wyrtki, 1973).

The monsoon gyre, unique to the Indian Ocean, is separated from the subtropical anticyclonic gyre by a front in the hydrochemical structure at about 10° S latitude.

The Indian Ocean, north of the equator, comprising of the Arabian Sea, the Bay of Bengal, the Andaman and Laccadive Seas, in addition to the equatorial region, comes under the monsoon gyre. However, the hydrographical and hydrochemical characteristics are widely different in different parts of this gyre itself owing to the diverse meteorological and geographical factors characteristic of each area.

The Arabian Sea is bordered on the northern, eastern and western sides by the land masses of Asia and Africa. It is connected to the Gulf through the Gulf of Oman by a 50 m deep sill at the Hormuz Strait. Similarly, a 125 m deep sill at the Strait of Bab-el-Mandab separates the Red Sea from the Arabian Sea through the Gulf of Aden. The Arabian Sea is an area of negative water balance where evaporation exceeds precipitation and runoff. The excess of evaporation over precipitation is highest (100-150 cm) off the Arabian coast and decreases steadily towards the southeast (Venkateswaran, 1956). A slight excess of precipitation over evaporation (<20 cm) occurs annually off the southwest coast of India. The high rate of evaporation results in the formation of several high-salinity water masses. The Arabian Sea high salinity water, formed in the northwestern Arabian Sea, flows southward and can be traced as a tongue of high salinity within the surface layer. The high salinity water in the Gulf, characterised by a sigma-t (density minus 1) x 10^3 value of 26.6, flows through the Hormuz Strait and the Gulf of Oman into the Arabian Sea and maintains its density level at about 300 m depth (Wyrtki, 1971). This water mass flows south, mostly east of 63° E longitude (Varma et al, 1980) and loses its characteristics in the southern Arabian Sea (Rameshbabu et al, 1980). The Red Sea water enters the Arabian Sea through the Strait of Bab-el-Mandab and the Gulf of Aden along sigma-t 27.2 surface (Wyrtki, 1971). This water mass is generally confined to south of about 17° N latitude (Rameshbabu et al, 1980).

Occasionally, the sub-surface high salinity water masses originating in the Gulf and the Red Sea form a thick layer which is of almost uniform vertical salinity, although the individual layers can still be recognized as weak salinity maxima. The whole layer is called the North Indian high-salinity intermediate water (Wyrtki, 1973). The deep and bottom waters are of circumpolar origin, probably transported by a deep western boundary current through a chain of basins (Warren et al, 1966; Warren 1978, 1981). They are called the North Indian Deep Water and North Indian Bottom Water.

Surface circulation in the Arabian Sea undergoes biannual reversal associated with the southwest (SW) and northeast (NE) monsoons. The NE monsoon is weak in this region, but the SW monsoon is very intense. Strong winds blowing with the Somali and the Arabian coasts to the left cause intense upwelling off these coasts during the SW monsoon period. Moderate upwelling also occurs off the southwest coast of India, partly due to the cyclonic motion in the neighbourhood of the Maldives and the Laccadives (Sastry & De Sousa, 1972).

In contrast to the Arabian Sea, the Bay of Bengal is a region of positive water balance. The average annual excess of precipitation is of the order of 70 cm (Venkateswaran, 1956). The total annual river runoff to the Bay of Bengal has been estimated to be about 2,000 cubic kilometres (Sen Gupta et al, 1977). The high excess of precipitation over evaporation and the massive river runoff result in low surface salinities, especially in the northern Bay of Bengal. The salinity, lower at any level in the Bay of Bengal as compared to the Arabian Sea, increases steeply within the thermocline/pycnocline and a weak salinity maximum may be observed at a depth of about 500 m. The salinity thereafter decreases monotonously with depth. The SW monsoon current probably carries the North Indian high salinity intermediate water from the Arabian Sea and fills the Bay of Bengal at intermediate depths, resulting in the salinity maximum (Wyrtki, 1973). The deep water is of circumpolar origin probably derived from the central Indian basin.

As in the Arabian Sea, the surface circulation in the Bay of Bengal changes with the monsoonal cycle. The NE monsoon is much more intense here as compared to the Arabian Sea. Induced by favourable currents and winds, moderate upwelling occurs along the coast of India, during the SW monsoon (Murty & Varadachari, 1968; Naqvi et al, 1979), even though the runoff from the rivers may partially compensate for the offshore movement of surface waters (Sen Gupta et al, 1977).

Heat budget computations for the Arabian Sea indicate that about 80% of the changes in the heat content are affected by surface exchange processes prior to the onset of the monsoon. High sea-surface temperature under calm weather conditions, prior to the onset of the southwest monsoon was observed. These surface waters were laden with large quantities of suspended biomass and hydrocarbons causing intense absorption and insolation resulting in a rise in temperature in a thin surface layer.

There is an influx of heat from the Central Indian Ocean region to the Arabian Sea across the eastern boundary before the onset of the monsoon. This is more than the outflux of moisture over the Arabian Sea and is the main source of monsoon activity over the Indian sub-continent (Mohanty et al, 1983).

The most significant chemical observation was the accurate determination of oxygen concentration in the low-oxygenated waters of the northern Indian Ocean by applying a photometric method (Sen Gupta & Naqvi 1984). This real oxygen level was used to compute the original nitrate concentration in water before the onset of denitrification processes. This, combined with the accepted values of diffusion and advection constants, helps to establish a reliable rate of denitrification and the "standing crop" of denitrified nitrogen. Combination of these two, gave a turnover time for the oxygen-poor layer of about 4 years. This short renewal time of intermediate waters and the short-term variability of the denitrification intensity suggests that the oxygen-poor layer is an unstable time-variable feature which may react quickly to any future climatic and/or environmental perturbations. Hence there is an alarming possibility that a slight increase in organic carbon flux due to pollution and/or a climatic change could have a decisive impact on these intermediate waters turning completely anoxic (Naqvi, 1987).

3. MARINE CONTAMINANTS: LEVELS AND DISTRIBUTION

3.1 Concentration in water, sediments and biota

The most significant contaminants in all the countries of this region are bacteria and viruses arising out of human activities. These have been elaborated under Section 4.

We shall deal here with the concentrations of a few toxic heavy metals and organochlorine residues in different segments of the marine environment.

3.1.1 Metals

Regular data on monitoring of metals in water are lacking. Measurements are carried out in zooplankton, fish and sediments in a few countries. The concentrations show a wide range of variation from area to area and between analysts. These differences may be due to errors in sampling, analysis and personal bias. They may also be due to continuous improvement and sophistication of analytical instruments and methodologies.

Zooplankton hauls from different areas are analysed in India for several 'essential' and 'non-essential' heavy metals. The concentration ranges in ppm wet weight are: 2.12 - 31.95 (Cu); 3.01 - 6.99 (Mn); 7.78 - 367.09 (Zn); 36.36 - 426.49 (Fe); 0.23 - 3.12 (Ni); ND (Hg); 0.69 - 5.99 (Cd); and 4.27 - 31.87 (Pb). The most significant observation is the total absence of mercury in all the zooplankton samples (Kureishy et al, 1978, 1981, 1983; Kureishy, 1985).

Available Indian data on the concentrations of Hg, Cd, Pb and Cu in the muscles of several fish from the Northern Indian Ocean are summed up in Table 1. These are very common food fish in India. The fish were caught at different places along the coastline. Wherever ranges of values are stated in the table, they mean concentrations in several fish of varying length, sex and stages of maturity. Higher concentrations were observed in larger fish. In general, the values appear to be well within the maximum permissible limits for the metals. Occurrences of higher values are only occasional.

Examination of data on several metals in dissolved, suspended and particulate forms in the estuarine region of the River Ganges indicates very interesting results. About 85% of the dissolved metals settle within the river leaving only 15% to flow out. 10% of the suspended and particulate metals settle within the estuary, 50% at the confluence of river water with sea water and 40% finally flows out to the open Bay of Bengal (NIO, 1986).

Data from Thailand give mercury concentrations in some of the fish from the Andaman Sea. These were in the range of 0.026 - 0.234 in yellowfin tuna; 0.027 - 0.233 in bigeye tuna, and 0.057 - 0.478 in four shark species all in ppm fresh weight (Menasveta & Siriyong, 1977). These compare well with similar data from India.

Data on concentrations of some metals and metalloids (Khan et al - mss) eg.