

14886

~~27305~~

Sustainable Management of Natural Resources, Eds. T.N. Khoshoo & Manju Sharma
© (1992) Malhotra Publishing House, New Delhi - 110 064, India

Coastal Zone : Shelf-EEZ & Land Sea Interface

B. N. Desai and A. H. Parulekar

National-Institute of Oceanography,
Dona Paula, 403 004, Goa

ABSTRACT : Among the few vibrant ecotopes is the coastal zone, where multifaceted interactions among air, sea and land are dynamically balanced. An area of intense clash of interest of user community, the coastal zone harbouring vast potential of renewable and non-renewable resources, is one of the most vulnerable regions of ecological disturbances. A logical approach towards the development and monitoring of the coastal zone involves sustainable management of natural resources.

Key Words : Coastal Ecosystems ; Littoral States ; Cause and Effect Studies ; Environmental Impact Assessment ; Sustainable Management

INTRODUCTION

The coastal zone forming the interface between terrestrial and marine ecosystems has most dynamic physical and biological environment. Devoid of well-defined and rigid limits, the coastal zone consists of a system of physical interfaces, interdependently and hierarchically organized into primary and secondary interfaces. In many areas of the littoral states, the primary interface is synonymous with the shoreline.

From times immemorial, the coastal zone is an area of intense clash of interest among traditional and potential user community and consumers. Some of the typical use patterns and features of the coastal zone are :

- proximity to areas of dense human population [It is projected that 200 million or 25% of India's population inhabit the coastal zone (Qasim and Sen Gupta, 1988)],
- importance for capture and culture fisheries [Almost 60% of the world fish catch is taken from the coastal ecosystems (Lie, 1983)],
- navigational and port-harbour activities,
- location of industries, primarily due to proximity of sea transport facilities, and
- scope and preference for tourism, recreational and land reclamation activities.

In the Indian context, the coastal zone, in the absence of an agreed definition, is estimated to extend 20 km on either side of the shoreline and is projected to measure 0.3 million sq. km (Sharma and Kundra, 1985).

The human impacts on the earth now approximate the scale of the natural interactive processes that control the life-support system; all the evidences show that on the time scales of decades to centuries, human impacts on the coastal zone will exceed those of the natural processes (Anon, 1988). A deep concern for marine and estuarine habitats in coastal region is growing rapidly. Problems associated with pollution, once local in scale, have now reached regional proportions that transcend national boundaries. Assessment of effects of human activity or climatic changes that are likely to affect coastal ecosystems of particular value to mankind is the necessity of the present time and, for the future, the concept of sustainable management of natural resources is the most relevant approach (Parulekar, 1985).

STATE OF KNOWLEDGE

Economic importance of the coastal zone has been a strong impetus for investigation of the coastal ecosystems. In India, the coastal zone encompassing diverse but dynamic habitats like neritic waters, rocky foreshores, sandy beaches, mud flats, coastal lagoons, coral formations, estuaries, creeks, backwaters and mangroves has been fairly well studied, though not extensively on representative basis. As such, a century old tradition, especially in the marine biological research, has enriched the knowledge about the ecology and biota of varied ecosystems along the India's coastline stretching over 7200 km of peninsular and island ecosystems.

Recently, Desai and Das (1988), while reviewing the status of oceanographic research, have elaborated on the state of knowledge and

advances in marine science research in India. The coastal zone, a meeting point of sea, land and air, exhibits an unpredictable range of variability in and between biological, chemical, physical, geological and meteorological processes. Characterized as a fluid in constant motion, the marine environment as a whole, and the coastal zone in particular, display a wide magnitude of fluctuations, in relation to both space and time.

The coastal zone of India is rather unique in its characteristics, because it falls under the monsoon gyre. Through numerous investigations on hydrography and related factors, general information on the water masses, nearshore circulation, upwelling, accretion and erosion of foreshores is now readily available for some of the coastal areas. The variations in waves, tides, wind field, evaporation, precipitation and land drainage, for a large part of coastal zone of India, are well documented. Recent studies involving the use of remote sensing techniques are generating additional information on thermal structure, upwelling and frontal systems in relation to biological productivity, shoreline changes; littoral drift; expanse of coastal vegetation; radiation transfer; and deterioration/degradation of coastal zone in terms of land use patterns.

Considerable information is available on the chemical parameters—their distribution and relationship, specially in the coastal zone, including some of the critical ecosystems in the environs of highly industrialized urban conglomerates. The results of numerous studies on chemical parameters, viz., dissolved oxygen, alkalinity, nutrient salts, metals, pesticidal, insecticidal and fertilizer residues; and petroleum hydrocarbon contaminants, have set the stage for modelling the distribution of chemical constituents for estimating and monitoring their transfer rates from anthropogenic inputs to their fate in the coastal zone (Desai and Das, *op. cit.*).

The earliest publication relating to marine science and oceanographic research in India was a marine biology and that too in the year 1871 by J. Wood Mason. While the marine biological and biological oceanographic research in the later part of the nineteenth century and in the first half of the twentieth century was primarily concerned with the distribution, abundance, taxonomy and ecology of estuaries, intertidal and nearshore biota, the last four decades of biological research in the coastal zone of India, occupy a unique position in the overall oceanographic research and development work in the Indian Ocean, as elsewhere.

In general, the coastal waters of the tropical seas are biologically poor, with the exception of areas of coastal upwelling (Parsons, Takahashi and Hargrave, 1977). The reasons for biological impoverishment are to be sought in the high stability of waters, in the deep thermocline and in the absence

of good mixing of surface waters with deep waters, rich in nutrient salts. An exception is provided by the estuaries, mangroves, coral formations and coastal lagoons, which are characterized by strong interaction with the terrestrial ecosystems on one hand and between neritic (shelf) and oceanic (EEZ) waters on the other. However, the coastal ecosystems of India have been found to be far more productive than the offshore ecosystems (Parulekar, Harkantra and Ansari, 1982). Details about the ecology, productivity, distribution and abundance of biota, fishery, aquaculture potentials as also bioactivity or biomedical potentials of the coastal zone of India, are more than fairly known. Similarly, localized information on the biodegradation of materials in the coastal ecosystems of India is on record.

In the recent past, a major impetus to studies on the geological aspects of the coastal zone of India has come from the necessity of estimating offshore fossil fuel potentials. It gave a real boost to geological, geophysical and geochemical studies for mineral and petroleum hydrocarbon prospecting along the shelf and coastal ecosystems of India. At present, oil production from offshore oilfields accounts for 75% of the total production (Desai and Das, *op. cit.*). The shoreline mineral resources of high grade beach and low grade dune sands containing varying proportions of ilmenite and rutile together with other components like monazite, sillimanite, garnet, magnetite and silica, have been quantitatively delineated. The location of placer resources, their potentials and the present level of exploitation are also well documented (Siddiquie *et al.*, 1984).

Scientific information on the type, magnitude and extent of interaction among biological, chemical, geological, meteorological and physical parameters in the coastal zone of India is available, but on a rather modest scale. Such type of background and baseline information is an essential prerequisite for the development and monitoring of a conservation plan towards efficient exploitation of natural resources and protection of environment. The database, if further augmented, can be fruitfully used for coastal zone modelling, which is a time-honoured and proven method for forecasting and monitoring of coastal ecosystems in particular, and the coastal zone as a whole in general.

THE PROBLEM

It is apparent that the critical habitats like coastal ecosystems are being subjected to an increasing variety and severity of impacts as a result of the increased pace of industrial development and the pressures of a greatly increased human population (Ormond, 1985). Through ages, marine and estuarine biota are subjected to environmental and man-made changes and as an evolutionary response they have developed adaptive capabilities to overcome such nature induced stresses. However, in recent years, the magnitude

of man-made interferences in the coastal zone has increased so much that the self-cleansing or assimilative capacity of the most affected coastal ecosystems is not only losing its high potentials for generating harvestable living resources but also posing an imminent human health hazard (Rao and Parulekar, 1985).

The coastal zone of India, encompassing diverse but dynamic ecosystems, is subjected to variety of inputs of organic and inorganic contaminants as a direct effect of anthropogenic activities. It is estimated that 1600 million tonnes of sediments annually reach the coastal zone and EEZ from rivers flowing through the Indian sub-continent (Qasim and Sen Gupta, 1983). The greatest impact of river-borne sedimentation, besides siltation and posing navigational hazards, is on estuarine and nearshore capture and culture fisheries.

Another significant contaminant is the domestic sewage. Bombay city annually discharges 365 million tonnes of sewage and other effluents to the coastal zone. The sewage outflow from Calcutta city to the Hooghly estuary totals about 396 million tonnes per year (Sen Gupta *et al.*, 1990). The annual input of domestic sewage to the sea by the coastal population of India is estimated to be $4.1 \times 10^9 \text{ m}^3$. Similarly, industrial effluents added to the coastal zone of the India are projected to be $0.41 \times 10^9 \text{ m}^3$. Qasim and Sen Gupta (1988) have reported the annual input of sewage and industrial effluents added by the rivers to the coastal ecosystems of India to be $50 \times 10^6 \text{ m}^3$ and the solid wastes and garbage generated by coastal population to be 34×10^6 tonnes/year.

No authentic data on the entry of residues of pesticides, fertilizers and synthetic detergents into the seas around India are on record. However, deducing from the yearly use of these new types of chemicals, which is estimated to be 55,000 tonnes of pesticides, 5×10^6 tonnes of fertilizers and 1,25,000 tonnes of synthetic detergents (Qasim and Sen Gupta, 1988), the magnitude of entry of contaminants of these categories to the Indian seas and its possible effects on the ecology and biota of the coastal zone of India are a matter of concern. It is estimated that about 3000 tonnes of petroleum hydrocarbon residues in the form of tar ball get deposited on Indian beaches each year (Dwivedi and Parulekar, 1974).

From a review on the state of marine environment in India, Sen Gupta *et al.*, (1990) found sewage and other industrial effluents to be most important, as presently they are discharged into coastal marine and estuarine ecosystems in partially treated or raw form. The results are occasional fish mortality; damage to coral reefs; degradation of mangrove habitat; and lowering of environmental quality of estuarine and backwater ecosystems. Pollutants also enter into the coastal zone through huge amounts of silt, added

every year, into the coastal ecosystems. This sediment load is the direct consequence of massive deforestation leading to loss of nutrient-rich top soil. Similarly, land reclamation and erosion, though local to regional in nature, unless curbed, can assume a national dimension. Another significant problem is the deleterious effects of unplanned beach tourism on coastal zone ecosystems in specific areas.

The paradox of the whole situation is that though major changes in the marine environment as a whole, and in the coastal ecosystems in particular, are discernible, not many cause and effect studies or environmental impact assessment (EIA) are on record. One of the major constraints in devising remedial measures and a conservation strategy is the paucity of long-term and relevant baseline information of the ecology and biota of the extensive coastal ecosystems of India.

However, some attempts in the form of long-term studies, pertaining to environmental monitoring of coastal ecosystems threatened by man-made changes are on record. Parulekar and Untawale (1978) quantified the magnitude of detrimental changes in coral formations and mangrove vegetation at Pirotan and Deda Islands in the Gulf of Kutch, resulting from dredging of coral stones and coral sands for cement factories and indiscriminate cutting of mangroves for fuel and fodder. In a long-term study on the relative abundance of biota in relation to environmental quality in the coastal ecosystems of Bombay, Parulekar *et al.* (1985) observed total disappearance of bottom fauna in the severely affected shallow coastal ecosystems; 50% decrease in the relative abundance of biota in areas of lesser impact and total deoxygenation of near bottom water due to heavy input of sewage and domestic waste. Total degeneration of mangrove vegetation in the environs of Bombay due to land fill, reclamation and industrial pollutants has been observed. Such rampant destruction of marine natural resources, especially in the vicinity of metropolis and industrial centres, is glaringly evident along the coastline of India.

A study of long term effects of iron and manganese ore mining operations, especially of the mining rejects on the estuarine ecosystems of Goa, along the west coast of India, revealed (Parulekar, Ansari and Ingole, 1986) an overall 66% reduction in dissolved oxygen concentration; three-fold increase in the quantum of suspended solids; reduction in standing crop of commercially important shellfishes from 500 g m⁻² to 10 g m⁻² in less than ten years and more than 50% reduction in the quantitative distribution of bottom fauna in the same timeframe of 10 years. From a long term study on the effects of pollution on fisheries along the Bombay coast, Sivaprakasam and Somvanshi (1987) have reported drastic fall in annual catch of pelagic

fishes from 5507 tonnes in 1972 to 258 tonnes in 1982 and have attributed it to the increasing level of pollution rather than the natural causes. Similarly, elsewhere along the Indian coastline, the catch per unit effort (CPUE) in marine fisheries is showing a consistently decreasing trend, which is a testimony to exploitation higher than the maximum sustainable yield.

The aforesaid cause and effect studies are just a "tip of the iceberg" about the magnitude of deterioration of coastal zone, though only a few "hot spots" have been delineated.

SUSTAINABLE MANAGEMENT

The extent to which the coastal zone and ecosystems therein are affected by man-made changes and environmental variability, major qualitative and quantitative changes in the coastal environs of centres of industry and urban conglomerates have been reported. Even a slight change in the pattern of distribution, behaviour and physiology of biota can be taken advantage of and used as a warning system for avoiding greater damage in later years. This is of direct relevance in the management, monitoring and protection of coastal environment and resources.

The most pressing objective of environmental management is to meet basic human needs within the potentials and constraints of an ecosystem (Tolba, 1978), including natural resources. It includes environmental quality and extends to long term development on a sustainable basis. The past patterns of development in both developed and developing countries have been characterized by such serious environmental damages that they are simply not sustainable. The relentless pressures that arise when basic human needs are not met can erase the resource base from which man must inevitably gain his sustenance.

From ecological and resource consideration, a system to evaluate water based on the assessment of biota reflects directly on the existing conditions. The advantage of monitoring is that it directly reflects on the effects of toxicants on the environment and the biota, as the marine organisms integrate the overall effect of a combination of pollutants (Ketchum, 1973).

In respect of coastal zone, three major consequences of the changes have been identified for monitoring (Angel, 1984): long term variability in climate; direct effect of exploitation of resources; and the chemical changes brought about by full spectrum of human activities. Thus, for remedying the deterioration of environmental quality in relation to natural resources of the coastal zone, monitoring is an essential requirement (Tyagi and Chakravarti, 1987) and should be done with the following objectives :

- To identify the use—present and future—of coastal zone and classify on scientific basis the specific areas for specific uses like fishing, aquaculture, industry, housing, ports, reclamation, recreation and tourism,
- To identify ecological sensitive ecosystems for conservation,
- To identify sources of pollution and prepare an inventory of causative agents for treatment and safe disposal.

This new orientation must be less demanding of natural resources and the environment. The new forms of development should be based on environmentally sound sustainable management of natural resources and should avoid destruction of the resource base on which sustained development depends. It has been remarked that a pollutant is a resource in the wrong place. However, it is not rational to lose ever-increasing quantities of resources as pollutants and then to use greater quanta of resources to deal with the effect of that pollution (Tolba, *op. cit.*).

Sustainable management, which takes into account the environmental constraints, can be fruitfully used to maximize the yield from natural resources without destroying the ecological basis and to give sustainable production. Existing scientific and technical information can be better mobilized and applied more effectively and efficiently to ensure sustained rather than short term benefits. If development and management of natural resources of the dynamically balanced coastal zone are to be sustainable, their environmental impact must be assessed and an environmental approach adopted for the management of activities which make up the development process.

The Stockholm Conference recognized that environmental assessment encompasses four functions, namely evaluation and review, research, monitoring and information exchange. While evaluation and review involves analysis aimed at identifying gaps in knowledge and action, research provides new information or interpretation of old information, which helps in efficient sustainable management. Monitoring which gathers in a continuous and systematic fashion certain data on specific environmental variables, further aids in evaluating such data to determine and predict important short and long term environmental trends.

It has been aptly said that in the years to come "seas will be the last frontiers" of human development. The marine natural resources if managed and harvested on sustainable basis, can prove to be inexhaustible, not only literally but also realistically.

REFERENCES

- Angel, M. F. 1984. Biological Oceanography and the FORE Report. *Bruun Memorial Lecture 1982* : 33-40 (IOC Technical Series 28, UNESCO, Paris).
- Anon, 1988. Global Change. Report No. 4, 1988. pp 200 (The International Geosphere-Biosphere Programme : A Study of Global Change (IGBP)).
- Desai, B. N. and V. Kesava Das. 1988. Oceanography of the EEZ of India. In : *40 Years of Research—A CSIR Overview Series, II* : 23-51.
- Dwivedi, S. N. and A. H. Parulekar, 1974. Oil pollution along the Indian coastline. *Proceedings of Symposium & Workshop on Marine Pollution Monitoring (Petroleum)*. Gaithersburg, Maryland (USA), NBS. Spl. Publ. 409 : 101-105.
- Ketchum, B. H. 1973. Ecological effects of marine pollution. In : *Special Publication Dedicated to Dr. N. K. Panikkar* (Marine Biological Association of India) : 7-28.
- Lie, U. 1983. Marine ecosystem : Research and management. *Impact of Science of Society*, Vol. 33, No. 374 : 277-292.
- Ormond, R. 1985. Status of critical marine habitats in the Indian Ocean. *Proceedings of IOC/UNESCO Workshop on Regional Co-operation in Marine Sciences in the Central Indian Ocean, Adjacent Seas & Gulfs—SC-88/WS/62* : 167-194.
- Parsons, T. R., M. Takahashi and B. Hargrave 1977. *Biological Oceanographic Processes*, pp 325 (Pergamon Press, London).
- Parulekar, A. H. 1985. Benthic watch : a case study of biological monitoring of marine environment. *Biological Memoirs*, Vol. 11, No. 1 : 99-103.
- Parulekar, A. H. and A. G. Untawale 1978. Status report on Pirotan Island (Gulf of Kutch) for starting a conservation plan. In : *Report of Sponsored Project on Flora, Fauna & Natural History of Pirotan Island in the Gulf of Kutch—The World Wildlife Fund*, pp 16 (Mimeo).
- Parulekar, A. H., S. N. Harkantra and Z. A. Ansari 1982. Benthic production & assessment of demersal fishery resources of the Indian Seas. *Indian Journal of Marine Sciences*, Vol 11: 107-114.
- Parulekar, A. H., Z. A. Ansari, S. N. Harkantra and C. L. Rodrigues 1985. Long term variations in benthic macro-invertebrate assemblages off Bombay : 485-494. In : Eds. : M. F. Thompson, R. Sarojini and R. Nagabhushan *Biology of Marine Benthic Organisms : Techniques and Methods as Applied to the Indian Ocean*. (Oxford & IBH Publ. Co., New Delhi).
- Parulekar, A. H., Z. A. Ansari and B. S. Ingole, 1986. Effect of mining activities on the clam fisheries and bottom fauna of Goa estuaries. *Proceedings of the Indian Academy of Sciences (Animal Sciences)*, Vol. 95 : 325-339.
- Qasim S. Z. and R. Sen Gupta 1983, Environmental characteristics of the ocean. Vol. 1 : 294-309. In : Eds J. R. Pfafflin and E. N. Ziegler. *Encyclopaedia of Environmental Science and Engineering* (Gordon and Breach Science Publishers, New York).
- Qasim, S. Z. and R. Sen Gupta 1988. Some problems of coastal pollution in India. *Marine Pollution Bulletin*, Vol. 19 : 100-106.
- Rao, T. S. S. and A. H. Parulekar 1985. Biological monitoring for conservation of marine living resources along the Indian Coast—An uneasy experience. *Mahasagar—Bulletin of*

National Institute of Oceanography (Dr. V. V. R. Varadachari Sastabdapurthi Felicitation Volume) Vol. 18, No. 2 : 249-255.

Sen Gupta, R., M. Ali. A. L. Bhuiyan, M. M. Hossain, P. M. Sivalingam, S. Subasinghe and N. M. Tirmizi 1990. State of the marine environment in the South Asian Sea region. *UNEP Regional Seas Report and Studies*, No. 123, pp. 44.

Sharma, R. C. and P. Kundra 1985. Potentials and prospects of food from the seas around India. 149-150. In Sharma, R. C. (Ed.) *The Oceans—Realities and Prospects* (Rajosh Publications, Delhi).

Siddiquie, H. N., A. R. Gujar, N. H. Hashimi and A. B. Valasankar 1984. Surficial mineral resources of the Indian Ocean. *Deep Sea Research.*, Vol. 31 (6-8 A) : 763-812.

Sivaprakasam, T. E. and V. S. Somavanshi 1987. Marine pollution and fisheries in India. *Proceedings of Inter-departmental Seminar on Status of Marine Pollution in India* : 151-165. (Department of Ocean Development, Govt. of India, New Delhi).

Tolba, Mostafa K. 1978. Development without destruction : 49-74. In : Desh Bandhu, V. Bhardwaj and J. L. Bhat (Eds) *Managing the Environment* (Indian Environmental Society, Delhi 110 036).

Tyagi, P. C. and S. P. Chakravarti 1987. Land-based marine pollution control in India. *Proceedings of Inter-departmental Seminar on Status of Marine Pollution in India* : 140-145 (Department of Ocean Development, Govt. of India, New Delhi).